CONTENTS

SECTION 8 MAST

FOREWORD

1. STRUCTURE

This service manual has been prepared as an aid to improve the quality of repairs by giving the serviceman an accurate understanding of the product and by showing him the correct way to perform repairs and make judgements. Make sure you understand the contents of this manual and use it to full effect at every opportunity.
This service manual mainly contains the necessary technical information for operations performed in a service workshop.
For ease of understanding, the manual is divided into the following sections.

SECTION 1 GENERAL

This section gives the general information of the machine and explains the safety hints for maintenance.

SECTION 2 REMOVAL & INSTALLATION OF UNIT

This section explains the procedures and techniques of removal and installation of each component.

SECTION 3 POWER TRAIN SYSTEM

This section explains the structure of the transmission as well as control valve and drive axle.

SECTION 4 BRAKE SYSTEM

This section explains the brake piping, each component and operation.

SECTION 5 STEERING SYSTEM

This section explains the structure of the steering unit, priority valve, trail axle as well as steering circuit and operation.

SECTION 6 HYDRAULIC SYSTEM

This section explains the structure of the gear pump, main control valve as well as work equipment circuit, each component and operation.

SECTION 7 ELECTRICAL SYSTEM

This section explains the electrical circuit and each component.
It serves not only to give an understanding electrical system, but also serves as reference material for troubleshooting.

SECTION 8 MAST

This section explains the structure of mast, carriage, backrest and forks.

The specifications contained in this service manual are subject to change at any time and without any advance notice. Contact your HYUNDAI distributor for the latest information.

2. HOW TO READ THE SERVICE MANUAL

Distribution and updating

Any additions, amendments or other changes will be sent to HYUNDAI distributors.
Get the most up-to-date information before you start any work.

Filing method

1. See the page number on the bottom of the page.
   File the pages in correct order.
2. Following examples shows how to read the page number.
   Example 1
   2 - 3
   Item number(2. Structure and Function)
   Consecutive page number for each item.
3. Additional pages : Additional pages are indicated by a hyphen(-) and number after the page number. File as in the example.
   10 - 4
   10 - 4 - 1
   10 - 4 - 2
   Added pages
   10 - 5

Revised edition mark(①②③…)

When a manual is revised, an edition mark is recorded on the bottom outside corner of the pages.

Revisions

Revised pages are shown at the **list of revised pages** on the between the contents page and section 1 page.

Symbols

So that the shop manual can be of ample practical use, important places for safety and quality are marked with the following symbols.

Symbol	Item	Remarks
⚠	Safety	Special safety precautions are necessary when performing the work.
		Extra special safety precautions are necessary when performing the work because it is under internal pressure.
※	Caution	Special technical precautions or other precautions for preserving standards are necessary when performing the work.

3. CONVERSION TABLE

Method of using the Conversion Table

The Conversion Table in this section is provided to enable simple conversion of figures. For details of the method of using the Conversion Table, see the example given below.

Example

1. Method of using the Conversion Table to convert from millimeters to inches
   Convert 55mm into inches.
   (1) Locate the number 50in the vertical column at the left side, take this as ⓐ, then draw a horizontal line from ⓐ.
   (2) Locate the number 5in the row across the top, take this as ⓑ, then draw a perpendicular line down from ⓑ.
   (3) Take the point where the two lines cross as ⓒ. This point ⓒ gives the value when converting from millimeters to inches. Therefore, 55mm = 2.165 inches.

2. Convert 550mm into inches.
   (1) The number 550 does not appear in the table, so divide by 10(Move the decimal point one place to the left) to convert it to 55mm.
   (2) Carry out the same procedure as above to convert 55mm to 2.165 inches.
   (3) The original value(550mm) was divided by 10, so multiply 2.165 inches by 10(Move the decimal point one place to the right) to return to the original value.
   This gives 550mm = 21.65 inches.

Millimeters to inches

1mm = 0.03937 in

	0	1	2	3	4	5 ⓑ	6	7	8	9
0		0.039	0.079	0.118	0.157	0.197	0.236	0.276	0.315	0.354
10	0.394	0.433	0.472	0.512	0.551	0.591	0.630	0.669	0.709	0.748
20	0.787	0.827	0.866	0.906	0.945	0.984	1.024	1.063	1.102	1.142
30	1.181	1.220	1.260	1.299	1.339	1.378	1.417	1.457	1.496	1.536
40	1.575	1.614	1.654	1.693	1.732	1.772	1.811	1.850	1.890	1.929
ⓐ 50	1.969	2.008	2.047	2.087	2.126	ⓒ 2.165	2.205	2.244	2.283	2.323
60	2.362	2.402	2.441	2.480	2.520	2.559	2.598	2.638	2.677	2.717
70	2.756	2.795	2.835	2.874	2.913	2.953	2.992	3.032	3.071	3.110
80	3.150	3.189	3.228	3.268	3.307	3.346	3.386	3.425	3.465	3.504
90	3.543	3.583	3.622	3.661	3.701	3.740	3.780	3.819	3.858	3.898

Millimeters to inches

1mm = 0.03937in

	0	1	2	3	4	5	6	7	8	9
0		0.039	0.079	0.118	0.157	0.197	0.236	0.276	0.315	0.354
10	0.394	0.433	0.472	0.512	0.551	0.591	0.630	0.669	0.709	0.748
20	0.787	0.827	0.866	0.906	0.945	0.984	1.024	1.063	1.102	1.142
30	1.181	1.220	1.260	1.299	1.339	1.378	1.417	1.457	1.496	1.536
40	1.575	1.614	1.654	1.693	1.732	1.772	1.811	1.850	1.890	1.929
50	1.969	2.008	2.047	2.087	2.126	2.165	2.205	2.244	2.283	2.323
60	2.362	2.402	2.441	2.480	2.520	2.559	2.598	2.638	2.677	2.717
70	2.756	2.795	2.835	2.874	2.913	2.953	2.992	3.032	3.071	3.110
80	3.150	3.189	3.228	3.268	3.307	3.346	3.386	3.425	3.465	3.504
90	3.543	3.583	3.622	3.661	3.701	3.740	3.780	3.819	3.858	3.898

Kilogram to Pound

1kg = 2.2046lb

	0	1	2	3	4	5	6	7	8	9
0		2.20	4.41	6.61	8.82	11.02	13.23	15.43	17.64	19.84
10	22.05	24.25	26.46	28.66	30.86	33.07	35.27	37.48	39.68	41.89
20	44.09	46.30	48.50	50.71	51.91	55.12	57.32	59.5.	61.73	63.93
30	66.14	68.34	70.55	72.75	74.96	77.16	79.37	81.57	83.78	85.98
40	88.18	90.39	92.59	94.80	97.00	99.21	101.41	103.62	105.82	108.03
50	110.23	112.44	114.64	116.85	119.05	121.25	123.46	125.66	127.87	130.07
60	132.28	134.48	136.69	138.89	141.10	143.30	145.51	147.71	149.91	152.12
70	154.32	156.53	158.73	160.94	163.14	165.35	167.55	169.76	171.96	174.17
80	176.37	178.57	180.78	182.98	185.19	187.39	189.60	191.80	194.01	196.21
90	198.42	200.62	202.83	205.03	207.24	209.44	211.64	213.85	216.05	218.26

Liter to U.S. Gallon

1 l = 0.2642 U.S.Gal

	0	1	2	3	4	5	6	7	8	9
0		0.264	0.528	0.793	1.057	1.321	1.585	1.849	2.113	2.378
10	2.642	2.906	3.170	3.434	3.698	3.963	4.227	4.491	4.755	5.019
20	5.283	5.548	5.812	6.6076	6.340	6.604	6.869	7.133	7.397	7.661
30	7.925	8.189	8.454	8.718	8.982	9.246	9.510	9.774	10.039	10.303
40	10.567	10.831	11.095	11.359	11.624	11.888	12.152	12.416	12.680	12.944
50	13.209	13.473	13.737	14.001	14.265	14.529	14.795	15.058	15.322	15.586
60	15.850	16.115	16.379	16.643	16.907	17.171	17.435	17.700	17.964	18.228
70	18.492	18.756	19.020	19.285	19.549	19.813	20.077	20.341	20.605	20.870
80	21.134	21.398	21.662	21.926	22.190	22.455	22.719	22.983	23.247	23.511
90	23.775	24.040	24.304	24.568	24.832	25.096	25.631	25.625	25.889	26.153

Liter to U.K. Gallon

1 l = 0.21997 U.K.Gal

	0	1	2	3	4	5	6	7	8	9
0		0.220	0.440	0.660	0.880	1.100	1.320	1.540	1.760	1.980
10	2.200	2.420	2.640	2.860	3.080	3.300	3.520	3.740	3.950	4.179
20	4.399	4.619	4.839	5.059	5.279	5.499	5.719	5.939	6.159	6.379
30	6.599	6.819	7.039	7.259	7.479	7.969	7.919	8.139	8.359	8.579
40	8.799	9.019	9.239	9.459	9.679	9.899	10.119	10.339	10.559	10.778
50	10.998	11.281	11.438	11.658	11.878	12.098	12.318	12.528	12.758	12.978
60	13.198	13.418	13.638	13.858	14.078	14.298	14.518	14.738	14.958	15.178
70	15.398	15.618	15.838	16.058	16.278	16.498	16.718	16.938	17.158	17.378
80	17.598	17.818	18.037	18.257	18.477	18.697	18.917	19.137	19.357	19.577
90	19.797	20.017	20.237	20.457	20.677	20.897	21.117	21.337	21.557	21.777

kgf · m to lbf · ft

1kgf · m = 7.233lbf · ft

	0	1	2	3	4	5	6	7	8	9
		7.2	14.5	21.7	28.9	36.2	43.4	50.6	57.9	65.1
10	72.3	79.6	86.8	94.0	101.3	108.5	115.7	123.0	130.2	137.4
20	144.7	151.9	159.1	166.4	173.6	180.8	188.1	195.3	202.5	209.8
30	217.0	224.2	231.5	238.7	245.9	253.2	260.4	267.6	274.9	282.1
40	289.3	396.6	303.8	311.0	318.3	325.5	332.7	340.0	347.2	354.4
50	361.7	368.9	376.1	383.4	390.6	397.8	405.1	412.3	419.5	426.8
60	434.0	441.2	448.5	455.7	462.9	470.2	477.4	484.6	491.8	499.1
70	506.3	513.5	520.8	528.0	535.2	542.5	549.7	556.9	564.2	571.4
80	578.6	585.9	593.1	600.3	607.6	614.8	622.0	629.3	636.5	643.7
90	651.0	658.2	665.4	672.7	679.9	687.1	694.4	701.6	708.8	716.1
100	723.3	730.5	737.8	745.0	752.2	759.5	766.7	773.9	781.2	788.4
110	795.6	802.9	810.1	817.3	824.6	831.8	839.0	846.3	853.5	860.7
120	868.0	875.2	882.4	889.7	896.9	904.1	911.4	918.6	925.8	933.1
130	940.3	947.5	954.8	962.0	969.2	976.5	983.7	990.9	998.2	10005.4
140	1012.6	1019.9	1027.1	1034.3	1041.5	1048.8	1056.0	1063.2	1070.5	1077.7
150	1084.9	1092.2	1099.4	1106.6	1113.9	1121.1	1128.3	1135.6	1142.8	1150.0
160	1157.3	1164.5	1171.7	1179.0	1186.2	1193.4	1200.7	1207.9	1215.1	1222.4
170	1129.6	1236.8	1244.1	1251.3	1258.5	1265.8	1273.0	1280.1	1287.5	1294.7
180	1301.9	1309.2	1316.4	1323.6	1330.9	1338.1	1345.3	1352.6	1359.8	1367.0
190	1374.3	1381.5	1388.7	1396.0	1403.2	1410.4	1417.7	1424.9	1432.1	1439.4

kgf/cm^2 to lbf/in^2

$1 kgf / cm^2 = 14.2233 lbf / in^2$

	0	1	2	3	4	5	6	7	8	9
		14.2	28.4	42.7	56.9	71.1	85.3	99.6	113.8	128.0
10	142.2	156.5	170.7	184.9	199.1	213.4	227.6	241.8	256.0	270.2
20	284.5	298.7	312.9	327.1	341.4	355.6	369.8	384.0	398.3	412.5
30	426.7	440.9	455.1	469.4	483.6	497.8	512.0	526.3	540.5	554.7
40	568.9	583.2	597.4	611.6	625.8	640.1	654.3	668.5	682.7	696.9
50	711.2	725.4	739.6	753.8	768.1	782.3	796.5	810.7	825.0	839.2
60	853.4	867.6	881.8	896.1	910.3	924.5	938.7	953.0	967.2	981.4
70	995.6	1010	1024	1038	1053	1067	1081	1095	1109	1124
80	1138	1152	1166	1181	1195	1209	1223	1237	1252	1266
90	1280	1294	1309	1323	1337	1351	1365	1380	1394	1408
100	1422	1437	1451	1465	1479	1493	1508	1522	1536	1550
110	1565	1579	1593	1607	1621	1636	1650	1664	1678	1693
120	1707	1721	1735	1749	1764	1778	1792	1806	1821	1835
130	1849	2863	1877	1892	1906	1920	1934	1949	1963	1977
140	1991	2005	2020	2034	2048	2062	2077	2091	2105	2119
150	2134	2148	2162	2176	2190	2205	2219	2233	2247	2262
160	2276	2290	2304	2318	2333	2347	2361	2375	2389	2404
170	2418	2432	2446	2460	2475	2489	2503	2518	2532	2546
180	2560	2574	2589	5603	2617	2631	2646	2660	2674	2688
200	2845	2859	2873	2887	2901	2916	2930	2944	2958	2973
210	2987	3001	3015	3030	3044	3058	3072	3086	3101	3115
220	3129	3143	3158	3172	3186	3200	3214	3229	3243	3257
230	3271	3286	3300	3314	3328	3343	3357	3371	3385	3399
240	3414	3428	3442	3456	3470	3485	3499	3513	3527	3542

TEMPERATURE

Fahrenheit-Centigrade Conversion.

A simple way to convert a fahrenheit temperature reading into a centigrade temperature reading or vice verse is to enter the accompanying table in the center or boldface column of figures.

These figures refer to the temperature in either Fahrenheit or Centigrade degrees.

If it is desired to convert from Fahrenheit to Centigrade degrees, consider the center column as a table of Fahrenheit temperatures and read the corresponding Centigrade temperature in the column at the left.

If it is desired to convert from Centigrade to Fahrenheit degrees, consider the center column as a table of Centigrade values, and read the corresponding Fahrenheit temperature on the right.

˚C		˚F	˚C		˚F	˚C		˚F	˚C		˚F
-40.4	-40	-40.0	-11.7	11	51.8	7.8	46	114.8	27.2	81	117.8
-37.2	-35	-31.0	-11.1	12	53.6	8.3	47	116.6	27.8	82	179.6
-34.4	-30	-22.0	-10.6	13	55.4	8.9	48	118.4	28.3	83	181.4
-31.7	-25	-13.0	-10.0	14	57.2	9.4	49	120.2	28.9	84	183.2
-28.9	-20	-4.0	-9.4	15	59.0	10.0	50	122.0	29.4	85	185.0
-28.3	-19	-2.2	-8.9	16	60.8	10.6	51	123.8	30.0	86	186.8
-27.8	-18	-0.4	-8.3	17	62.6	11.1	52	125.6	30.6	87	188.6
-27.2	-17	1.4	-7.8	18	64.4	11.7	53	127.4	31.1	88	190.4
-26.7	-16	3.2	-6.7	20	68.0	12.8	55	131.0	32.2	90	194.0
-26.1	-15	5.0	-6.7	20	68.0	12.8	55	131.0	32.2	90	194.0
-25.6	-14	6.8	-6.1	21	69.8	13.3	56	132.8	32.8	91	195.8
-25.0	-13	8.6	-5.6	22	71.6	13.9	57	134.6	33.3	92	197.6
-24.4	-12	10.4	-5.0	23	73.4	14.4	58	136.4	33.9	93	199.4
-23.9	-11	12.2	-4.4	24	75.2	15.0	59	138.2	34.4	94	201.2
-23.3	-10	14.0	-3.9	25	77.0	15.6	60	140.0	35.0	95	203.0
-22.8	-9	15.8	-3.3	26	78.8	16.1	61	141.8	35.6	96	204.8
-22.2	-8	17.6	-2.8	27	80.6	16.7	62	143.6	36.1	97	206.6
-21.7	-7	19.4	-2.2	28	82.4	17.2	63	145.4	36.7	98	208.4
-21.1	-6	21.2	-1.7	29	84.2	17.8	64	147.2	37.2	99	210.2
-20.6	-5	23.0	-1.1	35	95.0	21.1	70	158.0	51.7	125	257.0
-20.0	-4	24.8	-0.6	31	87.8	18.9	66	150.8	40.6	105	221.0
-19.4	-3	26.6	0	32	89.6	19.4	67	152.6	43.3	110	230.0
-18.9	-2	28.4	0.6	33	91.4	20.0	68	154.4	46.1	115	239.0
-18.3	-1	30.2	1.1	34	93.2	20.6	69	156.2	48.9	120	248.0
-17.8	0	32.0	1.7	35	95.0	21.1	70	158.0	51.7	125	257.0
-17.2	1	33.8	2.2	36	96.8	21.7	71	159.8	54.4	130	266.0
-16.7	2	35.6	2.8	37	98.6	22.2	72	161.6	57.2	135	275.0
-16.1	3	37.4	3.3	38	100.4	22.8	73	163.4	60.0	140	284.0
-15.6	4	39.2	3.9	39	102.2	23.3	74	165.2	62.7	145	293.0
-15.0	5	41.0	4.4	40	104.0	23.9	75	167.0	65.6	150	302.0
-14.4	6	42.8	5.0	41	105.8	24.4	76	168.8	68.3	155	311.0
-13.9	7	44.6	5.6	42	107.6	25.0	77	170.6	71.1	160	320.0
-13.3	8	46.4	6.1	43	109.4	25.6	78	172.4	73.9	165	329.0
-12.8	9	48.2	6.7	44	111.2	26.1	79	174.2	76.7	170	338.0
-12.2	10	50.0	7.2	45	113.0	26.7	80	176.0	79.4	172	347.0

SECTION 1 GENERAL

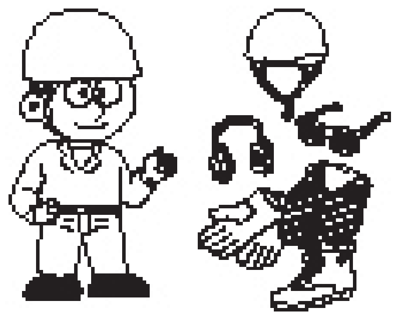
GROUP 1 SAFETY HINTS

Careless performing of the easy work may cause injuries.
Take care to always perform work safely, at least observing the following.

- Oil is a dangerous substance. Never handle oil, grease or oily clothes in places where there is any fire of flame.
  As preparation in case of fire, always know the location and directions for use of fire extinguishers and other fire fighting equipment.

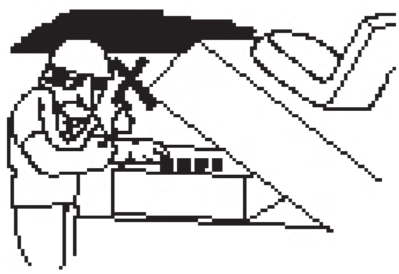
D35ASF01

- Wear well-fitting helmet, safety shoes and working clothes. When drilling, grinding or hammering, always wear protective goggles.
  Always do up safety clothes properly so that they do not catch on protruding parts of machines. Do not wear oily clothes.
  When checking, always release battery plug.



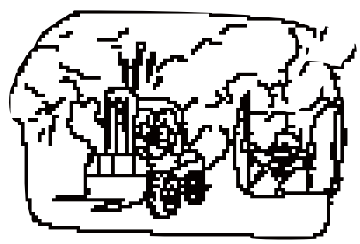
D35ASF02

- Flames should never be used instead of lamps. Never use a naked flame to check leaks or the level of oil or electrolyte.



D35ASF03

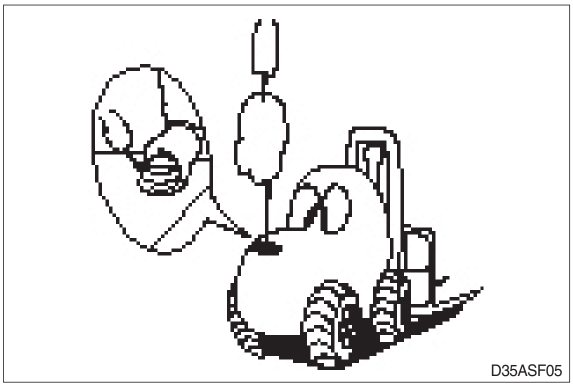
- Exhaust gas is dangerous. Provide adequate ventilation when working a closed space.



D35ASF04

▲ Be particularly careful when removing the radiator cap and the hydraulic oil tank filler cap, if this is done immediately after using the machine, there is a danger that boiled oil may spurt out.

· The procedure for releasing the hydraulic pressure is as follows : lower the fork to the ground, and stop the engine(Motor), move the control levers to each position two or three times.



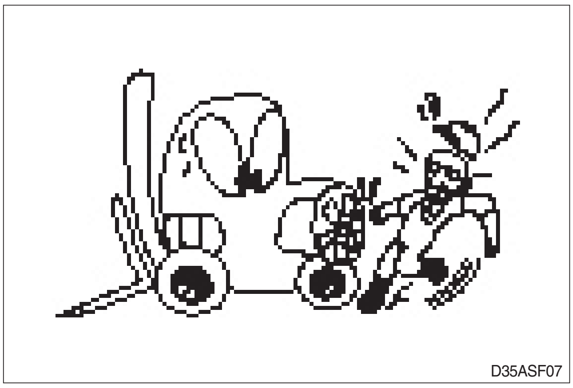
D35ASF05

· When working on top of the machine, be careful not to lose your balance and fall.

D35ASF06

· Hand a caution sign in the operator's compartment (For example Do not start or Maintenance in progress).
  This will prevent anyone from starting or moving the machine by mistake.

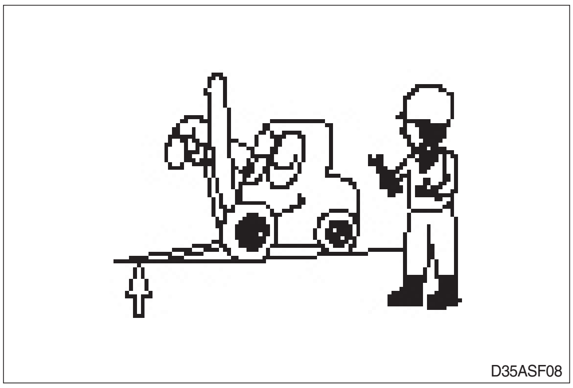
▲ It is extremely dangerous to try to check the fan belt tension while the engine is running.



D35ASF07

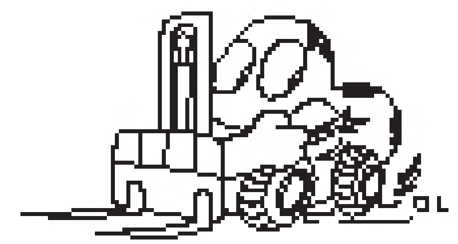
When inspecting the engine is running parts, or near such parts, always stop the engine first.
Before checking or servicing accumulator or piping, depress brake pedal repeatedLy to release pressure.

· Park the machine on firm, flat ground.
  Lower the fork to the ground and stop the engine.
  Return each lever to NEUTRAL and apply the brake lock.



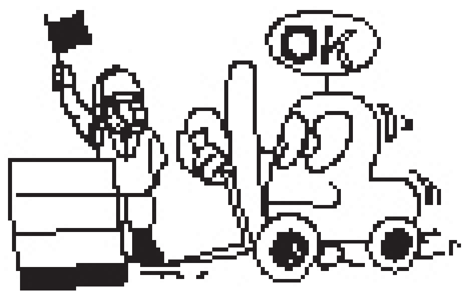
D35ASF08

· Immediately remove any oil or grease on the floor of the operator's compartment, or on the handrail. It is very dangerous if someone slips while on the machine.



D35ASF09

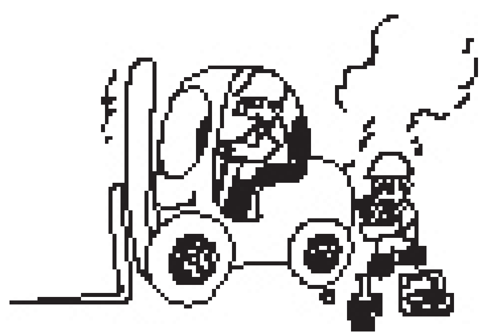
· When working with others, choose a group leader and work according to his instructions. Do not perform any maintenance beyond the agreed work.



D35ASF10

· Unless you have special instructions to the contrary, maintenance should always be carried out with the engine stopped. If maintenance is carried out with the engine running, there must be two men present : one sitting in the operator's seat and the other one performing the maintenance. In such a case, never touch any moving part.

· Always remember that the hydraulic oil circuit is under pressure. When feeding or draining the oil or carrying out inspection and maintenance, release the pressure first.



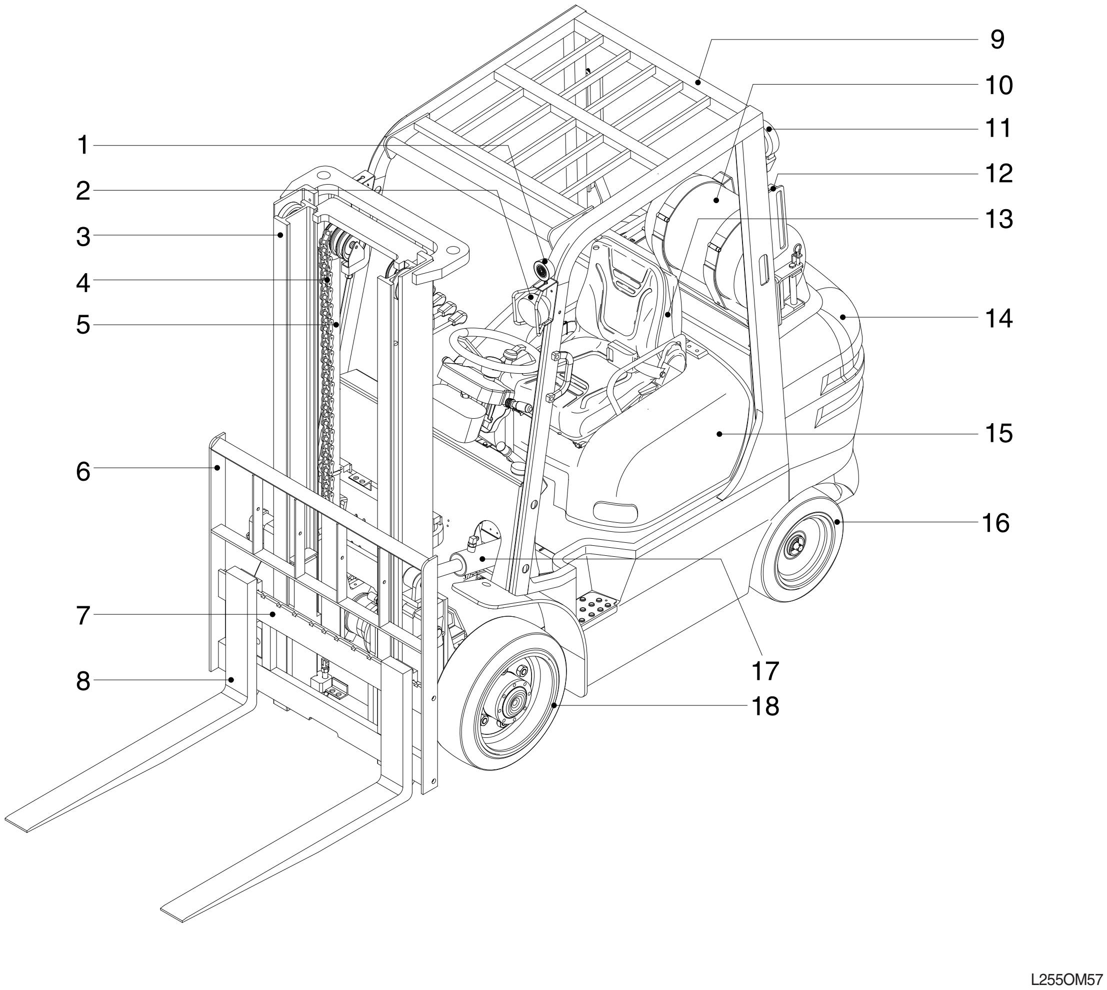
D35ASF11

- Thoroughly clean the machine. In particular, be careful to clean the filler caps, grease fittings and the area around the dipsticks. Be careful not to let any dirt or dust into the system.
- Always use HYUNDAI Forklift genuine parts for replacement.
- Always use the grades of grease and oil recommended by HYUNDAI Forklift.
  Choose the viscosity specified for the ambient temperature.
- Always use pure oil or grease, and be sure to use clean containers.
- When checking or changing the oil, do it in a place free of dust, and prevent any dirt from getting into the oil.
- Before draining the oil, warm it up to a temperature of 30 to 40° C .
- After replacing oil, filter element or strainer, bleed the air from circuit.
- When the strainer is located in the oil filler, the strainer must not be removed while adding oil.
- When changing the oil filter, check the drained oil and filter for any signs of excessive metal particles or other foreign materials.
- When removing parts containing O-ring, gaskets or seals, clean the mounting surface and replace with new sealing parts.
- After injecting grease, always wipe off the oil grease that was forced out.
- Do not handle electrical equipment while wearing wet places, as this can cause electric shock.
- During maintenance do not allow any unauthorized person to stand near the machine.
- Be sure you fully understand the contents of the operation. It is important to prepare necessary tools and parts and to keep the operating area clean.
- When checking an open gear case there is a risk of dropping things in. Before removing the covers to inspect such cases, empty everything from your pockets. Be particularly careful to remove wrenches and nuts.
- Way to use dipstick
  Push the dipstick fully into the guide, and then pull out.

Carrying out other difficult maintenance work carelessly can cause unexpected accidents. If you consider the maintenance is too difficult, always request the HYUNDAI Forklift distributor to carry out it.

GROUP 2 SPECIFICATIONS

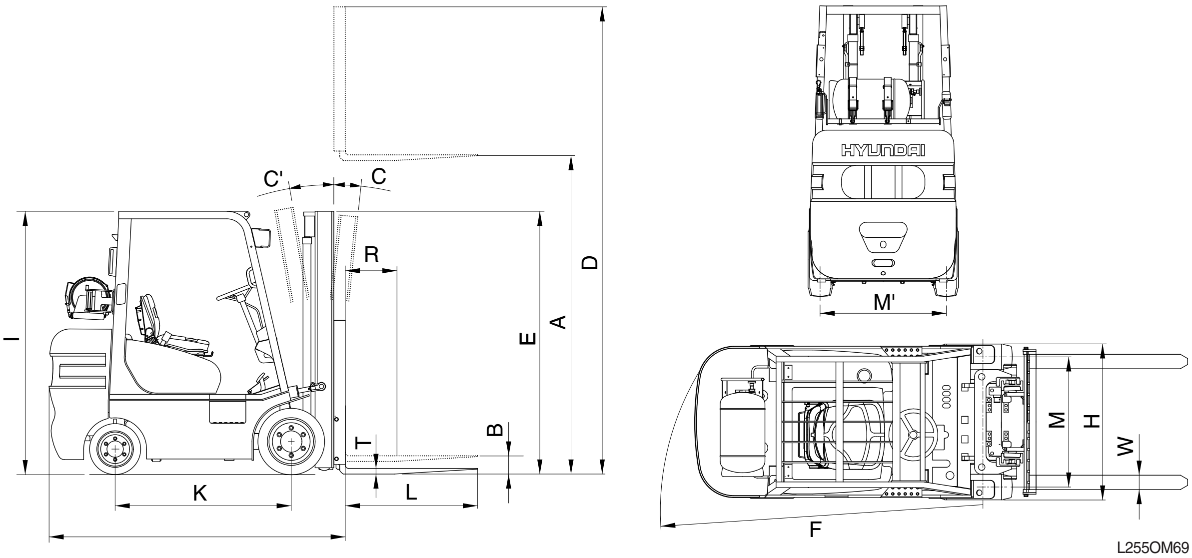
1. GENERAL LOCATIONS



1	Turn signal lamp	7	Carriage	13	Operator's seat
2	Head lamp	8	Forks	14	Counterweight
3	Mast	9	Overhead guard	15	Bonnet
4	Lift chain	10	LPG tank	16	Rear wheel
5	Lift cylinder	11	Rear working lamp(Option)	17	Tilt cylinder
6	Backrest	12	Rear combination lamp	18	Front wheel

2. SPECIFICATIONS

1) HLF20/25/30-5

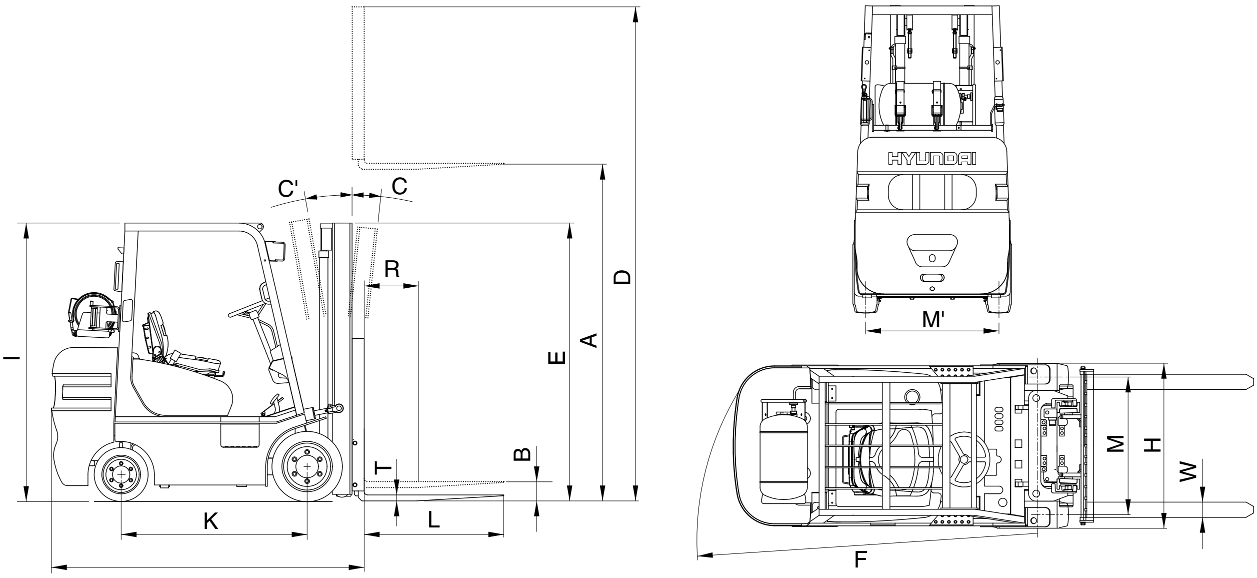


L255OM69

Model			Unit	HLF20-5	HLF25-5	HLF30-5
Capacity			kg	2000	2500	3000
Load center		R	mm	500	←	←
Weight(Unloaded)			kg	3560	3860	4325
Fork	Lifting height	A	mm	3300	←	←
	Free lift	B	mm	155	←	←
	Lifting speed(Unload/Load)		mm/sec	640/570(650/580★)	640/560(650/570★)	550/470(600/500★)
	Lowering speed(Unload/Load)		mm/sec	450/500	←	←
	L×W×T	L,W,T	mm	1050×100×45	←	1050×125×45
Mast	Tilt angle (forward/backward)	C/C'	degree	8/10	←	←
	Max height	D	mm	4485	←	←
	Min height	E	mm	2175	←	2190
Body	Travel speed		km/h	20.5(21.1★)	←	21.4(22.0★)
	Gradeability		degree	29.3(26.7★)	25.5(23.3★)	20.3(18.6★)
	Min turning radius(Outside)	F	mm	2275	2325	2380
ETC	Max hydraulic pressure		kgf/cm^2	190	←	←
	Hydraulic oil tank		l	50	←	←
	Fuel tank		l	64	←	←
Overall length		G	mm	2550	2605	2675
Overall width		H	mm	1160	←	1235
Overhead guard height		I	mm	2180	←	2195
Ground clearance(Load)		J	mm	130	←	145
Wheel base		K	mm	1650	←	←
Wheel tread front/rear		M, M'	mm	965/1000	←	1005/1000

★Non-Emission engine

2) HLF20/25/30C-5



L255OM69

Model			Unit	HLF20C-5	HLF25C-5	HLF30C-5
Capacity			kg	2000	2500	3000
Load center		R	mm	500	←	←
Weight(Unloaded)			kg	3491	3871	4372
Fork	Lifting height	A	mm	3300	←	←
	Free lift	B	mm	115	←	←
	Lifting speed(Unload/Load)		mm/sec	650/580	650/570	600/500
	Lowering speed(Unload/Load)		mm/sec	450/500	←	←
	L × W × T	L,W,T	mm	1050 × 100 × 45	←	1050 × 125 × 45
Mast	Tilt angle (forward/backward)	C/C'	degree	6/10	←	←
	Max height	D	mm	4485	←	←
	Min height	E	mm	2135	←	←
Body	Travel speed		km/h	16.8	←	16.7
	Gradeability		degree	19.0	16.8	13.4
	Min turning radius(Outside)	F	mm	2095	2145	2195
ETC	Max hydraulic pressure		kgf/cm^2	190	←	←
	Hydraulic oil tank		l	50	←	←
	Fuel tank		l	64	←	←
Overall length		G	mm	2250	2310	2355
Overall width		H	mm	1065	←	1110
Overhead guard height		I	mm	2100	←	←
Ground clearance(Load)		J	mm	85	←	←
Wheel base		K	mm	1400	←	←
Wheel tread front/rear		M, M'	mm	890/910	←	905/910

3. SPECIFICATION FOR MAJOR COMPONENTS

1) HLF20/25/30-5

(1) Engine

ITEM	UNIT	SPECIFICATION
Model	-	MITSUBISHI 4G64-33HL(4G64-32HL★)
Type	-	4-cycle, Overhead camshaft
Cooling Method	-	Water cooled
Number of cylinders and arrangement	-	4 cylinders, Hemisphere
Firing order	-	1-3-4-2
Cylinder bore X stroke	mm(in)	86.5×100(3.4×3.9)
Piston displacement	cc(cu in)	2350(143.6)
Compression ratio	-	8.6
Rated gross horse power	ps/rpm	50/2500
Maximum gross torque at rpm	kgf · m/rpm	17/1600(16.3/1500★)
Engine oil quantity	l (U.S.gal)	4.0(1.06)
Dry weight	kg	150(152★)
High idling speed	rpm	2700±50(2900±50★)
Low idling speed	rpm	800±50(750±50★)
Rated fuel consumption	g/ps.hr	195(210★)
Starting motor	V-kW	HITACHI 12V, 1.2kW
Alternator	V-A	DENSO 12V, 50A
Battery	V-AH	12V, 90AH
Fan belt deflection	mm	8~12(13.0~15.5★)

★Non-Emission engine

(2) Main pump

ITEM	UNIT	SPECIFICATION
Type	-	Fixed displacement gear pump
Capacity	cc/rev	31.8
Maximum operating pressure	bar	230
Rated speed (Max/Min)	rpm	3000/500

(3) Main control valve

ITEM	UNIT	SPECIFICATION
Type	-	Sectional
Operating method	-	Mechanical
Relief valve pressure(Main/Aux)	bar	200/165
Flow capacity	lpm	95

(4) Power train devices

Item			Specification
Torque converter	Model		280-D1(KOREA POWERTRAIN)
	Type		3 Element, 1 stage, 2 phase
	Stall ratio		2.8
Transmission	Type		Power shift
	Gear shift(FR/RR)		1/1
	Adjustment		Electrical single lever type, kick-down system
	Overhaul ratio	FR	16.028 : 1
		RR	18.317 : 1
Axle	Type		Front-wheel drive type, fixed location
	Gear		Hyoid gear type
Wheels	Quantity(FR/RR)		2/2
	Front(drive)	2.0-2.5	7.00-12-12PR
		3.0	28 × 9-15-12PR
	Rear(steer)	2.0-2.5	6.00-9-10PR
		3.0	6.5-10-10PR
Brakes	Travel		Front wheel, duo-servo & auto adjustment type
	Parking		Toggle, internal expanding mechanical type
Steering	Type		Full hydraulic, power steering
	Steering algle		77.8° to both right and left angle, respectively

2) HLF20/25/30C-5

(1) Engine

ITEM	UNIT	SPECIFICATION
Model	-	MITSUBISHI 4G64-33HL
Type	-	4-cycle, Overhead camshaft
Cooling Method	-	Water cooled
Number of cylinders and arrangement	-	4 cylinders, Hemisphere
Firing order	-	1-3-4-2
Cylinder bore X stroke	mm(in)	86.5×100(3.4×3.9)
Piston displacement	cc(cu in)	2350(143.6)
Compression ratio	-	8.6
Rated gross horse power	ps/rpm	50/2500
Maximum gross torque at rpm	kgf · m/rpm	17/1600
Engine oil quantity	ℓ (U.S.gal)	4.0(1.06)
Dry weight	kg(lb)	150
High idling speed	rpm	2700±50
Low idling speed	rpm	800±50
Rated fuel consumption	g/ps.hr	195
Starting motor	V-kW	HITACHI 12V, 1.2kW
Alternator	V-A	DENSO 12V, 50A
Battery	V-AH	12V, 90AH
Fan belt deflection	mm(in)	8~12(0.31~0.47)

(2) Main pump

ITEM	UNIT	SPECIFICATION
Type	-	Fixed displacement gear pump
Capacity	cc/rev	31.8
Maximum operating pressure	bar	230
Rated speed (Max/Min)	rpm	3000/500

(3) Main control valve

ITEM	UNIT	SPECIFICATION
Type	-	Sectional
Operating method	-	Mechanical
Relief valve pressure(Main/Aux)	bar	200/165
Flow capacity	lpm	95

(4) Power train devices

Item			Specification
Torque converter	Model		280-D1(KOREA POWERTRAIN)
	Type		3 Element, 1 stage, 2 phase
	Stall ratio		2.8
Transmission	Type		Power shift
	Gear shift(FR/RR)		1/1
	Adjustment		Electrical single lever type, kick-down system
	Overhaul ratio	FR	16.028 : 1
		RR	18.317 : 1
Axle	Type		Front-wheel drive type, fixed location
	Gear		Hyoid gear type
Wheels	Quantity(FR/RR)		2/2
	Front(drive)	2.0-2.5	21 × 7 × 15C
		3.0	21 × 8 × 15C
	Rear(steer)	2.0-2.5	16 × 6 × 10.5C
		3.0	16 × 6 × 10.5C
Brakes	Travel		Front wheel, duo-servo & auto adjustment type
	Parking		Toggle, internal expanding mechanical type
Steering	Type		Full hydraulic, power steering
	Steering algle		75.6° to both right and left angle, respectively

4. TIGHTENING TORQUE OF MAJOR COMPONENTS

1) HLF20/25/30-5

NO	ITEMS		SIZE	kgf · m	lbf · ft
1	Engine	Engine mounting bolt, nut	M16×2.0	7.5	54
2		Radiator mounting bolt, nut	M 8×1.25	2.5±0.5	18.1±3.6
3	Hydraulic system	Torque converter mounting bolt	M 8×1.25	3.4±0.7	24.6±5.1
4		MCV mounting bolt, nut	M10×1.5	6.9±1.4	50±10
5		Steering unit mounting bolt	M10×1.5	6.9±1.4	50±10
6	Power train system	Transmission mounting bolt, nut	M10×1.25	7.4±1.5	53.5±10.8
7		Drive axle mounting bolt, nut	M12×1.75	12.8±3.0	93±22
8		Steering axle mounting bolt, nut	M20×2.5	58±8.5	420±61
9		Front wheel mounting nut	M20×1.5	27.5±2.5	199±18.1
10		Rear wheel mounting nut	M12×1.25	17.5±1.5	127±10.8
11	Others	Counterweight mounting bolt	M30×3.0	215±33	1560±240
12		Operator's seat mounting nut	M 8×1.25	2.5±0.5	18.1±3.6
13		Head guard mounting bolt	M12×1.75	6.2	44.8

2) HLF20/25/30C-5

NO	ITEMS		SIZE	kgf · m	lbf · ft
1	Engine	Engine mounting bolt, nut	M16×2.0	7.5	54
2		Radiator mounting bolt, nut	M 8×1.25	2.5±0.5	18.1±3.6
3	Hydraulic system	Torque converter mounting bolt	M 8×1.25	3.4±0.7	24.6±5.1
4		MCV mounting bolt, nut	M10×1.5	6.9±1.4	50±10
5		Steering unit mounting bolt	M10×1.5	6.9±1.4	50±10
6	Power train system	Transmission mounting bolt, nut	M10×1.25	7.4±1.5	53.5±10.8
7		Drive axle mounting bolt, nut	M12×1.75	12.8±3.0	93±22
8		Steering axle mounting bolt, nut	M20×2.5	58±8.5	420±61
9		Front wheel mounting nut	M20×1.5	27.5±2.5	199±18.1
10	Others	Counterweight mounting bolt	M30×3.5	199±30	1440±217
11		Operator's seat mounting nut	M 8×1.25	2.5±0.5	18.1±3.6
12		Head guard mounting bolt	M12×1.75	6.2	44.8

5. TORQUE CHART

Use following table for unspecified torque.

1) BOLT AND NUT

(1) Coarse thread

Bolt size	8T		10T	
	kgf · m	lbf · ft	kgf · m	lbf · ft
M 6 × 1.0	0.85 ~ 1.25	6.15 ~ 9.04	1.14 ~ 1.74	8.2 ~ 12.6
M 8 × 1.25	2.0 ~ 3.0	14.5 ~ 21.7	2.7 ~ 4.1	19.5 ~ 29.7
M10 × 1.5	4.0 ~ 6.0	28.9 ~ 43.4	5.5 ~ 8.3	39.8 ~ 60.0
M12 × 1.75	7.4 ~ 11.2	53.5 ~ 81.0	9.8 ~ 15.8	70.9 ~ 114
M14 × 2.0	12.2 ~ 16.6	88.2 ~ 120	16.7 ~ 22.5	121 ~ 163
M16 × 2.0	18.6 ~ 25.2	135 ~ 182	25.2 ~ 34.2	182 ~ 247
M18 × 2.0	25.8 ~ 35.0	187 ~ 253	35.1 ~ 47.5	254 ~ 344
M20 × 2.5	36.2 ~ 49.0	262 ~ 354	49.2 ~ 66.6	356 ~ 482
M22 × 2.5	48.3 ~ 63.3	349 ~ 458	65.8 ~ 98.0	476 ~ 709
M24 × 3.0	62.5 ~ 84.5	452 ~ 611	85.0 ~ 115	615 ~ 832
M30 × 3.0	124 ~ 168	898 ~ 1214	169 ~ 229	1223 ~ 1656
M36 × 4.0	174 ~ 236	1261 ~ 1704	250 ~ 310	1808 ~ 2242

(2) Fine thread

Bolt size	8T		10T	
	kgf · m	lbf · ft	kgf · m	lbf · ft
M 8 × 1.0	2.2 ~ 3.4	15.9 ~ 24.6	3.0 ~ 4.4	21.7 ~ 31.8
M10 × 1.2	4.5 ~ 6.7	32.5 ~ 48.5	5.9 ~ 8.9	42.7 ~ 64.4
M12 × 1.25	7.8 ~ 11.6	56.4 ~ 83.9	10.6 ~ 16.0	76.7 ~ 116
M14 × 1.5	13.3 ~ 18.1	96.2 ~ 131	17.9 ~ 24.1	130 ~ 174
M16 × 1.5	19.9 ~ 26.9	144 ~ 195	26.6 ~ 36.0	192 ~ 260
M18 × 1.5	28.6 ~ 43.6	207 ~ 315	38.4 ~ 52.0	278 ~ 376
M20 × 1.5	40.0 ~ 54.0	289 ~ 391	53.4 ~ 72.2	386 ~ 522
M22 × 1.5	52.7 ~ 71.3	381 ~ 516	70.7 ~ 95.7	511 ~ 692
M24 × 2.0	67.9 ~ 91.9	491 ~ 665	90.9 ~ 123	658 ~ 890
M30 × 2.0	137 ~ 185	990 ~ 1339	182 ~ 248	1314 ~ 1796
M36 × 3.0	192 ~ 260	1390 ~ 1880	262 ~ 354	1894 ~ 2562

2) PIPE AND HOSE(FLARE TYPE)

Thread size(PF)	Width across flat(mm)	kgf · m	lbf · ft
1/4"	19	4	28.9
3/8"	22	5	36.2
1/2"	27	9.5	68.7
3/4"	36	18	130.2
1"	41	21	151.9
1-1/4"	50	35	253.2

3) PIPE AND HOSE(ORFS TYPE)

Thread size(UNF)	Width across flat(mm)	kgf · m	lbf · ft
9/16-18	19	4	28.9
11/16-16	22	5	36.2
13/16-16	27	9.5	68.7
1-3/16-12	36	18	130.2
1-7/16-12	41	21	151.9
1-11/16-12	50	35	253.2

4) FITTING

Thread size(PF)	Width across flat(mm)	kgf · m	lbf · ft
1/4"	19	4	28.9
3/8"	22	5	36.2
1/2"	27	9.5	68.7
3/4"	36	18	130.2
1"	41	21	151.9
1-1/4"	50	35	253.2

6. RECOMMENDED LUBRICANTS

Use only oils listed below or equivalent.

Do not mix different brand oil.

Service point	Kind of fluid	Capacity *l* (U.S.gal) 2.0~3.0ton	Ambient temperature °C (°F) -20 (-4), -10 (14), 0 (32), 10 (50), 20 (68), 30 (86), 40 (104)
Engine oil pan	Engine oil	7.5 (2.0)	SAE 10W-30/API SG or over
Torque converter transmission	ATF Engine oil	10 (2.6)	DEXRON III
Axle	Gear oil	5 (1.3)	SAE 80W-90/API GL-5
Hydraulic tank	Hydraulic oil	20/25/30-5: 35 (9.2)	ISO VG32
		20/25/30C-5: 32 (8.5)	ISO VG46
			ISO VG68
Fuel tank	LPG	-	LPG
Fitting (Grease nipple)	Grease	-	NLGI No.1
			NLGI No.2
Brake reservoir tank	Brake oil	0.5 (0.13)	DOT 3
Radiator	Antifreeze:Water 50:50	17 (4.5)	Ethylene glycol base permanent type

NOTES :

① SAE numbers given to engine oil should be selected according to ambient temperature.

② For engine oil used in engine oil pan, use SAE 10W oil when the temperature at the time of engine start up is below 0°C, even if the ambient temperature in daytime is expected to rise to 10°C or more.

③ If any engine oil of API service class CC is used instead of class CD engine oil, the frequency of oil change must be doubled.

GROUP 3 PERIODIC REPLACEMENT

For operation safety, never fail to perform periodic maintenance or make periodic replacement of the consumable parts listed in the following.

These parts may deteriorate in time and are susceptible to wear. It is difficult to estimate the degrees of wear at time of periodic maintenance; therefore, even if no apparent wear is found, always replace with new parts within the prescribed period of replacement(or earlier if trouble is found).

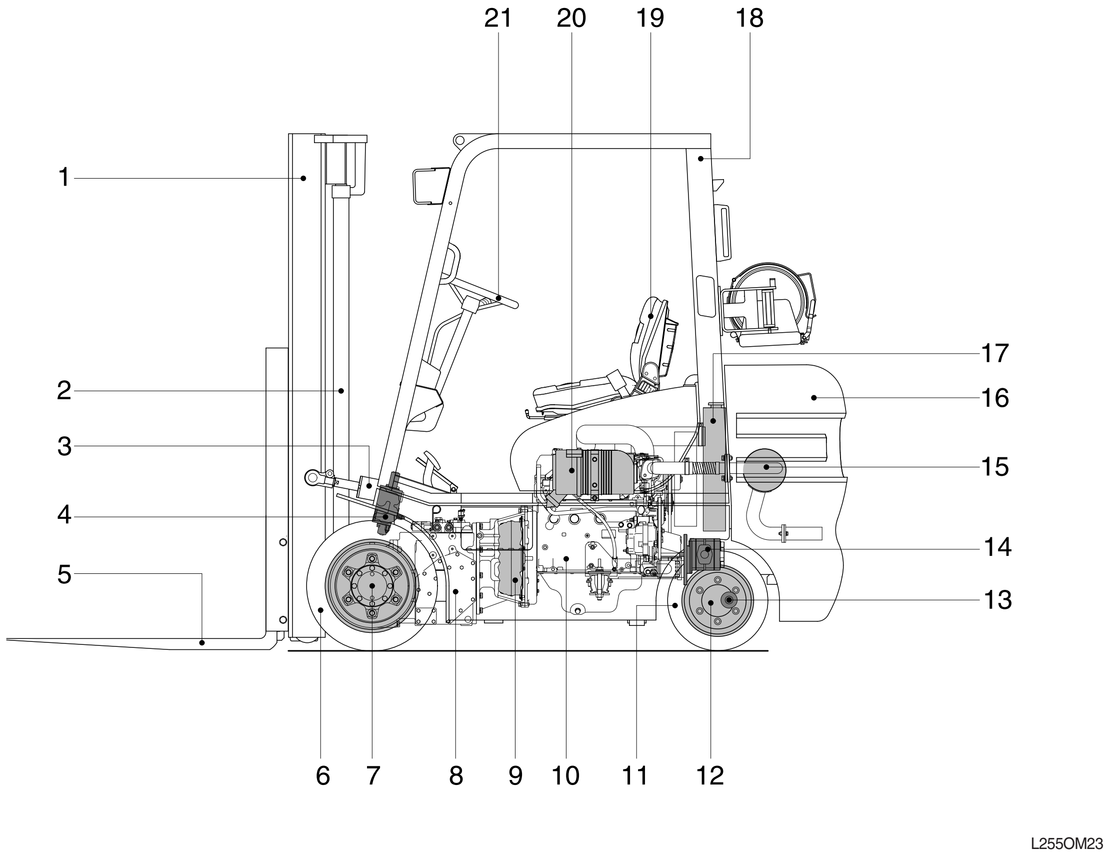
※ **Replacement of consumable service parts in not covered under warranty.**

No	Description	Period of replacement
1	Master cylinder and wheel cylinder caps, dust seals	Every 1 year
2	Brake hose or tube	Every 1 or 2 years
3	Brake reservoir tank and tube	Every 2 to 4 years
4	Power steering hose	Every 2 years
5	Stop lamp switch(oil pressure type)	Every 2 years
6	Fuel hose	Every 2 to 4 years
7	Rubber parts of power steering	Every 2 to 4 years
8	Lift chain	Every 2 to 4 years
9	Hose of load handling	Every 1 or 2 years

SECTION 2 REMOVAL AND INSTALLATION OF UNIT

SECTION 2 REMOVAL & INSTALLATION OF UNIT

GROUP 1 STRUCTURE



1	Mast	8	Transmission	15	Muffler
2	Lift cylinder	9	Torque converter	16	Counterweight
3	Tilt cylinder	10	Engine	17	Radiator
4	Main control valve	11	Rear wheel	18	Overhead guard
5	Fork	12	Steering axle	19	Seat
6	Front wheel	13	Steering cylinder	20	Air cleaner
7	Drive axle	14	Hydraulic pump	21	Steering wheel

GROUP 2 REMOVAL AND INSTALLATION OF UNIT

Remove and install following units as explained in the flow chart.

1. MAST

1) REMOVAL

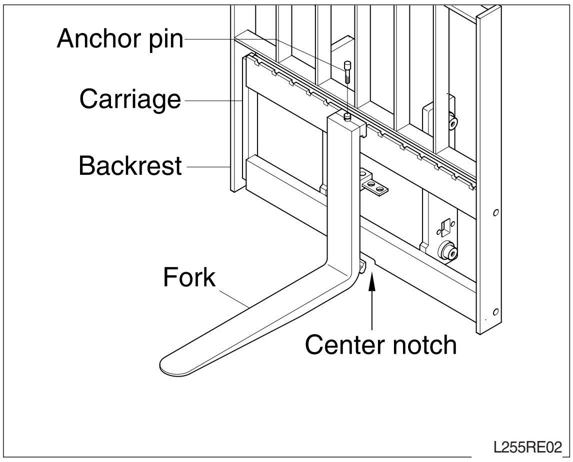
Fork — Carriage — Piping — Mast

(1) Forks

① Lower the fork carriage until the forks are approximately 25mm(1in) from the floor.

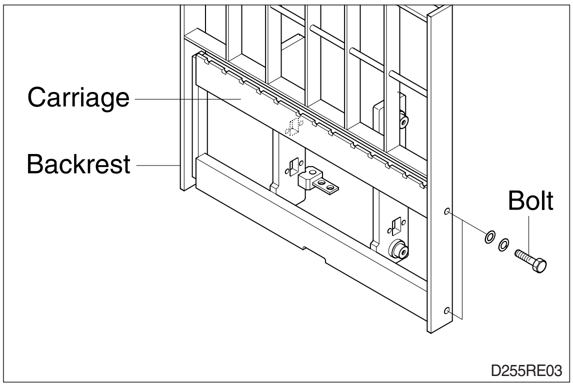
② Release fork anchor pins and slide one fork at a time toward the center of the carriage where a notch has been cut in the bottom plate for easy removal.

③ Remove only one fork at a time. On larger forks it may be necessary to use a block of wood.



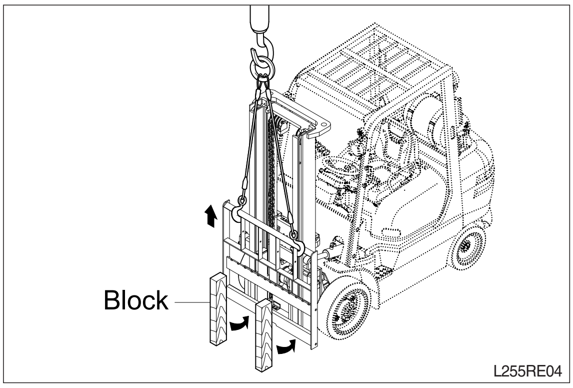
(2) Backrest(If necessary)

① Remove bolts securing backrest to fork carriage. Lift backrest straight up and remove it from carriage.

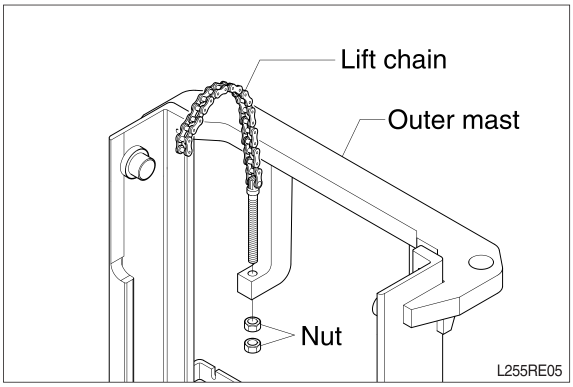


(3) Carriage

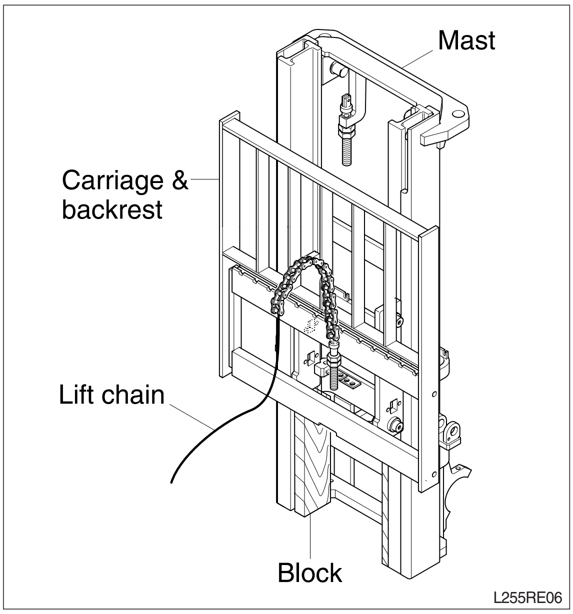
① With the mast vertical, raise the carriage high enough to place blocks under the load forks. This is done to create slack in the load chains when the carriage is lowered. Lower the carriage all the way down to the floor. Make sure the carriage is level, this will prevent any binding when the mast is raised.



② While supporting lift chains, remove the nuts from the chain anchors of stationary upright.



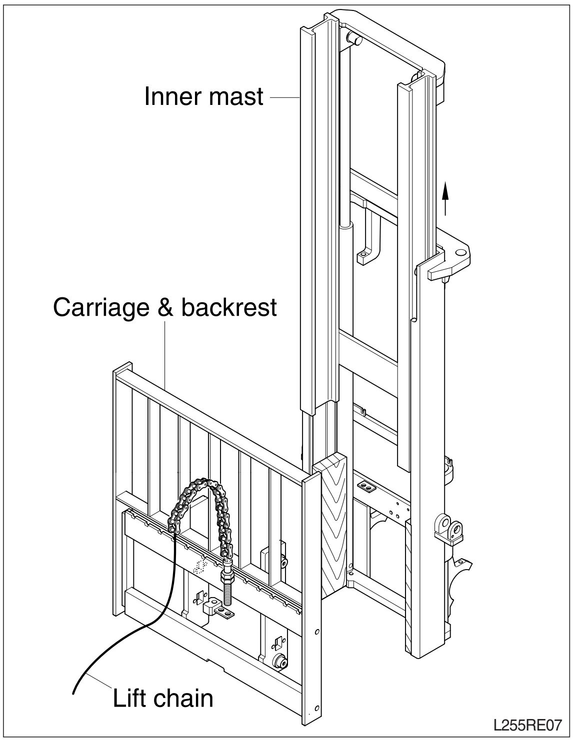
③ Pull the chains out of the sheaves and drape them over the front of the carriage.



④ Slowly raise inner mast upright until mast clears top of fork carriage. Move carriage to work area and lower the mast.

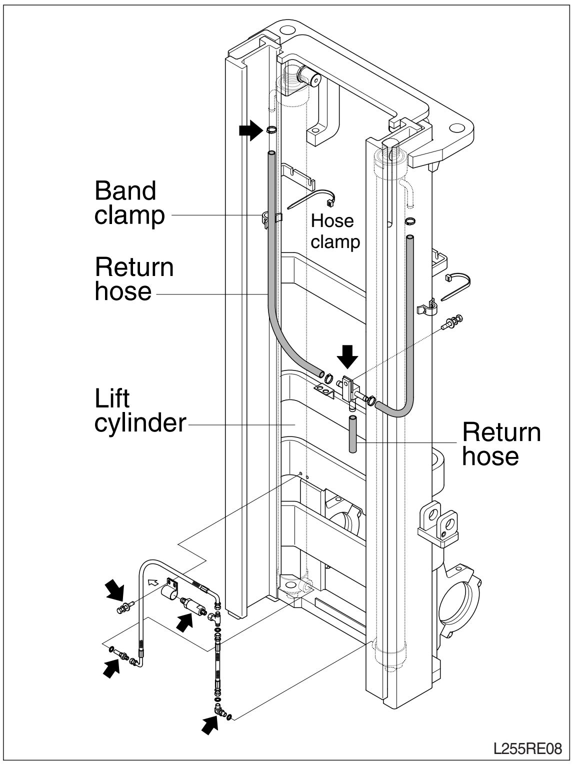
⚠ **Make sure that carriage remains on floor and does not bind while mast is being raised.**

⑤ Inspect all parts for wear or damage. Replace all worn or damaged parts.



(4) PIPING

① Remove the return hoses and clamps attached to the cylinder.
② Remove the return hoses from the connector.
③ Remove hose assembly, connector, down safety valve from the lift cylinder.
④ Disconnect hose assembly from the flow regulator.

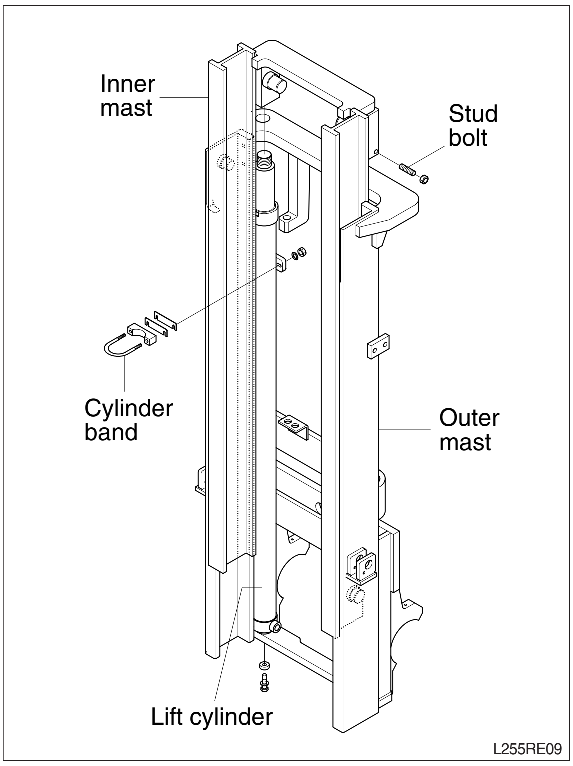


(5) LIFT CYLINDER

① Loosen hexagonal bolts and remove washers securing the lift cylinders to inner mast.
② Bind the lift cylinder with overhead hoist rope and pull up so that the rope has no slack or binding.

⚠ **Make sure that the lift cylinder be tightened firmly for safety.**

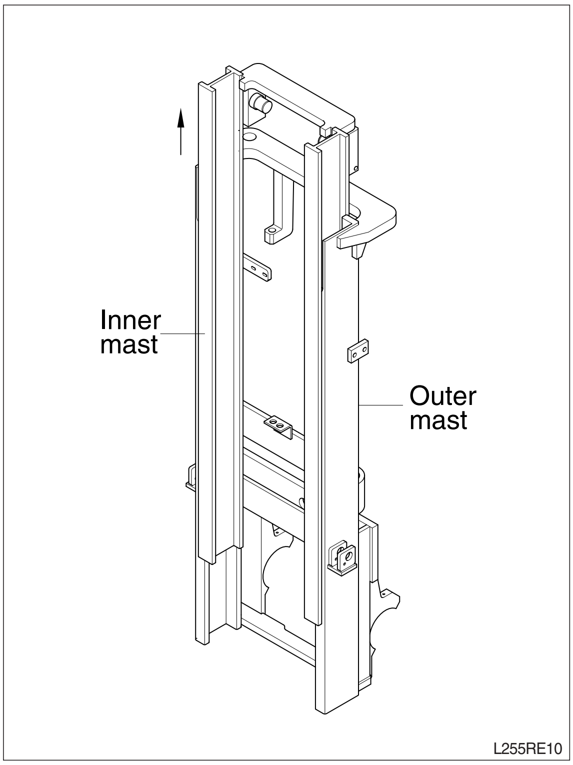
③ Loosen and remove hexagon nuts and cylinder band securing cylinder to outer mast.
④ Using an overhead hoist, slowly raise the inner mast high enough to clear lift cylinder.
⑤ Using an overhead hoist, draw out lift cylinder carefully and put down on the work floor.



(6) INNER MAST

① Using an overhead hoist raise the inner mast straight and carefully draw out of outer mast section.

⚠ **Be careful the mast not to swing or fall.**



(7) MAST SUPPORT CAP

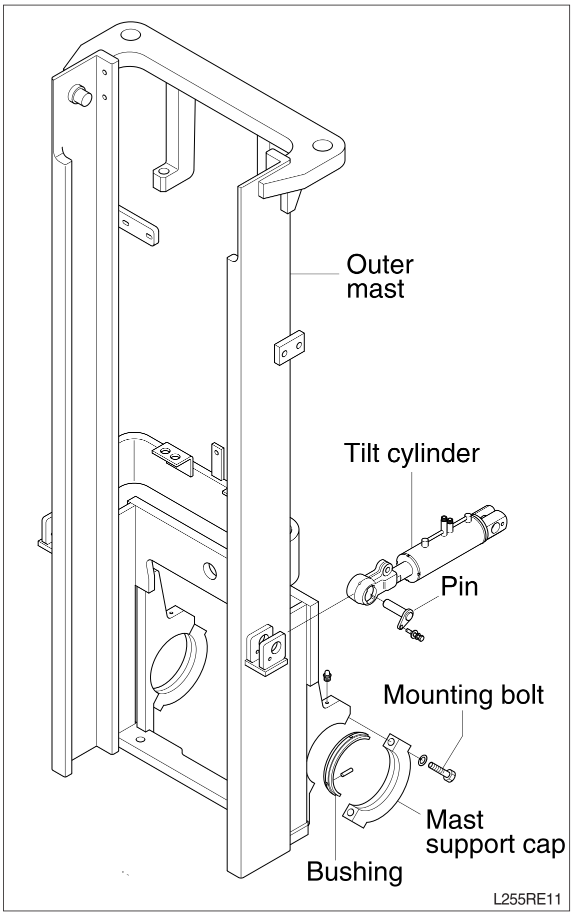
① Attach a crane to the stay at the top of the outer mast, and raise enough to sustain jacked up machine.

※ **This operation is carried out from under the machine, so use a pit, or if there is no pit, jack up the machine and loosen with on impact wrench.**

② Remove the mounting bolts from the cap then slowly raise the outer mast.

(8) TILT CYLINDER PIN

① Loosen the bolt and remove the pin.



2) INSTALLATION

After assembling mast components totally without piping connections, install mast assembly to the equipment.

※ **Installation procedure for each of mast component is the reverse of the removal procedure.**

(1) MAST SUPPORT CAP

① Check the mast support cap and spring pin for wear.

② Jack up the machine so that the front is raised and then using an overhead hoist assemble outer mast to drive axle unit.

③ Tighten mounting bolts to mast support cap. Coat the loctite(#277).

· Tightening torque : 19.9~26.9kgf · m(144~195lbf · ft)

(2) TILT CYLINDER PIN

Hold the mast with a crane, operate the tilt control lever and aligh the holes, then knock the pin.

(3) LIFT CYLINDER INSTALLATION AND ADJUSTMENT

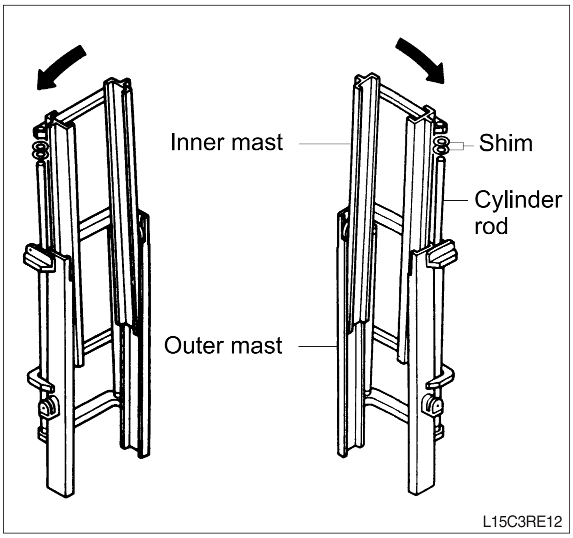
① Assemble the lift cylinder inside the outer mast, then tighten the stopper bolt. If the cylinder assembly has been replaced, adjust as follows so that the left and right cylinders are synchronized at the maximum lifting height.

② Assemble the cylinder rod to the inner mast, and check the left-to-right play of the mast at the maximum lifting height.

※ **If play is to LEFT, install adjustment shim to LEFT cylinder.**

※ **If play is to RIGHT, install adjustment shim to RIGHT cylinder.**

· Shim thickness : 1.0mm(0.04in)



2. POWER TRAIN ASSEMBLY

1) REMOVAL

Mast — Brake piping — Parking brake cable — Drive axle

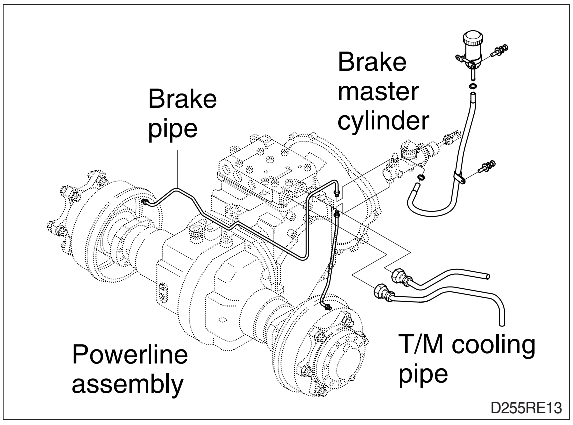
B153RE00

(1) Mast

Refer to section on mast.

(2) Brake piping and T/M cooling piping

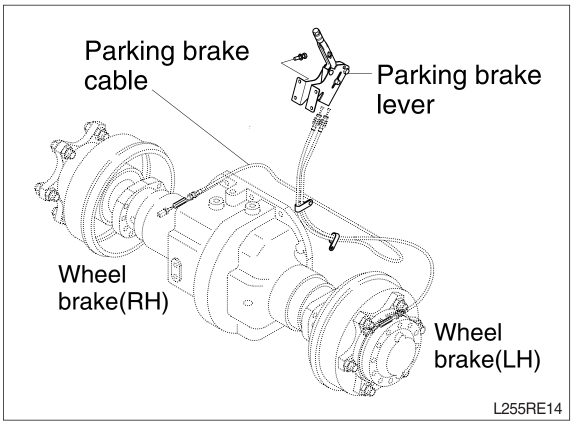
Disconnect the brake pipes and T/M cooling pipes from powerline assembly.



D255RE13

(3) Parking brake cable

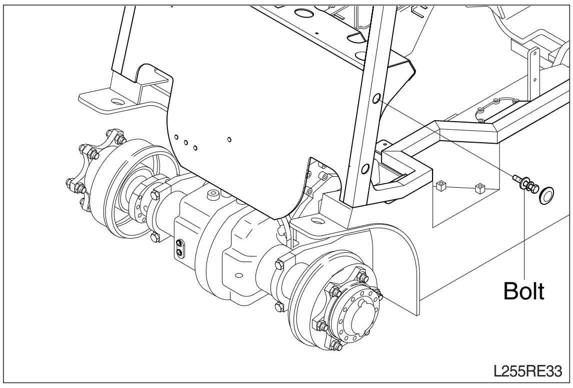
Disconnect parking brake cable from the wheel brake assembly.



L255RE14

(4) Dashboard

Loosen hexagonal bolts and remove dashboard.

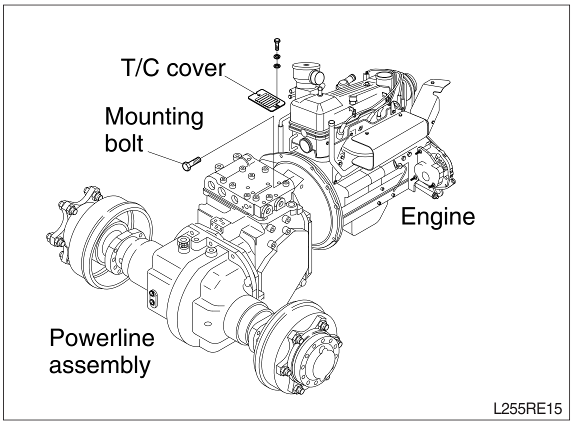


L255RE33

(5) Flexible plate

Remove the cover on the top face of the torque converter housing then remove the 8 mounting bolts installed to the engine flywheel.

To rotate the flywheel, remove 1 mounting bolt, then insert a turning tool in the mounting hole. One man must turn the engine fan by hand while the other turns the flywheel.

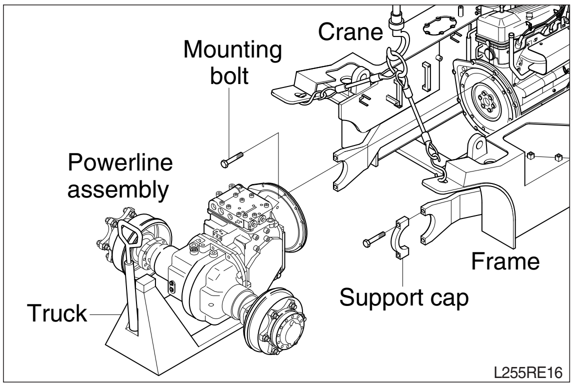


(6) Powerline assembly

① Attach a crane to the front frame and raise the machine enough for truck to slide under powerline assembly.

② Put the block between the truck and powerline assembly.

③ Remove support cap bolts from the frame and then slowly pull out the truck.

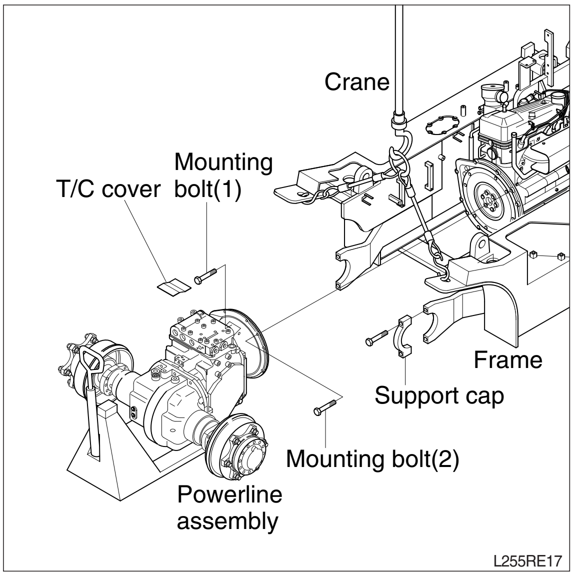


2) INSTALLATION

Installation is the reverse order of removal, but be careful of the following points.

(1) Tightening torque of mounting bolt for powerline assembly.

· Bolt(1) : 2.7~4.1kgf · m(19.5~29.7lbf · ft)
  Bolt(2) : 5.9~8.9kgf · m(42.7~64.4lbf · ft)



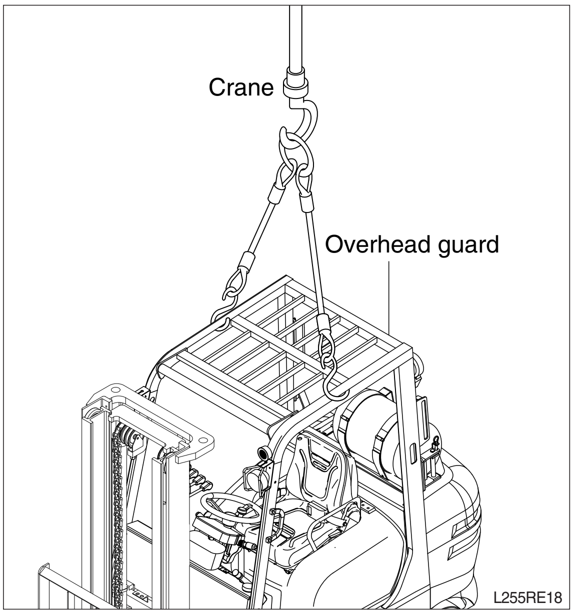
3. ENGINE

Lever the torque converter, transmission and drive axle inside the frame, the remove the engine assembly.

1) REMOVAL

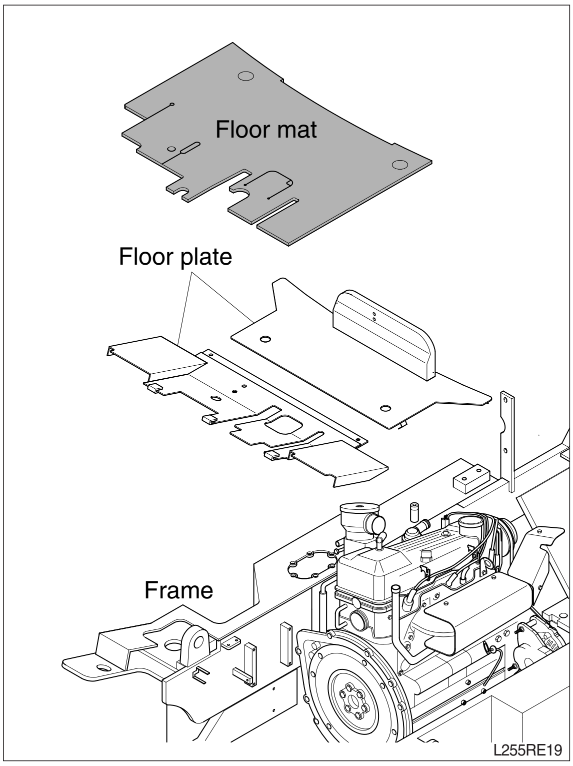
(1) Overhead guard

Remove the wiring for rear combination lamp, working lamp, head lamp and flasher lamp on the stay of the overhead guard and then raise it together with the bonnet.



(2) Floor plate

Uncover the floor mat first and then remove the floor plate.

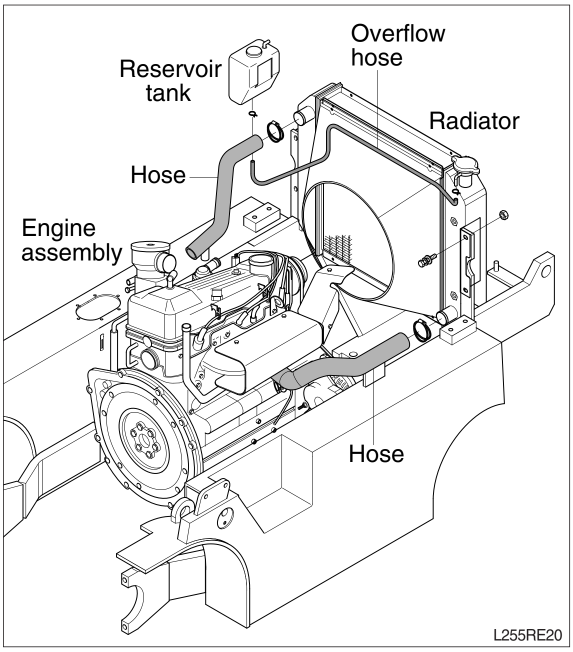


(3) Engine accessory

Remove all wiring harnesses, cables and hoses among the engine, dashboard and frame.

① Wiring harness to alternator and starter.

② Wiring harness for oil pressure and engine water.



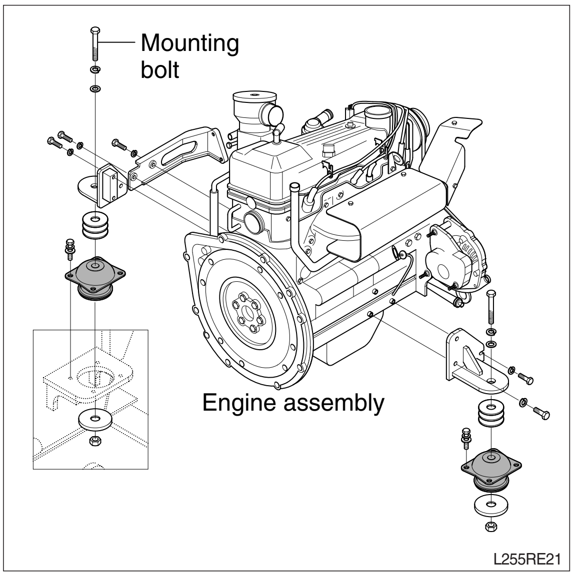
(4) Radiator hose

Open the drain valve of the radiator and drain the cooling water, then remove the radiator hose.

(5) Mounting bolt

Attach a crane to the engine hook and raise, then remove the left and the right mounting bolts. Raise the engine slightly, sliding towards the radiator, then lift up.

※ **When sliding the engine, if it hits the radiator it will damage the radiator, so it is better to remove the radiator if possible.**



2) INSTALLATION

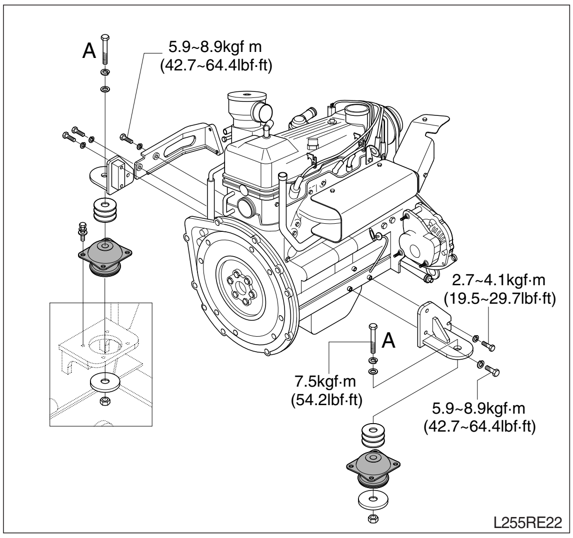
Installation is in the reverse order to removal, but be careful of the following points.

(1) Tighten the engine mounting bolts(A) and nuts.

(2) Tighten the engine mounting bracket bolts.

※ **Do not remove the bolts unless necessary. Loctite is coated on the thread of bolt. So if the bolts must be removed, coat the loctite(#243) when installing.**

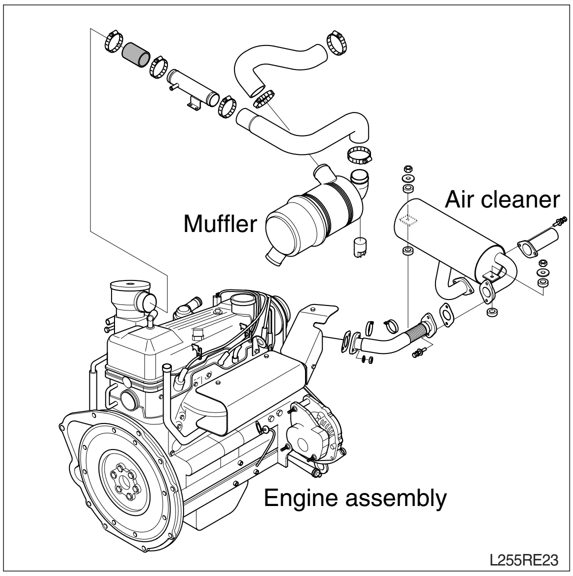
※ **Before installing the bolts, loctite in the holes should be removed by a tap.**



L255RE22

(3) Radiator hoses
  · Distance to insert hose : 40mm(1.57in)

(4) Air cleaner hose
Insert the air cleaner hose securely and fit a clamp.
Distance to insert hose
  · Air cleaner hose : 40mm(1.57in)
  · Engine end : 20mm(0.8in)



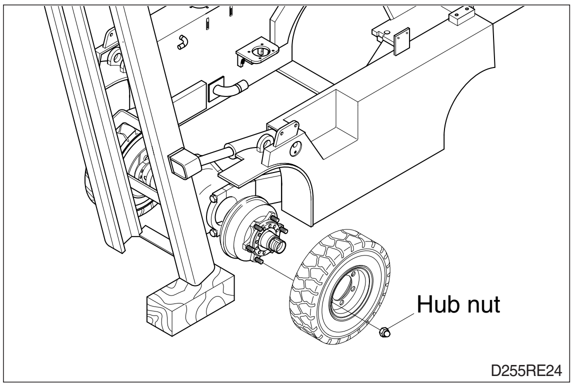
L255RE23

4. WHEEL BRAKE

1) REMOVAL

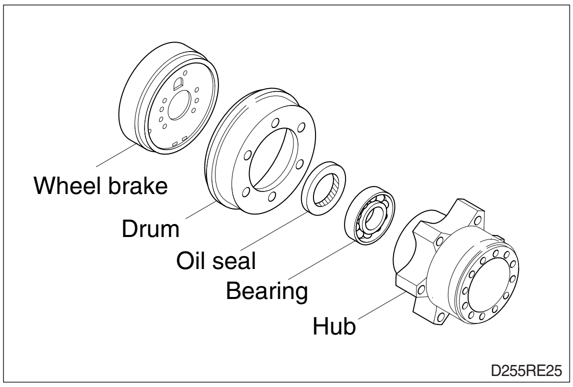
(1) Front wheel

Put a block under the mast and tilt forward, or jack up the bottom of the frame to raise the front wheels off the ground, then loosen the hub nuts to remove wheels.



(2) Brake, drum assembly

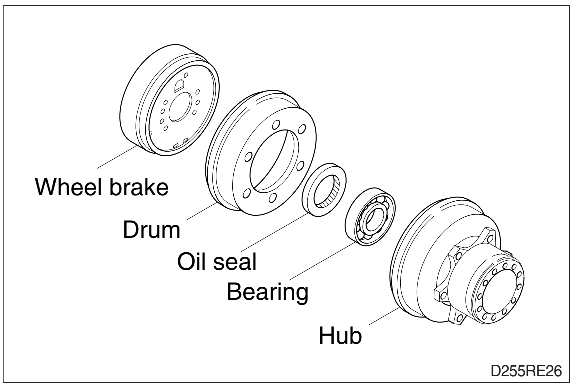
The oil seal inside the hub acts as a seal for the axle shaft end. Therefore when removing or installing the brake and drum assembly, remove or install in a straight line to prevent twisting the seal up and down or to the right and left.



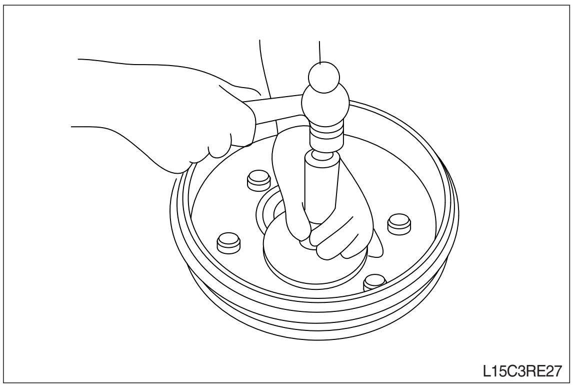
2) INSTALLATION

Installation is in the reverse order to removal, but be careful of the following points.

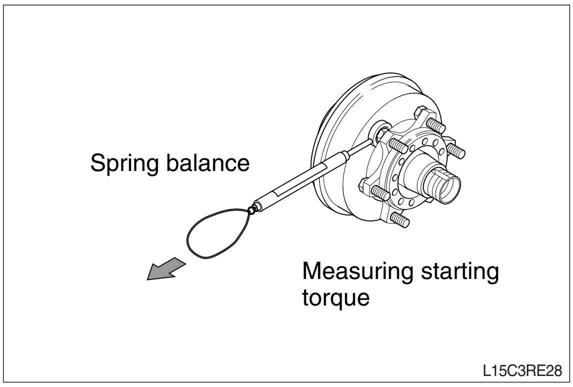
(1) Coat the mounting bolts with loctite and tighten to 19.6kgf · m(141lbf · ft).



(2) When replacing the oil seal inside the hub, be careful to install the seal in the correct direction(Lip on outside) and knock into place.



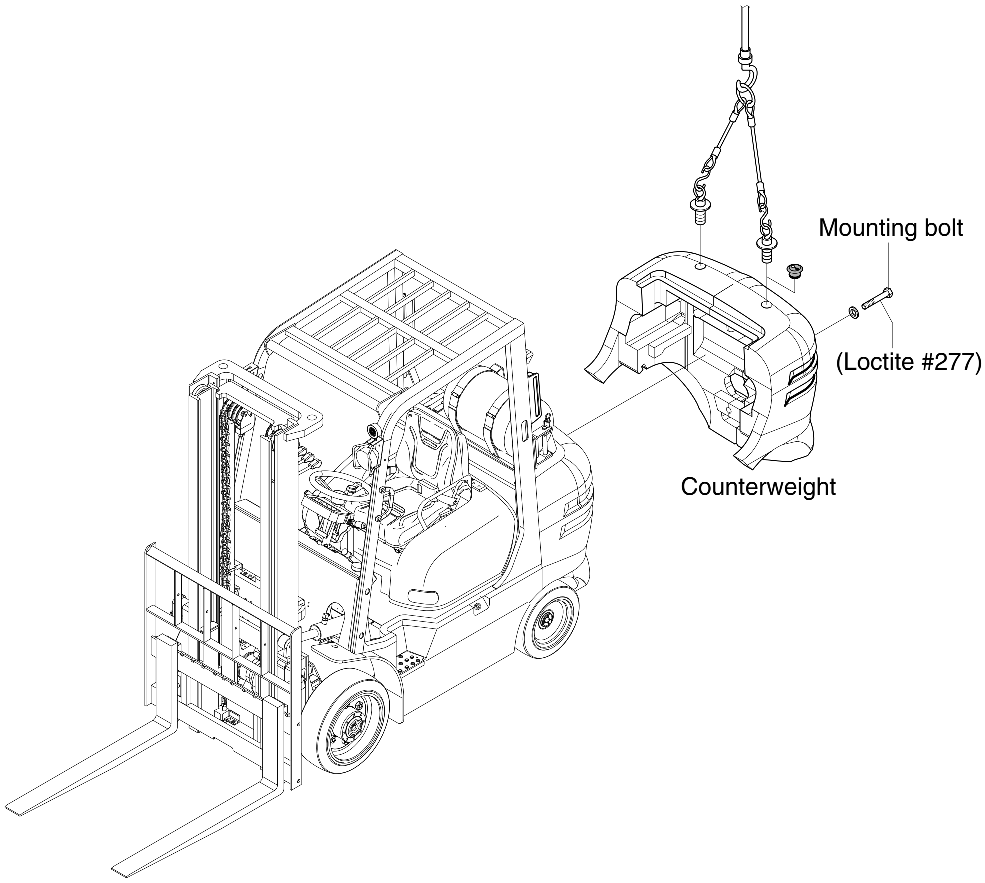
(3) Wipe the inside of the brake drum clean, coat the lip of the seal with grease, and assemble the brake and drum assembly. Adjust a spring balance to the hub bolt and adjust the nut to give a starting force of 12 to 20kgf(27~44lbf).



(4) Tightening torque of hub nut for front wheel.
 · 25~30kgf · m(181~217lbf · ft)
 Coat the hub bolt with molybdenum disulphide.

5. REAR AXLE

1) REMOVAL



L255RE29

(1) Counterweight

Install a lifting tool in the hole in the counterweight, and raise it with a crane.

Remove the mounting bolts and raise the counterweight slightly and move it to the rear side.

· Weight of counterweight(standard)

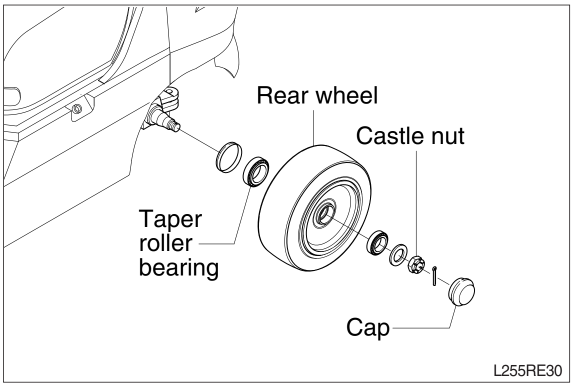
HLF20-5	1170kg(2580lb)	HLF20C-5	1080kg(2380lb)
HLF25-5	1470kg(3240lb)	HLF25C-5	1460kg(3220lb)
HLF30-5	1800kg(3970lb)	HLF30C-5	1900kg(4190lb)

(2) Rear wheels

※ **Before removing rear wheels lift up the rear side with a crane or jack up.**

Remove cap, split pin and then loosen castle nut.

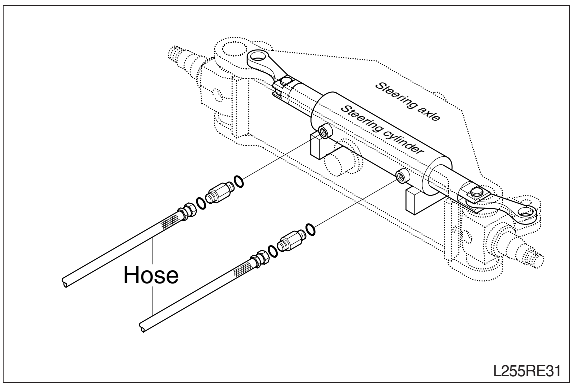
Take out rear wheel assembly with taper roller bearing and oil seal.



(3) Hose

Drain hydraulic oil in the hoses and cylinder before removing them.

Loosen long connector and then disconnect the hoses.

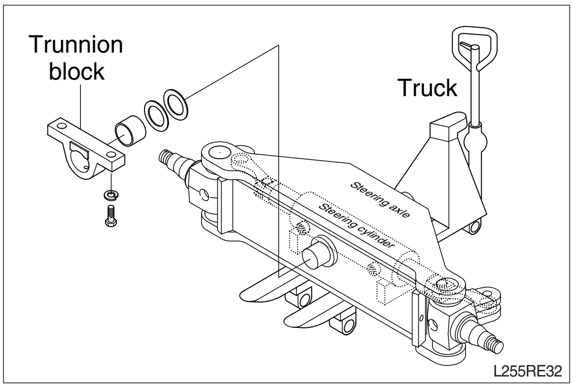


(4) Mounting bolts

Put a block under the steering axle, support on a truck and raise the frame with a crane.

Remove the mounting bolts installed to the frame, and pull out to the rear.

※ **There are shims between the trunnion block and the steering axle to prevent play.**

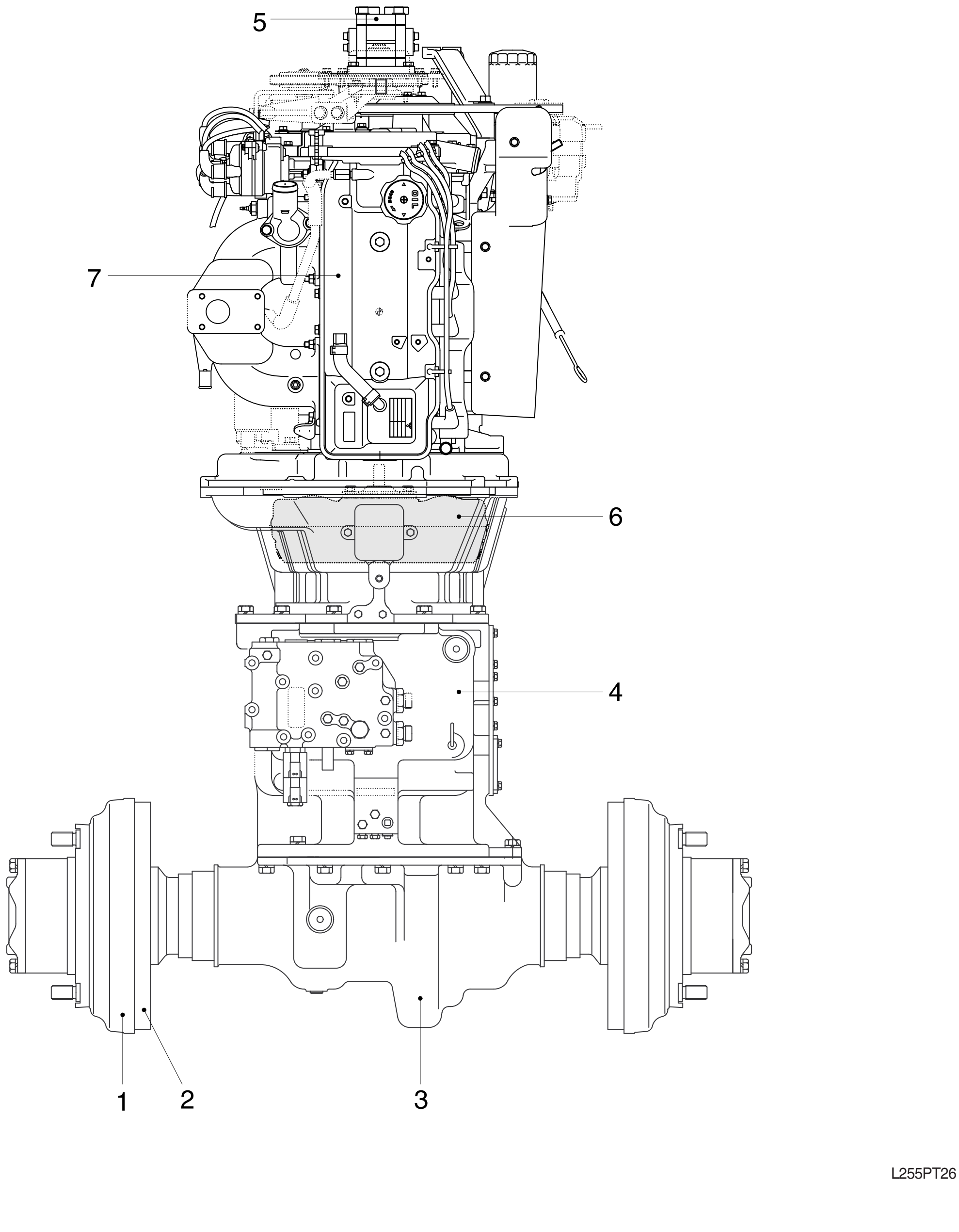


SECTION 3 POWER TRAIN SYSTEM

GROUP 1 STRUCTURE AND OPERATION

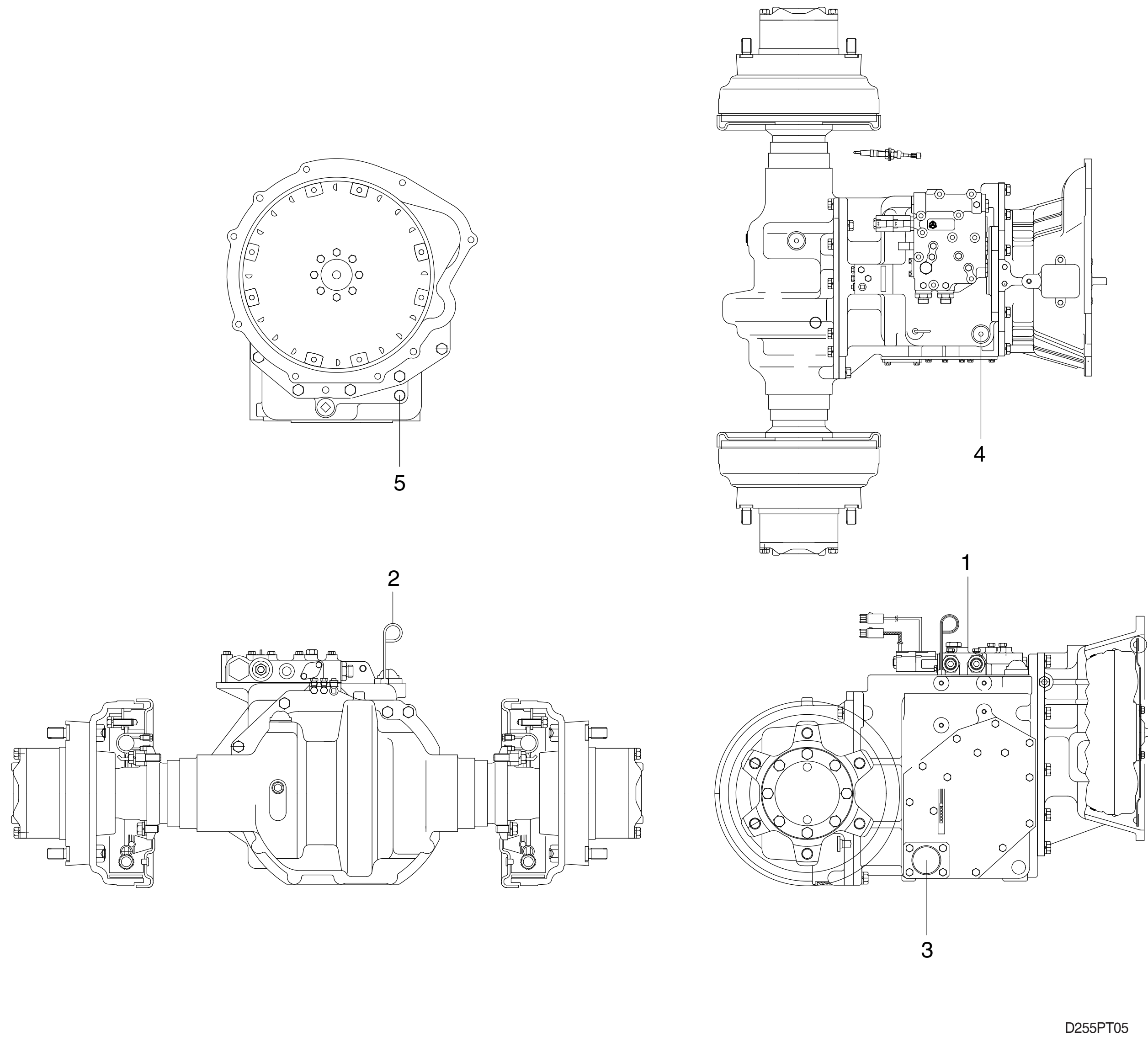
1. POWER TRAIN DIAGRAM

The TORQFLOW transmission uses one-speed forward and one-speed reverse transmission.
The torque converter, differential, and final drives are strengthened to match them with increased engine output and machine traveling performance.



1	Brake drum	4	Transmission	6	Torque converter
2	Brake	5	Hydraulic gear pump	7	Engine
3	Drive axle				

2. INSTALLATION VIEW



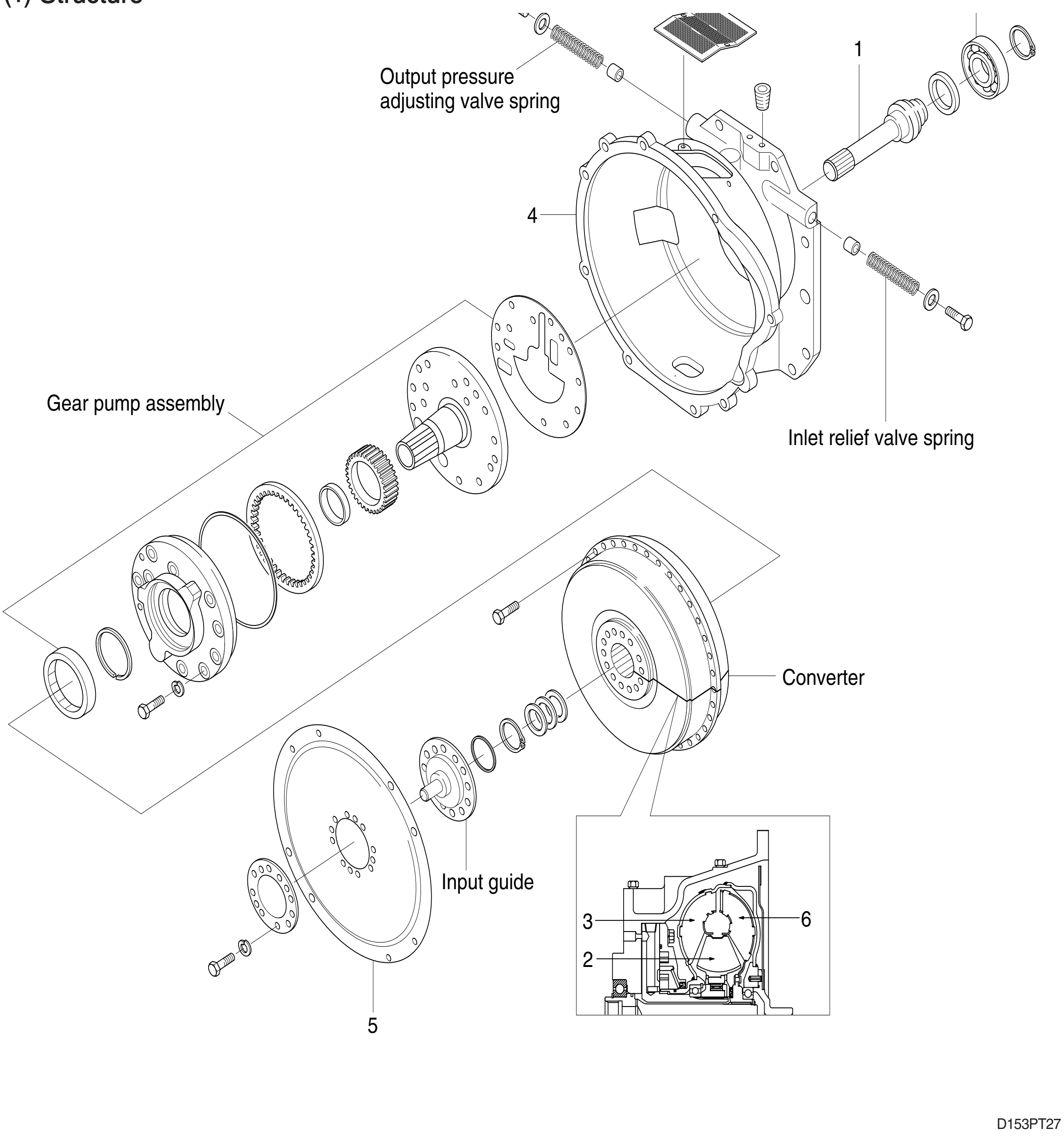
1	Control valve	3	Oil filter	5	Temperature sender
2	Dipstick	4	Air breather		

3. TRANSMISSION

1) TORQUE CONVERTER

The torque converter is directly bolted to the engine flywheel housing.
Engine output is delivered from the flywheel to the flexible plate.

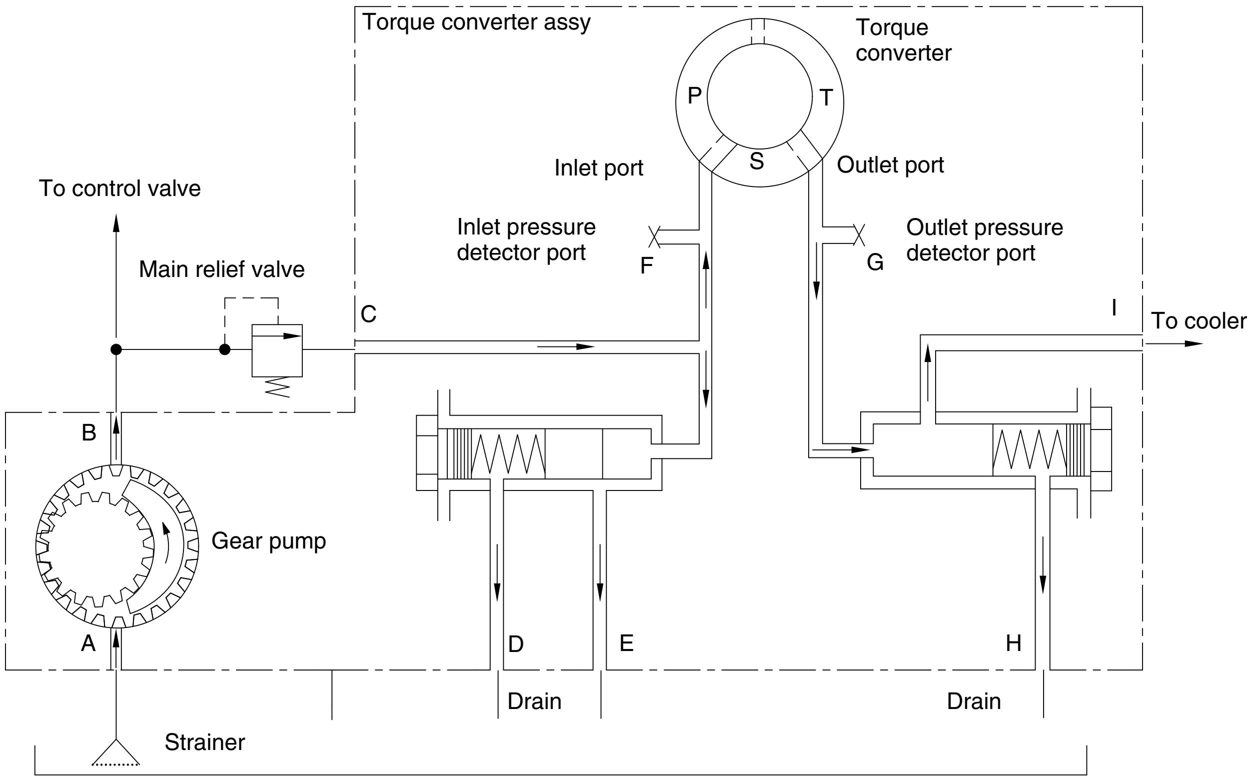
(1) Structure



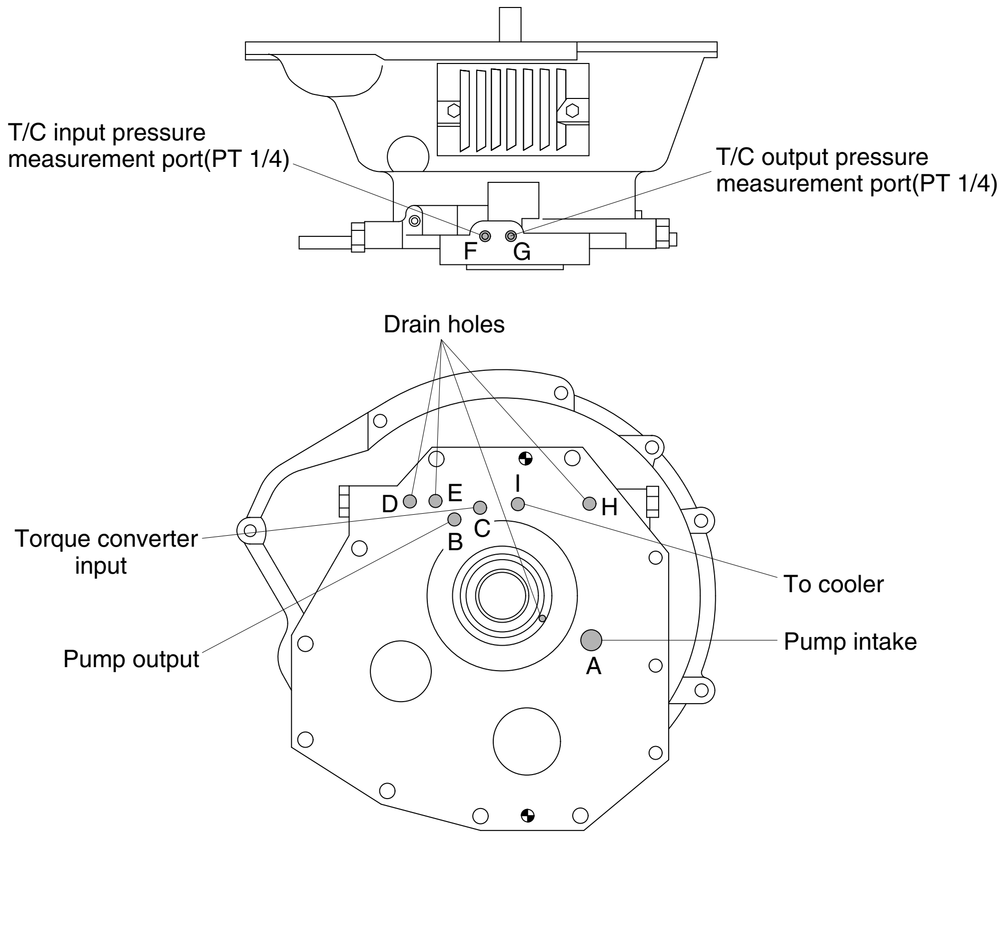
1 Turbine shaft
2 Stator
3 Impeller
4 Housing
5 Flexible plate
6 Turbine

· 3-element, 1-stage, 2-phase
· Stall speed : 3500rpm
· Maximum input pressure : 7kgf/cm^2

(2) Hydraulic circuit

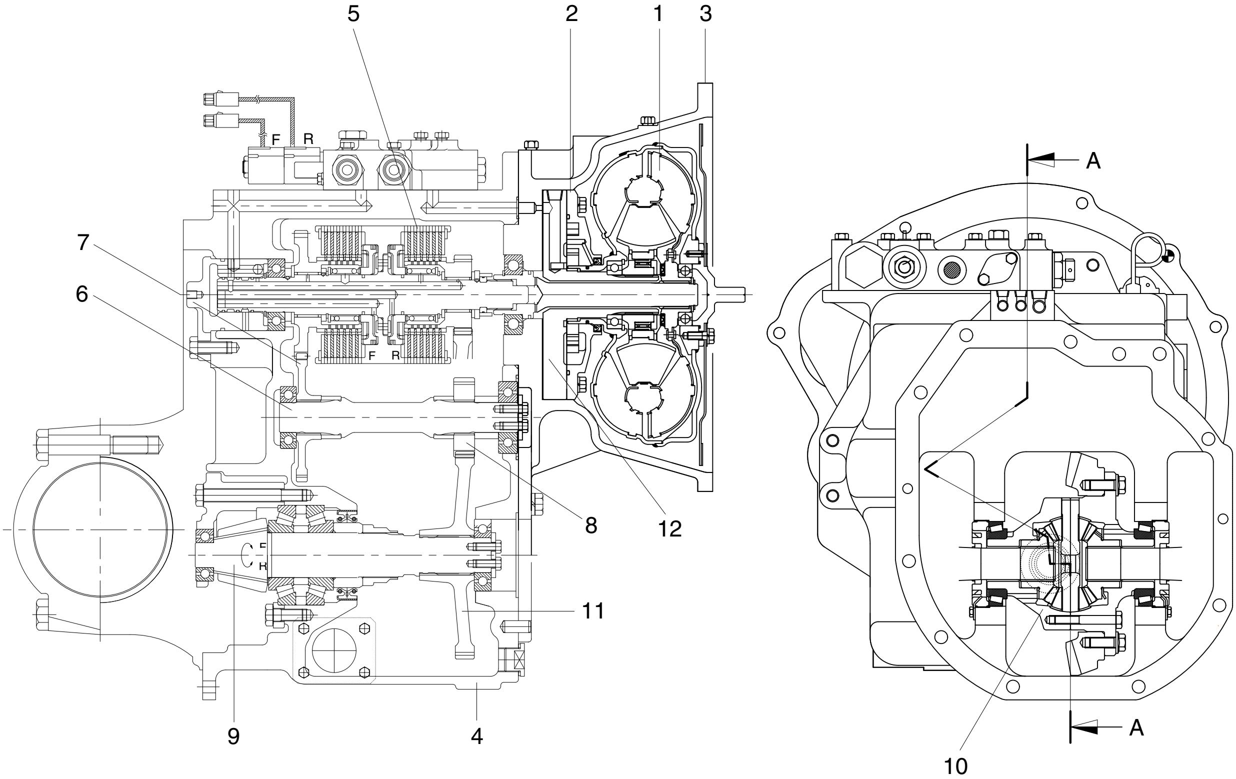


L15C3TC11

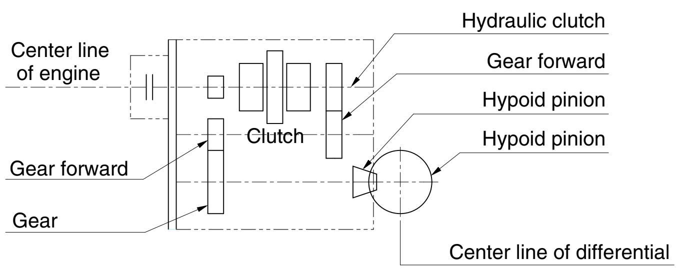


L255PT24

2) TORQFLOW TRANSMISSION



SECTION A - A



	F	R
GEAR RATIO	16.028	18.317

D255PT01

1	Torque converter	5	Hydraulic clutch	9	Hypoid gear set
2	Pump	6	Forward shaft	10	Differential
3	Torque converter housing	7	Forward gear	11	Drive gear
4	Transmission case	8	Forward gear	12	Stator shaft

3) OPERATION

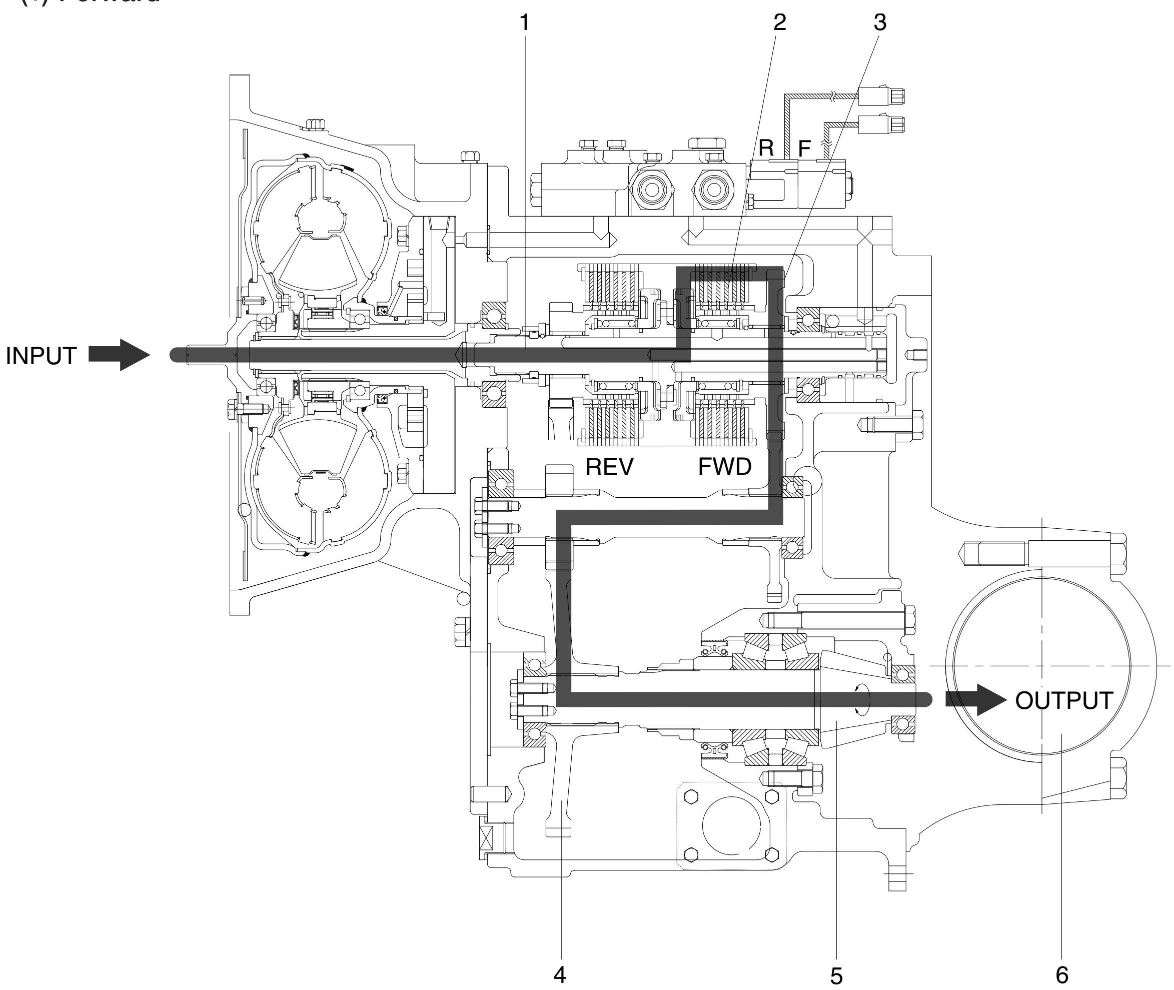
The torque converter consists of three elements; an impeller wheel connected to the input side and a turbine wheel and stator wheel connected to the output side. The torque converter is filled with oil. The engine rotates the impeller wheel and the impeller blade will give the fluid energy. Oil flows out along the path by centrifugal force, and this energy will give the turbine wheel torque. The fluid passing through the rotating turbine wheel generates counter torque of the stator while its flow is changed by the stator. Counter torque is added to the turbine, and as the result of this, the output torque is increased several times as engine torque.

The torque converter gives the maximum output torque when the truck starts running. When the truck runs at high speed, high torque is not required and output torque is gradually reduced. Since the engine and driven axle are connected through the fluid, return vibrations or shocks from the axle is absorbed and the longevity of the power transmission system is extended. Truck speed cannot cause the engine to stall. Torque is automatically converted according to the trucks speed. This makes the drive operation much easier and work can be done more efficiently.

The power of the engine is transferred from the turbine shaft to the clutch shaft through the torque converter, and the forward/reverse rotation is selected by the hydraulic clutch. The power is transferred from the forward drive gear to the driven gear of the hypoid pinion through the drive shaft and gear. For reverse, the power is transferred from the reverse drive gear of the clutch to the driven gear of the hypoid pinion through the reverse shaft and gear, drive shaft and gear to reversely rotate the pinion.

4) TRANSMISSION OPERATING MODES

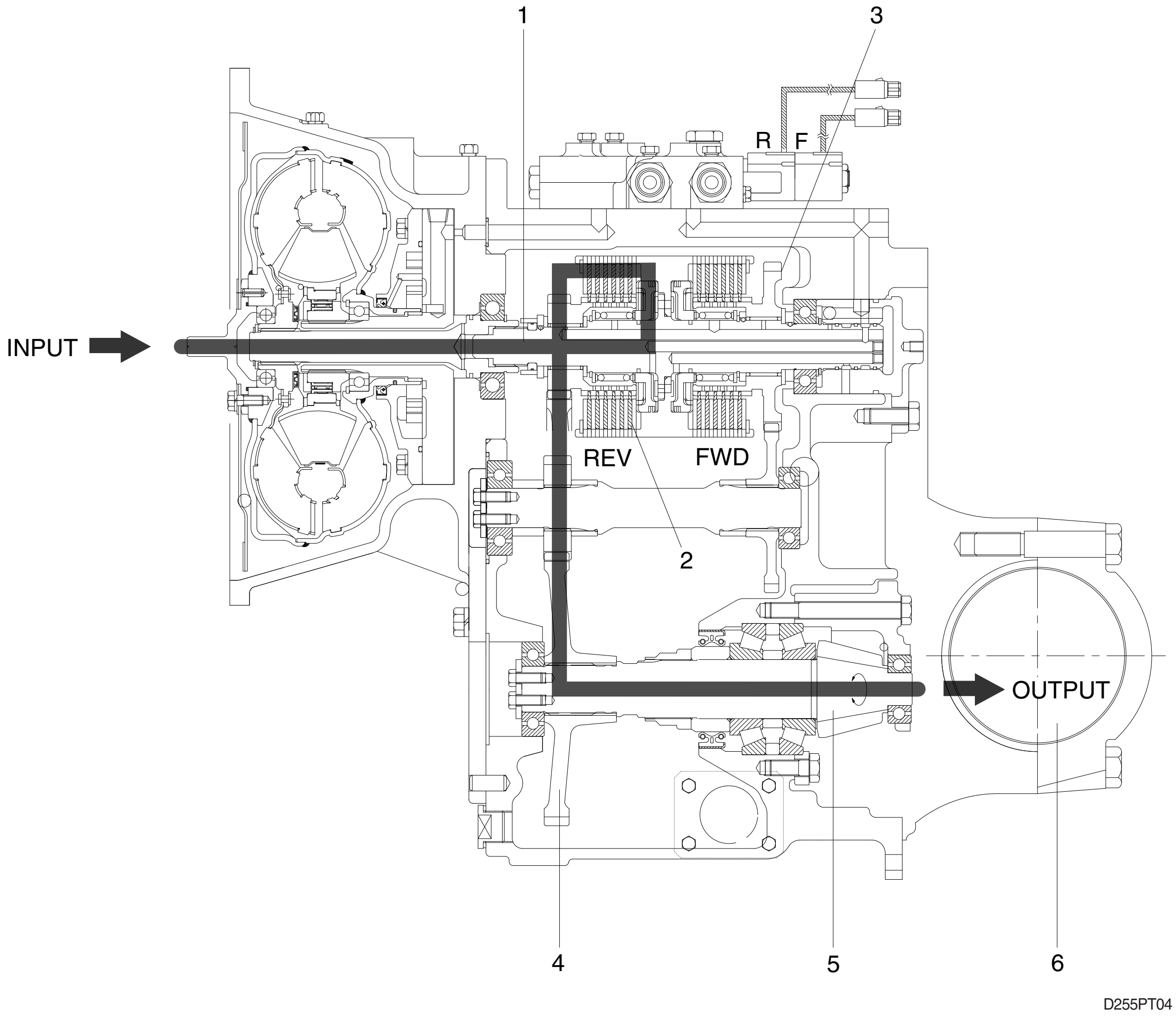
(1) Forward



D255PT02

In forward the torque converter is turned by the engine. The torque converter turbine shaft turns the forward/reverse clutch pack shaft(1) and clutch packs at turbine speed. The piston in the forward clutch pack(2) is pressurized by transmission fluid from the control valve. The piston applies pressure to the discs in the clutch pack, causing the clutch to engage. As the clutch engages, it turns the low forward output gear(3). The low forward output gear engages the forward shaft gear and turns the forward shaft. The gear on the other end of the forward shaft engages the pinion shaft spur gear(4) which turns the pinion shaft and pinion gear(5). The pinion gear then turns the ring gear(6) in a forward direction, moving the machine forward.

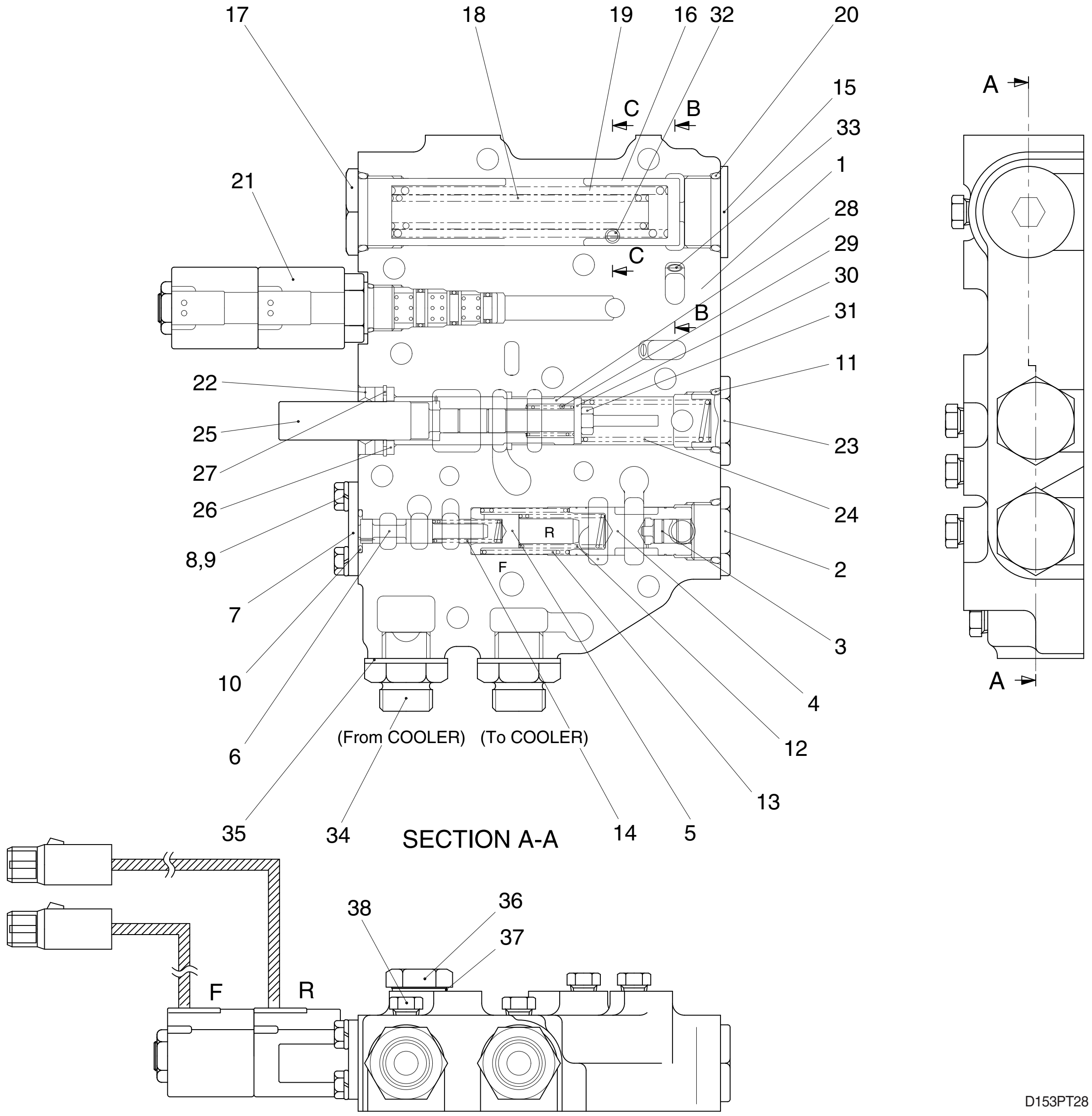
(2) Reverse



In reverse the torque converter is turned by the engine. The torque converter turbine shaft turns the forward/reverse clutch pack shaft(1) and clutch packs. The piston in the reverse clutch pack(2) is pressurized by transmission fluid from the control valve. The piston applies pressure to the discs in the reverse clutch pack, causing the clutch to engage. As the clutch engages, it turns the reverse output gear(3), the reverse output gear engages the pinion shaft spur gear(4), turning the spur gear, the pinion shaft, and the pinion gear(5). The pinion gear then turns the ring gear(6) in a rearward direction moving the truck in reverse.

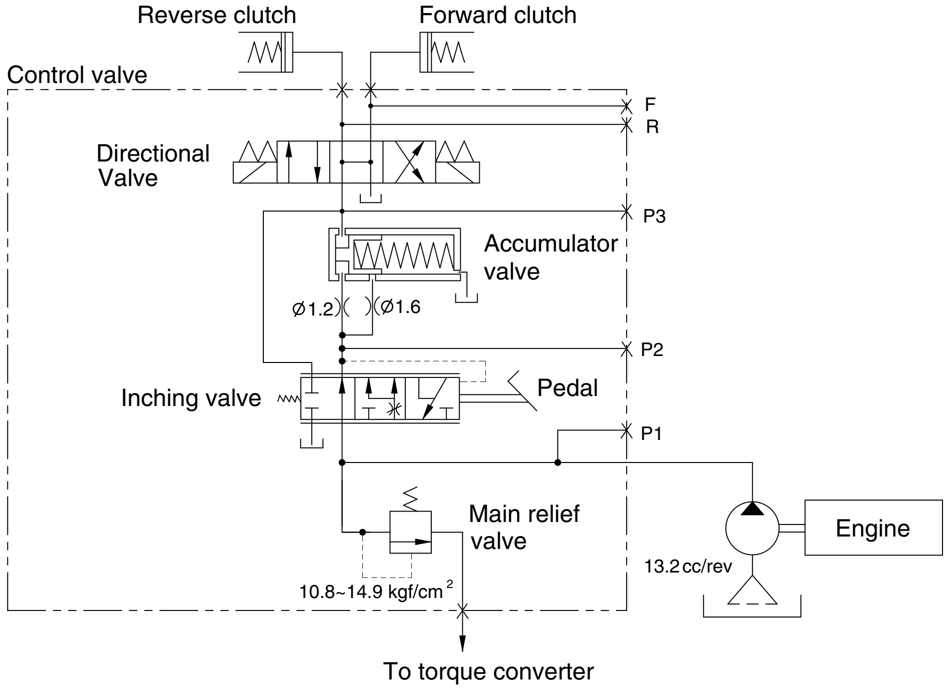
4. CONTROL VALVE

1) STRUCTURE



1	Body	14	Spring	27	Snap ring
2	Plug	15	Plug	28	Valve
3	Piston	16	Piston	29	Spring
4	Valve	17	Stopper	30	Stopper
5	Stopper	18	Spring	31	Nut
6	Valve	19	Spring	32	Screw
7	Plate	20	O-ring	33	Screw
8	Washer	21	Solenoid valve	34	Nipple
9	Bolt	22	Oil seal	35	Spring washer
10	O-ring	23	Plug	36	Plug
11	O-ring	24	Spring	37	Washer
12	Spring	25	Spool	38	Plug
13	Spring	26	Plate		

2) HYDRAULIC CIRCUIT



3) OPERATION

The control valve mainly consists of the main relief valve, inching valve, accumulator valve and directional valve.

The discharged oil from the gear pump enters main relief valve of the control valve and its pressure is adjusted 10.8~14.9kgf/cm^2 (153.6~211.9psi).

The oil sent from the main relief valve flows into the torque converter. The main relief valve is built into the torque converter to prevent excessively raising the oil pressure in the converter due to oil viscosity rising when cold.

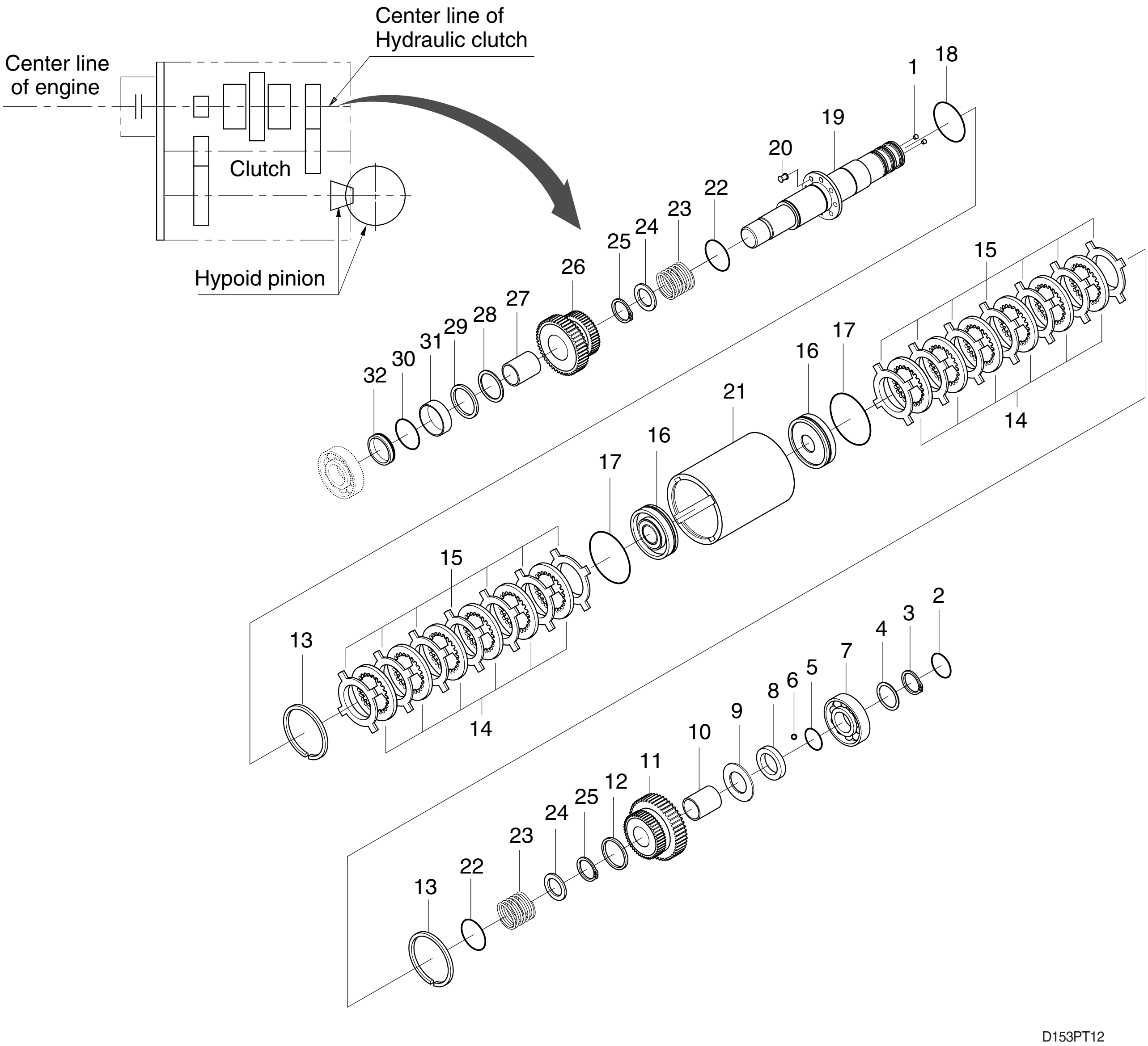
Pressure adjusted oil passes through pressure detecting valve, inching valve and directional valve, and operates the forward or reverse hydraulic clutch.

The pressure detecting valve and built in accumulator provide a soft plugging when changing gears. The pressure detecting valve allows the accumulator to absorb the small shocks of rapid pressure build-up and quick release during gear changes. When full pressure builds up, the pressure detecting valve shuts the accumulator off and allows it to empty so it is ready to function again during gear change.

The inching control is actuated through the inching pedal. This permits the clutch to partially disengage, so that engine rpm can be increased for lifting while travel speed remains low.

5. HYDRAULIC CLUTCH

1) STRUCTURE(Reverse and forward 1st)



1	T/Plug	12	Spacer	23	Spring
2	Seal ring	13	Ring	24	Washer
3	Snap ring	14	Disc	25	Snap ring
4	Spacer	15	Plate	26	Gear
5	Spring	16	Piston	27	Needle bearing
6	Steel ball	17	Seal ring	28	Washer
7	Ball bearing	18	O-ring	29	Spacer
8	Spacer	19	Shaft	30	Spring
9	Washer	20	Rivet	31	Spacer
10	Bearing	21	Drum	32	Spacer
11	Gear	22	Seal ring		

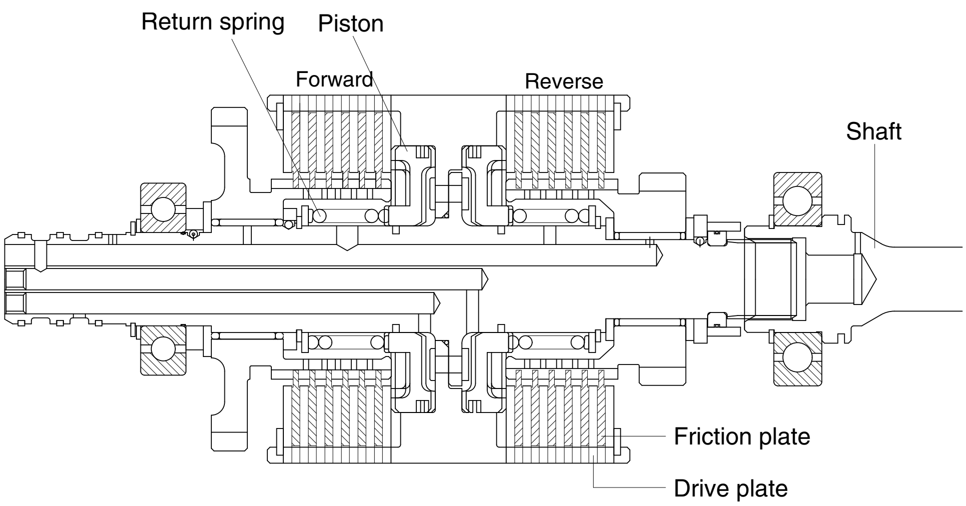
2) CLUTCH PACKS

The clutch packs have a driving side and a driven side for each gear selection, a total of two(1 forward, 1 reverse). One clutch pack assembly has two selections on the same shaft, forward and reverse, and the clutches are back to back with a spur gear in the middle.

The forward reverse clutch pack is driven by the turbine shaft of the torque converter. The assembly makes up the main part of the driving sides of the two clutch packs. This assembly is rotating at turbine speed whenever the torque converter turbine is rotating, no matter what gear is selected, including neutral.

Into each of these driven clutch pack bodies fits a hydraulic piston, and a set of alternating drive plates(steel) and friction plates(fiber faced). The steel plates have teeth on the outer edge which slide into the slots in the clutch pack body, and rotate with the clutch pack. Each of the fiber faced plates have teeth on the inner edge which engage a spline on a driven gear. A return spring on the shaft keeps the piston from engaging the clutch when there is no hydraulic pressure from the control valve.

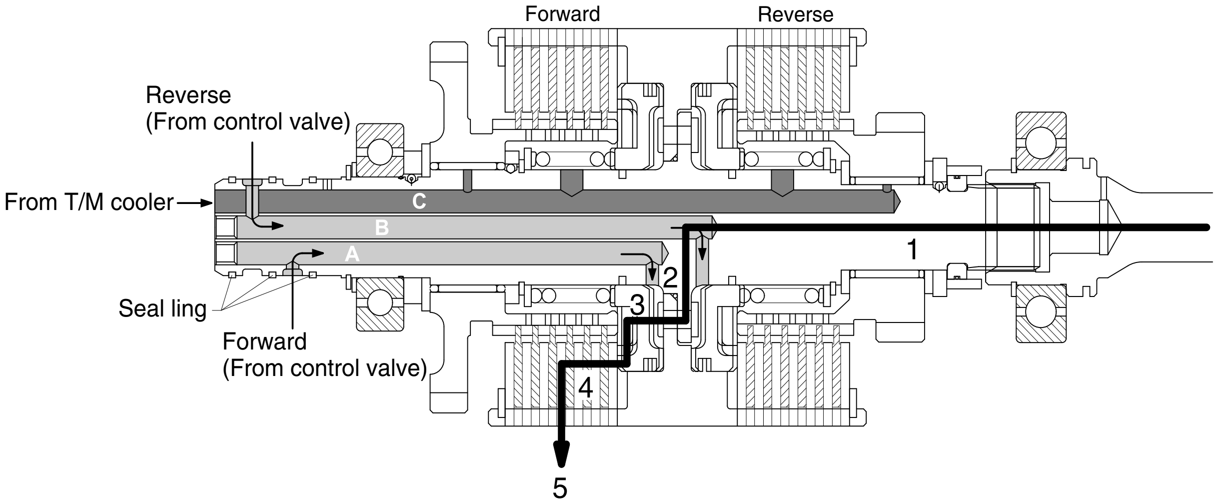
A driven gear(or output gear) slides over the clutch pack shaft and engages the teeth on the inside edge of the friction plates.



Forward/reverse clutch pack assembly

D255PT23

3) OPERATION



D255PT24

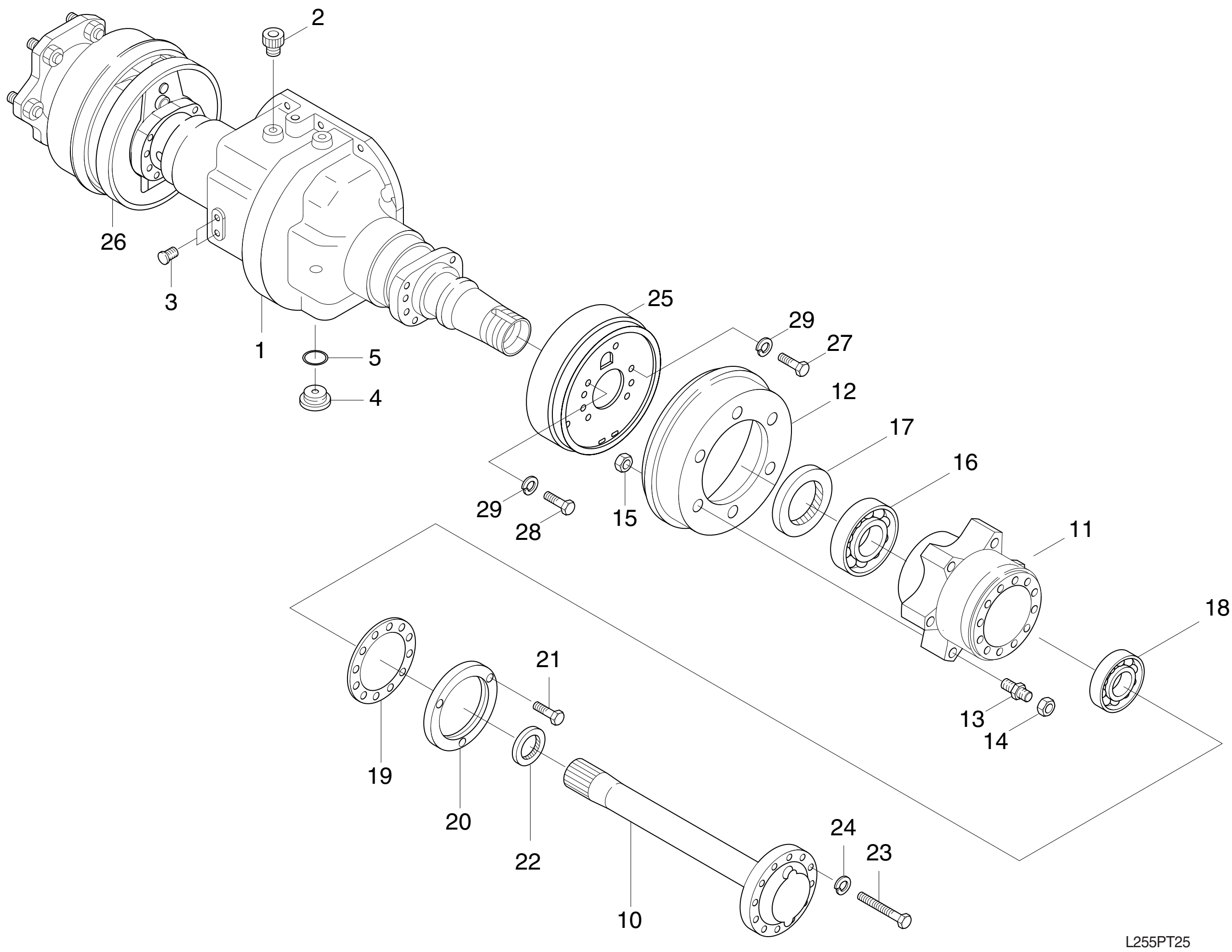
When a gear is selected by the operator, the following happens.

1 The clutch pack shaft is being driven by the torque converter.
2 The spur gear and clutch pack body is attached to shaft and rotates with it.
3 The clutch piston is pressurized by transmission fluid from the control valve.
4 The pressurized piston compresses the drive plates and the friction plates, causing them to rotate together.
5 The driven(or output) gear rotates with the clutch pack body and drives the forward shaft gear or pinion spur gear, depending on gear selection.

There are three oil ports that enter the clutch pack shafts through the manifold caps. Two(A, B) are for supplying transmission fluid to the clutch pistons. The third(C) is to supply lubrication to the gears and clutch discs. Seal rings separate oil flow from manifold cap.

6. DRIVE AXLE

1) STRUCTURE



1	Housing	14	Nut	22	Oil seal
2	Cap	15	Nut	23	Bolt
3	Plug	16	Bearing	24	Spring washer
4	Plug	17	Oil seal	25	Brake assy(LH)
5	Gasket	18	Bearing	26	Brake assy(RH)
10	Shaft	19	Plate	27	Reamer bolt
11	Hub	20	Nut	28	Bolt
12	Brake drum	21	Bolt	29	Spring washer
13	Bolt				

2) OPERATION

Both sides of the housing are supported by the frame and the center is mounted on the transmission case with bolts.

The mast is installed on the front of the drive axle housing through the trunnion. The final deceleration and differential device built in the housing guarantee accurate rotation and smooth operation. The power from the transmission is transferred through the hypoid pinion, hypoid gear, differential case, the pinion of the differential device and the side gear to the drive axle shaft by the side gear spline and to the hub and wheel mounted on the shaft by high tension bolts.

GROUP 2 TROUBLESHOOTING

Trouble symptom	Probable cause	Remedy
1. Excessive oil temperature rise 1) Torque converter	· Improper oil level.	· Check oil level. Add or drain oil as necessary.
	· Impeller interfering with surroundings.	· After draining oil from oil tank and transmission, check and replace interfering parts.
	· Stator and free wheel malfunctioning.	· Check enigne (stalling) speed. If necessary, replace.
	· Air sucked in.	· Check the inlet side joint or pipe. If necessary, retighten joint or replace gasket.
	· Water intruding into transmission case.	· Check drained oil. If necessary, change oil.
	· Bearing worn or seizing.	· Disassemble, inspect, repair or replace.
	· Gauge malfunctioning.	· Check and, if necessary, replace.
2) Transmission	· Clutch dragging.	· Check to see whether or not machine moves even when transmission is placed in neutral position. If so, replace clutch plate.
	· Bearing worn or seized.	· Disassemble, check and replace.
2. Noise operation 1) Torque converter	· Cavitation produced.	· Change oil, replace parts leaking air.
	· Flexible plate damaged.	· Listen to rotating sound at lowspeed operation. If necessary, repacle flexible plate.
	· Bearing damaged or worn.	· Disassemble, check and replace.
	· Gear damaged.	· Disassemble, check and replace.
	· Impeller interfering with surroundings.	· Check impeller or check drained oil for mixing of foreign matter. If necessary, change oil.
	· Bolt loosening.	· Disassemble and check. If necessary, retighten or repalce.
	· Spline worn.	· Disassemble, check and replace.
	· Noise gear pump operation.	· Disassemble, check and replace.
2) Transmission	· Dragging caused by seizing clutch.	· Check to see whether or not machine moves even when transmission is in neutral position. If so, replace clutch plate.
	· Bearing worn or seizing.	· Disassemble, check and replace.
	· Gear damaged.	· Disassemble, check and replace.
	· Bolt loosening.	· Disassemble, check and retighten or replace.
	· Spline worn.	· Disassemble, check and replace.

Trouble symptom	Probable cause	Remedy
3.Low output power 1) Torque converter	· Insufficient hydraulic pressure : - Low oil level. - Air sucked in. - Oil filter clogging. - Oil pump worn. (Low delivery flow) - Regulator valve coil spring fatigued. - Control valve spool malfunctioning. - Piston or O-ring worn. · Stator free wheel cam damaged.	 - Check oil level and add oil. - Check joints and pipes. If necessary, retighten joint or replace packing. - Check and replace. - Check oil pressure. If necessary replace pump. - Check spring tension. If necessary, replace. - Disassemble, check and repair or replace. - Disassemble, check measure and replace. - Check stalling speed. (Increased engine load will cause excessive drop of stalling speed.) - Check oil temperature rise. If any, replace free wheel.
2) Transmission	· Flexile plate deformed · Stator free wheel seizing. · Impeller damaged for interfering with the surroundings. · Use of poor quality of oil or arising of air bubbles. - Air sucked in from inlet side. - Low torque converter oil pressure accelerates generation of air bebbles. - Oil mixing with water. - Inching rod out of adjustment. · Clutch slipping - Lowering of weight. - Piston ring or O-ring worn. - Clutch piston damaged. - Clutch plate seizing or dragging.	· Replace flexible plate. - Check temperature plate. (No-load will cause temperature rise) - Replace free wheel if a drop of starting output is found. - Check drained oil for foreign matter. If any, change oil. - Check and change oil. - Check joints and pipes. If necessary, retighten joint or replace packing. - Check oil pressure. - Check drained oil and change oil. - Check and adjust. - Check oil pressure. - Disassemble, check, measure and replace. - Disassemble, check and replace. - Check to see whether or not machine moves even when transmission is in neutral position. If so, replace.

Trouble symptom	Probable cause	Remedy
4.Unusual oil pressure 1) Oil pressure is high	· Control valve malfunctioning.	(1)Check for spool operation. If necessary, replace valve. (2)Check for clogging of small hole in valve body. If necessary, clean or repair.
	· Cold weather. (high oil viscosity)	· When atmospheric temp is below freezing point (when normal oil pressure is recovered if heated to 60 ~ 80° C), change oil.
	· Use of improper oil.	· Check and change oil.
2) Oil pressure is low	· Gear pump malfunctioning(worn).	· Disassemble, check and replace.
	· Oil leaks excessively : (1)Control valve oil spring defective.	· Check spring tension (see spring specification). If necessary replace.
	(2)Control valve spool defective.	· Disassemble, check, and repair or replace valve.
	· Air sucked in.	· Check joints and pipes. If necessary, retighten joint or replace packing.
	· Low oil level.	· Check oil level and add oil.
	· Oil filter clogging.	· Check and replace.
3) Transmission	· Oil leaks excessively.	· Disassemble, check (piston ring and O-ring for wear and other defects), and replace.
5.Power is not transmitted 1) Torque converter	· Clutch plate damaged.	· Check for damage by listening to abnormal sounds at a low converter speed and replace.
	· Low oil level.	· Check oil level and add oil.
	· Oil pump driving system faulty.	· Disassemble and check for wear of pump gear, shaft and spline. Replace defective parts.
	· Shaft broken.	· Check and replace.
	· Lack of oil pressure.	· Check oil pump gear for wear and for oil suction force. If necessary, replace pump.
2) Transmission	· Low oil level.	· Check oil level and add oil.
	· Inching valve and link lever improperly positioned.	· Check measure and adjust.
	· Forward/reverse spool and link lever improperly positioned.	· Check and adjust.
	· Clutch fails to disengage : (1)Clutch case piston ring defective.	· Disassemble, check and replace.
	(2)Main shaft plug slipping out.	· Disassemble, check and repair or replace.
	· Clutch seizing.	· Check to see whether or not machine moves even then transmission is in neutral position. If so, replace.
	· Shaft broken off.	· Disassemble, check(main shaft, etc.), and replace.
	· Clutch drum damaged (spring groove).	· Disassemble, check and replace.
	· Clutch snap ring broken.	· Disassemble, check and repair or replace.

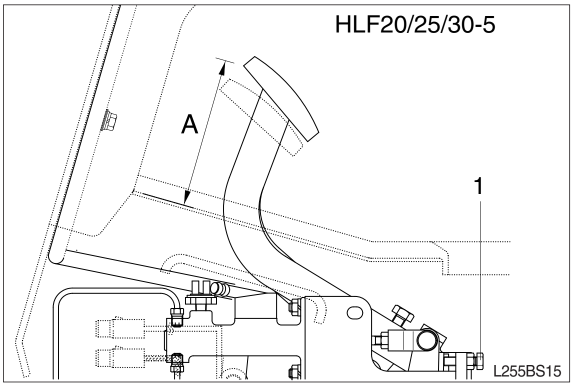
Trouble symptom	Probable cause	Remedy
5. Power is not transmitted (Continue)	· Foreign matter intruding into oil passage to clutch. · Shaft spline worn.	· Disassemble, check and repair or replace. · Disassemble, check and replace.
6. Oil leakage (Transmission and torque converter)	· Oil leaks from oil seal. · Oil leaks from case joining surfaces. · Oil leaks from joint or pipe. · Oil leaks from drain plug. · Oil leaks from a crack.	· Disassemble and check for wear of seal lips and mating sliding surfaces (pump boss, coupling etc.) Replace oil seal, pump boss, coupling, etc. · Check and retighten or replace packing. · Check and repair or replace gasket. · Check and retighten or gasket. · Check and replace cracked part.

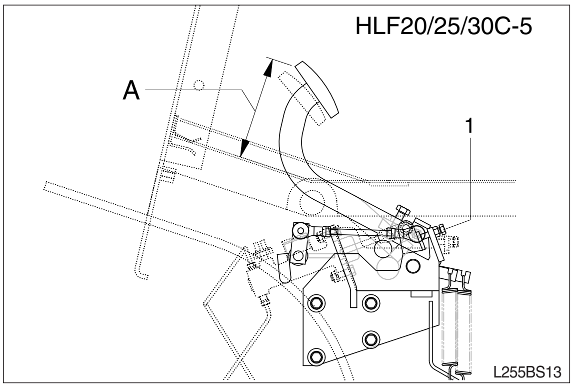
GROUP 3 TESTS AND ADJUSTMENTS

1. INCHING PEDAL

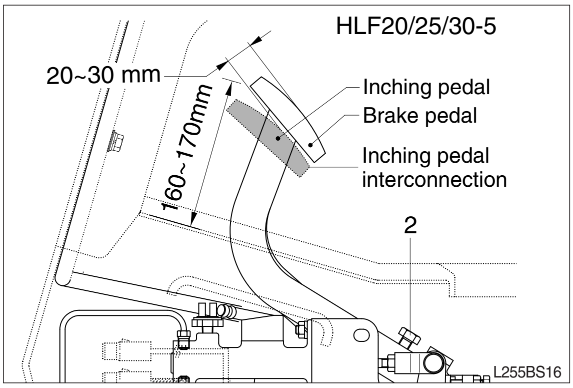
1) Depress inching pedal fully, and move gear shift lever to FORWARD or REVERSE. Check that machine does not move even when engine speed is increased slightly.
2) Adjust stopper bolt(1) so that pedal height is A.

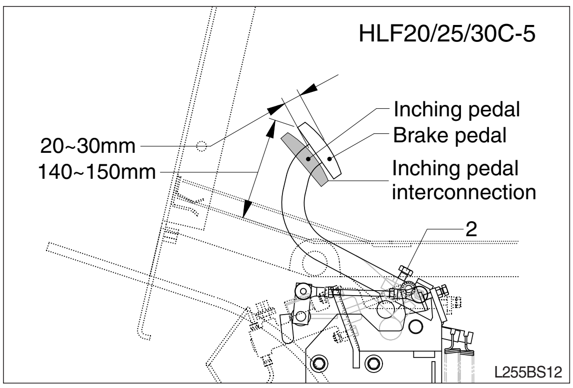
Model	A
HLF20/25/30-5	160~170mm(6.3~6.7in)14
HLF20/25/30C-5	0~150mm(5.5~5.9in)





3) Adjust bolt(2) so that brake pedal interconnects with inching pedal at a stroke of 20~30mm(0.8~1.8in).





2. HYDRAULIC PRESSURE

1) Block wheels of truck, and pull parking lever. Install oil pressure gauge at inlet of control valve.
2) Move direction control lever to FORWARD or REVERSE, depress accelerator pedal and run engine at 1500rpm. Measure clutch pressure and torque converter pressure and check that they are within specified range.

3. ENGINE STALL SPEED

Move direction control lever to FORWARD or REVERSES, and run engine at maximum speed. Check that maximum engine speed is within specified range.

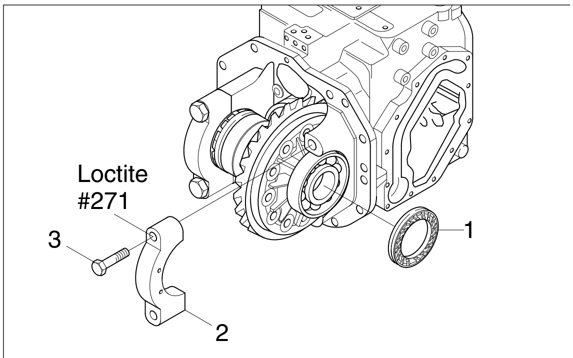
※ **This check raises the temperature of the oil in the torque converter, so do not run this test for a long period.**

Model	Stall speed
MITSUBISHI 4G64-33HL	1890rpm

4. DIFFERENTIAL

1) FITTING DIFFERENTIAL ASSEMBLY

(1) Install the differential assembly and fit adjust screw gear(1).
(2) Apply loctite in the hole of cap(2), and temporarily tighten with bolt(3).

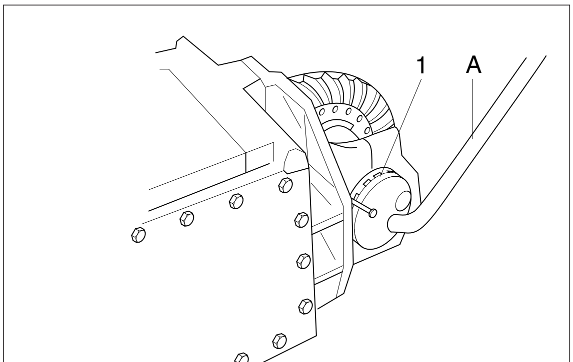


L15C3DF01

2) ADJUSTMENT OF BACKLASH

※ **Tighten the adjust screw gear(1).**

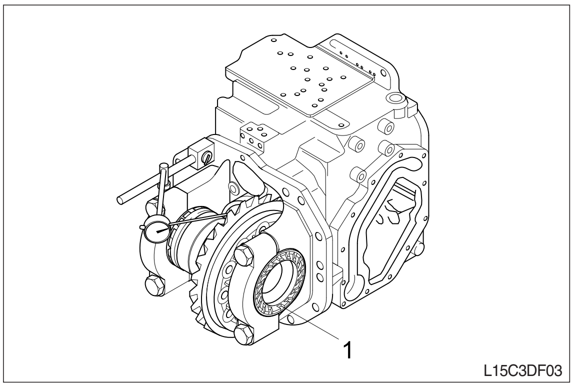
(1) To adjust the backlash, loosen one adjustment screw gear 1 notch and tighten the other screw gear 1 notch. Gradually move the differential case in this way, and watch the indicator of the dial gauge to adjust to the correct value.
   · Backlash between ring gear and pinion gear : 0.15~0.23mm(0.006~0.009in).
(2) Turn the bevel gear to adjust screw gear(1) at 4 places.



L15C3DF02

3) ADJUSTMENT OF THE SIDE BEARING PRELOAD

Tighten adjust screw gear(1) uniformly at 20kgf · m(145lbf · ft)



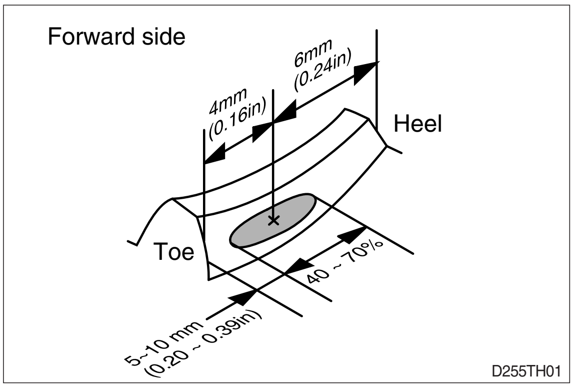
4) ADJUSTING TOOTH CONTACT

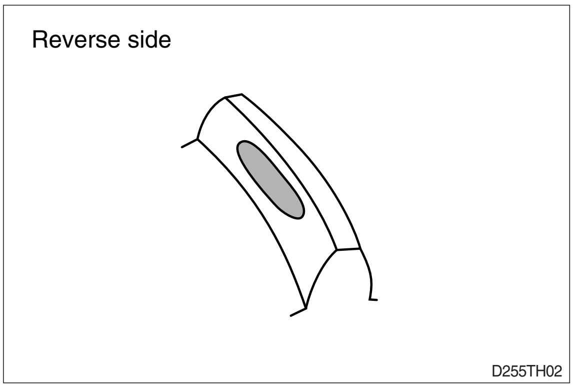
(1) Coat the tooth face of the bevel pinion lightly with red lead(minimum).

(2) Rotate the bevel gear forward and backward.

(3) Inspect the pattern left on the teeth.

· Tooth contact should be checked with no load on the bevel pinion. The tooth contact pattern should cover about 40~75% of the length of the tooth, with weak contact at both ends.





(4) If the result of the inspection shows that the correct tooth contact is not being obtained, adjust again as follows.

(See next page for details)

Adjust shims at pinion shaft.

Adjust backlash of bevel gear.

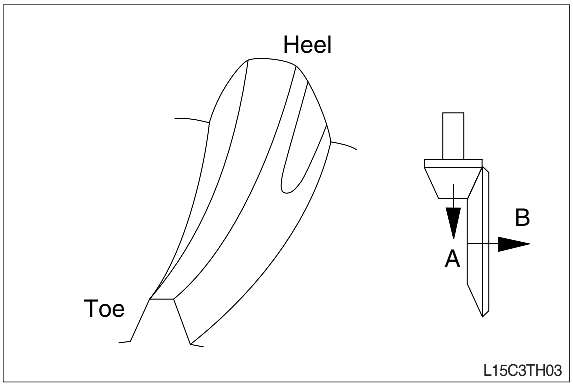
Adjust backlash of bevel gear side bearing.

※ Tooth contact should be checked with no load on the bevel pinion. The tooth contact pattern should cover about 40~75% of the length of the tooth, with weak contact at both ends.

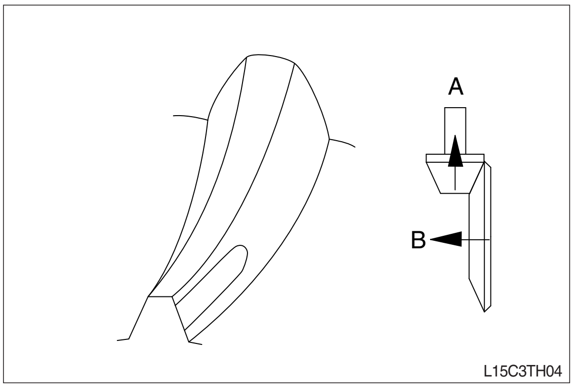
※ The tooth contact should be correct on both the FORWARD and REVERCE side of the teeth, however, if it is impossible to adjust both sides correctly, the FORWARD side must be correct.

5) INCORRECT TOOTH CONTACT

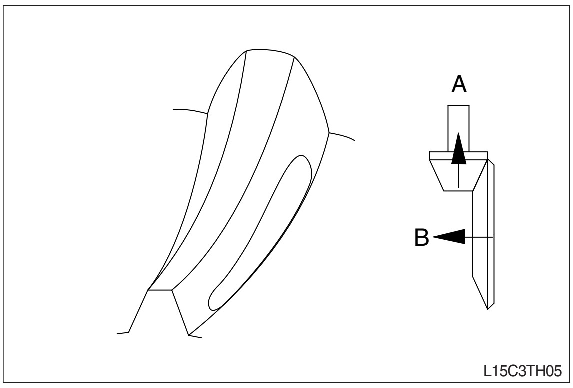
(1) Increase the shim thickness at the pinion shaft to move the pinion in direction A.
Then move the bevel gear away from the pinion gear in direction B.
Adjust the backlash again.



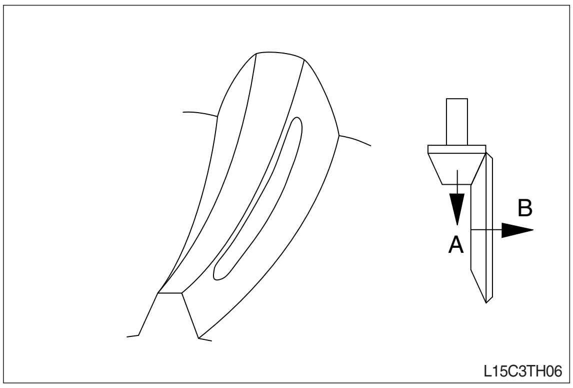
(2) Reduce the shim thickness at the pinion shaft to move the pinion in direction A.
Then move the bevel gear closer to the pinion gear in direction B.
Adjust the backlash again.



(3) Reduce the shim thickness at the pinion shaft to move the pinion in direction A.
Then move the bevel gear closer to the pinion gear in direction B.
Adjust the backlash again.



(4) Increase the shim thickness at the pinion shaft to move the pinion in direction A.
Then move the bevel gear away from the pinion gear in direction B.
Adjust the backlash again.



GROUP 4 DISASSEMBLY AND ASSEMBLY

1. TRANSMISSION

1) DISASSEMBLY

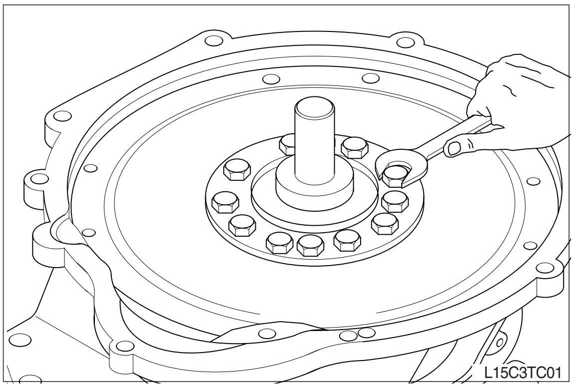
(1) Disassemble torque converter assembly

Drain the transmission fluid and disconnect the torque converter assembly from the engine and the transmission.

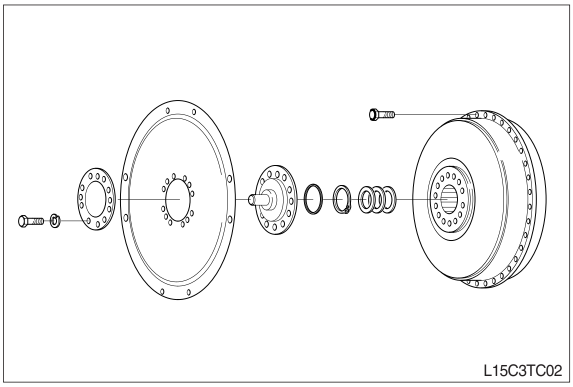
(2) Disassemble input side of torque converter

Remove the input plate bolts and the input plate, input guide, and O-rings.

Tool(s) required : 12mm wrench.



L15C3TC01

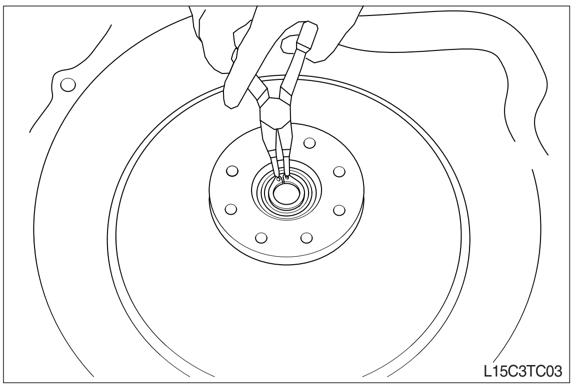


L15C3TC02

(3) Extract torque converter

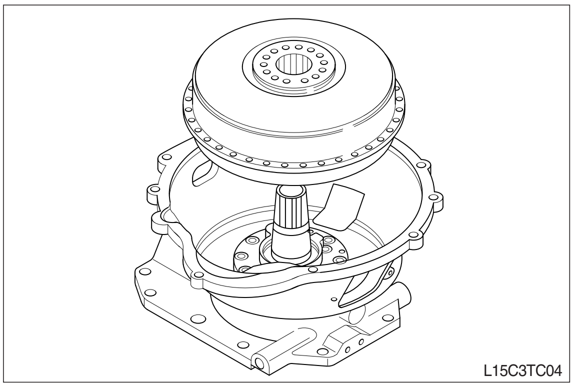
① Remove the turbine shaft snap ring.

Tool(s) required : Snap ring pliers



L15C3TC03

② Ease the torque converter out of the housing so as not to damage the pump oil seal.

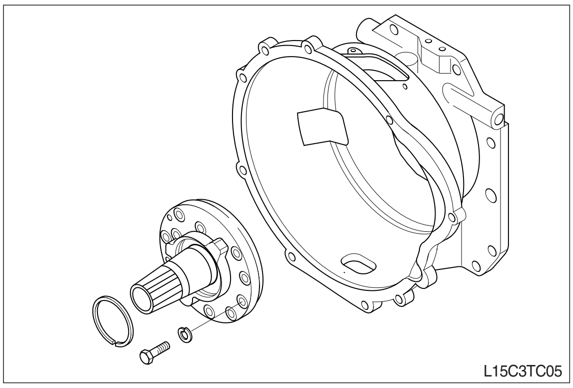


L15C3TC04

(4) Extract pump

Remove the inner turbine shaft snap ring and all bolts holding the pump.

Tool(s) required : 12mm socket wrench

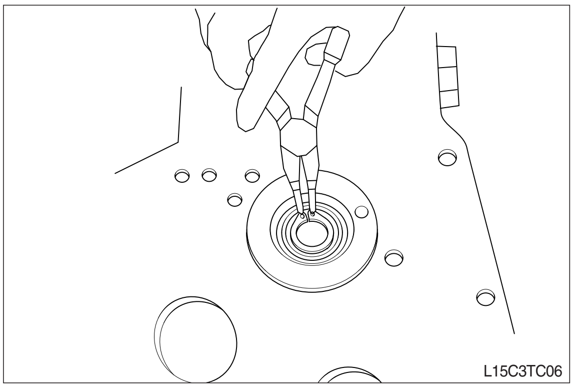


L15C3TC05

(5) Extract turbine shaft

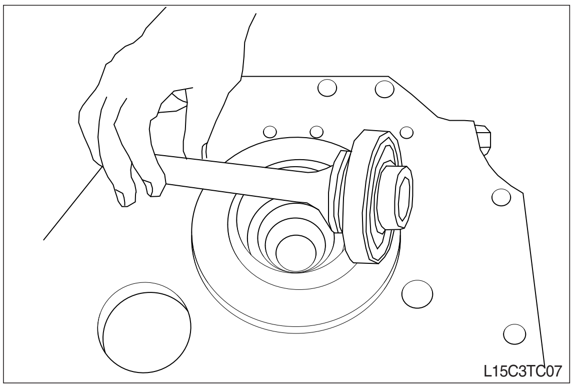
① Remove the two snap rings.

Tool(s) required : Snap ring pliers



L15C3TC06

② Extract the turbine shaft.

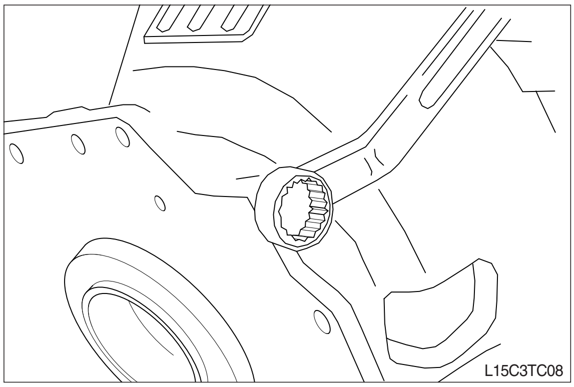


L15C3TC07

(6) Extract valves

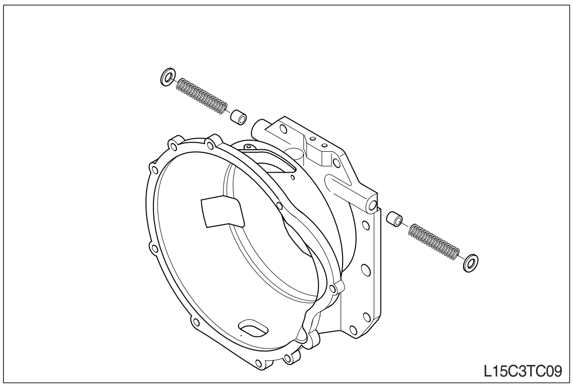
① Remove the two plugs.

Tool(s) required : 24mm wrench.



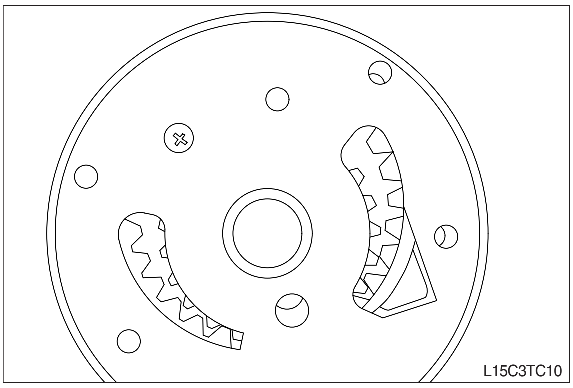
② Remove the springs and pistons.
Level the two sets-the springs especially-so that they do not get confused.

Tool(s) required : 24mm wrench.



(7) Disassemble oil pump
Remove the O-ring and philips screws and disassemble the pump.

※ **Limit disassembly to the minimum amount required.**



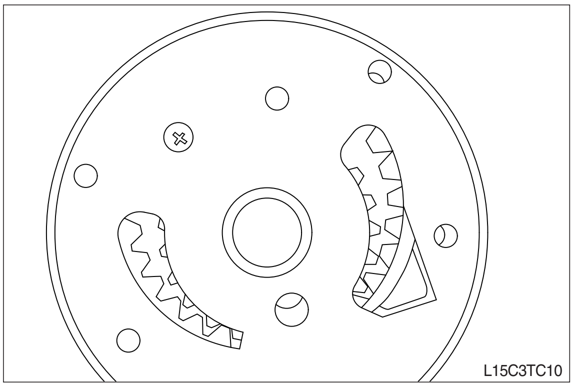
2) ASSEMBLY

The assembly procedure is the reverse of the disassembly procedure above, but requires additional care as noted below.

(1) Assembly oil pump

Return the gears and stator support to their positions before disassembly.
Check the gear action. If the gears do not rotate smoothly, disassemble the pump and start over.

· Bolt tightening torque :
0.1kgf · m(0.72lbf · ft)



L15C3TC10

(2) Install valves

The valve assemblies are different, so make sure that they go back into the proper holes.

· Plug tightening torque : 5.0kgf · m(36.2lbf · ft)

(3) Install turbine shaft

Make sure that the sealing material is seal completely inside before inserting the shaft.

· Bolt tightening torque : 2.1kgf · m(5.2lbf · ft)

(4) Install pump

Lightly grease the pump casing with lithium grease (Shell albania Z or equivalent) to avoid breaking or twisting O-ring when you insert it.

(5) Install torque convert

Fill the oil seal lip cavity one-half full with lithium grease or coat the surface with clean hydraulic fluid to avoid damaging the oil seal and bushing when you insert the torque converter.

(6) Install input side of torque converter

Coat the O-ring with lithium grease before installing.

· Bolt tightening torque : 2.1kgf · m(15.2lbf · ft)

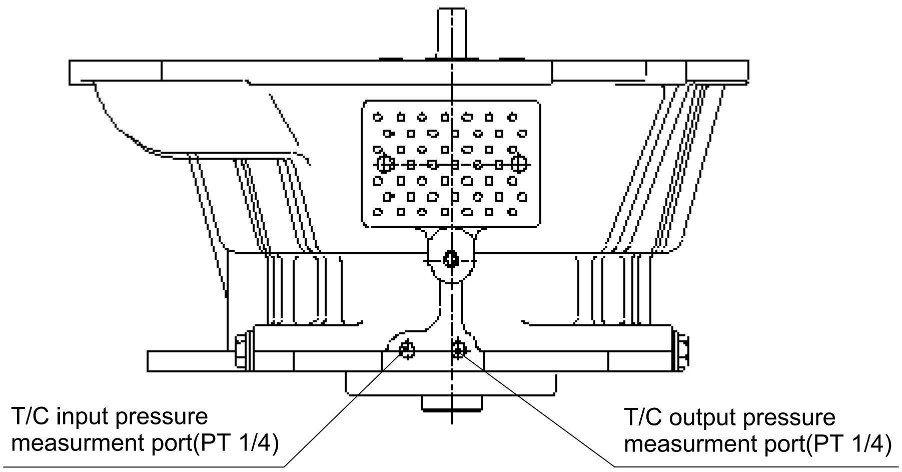
(7) Install torque converter assembly

Connect the torque converter assembly to the engine and the transmission.

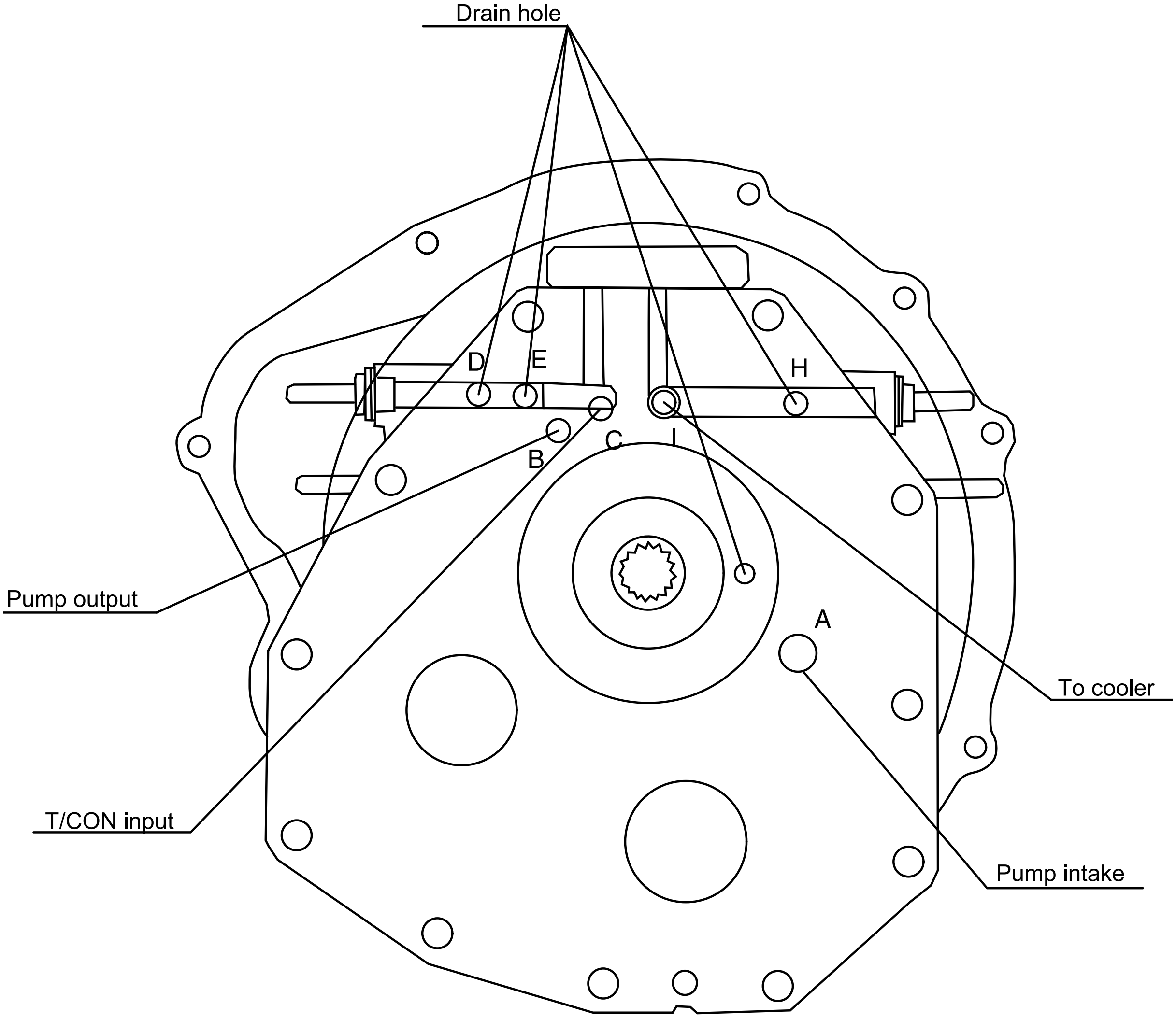
※ **After each step, check your work against the maintenance standards which appear after the procedure.**

※ **Apply semidrying liquid gasket to the circumference of oil seals, but do not allow it to get on the lips or the shaft's sliding surface.**

3) TORQUE CONVERTER ASSEMBLY DRAWING

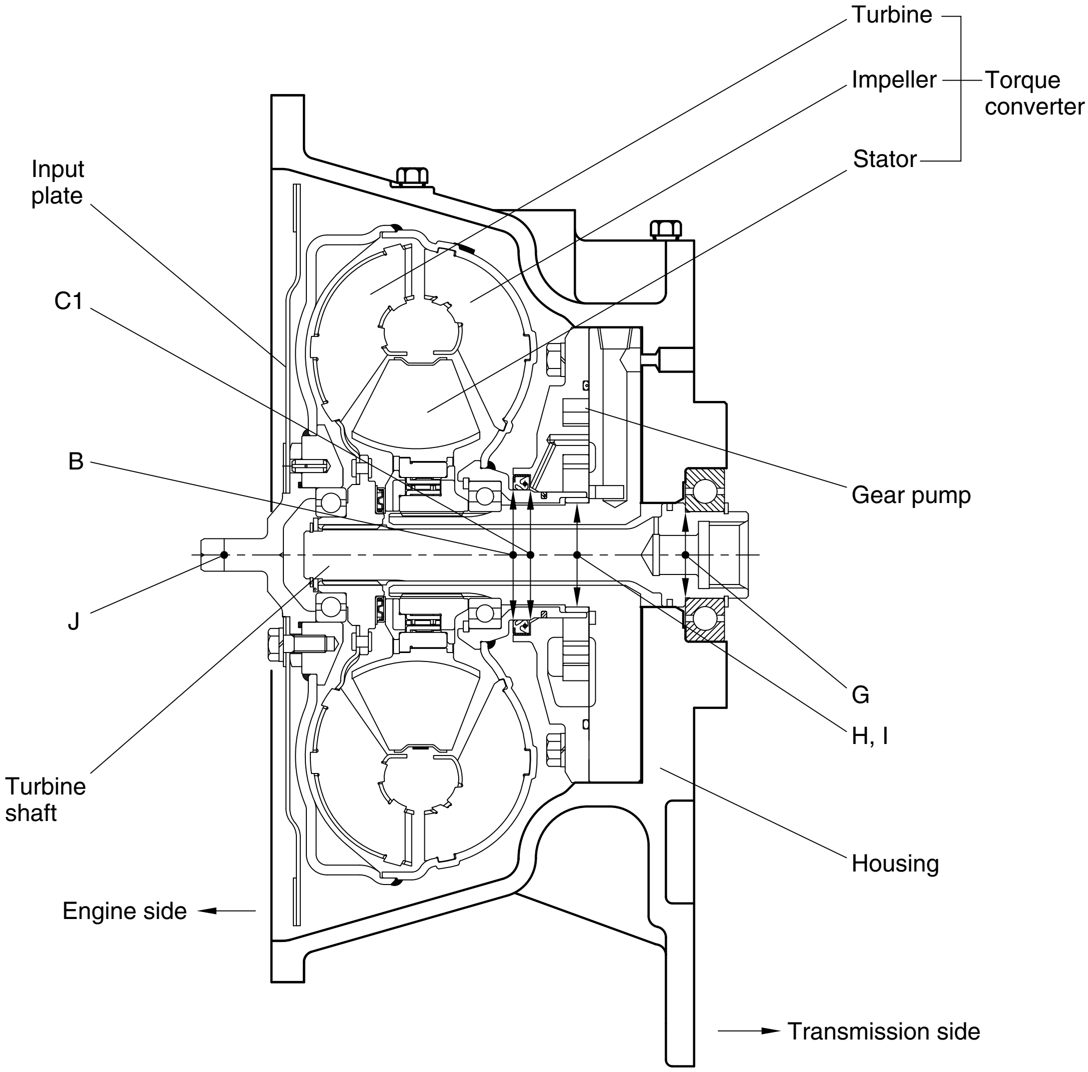


D255TC12

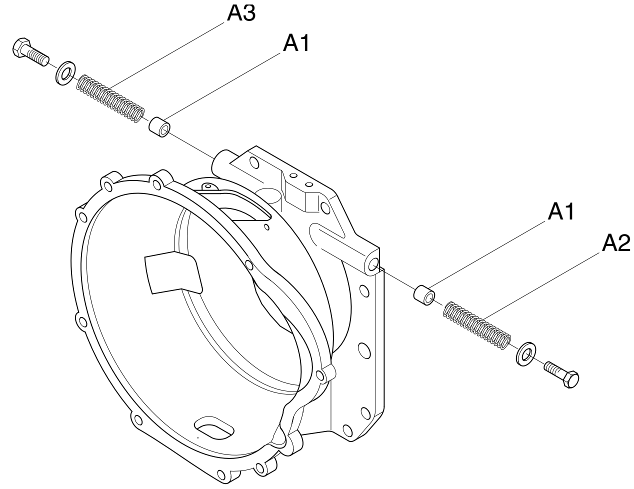


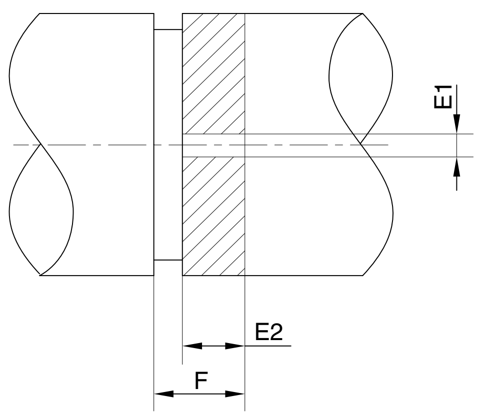
L15C3TC13

4) CHECK AND INSPECTION



L15C3TC14





L15C3TC15

Unit : mm(in), kg(lb)

No.	Check item				Criteria: Standard size	Criteria: Repair limit	Remedy
A	Torque converter input output valve	A_1	Clearance between piston and housing hole		0.015-0.025 (0.0006-0.001)	0.065 (0.0025)	Replace piston
		A_2	Torque converter inlet relief valve spring	Free length	89.9 (3.54)	87.3 (3.43)	Replace
				Installed length	63 (2.48)	63 (2.48)	
				Installed load	7.70 (16.98)	6.94 (15.3)	
		A_3	Torque converter output pressure adjusting valve spring	Free length	122 (4.80)	120.4 (4.74)	
				Installed length	103.5 (4.07)	103.5 (4.07)	
				Installed load	3.45 (7.61)	3.11 (2.36)	
B	Oil seal O.D				-	60 (2.36)	
C	Torque converter impeller valve	C_1	Oil seal mating face outer dia		59.952-60.000 (2.360-2.362)	59.852 (2.356)	
E	Seal spring	E_1	Clearance of abutment when housing is inserted		0.1-0.3 (0.004-0.012)	1.0 (0.04)	
		E_2	Ring with		2.47-2.49 (0.097-0.098)	2.27 (0.089)	
F	Turbine shaft(Seal ring groove width)				2.56-2.60 (0.100-0.102)	2.7 (0.106)	
G	Housing(Seal ring portion inner dia)				48.0-48.025 (1.889-1.890)	48.12 (1.894)	
H	Impeller hub O.D				47.951-47.970 (1.887-1.888)	Clearance between hub and bushing 0.1(0.0039)	
I	Pump bushing				47.975-48.000 (1.889-1.890)		
J	Pilot(Tip outer dia)		MITSUBISHI engine		15 (0.59)	14.85 (0.38)	Corrected by hard chrome plating

5) MAINTENANCE STANDARDS

(1) Hydraulic pressure

No	Location	Pressure (kgf/cm²)	Cracking pressure (kgf/cm²)
1	Torque converter input	5 ~ 7	5
2	Torque converter output	2.2 ~ 4	2.2

※ Cracking pressure means the pressure at which the valve begins to open.

(2) Tightening torques

No	Location	Thread specifications		Tightening torque in kgf · m(lbf · ft)	
				Target	Maximum
1	Input plate	Small hex bolt	M8×1.25×20	2.1(15.2)	2.7(19.5)
2	Pump	Small hex bolt	M8×1.25×40	2.1(15.2)	2.7(19.5)
3	Valves	Plug	M16×1.5 ×10	5.0(36)	6.5(47)
4	Cover	Small hex bolt	M8×1.25×12	0.98(7)	1.3(9)
5	Torque converter fluid outlets	Hex plug with hole	PT 1/4	3.5(25.3)	4.4(31.8)
6	Pump assembly	Small flathead screw	M5×0.8×16	0.1(0.72)	0.3(2.2)
7	Blind plug	Hex plug with hole	PT3/4	5.8(42)	7.2(52.1)

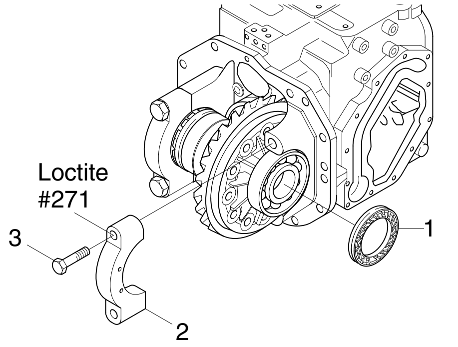
2. TRANSMISSION

※ Keep all parts in order as disassembly progresses. Take care to properly identify each part and its order of removal.
If necessary, keep notes and put markings on parts using a non-destructive marker such as a felt-tipped pen.

1) DISASSEMBLY

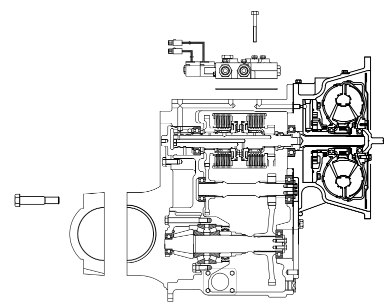
(1) Differential, torque converter, control valve

① Detach the differential from the torque converter.



L15C3DF01

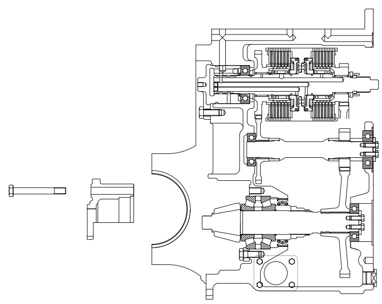
② Remove the control valve.



D255TM01

(2) Cage

① Remove the cage.
(With holder at the pinion end).

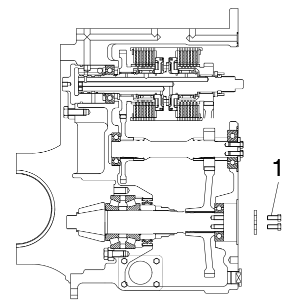


D255TM02

(3) Pinion shaft

① Remove pinion shaft bolt(1).

② Fit a dolly block(copper rod) and tap the pinion shaft with a hammer to remove.



D255TM03

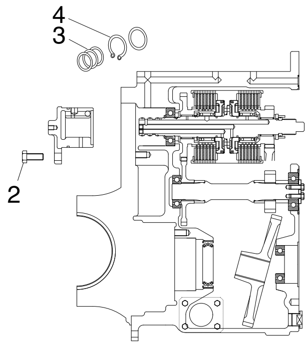
(4) Seal ring cap

① Remove bolt(2) and fit the bolt to the tapped hole.
Remove the seal ring cap.

※ **Pull out the cap straight without twisting it.**

② Remove seal ring(3).

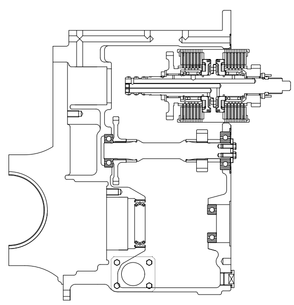
③ Remove snap ring(4).



D255TM04

(5) Clutch pack assembly

Remove front and rear clutch pack assembly.

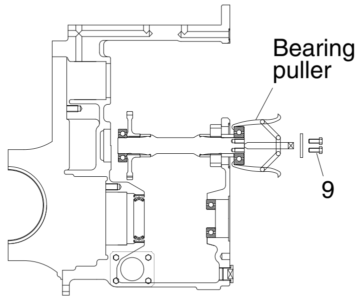


D255TM05

(6) Idler shaft assembly

① Remove bolt(9) and slide the shaft assembly as shown in the drawing.

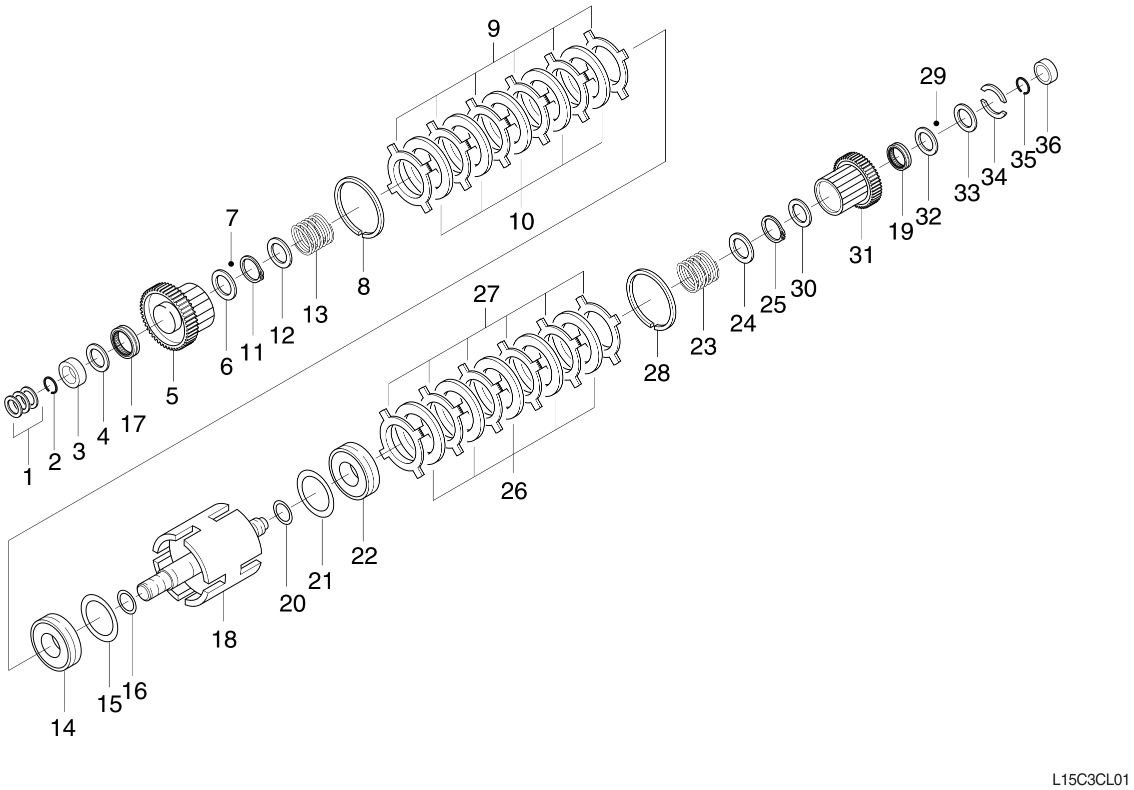
② Remove the bearing and the shaft assembly using a bearing puller.



D255TM06

(7) Disassembly of components of clutch pack assembly

※ The number shows the sequence of disassembly.



1	Sealing	13	Spring	25	Snap ring
2	Spring	14	Piston	26	Disc
3	Spacer	15	Sealing	27	Plate
4	Washer	16	Sealing	28	Ring
5	Gear	17	Needle bearing	29	Ball
6	Spacer	18	Shaft assembly	30	Washer
7	Ball	19	Needle bearing	31	Gear
8	Ring	20	Sealing	32	Washer
9	Plate	21	Sealing	33	Spacer
10	Disc	22	Piston	34	Spacer
11	Snap ring	23	Spring	35	Spring
12	Washer	24	Washer	36	Spacer

※ Spring under heavy compression. Carefully remove with press.

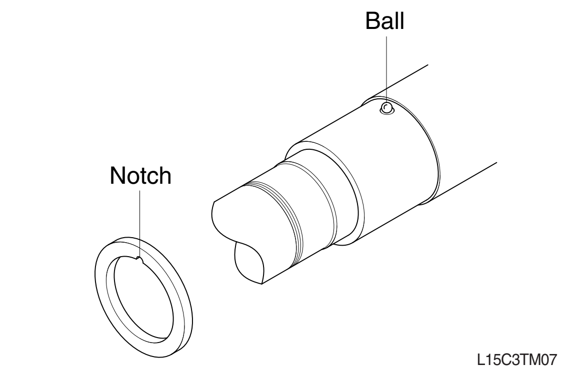
2) ASSEMBLY

※ Cleanliness is of extreme importance in the repair and overhaul of this assembly. Perform all disassembly work in a clean area. Overhaul the transaxle only in a clean, dust-free location, using clean tools and equipment. Dirt or grit will damage the highly-machined sufaces and result in premature failure of components. Cleanliness of interior surfaces, orifices, etc. is extremely important to the proper operation of the hydraulic circuit. The exterior surface of the unit must be thoroughly cleaned of all dirt and foreign substances to prevent contamination of the parts during overhaul. Protect all components from dust and dirt while repairs are being made. Be sure the work area is kept clean.

(1) Assembly of components of the clutch pack assembly.
Assembly is in the reverse order to disassembly but pay attention to the following.

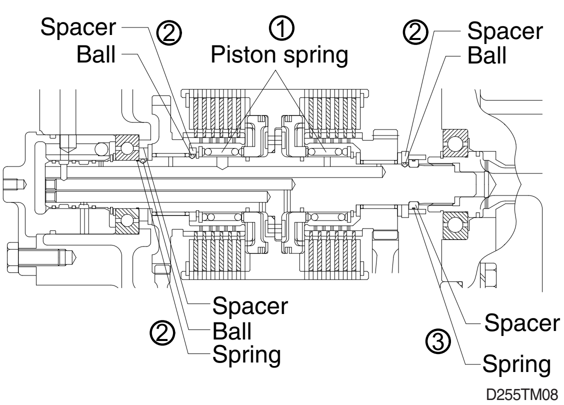
① Piston ring
Fit the piston ring.

② Ball, Spacer, Spring
Coat the ball with oil and then fix it to the hole of the shaft match the notch of the spacer with the ball and insert.



L15C3TM07

③ Spacer, Spring
Spacer consists of two halves.
Fix the spacer with a spring.



D255TM08

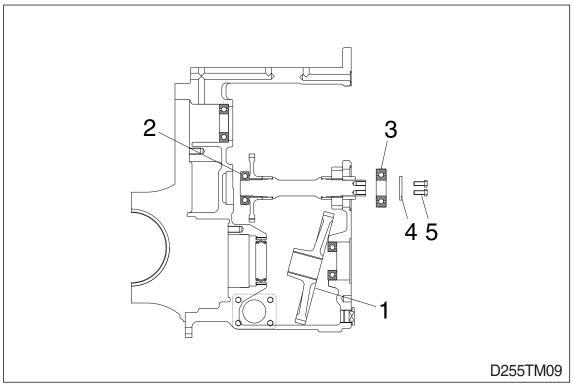
(2) Idler shaft assembly

① Prefit gear(1) in the case.

② Fit bearing(2) on the idler shaft and install in the case.

③ Fix bearing(3) fix it with plate(4) and bolt (5).

· Tightening torque : 2.8 ~ 3.5kgf · m
(20 ~25lbf · ft)



(3) Clutch pack assembly

① Fit bearing(1) in the case.

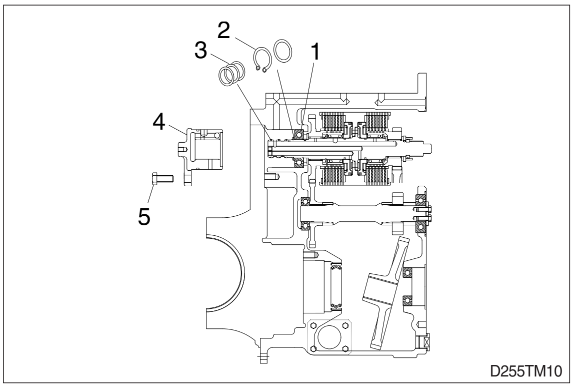
② Fit F-R clutch pack assembly.

③ Fit snap ring(2).

④ Fit seal ring(3).

⑤ Fit seal ring cap fix with bolt(5).

· Tightening torque : 10 ~ 12.5kgf · m
(72 ~90lbf · ft)

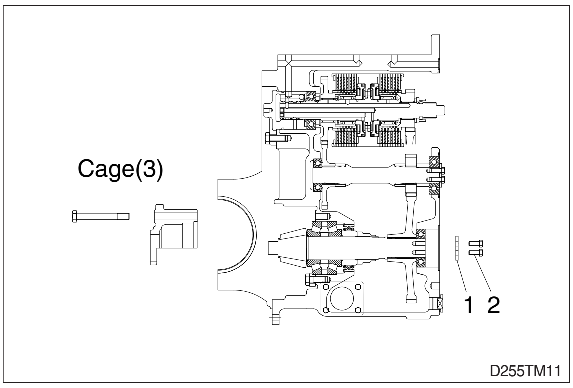


(4) Pinion shaft assembly

① Install pinion shaft assembly in the case.

② Fix with plate(1) and bolt(2).

③ Fix cage(3).



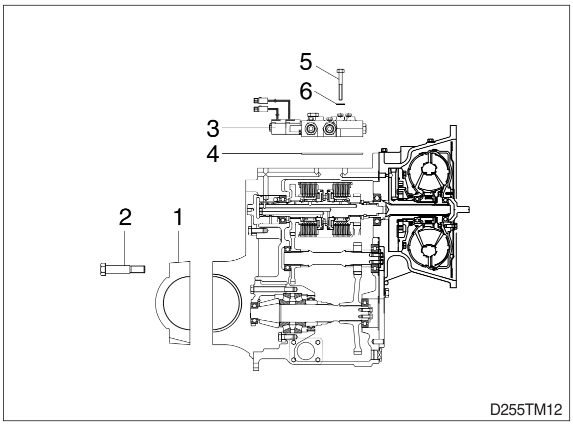
(5) Differential, control valve

① Fit the differential to the case with cap(1) and bolt(2).

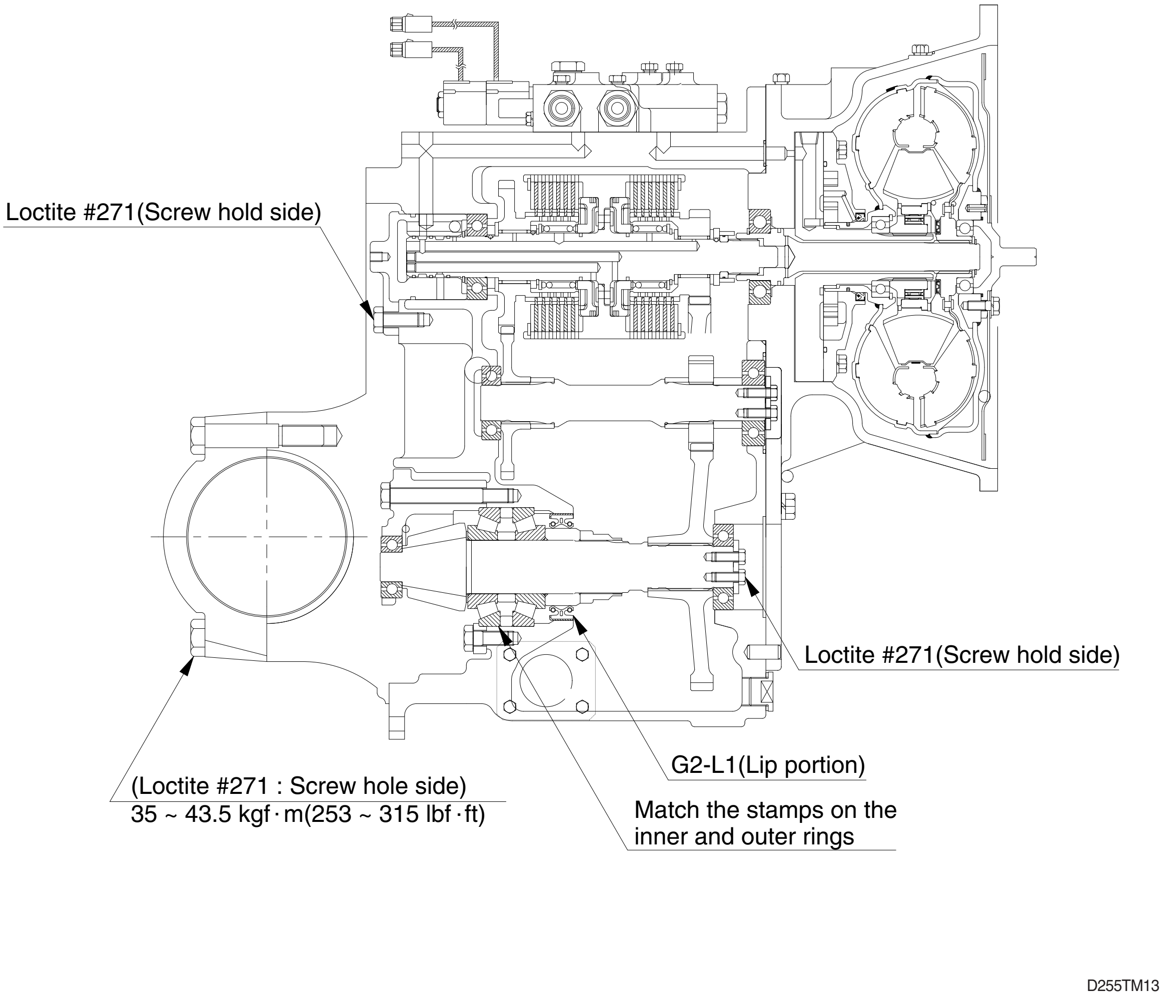
※ **Refer to adjustment of backlash after attaching the differention.**

② Fit control valve(3) and gasket(4) with bolt(5).

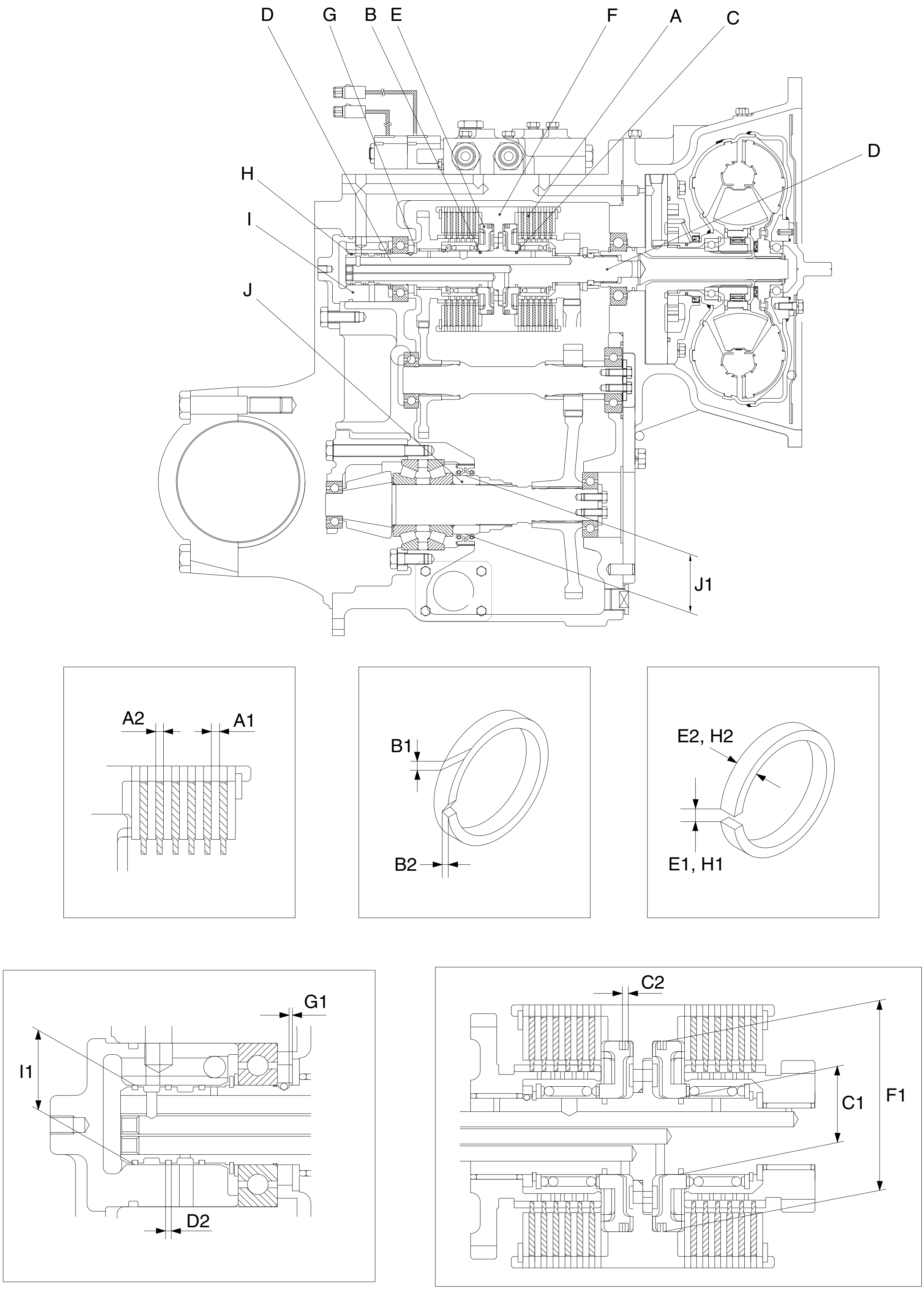
· Tightening torque : 2.8 ~ 3.5kgf · m
(20 ~25lbf · ft)



3) TORQUEFLOW TRANSMISSION ASSEMBLY DRAWING



4) CHECK AND INSPECTION



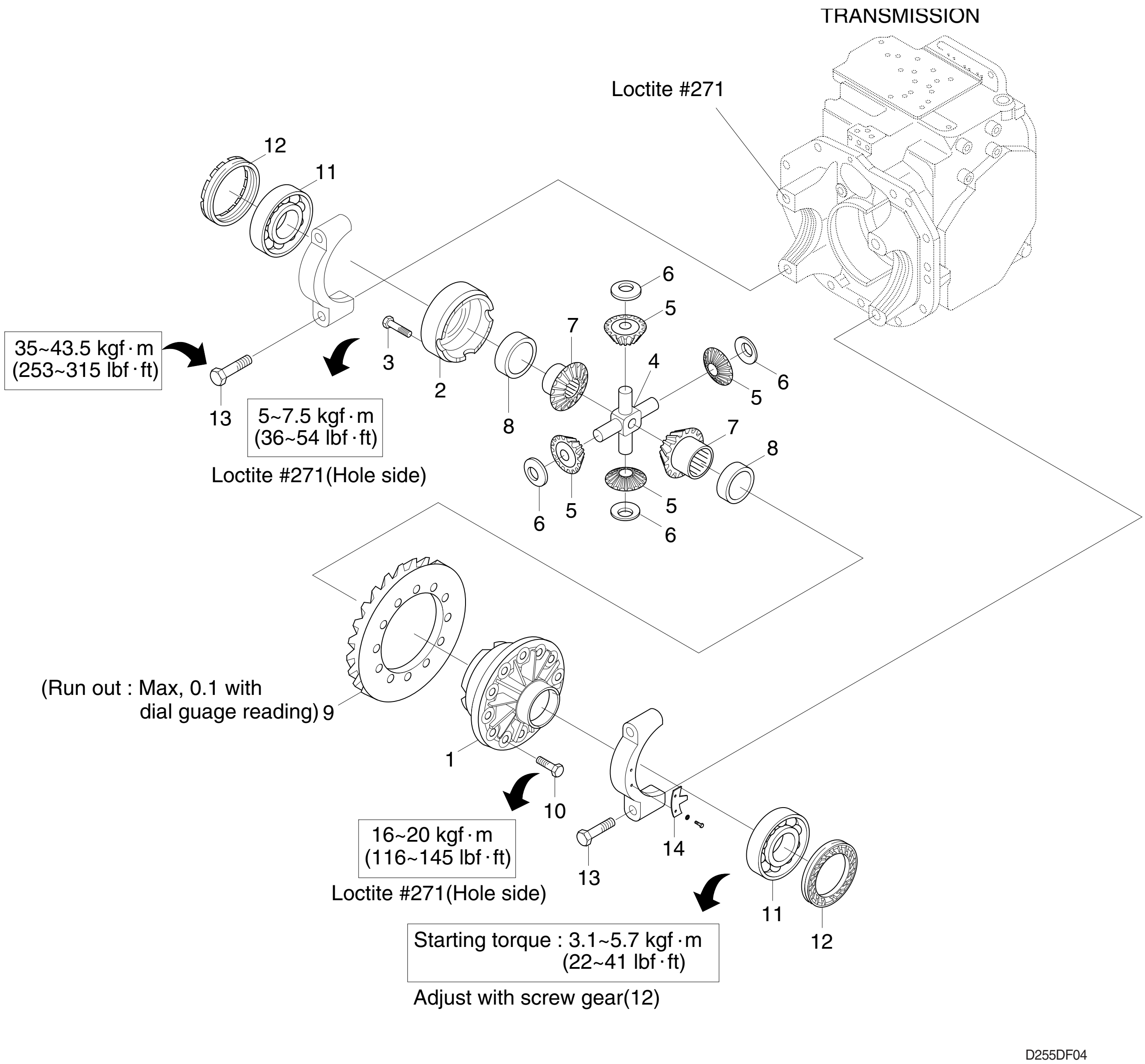
D255TM14

Unit : mm(in)

No	Check item			Criteria		Remedy
				Standard size	Repair limit	
A	Plate	A_1	Thickness of drive plate	3.13-3.27 (0.123-0.129)	2.9 (0.114)	Replace
		A_2	Thickness of driven plate	2.90-3.05 (0.114-0.120)	2.6(0.102) (Oil groove depth Min0.2)(0.008)	
B	Sealing	B_1	Clearance of abutment when piston is inserted	0.36-0.56 (0.014-0.002)	-	Replace at each disassembly
		B_2	Depth of the side face oil groove	0.15-0.35 (0.006-0.014)	To be grooved	
		(D_1)	Width of groove for insertion	2.60-2.65 (0.102-0.104)	2.8 (0.110)	
C	Piston	C_1	Sealing matching face I.D	40.025-40.050 (1.576-1.577)	40.2 (1.583)	Replace
		C_2	Width of groove when sealing is inserted.	3.1-3.2 (0.122-0.126)	3.4 (0.134)	
D	Drive shaft	D_1	Width of the groove for inserting sealing.	2.60-2.65 (0.102-0.104)	2.8 (0.110)	
		D_2	Width of the groove of inserting sealing.	2.60-2.65 (0.102-0.104)	2.8 (0.110)	
E	Sealing	E_1	Clearance of abutment when clutch case is inserted	0.2-0.4 (0.008-0.157)	1.0 (0.039)	
		E_2	Width	2.97-2.99 (0.117-0.118)	2.77 (0.109)	
		(C_2)	Width of groove for insertions	3.1-3.2 (0.122-0.126)	3.4 (0.109)	
F	Clutch case	F_1	Sealing matching face I.D	100-100.054 (3.937-3.939)	100.3 (3.949)	
G	Thrust	G_1	Thickness	2.9-3.1 (0.114-0.122)	2.5 (0.098)	
H	Sealing	H_1	Clearance of abutment when cap is inserted	0.05-0.25 (0.002-0.010)	0.65 (0.026)	
		H_2	Width	2.47-2.49 (0.097-0.098)	2.25 (0.089)	
		(D_1)	Width of groove for insertions	2.60-2.65 (0.102-0.104)	2.8 (0.110)	
I	Cap	I_1	Sealing matching face I.D	35.000-35.021 (1.378-1.379)	35.2 (2.552)	
J	Retainer	J_1	Oil seal maching face O.D	64.926-65.000 (2.556-2.559)	64.83 (1.386)	
-	Each gear	-	Backlash	0.08-0.28 (0.003-0.011)	-	
		-	Clearance of thrust	0.3-0.7 (0.012-0.028)	-	
-	Gasket, O-ring, seals			-	-	Replace with a new part when disassembly and assembly

3. DIFFERENTIAL

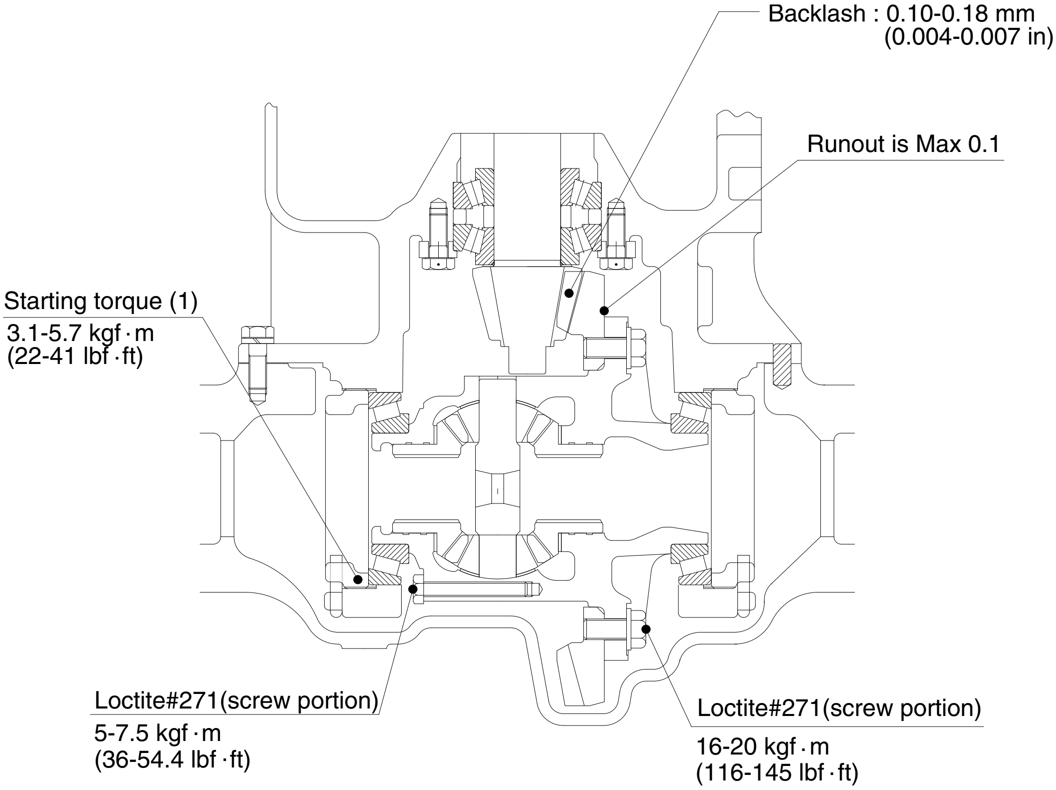
1) STRUCTURE

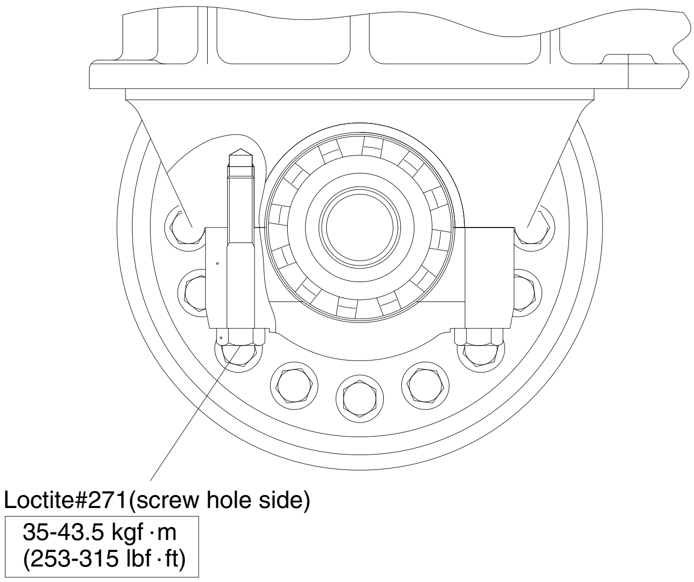


※ Ring gear and pinion must be replaced as one unit.
Do not replace one without the other.

1	Case	6	Washer	11	Taper bearing
2	Case	7	Differential pinion	12	Screw gear
3	Hexagon bolt	8	Bushing	13	Bolt
4	Spider	9	Bevel gear	14	Plate
5	Differential pinion	10	Bolt		

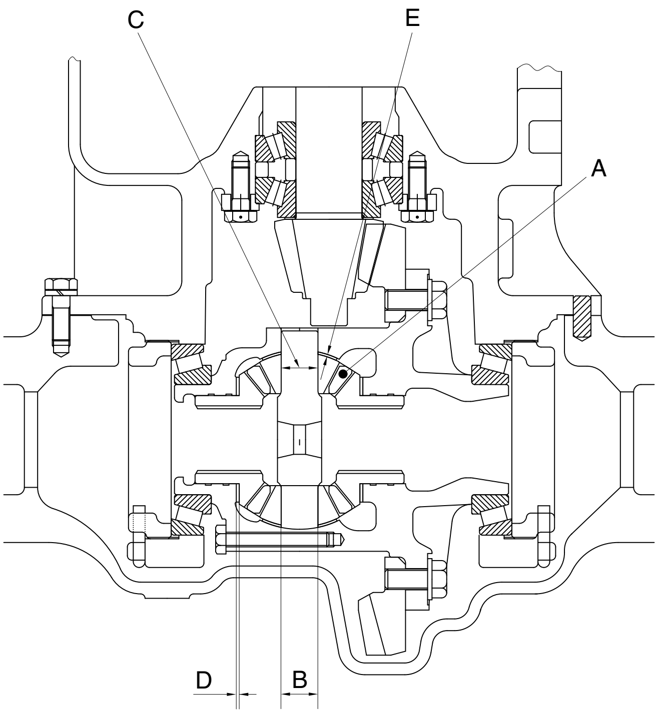
2) DIFFERENTIAL ASSEMBLY DRAWING





D255DF05

3) CHECK AND INSPECTION

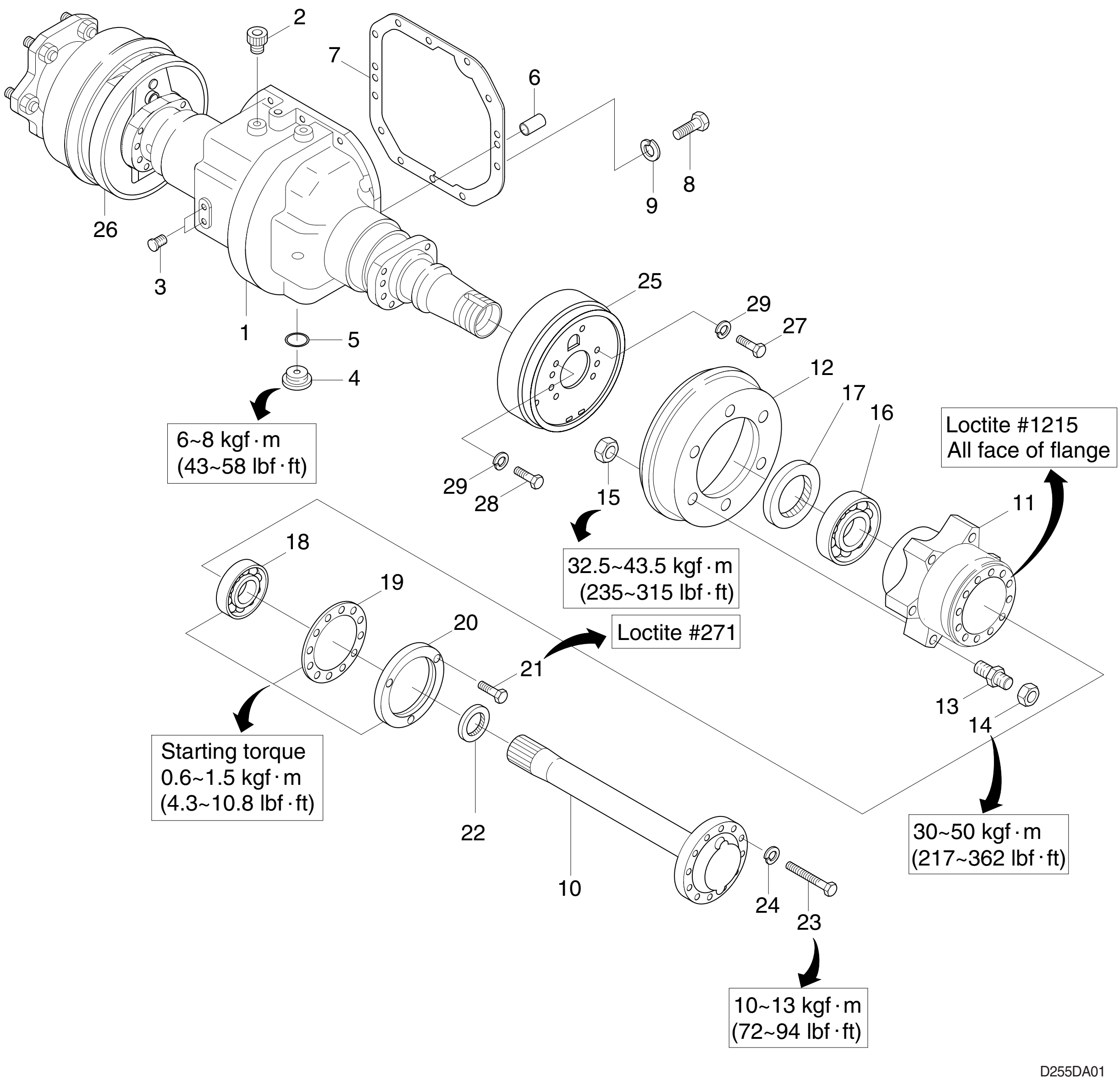


Unit : mm(in)

No	Check item	Criteria		Remedy
		Standard size	Repair limit	
A	Differential pinion gear and side gear	-	Scratches on the teeth	Replace (Replace bevel gear and pinion)
B	O.D of spider	24.959-24.980 (0.983-0.984)	24.75 (0.974)	Replace
C	I.D of differential pinion gear	25.0-25.1 (0.984-0.988)	25.2 (0.992)	
D	Width of bushing	1.94-2.06 (0.076-0.081)	1.7 (0.067)	
E	Width of bushing	1.52-1.68 (0.060-0.066)	1.3 (0.05)	
-	(I.D of brake drum)	310.0-310.2 (12.20-12.21)	312 (12.28)	
-	Gasket O-ring Seals	-	-	Replace with new parts when reassembling after disassembling.

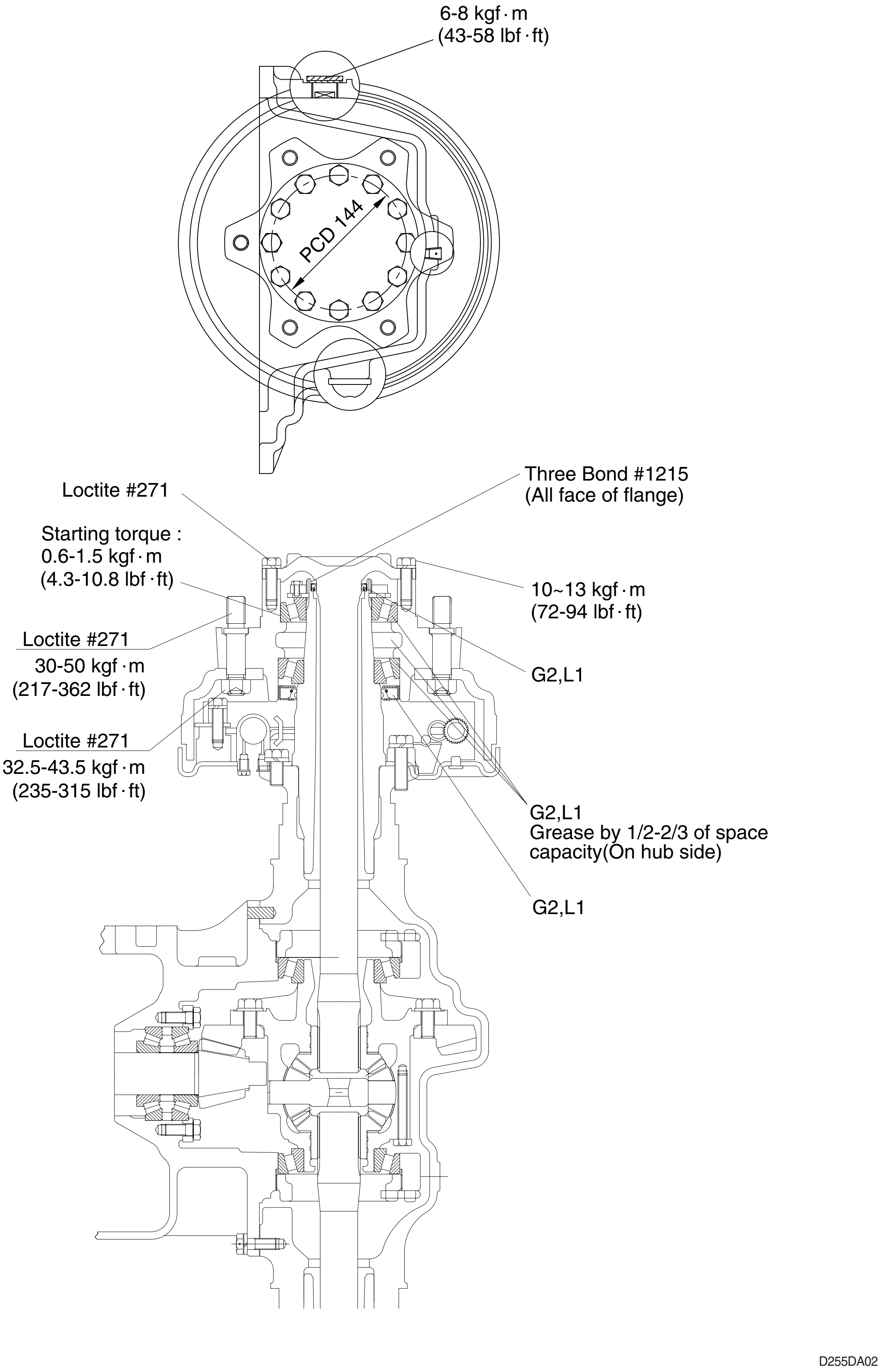
4. DRIVE AXLE

1) DISASSEMBLY AND ASSEMBLY



1	Housing	11	Hub	21	Bolt
2	Cap	12	Brake drum	22	Oil seal
3	Plug	13	Bolt	23	Bolt
4	Plug	14	Nut	24	Spring washer
5	Gasket	15	Nut	25	Brake assy(LH)
6	Dowel pin	16	Bearing	26	Brake assy(RH)
7	Gasket	17	Oil seal	27	Reamer bolt
8	Bolt	18	Bearing	28	Bolt
9	Spring washer	19	Plate	29	Spring washer
10	Shaft	20	Nut		

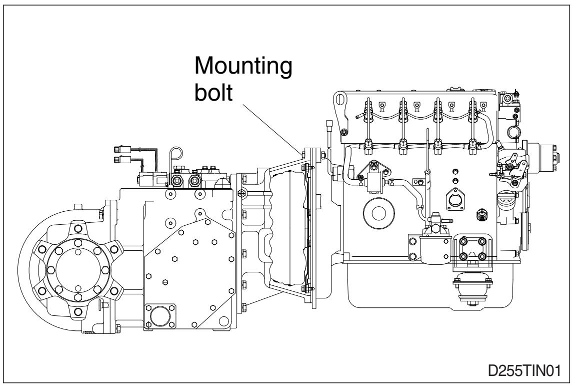
2) ASSEMBLY OF DRIVE AXLE



3) INSTALLATION
Perform installation in the reverse order to removal, paying attention to the following.

(1) Tightening torque converter case mounting bolt.

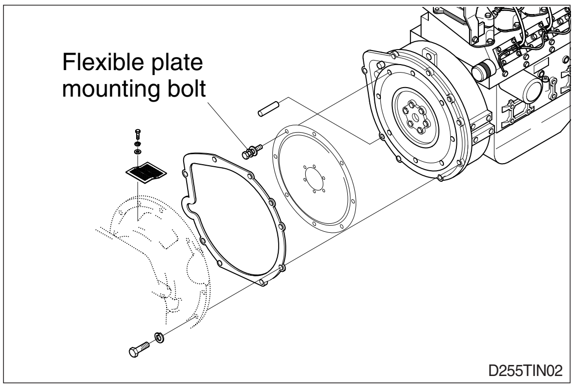
· Tightening torque : 6.0-7.5kgf · m
(43-54lbf · ft)



D255TIN01

(2) Tightening flexible plate mounting bolt.

· Tightening torque : 2.8-3.5kgf · m
(20-25lbf · ft)

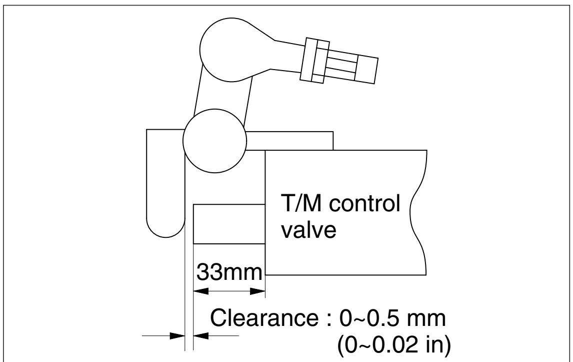


D255TIN02

(3) Pedal assembly brake piping.

① Inching drawing
Refer to the drawing on the right.

② Adjustment of pedal
Refer to "Adjustment of pedal"



D255TIN03

(4) Mast

Cap mounting bolt.
· Tightening torque : 25-31.5kgf · m
(181-228lbf · ft)

SECTION 4 BRAKE SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. OUTLINE

There are two brake systems, the foot brake system and the hand brake system.

In the foot brake system, oil pressure is generated in the master cylinder by treading on the brake pedal. This pressure causes the wheel cylinder pistons to extend, expanding the brake shoes and pressing them against the brake drums to attain braking force.

In the hand brake system, the brake shoes are expanded by operating the brake lever.
Force from the lever is transmitted to the brake shoes through the hand brake cables and a lever arm in each wheel brake assembly.

The wheel brake is the duo-servo type. With force applied to both the primary and secondary shoes, this type provides a large amount of brake force.
In addition, the brake equipped with automatic adjusters which constantly adjust the clearance between the shoe and the drum, compensation for wear due to the shoe friction and thus keeping the clearance constant.

2. SPECIFICATION

1) WHEEL BRAKE

Item			Specification
Type			Front wheel, duo-servo & auto adjustment type
Brake shoe size			310×60mm
Wheel cylinder bore diameter			28.57mm
Master cylinder diameter			19.05mm
Pedal adjustment	Free height	20/25/30-5	160~170mm
		20/25/30C-5	140~150mm
	Pedal play		10~15mm
Brake drum diameter	Normal		310mm
Wheel cylinder installation torque			0.7~1.3kgf · m
Backing plate installation torque			15~20kgf · m
Brake oil			Only use for brake fluid DOT3

2) PARKING BRAKE

Item	Specification
Type	Toggle, internal expanding mechanical type
Parking lever stroke	214mm
Parking cable stroke	18~19mm

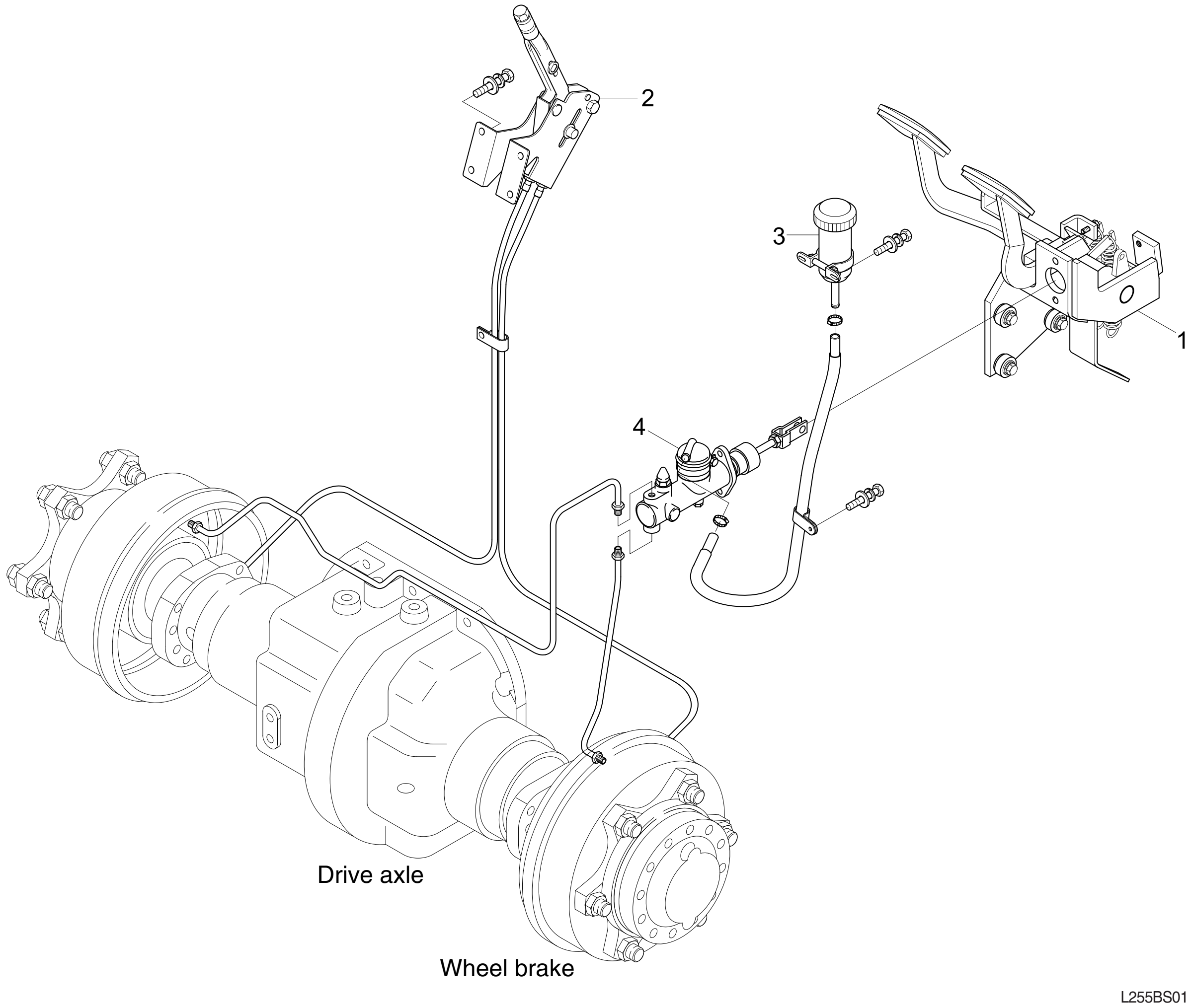
3. BRAKE PEDAL AND PIPING

The brake system provides two systems, a foot brake and a parking brake.

In the foot brake system, the oil pressure which is generated in the master cylinder when the brake pedal is depressed is transmitted to the wheel cylinders. The piston of the wheel cylinder presses the brake shoes and then moves outward causing contact with the drums and braking force is obtained. In the parking brake system, the force is transmitted to move the brake shoe through a brake cable to activate the brake when the brake lever is operated.

The wheel brake is a dual servo type in which the actuating force is applied to both the primary and secondary shoes. Even if the applied force is small, a large braking force will be obtained.

These brakes are equipped with self adjusters which continuously adjusts the brakes in small increments in direct proportion to the wear of the linings.

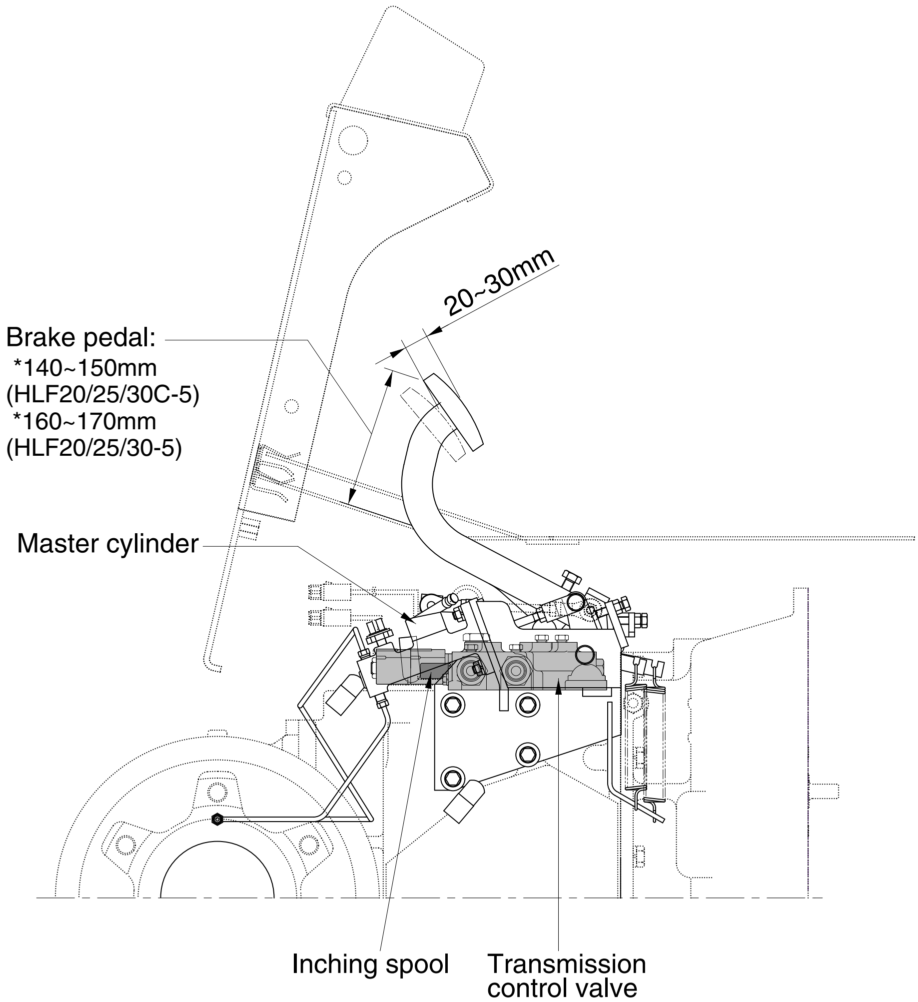


1	Brake pedal & bracket assy	3	Reservoir tank assy
2	Parking lever assy	4	Master cylinder

4. INCHING PEDAL AND LINKAGE

The brake pedal serves to actuate the hydraulic brakes on the front axle.

At the beginning of the pedal stroke, the inching spool of the transmission control valve is actuated to shift the hydraulic clutch to neutral and turn off the driving force. By treading the pedal further, the brake are applied.



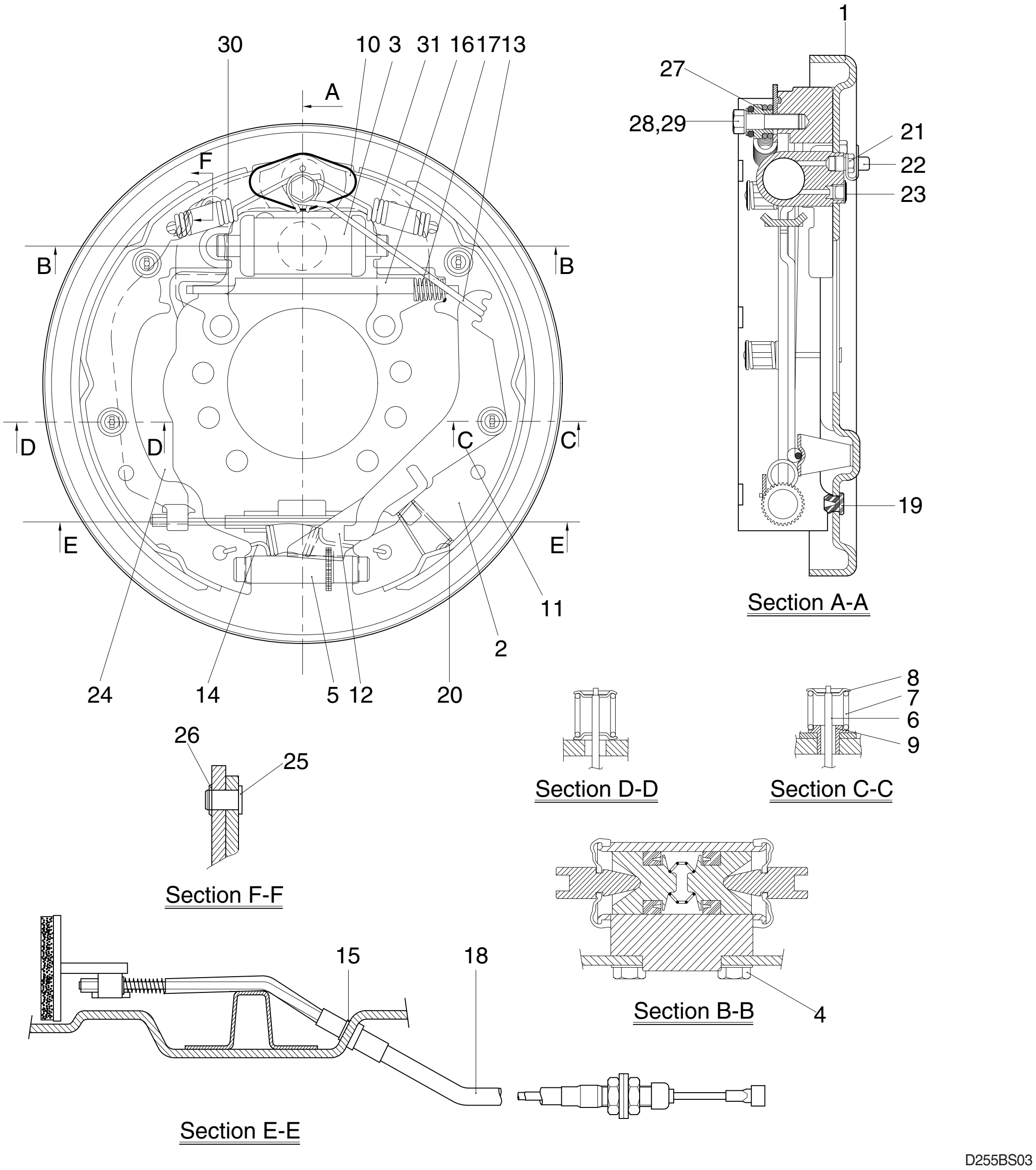
L255BS02

5. WHEEL BRAKE

1) STRUCTURE

The wheel brake assembly mounts to the flange on the drive axle housing casting and is basically contained within the hub assembly.

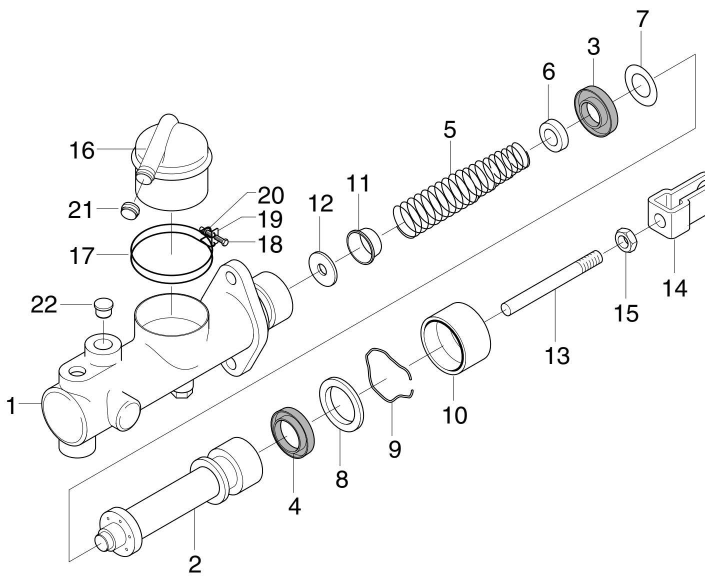
The inside of the hub is machined and acts as the brake drum.



1 Back plate assy(LH/RH)
2 Lined shoe assy
3 Wheel cylinder assy
4 Bolt-set
5 Adjuster assy(LH/RH)
6 Pin
7 Spring
8 Washer
9 Bush
10 Plate
11 Lever actuator(LH/RH)
12 Lever pawl(LH/RH)
13 Stopper
14 Spring
15 Retaining-ring
16 Strut
17 Spring
18 Parking cable assy(LH/RH)
19 Plug
20 Spring
21 Bleed-screw
22 Bleed screw-cap
23 Plug
24 Lever(LH/RH)
25 Pin
26 Retaining-ring
27 Sleeve
28 Bolt
29 Spring-washer
30 Shoe A
31 Shoe B

6. BRAKE MASTER CYLINDER

1) STRUCTURE



D255BS04

1	Body	7	Spacer	13	Rod	18	Band bolt
2	Piston	8	Plate	14	Yoke	19	Band plate
3	Primary cup	9	Key wire	15	Nut	20	Band washer
4	Secondary cup	10	Boot	16	Nipple	21	Cap
5	Spring	11	Check valve	17	Band	22	Cap
6	Spring seat	12	Valve seat				

2) DISASSEMBLY

(1) Remove the master cylinder boot(10) and remove the rod(13).

(2) Remove the key wire(9) and take out the plate(8), the piston(2), the piston primary cup(3), and piston spring(5).

(3) Specification of master cylinder.

- Cylinder bore diameter : 19.05mm
- Piston stroke : 23.0mm

3) INSPECTION

(1) **Clean and check these components.**

※ **Use isopropyl alcohol or brake fluid for washing the components. Do not use gasoline, kerosene or any other mineral oils. When using alcohol, do not leave rubber parts in the liquid for more than 30 seconds.**

(2) Inspect the inside wall of the master cylinder, and if any faults are found, replace the cylinder assembly.

(3) Replace the boot(10), the primary cup(3), piston(2), if deformation or any other defect is found.

4) ASSEMBLY

※ **Prior to assembly make sure again of no contaminant of the components. Apply a thin coat of brake oil to the components.**

- Assembly is in opposite order to disassembly.

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

1) BRAKE PIPING

(1) Check pipes, hoses and joints for damage, oil leakage or interference.
(2) Operate brake pedal and check operating force when pedal is depressed. Check also change in operating force, and change in position of pedal when pedal is kept depressed.

2) WHEEL BRAKE

Compact wheel base chassis
(1) Measure lining at point with most wear, and check that lining thickness is at least 2.0mm(0.08in).
(2) Hold lining surface with screwdriver to prevent piston from coming out, depress brake pedal and check movement of shoe.
(3) Remove brake shoe from anchor pin, and check for rust or wear.
When assembling, coat sliding parts with special brake grease.

3) BRAKE DRUM

(1) Measure inside diameter of drum, and check that it is within 310mm(12.2in).

4) BACKING PLATE

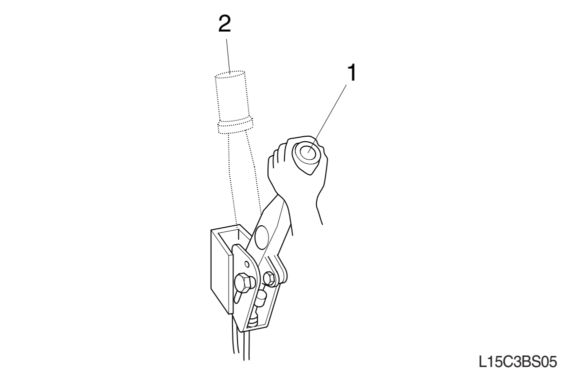
(1) Check visually for deformation or cracks.
Check particularly for deformation at outside circumference of plate and at mounting bolt.
(2) Coat mounting bolt with loctite and tighten : 15~20kgf · m(108~145lbf · ft).

5) BRAKING FORCE

(1) Select a dry, flat, paved surface and drive truck at maximum speed. When signal is given, stop truck immediately and measure distance from point where signal was given to point where truck stopped. (unloaded)
· Stopping distance : Within 5m(16.4ft)
(2) Check that there is no pulling of steering wheel, pulling by brakes to one side or abnormal noise when making emergency stops.

6) PARKING BRAKE

(1) Operating force of parking lever is 20 - 30 kgf(44 - 66lbf).
(2) Check that parking brake can hold machine in position when loaded on 15% slope. If there is no slope available, travel at low speed and check braking effect of parking brake.



L15C3BS05

2. TROUBLESHOOTING

Problem	cause	Remedy
Insufficient braking force	· Hydraulic system leaks oil. · Hydraulic system leaks air. · Lining surface soiled with water or oil. · Lining surface roughened or in poor contact with drum. · Lining worn. · Brake valve or wheel cylinder mal-functioning. · Hydraulic system clogged.	· Repair and add oil. · Bleed air. · Clean or replace. · Repair by polishing or replace. · Replace. · Repair or replace. · Clean.
Brake acting unevenly. (Machine is turned to one side during braking.)	· Tires unequally inflated. · Brake out of adjustment. · Lining surface soiled with water or oil. · Earth intruding into brake drum. · Lining surface roughened. · Lining in poor contact with drum. · Lining worn. · Brake drum worn or damaged (distortion or rusting). · Wheel cylinder malfunctioning. · Brake shoe poorly sliding. · Back plate mounting bolt loose. · Back plate deformed. · Wheel bearing out of adjustment. · Hydraulic system clogged.	· Adjust tire pressure. · Adjust. · Clean or replace. · Clean. · Repair by polishing or replace. · Repair by polishing. · Replace. · Repair or replace. · Repair or replace. · Adjust. · Retighten or replace. · Replace. · Adjust or replace. · Clean.
Brake trailing.	· Pedal has no play. · Brake shoe poorly sliding. · Wheel cylinder mal-functioning. · Piston cup faulty. · Return spring fatigued or bent. · Parking brake fails to return or out of adjustment. · Brake valve return port clogged. · Hydraulic system clogged. · Wheel bearing out of adjustment.	· Adjust. · Adjust. · Repair or replace. · Replace. · Replace. · Repair or adjust. · Clean. · Clean. · Adjust or replace.
Brake chirps	· Brake trailing. · Piston fails to return. · Lining worn. · Lining surface roughened.	· See above. Brake trailing. · Replace. · Replace. · Repair by polishing or replace.

Problem	cause	Remedy
Brake squeaks	· Lining surface roughened. · Lining worn. · Poor shoe to lining contact. · Excessively large friction between shoe and back plate. · Foreign matter on drum sliding surface. · Drum sliding surface damaged or distorted. · Brake shoe deformed or poorly installed. · Back plate mounting bolt loosening. · Worn anchor or other contact portion. · Lining poor contact with drum. · Anti-rattle spring poorly installed.	· Repair by polishing or replace. · Replace. · Replace. · Clean and apply brake grease. · Clean · Replace. · Replace or repair. · Retighten. · Replace. · Repair or replace. · Repair or replace.
Brake rapping	· Drum sliding surface roughened. · Drum eccentric or excessively distorted. · Lining surface roughened.	· Repair by polishing or replace. · Replace. · Repair by polishing or replace.
Large pedal stroke	· Brake out of adjustment. · Hydraulic line sucking air. · Oil leaks from hydraulic line, or lack of oil. · Lining worn. · Shoe tilting or does not return completely. · Lining in poor contact with brake drum.	· Adjust. · Bleed air. · Check and repair or add oil. · Replace. · Repair. · Repair.
Pedal dragging.	· Twisted push rod caused by improperly fitted brake valve. · Brake valve seal faulty. · Flow control valve orifice clogged.	· Adjust. · Replace. · Clean or replace.
Abnormal noise	· Lining worn. · Lining surface roughened. · Poor shoe to lining contact. · Excessively large friction between shoe and back plate. · Foreign matter on drum sliding surface. · Drum sliding surface damaged or distorted. · Brake shoe deformed or poorly installed. · Back plate mounting bolt loosening. · Worm anchor or other contact portion. · Lining in poor contact with drum.	· Replace · Repair by polishing or replace. · Replace. · Clean and apply brake grease. · Clean · Replace · Replace or repair. · Retighten · Replace · Repair or replace.

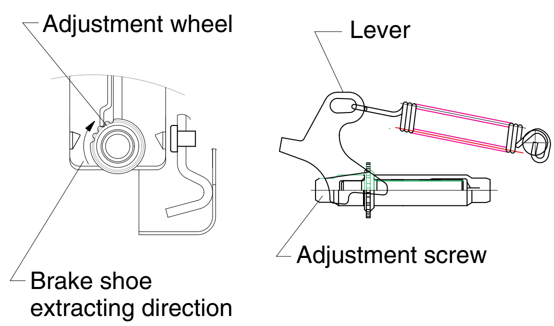
GROUP 3 TESTS AND ADJUSTMENTS

1. ADJUSTMENT OF WHEEL BRAKE

⚠ **Adjust with engine stopped.**

1) Jack up truck. Extend adjustment screw by clicking adjustment wheel teeth with a screwdriver until wheel (mounted on brake drum being adjusted) offers a light resistance when turned by hand. Back adjustment wheel by 25~30 teeth to shorten length of adjustment screw.

※ **When backing adjustment wheel, be sure to adequately raise adjustment lever to keep it free from interference with adjustment wheel. If lever is bent by mistake, it loses proper function.**

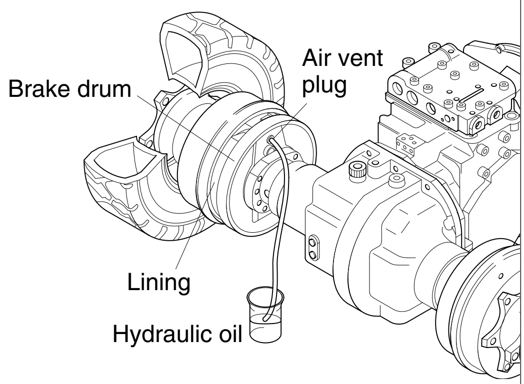


L15C3BS06

2) After adjusting brake, drive machine for about 500m, then check heat of brake drum at 4 points to confirm that brakes are not dragging.
3) After adjusting, confirm that brake stopping distance is within standard range.

2. AIR BLEEDING OF BRAKE SYSTEM

1) Air bleeding should be performed by two persons :
   One rides on truck for depressing and releasing brake pedal : the other person is on the ground and removes cap from air vent plug on wheel cylinder.
2) Block the front wheel securely and apply parking brake.
3) Start the engine.
4) Attach a vinyl tube to air vent plug and immerse other end of tube into a vessel filled with hydraulic oil.
5) Loosen air vent plug by turning it 3/4 with a wrench. Depress brake pedal to drain oil mixed with air bubbles from plug hole.
6) Depress brake pedal until no air bubbles come out of air vent plug hole.
7) After completion of air bleeding, securely tighten air vent plug. Install cap on plug.



L15C3BS07

3. ADJUSTMENT OF PEDAL

1) BRAKE PEDAL

(1) Pedal height from floor plate

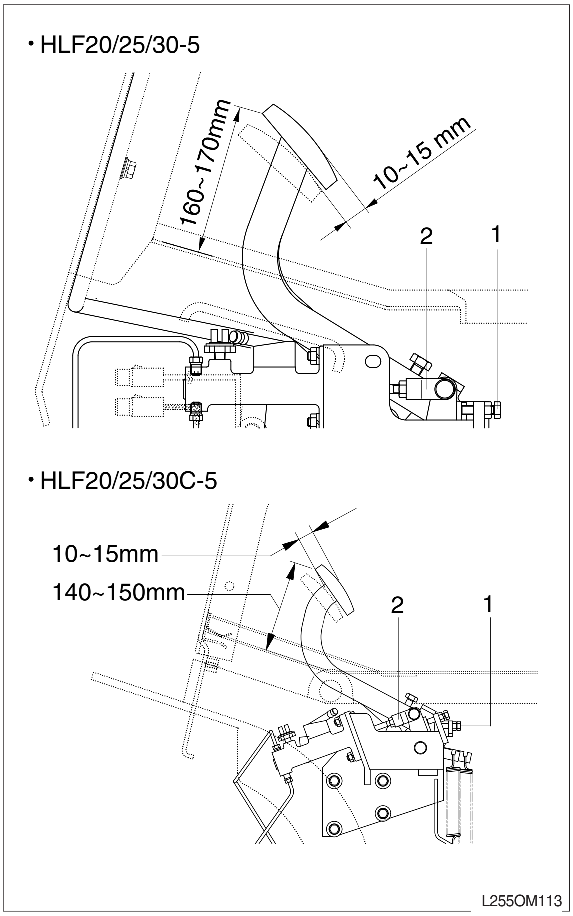
Adjust with stopper bolt(1).

Model	Pedal height
HLF20/25/30-5	160~170mm(6.3~6.7in)
HLF20/25/30C-5	140~150mm(5.5~5.9in)

(2) Play

Adjust with rod(2) of master cylinder.

Model	Play
HLF20/25/30(C)-5	10~15mm(0.4~0.6in)



2) INCHING PEDAL

(1) Pedal height from floor plate

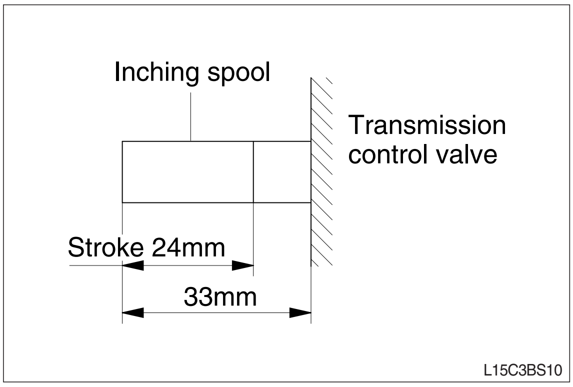
Adjust with stopper bolt.

Model	Pedal height
HLF20/25/30-5	160~170mm(6.3~6.7in)
HLF20/25/30C-5	140~150mm(5.5~5.9in)

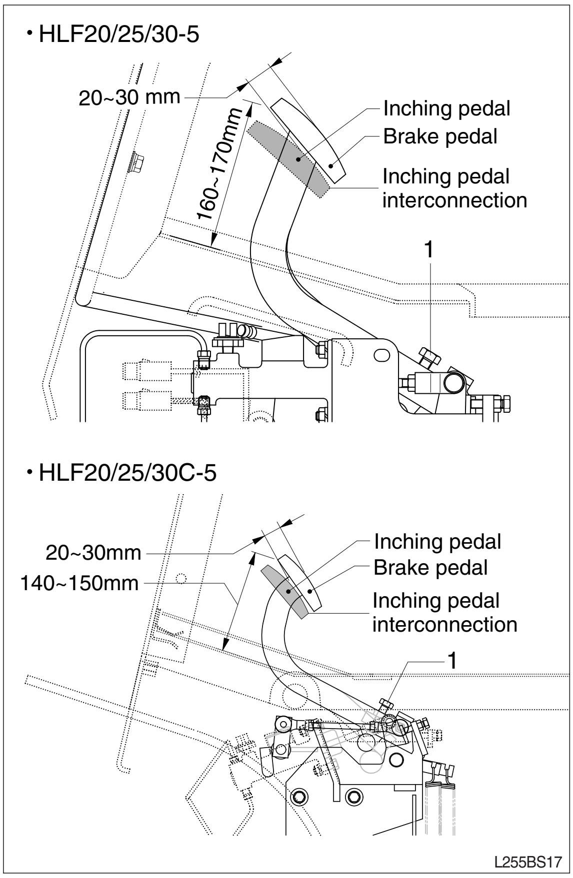
(2) Inching spool protrusion

Adjust with inching cable so that when the inching pedal is fully returned, the protrusion of spool from the end face of the control valve is the specified valve.

· Protrusion : 33mm(1.3in)



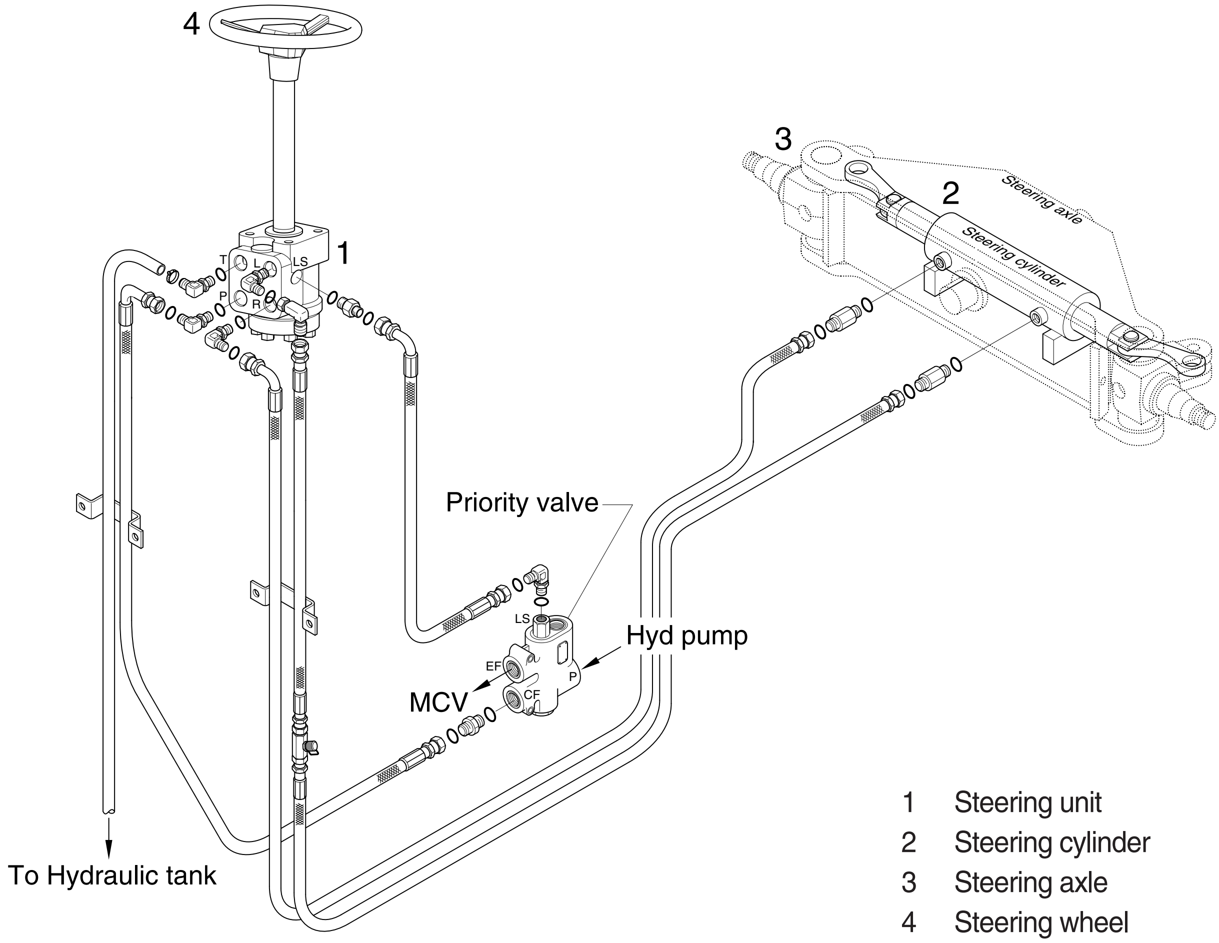
(3) Adjust bolt(1) so that brake pedal interconnects with inching pedal at inching pedal stroke 20~30mm(0.8~1.2in).



SECTION 5 STEERING SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. OUTLINE

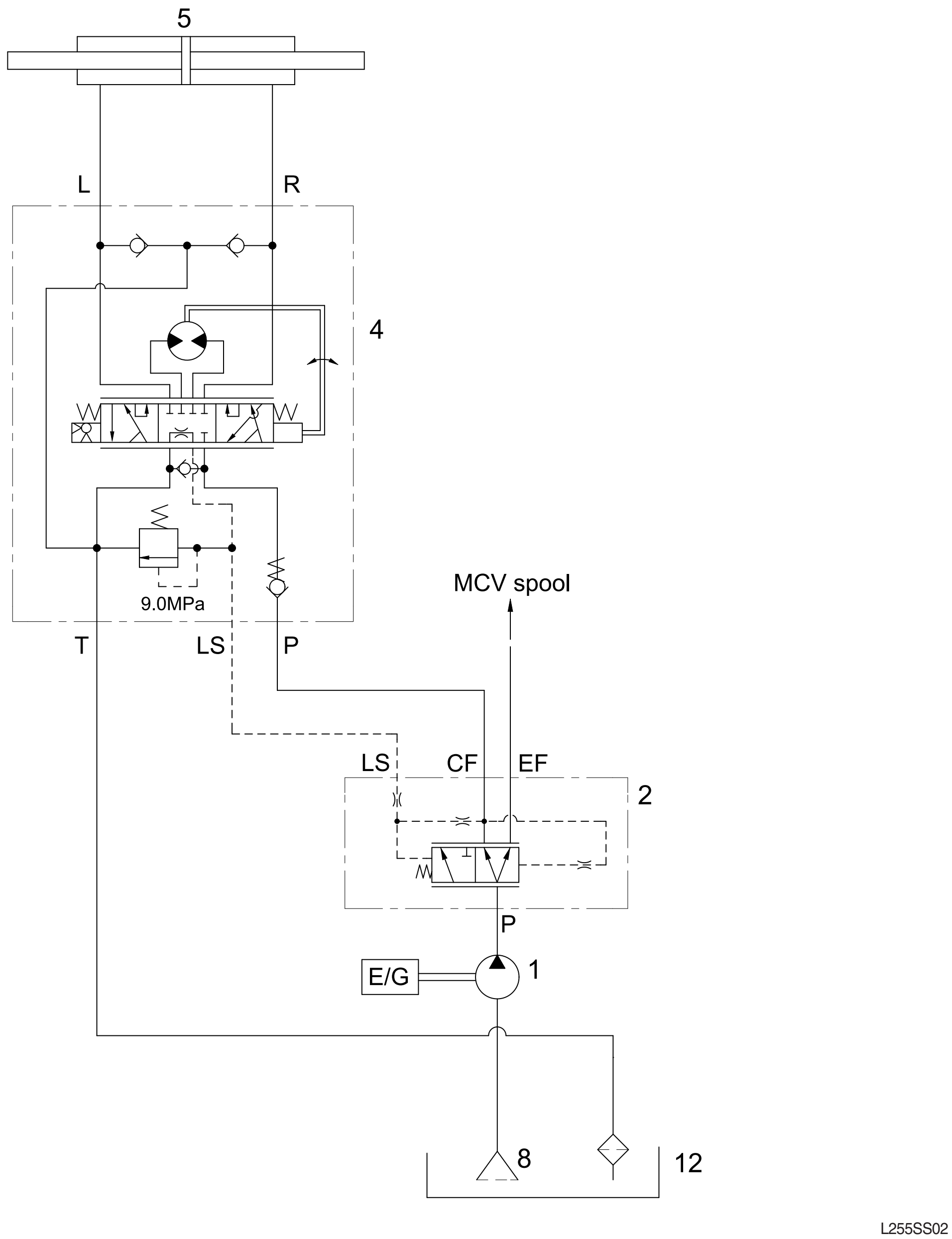


L255SS01

The steering system for this machine is composed of steering wheel assembly(4), steering unit(1), steering cylinder(2), steering axle(3) and pipings. The steering force given to the steering wheel enters the steering unit through the steering column. The required oil flow is sensed by the function of the control section of the unit, and pressurized oil delivered from the hydraulic pump is fed to the steering cylinder. The force produced by the steering cylinder moves the knuckle of steering tires through the intermediate link.

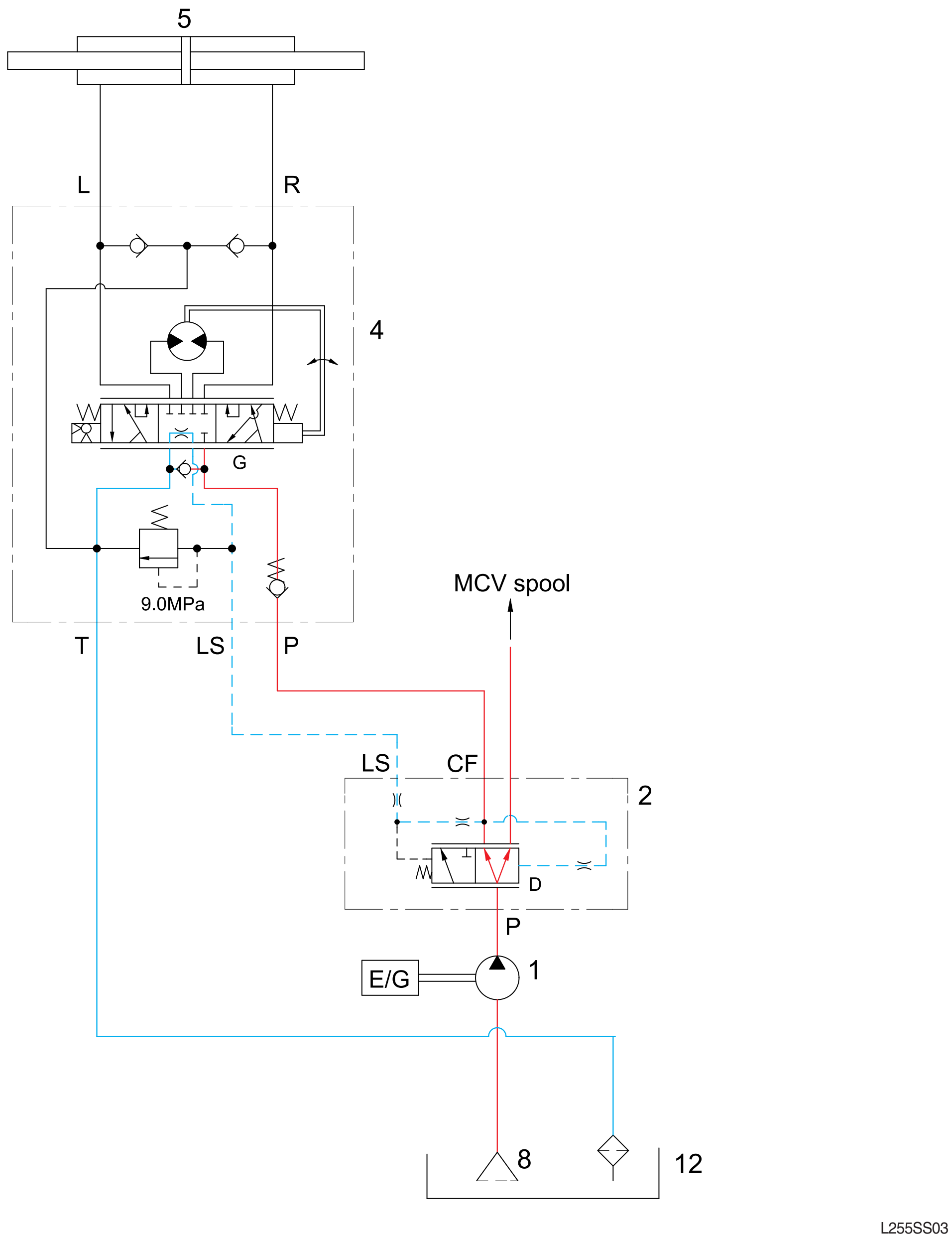
The axle body is unit structure having steering knuckles installed to its both ends by means of kingpins. Hub and wheel are mounted through bearing to spindle of knuckle.

2. HYDRAULIC CIRCUIT



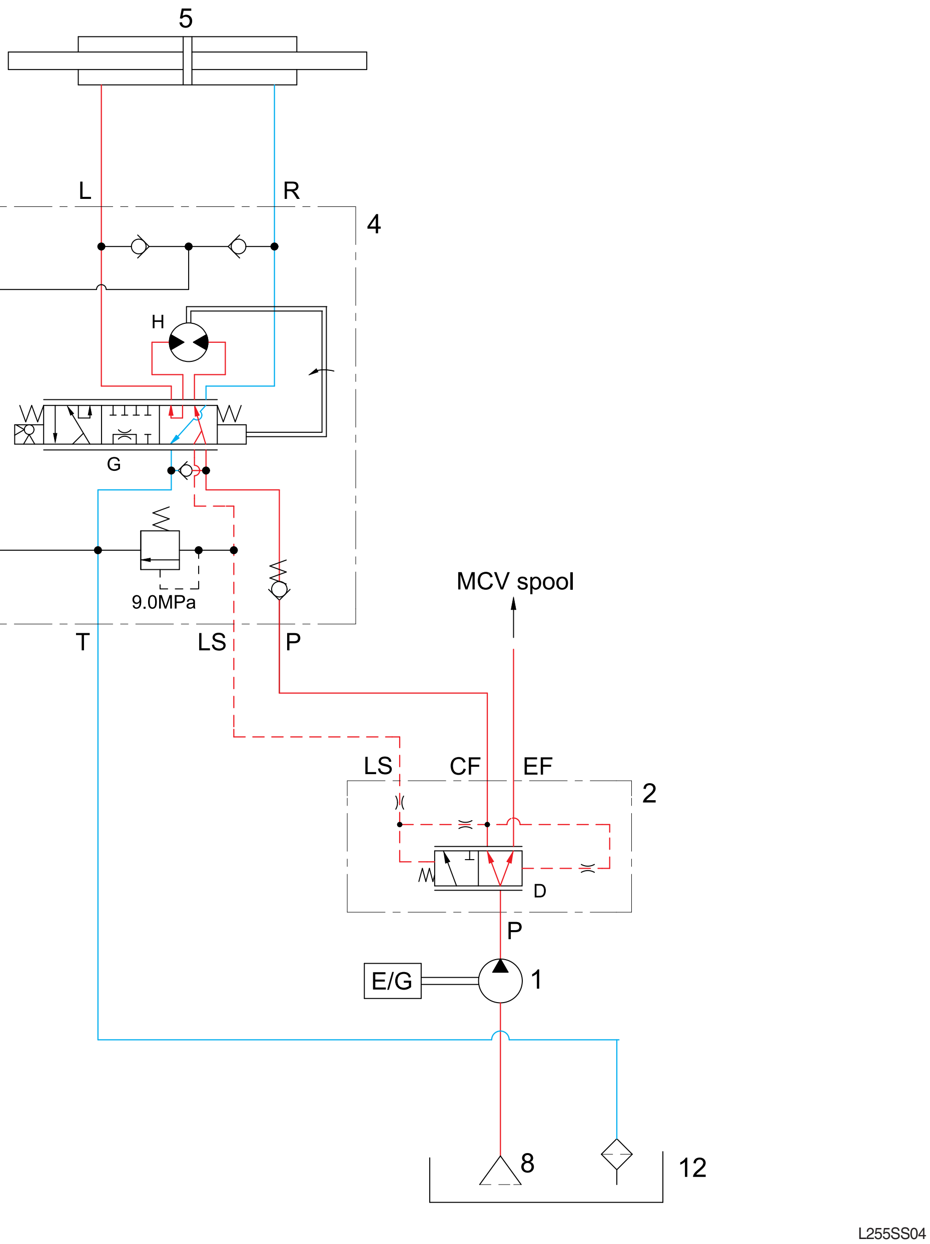
1	Hydraulic gear pump	5	Steering cylinder
2	Priority valve	8	Suction filter
4	Steering unit	12	Hydraulic tank

1) NEUTRAL



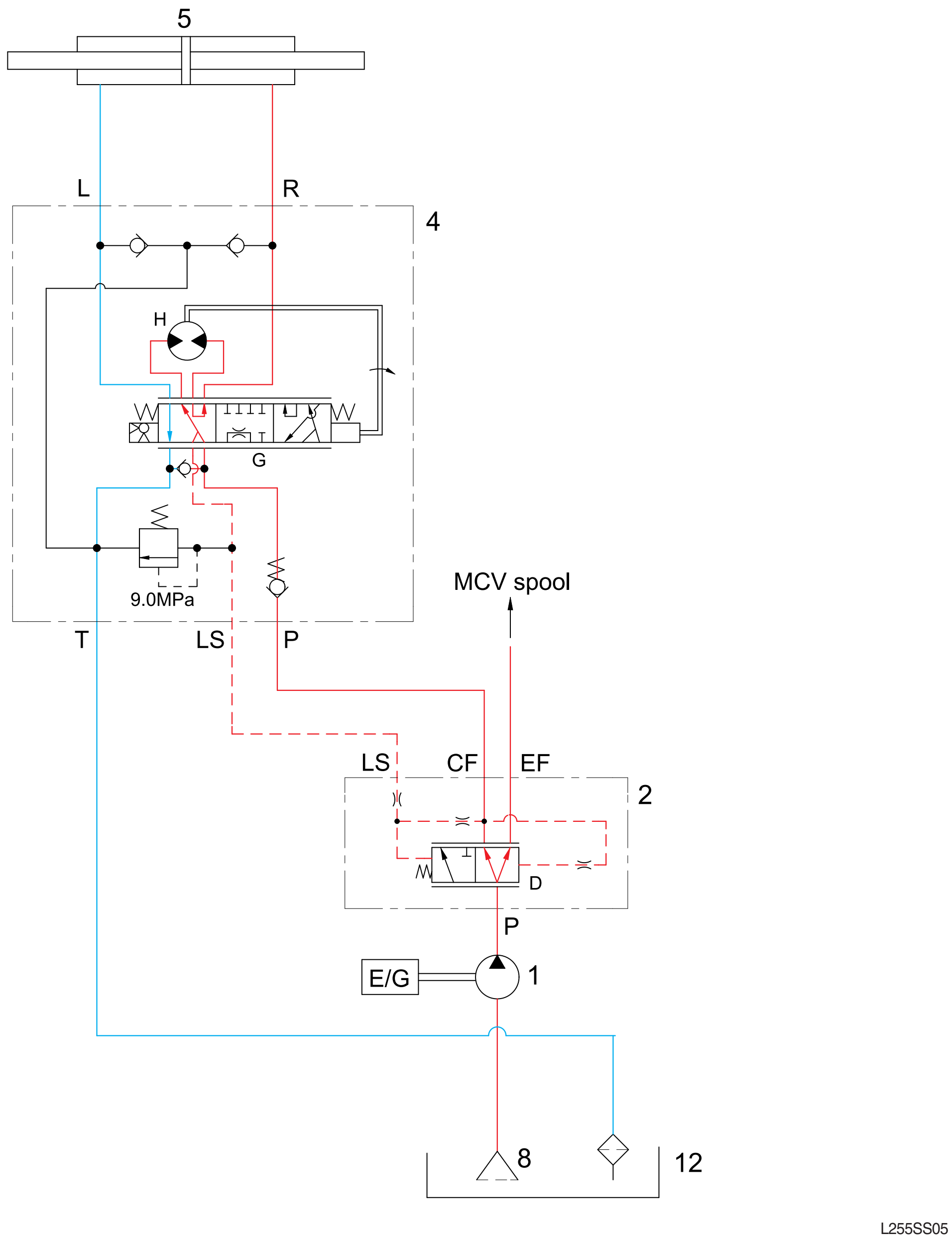
The steering wheel is not being operated so control spool(G) does not move.
The oil from hydraulic gear pump(1) enters port P of Priority valve(2) and the inlet pressure oil moves the spool(D) to the left.
Oil flow into LS port to the hydraulic tank(12).
So, the pump flow is routed to the main control valve.

2) LEFT TURN



When the steering wheel is turned to the left, the spool(G) within the steering unit(4) connected with steering column turns in left hand direction.
At this time, the oil discharged from the pump flows into the spool(G) within the steering unit(4) through the spool(D) of priority valve(2) and flows to the gerotor(H).
Oil flow from the gerotor(H) flows back into the spool(G) where it is directed out of the left work port(L).
Oil returned from cylinder returns to hydraulic tank(12).
When the above operation is completed, the machine turns to the left.

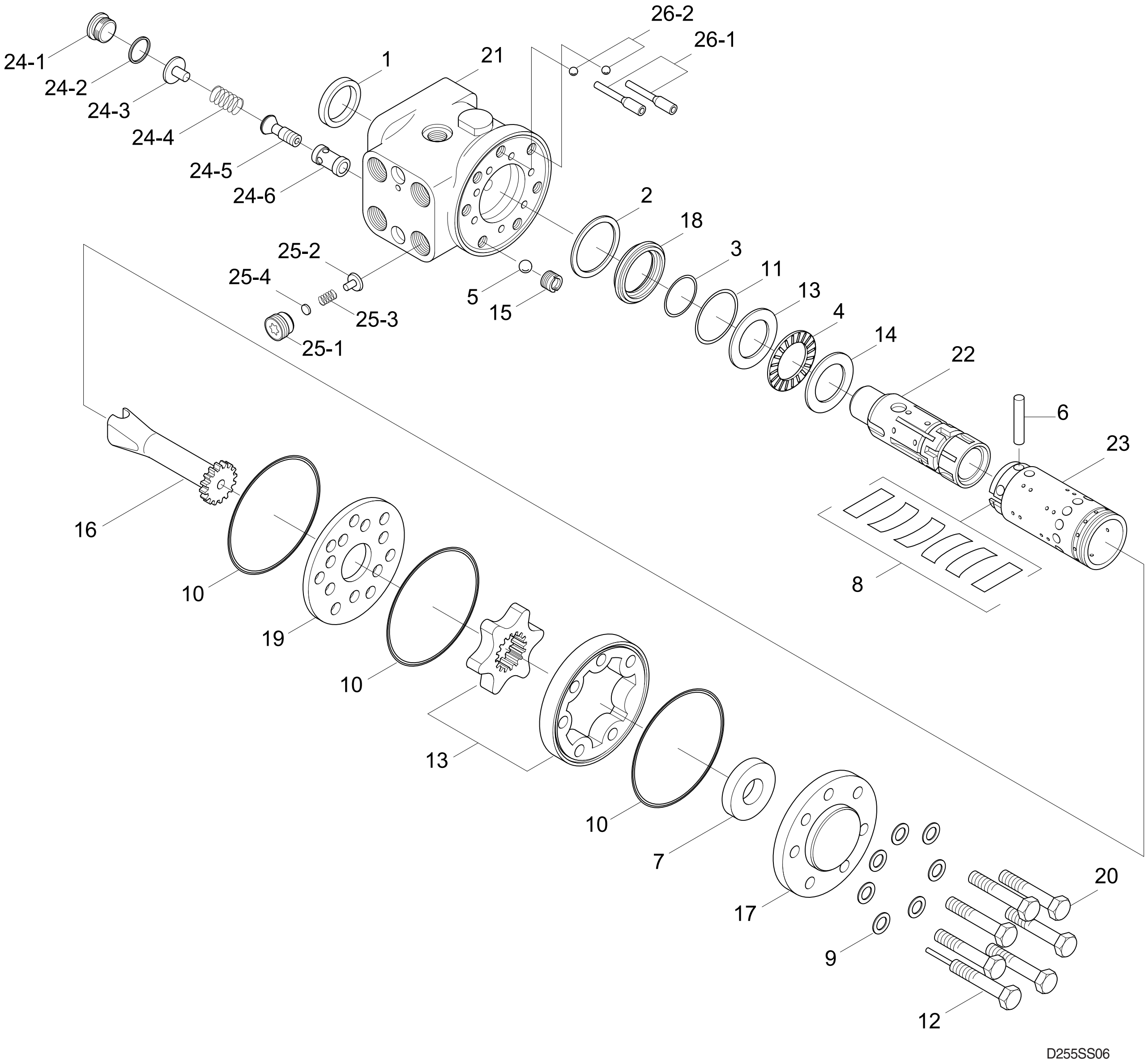
3) RIGHT TURN



When the steering wheel is turned to the right, the spool(G) within the steering unit(4) connected with steering column turns in right hand direction.
At this time, the oil discharged from the pump flows into the spool(G) where it is directed out of the right work port(R).
Oil returned from cylinder returns to hydraulic tank(12).
When the above operation is completed, the machine turns to the right.

3. STEERING UNIT

1) STRUCTURE



1	Dust seal	14	Bearing race	24-3	Spring seat
2	Retaining ring	15	Bore screw	24-4	Spring
3	Cap seal	16	Drive	24-5	Spool
4	Thrust bearing	17	End cap	24-6	Bushing
5	Ball	18	Gland bushing	25	Check valve
6	Pin	19	Plate	25-1	Guide
7	Spacer	20	Cap screw	25-2	Shim
8	Center spring	21	Housing	25-3	Spring
9	Washer	22	Spool	25-4	Washer
10	O-ring	23	Sleeve	26	Suction valve
11	Seal	24	Relief valve	26-1	Roll pin
12	Roller screw	24-1	Plug	26-2	Ball
13	Gerotor set	24-2	O-ring		

2) OPERATION

The steering unit is composed of the control valve(rotary valve) and the metering device. The control valve controls the flow of oil from the pump in the interior of the unit depending on the condition of the steering wheel. The metering device is a kind of hydraulic motor composed of a stator and a rotor. It meters the required oil volume, feeds the metered oil to the power cylinder and detects cylinder's motion value, that is, cylinder's motion rate.

When the steering wheel is turned, the spool turns, the oil path is switched and the oil is fed into the metering device. As a result, the rotor is caused to run by oil pressure, and the sleeve is caused to run through the drive shaft and cross pin. Therefore, when the spool is turned, the spool turns by the same value in such a manner that it follows the motion of the spool. Steering motion can be accomplished when this operation is performed in a continuous state.

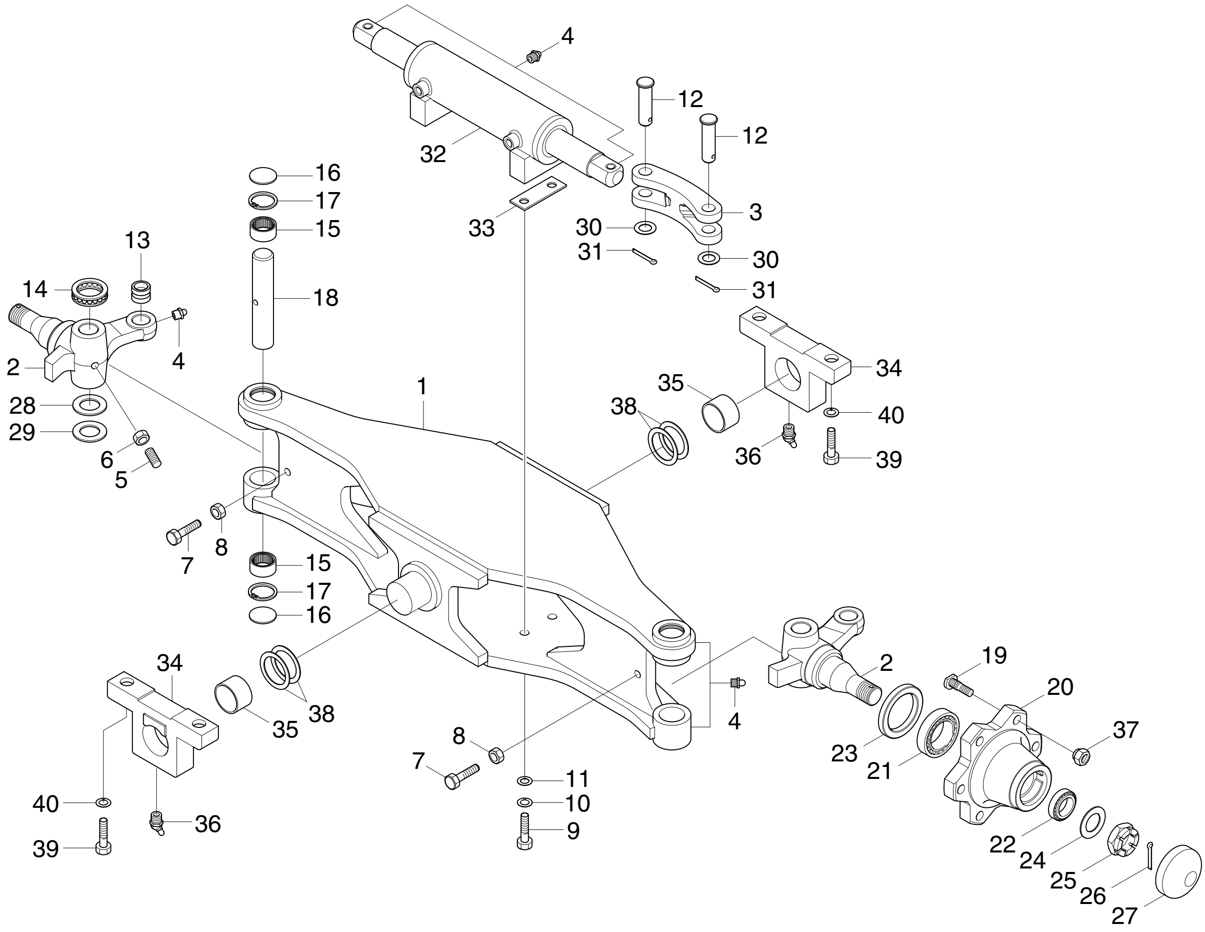
⚠ **If the hoses of the steering system are incorrectly connected, the steering wheel can turn very rapidly when the engine is started. Keep clear of the steering wheel when starting the engine.**

The centering spring for the spool and sleeve is provided to cause the valve to return to the neutral position. It is therefore possible to obtain a constant steering feeling, which is transmitted to the hands of the driver. Return to the center position occurs when the steering wheel is released.

4. STEERING AXLE

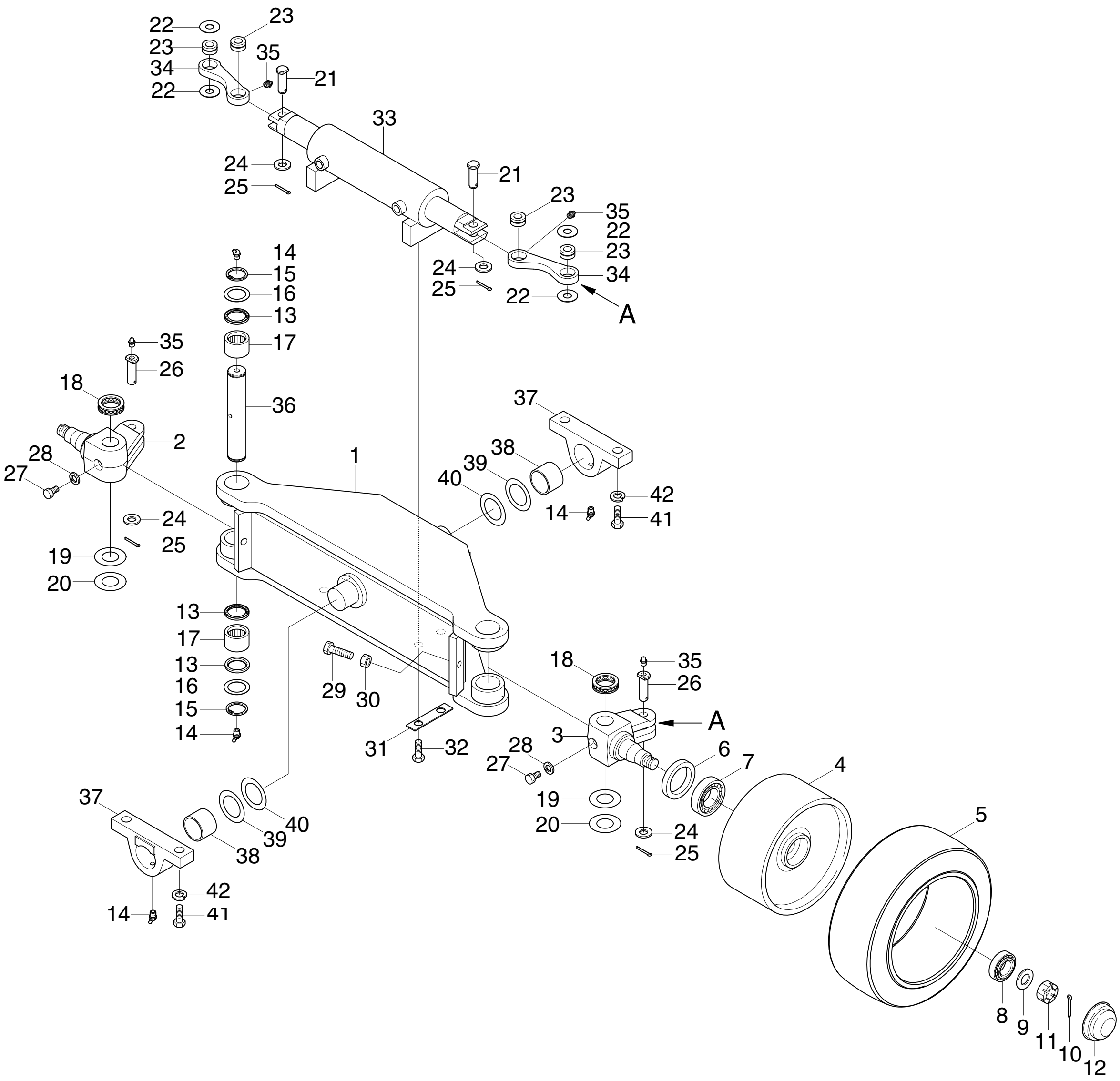
1) STRUCTURE

(1) HLF20/25/30-5



1	Steering axle	15	Needle bearing	28	Shim
2	Knuckle	16	Plate plug	29	Shim
3	Intermediate link	17	Retaining ring	30	Special washer
4	Grease nipple	18	King pin	31	Split pin
5	Set screw	19	Hub bolt	32	Steer cylinder
6	Nut	20	Hub	33	Shim
7	Bolt	21	Taper roller bearing	34	Block
8	Nut	22	Taper roller bearing	35	Bushing
9	Bolt	23	Oil seal	36	Grease nipple
10	Spring washer	24	Washer	37	Hub nut
11	Plain washer	25	Slotted nut	38	Shim
12	Link pin	26	Split pin	39	Bolt
13	Inner race bush	27	Hub cap	40	Hardened washer
14	Thrust bearing				

(2) HLF20/25/30C-5

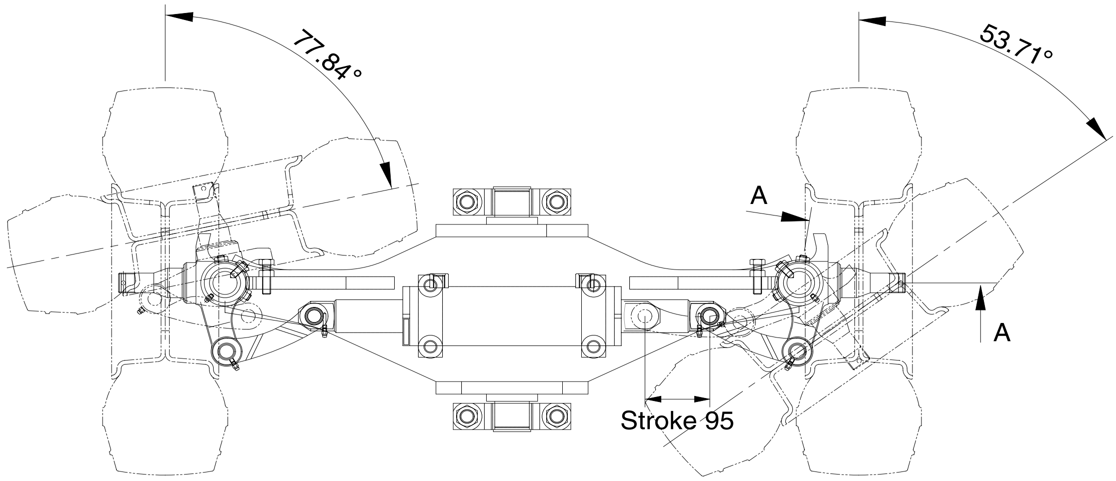


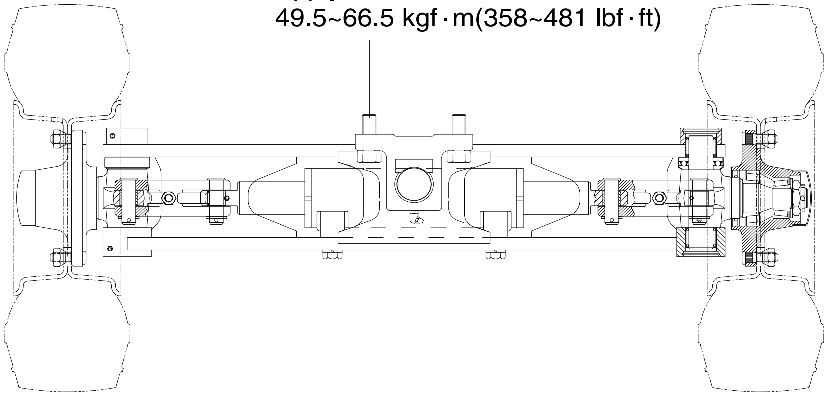
L225SS07

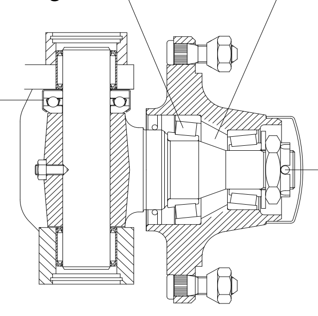
1	Steering axle wa	15	Retaining ring	29	Hexagon bolt
2	Knuckle-RH	16	King pin washer	30	Hexagon nut
3	Knuckle-LH	17	Needle bearing	31	Lock plate
4	Wheel hub	18	Thrust bearing	32	Hexagon bolt
5	Rear wheel	19	Shim(0.13T)	33	Steering cylinder
6	Oil seal	20	Shim(0.25T)	34	Link
7	Taper roller bearing	21	Clevis pin	35	Grease nipple
8	Taper roller bearing	22	Thrust washer	36	King pin
9	Plain washer	23	Bearing	37	Block
10	Split pin	24	Plain washer	38	Bushing
11	Castle nut	25	Split pin	39	Shim(1.0T)
12	Hub cap	26	Clevis pin	40	Shim(0.5T)
13	Oil seal	27	Special bolt	41	Hexagon bolt
14	Grease nipple	28	Spring washer	42	Spring waher

2) TIGHTENING TORQUE AND SPECIFICATION

(1) HLF20/25/30-5





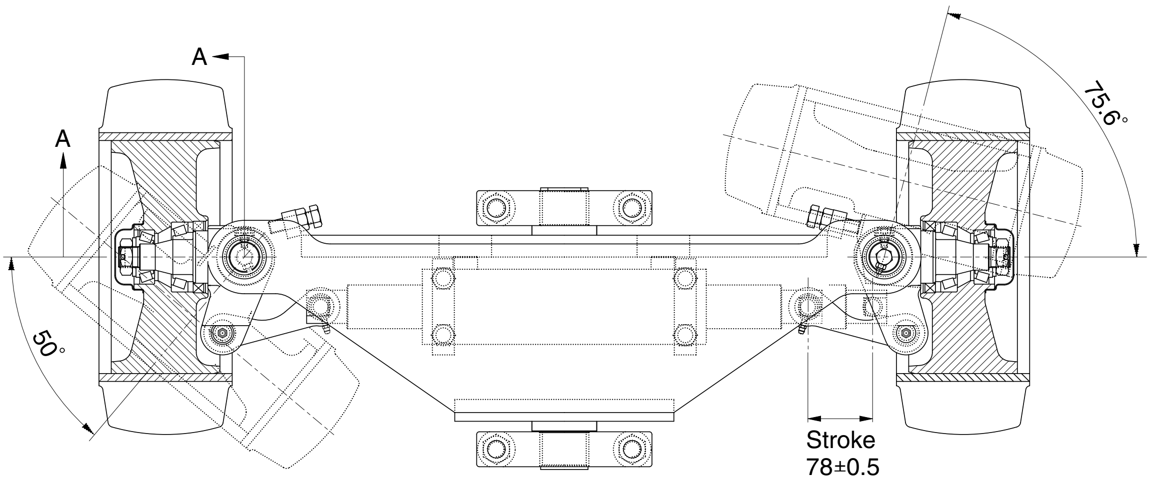


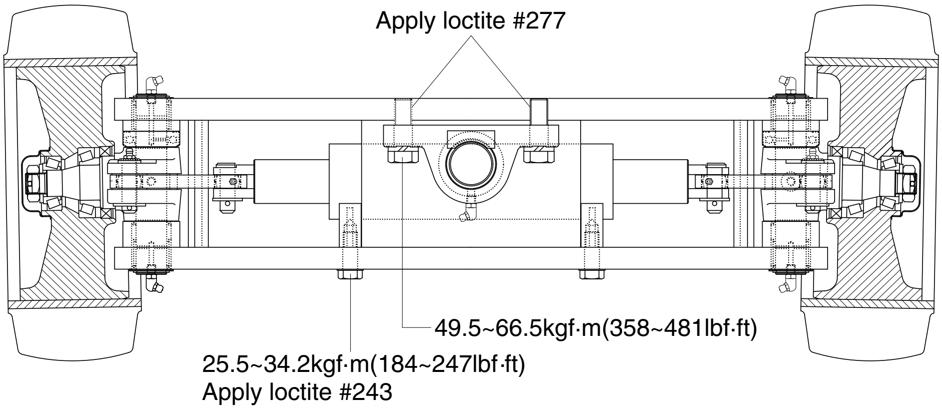
SECTION A-A

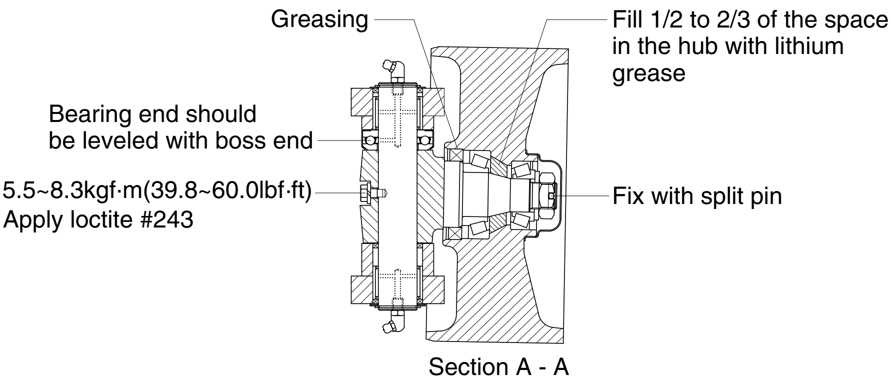
D255SS09

Type	Unit	Center pin support single shaft
Structure of knuckle	-	Elliott type
Toe-in	degree	0
Camber	degree	1
Caster	degree	0
King pin angle	degree	0
Max steering angle of wheels (Inside/Outside)	degree	77.84 / 53.71
Tread	mm(in)	1003(39.5)

(2) HLF20/25/30C-5





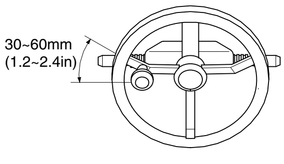


L255SS09

Type	Unit	Center pin support single shaft
Structure of knuckle	-	Elliott type
Toe-in	degree	0
Camber	degree	1
Caster	degree	0
King pin angle	degree	0
Max steering angle of wheels (Inside/Outside)	degree	75.6/50
Tread	mm(in)	910(35.8)

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

<table>
<tr><th>Check item</th><th>Checking procedure</th></tr>
<tr><td>Steering wheel
</td><td>· Set rear wheels facing straight forward, then turn steering wheel to left and right. Measure range of steering wheel movement before rear wheel starts to move. Range should be 30~60mm at rim of steering wheel. If play is too large, adjust at gear box.
Test steering wheel play with engine at idling.</td></tr>
<tr><td>Knuckle</td><td>· Check knuckle visually or use crack detection method. If the knuckle is bent, the tire wear is uneven, so check tire wear.</td></tr>
<tr><td>Steering axle</td><td>· Put camber gauge in contact with hub and measure camber.
If camber is not within 1±0.5° ; rear axle is bent.
· Ask assistant to drive machine at minimum turning radius.
· Fit bar and a piece of chalk at outside edge of counterweight to mark line of turning radius.
· If minimum turning radius is not within±100mm (±4in)of specified value, adjust turning angle stopper bolt.
Min turning radius(Outside)<table><tr><td>HLF20-5</td><td>2275mm(90in)</td><td>HLF20C-5</td><td>2095mm(82in)</td></tr><tr><td>HLF25-5</td><td>2325mm(92in)</td><td>HLF25C-5</td><td>2145mm(84in)</td></tr><tr><td>HLF30-5</td><td>2380mm(94in)</td><td>HLF30C-5</td><td>2195mm(86in)</td></tr></table></td></tr>
<tr><td>Hydraulic pressure of power steering</td><td>Remove plug from outlet port of flow divider and install oil pressure gauge.
Turn steering wheel fully and check oil pressure.
※ Oil pressure : 91.8kgf/cm^2 (90bar)</td></tr>
</table>

2. TROUBLESHOOTING

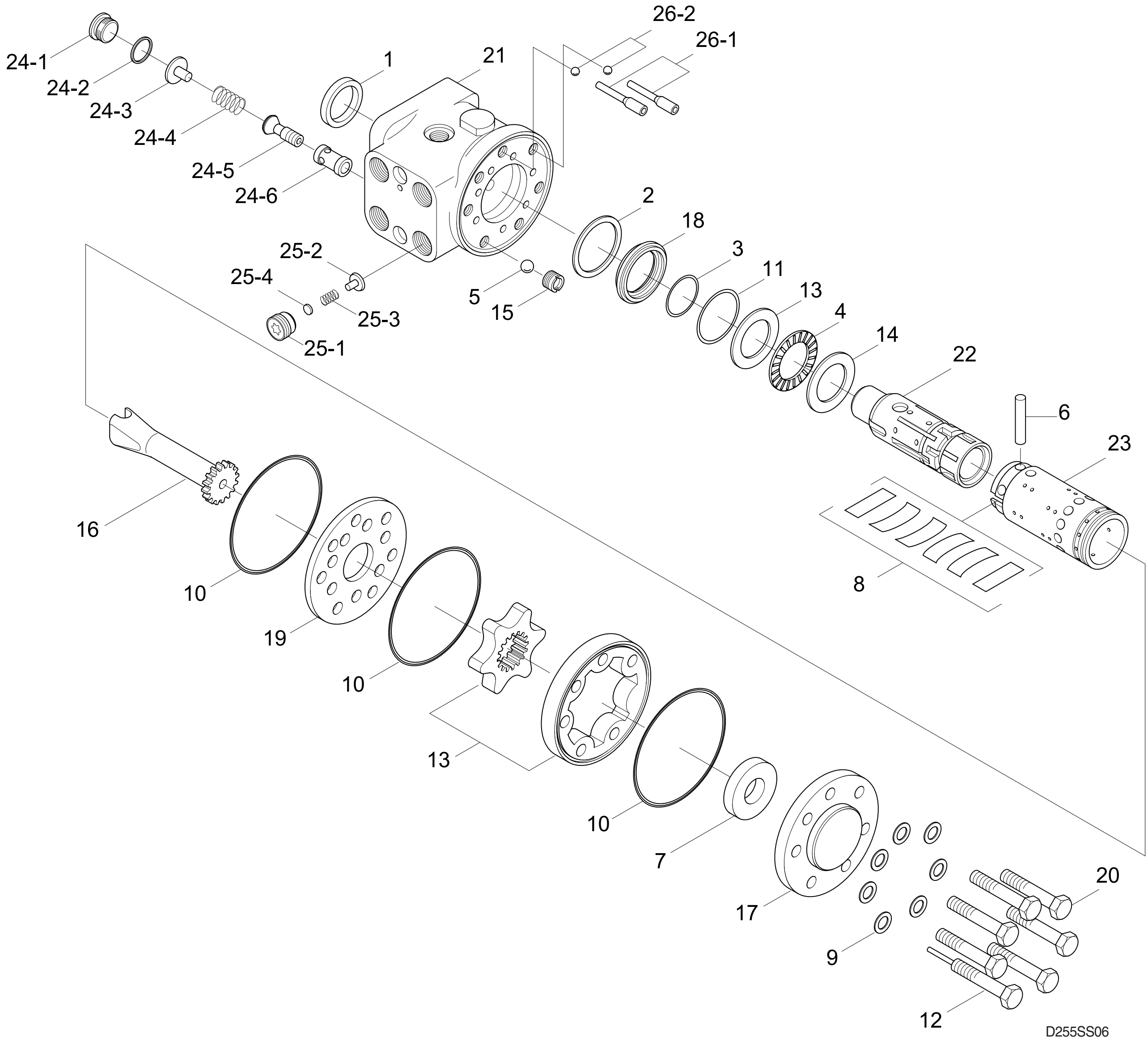
Problem	Cause	Remedy
Steering wheel drags.	· Low oil pressure. · Bearing faulty. · Spring spool faulty. · Reaction plunger faulty. · Ball-and-screw assembly faulty. · Sector shaft adjusting screw excessively tight. · Gears poorly meshing. · Flow divider coil spring fatigued.	· Check lockout. Repair. · Clean or replace. · Clean or replace. · Replace. · Clean or replace. · Adjust. · Check and correct meshing. · Replace.
Steering wheel fails to return smoothly.	· Bearing faulty. · Reaction plunger faulty. · Ball-and-screw assy faulty · Gears poorly meshing.	· Clean or replace. · Replace. · Clean or replace. · Check and correct meshing.

Problem	Cause	Remedy
Steering wheel turns unsteadily. Steering system makes abnormal sound or vibration.	· Lockout loosening. · Metal spring deteriorated. · Gear backlash out of adjustment. · Lockout loosening. · Air in oil circuit.	· Retighten. · Replace. · Adjust. · Retighten. · Bleed air.
Abnormal sound heard when steering wheel is turned fully	Valve · Faulty. (Valve fails to open.) Piping · Pipe(from pump to power steering cylinder) dented or clogged.	· Adjust valve set pressure and check for specified oil pressure. · Repair or replace.
Piping makes abnormal sounds.	Oil pump · Lack of oil. · Oil inlet pipe sucks air. · Insufficient air bleeding.	· Add oil. · Repair. · Bleed air completely.
Valve or valve unit makes abnormal sounds.	Oil pump · Oil inlet pipe sucks air. Valve · Faulty. (Unbalance oil pressure) Piping · Pipe(from pump to power steering) dented or clogged. · Insufficient air bleeding.	· Repair or replace. · Adjust valve set pressure and check specified oil pressure. · Repair or replace. · Bleed air completely.
Insufficient or variable oil flow.	· Flow control valve orifice clogged.	· Clean
Insufficient or variable discharge pressure.	Piping · Pipe(from tank to pipe) dented or clogged.	· Repair or replace.
Steering cylinder head leakage (Piston rod)	· Packing foreign materal. · Piston rod damage. · Rod seal damage and distortion. · Chrome gilding damage.	· Replace · Grind surface with oil stone. · Replace · Grind
Steering cylinder head thread (A little bit leak is no problem)	· O-ring damage.	· Replace
Welding leakage	· Cylinder tube damage.	· Tube replace.
Rod	· Tube inside damage. · Piston seal damage and distortion	· Grind surface with oil store. · Replace
Piston rod bushing inner diameter excessive gap	· Bushing wear.	· Replace

GROUP 3 DISASSEMBLY AND ASSEMBLY

1. STEERING UNIT

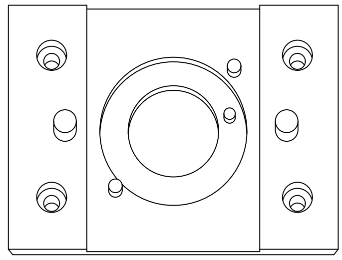
1) STRUCTURE



1	Dust seal	14	Bearing race	24-3	Spring seat
2	Retaining ring	15	Bore screw	24-4	Spring
3	Cap seal	16	Drive	24-5	Spool
4	Thrust bearing	17	End cap	24-6	Bushing
5	Ball	18	Gland bushing	25	Check valve
6	Pin	19	Plate	25-1	Guide
7	Spacer	20	Cap screw	25-2	Shim
8	Center spring	21	Housing	25-3	Spring
9	Washer	22	Spool	25-4	Washer
10	O-ring	23	Sleeve	26	Suction valve
11	Seal	24	Relief valve	26-1	Roll pin
12	Roller screw	24-1	Plug	26-2	Ball
13	Gerotor set	24-2	O-ring		

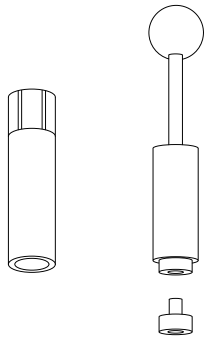
2) TOOLS

(1) Holding tool.



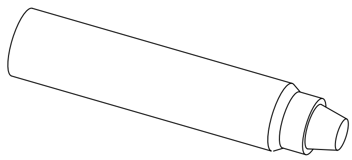
5-69(1)

(2) Assembly tool for O-ring and kin-ring.



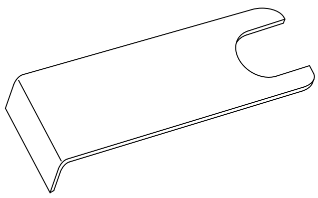
5-69(2)

(3) Assembly tool for lip seal.



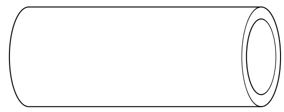
5-69(3)

(4) Assembly tool for cardan shaft.

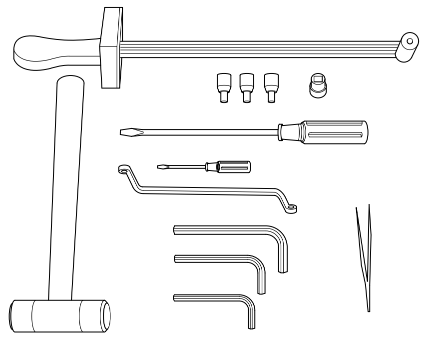


5-69(4)

(5) Assembly tool for dust seal.

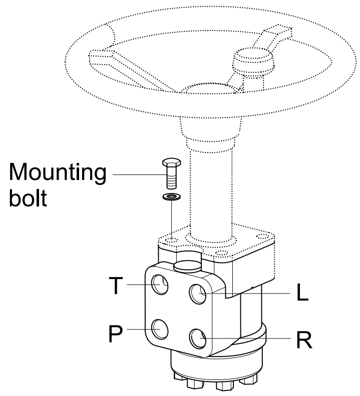

5-70(1)

(6) Torque wrench 0~7.1kgf · m
(0~54.4lbf · ft)
13mm socket spanner
6,8mm and 12mm hexagon sockets
12mm screwdriver
2mm screwdriver
13mm ring spanner
6, 8 and 12mm hexagon socket spanners
Plastic hammer
Tweezers


5-70(2)

3) TIGHTENING TORQUE

L : Left port
R: Right port
T : Tank
P: Pump
L : Load sensing

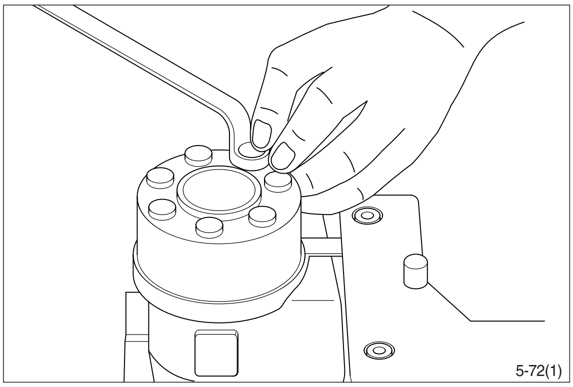


D353SE23

Port	Size	Torque [kgf · m(lbf · ft)]
L	3/4 UNF - 16	5.75 (42)
R	3/4 UNF - 16	5.75 (42)
T	3/4 UNF - 16	5.75 (42)
P	3/4 UNF - 16	5.75 (42)
LS	9/16 UNF - 18	3.45 (25)
Mounting bolt	M10 × 1.5	4.0 ± 1.0(36 ± 7.2)

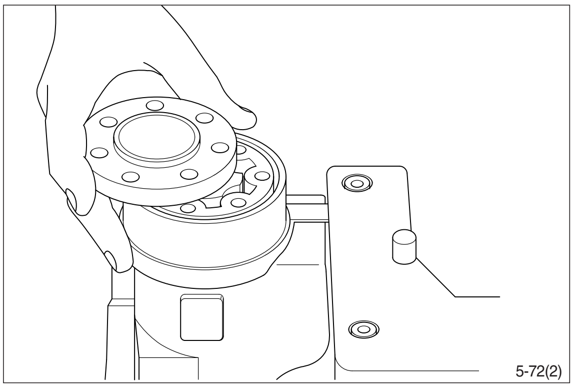
4) DISASSEMBLY

(1) Disassemble steering column from steering unit and place the steering unit in the holding tool.
Screw out the screws in the end cover(6-off plus one special screw).



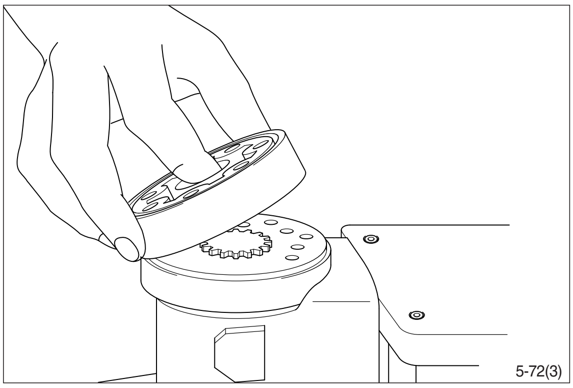
5-72(1)

(2) Remove the end cover, sideways.



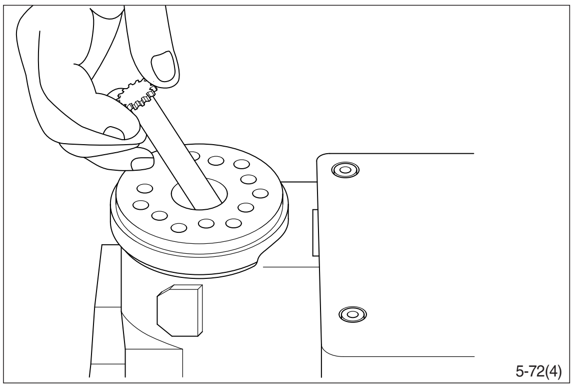
5-72(2)

(3) Lift the gearwheel set(With spacer if fitted) off the unit.
Take out the two O-rings.



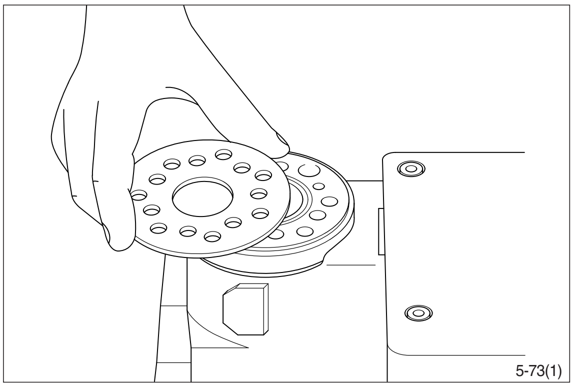
5-72(3)

(4) Remove cardan shaft.



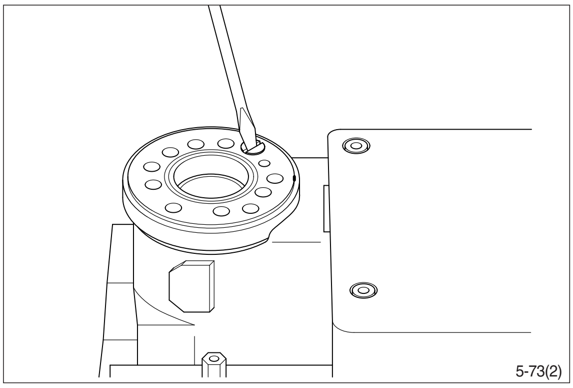
5-72(4)

(5) Remove distributor plate.



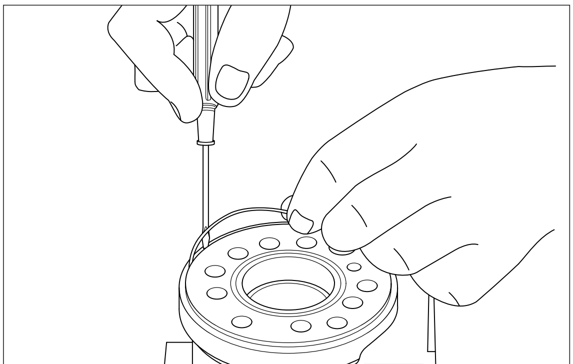
5-73(1)

(6) Screw out the threaded bush over the check valve.



5-73(2)

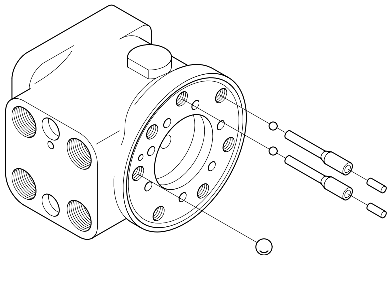
(7) Remove O-ring.



5-73(3)

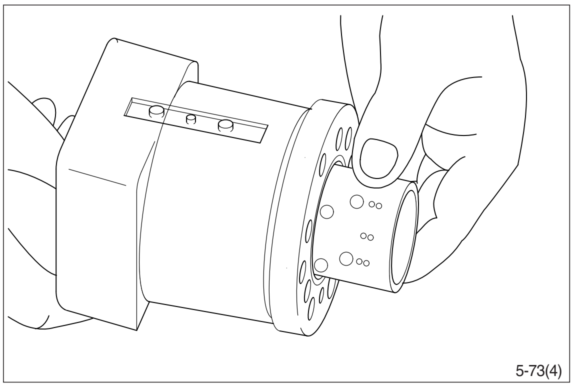
(8) Shake out the check valve ball and suction valve pins and balls.

※ **On some pins in which there are two springs.**



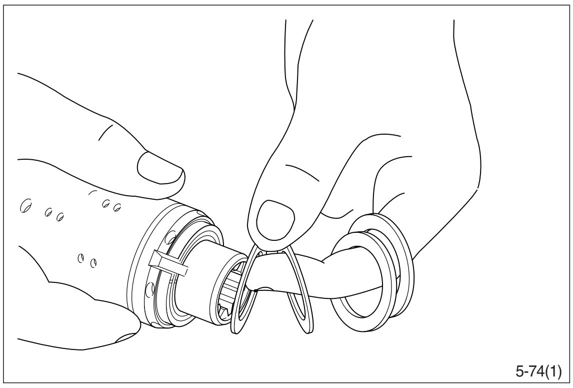
D353SE09

(9) Take care to keep the cross pin in the sleeve and spool horizontal. The pin can be seen through the open end of the spool. Press the spool inwards and the sleeve, ring, bearing races and thrust bearing will be pushed out of the housing together.



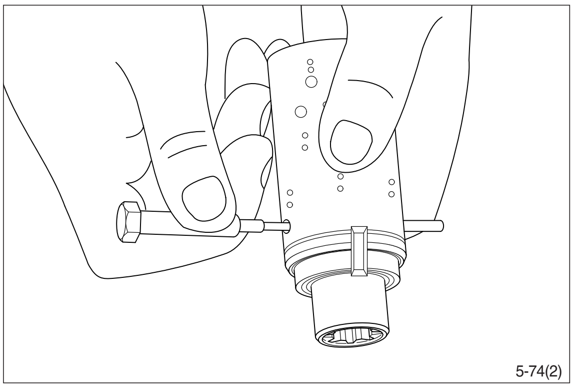
5-73(4)

(10) Take ring, bearing races and thrust bearing from sleeve and spool. The outer (Thin) bearing race can sometimes "stick" in the housing, therefore check that it has come out.



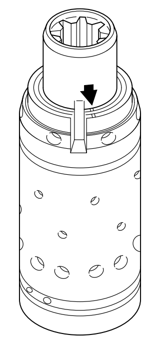
5-74(1)

(11) Press out the cross pin. Use the special screw from the end cover.



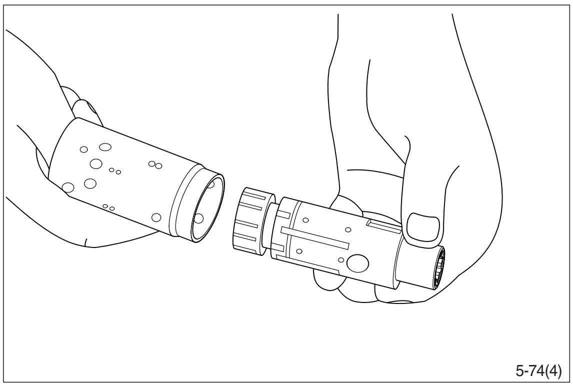
5-74(2)

※ A small mark has been made with a pumice stone on both spool and sleeve close to one of the slots for the neutral position springs(See drawing). If the mark is not visible, remember to leave a mark of your own on sleeve and spool before the neutral position springs are disassembled.



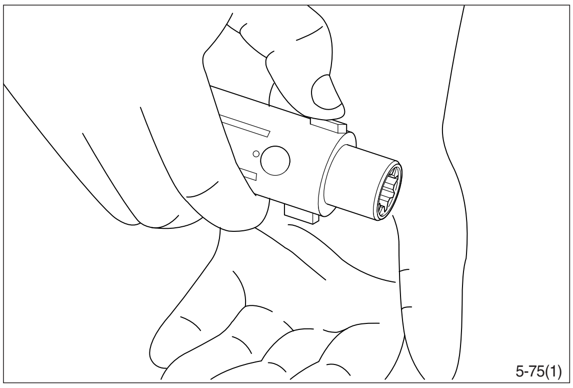
5-74(3)

(12) Carefully press the spool out of the sleeve.



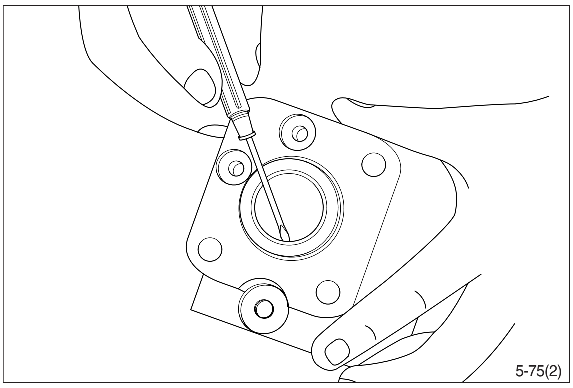
5-74(4)

(13) Press the neutral position springs out of their slots in the spool.



5-75(1)

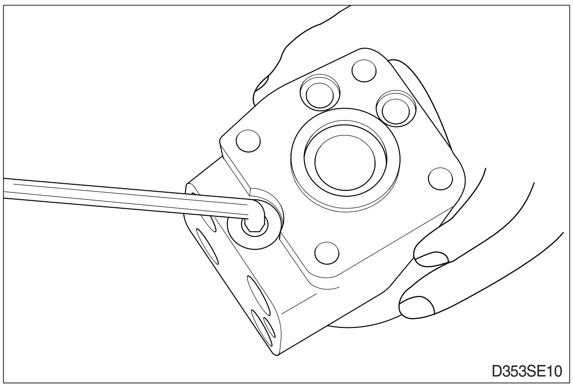
(14) Remove dust seal and O-ring.



5-75(2)

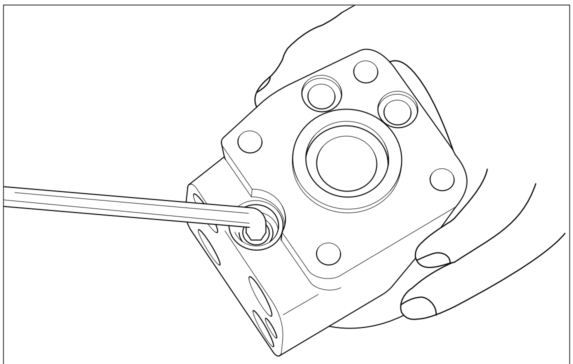
Disassembling the pressure relief valve

(15) Screw out the plug using an 8mm hexagon socket spanner.
Remove seal washers.



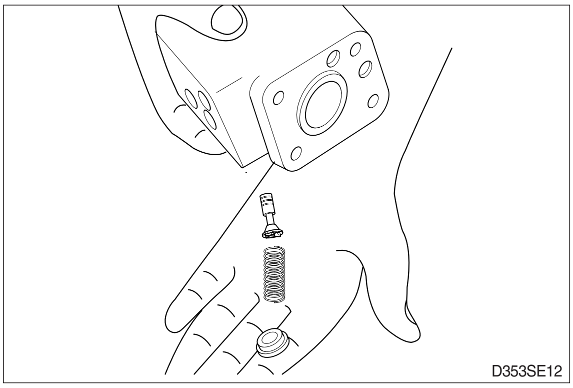
D353SE10

(16) Unscrew the setting screw using an 8mm hexagon socket spanner.



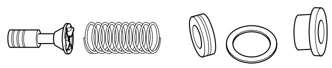
D353SE11

(17) Shake out spring and piston. The valve seat is bonded into the housing and cannot be removed.



D353SE12

(18) The pressure relief valve is now disassem-bled.

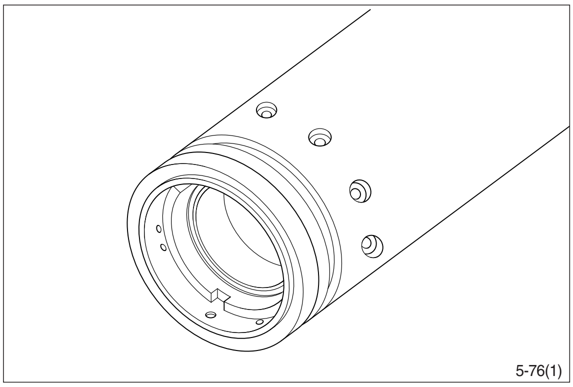


D353SE13

5) ASSEMBLY

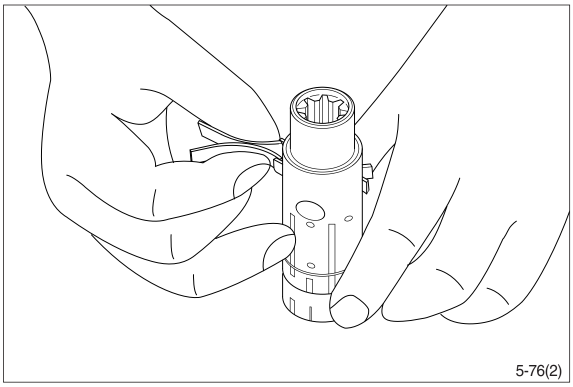
(1) Assemble spool and sleeve.

※ When assembling spool and sleeve only one of two possible ways of positioning the spring slots is correct. There are three slots in the spool and three holes in the sleeve in the end of the spool / sleeve opposite to the end with spring slots. Place the slots and holes opposite each other so that parts of the holes in the sleeve are visible through the slots in the spool.



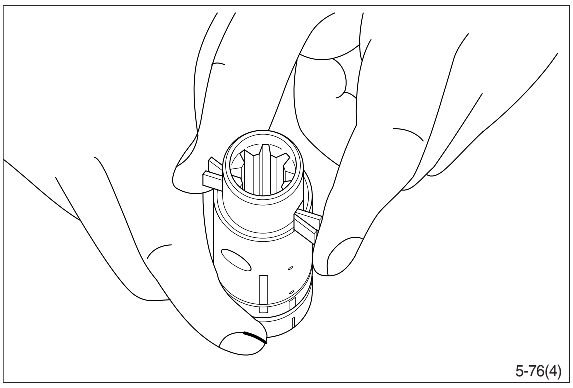
5-76(1)

(2) Place the two flat neutral position springs in the slot.
Place the curved springs between the flat ones and press them into place (see assembly pattern).



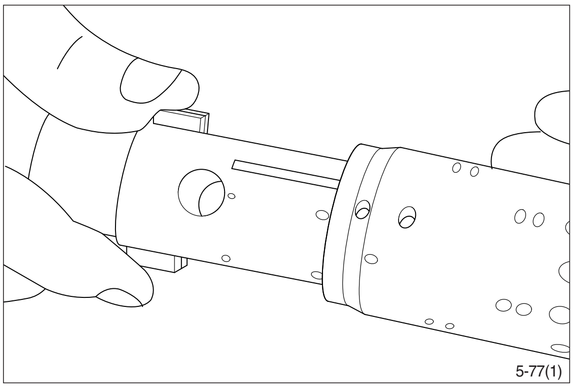
5-76(2)

(3) Line up the spring set.



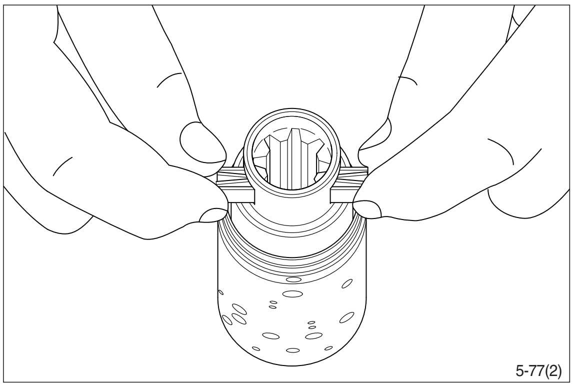
5-76(4)

(4) Guide the spool into the sleeve. Make sure that spool and sleeve are placed correctly in relation to each other.



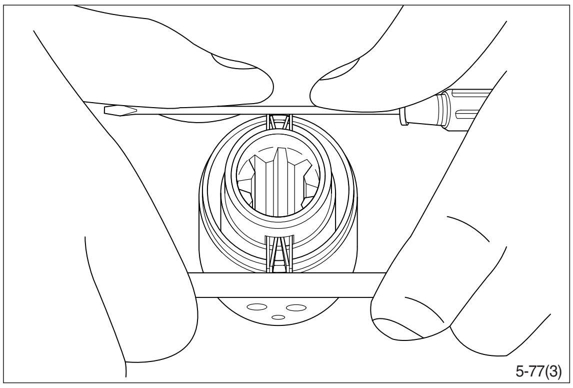
5-77(1)

(5) Press the springs together and push the neutral position springs into place in the sleeve.



5-77(2)

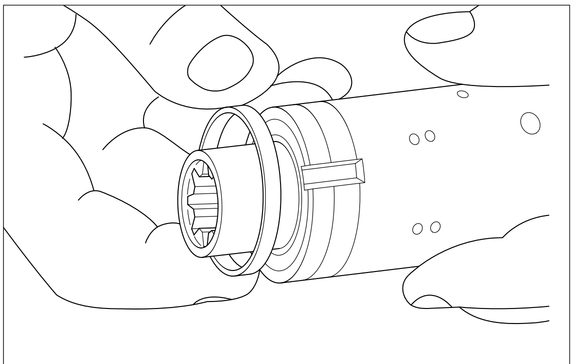
(6) Line up the springs and center them.



5-77(3)

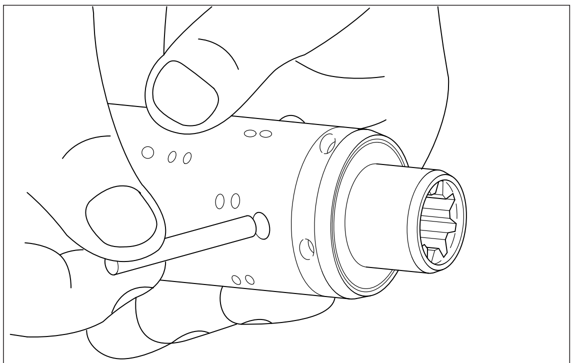
(7) Guide the ring down over the sleeve.

※ **The ring should be able to rotate free of the springs.**



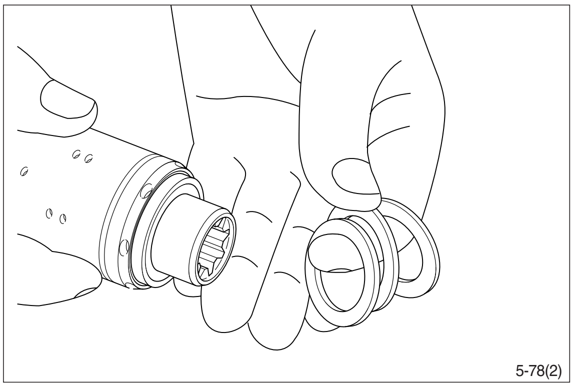
5-77(4)

(8) Fit the cross pin into the spool/ sleeve.



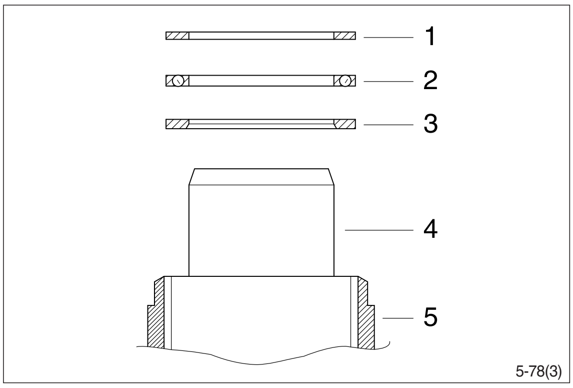
5-78(1)

(9) Fit bearing races and needle bearing as shown on below drawing.



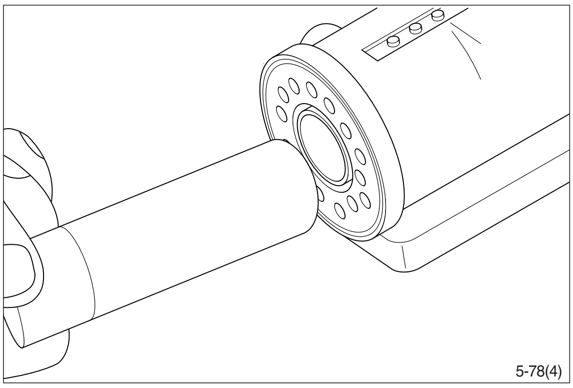
※ Assembly pattern for standard bearings

1 Outer bearing race
2 Thrust bearing
3 Inner bearing race
4 Spool
5 Sleeve

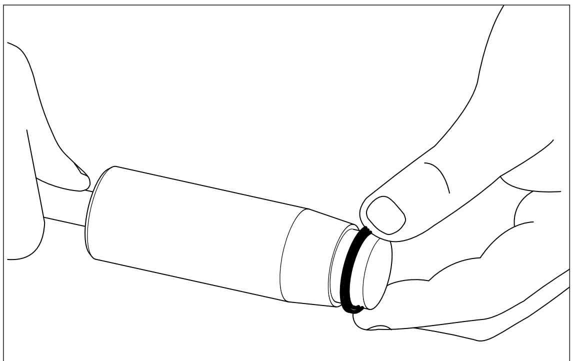


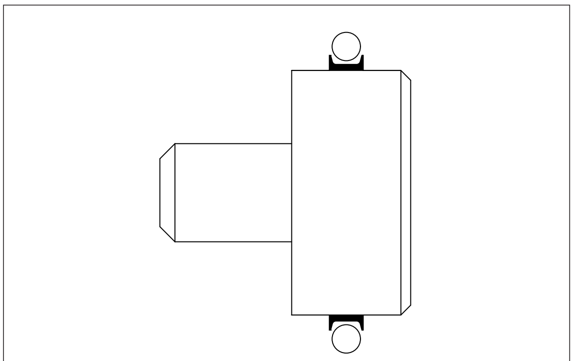
Installation instruction for O-ring

(10) Turn the steering unit until the bore is horizontal. Guide the outer part of the assembly tool into the bore for the spool / sleeve.

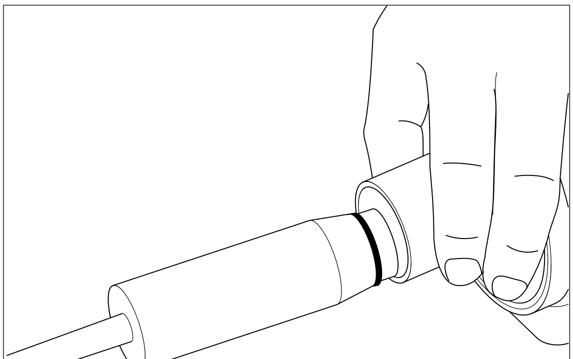


(11) Grease O-ring with hydraulic oil and place them on the tool.

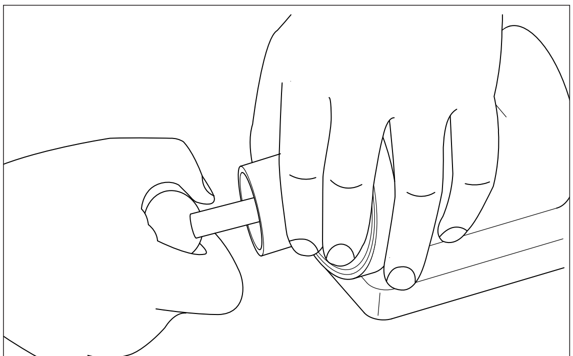

5-79(1)


5-79(2)

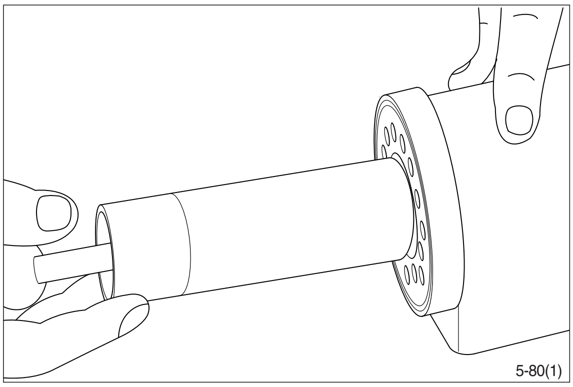
(12) Hold the outer part of the assembly tool in the bottom of the steering unit housing and guide the inner part of the tool right to the bottom.


5-79(3)

(13) Press and turn the O-ring into position in the housing.


5-79(4)

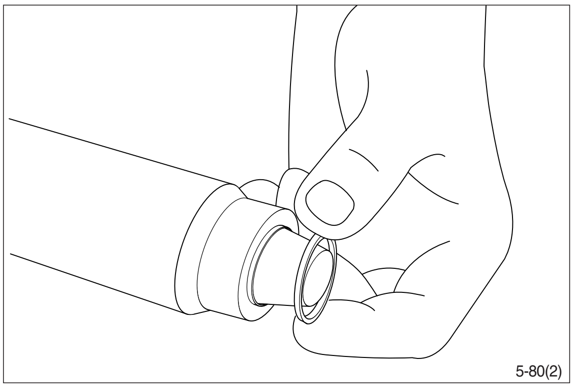
(14) Draw the inner and outer parts of the assembly tool out of the steering unit bore, leaving the guide from the inner part in the bore.



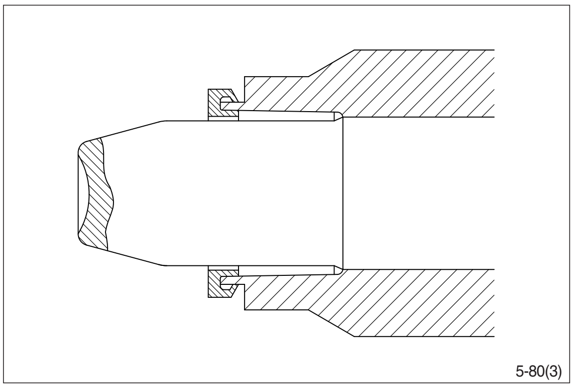
5-80(1)

Installation instructions for lip seal

(15) Lubricate the lip seal with hydraulic oil and place it on the assembly tool.

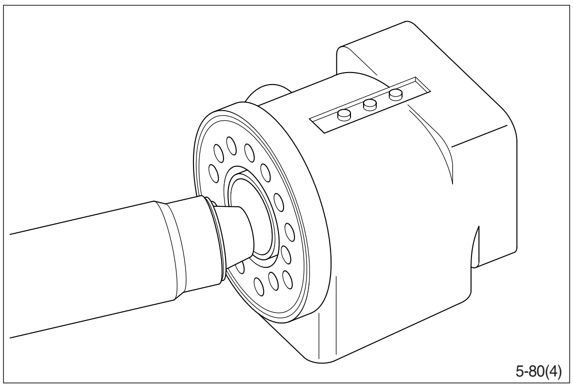


5-80(2)



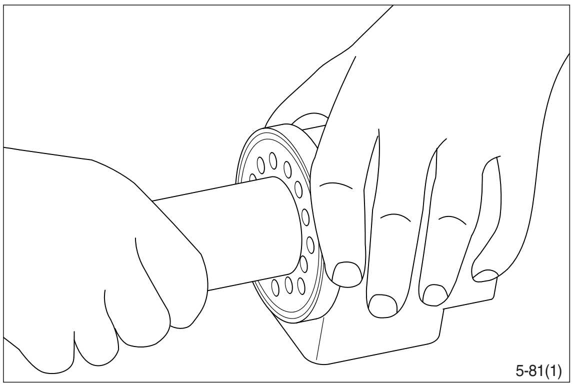
5-80(3)

(16) Guide the assembly tool right to the bottom.



5-80(4)

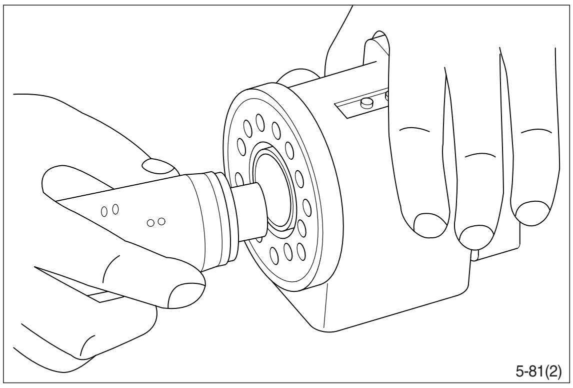
(17) Press and turn the lip seal into place in the housing.



5-81(1)

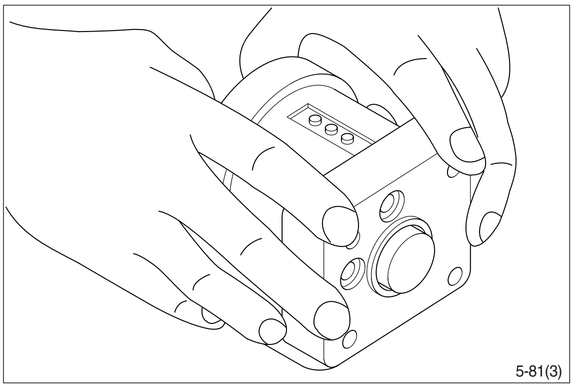
(18) With a light turning movement, guide the spool and sleeve into the bore.

※ **Fit the spool set holding the cross pin horizontal.**



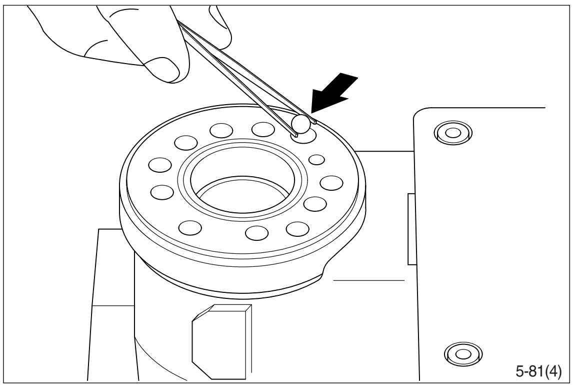
5-81(2)

(19) The spool set will push out the assembly tool guide. The O-ring are now in position.



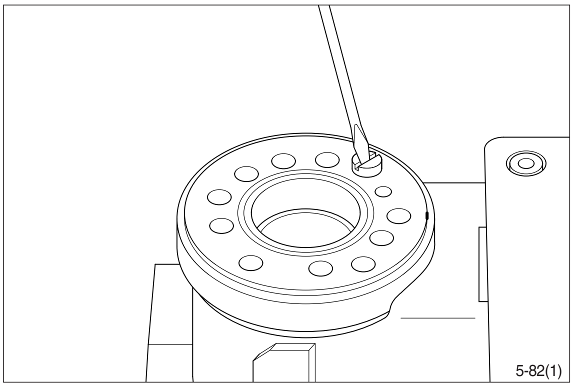
5-81(3)

(20) Turn the steering unit until the bore is vertical again. Put the check valve ball into the hole indicated by the arrow.



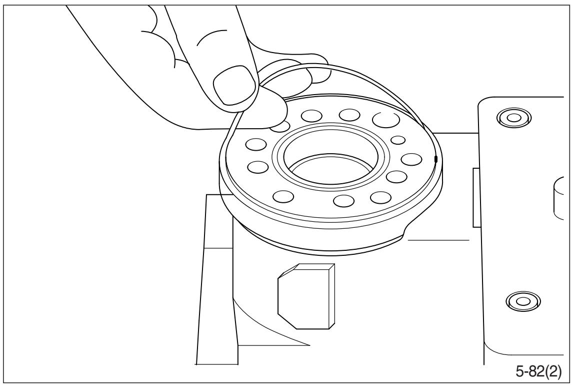
5-81(4)

(21) Screw the threaded bush lightly into the check valve bore. The top of the bush must lie just below the surface of the housing.



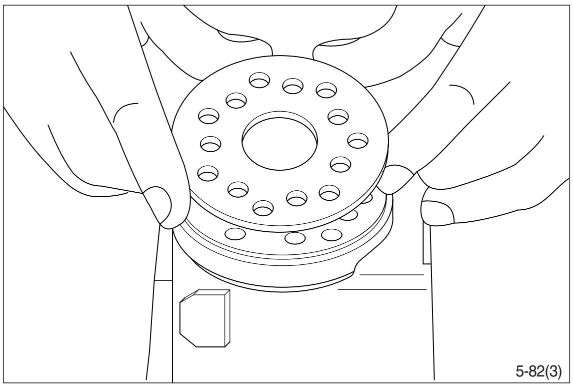
5-82(1)

(22) Grease the O-ring with mineral oil approx. viscosity 500 cSt at 20˚C.



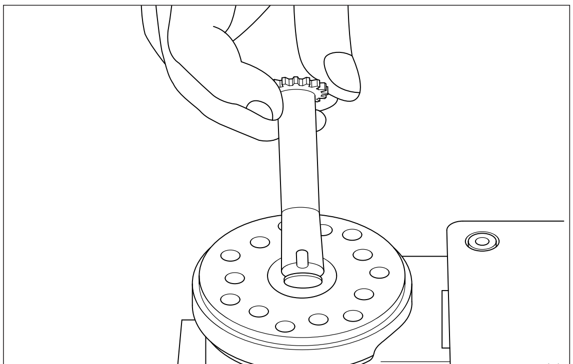
5-82(2)

(23) Place the distributor plate so that the channel holes match the holes in the housing.



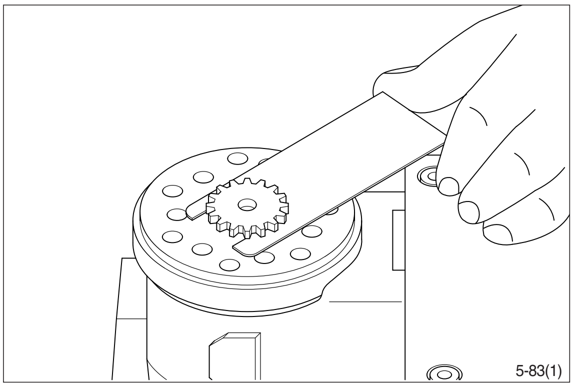
5-82(3)

(24) Guide the cardan shaft down into the bore so that the slot is parallel with the connection flange.



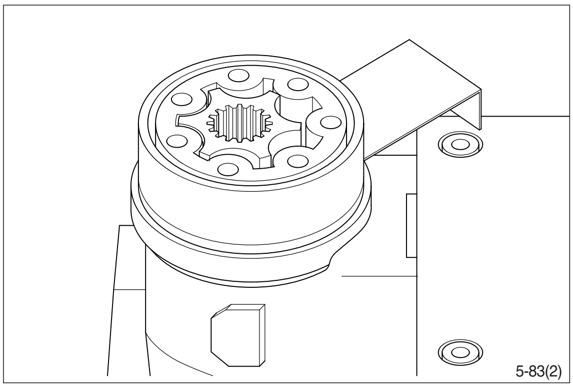
5-82(4)

(25) Place the cardan shaft as shown - so that it is held in position by the mounting fork.



5-83(1)

(26) Grease the two O-rings with mineral oil approx. viscosity 500 cSt at 20° C and place them in the two grooves in the gear rim. Fit the gearwheel and rim on the cardan shaft.

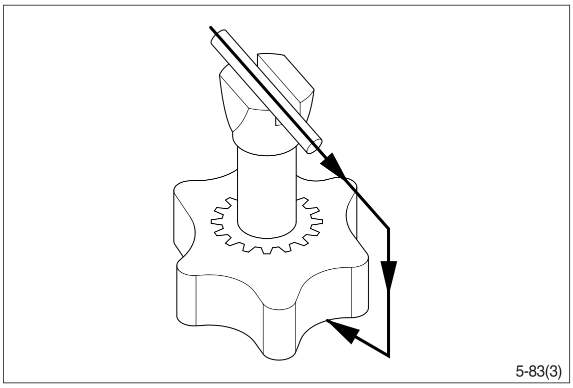


5-83(2)

(27) Important

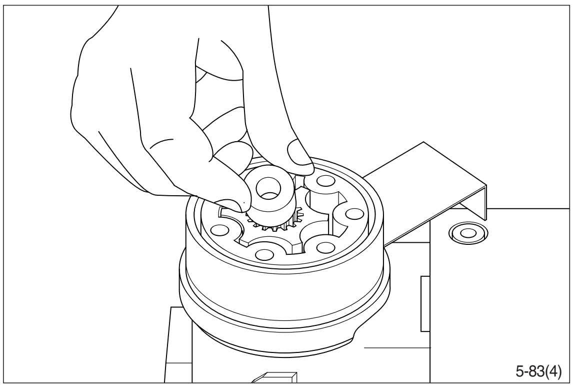
Fit the gearwheel(Rotor) and cardan shaft so that a tooth base in the rotor is positioned in relation to the shaft slot as shown.

Turn the gear rim so that the seven through holes match the holes in the housing.



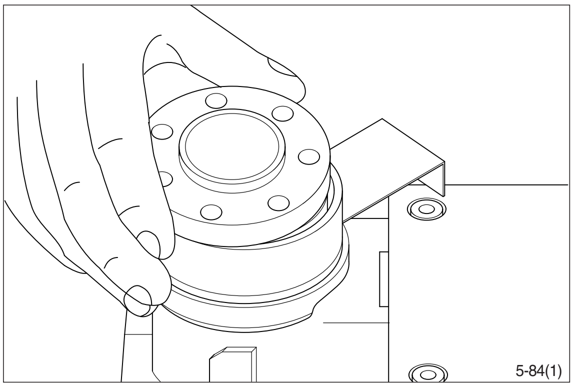
5-83(3)

(28) Fit the spacer, if any.

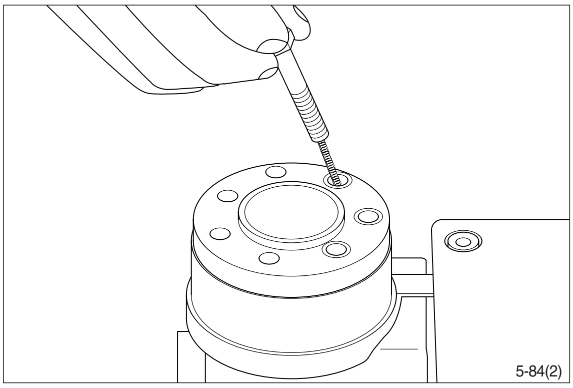


5-83(4)

(29) Place the end cover in position.

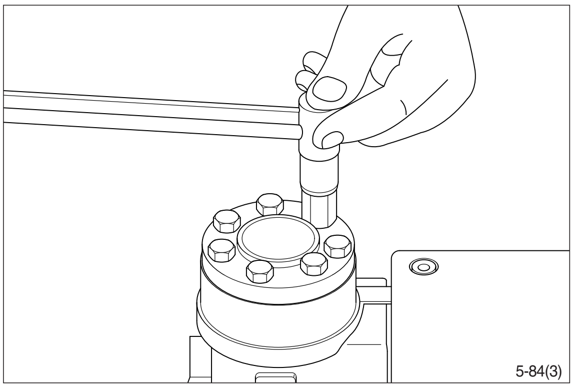


(30) Fit the special screw with washer and place it in the hole shown.

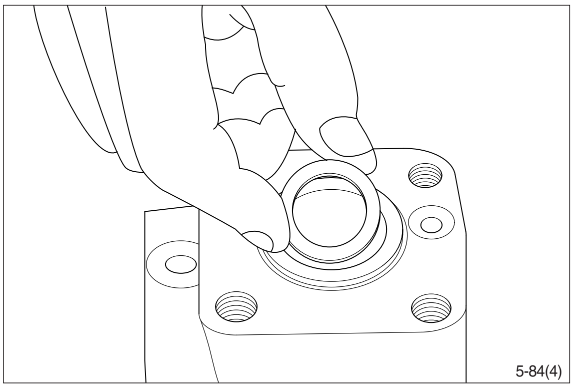


(31) Fit the six screws with washers and insert them. Cross-tighten all the screws and the rolled pin.

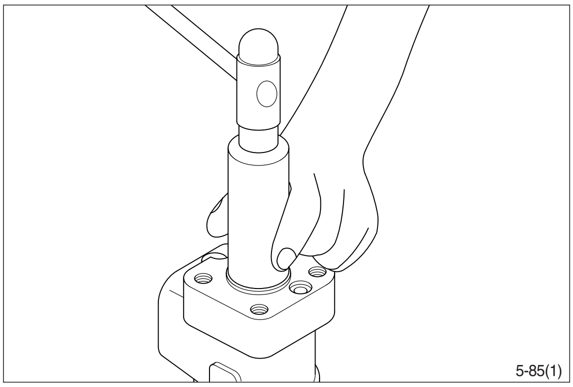
· Tightening torque : 3.0 ± 0.6kgf · m
(21.7 ± 4.3lbf · ft)



(32) Place the dust seal ring in the housing.

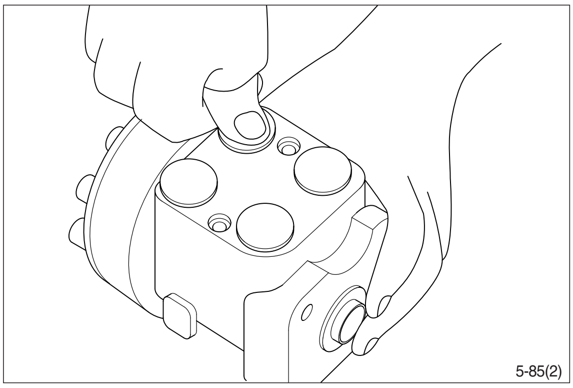


(33) Fit the dust seal ring in the housing.


5-85(1)

(34) Press the plastic plugs into the connection ports.

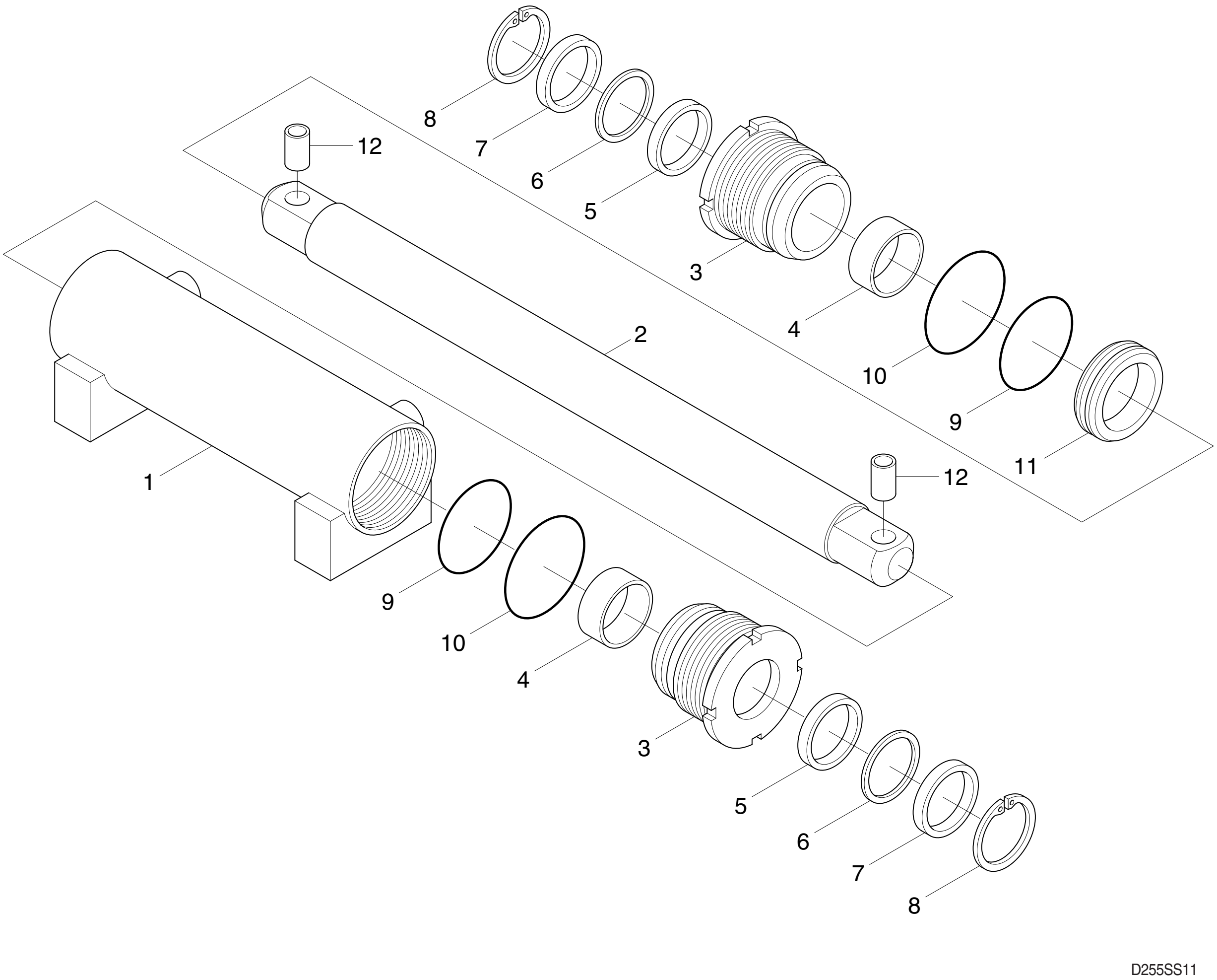
※ Do not use a hammer!


5-85(2)

2. STEERING CYLINDER

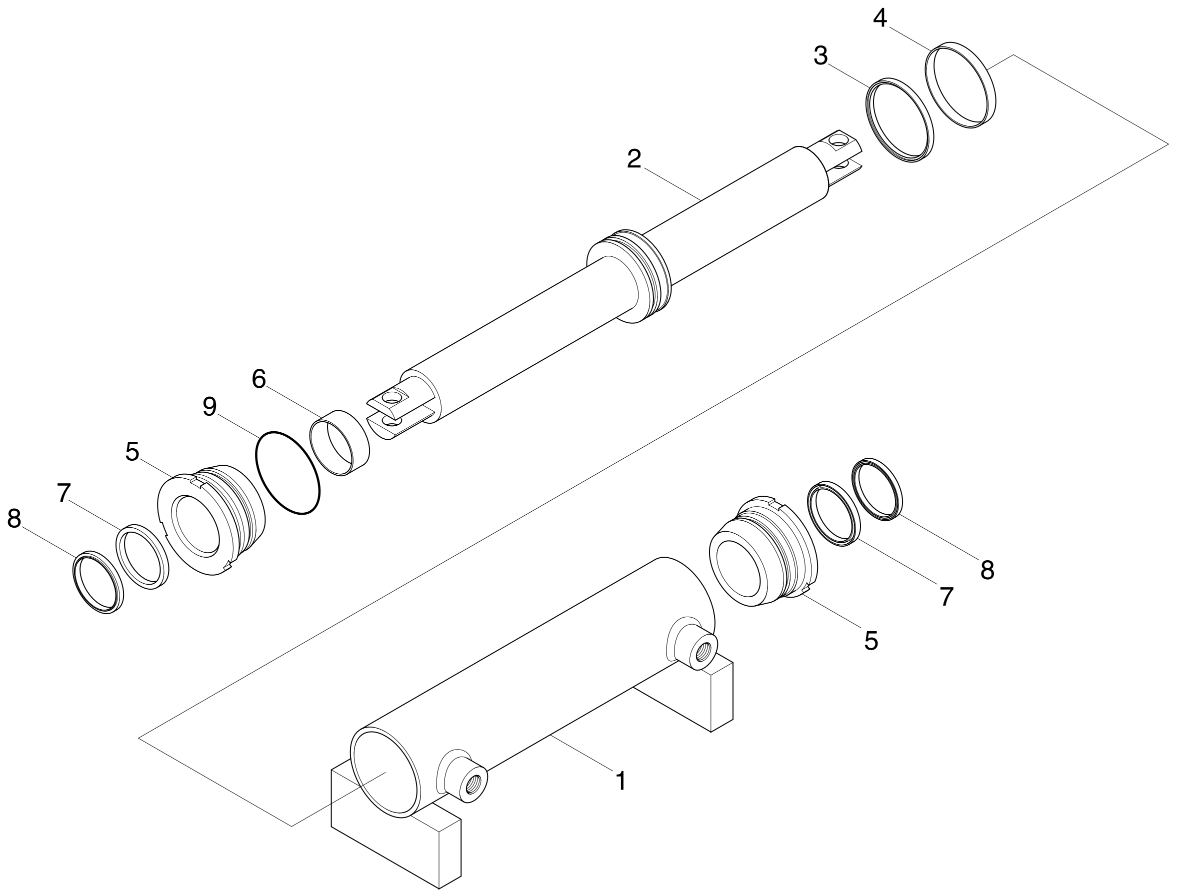
1) STRUCTURE

(1) HLF20/25/30-5



1	Tube assembly	5	Rod seal	9	O-ring
2	Rod	6	Back up ring	10	O-ring
3	Gland	7	Dust wiper	11	Piston seal
4	DU bushing	8	Snap ring	12	Pin bush

(2) HLF20/25/30C-5



1	Tube assembly	6	Bushing
2	Rod assembly	7	U-packing
3	Piston seal	8	Dust wiper
4	Wear ring	9	O-ring
5	Gland		

2) DISASSEMBLY

※ **Before disassembling steering cylinder, release oil in the cylinder first.**

(1) Put wooden blocks against the cylinder tube, then hold in a vice.

(2) Remove the gland by hook a wrench in the notch of cylinder head and turn counter-clockwise.

(3) Remove the cylinder rod and piston from the tube.

(4) Check wear condition of the sealing parts. If there are some damage, replace with new parts.

3) CHECK AND INSPECTION

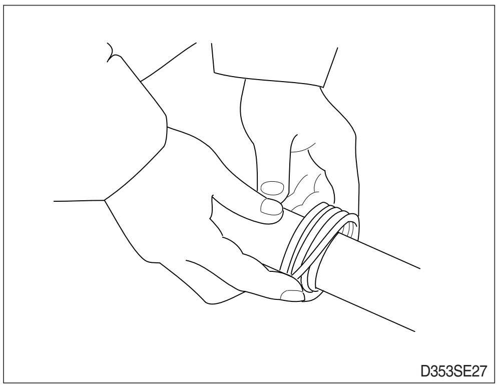
mm(in)

Check item	Criteria		Remedy
	Standard size	Repair limit	
Clearance between piston & cylinder tube	0.064~0.137 (0.0025~0.0054)	0.180 (0.0070)	Replace piston seal
Clearance between cylinder rod & bushing	0.024~0.112 (0.0009~0.0044)	0.120 (0.0049)	Replace bushing
Seals, O-ring	Damage		Replace
Cylinder rod	Dents		Replace
Cylinder tube	Biting		Replace

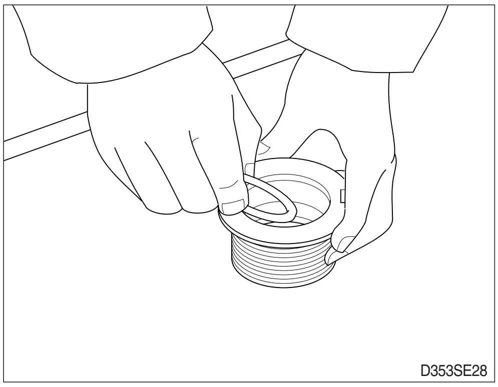
4) ASSEMBLY

(1) Install a new piston seal the groove on the piston.

※ **Be careful not to scratch the seal too much during installation or it will not seat properly.**

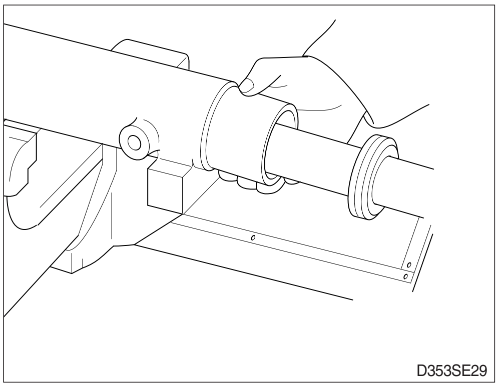


(2) Install the rod seal to the position in the gland applying a slight coat with grease prior to install.

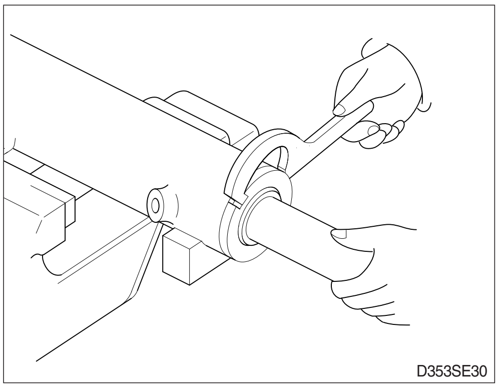


(3) Install the dust wiper to the gland using a special installing tool. Coat the dust wiper with grease slightly before installing.

(4) Set a special tool the cylinder, gland assembly into the cylinder tube.

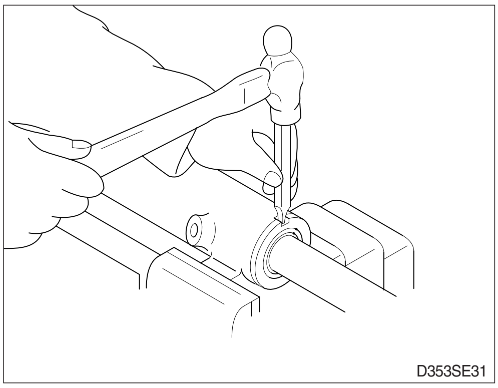


(5) Using a hook spanner, install the gland assembly, and tighten it with torque 45±4.5kgf · m (325±32.5lbf · ft).



(6) After the gland assembly was installed to the cylinder tube, calk at the tube end into the groove on the gland to prevent screw loosening.

※ **If it need calking again, never using previous calking position.**



(7) Move the piston rod back and forth several times for the full distance of its stroke. This helps to seat the ring and seals before applying full hydraulic pressure to the cylinder.

(8) Install cylinder into steering axle.

(9) While idling the engine with the rear wheels off the ground, operate the steering wheel left and right alternately.

※ **Then, repeat the above operation at gradually increasing engine rpm. This releases air from the system and completes preparation for operation.**

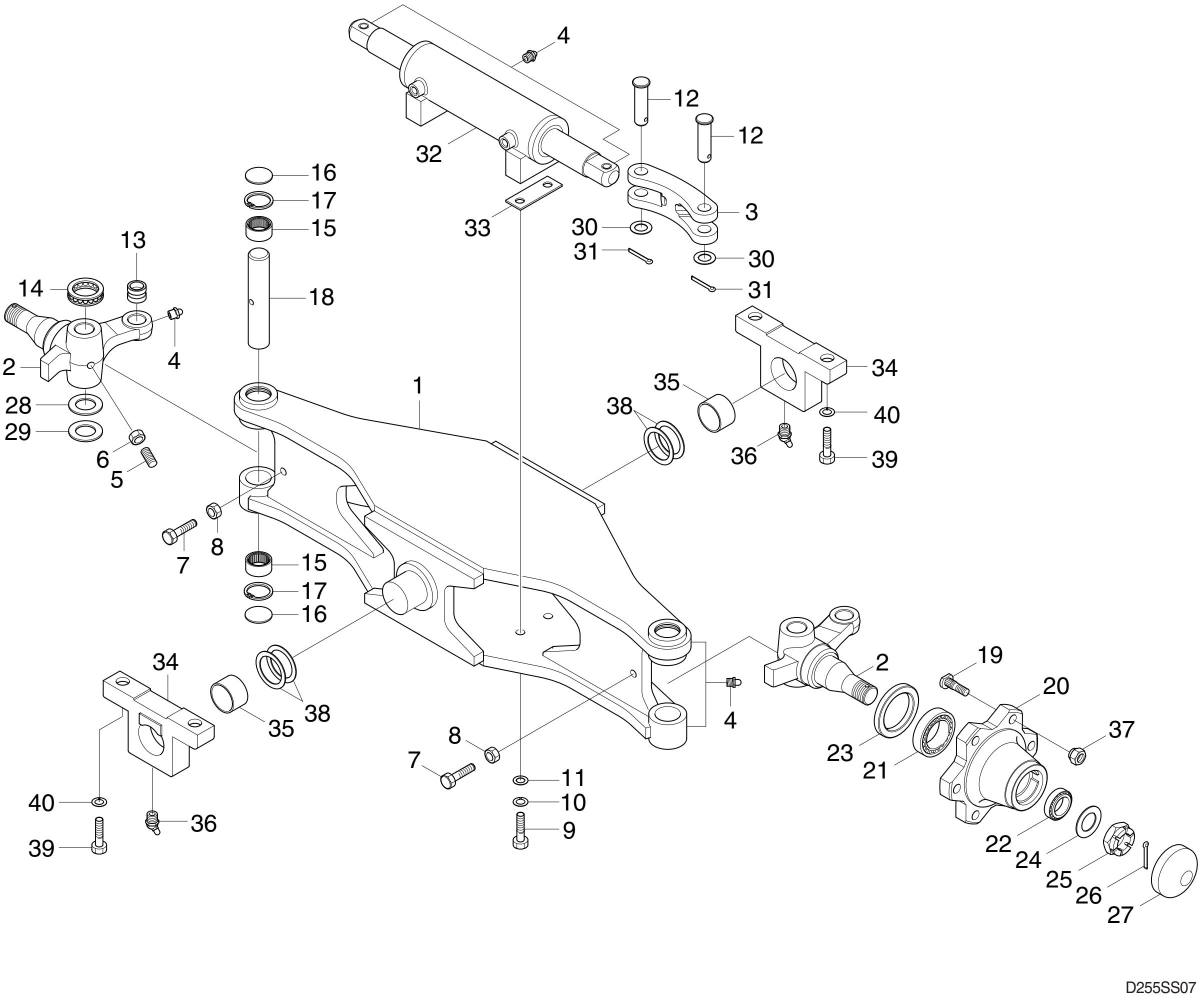
(10) Stop the engine, lower the floating rear wheels, and check pump joints for oil leaks and looseness and retighten, them as required.

3. STEERING AXLE

1) STRUCTURE

(1) HLF20/25/30-5

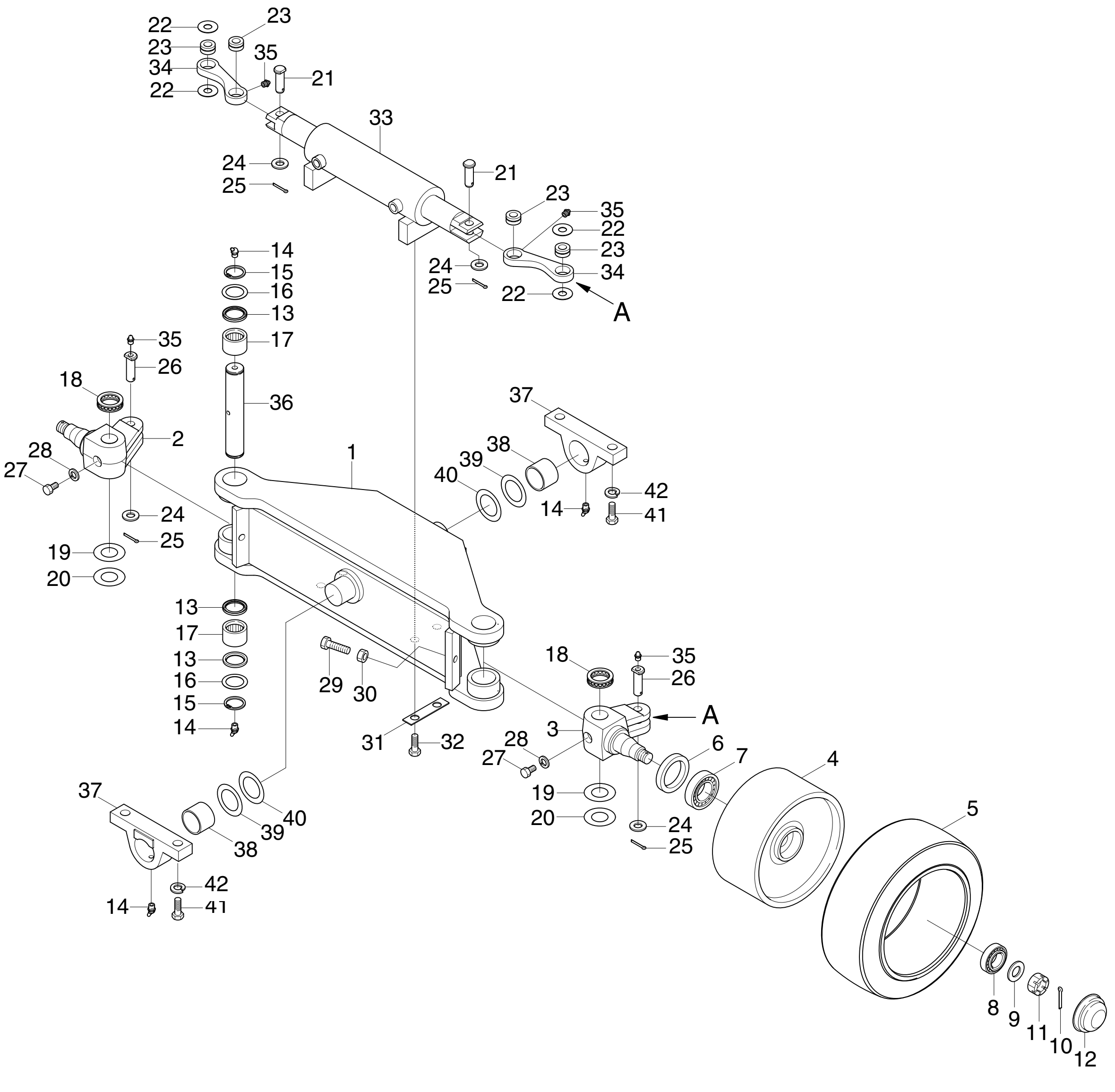
※ Do not remove the stopper bolt unless necessary.



1	Steering axle	15	Needle bearing	28	Shim
2	Knuckle	16	Plate plug	29	Shim
3	Intermediate link	17	Retaining ring	30	Special washer
4	Grease nipple	18	King pin	31	Split pin
5	Set screw	19	Hub bolt	32	Steer cylinder
6	Nut	20	Hub	33	Shim
7	Bolt	21	Taper roller bearing	34	Block
8	Nut	22	Taper roller bearing	35	Bushing
9	Bolt	23	Oil seal	36	Grease nipple
10	Spring washer	24	Washer	37	Hub nut
11	Plain washer	25	Slotted nut	38	Shim
12	Link pin	26	Split pin	39	Bolt
13	Inner race bush	27	Hub cap	40	Hardened washer
14	Thrust bearing				

⑵ HLF20/25/30C-5

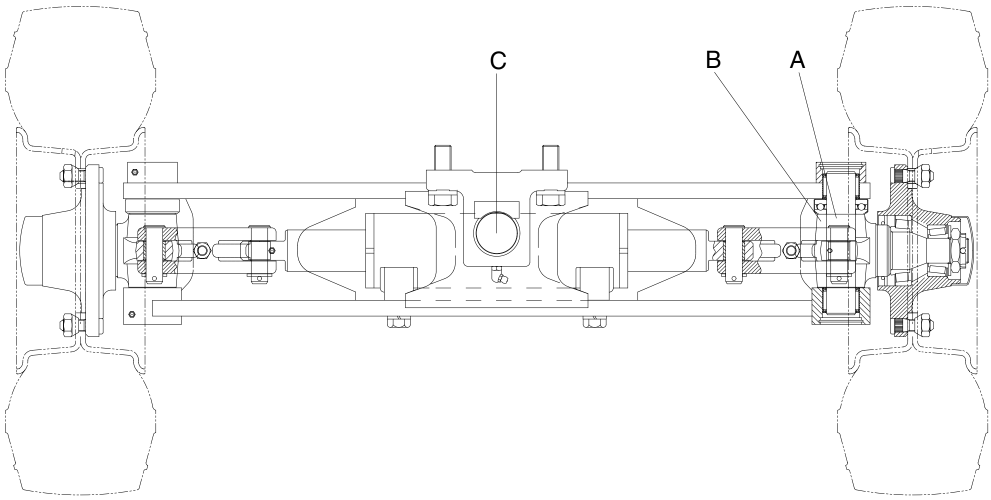
※ Do not remove the stopper bolt unless necessary.



1	Steering axle wa	15	Retaining ring	29	Hexagon bolt
2	Knuckle-RH	16	King pin washer	30	Hexagon nut
3	Knuckle-LH	17	Needle bearing	31	Lock plate
4	Wheel hub	18	Thrust bearing	32	Hexagon bolt
5	Rear wheel	19	Shim(0.13T)	33	Steering cylinder
6	Oil seal	20	Shim(0.25T)	34	Link
7	Taper roller bearing	21	Clevis pin	35	Grease nipple
8	Taper roller bearing	22	Thrust washer	36	King pin
9	Plain washer	23	Bearing	37	Block
10	Split pin	24	Plain washer	38	Bushing
11	Castle nut	25	Split pin	39	Shim(1.0T)
12	Hub cap	26	Clevis pin	40	Shim(0.5T)
13	Oil seal	27	Special bolt	41	Hexagon bolt
14	Grease nipple	28	Spring washer	42	Spring waher

2) CHECK AND INSPECTION

(1) HLF20/25/30-5

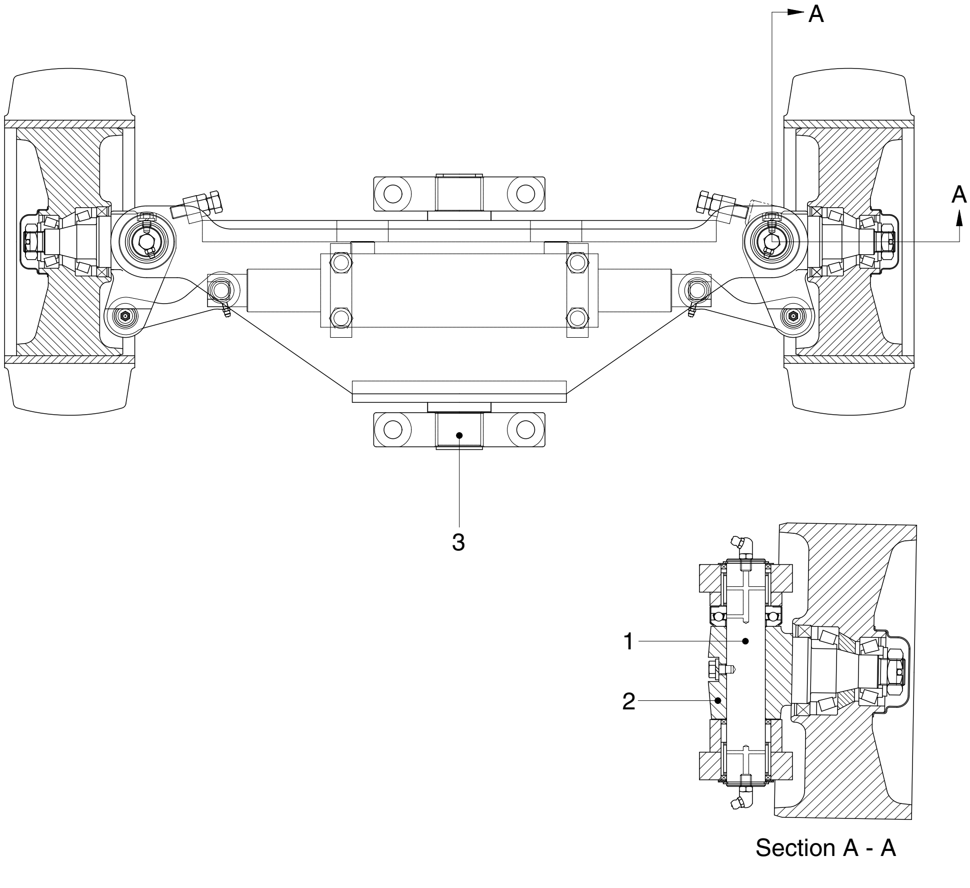


D255SS12

mm(in)

No.	Check item	Criteria		Remedy
		Standard size	Repair limit	
A	Diameter of king pin	45(1.77)	44.8(1.76)	Replace
B	Vertical play of knuckle	-	0.2(0.008)	Adjust with shims
C	Diameter of center pin	50(1.96)	49.5(1.94)	Replace
-	Rear axle, hub, knuckle, bearing	· Damage, wear · Seizure, abnormal noise, defective rotation		Replace

(2) HLF20/25/30C-5

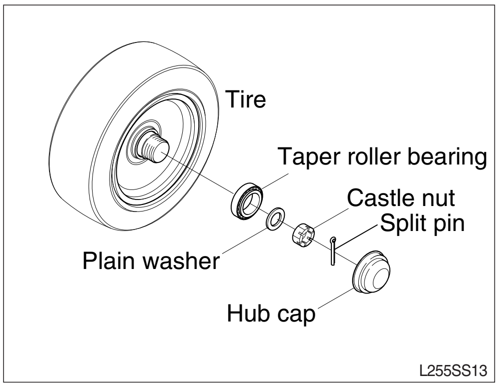


mm(in)

No.	Check item	Criteria		Remedy
		Standard size	Repair limit	
1	Diameter of king pin	45(1.77)	44.8(1.76)	Replace
2	Vertical play of knuckle	-	0.2(0.008)	Adjust with shims
3	Diameter of center pin	50(1.96)	49.5(1.94)	Replace
-	Rear axle, hub, knuckle, bearing	· Damage, wear · Seizure, abnormal noise, defective rotation		Replace

3) DISASSEMBLY

※ **Servicing work on the knuckle part can be carried out without removing the axle assy from chassis.**
The work can be done by jacking up the balance weight part of the truck.

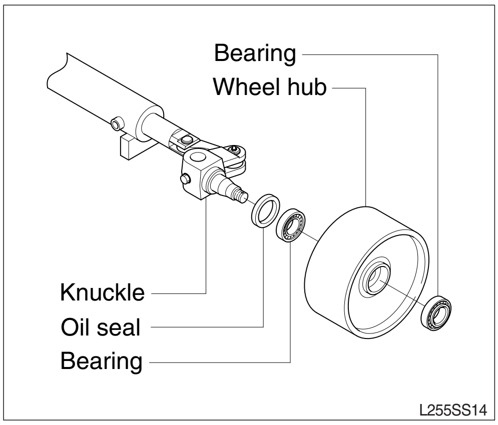


(1) Remove hub cap.

(2) Pull out split pin and remove castle nut and plain washer.

(3) Take off the steering wheel tire.

(4) Using the puller, take off the wheel hub together with the bearing.
Be very careful because just before the hub comes off, tapered roller bearing will fall out.



(5) After wheel hub is removed take off the inner race of bearing.

(6) Pull out oil seal.

※ **Don't use same oil seal twice.**

(7) Repeat the same procedure for the other side.
Moreover, when disassembling is completed, part the castle nut in the knuckle to protect the threaded portion.

(8) Loosen special bolt(27) and spring washer(28).

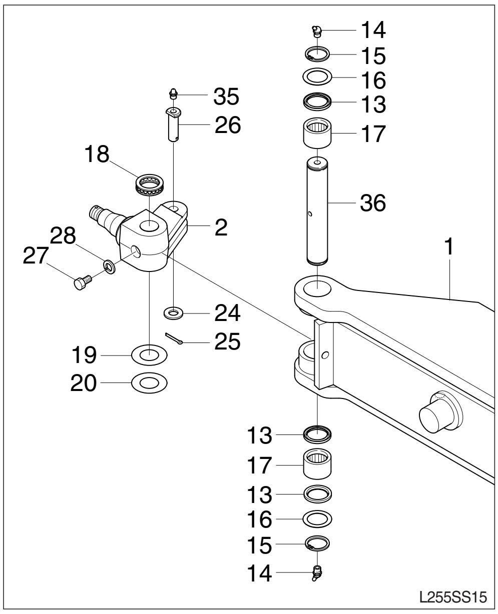
(9) Pry out the retaining ring(15) and remove oil seal(13).

(10) Push out the king pin(36) without damaging the knuckle(2).

(11) Pull out the needle bearing(17).
If defect is observed in needle bearing(17), pull it out by using extractor.

(12) Remove the split pin(25) and the clevis pin(26).
Then, remove the knuckle(2).

※ **Repeat the same procedure for the other side.**



4) ASSEMBLY

※ **In reassembling, have all parts washed, grease applied to lubricating parts, and all expendable items such as oil seal and spring washers replaced by new ones.**
Perform the disassembly in reverse order.

(1) Tighten the special bolt(27) of king pin.

※ **There is a notch in the middle of the king pin(36), make sure that this notch is on the special bolt side.**

(2) Do not hammer to drive in needle bearing(17) because it will break.
Always use drive-in tool. Be sure that the fixed ring of the bearing is placed in position facing the knuckle.

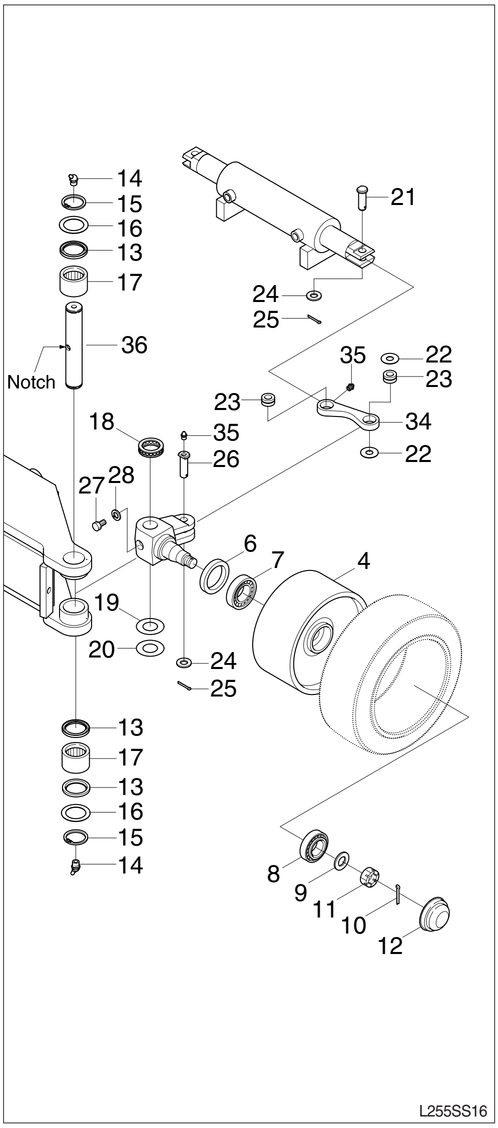
(3) Wheel hub

① Mount oil seal(6) and inner race of tapered roller bearing(7) on the knuckle(2). The bearing should be well greased before assembling.

② Install the outer race of the bearing(8) in the wheel center and assemble to the knuckle.

③ Tighten with castle nut(11) and locked with split pin (10). In locking with split pin, locate the hole for the split pin by turning the nut back 1/6 of a turn. Adjust the preload of bearing.

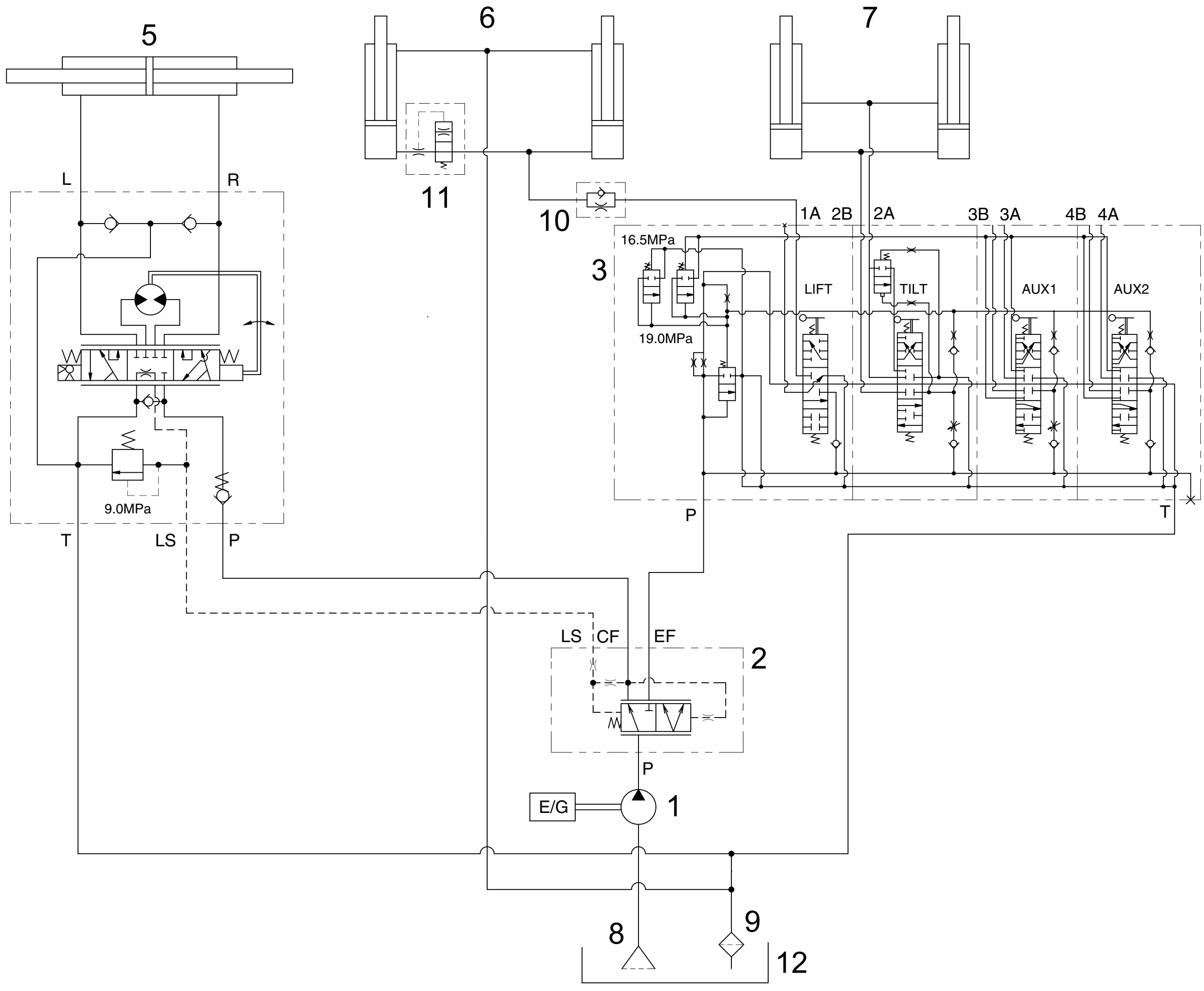
④ Mount the hub cap(12). Bearing should be well greased before assembling.



SECTION 6 HYDRAULIC SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

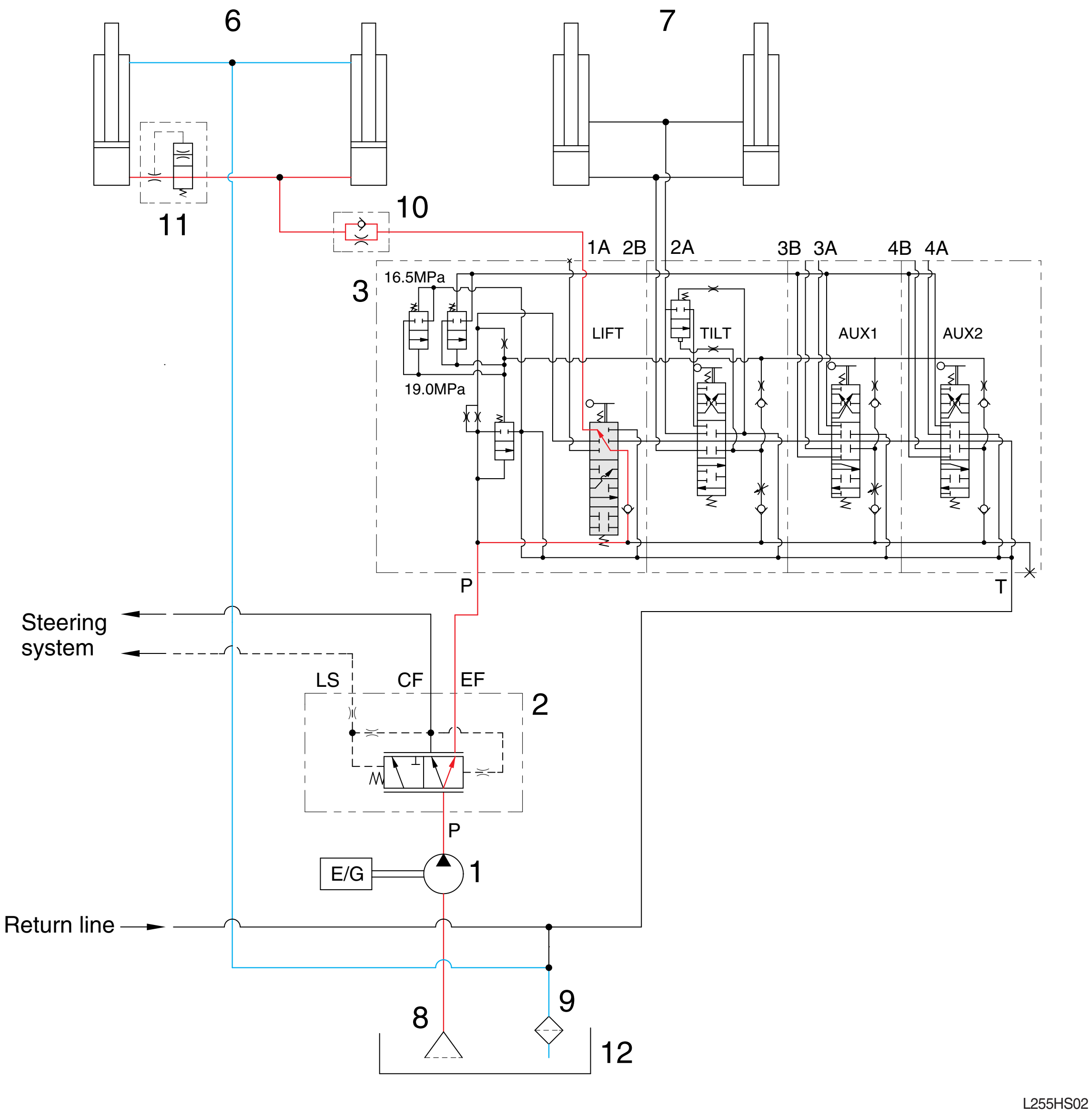
1. HYDRAULIC CIRCUIT



L255HS01

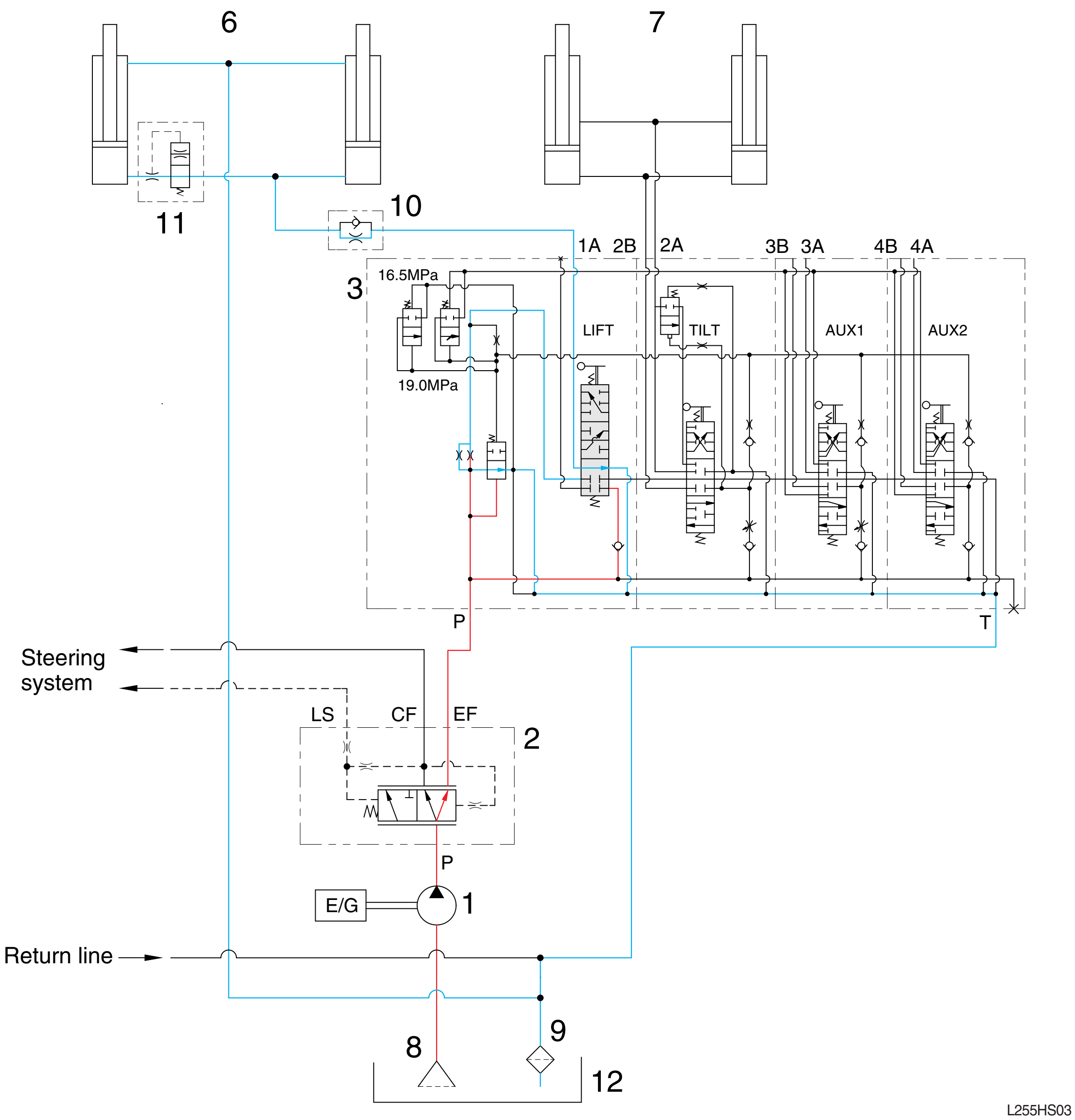
1	Hydraulic gear pump	7	Tilt cylinder
2	Priority valve	8	Suction filter
3	Main control valve	9	Return filter
4	Steering unit	10	Down control valve
5	Steering cylinder	11	Down safety valve
6	Lift cylinder	12	Hydraulic tank

1) WHEN THE LIFT CONTROL LEVER IS IN THE LIFT POSITION



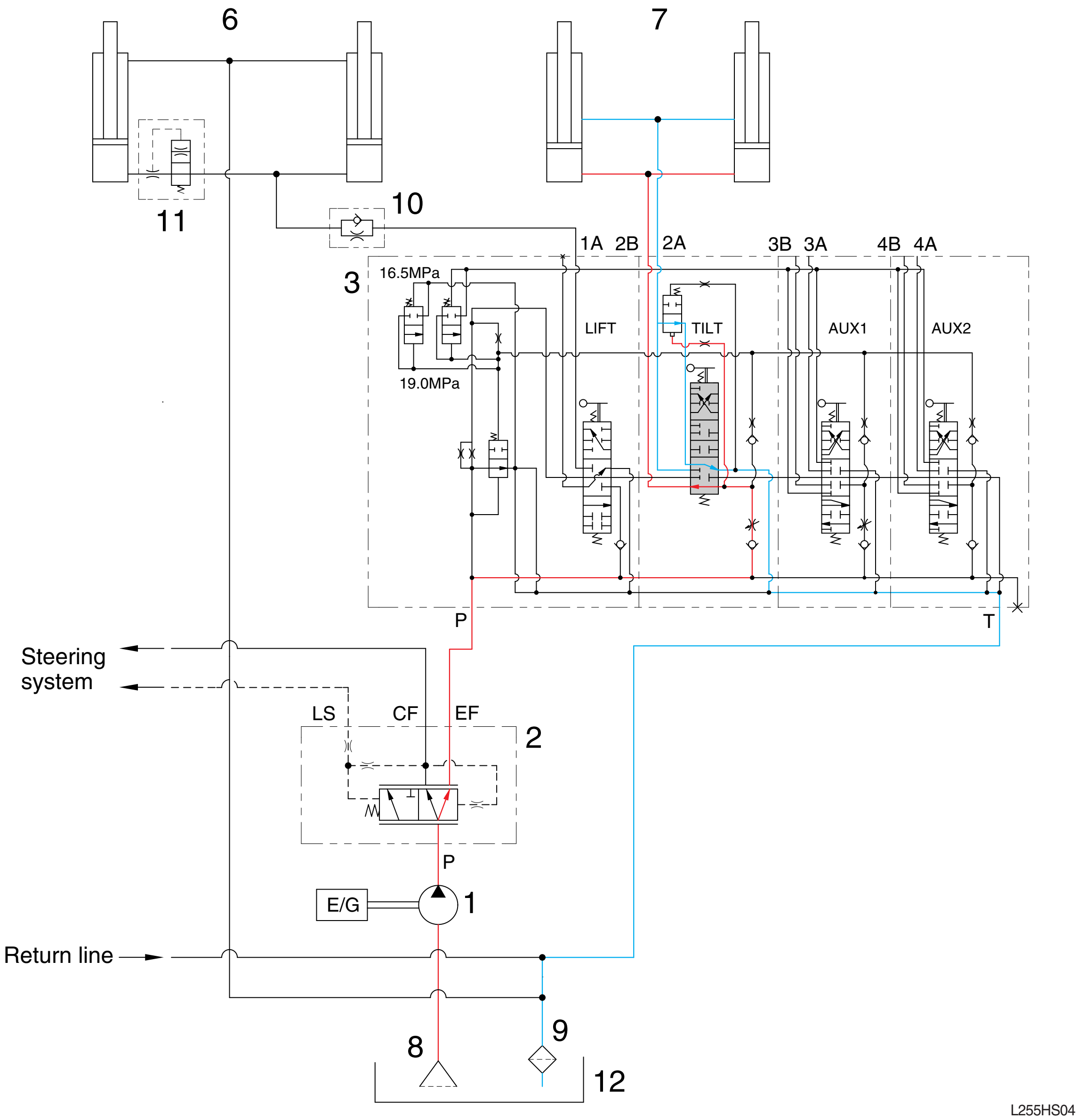
When the lift control lever is pulled back, the spool on the first block moves to lift position.
The oil from hydraulic gear pump(1) flows into main control valve(3) and then goes to the large chamber of lift cylinder(6) by pushing the load check valve of the spool.
The oil from the small chamber of lift cylinder(6) returns to hydraulic oil tank(12) at the same time.
When this happens, the fork goes up.

2) WHEN THE LIFT CONTROL LEVER IS IN THE LOWER POSITION



When the lift control lever is pushed forward, the spool on the first block moves to lower position. The work port(1A) and the small and the large chamber of lift cylinder are connected to the return passage, so the fork will be lowered due to its own weight.

3) WHEN THE TILT CONTROL LEVER IS IN THE FORWARD POSITION



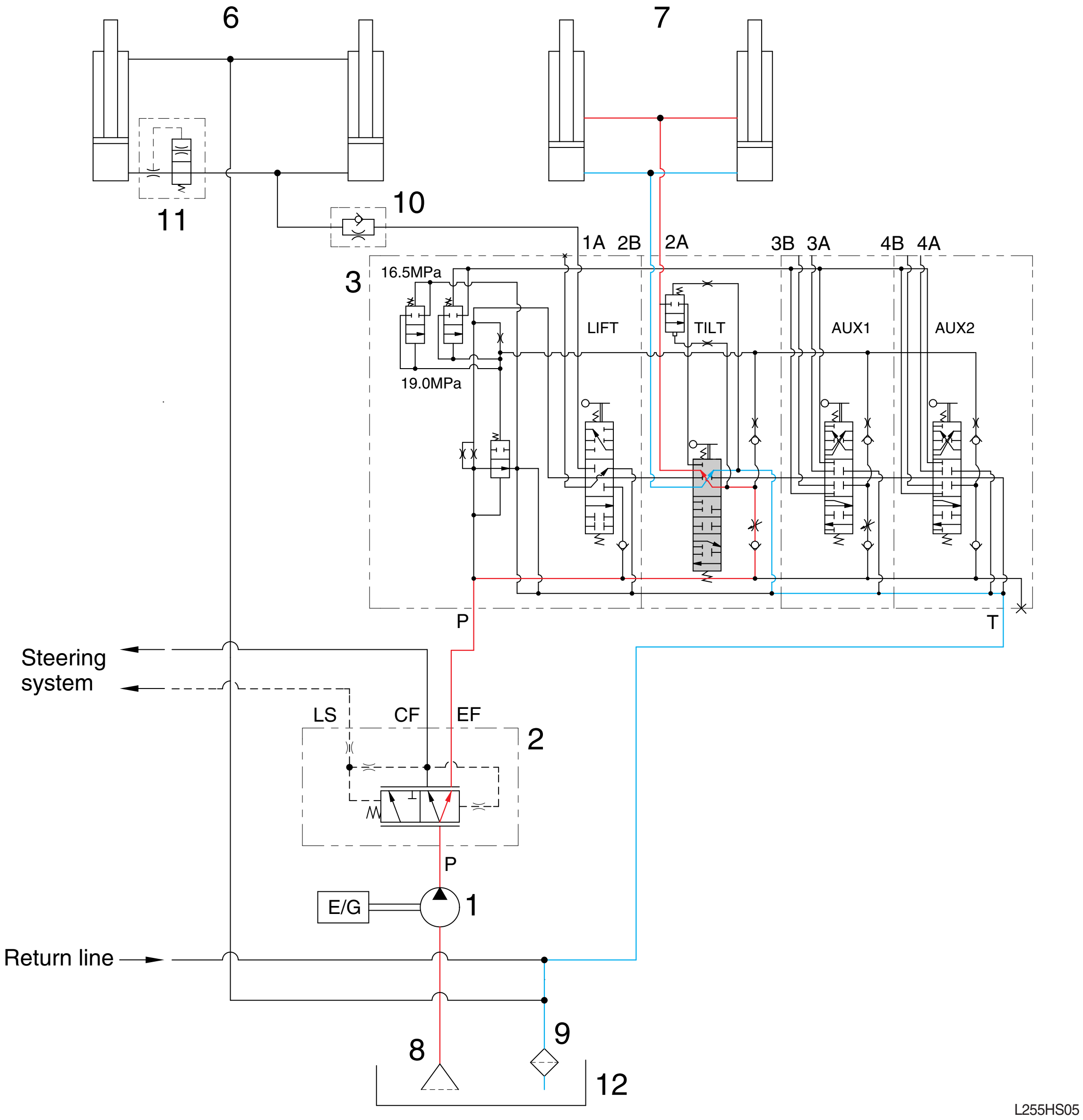
When the tilt control lever is pushed forward, the spool on the second block is moved to tilt forward position.

The oil from hydraulic gear pump(1) flows into main control valve(3) and then goes to the large chamber of tilt cylinder(7) by pushing the load check valve of the spool.

The oil at the small chamber of tilt cylinder(7) returns to hydraulic tank(12) at the same time.

When this happens, the mast tilt forward.

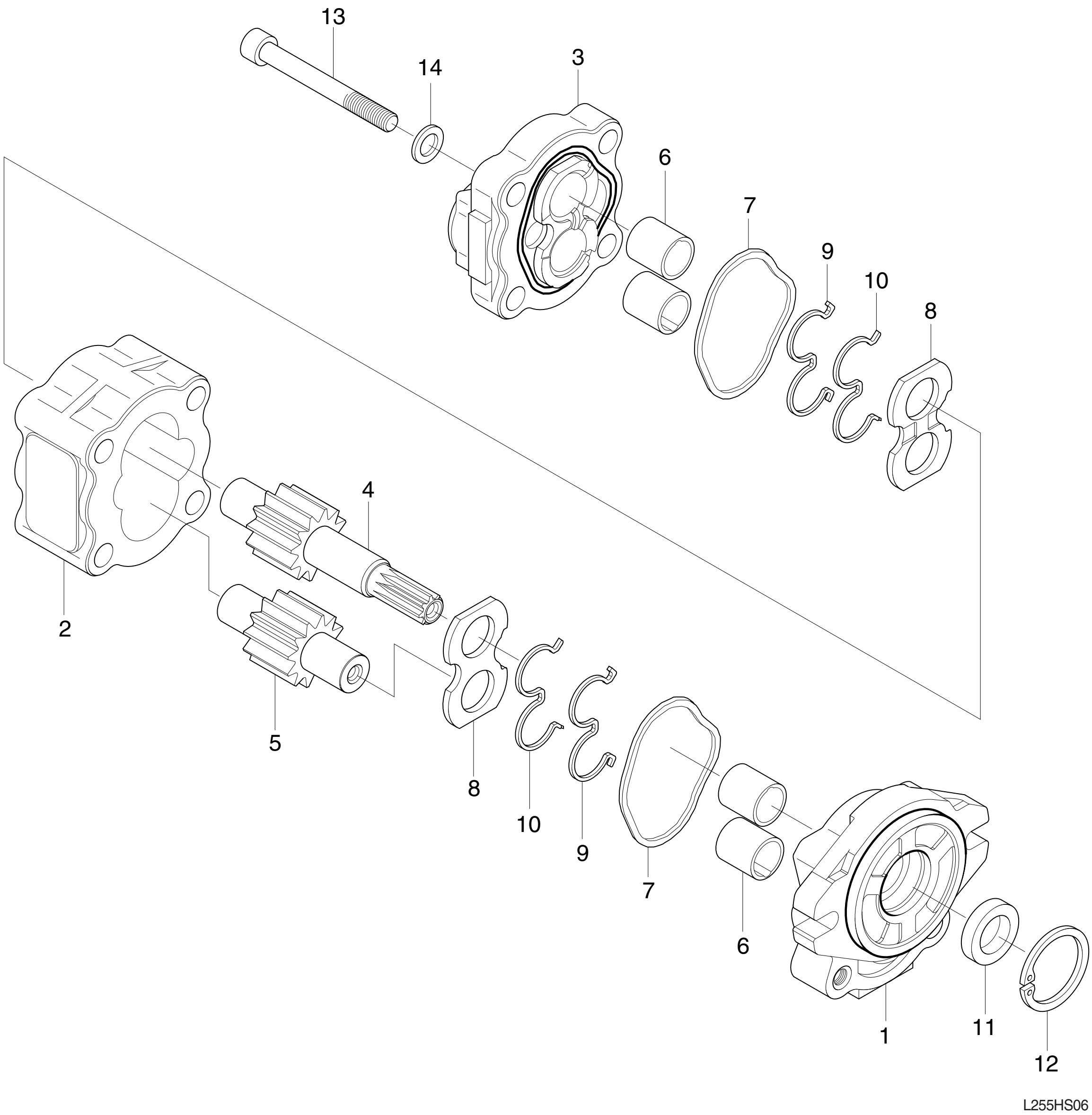
4) WHEN THE TILT CONTROL LEVER IS IN THE BACKWARD POSITION



When the tilt control lever is pulled back, the spool on the second block is moved to tilt backward position.
The oil from hydraulic gear pump(1) flows into main control valve(3) and then goes to the small chamber of tilt cylinder(7) by pushing the load check valve of the spool.
The oil at the large chamber of tilt cylinder(7) returns to hydraulic tank(12) at the same time.
When this happens, the mast tilts backward.

2. HYDRAULIC GEAR PUMP

1) STRUCTURE



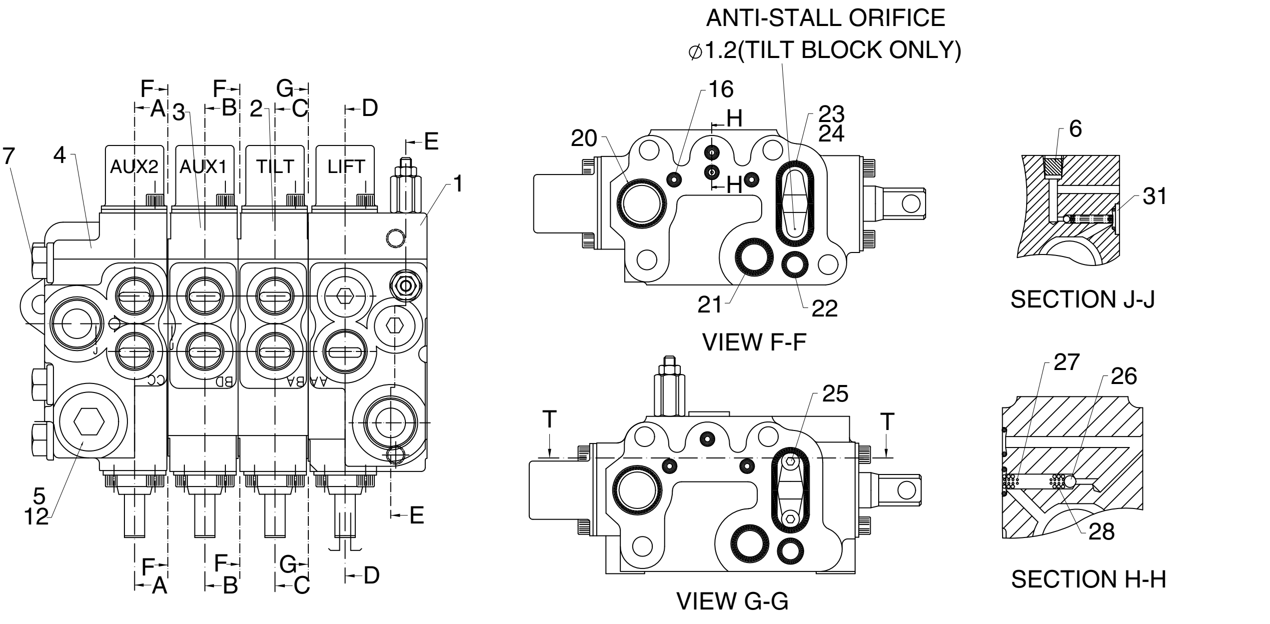
1	Front cover	6	Bearing	11	Oil seal
2	Gear plate	7	Square ring	12	Retainer ring
3	Rear cover	8	Wear plate	13	Bolt
4	Drive gear	9	Balance seal	14	Plain washer
5	Idler gear	10	Back up ring		

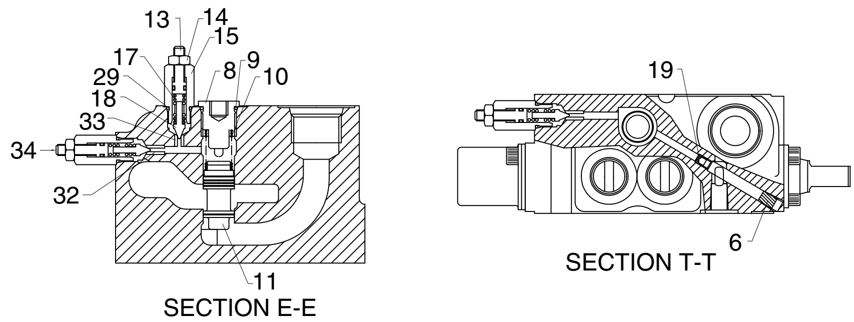
2) OPERATION

This pump comprises of a rear cover(3), a gear plate(2) and a front cover(1) bolted together. The gear journals are supported by bearings(6) to give high volumetric and mechanical efficiencies.

3. MAIN CONTROL VALVE

1) STRUCTURE (4- Spool)





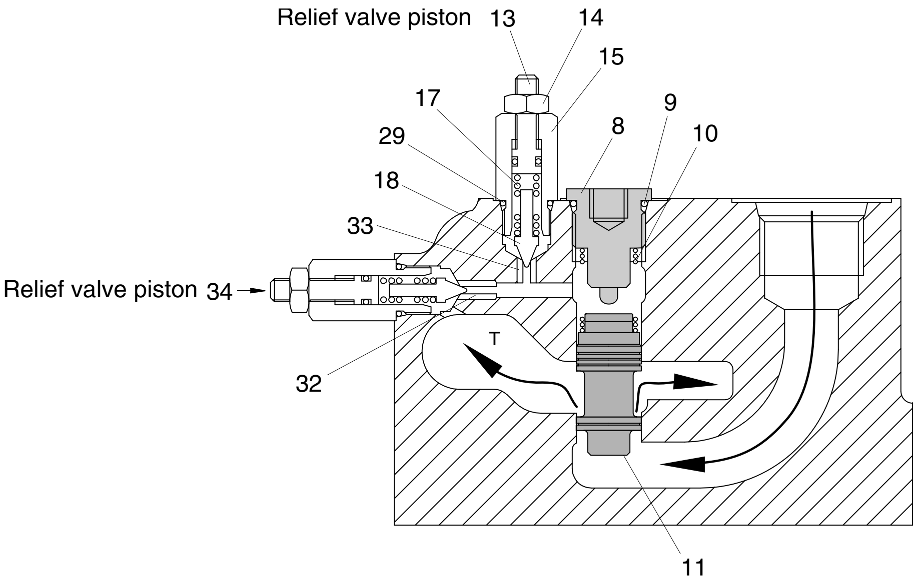
Port name	Size
Inlet port	1-1/16-12UNF-2B
Outlet port	1-1/16-12UNF-2B

D255HS07

1	Lift block assy
2	Tilt block assy
3	Aux1 block assy
4	Aux2 block assy
5	Plug
6	Plug
7	Long bolt
8	Hydrostat plug
9	O-ring
10	Hydrostat spring
11	Hydrostat sleeve
12	O-ring
13	Relief piston
14	Nut
15	Relief plug
16	O-ring
17	Relief spring
18	Pilot poppet
19	Plug
20	O-ring
21	O-ring
22	O-ring
23	O-ring
24	O-ring, retainer
25	Plug
26	Steel ball
27	Load sensor spring
28	Load sensor spring
29	O-ring
30	O-ring
31	Side plate
32	Seat
33	Seat
34	Piston

2) INLET SECTION OPERATION

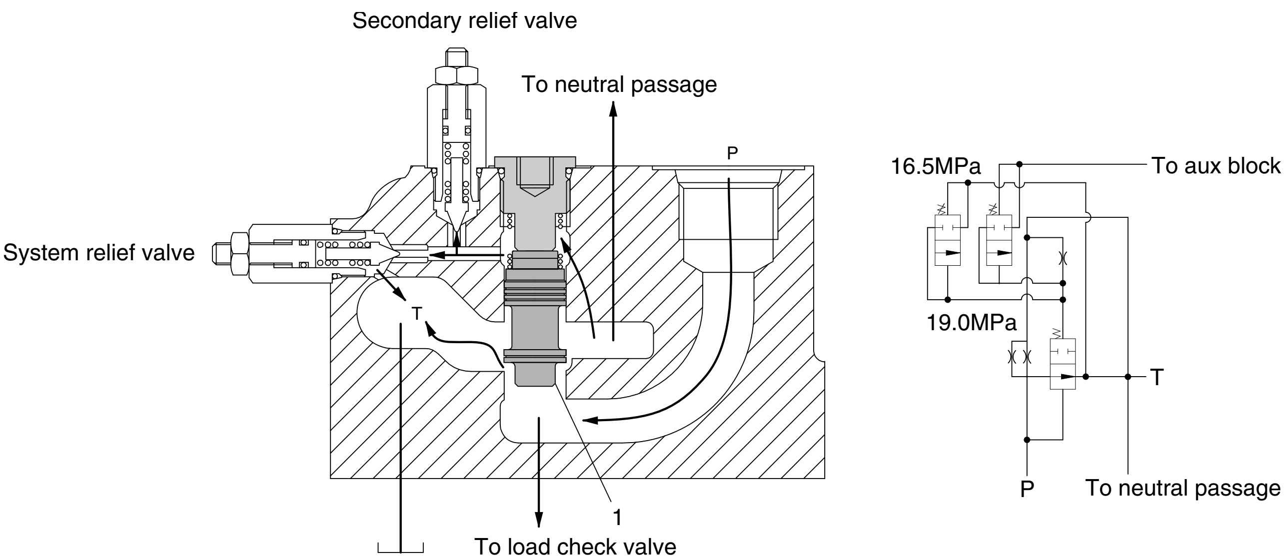
(1) Structure and description



D255HS071

8	Hydrostat plug	15	Relief plug
9	O-ring	17	Relief spring
10	Hydrostat spring	18	Pilot poppet
11	Hydrostat sleeve	29	O-ring
13	Relief piston	32	Seat
14	Nut	33	Seat

(2) Operation

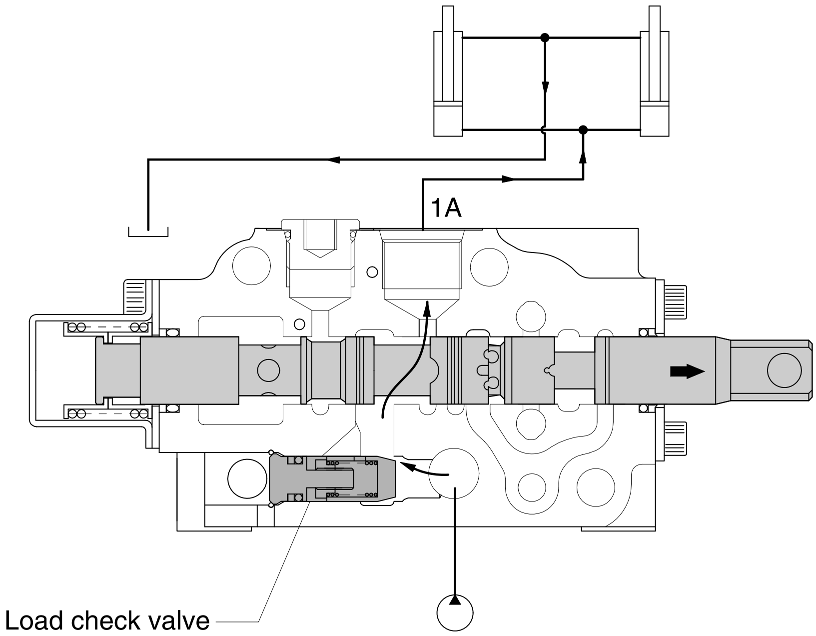


L255HS23

Oil flows from P(pump) port to reservoir(T) by pushing hydrostat spool(1).
Before the center bypass line closed, hydrostat spool is keep opening, so pump port(P) and tank port(T) are always connected in operation to minimize heat generation.

3) LIFT SECTION OPERATION

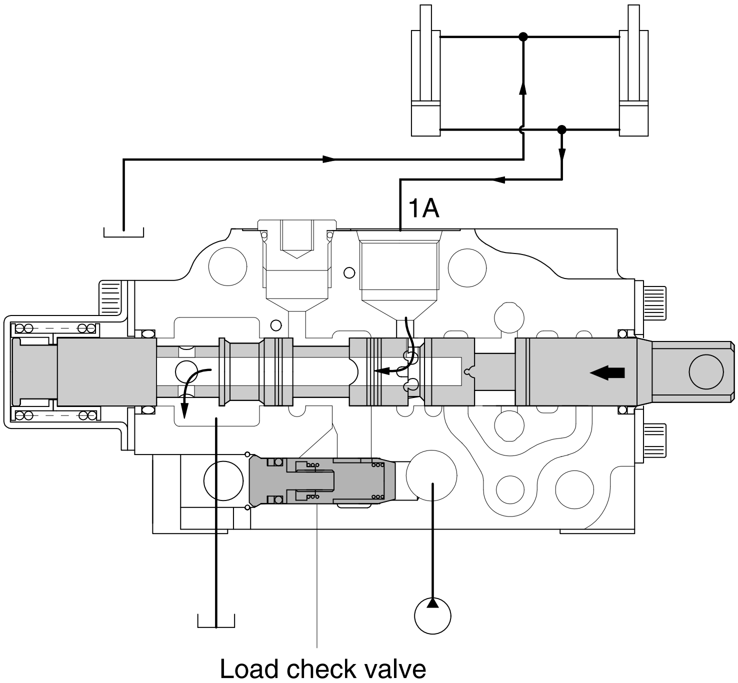
(1) Lift position



D255HS08

When the lift control lever is pulled back, the spool moves to the right and the neutral passage is closed.
The oil supplied from the pump pushes up the load check valve and flow into lift cylinder port(1A).
The pump pressure reaches proportionally the load of cylinder and fine control finished by shut off of the neutral passage.
The return oil from cylinder flows into the tank.

(2) Lower position

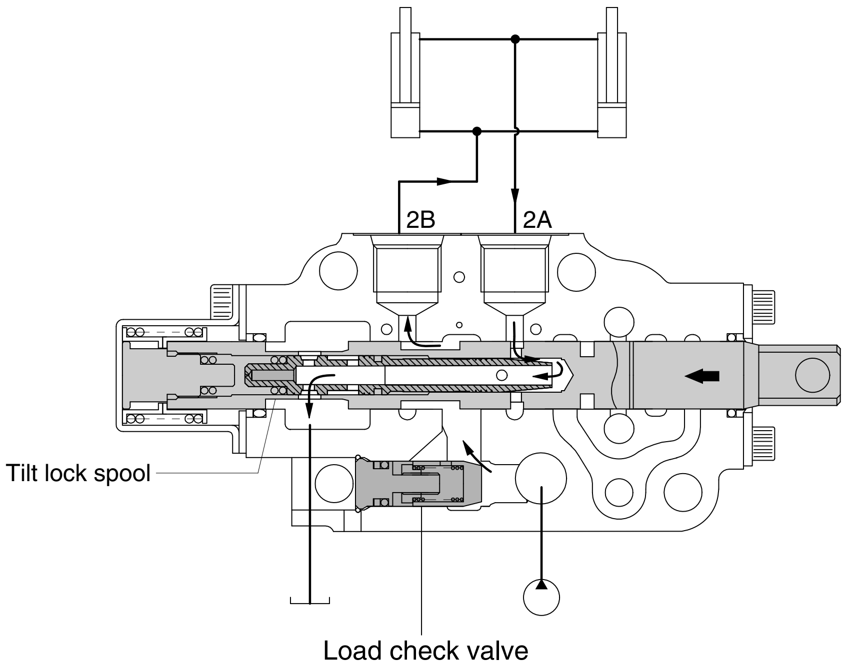


D255HS09

When the lift control lever is pushed forward, the spool moves to the left and the neutral passage is closed.
The spool moves to the lift lower position, opening up the neutral passage to tank and (1A)→T.
In lift lower position the fork drops due to its own weight.

4) TILT SECTION OPERATION

(1) Tilt forward position



D255HS10

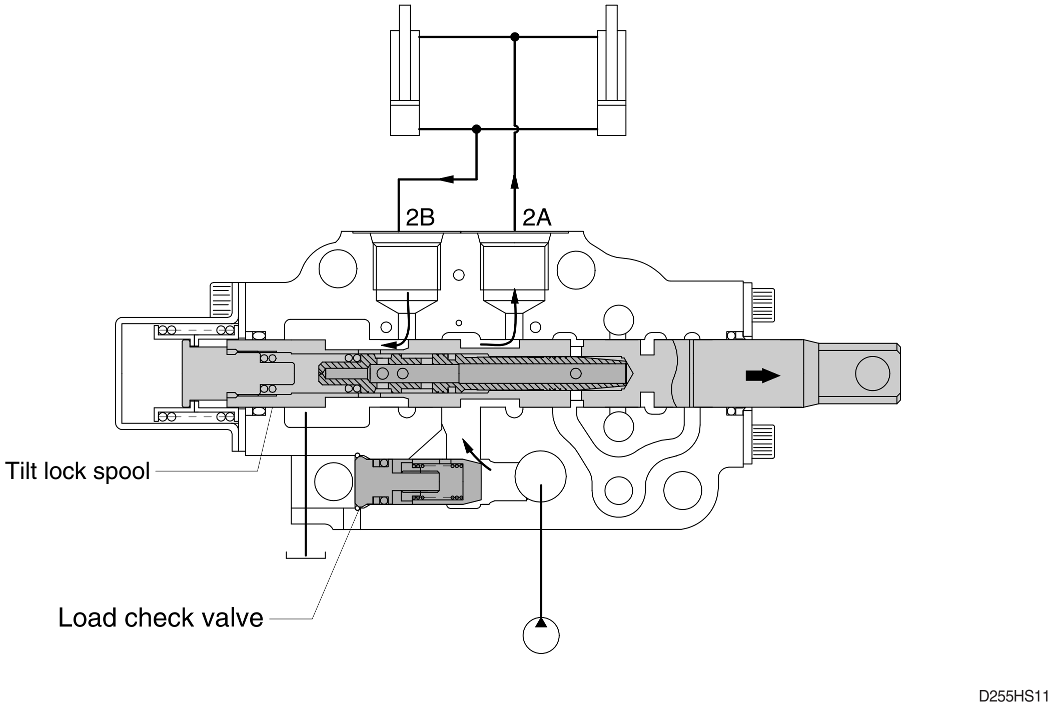
When the tilt control lever is pushed forward, the spool moves to the left and the neutral passage is closed.

The oil supplied from the pump pushes up the load check valve and flow into tilt cylinder port(2B).

The pump pressure reaches proportionally the load of cylinders and fine control finished by closing the neutral passage.

The return oil from cylinder port(2A) flows into the tank through the hole of the tilt lock spool.

(2) Tilt backward position



When the tilt control lever is pulled back, the spool moves to the right and the neutral passage is closed.

The oil supplied from the pump pushes up the load check valve and flows into tilt cylinder port(2A).

The pump pressure reaches proportionally the load of cylinder and fine control finished by shut off of the neutral passage.

The return oil from cylinder port(2B) flows into the tank via the low pressure passage.

5) MAIN RELIEF VALVE

(1) Pressure setting

A good pressure gauge must be installed in the line which is in communication with the work port relief. A load must be applied in a manner to reach the set pressure of the relief unit.

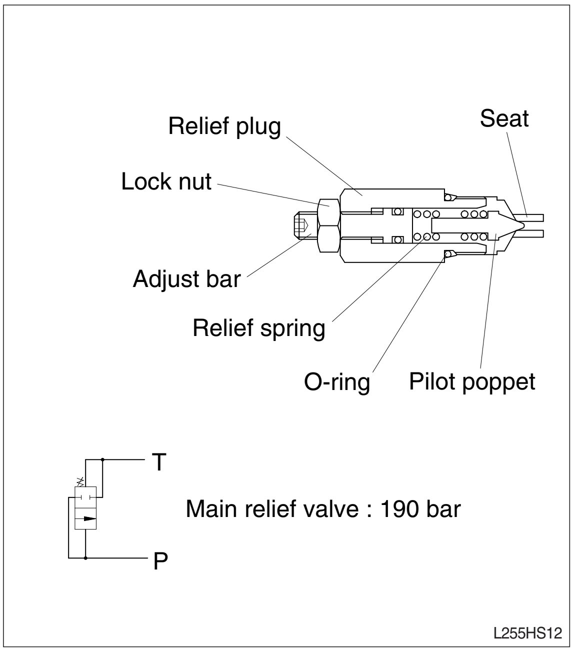
Procedure

① Loosen lock nut.

② Set adjusting bar to desired pressure setting.

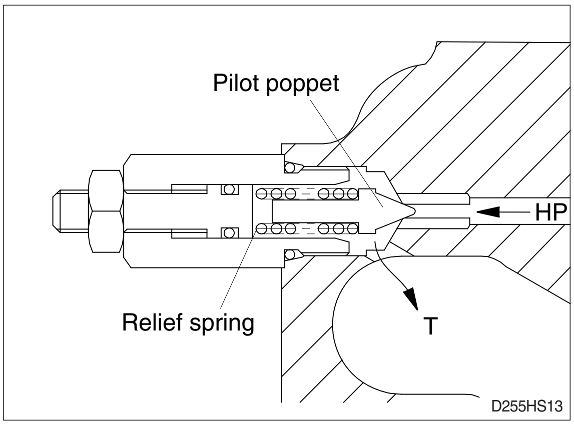
③ Tighten lock nut.

④ Retest in similar manner as above.

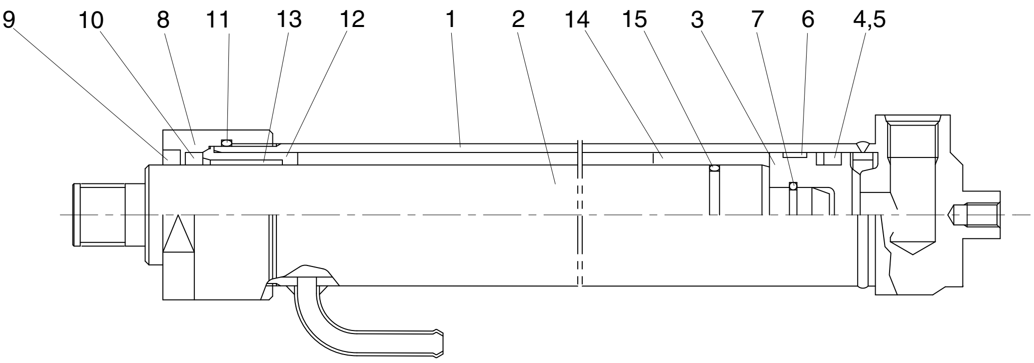


(2) Operation

Pressurized oil over the relief pressure pushes pilot poppet and flows to tank passage, therefore the system pressure keeps under the adjusted relief pressure.



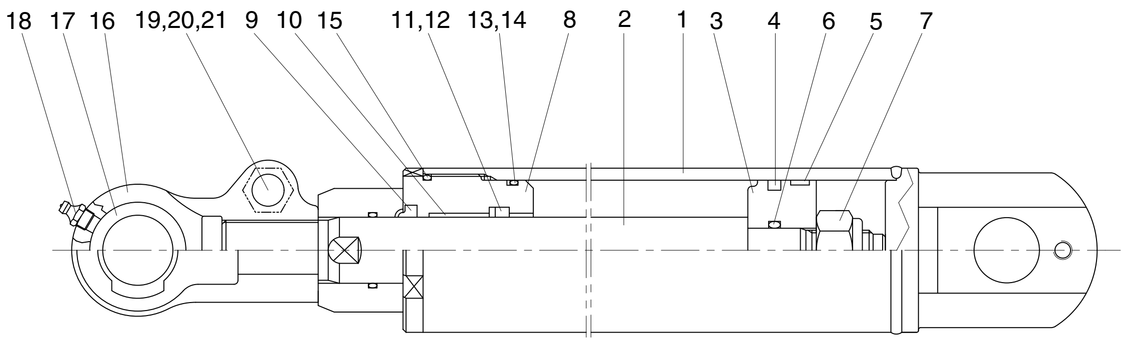
4. LIFT CYLINDER



D255HS18

1	Tube assembly	6	Wear ring	11	O-ring
2	Rod	7	Retaining ring	12	Guide
3	Piston	8	Gland	13	DU bushing
4	Piston seal	9	Dust wiper	14	Spacer
5	Back up ring	10	Rod seal	15	O-ring

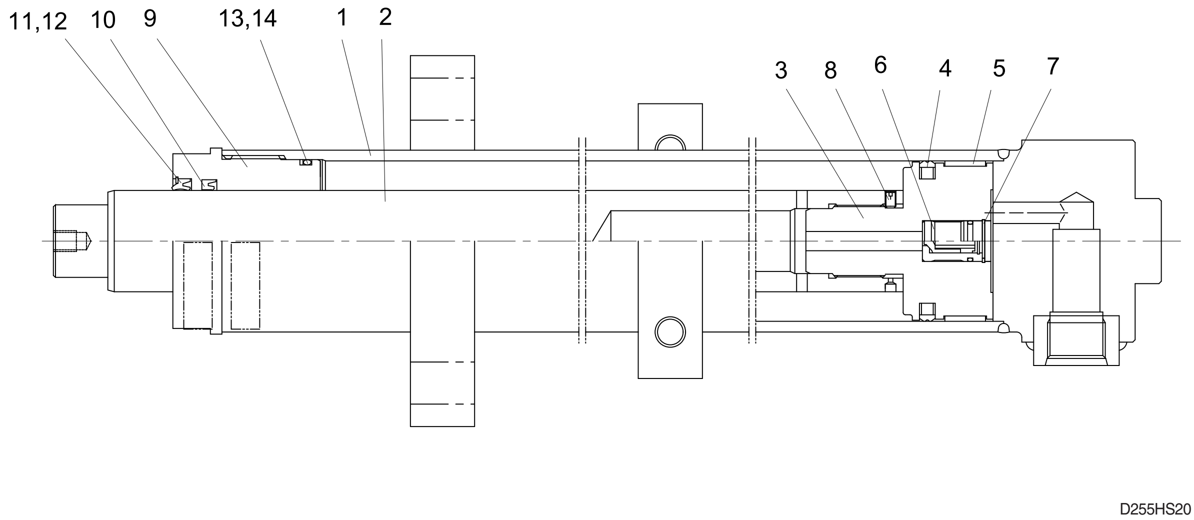
5. TILT CYLINDER



L255HS19

1	Tube assembly	8	Rod cover	15	O-ring
2	Rod	9	Dust wiper	16	Rod eye
3	Piston	10	Du bushing	17	Bushing
4	Piston seal	11	Rod seal	18	Grease nipple
5	Wear ring	12	Back up ring	19	Hexagon bolt
6	O-ring	13	O-ring	20	Spring washer
7	Hexagon nut	14	Back up ring	21	Hexagon nut

6. FREE LIFT CYLINDER



1	Tube assembly	6	Check valve	11	Dust wiper
2	Rod	7	Back up ring	12	Snap ring
3	Piston	8	Set screw	13	O-ring
4	Piston seal	9	Gland	14	Back up ring
5	Wear ring	10	Rod seal		

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

1) CHECK ITEM

(1) Check visually for deformation, cracks or damage of rod.

(2) Load rated load, set mast vertical and raise 1m from ground. Wait for 2 minutes and measure hydraulic drift(amount forks move down and amount mast tilts forward).

· Hydraulic drift

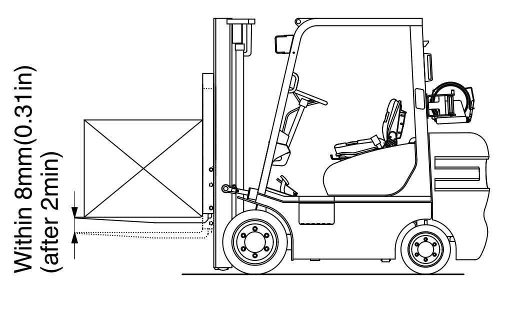
- Down(Downward movement of forks)
: Within 8mm(0.31in)
- Forward(Extension of tilt cylinder)
: Within 4mm(0.16in)

If the hydraulic drift is more than the specified value, replace the control valve or cylinder packing.

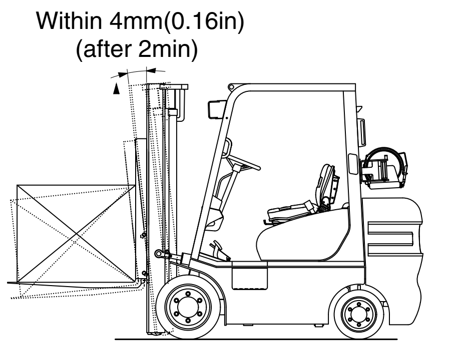
(3) Check that clearance between tilt cylinder bushing and mounting pin is within standard range.

mm (in)

Standard	Under 0.6 (0.02)



L255HS21

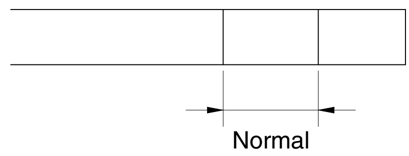


L255HS22

2) HYDRAULIC OIL

(1) Using dipstick, measure oil level, and oil if necessary.

(2) When changing hydraulic oil, clean suction strainer(screwed into outlet port pipe) and line filter(screwed into inlet pipe). Line filter uses paper element, so replace periodically(every 6 months or 1200 hours)



L15C3HS23

3) CONTROL VALVE

(1) Raise forks to maximum height and measure oil pressure.
Check that oil pressure is 190kgf/cm^2. (2700psi)

2. TROUBLESHOOTING

1) SYSTEM

Problem	Cause	Remedy
Large fork lowering speed.	· Seal inside control valve defective. · Oil leaks from joint or hose. · Seal inside cylinder defective.	· Replace spool or valve body. · Replace. · Replace packing.
Large spontaneous tilt of mast.	· Tilting backward : Check valve defective. · Tilting forward : tilt lock valve defective. · Oil leaks from joint or hose. · Seal inside cylinder defective.	· Clean or replace. · Clean or replace. · Replace. · Replace seal.
Slow fork lifting or slow mast tilting.	· Lack of hydraulic oil. · Hydraulic oil mixed with air. · Oil leaks from joint or hose. · Excessive restriction of oil flow on pump suction side. · Relief valve fails to keep specified pressure. · Poor sealing inside cylinder. · High hydraulic oil viscosity. · Mast fails to move smoothly. · Oil leaks from lift control valve spool. · Oil leaks from tilt control valve spool.	· Add oil. · Bleed air. · Replace. · Clean filter. · Adjust relief valve. · Replace packing. · Change to SAE10W, class CF engine oil. · Adjust roll to rail clearance. · Replace spool or valve body. · Replace spool or valve body.
Hydraulic system makes abnormal sounds.	· Excessive restriction of oil flow pump suction side. · Gear or bearing in hydraulic pump defective.	· Clean filter. · Replace gear or bearing.
Control valve lever is locked.	· Foreign matter jammed between spool and valve body. · Valve body defective.	· Clean. · Tighten body mounting bolts uniformly.
High oil temperature.	· Lack of hydraulic oil. · High oil viscosity. · Oil filter clogged.	· Add oil. · Change to SAE10W, class CF engine oil. · Clean filter.

2) HYDRAULIC GEAR PUMP

Problem	Cause	Remedy
Pump does not develop full pressure.	· System relief valve set too low or leaking. · Oil viscosity too low. · Pump is worn out.	· Check system relief valve for proper setting. · Change to proper viscosity oil. · Repair or replace pump.
Pump will not pump oil.	· Reservoir low or empty. · Suction strainer clogged.	· Fill reservoir to proper level. · Clean suction strainer.
Noisy pump caused by cavitation.	· Oil too thick. · Oil filter plugged. · Suction line plugged or too small.	· Change to proper viscosity. · Clean filters. · Clean line and check for proper size.
Oil heating.	· Oil supply low. · Contaminated oil. · Setting of relief valve too high or too low. · Oil viscosity too low.	· Fill reservoir to proper level. · Drain reservoir and refill with clean oil. · Set to correct pressure. · Drain reservoir and fill with proper viscosity.
Foaming oil.	· Low oil level. · Air leaking into suction line. · Wrong kind of oil.	· Fill reservoir to proper level. · Tighten fittings, check condition of line. · Drain reservoir, fill with non-foaming oil.
Shaft seal leakage.	· Worn shaft seal. · Worn shaft in seal area.	· Replace shaft seal. · Replace drive shaft and seal.

3) MAIN RELIEF VALVE

Problem	Cause	Remedy
Can't get pressure.	· Poppet D, E or K stuck open or contamination under seat.	· Check for foreign matter between poppets D, E or K and their mating parts. Parts must slide freely.
Erratic pressure.	· Pilot poppet seat damaged.	· Replace the relief valve. · Clean and remove surface marks for free movement.
Pressure setting not correct.	· Normal wear. Lock nut & adjust screw loose.	· See page 6-15 for How to set pressure on work main relief.
Leaks.	· Damaged seats. · Worn O-rings. · Parts sticking due to contamination.	· Replace the relief valve. · Install seal and spring kit. · Disassemble and clean.

4) LIFT CYLINDER

Problem	Cause	Remedy
Oil leaks out from gland through rod.	· Foreign matters on packing. · Unallowable score on rod. · Unusual distortion of dust seal. · Chrome plating is striped.	· Replace packing. · Smooth rod surface with an oil stone. · Replace dust seal. · Replace rod.
Oil leaks out from cylinder gland thread.	· O-ring damaged.	· Replace O-ring.
Rod spontaneously retract.	· Scores on inner surface of tube. · Unallowable score on the inner suface of tube. · Foreign matters in piston seal.	· Smooth rod surface with an oil stone. · Replace cylinder tube. · Replace piston seal.
Wear(clearance between cylinder tube and wear ring).	· Excessive clearance between cylinder tube and wear ring.	· Replace wear ring.
Abnormal noise is produced during tilting operation.	· Insufficient lubrication of anchor pin or worn bushing and pin. · Bent tilt cylinder rod.	· Lubricate or replace. · Replace.

GROUP 3 DISASSEMBLY AND ASSEMBLY

1. HYDRAULIC GEAR PUMP

※ **Tools required**

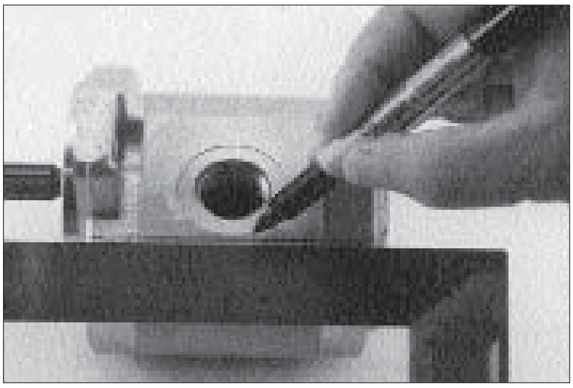
- · Metric socket set
- · Internal snap ring pliers
- · Shaft seal sleeve
- · Torque wrench

(1) It is very important to work in a clean work area when repairing hydraulic products. Plug ports and wash exterior of pump with a proper cleaning solvent before continuing.

(2) Remove port plugs and drain oil from pump.

(3) Use a permanent marker pen to mark a line across the mounting flange, gear housing and end cover. This will assure proper reassembly and rotation of pump.

(4) Remove key from drive shaft if applicable.

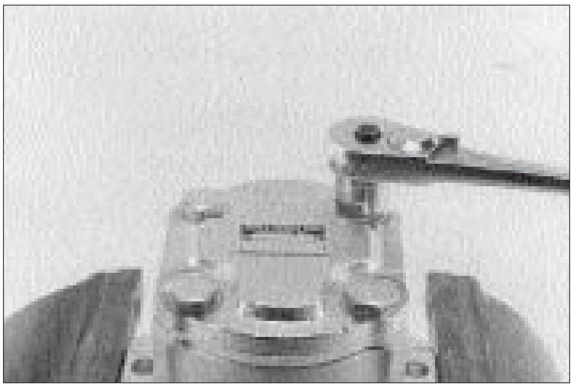


PUMP 01

(5) Clamp mounting flange in a protected jaw vise with pump shaft facing down.

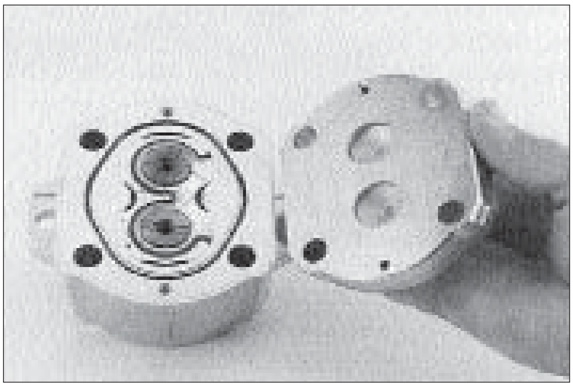
(6) Loosen the four metric hexagon head bolts.

(7) Remove pump from vise and place on clean work bench, remove the four hexagon head bolts and spacers applicable.



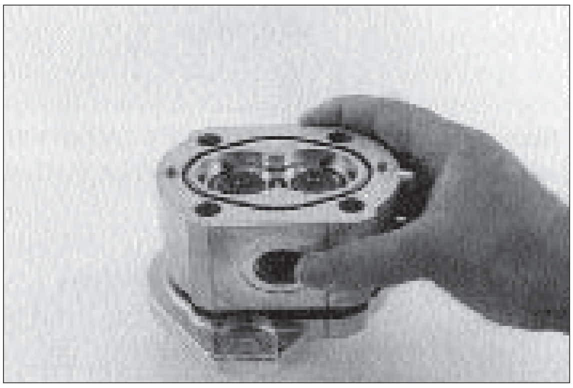
PUMP 02

(8) Lift and remove end cover.



PUMP 03

(9) Carefully remove gear housing and place on work bench. Make sure the rear bearing block remains on the drive and idler shafts.

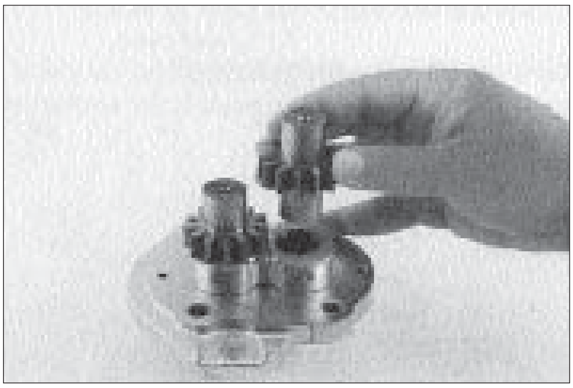


PUMP 04

(10) Remove rear bearing block from drive and idler shafts.

PUMP 05

(11) Remove idler shaft from bearing block.

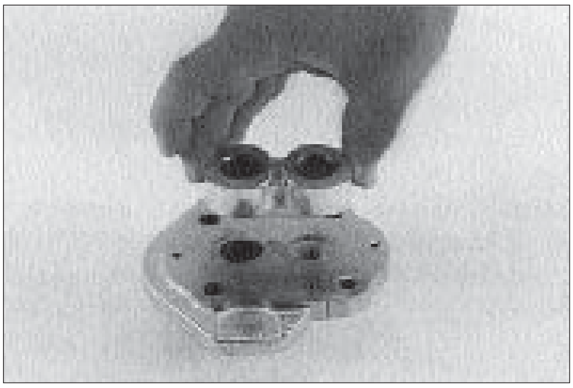


PUMP 06

(12) Remove drive shaft from mounting flange. There is no need to protect the shaft seal as it will be replaced as a new item.

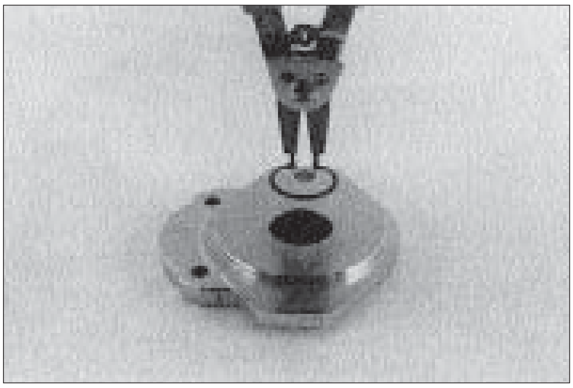
PUMP 07

(13) Remove the front bearing block.



PUMP 08

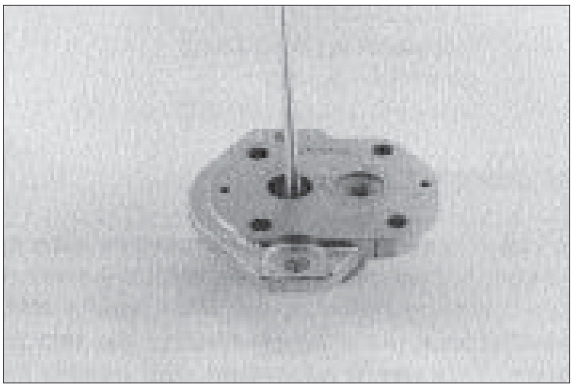
(14) Turn mounting flange over, with shaft seal up, and remove the retaining ring with proper snap ring pliers.



PUMP 09

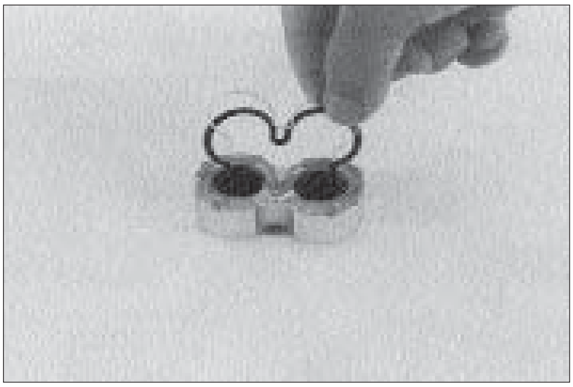
(15) Remove the oil seal from mounting flange, be careful not to mar or scratch the seal bore.

(16) Remove the dowel pins from the gear housing. Do not lose pins.



PUMP 10

(17) Remove seals from both bearing blocks and discard.



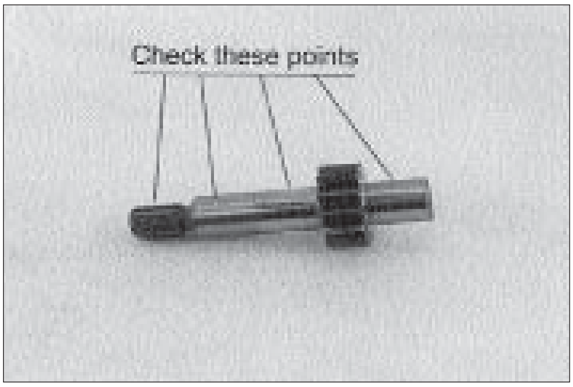
PUMP 11

2) INSPECT PARTS FOR WEAR

(1) Clean and dry all parts thoroughly prior to inspection. It is not necessary to inspect the seals as they will be replaced as new items.

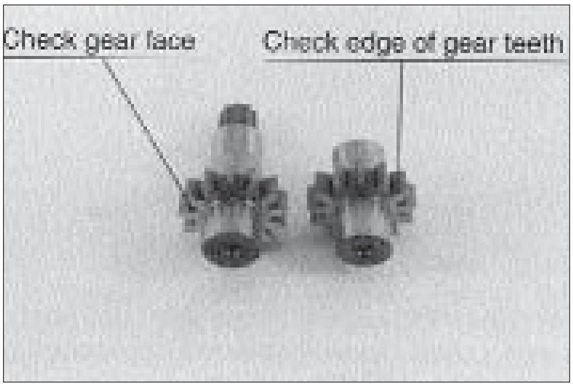
(2) Check drive shaft spline for twisted or broken teeth, check keyed drive shaft for broken or chipped keyway. No marks or grooves on shaft in seal area, some discoloration of shaft is allowable.

(3) Inspect both the drive gear shaft and idler gear shafts at the bearing points and seal area for rough surfaces and excessive wear.



PUMP 12

(4) Inspect gear face for scoring or excessive wear. If the face edge of gear teeth are sharp, they will mill into the bearing blocks. If wear has occurred, the parts are unusable.



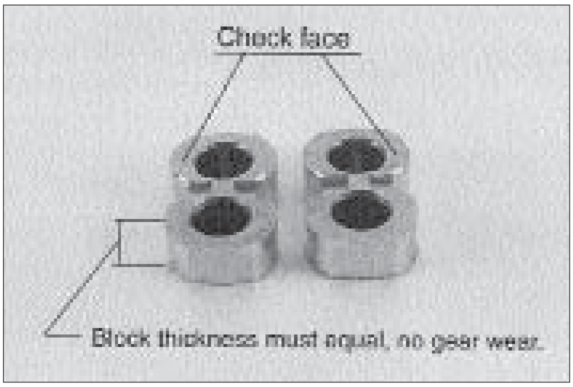
PUMP 13

(5) Inspect bearing blocks for excessive wear or scoring on the surfaces which are in contact with the gears. Also inspect the bearings for excessive wear or scoring.

(6) Inspect the area inside the gear housing. It is normal for the surface inside the gear housing to show a clean "wipe" on the inside surface on the intake side. There should not be excessive wear or deep scratches and gouges.

※ General information
It is important that the relationship of the mounting flange, bearing blocks and gear housing is correct. Failure to properly assemble this pump will result with little or no flow at rated pressure.

※ This pump is not bi-rotational.

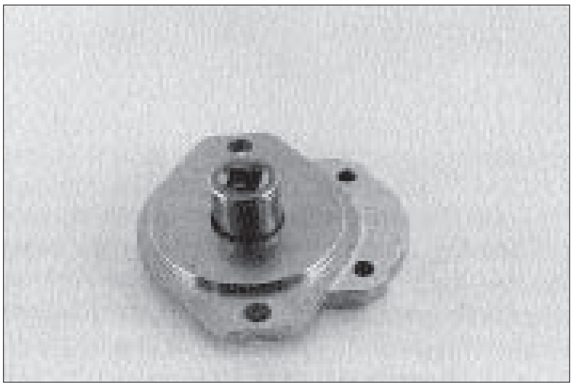


PUMP 14

3) ASSEMBLY

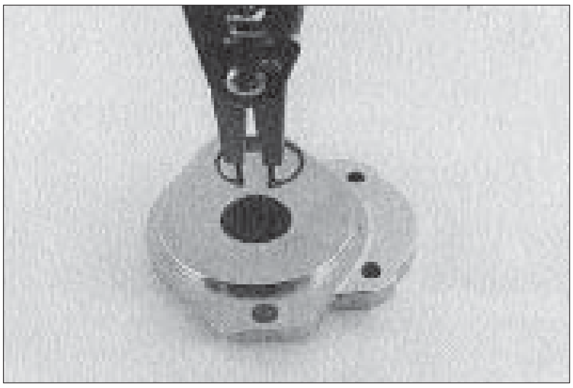
※ **New seals should be installed upon reassembly of pump.**

(1) Install new shaft seal in mounting flange with part number side facing outboard. Press the seal into the seal bore until the seal reaches the bottom of the bore. Uniform pressure must be used to prevent misalignment or damage to the seal.



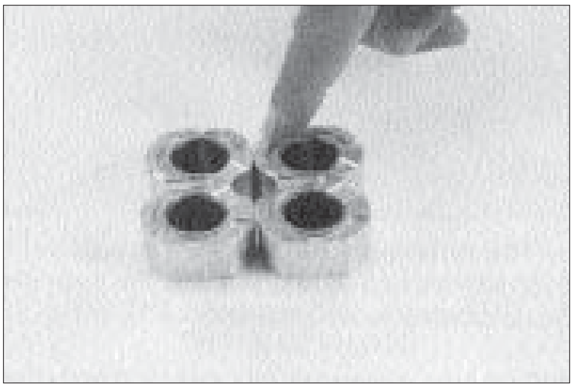
PUMP 15

(2) Install retaining ring in groove in seal bore of mounting flange.



PUMP 16

(3) Place front and back bearing blocks on a clean surface with the E-seal grooves facing up. Apply a light coating of petroleum jelly in the grooves. Also coat the E-seal and backup with the petroleum jelly, this will help keep the seals in place during assembly.

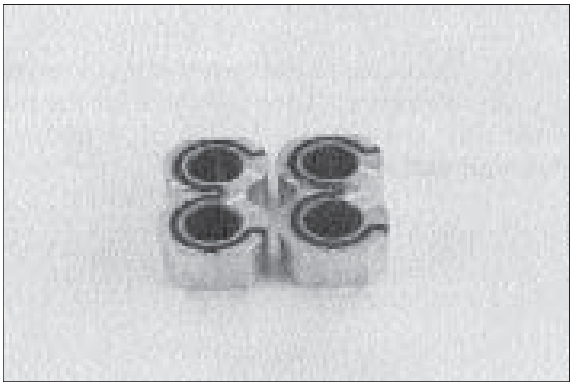


PUMP 17

(4) Place the E-seals, flat side outward, into the grooves in both bearing blocks. Follow by carefully placing the backup ring, flat side outward, in the groove made by the E-seal and the groove in the bearing block.

(5) Place mounting flange, with shaft seal side down, on a clean flat surface.

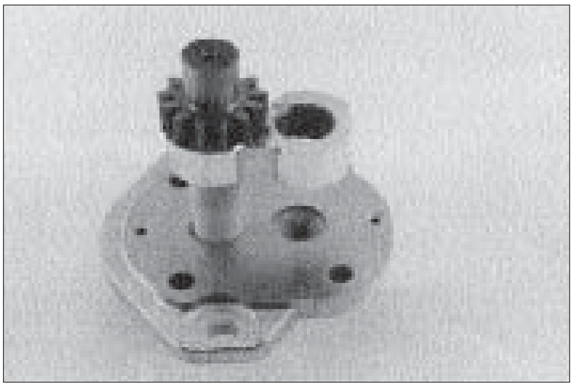
(6) Apply a light coating of petroleum jelly to the exposed face of the front bearing block.



PUMP 18

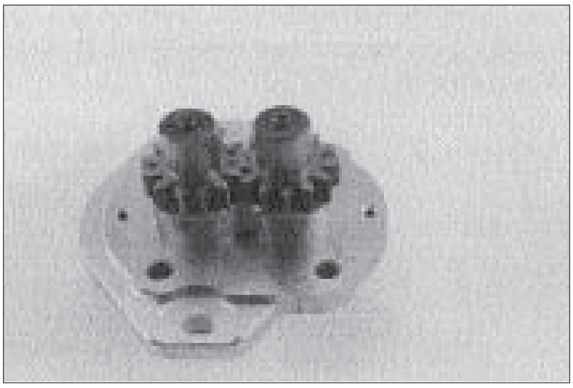
(7) Insert the drive end of the drive shaft through the bearing block with the seal side down, and the open side of the E-seal pointing to the intake side of the pump.

(8) Install the seal sleeve over the drive shaft and carefully slide the drive shaft through the shaft seal. Remove the seal sleeve from shaft.



PUMP 19

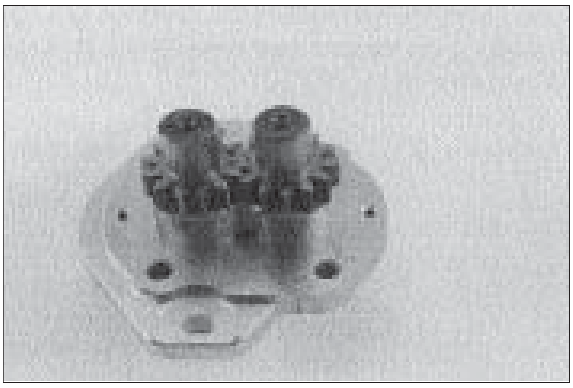
(9) Install the idler gear shaft in the remaining position in the bearing block. Apply a light coat of clean oil to the face of the drive and idler gears.



PUMP 20

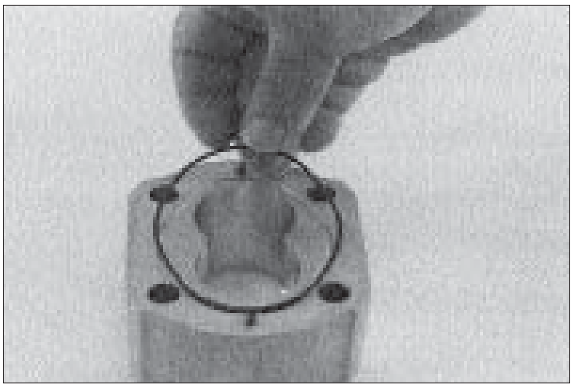
(10) Pick up the rear bearing block, with seal side up and with open end of the E-seal facing the intake side of the pump, place over the drive and idler gear shafts.

(11) Install two dowel pins in the holes in the mounting flange or two long dowel pins through gear housing if pump is a multiple section pump.



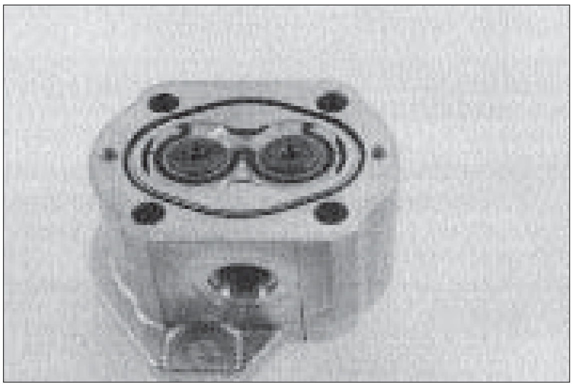
PUMP 21

(12) To install the O-rings in the gear housing, apply a light coating of petroleum jelly in the grooves on both sides of the gear housing.
Also coat the new O-ring and install them in the grooves.



PUMP 22

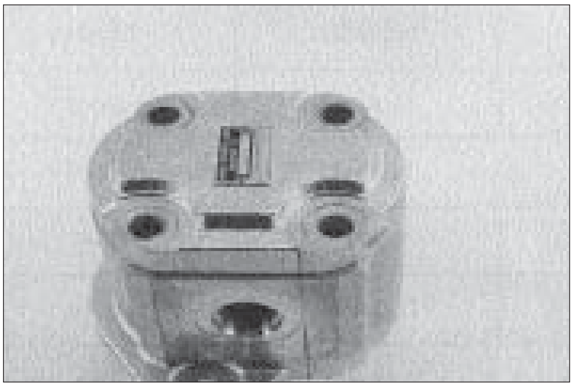
(13) Gently slide the gear housing over the rear bearing block assembly, slide housing down until the housing engages the dowel pins. Press firmly in place with hands, do not force or use any tool. Check to make sure the intake port in the housing in on the same side as the open end of the E-seal and that the marked lines on the mounting flange and gear housing are in alignment.



PUMP 23

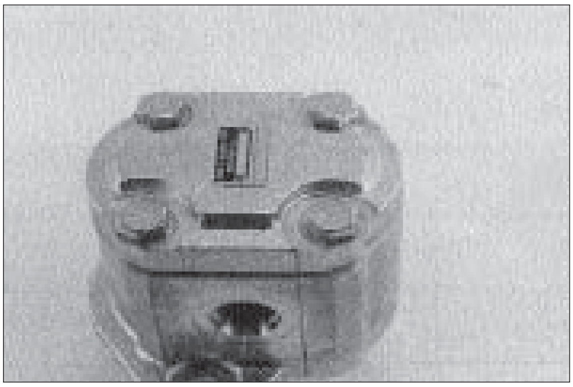
(14) The surface of the rear bearing block should be slightly below the face of the gear housing. If the bearing block sits higher then the rear face of the gear housing then the E-seal or O-ring have shifted out of the groove. If this is the case, remove the gear housing and check for proper seal installation.

(15) Install the two remaining dowel pins in the rear of the gear housing and place the end cover over the back of the pump.



PUMP 24

(16) Install the four spacers and hexagon head bolts through the bolt holes in the end cover, hand tighten.

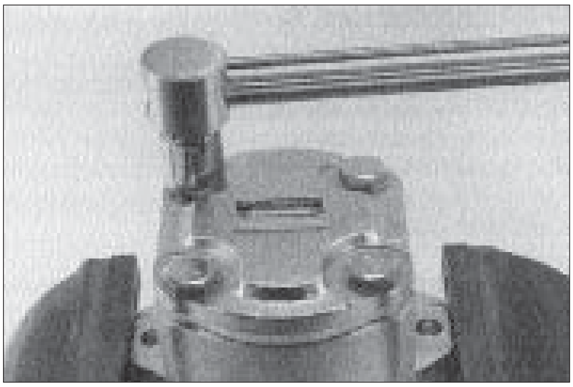


PUMP 25

(17) Place mounting flange of the pump back in the protected jawed vise and alternately torque the bolts.
  · Tighten torque : 3.0~4.0kgf · m
  (22~29lbf · ft)

(18) Remove pump from vise.

(19) Place a small amount of clean oil in the inlet of the pump and rotate the drive shaft away from the inlet one revolution. If the drive shaft binds, disassemble the pump and check for assembly problems, then reassemble the pump.



PUMP 26

2. MAIN CONTROL VALVE

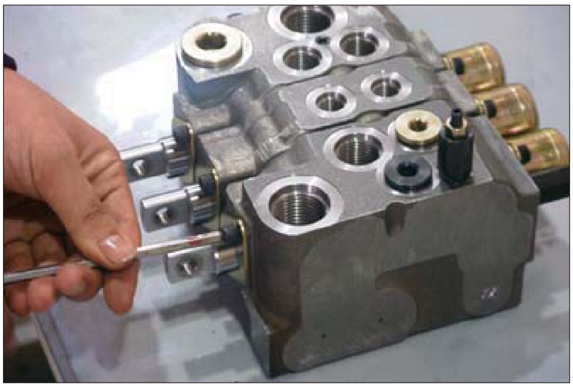
1) DISASSEMBLY

※ All hydraulic components are manufactured to a high precision. Consequently before disassembling or assembling, it is essential to select an especially clean place.

⚠ In handling a control valve, pay full attention to prevent dust, sand, etc. from entering into it.

D255CV24

(1) Loosen socket bolts from the valve and then remove seal plate and dust wiper.



D255CV23

(2) Remove seal plate, dust wiper and O-ring in order from the opposite side of return cap.

D255CV22

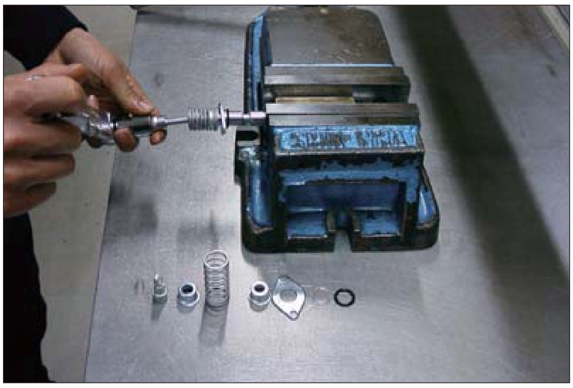
(3) Loosen socket bolt fixing the return cap from the return spring side of spool assembly.

D255CV21

(4) Pull out spool assembly from the block.

D255CV20

(5) Using a jig, vise the spool assembly. Remove spring seat, spring, seal, plate, dust wiper and O-ring from the spool assembly.

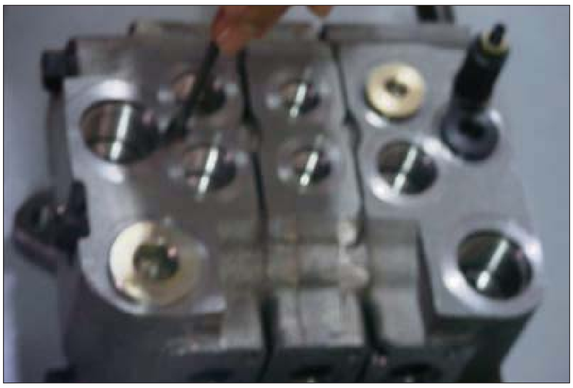


D255CV19

(6) Loosen blind plugs.

D255CV18

(7) Loosen blind plugs.



D255CV17

(8) Loosen plugs.

D255CV16

(9) Loosen hydrostat plug, spring and sleeve from the inlet block.

※ **When disassembling sleeve, use a forceful magnet.**

D255CV15

(10) Remove secondary relief valve.

D255CV14

(11) Remove spring and relief assembly.

D255CV13

(12) Remove pilot poppet.

D255CV12

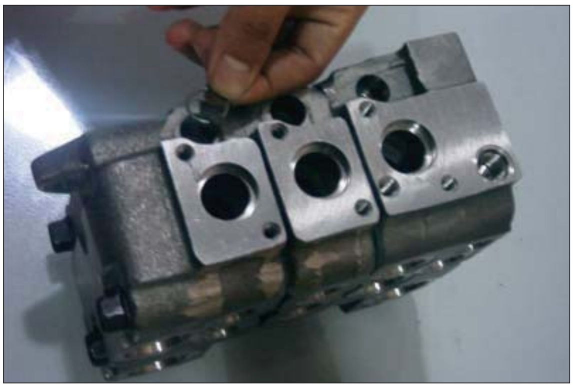
(13) Remove relief valve assembly and then disassemble relief assembly, relief spring, pilot poppet in order from the relief valve assembly.

D255CV11

(14) When removing C-ring, as the picture, using a thin and soft tool, push up the C-ring out of block.

D255CV10

(15) Remove another C-rings.
※ Check the C-ring's cut side faces to block's center line.



D255CV09

(16) Remove adjust plug from the block.

D255CV08

(17) C-ring and adjuster assembly and disassembly tool.

D255CV06

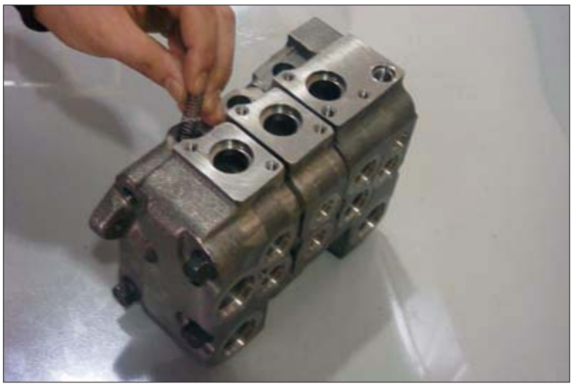
(18) For easy reassembly, check out the direction of adjuster.

D255CV07

(19) For easy reassembly, check out the direction of adjuster.

D255CV05

(20) Remove spring.



D255CV04

(21) Remove poppet.

D255CV03

(22) Procedure from (14) to (21) is load check valve disassembly.
Remove O-ring and back up ring from adjust plug.

D255CV02

(23) Separate inlet block, mid block and outlet block each other by loosening the long socket bolts from the block assembly.

D255CV01

2) ASSEMBLY

(1) With socket bolts fasten inlet block, mid block and outlet block into one block.

· Tightening torque : 5.0kgf · m(36.2lbf · ft)

D255CV01

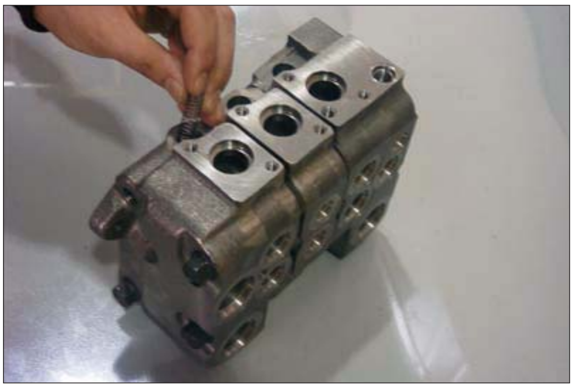
(2) Assemble load check valve in the order of poppet, spring, adjuster, adjust plug and C-ring.

D255CV02

(3) Install poppet into load check valve hole.

D255CV03

(4) Install spring into load check valve hole.



D255CV04

(5) Install adjuster into load check valve hole.

D255CV05

(6) A tool for disassembly and assembly of C-ring or adjuster.
When assembling adjuster, push one of two adjuster wings into the groove of block and then the other in a same method.

D255CV06

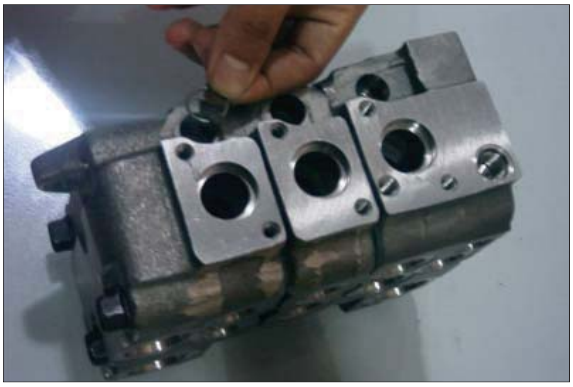
(7) Assemble adjuster with attention of the direction of wings.

D255CV07

(8) Assemble adjuster plug into load check valve hole.

D255CV08

(9) Install C-ring into load check valve hole so that cut side can face the center line of the block.



D255CV09

(10) Assemble relief valve assembly.

D255CV11

(11) Install pilot poppet into relief valve hole.

D255CV12

(12) Install spring and relief assembly into relief valve hole.
  · Tightening torque : 2.5kgf · m(18.1lbf · ft)

D255CV13

(13) Install secondary relief valve.

· Tightening torque : 2.5kgf · m(18.1lbf · ft)

D255CV14

(14) Assemble hydrostat assembly in the order of hydrostat sleeve, spring and plug.

※ **Check the direction of sleeve.**

※ **Use a forceful magnet to pull out the sleeve.**

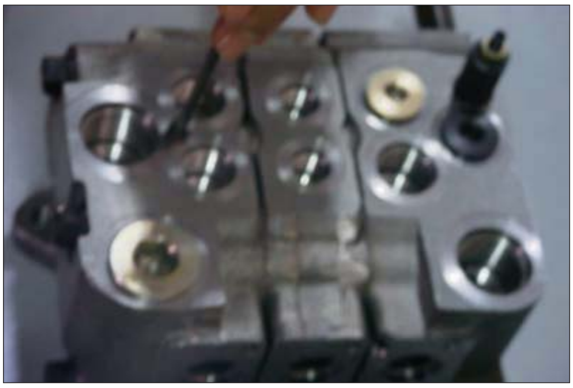
D255CV15

(15) Install plug.

· Tightening torque : 7.0kgf · m(50.6lbf · ft)

D255CV16

(16) Install blind plug.



D255CV17

(17) Using a jig, vise a spool assembly. Assemble in the order of O-ring, dust wiper, seal plate, spring seat, and plug of each spool.
  · Tightening torque : 2.0kgf · m(14.5lbf · ft)

D255CV19

(18) Install spool assembly into the block assembly.

D255CV20

(19) Cover the return cap onto the return spring side of spool assembly and then tighten the socket bolt as following torque.
  · Tightening torque : 1.2kgf · m

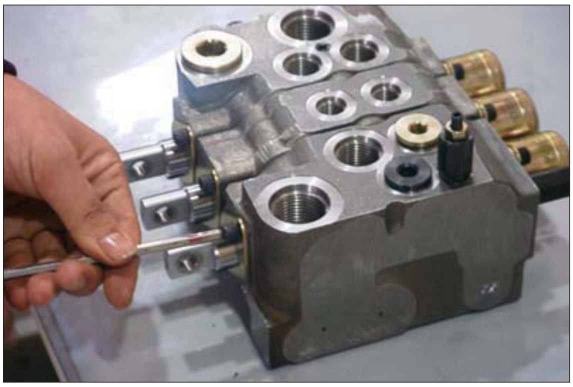
D255CV21

(20) On the opposite side of the return cap, install O-ring, dust wiper and seal plate to the spool in order.

D255CV22

(21) After assembling seal plate tighten socket bolt as following torque.

- · Tightening torque : 1.2kgf · m(8.7lbf · ft)
- · Install dust wiper so as lip side to face outside.



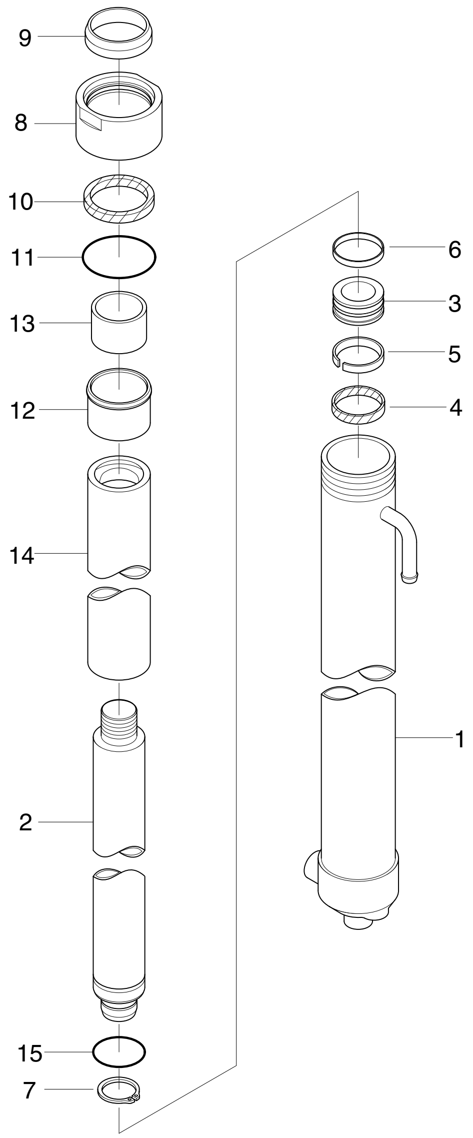
D255CV23

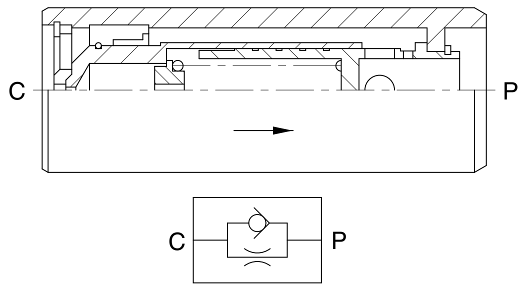
(22) This is complete assembly procedure.

D255CV24

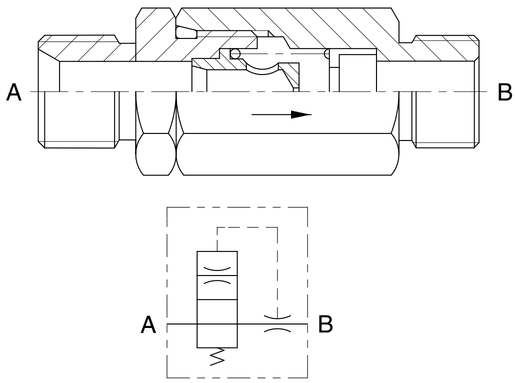
3. LIFT CYLINDER

1) STRUCTURE





Down control valve



Down safety valve

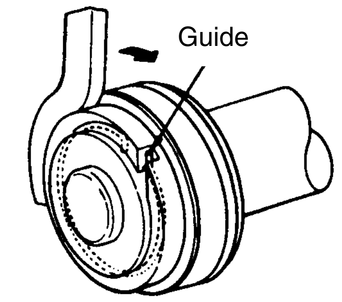
- I.D × O.D × Stroke : 50 × 58 × 1630mm
  (2.0 × 2.3 × 64.2 in)
- Rod O.D : 40mm (1.6 in)

D255HS24

1	Tube assy	6	Wear ring	11	O-ring
2	Rod assy	7	Retaining ring	12	Guide
3	Piston	8	Gland	13	Du bushing
4	Piston seal	9	Dust wiper	14	Spacer
5	Back up ring	10	Rod seal	15	O-ring

2) DISASSEMBLY

(1) Hold the cylinder tube in a vice, loosen the cylinder head and remove it.
Remove the spacer from the cylinder tube and knock out the bushing. Hook a wrench in the hole in the retainer at the piston end and turn. Lever up the edge of the guide, then turn the guide in again and the guide can be removed.



L15C3HS25

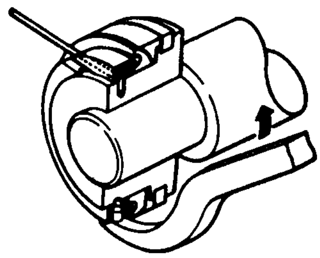
3) CHECK AND INSPECTION

mm(in)

Check item	Standard size	Repair limit	Remedy
Clearance between cylinder rod & bushing	0.072~0.288 (0.003~0.011)	0.5 (0.020)	Replace bushing
Clearance between piston ring & tube	0.05~0.030 (0.002~0.012)	0.5 (0.020)	Replace piston ring

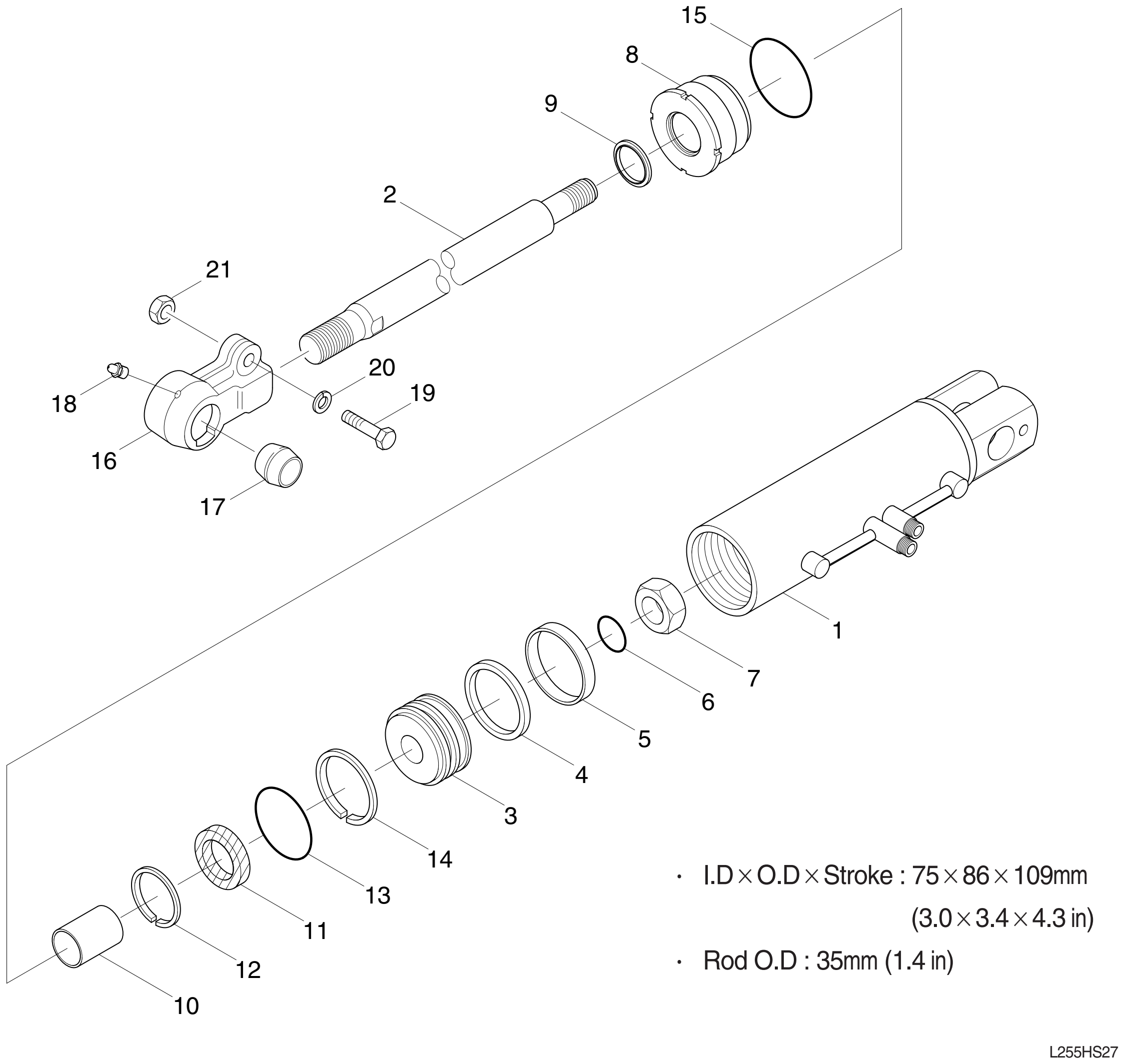
4) ASSEMBLY

(1) Soak the piston ring in hydraulic oil at a temperature of 40 to 50° C, expand the inside diameter and assemble on the piston. Install a piston seal.
Bend the edge of the guide and rotate it to install the guide completely.


L15C3HS26

4. TILT CYLINDER

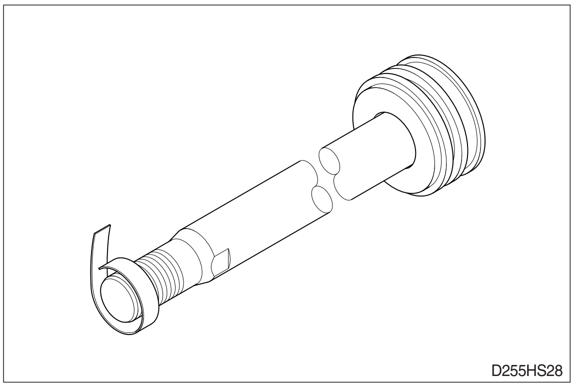
1) STRUCTURE



1	Tube assy	8	Rod cover	15	O-ring
2	Rod	9	Dust wiper	16	Eye
3	Piston	10	DU bushing	17	Bushing
4	Piston seal	11	Rod seal	18	Grease nipple
5	Wear ring	12	Back up ring	19	Hexagon bolt
6	O-ring	13	O-ring	20	Spring washer
7	Nylon nut	14	Back up ring	21	Hexagon nut

2) DISASSEMBLY

(1) Hold the parallel parts of the cylinder tube bottom in a vice and mark the rod head end to show how much it is screwed in, then remove the rod head. Next, hook a wrench into the notch at the cylinder head and remove the cylinder head from cylinder tube.
When doing this, wind tape round the threaded part of the rod and be careful not to damage the dust seal and rod seal inside cylinder head.


D255HS28

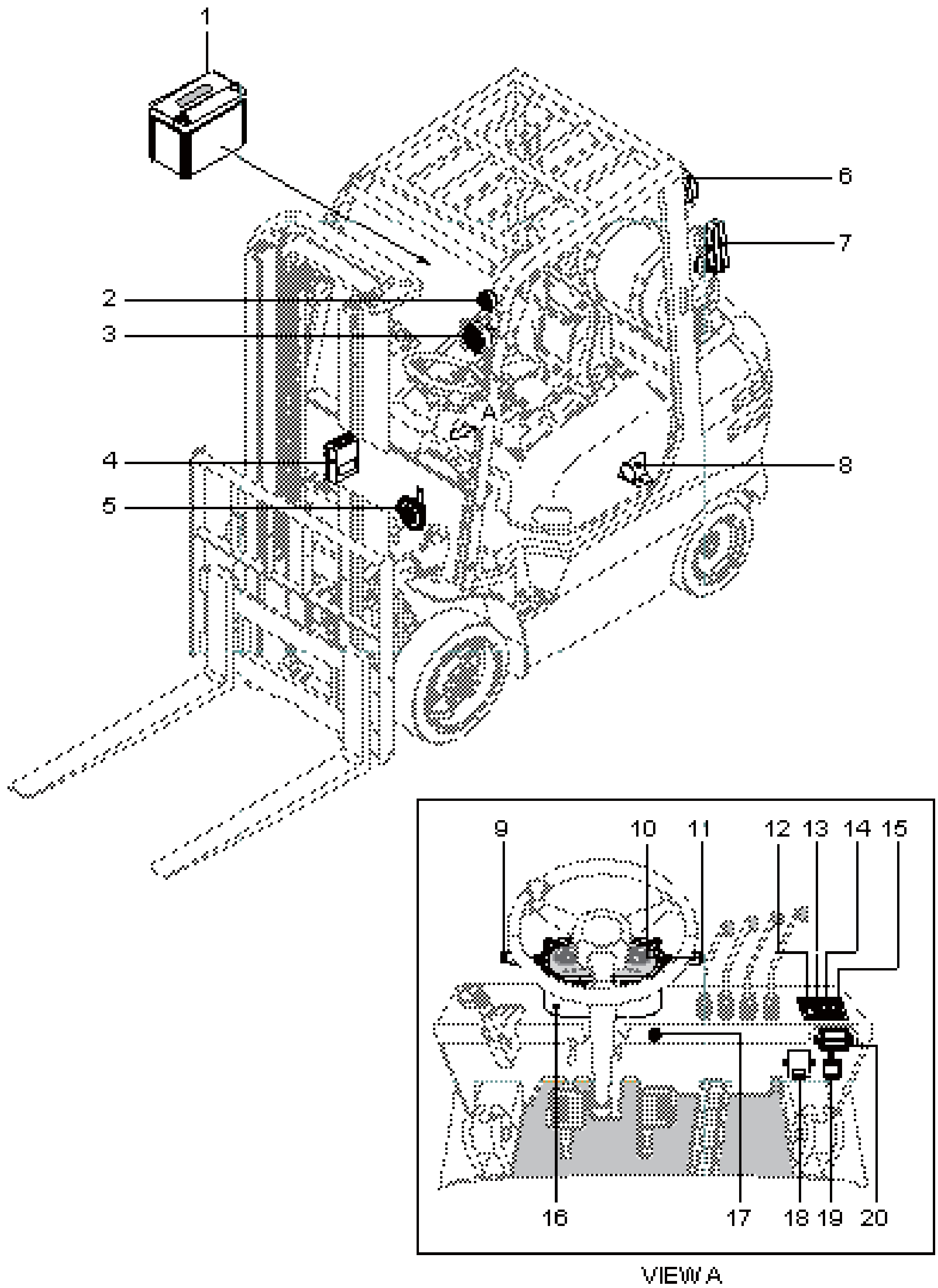
3) CHECK AND INSPECTION

mm(in)

Check item	Standard size	Repair limit	Remedy
Clearance between cylinder rod & bushing	0.072~0.288 (0.003~0.011)	0.5 (0.020)	Replace bushing
Clearance between rod head bushing & pin	0.10~0.35 (0.004~0.014)	0.6 (0.024)	Replace bushing

SECTION 7 ELECTRICAL SYSTEM

GROUP 1 COMPONENT LOCATION

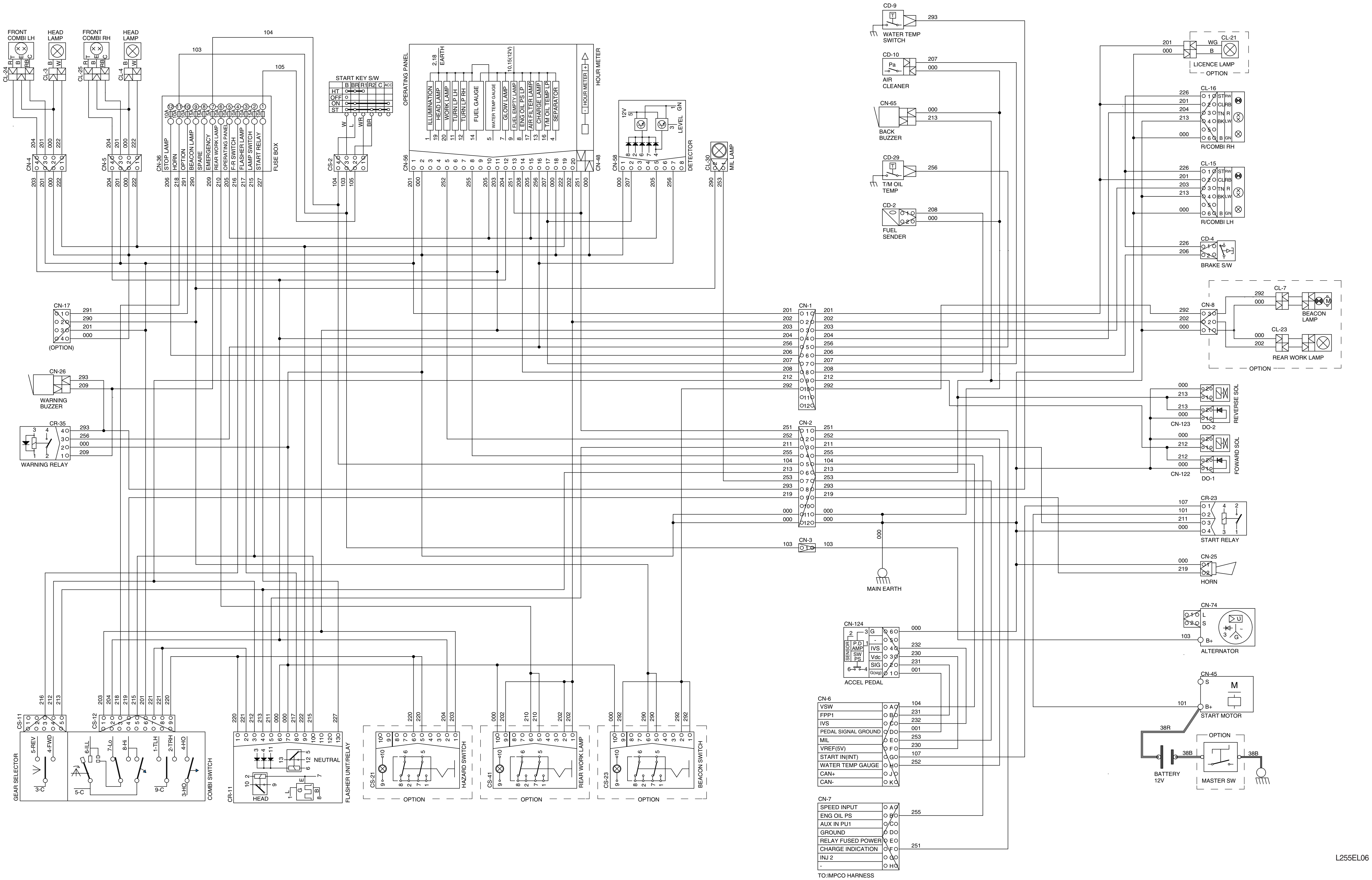


L255EL01

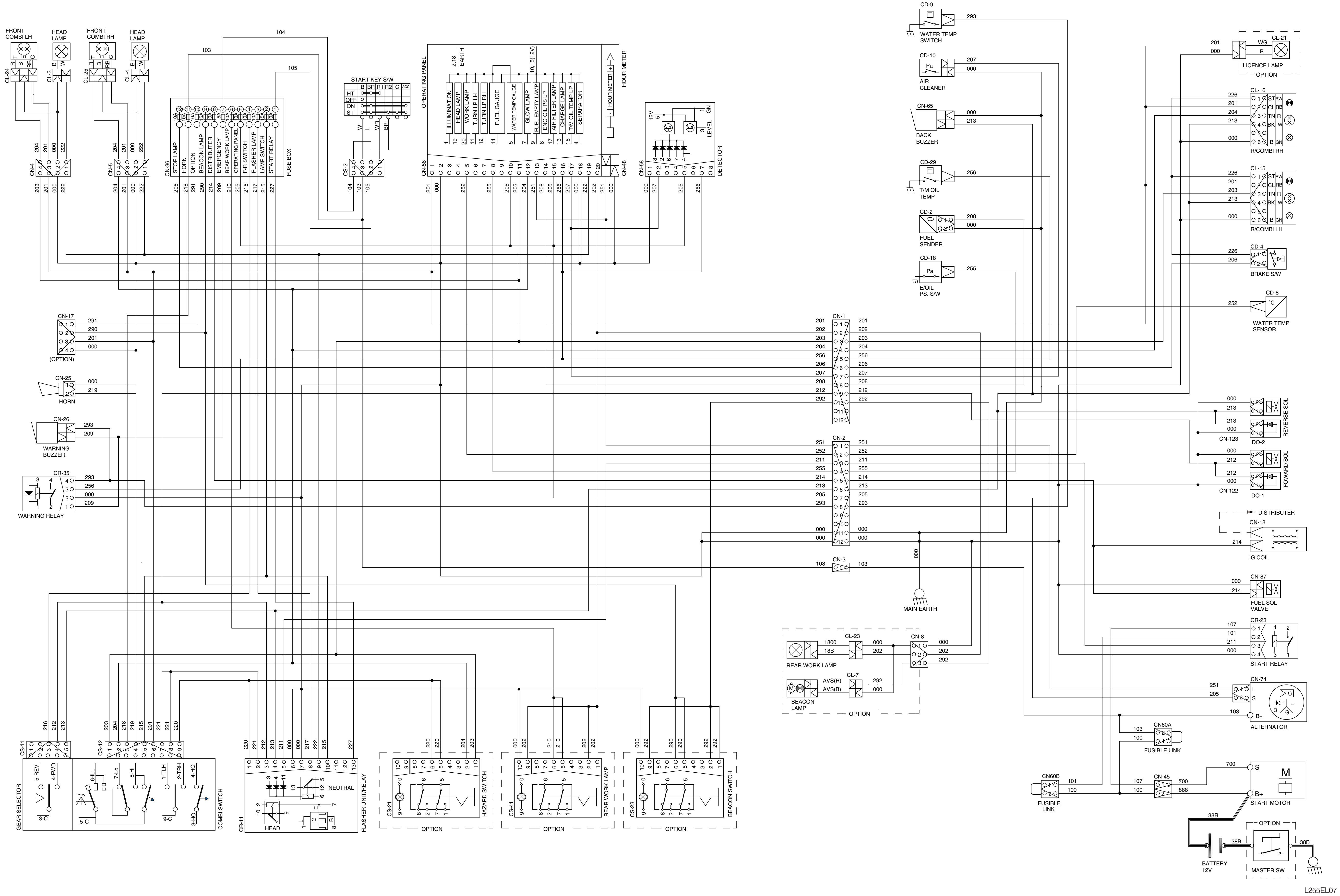
1	Battery	8	Back buzzer	15	Beacon switch(Option)
2	Flasher lamp	9	Gear selector	16	Operating panel
3	Head lamp	10	Combination switch	17	Start switch
4	Controller(IMPCO)	11	Horn button	18	Flasher relay
5	Horn assembly	12	Malfunction indicator lamp(MIL)	19	Detector
6	Rear work lamp(Option)	13	Rear work lamp switch(Option)	20	Fuse box
7	Combination lamp	14	Hazard switch(Option)		

GROUP 2 ELECTRICAL CIRCUIT

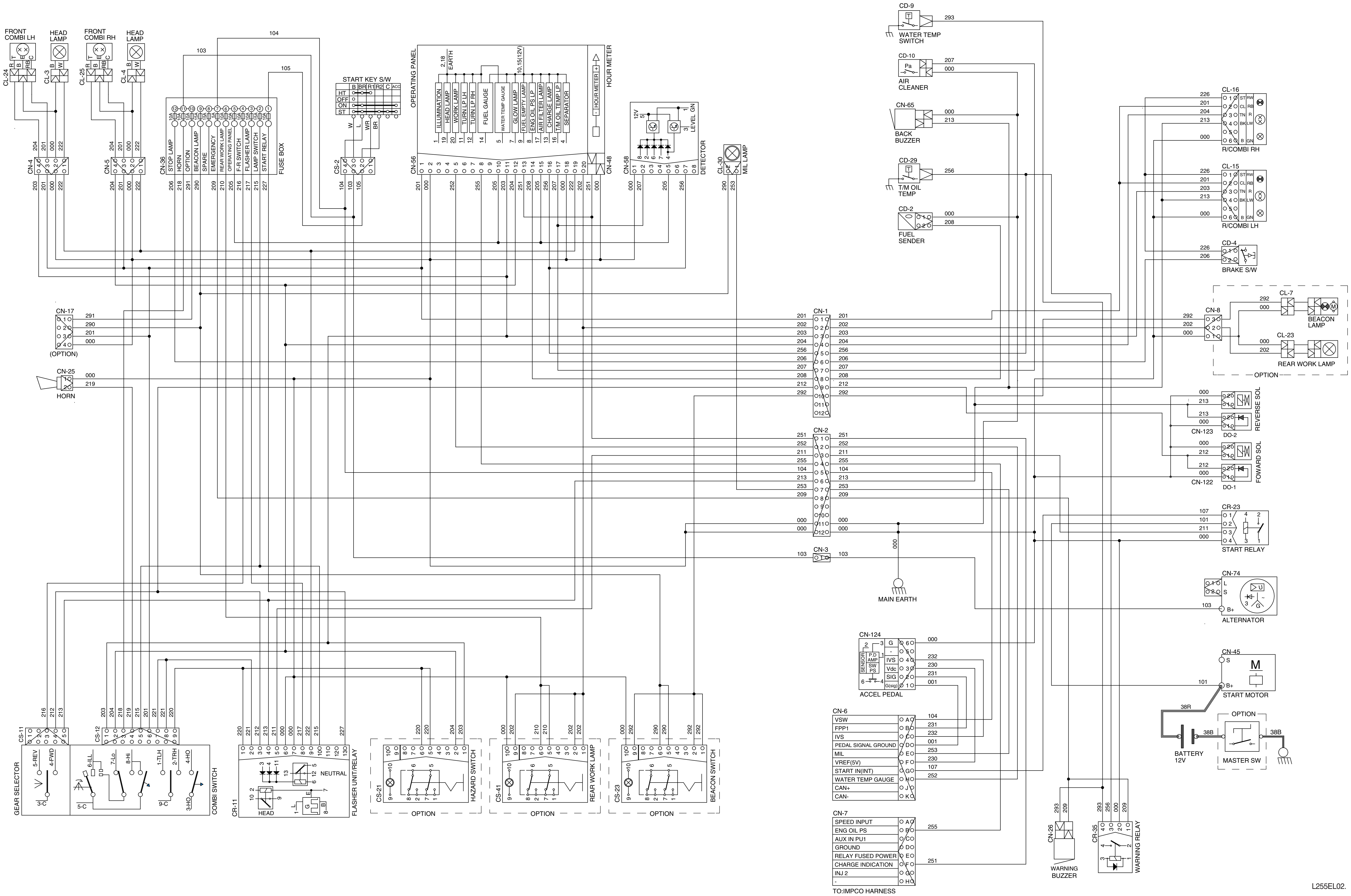
1. HLF20/25/30-5(Tier II)



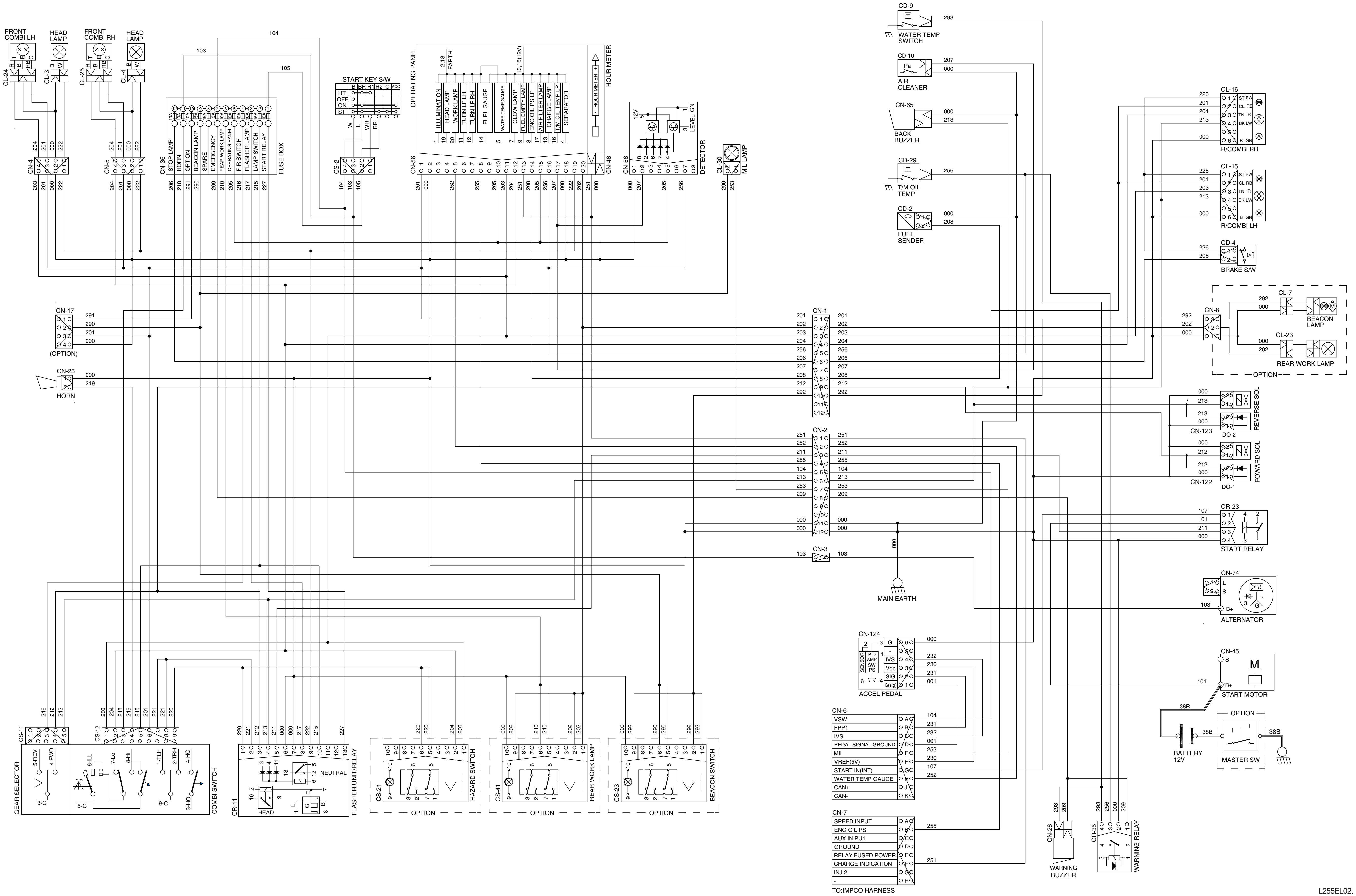
2. HLF20/25/30-5(Non-Emission)



3. HLF20/25/30C-5(Tier II)



4. OPSS (Operator Presence Sensing System)



1. POWER CIRCUIT

The negative terminal of the battery is grounded to the machine chassis.
When the start switch is in the off position, the current flows from the positive battery terminal.

1) OPERATING FLOW

(1) Tier II engine

Battery(+) → Start motor[CN-45(B+)] → Start relay[CR-23(2)]
→ Alternator[CN-74(B+)] → I/conn[CN-3] →
→ I/conn[CS-2(3)] → Start switch OFF
→ Fuse box[CN-36] →
→ Fuse box(No.12) → I/conn[CN-1(6)]
→ Brake switch[CD-4(2)→(1)] →
→ Rear combi switch[CL-16(1)]
→ Rear combi switch[CL-15(1)]
→ Fuse box(No.11) → Combi switch[CS-12(3)→(4)]
→ Horn[CN-25(2)]
→ Fuse box(No.10) → I/conn[CN-17(1)]

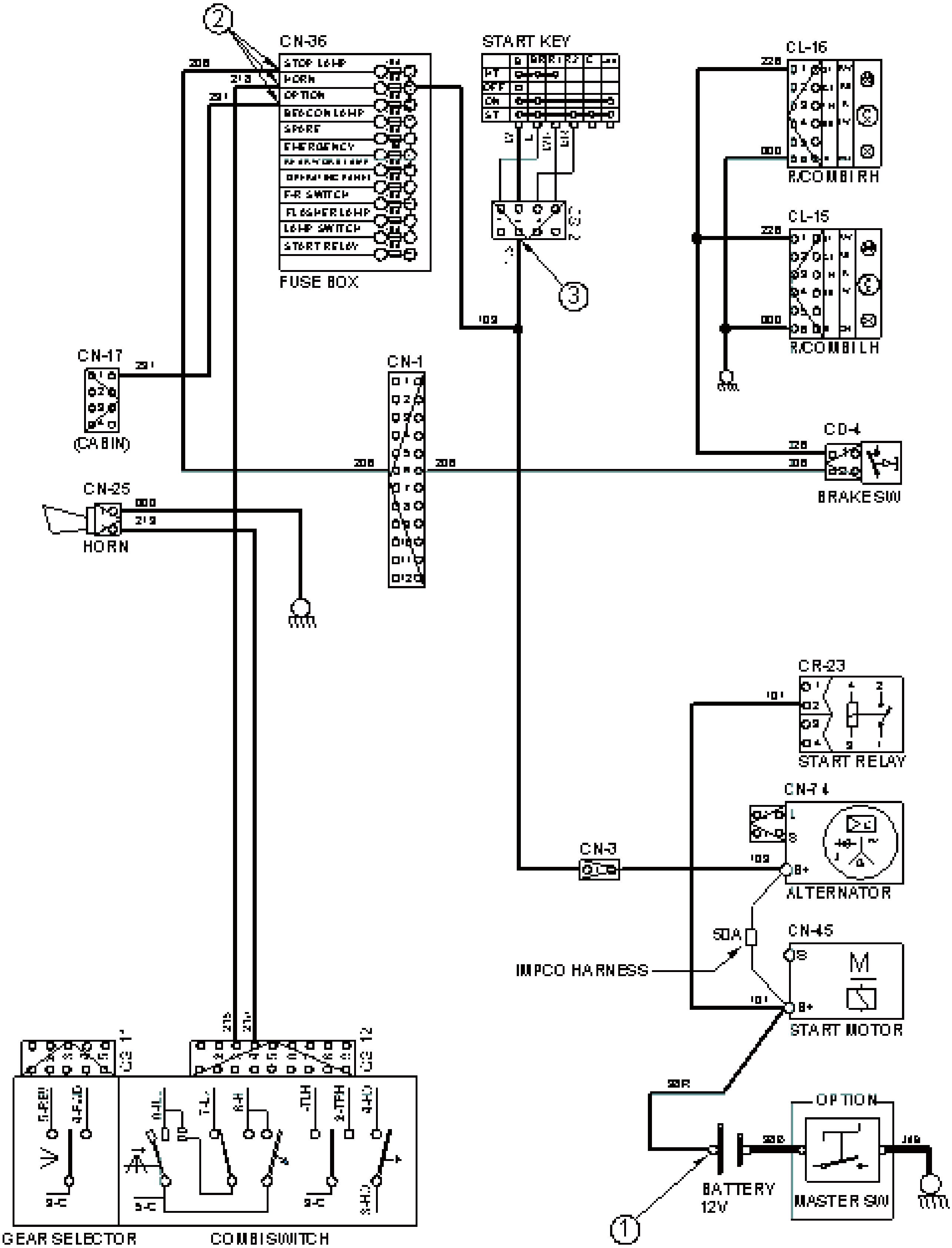
(2) Non-Emission engine

Battery(+) terminal → Start motor[CN-45(B+)] → I/conn[CN-45(2)]
→ Fusible link[CN-60B(1→2)] → Start relay[CR-23(2)]
→ Fusible link[CN-60A(1→2)] →
→ Altercnator[CN-74(B+)
→ I/conn[CN-3] → I/conn[CS-2(3)] → Start switch OFF
→ Fuse box[CN-36] →
→ Fuse box(No.12) → I/conn[CN-1(6)]
→ Brake switch[CD-4(2)→(1)] →
→ Rear combi switch[CL-16(1)]
→ Rear combi switch[CL-15(1)]
→ Fuse box(No.11) → Combi switch[CS-12(3)→(4)]
→ Horn[CN-25(2)]
→ Fuse box(No.10) → I/conn[CN-17(1)]

2) CHECK POINT

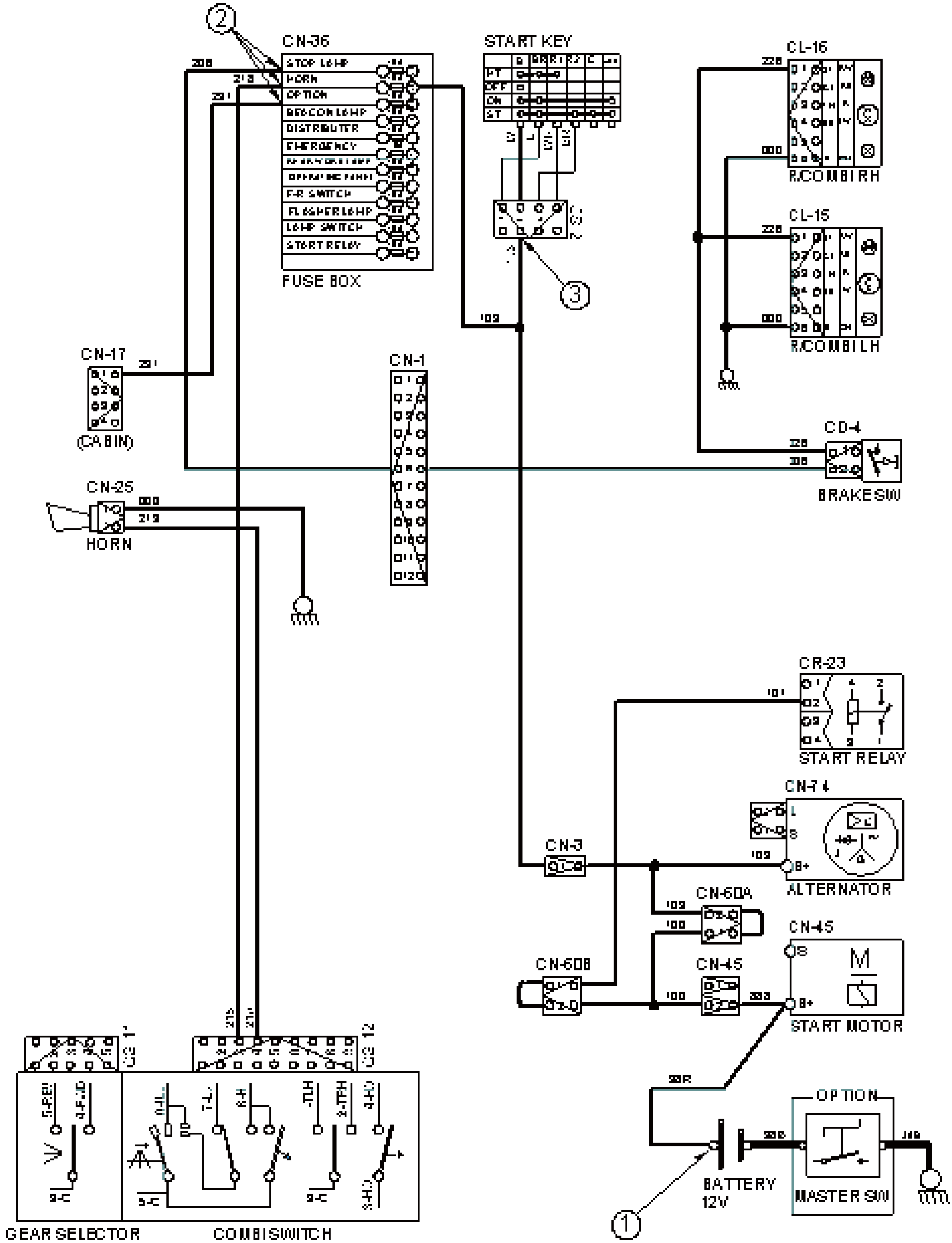
Engine	Key switch	Check point	Voltage
OFF	OFF	① - GND (Battery(+)) ② - GND (Fuse No.10, 11, 12) ③ - GND (Start key)	10 ~ 13V

POWER CIRCUIT(TIER II)



L255EL03

POWER CIRCUIT(NON-EMISSION)



L255EL03-1

2. STARTING CIRCUIT

1) OPERATING FLOW

(1) Tier II engine

Battery(+) terminal → Start motor[CN-45(B+)] → Start relay[CR-23(2)] →
→ Alternator[CN-74(B+)] → I/conn[CN-3]
→ Start switch[CS-2(3)]

※The engine can be started only when the gearshift lever is in neutral position.

① When start key switch is in ON position

Start switch ON [CS-2(4)] → Fuse box[No. 7→4] → Gear selector[CS-11(3)]
→ I/conn[CN-2(5)] → I/conn[CN-6(A)]

② When start key switch is START position

Start switch START[CS-2(2)] → Fuse box[CN-36(1)] → Flasher unit/Relay[CR-11(13)→(5)]
→ I /conn[CN-2(3)] → Start relay[CR-23(3)→(1)] → I/conn[CN-6(G)] → Starter

(2) Non-Emission engine

Battery(+) terminal → Start motor[CN-45(B+)] → I/conn[CN-45(2)] →
→ Fusible link[CN-60(A)] → Altemator[CN-74(B+)]
→ I/conn[CN-3] → Start switch[CS-2(3)]
→ Fusible link[CN-60(B)] → Start relay[CR-23(2)]

※The engine can be started only when the gearshift lever is in neutral position.

① When start key switch is in ON position

Start switch ON[CS-2(4)] → Fuse box[No.7→4] → Gear selector[CS-11(3)]
→ Fuse box[No.7→8] → I/conn[CN-2(5)] → IG coil[CN-18]
→ Fuel sol valve[CN-87]

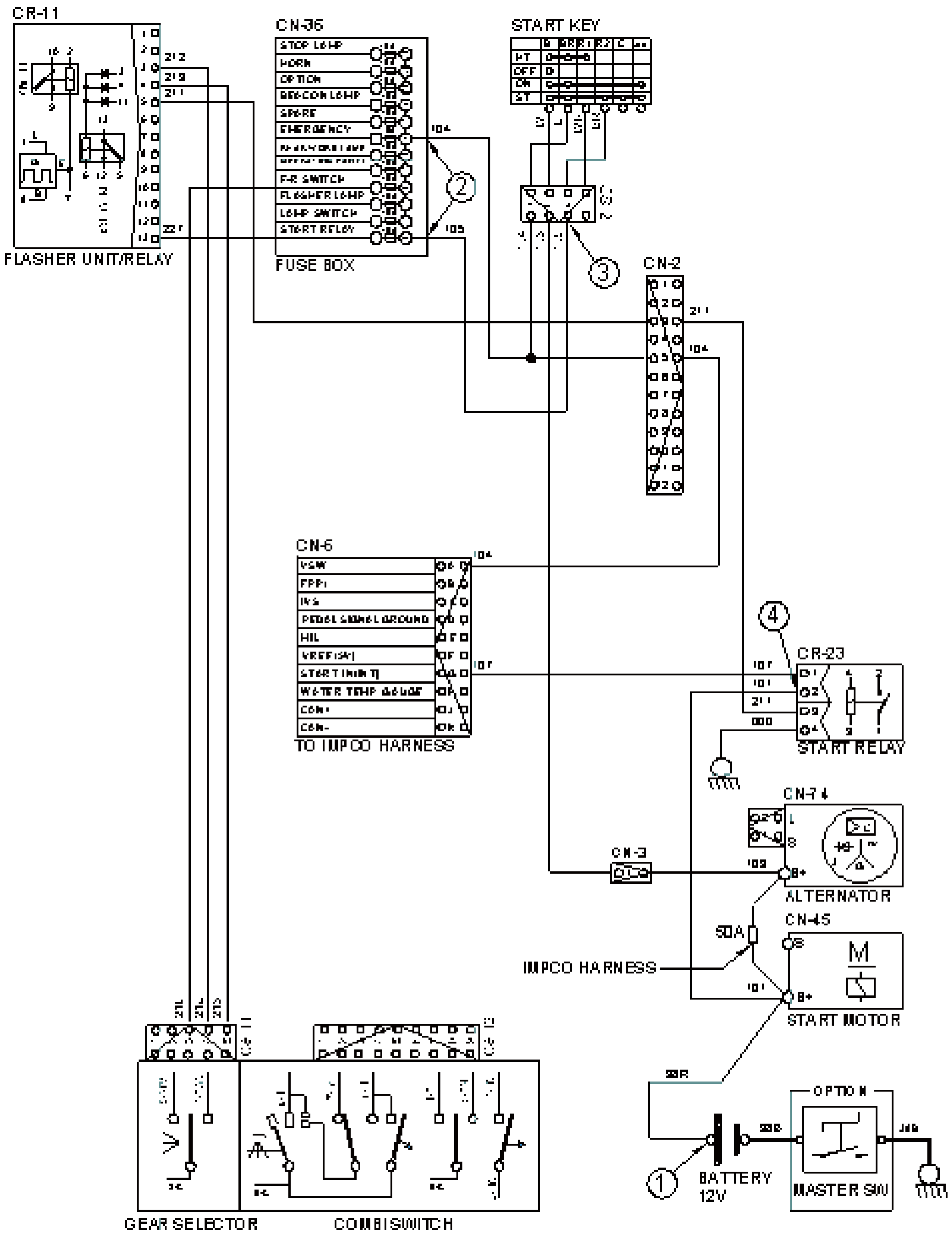
② When start key switch is START position

Start switch START[CS-2(2)] → Fuse box[CN-36(1)] → Flasher unit/Relay[CR-11(13)→15]
→ I/conn[CN-2(3)] → Start relay[CR-23(3)→(1)] → I/conn[CN-45(1)] → Starter

2) CHECK POINT

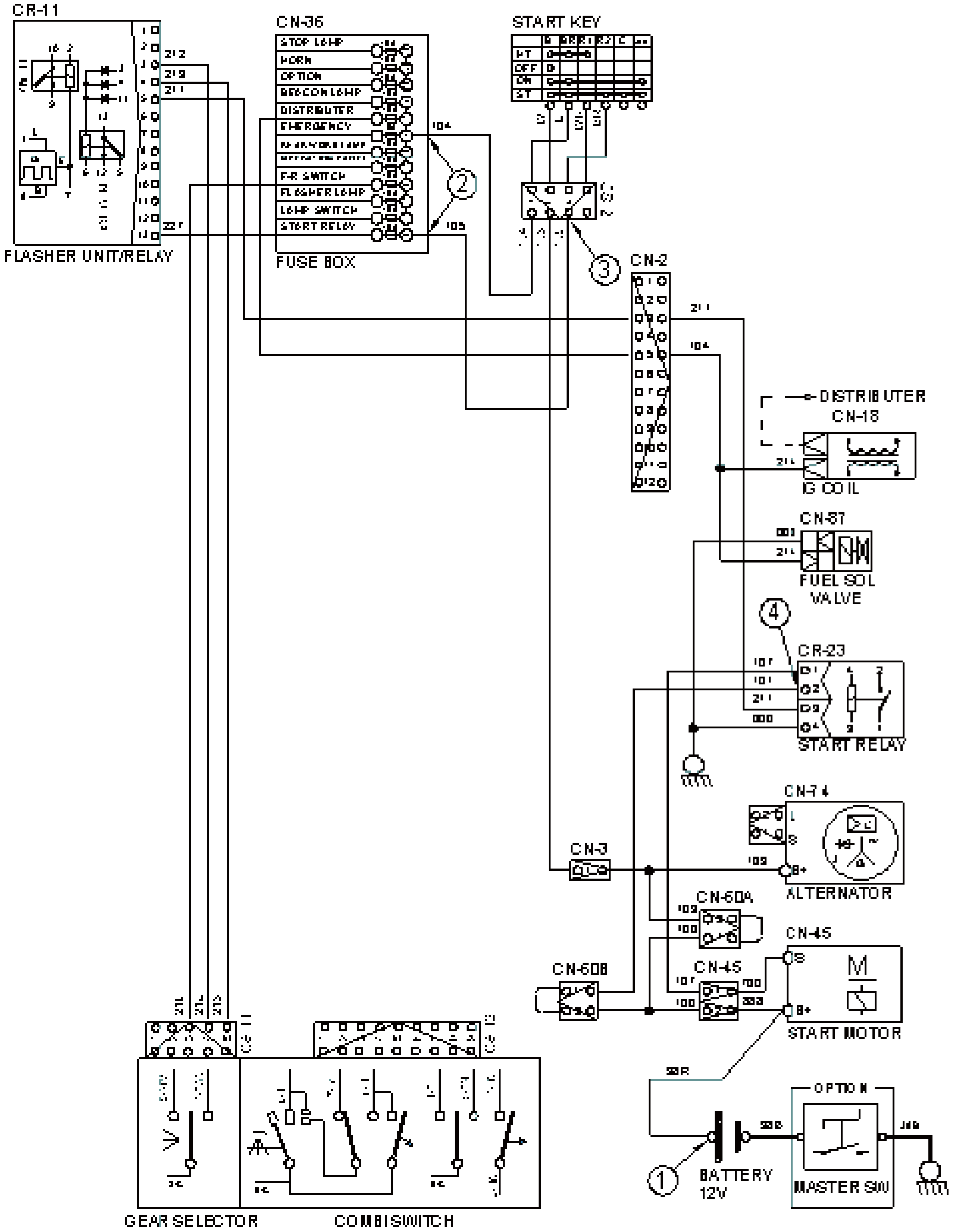
Engine	Key switch	Check point	Voltage
Running	ON	① - GND (Battery B+) ② - GND (Fuse box No.1, 7) ③ - GND (Start key) ④ - GND (Safety relay)	10 ~ 14.5V

STARTING CIRCUIT(TIER II)



L255EL04

STARTING CIRCUIT(Non-Emission)



L255EL04-1

3. CHARGING CIRCUIT

When the starter is activated and the engine is started, the operator release the start switch to the ON position. Charging current generated by operating alternator flows into the battery.
The current also flows from alternator to each electrical component through the fusible link(CN-95A) and the fuse box.

1) OPERATING FLOW

(1) Tier II engine

① **Warning flow**

I/conn[CN-7(F)] → I/conn[CN-2(1)] → Operating panel charging warning lamp ON[CN-56(13)]

② **Charging flow**

Alternator[CN-74(B+)] → Starter motor[CN-45(B+)] → Battery (+)terminal → Charging

(2) Non-Emission engine

① Warning flow

Alternator[CN-74(2)] → I/conn[CN-2(1)] → Cluster charging warning lamp ON[CN-56(13)]

② Charging flow

Alternator[CN-74(B+)] → Fusible link[CN-60A] → I/conn[CN-45(2)] → Start motor[CN-45(B+)] → Battery(+) terminal → Charging

2) CHECK POINT

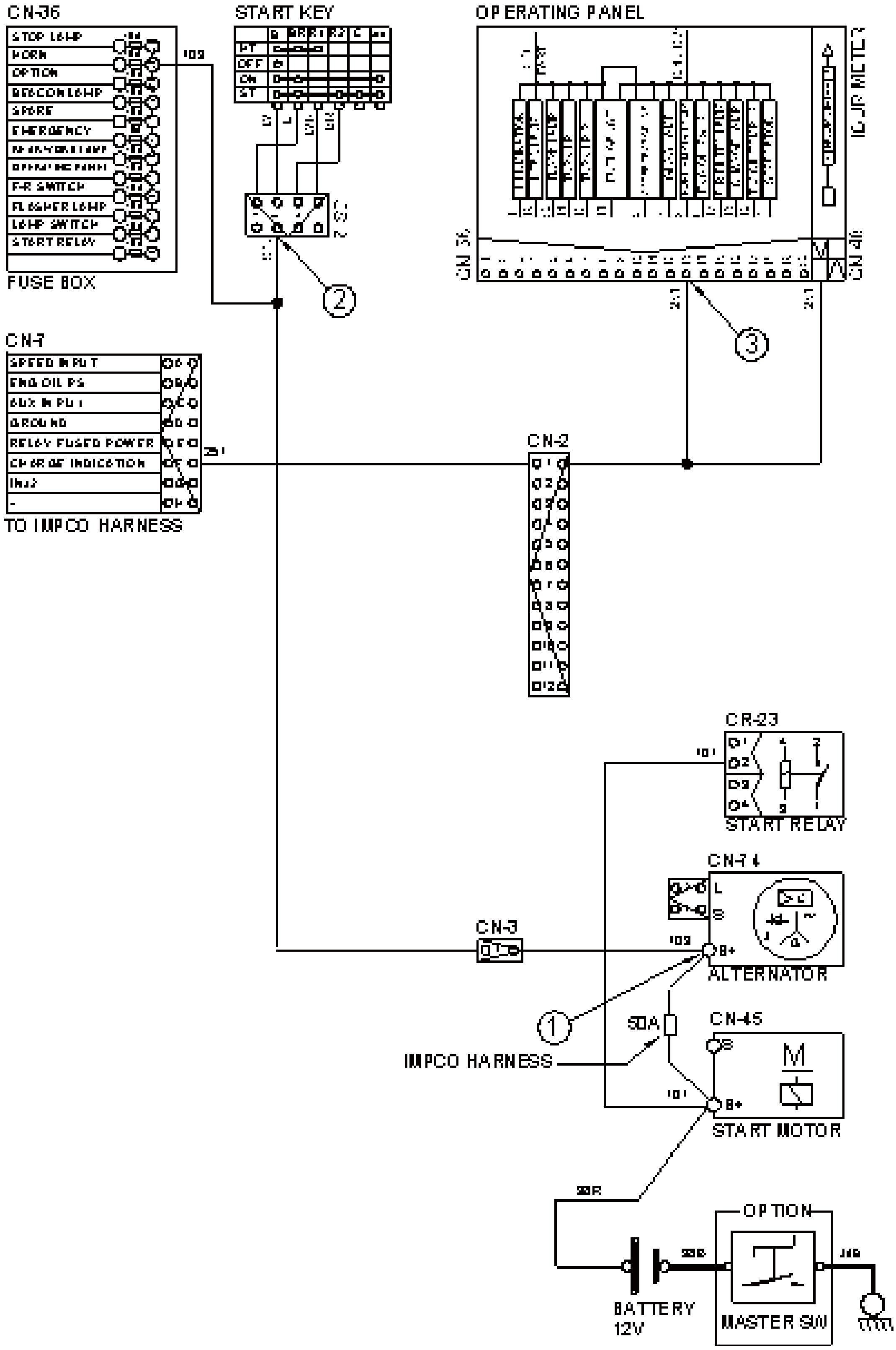
Engine	Key switch	Check point	Voltage
ON	ON	① - GND (Alternator B+) ② - GND (Start key) ③ - GND (Operating panel)	10 ~ 14.5V

※ GND : Ground

※ Cautions

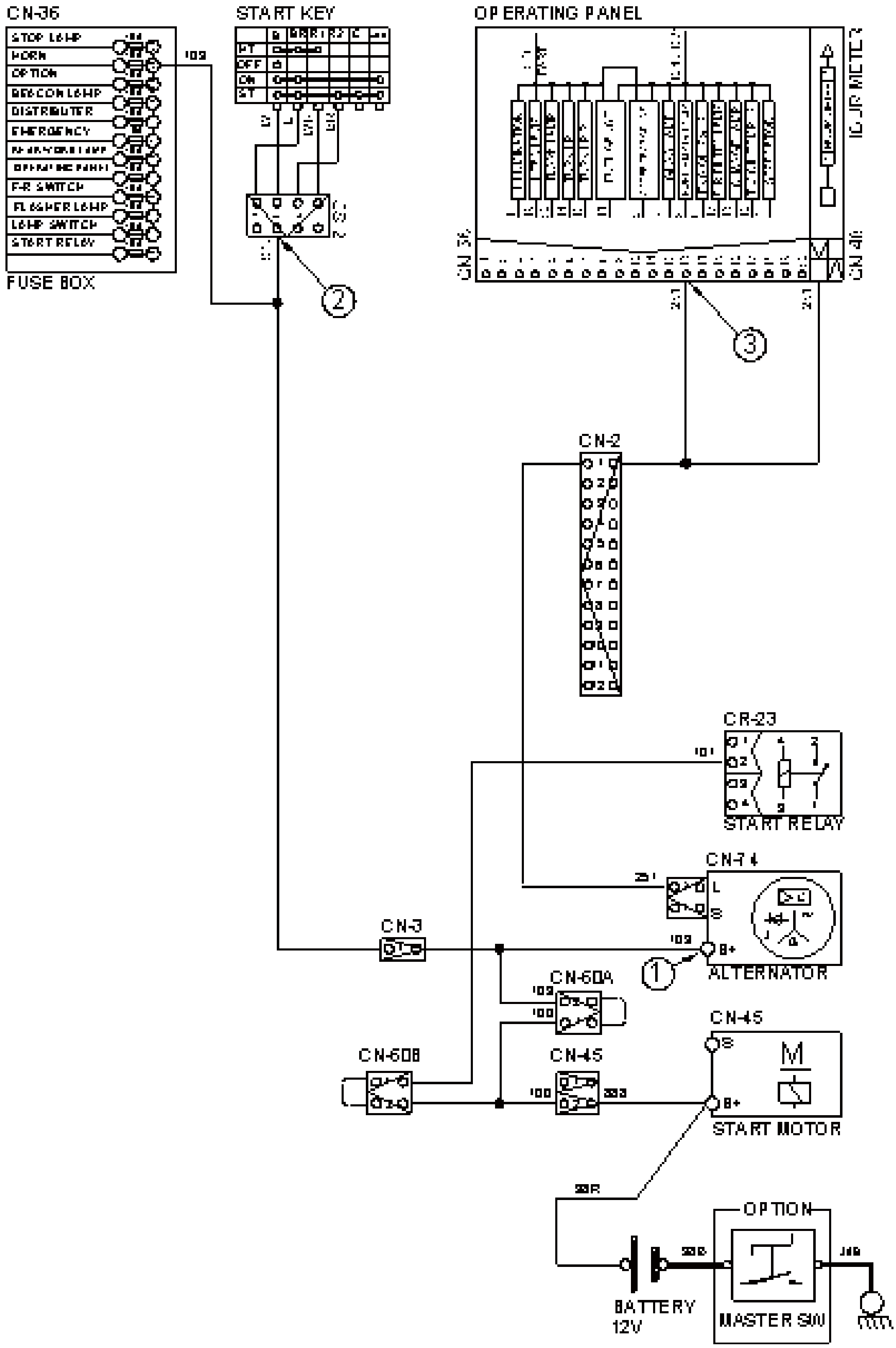
1. When using an arc welder, always disconnect the ground lead from the battery to prevent alternator or battery damage.
2. Attach the welding ground clamp as close to the weld area as possible to prevent welding current from damaging the bearings of the alternator.
3. Do not disconnect the battery when the engine is running. The voltage surge can damage the diode and resistors in the electrical system.
4. Do not disconnect an electric wire before the engine is stopped and the switches are OFF.

CHARGING CIRCUIT(TIER II)



L255EL05

CHARGING CIRCUIT(NON-EMISSION)



L255EL05-1

GROUP 3 COMPONENT SPECIFICATION

No	Part name	Qty	Specification	Remark
1	Battery	1	CCA : 550 20HR : 60AH CMF 60(223×168×220)	
2	Working lamp	1	12V, 55W	
3	License lamp	1	12V, 3.4W×12	
4	Combination lamp	2	12V, 21W(T/S) 12V, 10W(Back) 12V, 5W (Tail) 12V, 21W(Stop)	
5	Head lamp	2	12V, 55W	
6	Flasher lamp	2	12V, 23/8W	
7	Flasher & Relay	1	12V, 20A (Relay) 12V, (21W+21W)×2+3W(Flasher) 130W (Harzard)	
8	Back horn	1	12V, 90±5dB, 60±10C/M	
9	Horn	1	12V, MAX 3.5A, 105~120dB	
10	Master switch	1	180A	
11	Combination switch	1	12V, 10A	
12	Hazard switch	1	12V, 16A	
13	Start switch	1	12V/24V, 15~28A	
14	Safety relay	1	12V, 40A(Contact point capacity) Automatically broken at 1350rpm of alternator.	

Connector number	Type	No. of pin	Destination	Connector part No.	
				Female	Male
CN-1	KET	12	I/conn(Dashboard harness-frame harness)	S814-012100	S814-112100
CN-2	KET	12	I/conn(Dashboard harness-frame harness)	S814-012100	S814-112100
CN-3	KET	1	I/conn(Dashboard harness-frame harness)	MG640944-5	MG650943-5
CN-4	AMP	4	Support harness-LH	S810-004201	-
CN-5	KET	4	Support harness-RH	S811-001301	-
CN-6	PACKARD	12	I/conn(Impco hamess-Frame harness)	-	12045808
CN-7	PACKARD	8	I/conn(Impco hamess-Frame harness)	-	12047931
CN-8	KET	3	I/conn(Rear support harness-Frame harness)	S810-003201	S810-103201
CN-17	KET	4	Power output	S814-004100	-
CN-18	KET	2	Power	S814-002100	-
CN-25	MOLEX	2	Horn	35825-0211	-
CN-26	KET	2	Warning buzzer	S814-002100	-
CN-36	-	-	Fuse box	F12890010	-
CN-48	KET	2	Hour meter	S822-014000	S822-114000
CN-56	MOLEX	20	Operating panel	35109-2010	-
CN-58	KET	8	Detector	S810-008201	-
CN-65	KET	2	Back buzzer	S822-014000	S822-114000
CN-74	RING TERM	1	Alternator	S820-206000	-
CN-122	KET	2	Forward solenoid	S812-002001	-
CN-123	KET	2	Reverse solenoid	S812-002001	-
CN-124	AMP	6	Accel pedal	S816-006002	-
Switch					
CS-2	KET	4	Start switch	S810-004201	-
CS-11	AMP	5	Gear selector switch	S811-005002	-
CS-12	AMP	9	Combinaton switch	S811-009002	-
CS-21	SWF	10	Harzard switch	593757	-
CS-23	SWF	10	Beacon lamp switch	593757	-
CS-41	SWF	10	Work lamp switch	593757	-
Lamp					
CL-7	KET	2	Beacon lamp	S822-014000	S822-114000
CL-15	DAEDONG	6	Combination lamp-LH	110-6PR	-
CL-16	DAEDONG	6	Combination lamp-RH	110-6PR	-
CL-23	KET	2	Rear working lamp	S822-014000	S822-114000
CL-30	SWP	2	Malfunction indicator lamp	913328	-
Relay					
CR-11	KET	13	Flasher unit / Relay	S811-001301	-
CR-23	-	2/2	Safety relay	S810-002202/302	-
CR-35	AMP	4	Warning relay	S810-004202	-

Connector number	Type	No. of pin	Destination	Connector part No.	
				Female	Male
Sensor and pressure switch					
CD-2	KET	2	Fuel level sensor	S810-002201	-
CD-4	KET	2	Brake switch	S822-014000	-
CD-8	AMP	1	Water temp sender	S819-010122	-
CD-9	AMP	1	Water temp switch	S819-010122	-
CD-10	KET	2	Air cleaner switch	ST730057-2	-
CD-29	AMP	1	T/M temp switch	S819-010122	-

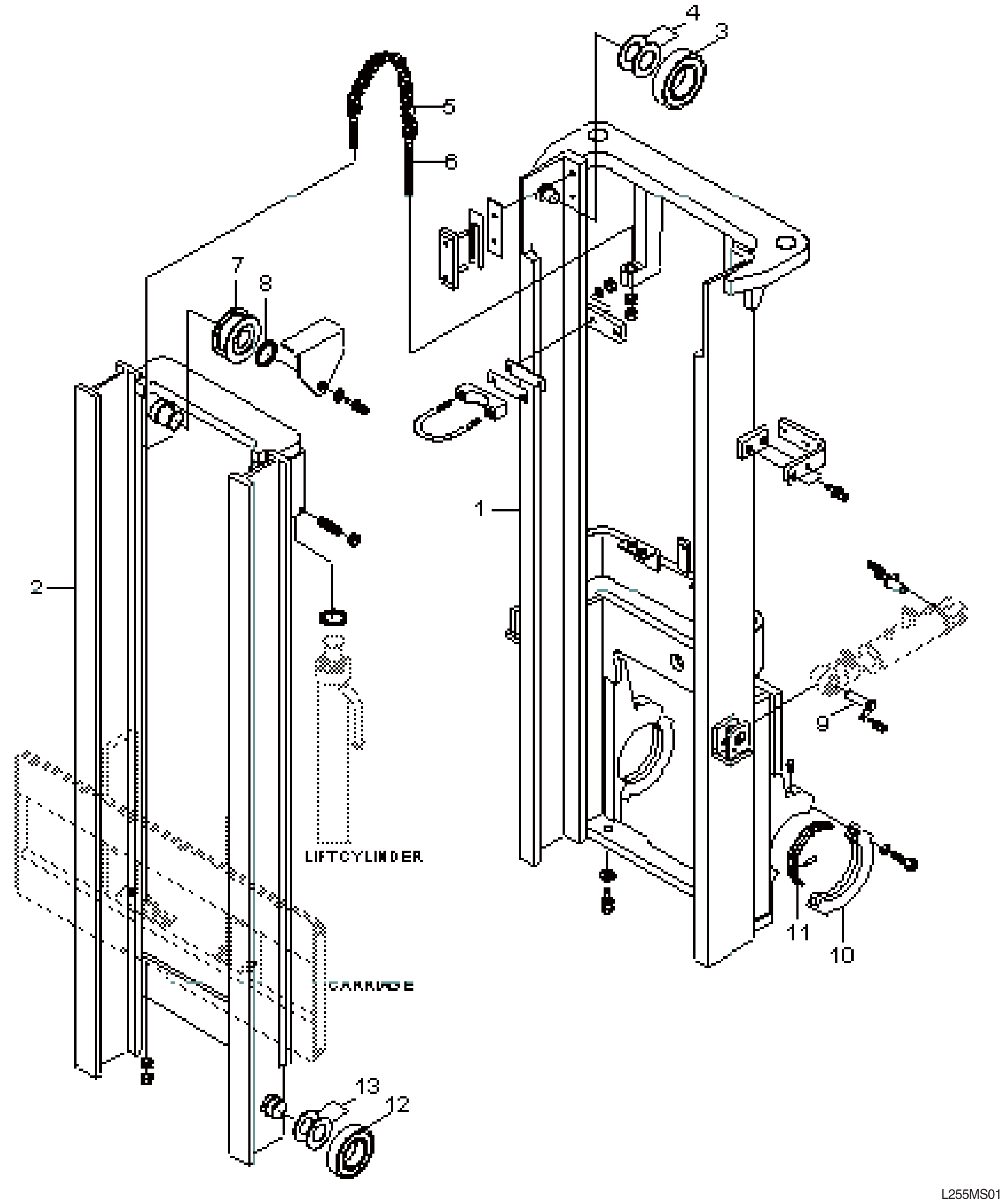
GROUP 4 TROUBLESHOOTING

Trouble symptom	Probable cause	Remedy
Lamps dimming even at max engine speed.	· Faulty wiring.	· Check for loose terminal and disconnected wire.
Lamps flicker during engine operation.	· Improper belt tension.	· Adjust belt tension.
Charge lamp does not light during normal engine operation.	· Charge lamp defective. · Faulty wiring.	· Replace. · Check and repair.
Alternator makes abnormal sounds.	· Alternator defective.	· Replace
Starting motor fails to run.	· Faulty wiring. · Insufficient battery voltage.	· Check and repair. · Recharge battery.
Starting motor pinion repeats going in and out.	· Insufficient battery voltage.	· Recharge battery.
Excessively low starting motor speed.	· Insufficient battery voltage. · Starting motor defective.	· Recharge battery. · Replace
Starting motor comes to a stop before engine starts up.	· Faulty wiring. · Insufficient battery voltage.	· Check and repair. · Recharge battery.
Heater signal does not become red.	· Faulty wiring. · Glow plug damaged.	· Check and repair. · Replace
Engine oil pressure caution lamp does not light when engine is stopped. (with starting switch left in"ON" position).	· Caution lamp defective. · Caution lamp switch defective.	· Replace · Replace

SECTION 8 MAST

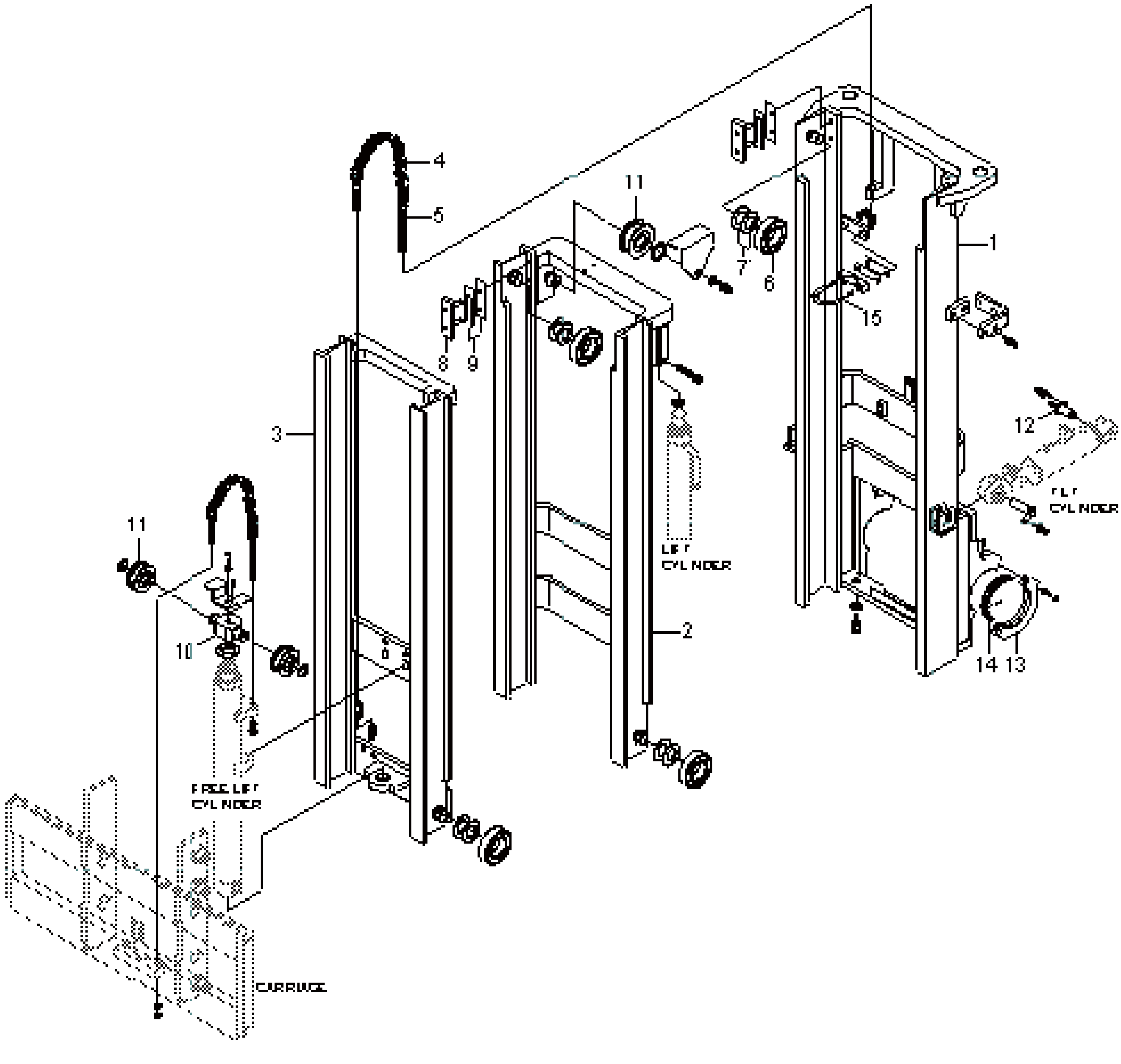
GROUP 1 STRUCTURE

1. 2 STAGE MAST(V MAST)



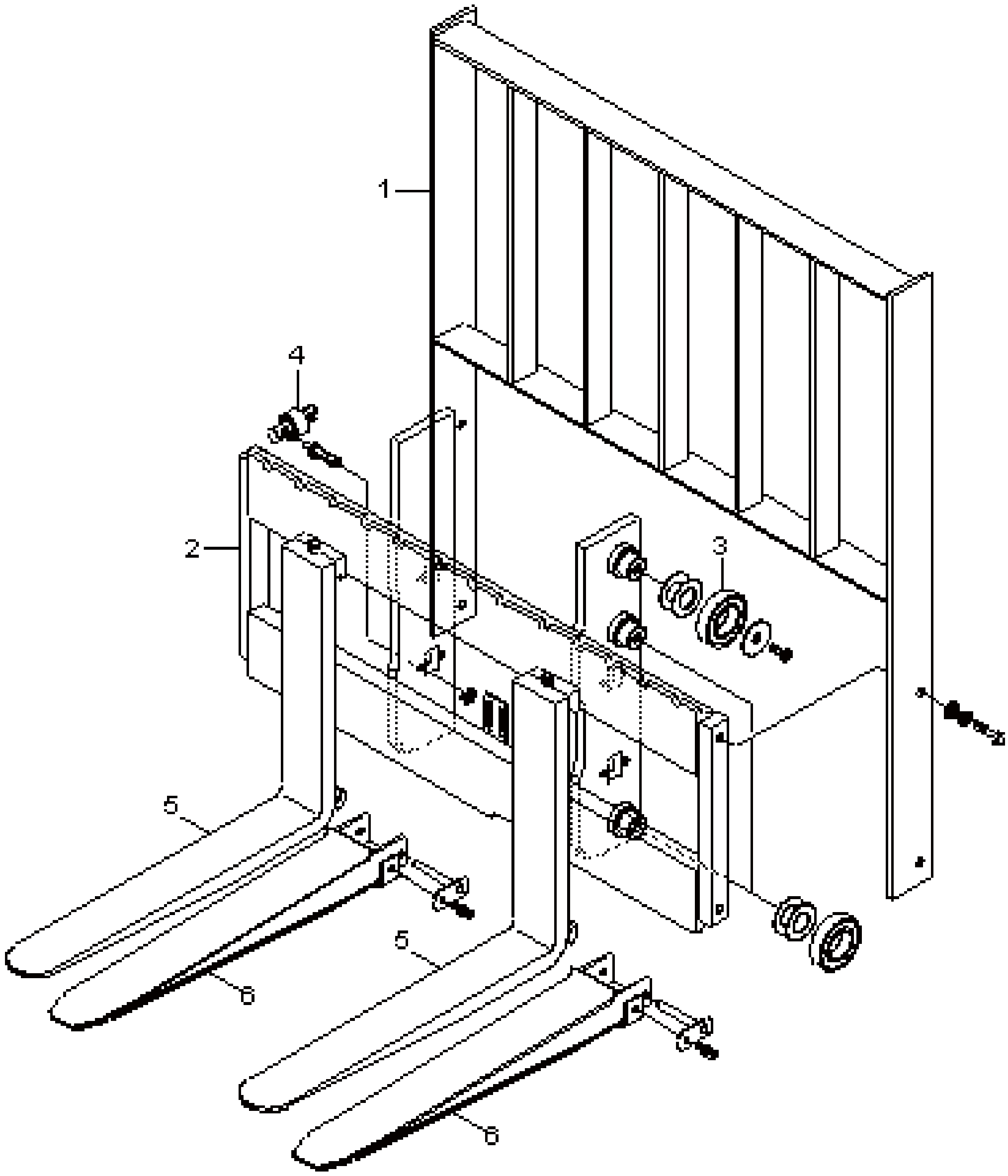
1	Outer mast	6	Anchor bolt	10	Trunnion cap
2	Inner mast	7	Chain wheel bearing	11	Bushing
3	Roller	8	Retaining ring	12	Roller
4	Shim(0.5, 1.0t)	9	Tilt cylinder pin	13	Shim(0.5, 1.0t)
5	Chain				

2. 3 STAGE MAST(TF MAST)



1	Outer mast	6	Roller	11	Sheave
2	Middle mast	7	Shim(0.5, 1.0t)	12	Tilt cylinder pin
3	Inner mast	8	Back up liner	13	Support cap
4	Chain	9	Shim(0.5, 1.0t)	14	Bushing
5	Anchor bolt	10	Sheave bracket	15	U-bolt

3. CARRIAGE, BACKREST AND FORK



L255MS03

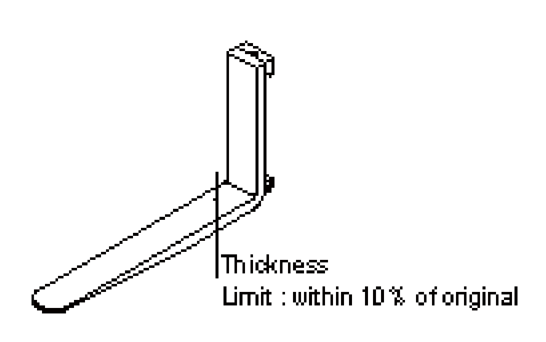
1	Backrest	3	Load roller	5	Fork assembly
2	Carriage	4	Side roller	6	Extension fork

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

1) FORKS

(1) Measure thickness of root of forks and check that it is more than specified value.
EX : l =1050mm(41.3in)

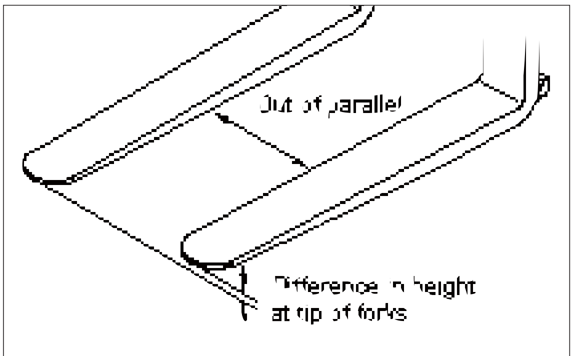


D255FK01

mm(in)

STD Fork assy	Applicable model	Standard	Limit
F173796-02	HLF20/25(C)-5	45(1.8)	40(1.6)
64FG-31020	HLF30(C)-5	45(1.8)	40(1.6)

(2) Set forks in middle and measure out of parallel and difference in height at top of forks.



D255FK02

mm(in)

Difference in height	Max 15(0.6)
Out-of-parallel	Max 35(1.4)

(3) Most force is concentrated at root of fork and at hook, so use crack detection method to check cracks.

2. MAST

1) Check for cracks at mast stay, tilt cylinder bracket, guide bar, fork carriage and roller shaft weld. Check visually or use crack detection method. Repair any abnormality.
2) Set mast vertical, raise forks about 10cm from ground and check front-to-rear clearance and left-to-right clearance between inner mast and fork carriage, and between outer mast and inner mast. Use these figures to judge if there is any play at roller or rail.
 · Front-to-rear clearance : Within 2.0mm(0.08in)
 · Left-to-right clearance : Within 2.5mm (0.10in)
3) Check that there is an oil groove in bushing at mast support.
4) Set mast vertical, raise forks about 10cm from ground, and push center of lift chain with finger to check for difference in tension.
If there is any difference in tension, adjust chain stopper bolt.
5) Check visually for abnormalities at thread of chain anchor bolt, and at contact surface between chain wheel and chain.
Rotate chain wheel by hand and check for any play of bearing.

2. TROUBLESHOOTING

1) MAST

Problem	Cause	Remedy
Forks fail to lower.	· Deformed mast or carriage.	· Disassemble, repair or replace.
Fork fails to elevate.	· Faulty hydraulic equipment. · Deformed mast assembly.	· See troubleshooting hydraulic pump and cylinders in section 6, hydraulic system. · Disassemble mast and replace damaged parts or replace complete mast assembly.
Slow lifting speed and insufficient handling capacity.	· Faulty hydraulic equipment. · Deformed mast assembly.	· See troubleshooting hydraulic pump and cylinders in section 6, hydraulic system. · Disassemble mast and replace damaged parts or replace complete mast assembly.
Mast fails to lift smoothly.	· Deformed masts or carriage. · Faulty hydraulic equipment. · Damaged load and side rollers. · Unequal chain tension between LH & RH sides. · LH & RH mast inclination angles are unequal. (Mast assembly is twisted when tilted)	· Disassembly, repair or replace. · See Troubleshooting Hydraulic Cylinders, pump and control valve in section 6, hydraulic system. · Replace. · Adjust chains. · Adjust tilt cylinder rods.
Abnormal noise is produced when mast is lifted and lowered.	· Broken load roller bearings. · Broken side roller bearings. · Deformed masts. · Bent lift cylinder rod. · Deformed carriage. · Broken sheave bearing.	· Replace. · Replace. · Disassemble, repair or replace. · Replace. · Replace. · Replace.
Abnormal noise is produced during tilting operation.	· Insufficient lubrication of anchor pin, or worn bushing and pin. · Bent tilt cylinder rod.	· Lubricate or replace. · Replace.

2) FORKS

Problem	Cause	Remedy
Abrasion	Long-time operations causes the fork to wear and reduces the thickness of the fork. Inspection for thickness is needed. · Wear limit : Must be 90% of fork thickness	If the measured value is below the wear limit, replace fork.
Distortion	Forks are bent out of shape by a number of reasons such as overloading, glancing blows against walls and objects, and picking up load unevenly. · Difference in fork tip height : 15mm · Difference in fork tip width : 35mm	If the measured value exceeds the allowance, replace fork.
Fatigue	Fatigue failure may result from the fatigue crack even though the stress to fork is below the static strength of the fork. Therefore, a daily inspection should be done. · Crack on the fork heel. · Crack on the fork weldments.	Repair fork by expert. In case of excessive distortion, replace fork.

GROUP 3 ADJUSTMENT

1. MAST LOAD ROLLER(V MAST)

1) INNER/OUTER MAST ROLLER CLEARANCE ADJUSTMENT

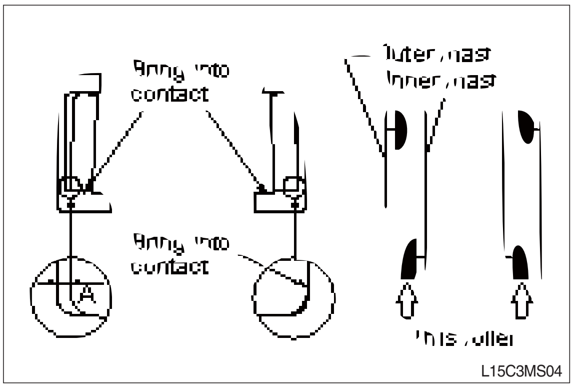
(1) Measure the clearance with the mast overlap at near 480mm.

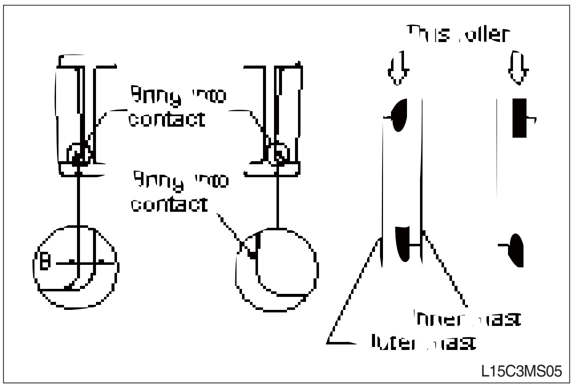
(2) Shift the inner mast to one side to bring the roller into contact with the outer mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner/outer mast roller shim.

· Standard clearance A, B = 0~0.6mm
· Shim thickness 0.5, 1.0mm

(3) Distribute the shim thickness equally to the left and right roller. Refer to Mast load roller and back up liner, removal and Installation.

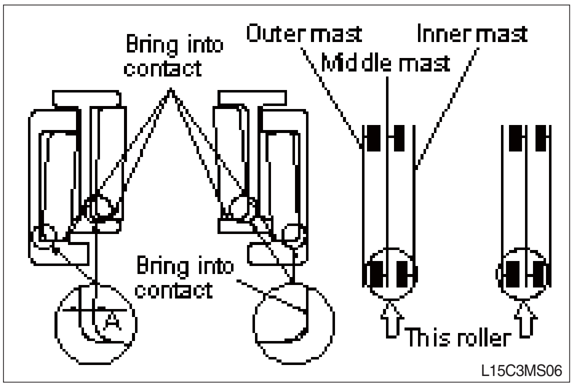
(4) After the adjustment, check that the inner mast moves smoothly in the outer mast.





2. MAST LOAD ROLLER(TF MAST)

1) INNER AND MIDDLE MAST ROLLER CLEARANCE ADJUSTMENT



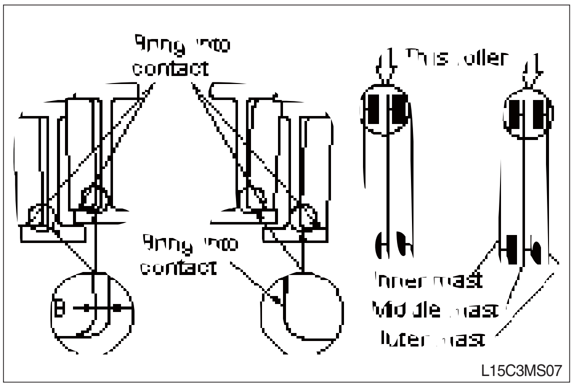
(1) Measure the clearance with the mast overlap at near 480mm.

(2) Shift the inner mast to one side to bring the roller into contact with the outer mast and the middle mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner and middle mast roller shim, respectively.
- · Standard clearance A = 0~0.6mm
- · Shim thickness 0.5, 1.0mm

(3) Distribute the shim thickness equally to the left and right roller. Refer to Mast load roller and back up liner, removal and Installation.

(4) After the adjustment, check that the inner mast moves smoothly in the middle mast, and the middle mast moves smoothly in the outer mast.

2) OUTER AND MIDDLE MAST UPPER ROLLER CLEARANCE ADJUSTMENT



(1) Measure the clearance with the mast overlap at near 480mm.

(2) Shift the inner mast to one side to bring the roller into contact with the outer mast and the middle mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the outer and middle mast roller shim, respectively.
- · Standard clearance B = 0~0.6mm
- · Shim thickness 0.5, 1.0mm

(3) Distribute the shim thickness equally to the left and right roller. Refer to Mast load roller and back up liner, removal and Installation.

(4) After the adjustment, check that the inner mast moves smoothly in the middle mast, and the middle mast moves smoothly in the outer mast.

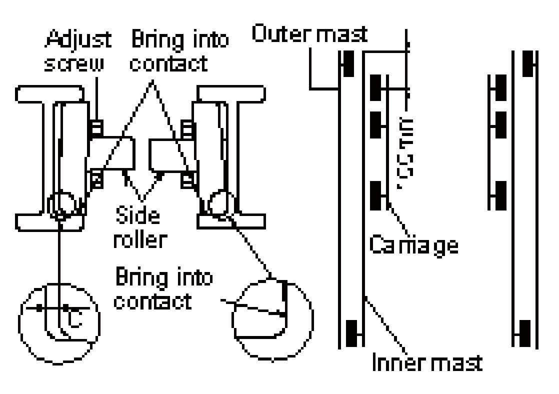
3) CARRIAGE LOAD ROLLER

(1) Measure the clearance when the center of the carriage upper roller is 100mm from the top of the inner mast.

(2) Measure the clearance at upper, middle and lower rollers after loosen the adjust screws from the side rollers. Shift the carriage to one side to bring the roller into contact with the inner mast, and measure the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the carriage roller shim.
- · Standard clearance C = 0~0.6mm
- · Shim thickness 0.5, 1.0mm

(3) Distribute the shim thickness equally to the left and right roller. Refer to Carriage assembly.

(4) After the adjustment, the carriage should move smoothly along the overall mast length.



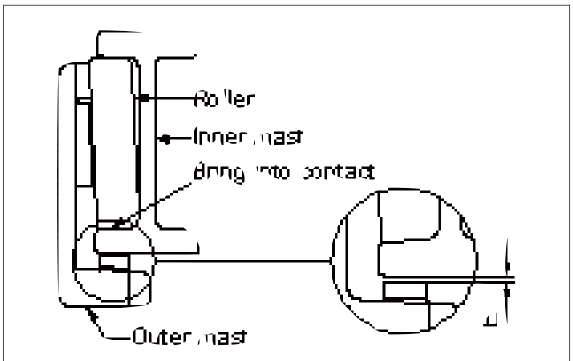
D255MS08

4) MAST BACK UP LINER

(1) Measure the clearance with the middle mast at the bottom position.

(2) With the middle mast in contact with the outer mast roller, adjust the clearance between the mast back up liner and middle mast to the following value by inserting the back up liner shim.
- · Standard clearance E = 0.2 ~ 0.6mm
- · Shim thickness 0.5, 1.0mm

(3) After the adjustment, the mast should move smoothly.

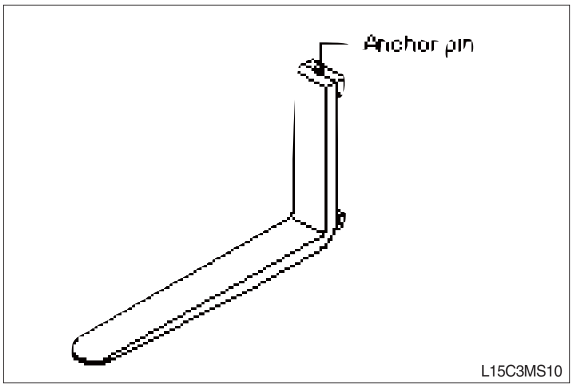


L15C3MS09

GROUP 4 REMOVAL AND INSTALLATION

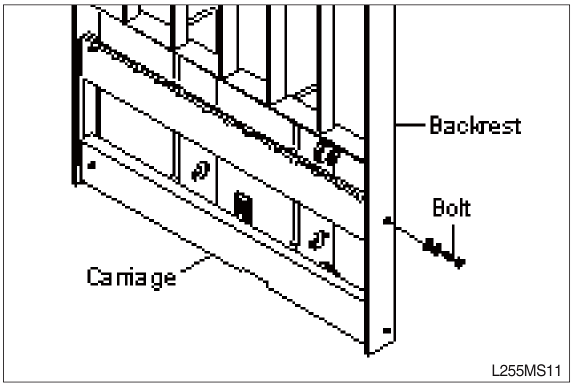
1. FORKS

1) Lower the fork carriage until the forks are approximately 25mm(1inch) from the floor.
2) Release fork anchor pins and slide forks, one by one, toward the center of the carriage where a notch has been cut in the bottom plate for easy fork removal.
3) Remove the fork one by one. On larger forks it may be necessary to use a block of wood.
4) Reverse the above procedure to install load forks.



2. BACKREST

1) Remove bolts securing backrest to fork carriage. Lift backrest straight up and remove from carriage.
2) Position backrest on carriage and lower in place. Install and tighten bolts.



3. CARRIAGE ASSEMBLY

1) CARRIAGE

(1) With the mast vertical, raise the carriage high enough to place blocks under the load forks. This is done to create slack in the load chains when the carriage is lowered. Lower the carriage all the way down to the floor. Make sure the carriage is level, this will prevent any binding when the mast is raised.
(2) While supporting lift chains, remove the split pin and slide out chain anchor pins from the chain anchors of stationary upright.
(3) Pull the chains out of the sheaves and drape them over the front of the carriage.
(4) Slowly raise elevating upright until mast clears top of fork carriage. Move carriage to work area and lower mast.

⚠ **Make sure carriage remains on floor and does not bind while mast is being raised.**

(5) Inspect all parts for wear or damage. Replace all worn or damaged pars.
(6) Reverse the above steps to reinstall.

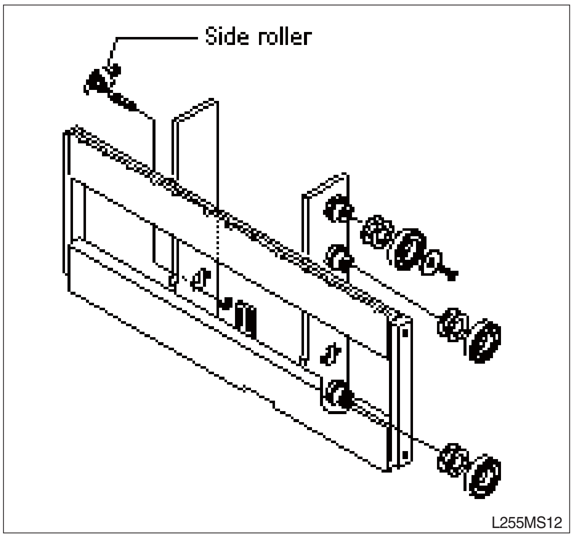
⚠ **Replace the split pin of chain anchor with new one.**

2) SIDE ROLLER

(1) Remove carriage as outlined in the carriage assembly and removal paragraph.
(2) Loosen and remove nuts, adjust screws and side rollers from carriage side pate.
(3) Thoroughly clean, inspect and replace all worn or damaged parts.
(4) Reverse the above procedure to assembly.

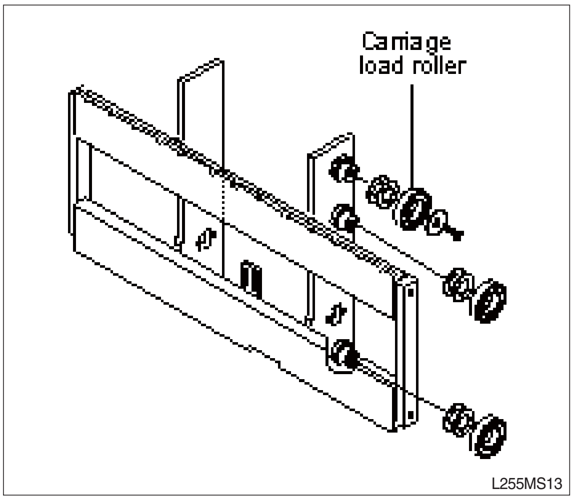
※ Adjustment

- Once carriage is properly installed, loosen nuts and adjust screws, (if not already done) allowing carriage to be centered in the inner mast.
- Adjust side roller by tightening screw until side roller just makes contact with mast. Back off approximately 1/10 turn on screw and tighten nut to lock screw in place.
- Run carriage up and down for the inner mast to be sure the carriage has free movement and does not stick. Also, make sure chains are properly adjusted. Refer to chain adjustment paragraph. Make adjustment when necessary and recheck operation of carriage.



3) CARRIAGE LOAD ROLLER

(1) Remove carriage as outlined in the carriage assembly removal paragraph.
(2) Loosen and remove flat head bolts and plain washers from top load roller bracket.
(3) Using a pryer, remove load rollers from load roller bracket.
(4) Reverse the above procedure to assemble. Refer to MAST ROLLER ADJUSTMENT paragraph.



4) MAST LOAD ROLLER AND BACK UP LINER

(1) 2 stage mast(V mast)

① Remove the carriage assembly and move them to one side.

② Loosen and remove hexagon bolts and washers securing lift cylinders to inner mast.

③ Loosen and remove hexagon bolts and nuts securing lift cylinders to inner mast.

④ Attach chains or sling to the inner mast section at top crossmember. Using an overhead hoist, slowly raise the inner mast high enough to clear lift cylinder.

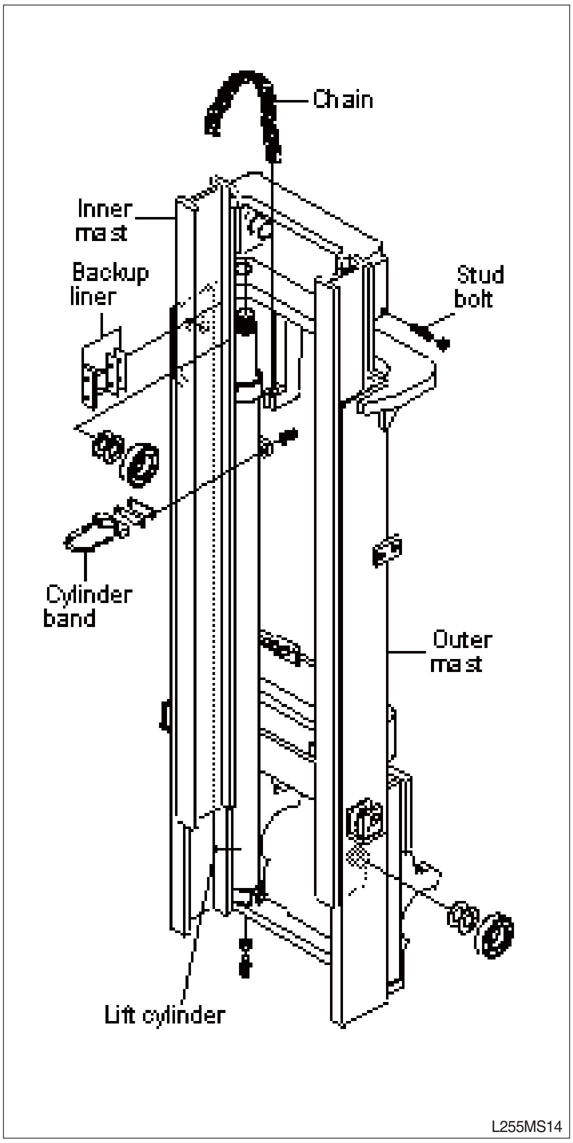
⑤ After lowering the lift cylinder rods, and disconnecting lift cylinder hose, tilt the lift cylinders LH and RH and them with ropes to the outer mast.

⑥ Using the overhead hoist, lower inner mast until top and bottom rollers and back up liners are exposed.

⑦ Using a pryer, remove load rollers from load roller bracket. Remove back up liners and shims.

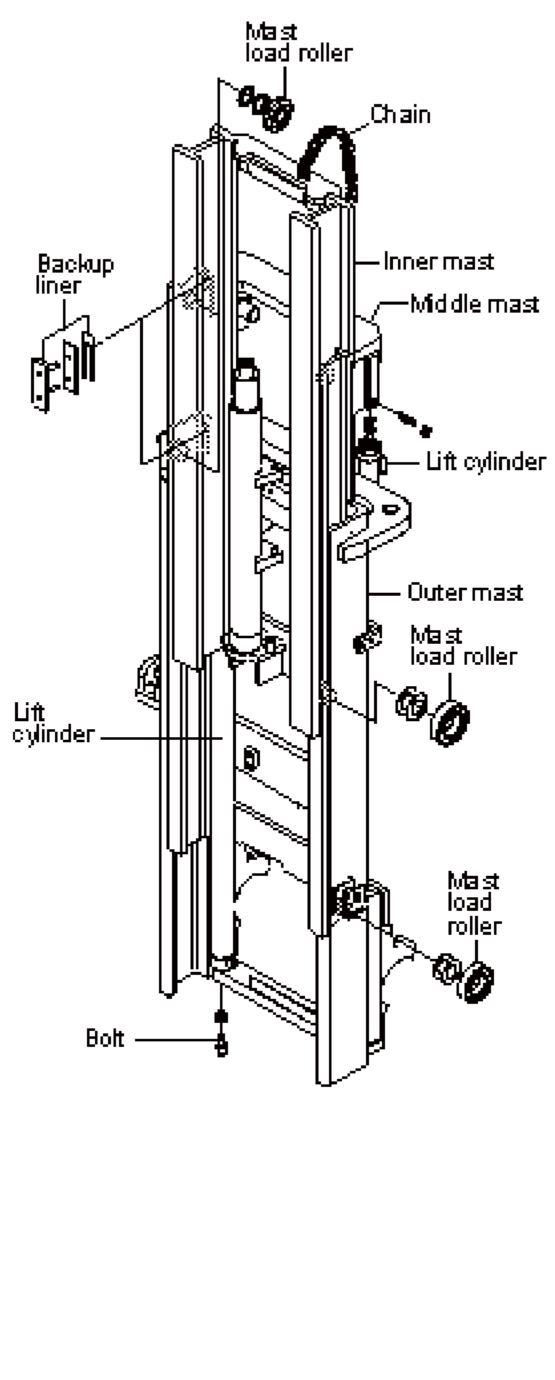
⑧ Thoroughly clean, inspect and replace all worn or damaged parts.

⑨ Reverse the above procedure to assemble. Refer to MAST LOAD ROLLER ADJUSTMENT paragraph.



(2) 3 stage mast(TF mast)

① Remove the carriage assembly and move to one side.
② Loosen and remove hexagon bolt securing bottom cylinder from outer mast.
③ Loosen and remove bolts and special washers securing lift cylinders to middle mast.
④ Attach chains or sling to the inner and middle mast section at top crossmember. Using an overhead hoist, slowly raise the uprights high enough to clear lift cylinder.
⑤ After lowering the lift cylinder rods, and disconnecting lift cylinder hose, tilt the lift cylinders LH and RH and tie them with ropes to the outer mast.
⑥ Using the overhead hoist raise inner and middle masts. Place 4 inch block of wood under the free lift cylinder bracket of the inner mast then lower mast sections (this will create slack in the chains).
⑦ Remove retaining rings securing chain sheaves to sheave support brackets. While support chains, remove chain sheaves and let chains hang free. The upper outer and lower middle mast rollers and back up liners are now exposed.
⑧ Using a pryer, remove load rollers from load bracket. Remove back up liners and shims.
⑨ Attach chains or sling to the middle mast section at top crossmember. Using an overhead hoist, slowly raise the middle mast until top and bottom rollers are exposed.
⑩ Using a player, remove load rollers from load roller bracket.
⑪ Thoroughly clean, inspect and replace all worn or damaged parts.
⑫ Reverse the above procedure to assemble. Refer to MAST LOAD ROLLER ADJUSTMENT paragraph.



5) ELEVATING MAST

(1) Inner mast (V mast)

① After completing all necessary steps for load rollers and back up liner removal use an overhead hoist and sling or chain around upper crossmember of the inner mast section.

② Lift inner mast upright straight up and out of outer mast section.

③ Replace and reverse above procedure to install. Make all necessary measurements and adjustments.

(2) Inner and middle mast(TF mast)

① After completing all necessary steps for load rollers and back up liner removal. Remove rear chains and sheave support if not already done.

② Disconnect free lift cylinder hose. Drain hose into a suitable pan or container and cap hose.

③ While supporting free lift cylinder assembly, remove bolts and washers securing cylinder to mast crossmember.

④ Place a sling around free lift cylinder and attach to an overhead hoist. Slowly raise and move cylinder to one side.

⑤ Attach chains or sling to the inner mast section at top crossmember. Using an overhead hoist slowly raise the upright straight up and out of middle mast section.

⑥ Attach chains or sling to the middle mast section at top crossmember. Using an overhead hoist slowly raise the upright straight up and out of outer mast section.

⑦ Replace upright and reverse above procedure to install. Make all necessary measurements and adjustments.

6) CHAIN

(1) Chain sheave(V mast)

① Place a sling around carriage and attach to an overhead hoist. Lift carriage high enough so that the tension on the chain over sheaves is relieved after the carriage is blocked. Position wooden blocks under the carriage and lower it.

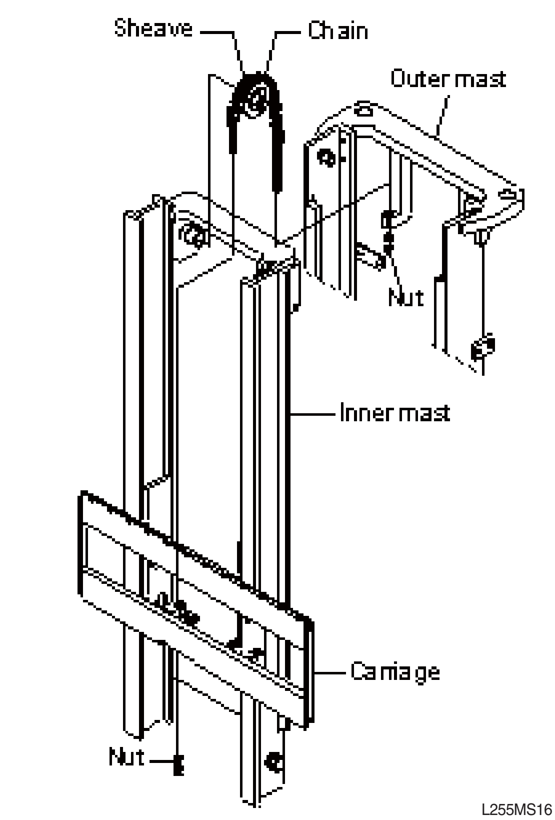
② Loosen the nuts and drape the chains over the carriage.

③ Remove retaining ring securing sheaves to sheave support. Remove sheaves with bearings.

④ Remove beariningretaining ring from sheave and press bearings from sheaves.

⑤ Thoroughly clean, inspect and replace all worn or damaged parts.

⑥ Reverse the above to assemble and install.



L255MS16

(2) Rear chain sheave(TF mast)

① Raise and securely block carriage and inner mast section.

② Loosen the nuts.

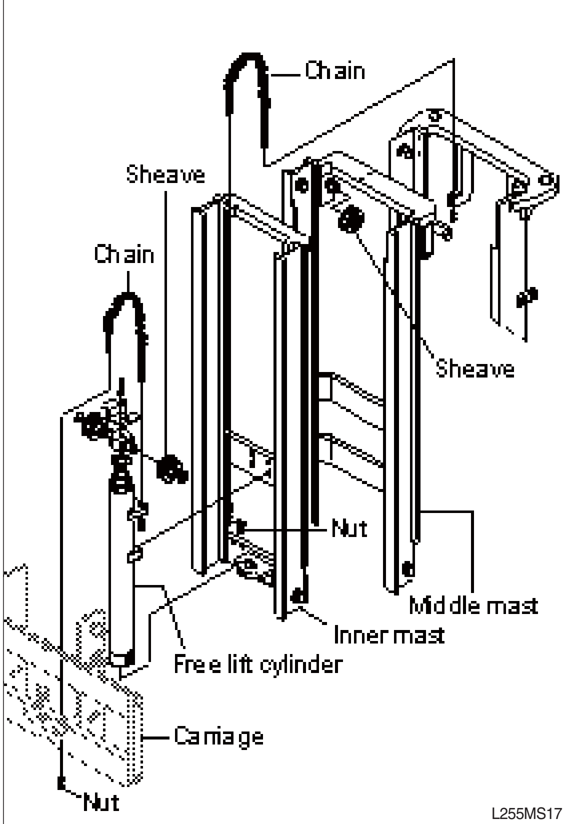
③ Remove chains.

④ Remove retaining ring securing chain sheaves to sheave support. Pry off sheaves with bearings.

⑤ Remove bearing retaining ring from sheave and press bearings from sheaves.

⑥ Thoroughly clean, inspect and replace all worn or damaged parts.

⑦ Reverse the above procedure to assemble and install.



L255MS17

(3) Chain wheel bearing support(TF mast)

① Remove the carriage assembly and move to one side.
② After removing bolt to securing chain wheel bearing support assembly to free lift cylinder. After a sling to the chain wheel bearing support assembly. Using an overhead hoist, lift support assembly straight up and off of free lift cylinder. Move assembly to work area.
③ Remove retaining ring securing chain wheel bearing to chain wheel bearing support.
④ Remove bearing retaining ring from chain wheel bearing and press bearings from chain wheel bearings.
⑤ Thoroughly clean, inspect and replace all worn or damaged parts.
⑥ Reverse the above procedure to install.

(4) Rear chain(TF mast)

① Remove the carriage assembly and move to one side. Refer to carriage removal and installation.
② Raise and securely block truck approximately 6 inches from the floor.
③ Using a sling or chain around inner mast section attached to an overhead hoist, slowly raise inner mast until there is enough slack in the chains to remove them. Block inner mast section.
④ Remove split pins and chain anchor pins securing chains to chain anchor(part of inner mast).
⑤ While supporting the chains, remove split and chain anchor pins securing chains to chain anchors attached to outer mast section.
⑥ Remove chains.
⑦ Reverse the above to assemble and install. Use new split pins in chain anchor pins. Refer to this section for Load chain lubrication and adjustment.

(5) Carriage chain

① Place a sling around carriage front plate and attach to an overhead hoist. Lift and secure carriage high enough so that split and chain anchor pins on carriage can be easily be removed. Remove chain anchor pins from carriage and drape chains out over carriage.
② Place a wooden block under the carriage and lower the carriage on the block.
③ While supporting the chains, remove split pins and chain anchor pins from chain anchors.
④ Remove chains and wash them with solvent. Refer to this section for Load chain inspection and maintenance.
⑤ Reverse the above procedure to assemble and install. Use new split pins in chain anchor pins. Refer to this section for Load chain lubrication and adjustment.

(6) Load chain inspection and maintenance

After every 200 hours of truck operation, lift chains should be inspected and lubricated inspect for the following chain conditions :

① Wear

As the chain flexes on and off the chain wheel bearings, the joints very gradually wear. The stretch a chain developes in service is due to material being worn off pin outer diameter and pitch hole inner diameter on the inside plate.

Chain wear can be measured using a wear scale or steel tape. When chains have elongated 2%, they should be discarded. When checking chain wear, be sure to measure a segment of chain that operates over a sheave. Do not repair chains by cutting our the worn section and splicing in a new piece. If part of the chain is worn, replace all the chains on the truck.

② Rust and corrosion

Chains used on lift trucks are highly stressed precision components. It is very important that the "as-manufactured" ultimate strength and fatigue strength be maintained throughout the chain service life. Corrosion will cause a major reduction in the load-carrying capacity of lift chain or roller chain because corrosion causes side plate cracking.

③ Cracked plate

The most common cause of plate cracking is fatigue failure. Fatigue is a penomenon that affects most metals and many plastics. After many repeated heavy loads, the plates may crack and the chains will eventually break. Fatigue cracks are almost always found through the pitch holes perpendicular to the pitch line. Contrast this failure mode to the random failures caused by stress-corrosion cracking. If cracks are present, replace all the chain on the truck. Noise in the chain indicates that the plate is on the verge of cracking and will be failed before long.

④ Tight joints

All joints in lift chain should flex freely. Tight joints resist flexure, increase internal friction, thus increasing chain tension required to lift a given load. Increased tension accelerates wear and fatigue problems.

Tight joints in lift chains can be caused by :

· Bent pins or plates.
· Rusty joints.
· Peened plate edges.

Oil rusty chains and replace chains with bent or peened components.

⑤ Protruding or turned pins

Heavily loaded chains operating with lube generate tremendous friction between pins and plates. In extreme cases, the frictional torque in the joint can actually turn pins in the press-fit outside plates. If chain is allowed to operate in this condition, the pins slowly work out of the chain causing chain failure. Turned pins can be quickly spotted because the flats on the V heads are no longer in line. Chains with turned or protruding pins should be replaced immediately. Do not attempt to repair the chain by driving pins back into the chain.

⑥ Chain side wear

A wear pattern on pin heads and outside plates indicates misalignment. This condition damages chain and sheaves as well as increasing internal friction in the chain system.

⑦ Chain anchors and chain wheel bearings

An inspection of the chain system includes a close examination of chain anchors and chain wheel bearings. Check chain anchors for wear, breakage and misalignment.

Anchors with worn or broken fingers should be replaced. Anchors should be adjusted to eliminate twisting or other misalignment in the chain. When chain is misaligned, load is not distributed uniformly between the plates. Prolonged operation will result in premature fatigue failure. Chain wheel bearings with badly worn flanges and outside diameter should be replaced. Heavy flange wear indicates chain misalignment.

⑧ Chain wear scale

The chain can be checked for wear or stretching with the use of a chain wear scale. Stretching of a chain is due to the elongation of the pitch holes and wearing of the pin O.D. The greatest amount of stretching occurs at the areas of the chain that flex over the sheaves most frequently. Check the chain at this point with a scale. The wear scale has instructions printed on the sides for use in determining chain stretch and are as follows :

· Determine pitch length of chain using 6 inch scale on one side of wear scale.
· If pitch is 1/2(12.7mm), 3/4(19.05mm), 1(25.4mm), 1-1/2(38.1mm), 2(50.8mm), use side A of scale.
· If pitch is 5/8(15.875mm), 1-1/4(31.75mm) or 2(50.8mm), use side B.
· Align point A or B to center of a pin and note position of the opposite A or B point.
· If other point also lines up with a pin, the chain is worn and should be replaced.

If any of the above conditions exists(cracked plates, turned pins, stretching etc), the chains should be replaced in pairs as a complete assembly. Order chains by part number to insure the correct chain length, pitch and material specifications.

(7) Load chain lubrication and adjustment

① Lubrication

The most important consideration in field maintenance of lift chains is lubrication. Hard working, heavily loaded chains cannot be expected to give satisfactory wear life without scheduled periodic re-lubrication. Like all bearing surfaces, the precision manufactured, hardened steel, joint-wearing surfaces require a film of oil between mating parts to prevent rapid wear. Oil must penetrate the chain joint to prevent wear. Applying oil to external surfaces will prevent rust, but oil must flow into the live bearing surfaces for maximum wear life. Frequency of re-lube will vary with operating conditions and environment, the best estimate of lube period is 200 hours. Trucks parked outdoors or trucks in extremely severe service, may require more frequent re-lube to maintain an oil film on all chain surface.

· **Wipe off the old oil with a clean cloth and blow out the remaining dirt with compressed air.**
⚠ **Wear eye protection.**
· **With a clean brush, apply EP-140 extreme pressure lubricant or heavy motor oil(40W).**

② Replacement

Replace chains as a pair. It will be virtually impossible to maintain uniform loading between the strands if a new chain is put into service opposite an old chain. The jonts in the old chain will be greater than that on the new chain, greatly complicating the problem of maintaining equal chain tension. The new chain will wear more slowly causing it to bear the major portion of the load resulting in premature wear and fatigue failure. Don’t steam clean or decrease new chains.
The manufacturer’s grease is effective in reducing wear and corrosion. If the original factory lube is dried out or wiped off, soak the new chain in heavy engine oil for at 1/2 hour prior to installing on truck. After the old chains have been stripped from the mast, very carefully inspect chain anchors and chain wheel bearing. Broken, cracked or worn anchor must be replaced using the new anchor pin and split pin. Do not paint newly replaced chain after it has been installed.

③ Adjustment

Chain adjustments are important for the following reasons :

- · Equal loading of chain.
- · Proper sequencing of mast.
- · Prevent over-stretching of chains.
- · Prevent chains from jumping off sheaves if they are too loose.

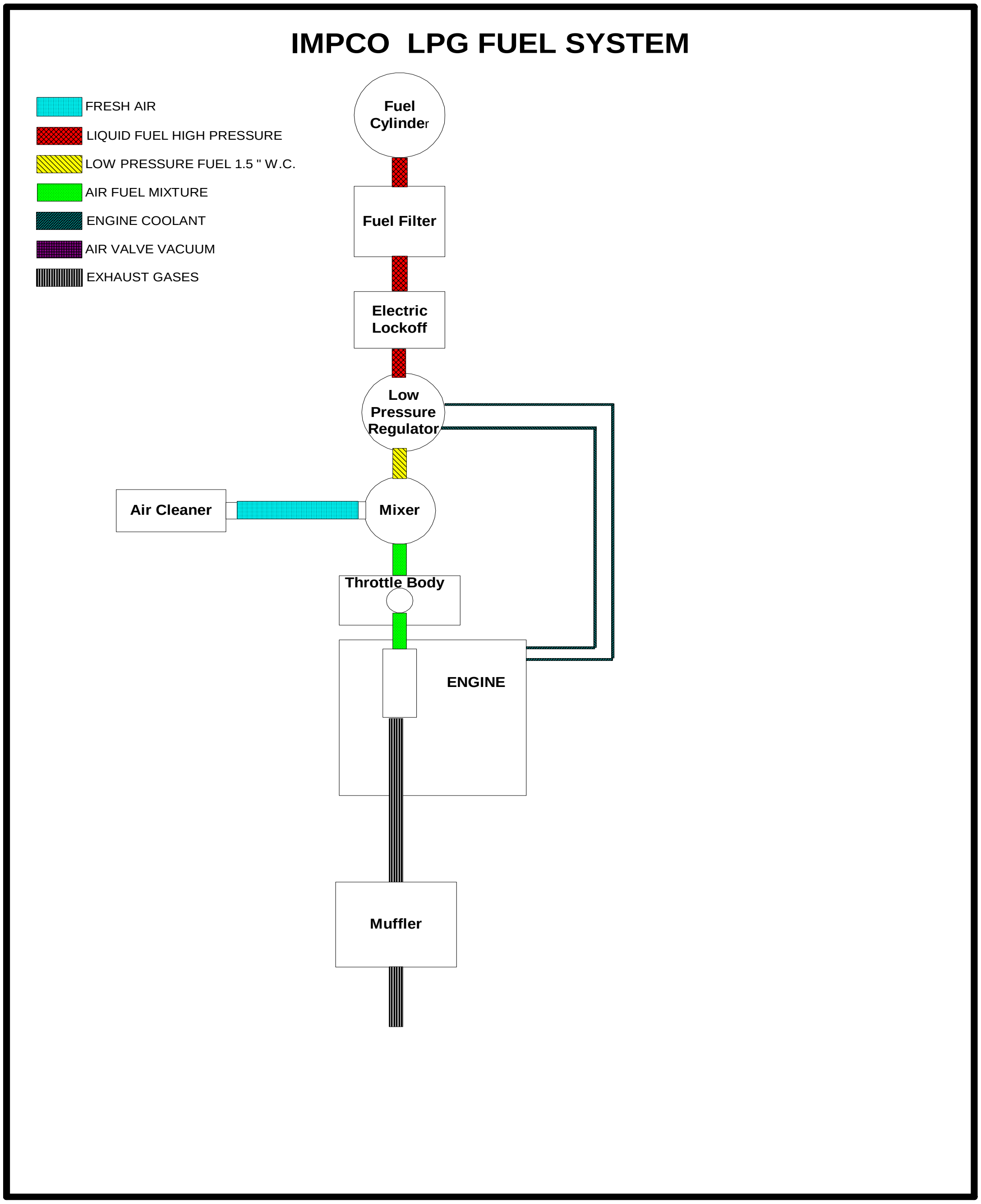
④ Adjustment procedure

- · With mast in its fully collapsed and vertical position, lower the fork to the floor.
- · Adjust the chain length by loosening or tightening nut on the chain anchor.
  After making adjustment on the mast, be sure to tighten the nut.

DESCRIPTION AND OPERATION OF THE FUEL SYSTEMS

PROPANE FUEL SYSTEM

The primary components of the propane fuel system are the fuel storage tank, low pressure regulator (LPR), fuel mixer module with throttle control device, electric fuel lock-off solenoid. The system operates at pressures which range from 355.60 mm (14.0 inches) of water column up to 21.5 BAR (312



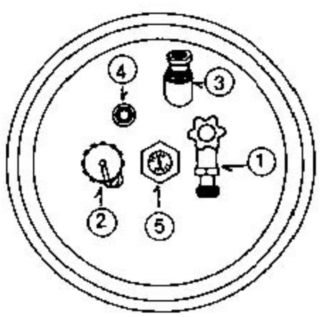
psi). Figure 1

Typical Fuel System Schematic

LPG FUEL TANK

Propane is stored in the fuel tank as a liquid. The approximate pressure of the fuel in the tank is 16.5 bar (240 psi) when the tank is full at an ambient temperature of 27° C (81°F). The boiling point, (temperature at which the liquid fuel becomes vapor) is approximately -40° C (-40° F). When the fuel changes from liquid to vapor the fuel expands and creates pressure inside the tank. When the tank service valve is opened the pressure inside the tank forces the liquid fuel out though the pick up tube located near the bottom of the fuel cylinder. Because the Propane is stored under pressure the tank is equipped with a safety valves which are normally set at 25.8 bar (375 psi) to prevent tank rupture due to over-pressurization of the cylinder. The service valve mounted in the end of the cylinder controls the flow of fuel from the tank. By turning the handle to its "open" position, fuel flows out of the tank and into the service line. The service valve is also equipped with a safety feature called an "excess flow check valve". This feature reduces the flow from the service valve in the event of a rupture of the fuel line or any down stream component.

1. Liquid Outage Valve w/Quick Disconnect Coupling
2. Filler Valve
3. Pressure Relief Valve
4. Liquid Outage Fill Check Valve (80% Approx.)
11. Vapor withdrawal
12. 80% limiter t
13. Gauge Float device
14. Liquid Withdrawal Tube



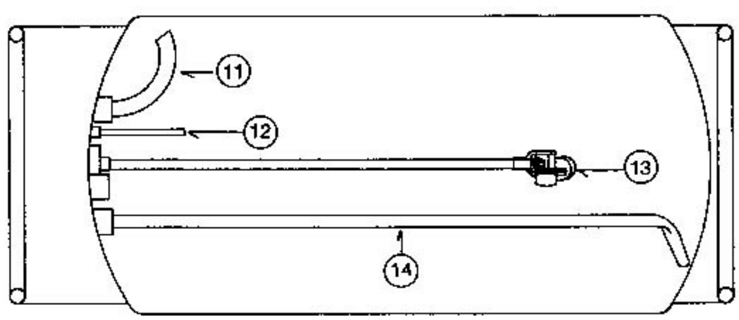


Figure 2 *Typical Propane Cylinders*

SERVICE LINE

Propane flows from the fuel tank to the electric lock via the service line. The service line is connected to the tank utilizing a quick coupler. The other end of the service line is connected to a "bulkhead connector" mounted on the equipment sheet metal. This bulkhead connector allows for a safe means of passing through the equipments engine compartment sheet metal and into the engine compartment. If a bulkhead connector is used a pressure relief device is mounted in the service line or the connector itself to prevent over pressurization of the service line. The service line is made of high pressure hose with special material or possibly tubing which is friendly to the LPG fuel and should always be replaced with an OEM supplied part.

CAUTION

The bulkhead assembly should never be removed and a service line, run through the sheet metal.

FUEL FILTER

Propane fuel like all other motor fuels is subject to contamination from outside sources. Refueling of the equipments tank and removal of the tank from the equipment can inadvertently introduce dirt and other foreign matter into the fuel system. It is therefore necessary to filter the fuel prior to entering the fuel system components down stream of the tank. An inline fuel filter has been installed in the fuel system to remove the dirt and foreign matter from the fuel. The inline filter is replaceable as a unit only. Maintenance of the filter is critical to proper operation of the fuel system and should be replaced as defined in the *Recommended Maintenance Schedule*. In severe operating condition more frequent replacement of the filter may be necessary.

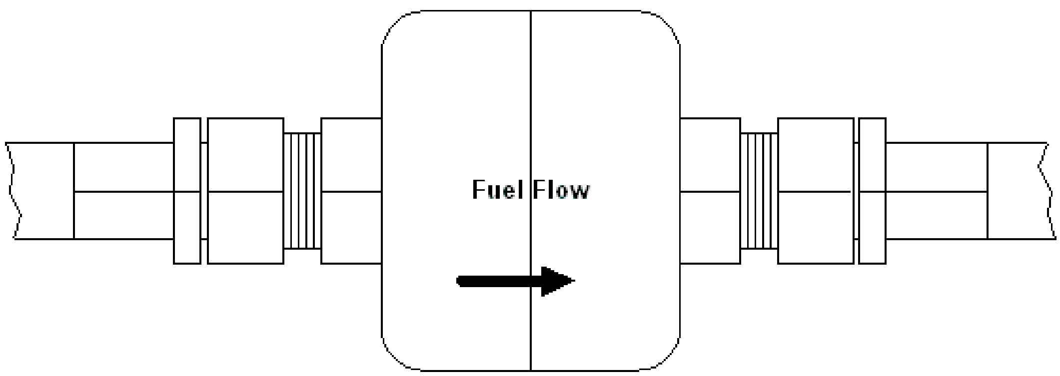


Figure 3 Inline Fuel Filter

ELECTRIC LOCK OFF

The Electric Lock Off device is an integrated assembly. The electric lock assembly is a 12 volt normally closed valve. The solenoid is mounted to the valve body. When energized the solenoid opens the valve and allows the Propane fuel to flow through the device. The valve opens during cranking and run cycles of the engine. The lock off supply voltage is controlled by the engine control module (ECM).

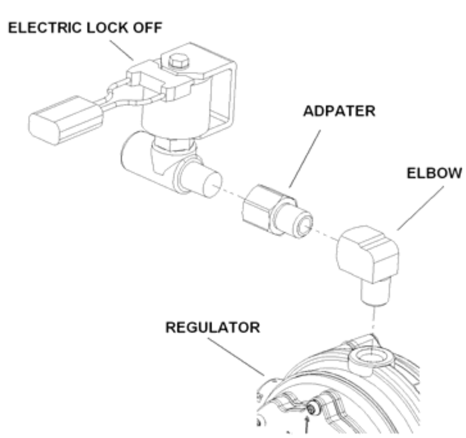


Figure 4 Electric Fuel Lock Off

LOW PRESSURE REGUALTOR (LPR)

The LPR is a combination vaporizer, pressure regulating device. The LPR is a negative pressure two stage regulator that is normally closed when the engine is not running. When the engine is cranking or running a partial vacuum is created in the fuel line which connects the regulator to the mixer. This partial vacuum opens the regulator permitting fuel to flow to the mixer.

Propane fuel enters the primary port of the LPR and passes through the primary jet and into the primary/exchanger chamber. As the propane passes through the heat exchanger the fuel expands and creates pressure inside the chamber. The pressure rises as the fuel expands when the pressure rises above 10.34 kpa (1.5 psi), sufficient pressure is exerted on the primary diaphragm to cause the diaphragm plate to pivot and press against the primary valve pin thus closing off the flow of fuel. This action causes the flow of fuel into the regulator to be regulated. When the engine is cranking, sufficient vacuum will be introduce into the secondary chamber from the mixer drawing the secondary diaphragm down onto the spring loaded lever and opening the secondary valve allowing vaporized fuel to pass to the mixer. Increased vacuum in the secondary chamber increases the downward action on the secondary lever causing it to open wider allowing more fuel to flow to the mixer.

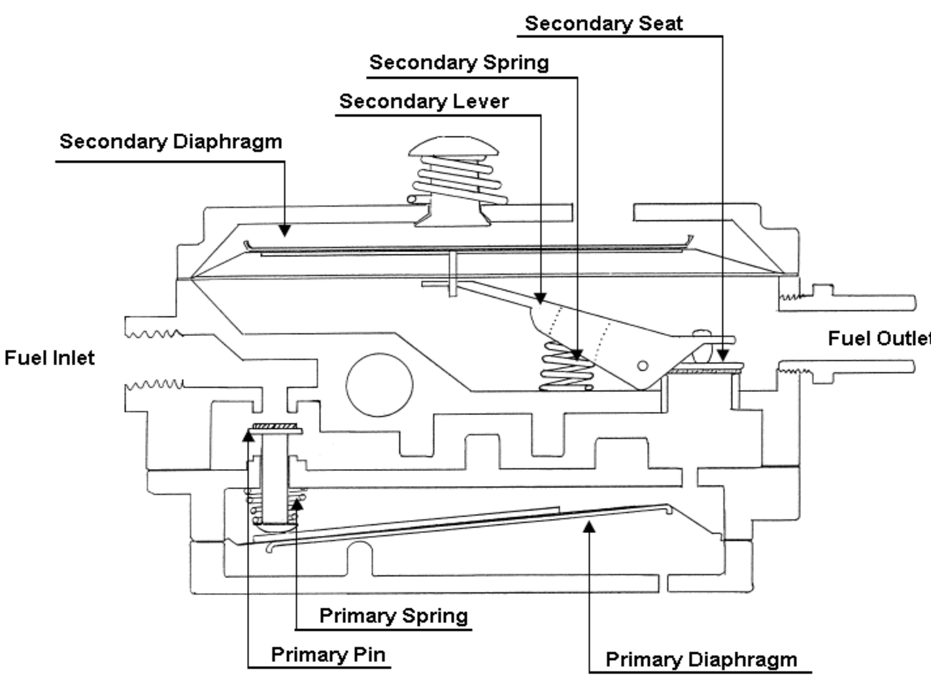


Figure 5 Low pressure regulator

AIR FUEL MIXER

The air valve mixer is an air-fuel metering device and is completely self-contained. The mixer is an air valve design, utilizing a relatively constant pressure drop to draw fuel into the mixer from cranking to full load. The mixer is mounted in the air stream ahead of the throttle control device.

When the engine begins to crank it draws in air with the air valve covering the inlet, negative pressure begins to build. This negative pressure signal is communicated to the top of the air valve chamber through 4 vacuum ports in the air valve assembly. A pressure/force imbalance begins to build across the air valve diaphragm between the air valve vacuum chamber and the atmospheric pressure below the diaphragm. The air valve vacuum spring is calibrated to generate from 101.6 mm (4.0 inches) of water column at start to as high as 355.60 mm (14.0 inches) of water column at full throttle. The vacuum being created is referred to as Air Valve Vacuum (AVV). As the air valve vacuum reaches 101.6mm (4.0 inches) of water column, the air valve begins to lift against the air valve spring. The amount of AVV generated is a direct result of the throttle position. At low engine speed the air valve vacuum is low and the air valve position is low thus creating a small venturi for the fuel to flow. As the engine speed increase the AVV increases and the air valve is lifted higher thus creating a much larger venturi. This air valve vacuum is communicated from the mixer venture to the LPR secondary chamber via the low pressure fuel supply hose. As the AVV increases in the secondary chamber the secondary diaphragm is drawn further down forcing the secondary valve lever to open wider.

The mixer is equipped with a low speed mixture adjustment which is retained in a tamper proof housing. The mixer has been preset at the factory and should not require any adjustment. In the event that the idle adjustment should need to be adjusted refer to the *Fuel System Repair* section of this manual.

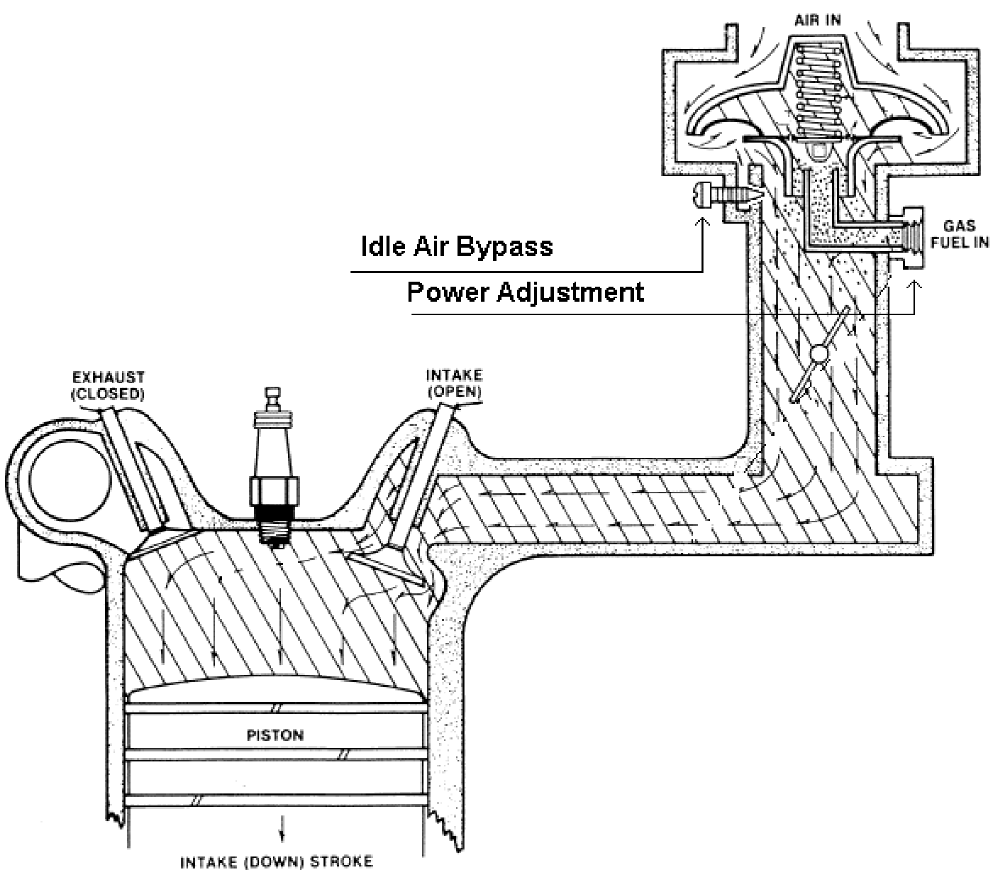


Figure 6 Air Fuel Mixer

Symptom Diagnosis

Important Preliminary Checks

Checks	Action
Before Using This Section	Before using this section, you should have verified that there is fuel in the fuel tank. Several of the following symptom procedures call for a careful visual and physical check. The visual and physical checks are very important. The checks can lead to correcting a problem without further checks that may save valuable time.
LPG Fuel System Check	1. Verify the customer complaint. 2. Locate the correct symptom table. 3. Check the items indicated under that symptom. 4.
Visual and Physical Checks	• Check all system fuses and circuit breakers. • Check the battery ground for being clean, tight and in its proper location. • Check the vacuum hoses for splits, kinks and proper connections. • Check thoroughly for any type of leak or restriction. • Check for air leaks at all the mounting areas of the intake manifold sealing surfaces. • Check for proper installation of the mixer module assembly. • Check for air leaks at the mixer assembly. • Check the ignition wires for the following conditions: – Cracking – Hardness – Proper routing – Carbon tracking • Check the wiring for the following items: – Proper connections, pinches or cuts. • The following symptom tables contain groups of possible causes for each symptom. The order of these procedures is not important. If the scan tool readings do not indicate the problems, then proceed in a logical order, easiest to check or most likely to cause first.

Intermittent

Checks	Action
DEFINITION: The problem occurs intermittently during normal operation	
Preliminary Checks	• Refer to *Important Preliminary Checks.* •
Faulty Electrical Connections or Wiring	• Faulty electrical connections or wiring can cause most intermittent problems. • Check the suspected circuit for the following conditions: – Faulty fuse or circuit breaker – Connectors poorly mated – Terminals not fully seated in the connector (backed out) – Terminals not properly formed or damaged – Terminal to wires poorly connected – Terminal tension insufficient. • Carefully remove all the connector terminals in the problem circuit in order to ensure the proper contact tension. If necessary, replace all the connector terminals in the problem circuit in order to ensure the proper contact tension. • Checking for poor terminal to wire connections requires removing the terminal from the connector body.
Fuel System	Check fuel tank and supply hose • Check excess flow check valve for activation • Check tank liquid pick up tube for brakage

No Start

Checks	Action
DEFINITION: The engine cranks OK but does not start.	
Preliminary Checks	• Refer to *Important Preliminary Checks*.
Power Checks	• Check battery power, ignition power and ground circuits. Refer to *Engine Control Schematics.* Verify voltage and/or continuity for each circuit.
Sensor Checks	• Oil Pressure Switch .
Fuel System Checks	**Important**: A closed LPG manual fuel shut off valve will create a no start condition. • Check for air intake system leakage between the mixer and the throttle body. • Verify proper operation of the low pressure lock-off solenoids. • Check the fuel system pressures. Refer to the *LPG Fuel System Diagnosis*. • Check for proper mixer air valve operation.
Ignition System Checks	Note: LPG being a gaseous fuel requires higher secondary ignition system voltages for the equivalent gasoline operating conditions. • Check for the proper ignition voltage output with *J 26792* or the equivalent. • Verify that the spark plugs are correct for use with LPG • Check the spark plugs for the following conditions: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Heavy deposits • Check for bare or shorted ignition wires. • Check for loose ignition coil connections at the coil.
Engine Mechanical Checks	**Important:** The LPG Fuel system works on a fumigation principle of fuel introduction and is more sensitive to intake manifold leakage than the gasoline fuel supply system. • Check for the following: – Vacuum leaks – Improper valve timing – Low compression – Bent pushrods – Worn rocker arms – Broken or weak valve springs – Worn camshaft lobes.
Exhaust System Checks	• Check the exhaust system for a possible restriction: – Inspect the exhaust system for damaged or collapsed pipes – Inspect the muffler for signs of heat distress or for possible internal failure.

Hard Start

Checks	Action
DEFINITION: The engine cranks OK, but does not start for a long time. The engine does eventually run, or may start but immediately dies.	
Preliminary Checks	• Refer to *Important Preliminary Checks*. • Make sure the vehicle's operator is using the correct starting procedure.
Fuel System Checks	**Important**: A closed LPG manual fuel shut off valve will create an extended crank OR no start condition. • Verify the excess flow valve in the LPG manual shut-off valve is not tripped. • Check mixer module assembly for proper installation and leakage. • Verify proper operation of the low pressure lock-off solenoids. • Check for air intake system leakage between the mixer and the throttle body. • Check the fuel system pressures. Refer to the *Fuel System Diagnosis*.
Ignition System Checks	Note: LPG being a gaseous fuel requires higher secondary ignition system voltages for the equivalent gasoline operating conditions. • Check for the proper ignition voltage output with *J 26792* or the equivalent. • Verify that the spark plugs are correct for use with LPG • Check the spark plugs for the following conditions: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Heavy deposits • Check for bare or shorted ignition wires. • Check for moisture in the distributor cap if applicable. • Check for loose ignition coil connections.
Engine Mechanical Checks	**Important:** The LPF Fuel system works on a fumigation principle of fuel introduction and is more sensitive to intake manifold leakage than the gasoline fuel supply system. • Check for the following: – Vacuum leaks – Improper valve timing – Low compression – Bent pushrods – Worn rocker arms – Broken or weak valve springs – Worn camshaft lobes. Ref • Check the intake and exhaust manifolds for casting flash.

Checks	Action
Exhaust System Checks	• Check the exhaust system for a possible restriction: – Inspect the exhaust system for damaged or collapsed pipes – Inspect the muffler for signs of heat distress or for possible internal failure.

Cuts Out, Misses

Checks	Action
DEFINITION: A surging or jerking that follows engine speed, usually more pronounced as the engine load increases which is not normally felt above 1500 RPM. The exhaust has a steady spitting sound at idle, low speed, or hard acceleration for the fuel starvation that can cause the engine to cut-out.	
Preliminary Checks	• Refer to *Important Preliminary Checks*.
Ignition System Checks	• Start the engine. • Wet down the secondary ignition system with water from a spray bottle, and look/listen for arcing or misfiring as you apply water. • Check for proper ignition output voltage with spark tester J 26792. • Check for a cylinder misfire. • Verify that the spark plugs are correct for use with LPG • Remove the spark plugs in these cylinders and check for the following conditions: • Insulation cracks • Wear • Improper gap • Burned electrodes • Heavy deposits • Visually/Physically inspect the secondary ignition for the following: • Ignition wires for arcing, cross-firing and proper routing • Ignition coils for cracks or carbon tracking
Engine Mechanical Checks	• Perform a cylinder compression check. • Check the engine for the following: – Improper valve timing – Bent pushrods – Worn rocker arms – Worn camshaft lobes. – Broken or weak valve springs. • Check the intake and exhaust manifold passages for casting flash.
Fuel System Checks	• Check the fuel system - plugged fuel filter, low fuel pressure, etc. Refer to *LPG Fuel System Diagnosis*. • Check the condition of the wiring to the low pressure lock-off solenoid.
Additional Check	Check for Electromagnetic Interference (EMI). • EMI on the reference circuit can cause a missing condition. • Monitoring the engine RPM with a scan tool can detect an EMI. • A sudden increase in the RPM with little change in the actual engine RPM, indicates EMI is present. • If the problem exists, check the routing of the secondary wires and the ground circuit.

Hesitation, Sag, Stumble

Checks	Action
DEFINITION: The vehicle has a momentary lack of response when depressing the accelerator. The condition can occur at any vehicle speed. The condition may cause the engine to stall if it's severe enough.	
Preliminary Checks	Refer to *Important Preliminary Checks*.
Fuel System Checks	• Check the fuel pressure. Refer to *LPG Fuel System Diagnosis*. • Check for low fuel pressure during a moderate or full throttle acceleration. If the fuel pressure drops below specification, there is possibly a faulty low pressure regulator or a restriction in the fuel system. • Check LPL electrical connection • Check the mixer air valve for sticking or binding. • Check the mixer module assembly for proper installation and leakage..
Ignition System Checks	Note: LPG being a gaseous fuel requires higher secondary ignition system voltages for the equivalent gasoline operating conditions. If a problem is reported on LPG and not gasoline, do not discount the possibility of a LPG only ignition system failure and test the system accordingly. • Check for the proper ignition voltage output with *J 26792* or the equivalent. • Verify that the spark plugs are correct for use with LPG Check for faulty spark plug wires • Check for fouled spark plugs. •
Additional Check	1. Check for manifold vacuum or air induction system leaks • Check the alternator output voltage.

Backfire

Checks	Action
DEFINITION: The fuel ignites in the intake manifold, or in the exhaust system, making a loud popping noise.	
Preliminary Check	• Refer to *Important Preliminary Checks*.
Ignition System Checks	**Important!** **LPG, being a gaseous fuel, requires higher secondary ignition system voltages for the equivalent gasoline operating conditions. The ignition system must be maintained in peak condition to prevent backfire.** • Check for the proper ignition coil output voltage using the spark tester *J26792* or the equivalent. • Check the spark plug wires by connecting an ohmmeter to the ends of each wire in question. If the meter reads over 30,000 ohms, replace the wires. • Check the connection at each ignition coil. • Check for deteriorated spark plug wire insulation. • Check the spark plugs. The correct spark plugs for LPG are • Remove the plugs and inspect them for the following conditions: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Heavy deposits
Engine Mechanical Check	**Important!** **The LPG Fuel system works on a fumigation principle of fuel introduction and is more sensitive to intake manifold leakage than a gasoline fuel supply system.** • Check the engine for the following: – Improper valve timing – Engine compression – Manifold vacuum leaks – Intake manifold gaskets – Sticking or leaking valves – Exhaust system leakage • Check the intake and exhaust system for casting flash or other restrictions.
Fuel System Checks	• Perform a fuel system diagnosis. Refer to *LPG Fuel System Diagnosis*.

Lack of Power, Sluggishness, or Sponginess

<table>
<tr><th>Checks</th><th>Action</th></tr>
<tr><td colspan="2">DEFINITION: The engine delivers less than expected power. There is little or no increase in speed when partially applying the accelerator pedal.</td></tr>
<tr><td>Preliminary Checks</td><td>• Refer to Important Preliminary Checks.
• Compare the customer’s vehicle with a similar unit. Make sure the customer has an actual problem. Do not compare the power output of the vehicle operating on LPG to a vehicle operating on gasoline as the fuels do have different drive feel characteristics
• Remove the air filter and check for dirt or restriction.
• Check the vehicle transmission Refer to the OEM transmission diagnostics.</td></tr>
<tr><td>Fuel System Checks</td><td>• Check for a restricted fuel filter, contaminated fuel, or improper fuel pressure. Refer to LPG Fuel System Diagnosis.
• Check for the proper ignition output voltage with the spark tester J 26792 or the equivalent.
• Check for proper installation of the mixer module assembly.
• Check all air inlet ducts for condition and proper installation.
• Check for fuel leaks between the LPR and the mixer.
• Verify that the LPG tank manual shut-off valve is fully open.
• Verify that liquid fuel (not vapor) is being delivered to the LPR.</td></tr>
<tr><td>Exhaust System Checks</td><td>• Check the exhaust system for a possible restriction:
– Inspect the exhaust system for damaged or collapsed pipes
– Inspect the muffler for signs of heat distress or for possible internal failure..</td></tr>
<tr><td>Engine Mechanical Check</td><td>Check the engine for the following:
• Engine compression
• Valve timing
• Improper or worn camshaft. Refer to Engine Mechanical in the Service Manual.</td></tr>
<tr><td>Additional Check</td><td>• Check the generator output voltage.
• If all procedures have been completed and no malfunction has been found, review and inspect the following items:
• Visually and physically, inspect all electrical connections within the suspected circuit and/or systems.</td></tr>
</table>

Poor Fuel Economy

Checks	Action
DEFINITION: Fuel economy, as measured by refueling records, is noticeably lower than expected. Also, the economy is noticeably lower than it was on this vehicle at one time, as previously shown by an by refueling records.	
Preliminary Checks	• Refer to *Important Preliminary Checks*. • Check the air cleaner element (filter) for dirt or being plugged. • Visually (Physically) check the vacuum hoses for splits, kinks, and proper connections. • Check the operators driving habits for the following items: – Is there excessive idling or stop and go driving? – Are the tires at the correct air pressure? – Are excessively heavy loads being carried? – Is their often rapid acceleration? • Suggest to the owner to fill the fuel tank and to recheck the fuel economy. • Suggest that a different operator use the equipment and record the results.
Fuel System Checks	• Check the LPR fuel pressure. Refer to *LPG Fuel System Diagnosis*. • Check the fuel system for leakage.
Ignition System Checks	• Verify that the spark plugs are correct for use with LPG • Check the spark plugs. Remove the plugs and inspect them for the following conditions: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Heavy deposits • Check the ignition wires for the following items: – Cracking – Hardness – Proper connections
Cooling System Checks	• Check the engine thermostat for always being open or for the wrong heat range
Additional Check	• Check the transmission shift pattern. Refer to the OEM Transmission Controls section the Service Manual. • Check for dragging brakes.

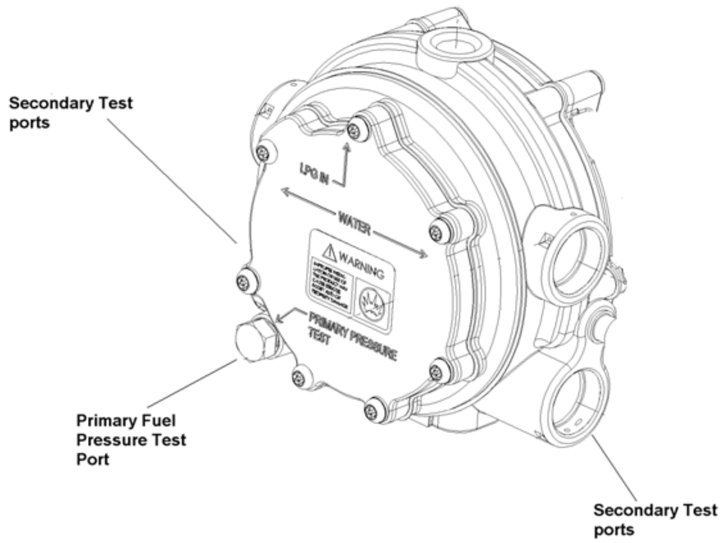
Rough, Unstable, or Incorrect Idle, Stalling

Checks	Action
DEFINITION: The engine runs unevenly at idle. If severe enough, the engine or vehicle may shake. The engine idle speed may vary in RPM. Either condition may be severe enough to stall the engine.	
Preliminary Check	• Refer to *Important Preliminary Checks*.
Fuel System Checks	• Check for rich or lean symptom that causes the condition. Drive the vehicle at the speed of the complaint. • Check for a sticking mixer air valve. • Perform a cylinder compression test. Refer to *Engine Mechanical* in the Service Manual. • Check the LPR fuel pressure. Refer to the *LPG Fuel System Diagnosis*. • Check mixer module assembly for proper installation and connection.
Ignition System Checks	• Check for the proper ignition output voltage using the spark tester *J26792* or the equivalent. • Verify that the spark plugs are correct for use with LPG Check the spark plugs. Remove the plugs and inspect them for the following conditions: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Blistered insulators – Heavy deposits • Check the spark plug wires by connecting an ohmmeter to the ends of each wire in question. If the meter reads over 30,000 ohms, replace the wires.
Additional Checks	**Important:** The LPG Fuel system works on a fumigation principle of fuel introduction and is more sensitive to intake manifold leakage than the gasoline fuel supply system. • Check for vacuum leaks. Vacuum leaks can cause a higher than normal idle and low throttle angle control command. • Check the battery cables and ground straps. They should be clean and secure. Erratic voltage may cause all sensor readings to be skewed resulting in poor idle quality..
Engine Mechanical Check	• Check the engine for the following: – Broken motor mounts – Improper valve timing – Low compression – Bent pushrods – Worn rocker arms – Broken or weak valve springs – Worn camshaft lobes

Surges/Chuggles

Checks	Action
DEFINITION: The engine has a power variation under a steady throttle or cruise. The vehicle feels as if it speeds up and slows down with no change in the accelerator pedal.	
Preliminary Checks	• Refer to *Important Preliminary Checks*. • Be sure the driver understands the Torque Converter Clutch operation.
Fuel System Checks	• Check for Rich or Lean symptom that causes the condition. Drive the vehicle at the speed of the complaint. • Check the fuel pressure while the condition exists. Refer to *LPG Fuel System Diagnosis.* • Verify that the LPG manual shut-off valve is fully open. • Check the in-line fuel filter for restrictions.
Ignition System Checks	• Check for the proper ignition output voltage using the spark tester J26792 or the equivalent. • Verify that the spark plugs are correct for use with LPG Check the spark plugs. Remove the plugs and inspect them for the following conditions: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Heavy deposits
Additional Check	• Check the Battery ground for being clean, tight, and in their proper locations. • Check the generator output voltage. • Check the vacuum hoses for kinks or leaks. • Check Transmission

LPG Fuel System Diagnosis



Fuel System Description

The Low Pressure Lockoff (LPL) solenoids prevent fuel flow unless the engine is cranking or running. LPG is stored in the tank and delivered under pressure to the system as a liquid. During key on, the LPL receives an electrical supply from the ignition circuit which opens the LPL, which allows LPG to flow from the tank through fuel filter and fuel lines to the low pressure regulator (LPR) at pressures up to 21.5 BAR (312 psi).

In the (LPR) the fuel is vaporized and the pressure reduced in two stages. The first stage reduces the pressure to approximately 20.68 kilopascals (3.0 psi). The second stage reduces the pressure to approximately negative 38.1 mm (1.5") of water column.

The fuel is then drawn from the secondary chamber of the LPR by the vacuum generated by air flowing through the mixer. This vacuum signal is also used to generate lift for the mixer air valve. This vacuum signal is most commonly referred to as air valve vacuum. In the mixer, the fuel mixes with the air entering the engine. This air/fuel mixture is then drawn into the engine for combustion.

Diagnostic Aids

This procedure is intended to diagnose a vehicle operating on LPG. If the vehicle will not continue to run on LPG, refer to *Hard Start* for preliminary checks. Before proceeding with this procedure, verify that the vehicle has a sufficient quantity of fuel and that liquid fuel is being delivered to the LPR. Also, ensure that the manual shut off valve on the LPG tank is fully opened and that the excess flow valve has not been activated.

Tools Required:

- 7/16 Open end wrench (for test port plugs)
- Straight Blade screw driver
- DVOM (GM J 39200, Fluke 88 or equivalent).

Pressure Gauges

- Water Column Gauge / Manometer (GM 7333-6 or equivalent).
- 0-10 PSI Gauge

Test Description

The numbers below refer to step numbers on the diagnostic table.

5. The vacuum on the secondary test port will be approximately –1.0 " to –2.0" w.c.
6. This step checks the base mechanical LPR output pressure.
9. This step checks for proper air valve operation.
19. This determines if fuel is available from the fuel tank supply system.

LPG Fuel System Diagnosis

Step	Action	Value(s)	Yes	No
1	Were you referred to this procedure by a Symptom chart?	—	Go to *Step 3*	Go to *Step 2*
2	What the symptom chart reviewed	—	Go to *Step 3*	Go to the symptom chart
3	Verify that the LPG fuel tank has a minimum of 1/4 tank of fuel, that the manual valve is open and the tank quick connect is fully engaged Does the vehicle have fuel?	—	Go to *Step 4*	—
4	1. Connect a water column gauge or a manometer to the secondary test port of the low pressure regulator (LPR). 2. Start the engine and allow it to reach operating temperature. Does the engine start and run?	—	Go to *Step 5*	Go to *Step 8*
5	With the engine idling, observe the pressure reading for the LPR secondary pressure. Does the fuel pressure fluctuate rhythmically **OUTSIDE** the specified range?	-1.0” to -2.0” w.c.	Go to *Step 25*	Go to *Step 6*
6	1. With the engine idling observe the pressure reading on the secondary test port. Is the fuel pressure **WITHIN** the specified range?	-1.0” to -2.0” w.c.	Go to *Fuel 26*	Go to *Step 7*
7	1. Inspect the air intake stream between the mixer assembly and the throttle body for leaks. 2. Inspect the fuel hose connection between the LPR and mixer assembly for damage or leakage. 3. Inspect the vacuum hoses to the FTV solenoid. Was a problem found and corrected?	—	Go to *Step 26*	Go to *Step 22*
8	1. Connect a water column gauge or a manometer to the secondary test port of the low pressure regulator (LPR). 2. Crank the engine and observe the pressure reading for the LPR secondary pressure. Does the fuel pressure indicate a vacuum is present?	—	Go to *Step 12*	Go to *Step 9*

Step	Action	Value(s)	Yes	No
9	1. Remove Air induction hose to the mixer 2. Observe the air valve for movement while the engine is cranking. **Note:** Movement of the air valve will be minimal at cranking speeds. Does the air valve move when the engine is cranked?	—	Go to *Step 11*	Go to *Step 10*
10	1. Inspect the air intake stream to the mixer assembly and the throttle body for vacuum leaks. Was a problem found and repaired?	—	Go to *Step 26*	Go to *Step 24*
11	Inspect the fuel hose connection between the LPR and the mixer assembly for damage or leakage. Was a problem found and repaired?	—	Go to *Step 26*	Go to *Step 12*
12	1. Connect a 0-10 psi gauge to the primary test port of the low pressure regulator (LPR). 2. Crank the engine and observe the pressure reading for the LPR primary pressure. Is the fuel pressure **ABOVE** the specified value?	2.0 – 3.0 psi	Go to *Step 22*	Go to *Step 13*
13	1. Turn OFF the ignition. 2. Disconnect the LPL connector. 3. Install a test light between the pins of the LPL connector. 4. Crank the engine. The test light should illuminate. Does the test light illuminate?	—	Go to *Step 14*	Go to *Step 16*
14	Using a DVOM, check the resistance of the low pressure lock-off (LPL). Is the resistance within the specified range?	12 - 24 Ω	Go to *Step 15*	Go to *Step 23*
15	1. Turn the ignition OFF. 2. Close the manual shut-off valve on the LPG tank. **CAUTION: When disconnecting LPG fuel lines, liquid LPG may be present. Perform this step in a well ventilated area.** 3. Loosen the fuel inlet hose fitting at the inlet of the LPL. Was fuel present when the fitting was loosened?	—	Go to *Step 23*	Go to *Step 17*

Step	Action	Value(s)	Yes	No
16	1. Turn OFF the ignition. 2. Connect the test light to chassis ground and probe pin A of the LPL connector. 3. Crank the engine. The test light should illuminate. Does the test light illuminate?	—	Go to *Step 20*	Go to *Step 21*
17	1. Remove the LPG fuel filter / LPL. 2. Remove the filter from the LPL. 3. Empty the contents of the inlet side of the LPG fuel filter onto a clean surface. 4. Inspect the contents of the LPG fuel filter for an excessive amount of foreign material or water. If necessary, locate and repair the source of contamination. 5. Verify the LPG fuel filter is not restricted or plugged. Was a problem found?	—	Go to *Step 19*	Go to *Step 23*
18	The fuel supply system or hoses are plugged or restricted, locate and repair the problem. Is the action complete?	—	Go to *Step 26*	—
19	Replace the fuel filter. Refer to *Fuel Filter Replacement.* Is the action complete?	—	Go to *Step 26*	—
20	Repair the open in the lock-off ground circuit. Is the action complete?	—	Go to *Step 26*	—
21	Repair the open in the lock-off power (OEM fuel pump) circuit. Is the action complete?	—	Go to *Step 26*	—
22	Replace the low pressure regulator (LPR). Refer to *Low Pressure Regulator Replacement*. Is the action complete?	—	Go to *Step 26*	—
23	Replace the lock-off. Refer to *Low Pressure Lock-off (LPL) Replacement*. Is the action complete?	—	Go to *Step 26*	—
24	Replace the mixer assembly. Refer to *Fuel Mixer Replacement*. Is the action complete?	—	Go to *Step 26*	—

<table>
<tr><th>Step</th><th>Action</th><th>Value(s)</th><th>Yes</th><th>No</th></tr>
<tr><td>25</td><td>The fuel supply system is operating normally, if a failure of the control solenoids is suspected. Refer to Fuel Control System Diagnosis.

1. Install the test plug in the LPR secondary chamber.
2. If you were sent to this routine by another diagnostic chart, return to the previous diagnostic procedure.

Is the action complete?</td><td>—</td><td>System OK</td><td>—</td></tr>
<tr><td>26</td><td>1. Disconnect all test equipment
2. Install the primary and secondary test port plugs.
3. Start the engine.
4. Using SNOOP® or equivalent, leak check the test port plugs.

Is the action complete?</td><td>—</td><td>System OK</td><td>—</td></tr>
</table>

MAINTENANCE OF IMPCO FUEL SYSTEM

The maintenance of the engine and its related components is critical to the life of the engine and optimum performance during its useful life. All engines require a certain amount of maintenance. The suggested maintenance requirements for the fuel system are contained in this section refer to the base engine manual for engine maintenance. Engines operate in various environments from extremely dusty environments, to hot and cold temperature environments and clean environments. The recommended schedule is a recommended guideline for the owner and servicing agency to follow, however certain environmental operating conditions may require more frequent inspection and maintenance. In addition the owner may have installed additional equipment to the vehicle, which may also increase the requirements for service on certain components. Therefore the owner and servicing agent should review the operating condition of the vehicle and determine if more frequent inspections and maintenance cycles maybe required.

GENERAL MAINTENANCE

The Recommended Maintenance Schedule contained in this section is the fuel system manufacturers suggested maintenance and the frequency in which those maintenance activities should be performed. Other than the daily inspections the fuel system manufacturer has indicated the suggested service interval in kilometers of operation.

DAILY INSPECTIONS

At the beginning of each shift or first use of the day the operator or maintenance technician should inspect the following items before starting and operating the equipment.

When visually checking for leaks check the following

- Check under the vehicle for large pools of coolant, oils
- Check around the fuel cylinder for any LPG leakage
- Open the hood and remove the Engine oil dip stick and check to ensure the oil level is between the “ADD” and “Full” marks

WARNING

When preforming maintenance on the engine shut off the engine to avoid injury or damage to the engine

COOLING SYSTEM

WARNING

Alcohol - or Methanol base antifreeze or plain water are not recommended for use in the cooling system at anytime

It is important to remember that the cooling system of this engine be maintained properly to insure the longevity of the engine. Maintenance of the cooling system is critical to not only the engine but the fuel system as well. Because the LPR is connected into the cooling system low coolant levels and restricted or plugged radiator cores can impact the performance of the fuel system. Therefore proper maintenance of the cooling system should include removing dust, dirt and debris from the radiator core on regular intervals. To properly maintain the cooling system follow the recommend maintenance schedule in this section.

Cooling System inspections should be performed as prescribed when inspecting the cooling system check for the following:

- Plugged or restricted radiator core clean with compressed air, blow dust and debris from the core and the fan shroud
- Check the radiator cap to insure proper sealing if damage replace
- Check for coolant leaks at the radiator tank seams and inlet joints repair or replace as necessary
- Check for leaks at the radiator hose connections, tighten hose clamps if necessary
- Check Radiator hoses for swelling, separation, cracks deterioration in the hoses, or hardening, if any of these conditions exist the hose should be replaced with the OEM replacement parts
- Check coolant level if low add with 50/50 mixture, Do not add plain water
- Replace coolant per the recommended schedule in this section

Checking the Coolant Level

Do not remove the cooling system pressure cap when the engine is hot. Allow the engine to cool and then remove the 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.

IMPORTANT:
Engine manufacturers and the fuel system supplier do not recommend the use of “stop leak” additives to repair leaks in the cooling system. If leaks are present the radiator should be removed and repaired.

If the radiator requires repair insure that the radiator core repairs did not result in a significant reduction in the cooling capacity of the radiator.

Engine manufacturers and fuel system suppliers recommend the cooling system be filled with a 50/50 mixture of ethelyene glychol anitfreeze and water.

ENGINE ELECTRICAL SYSTEM MAINTENANCE

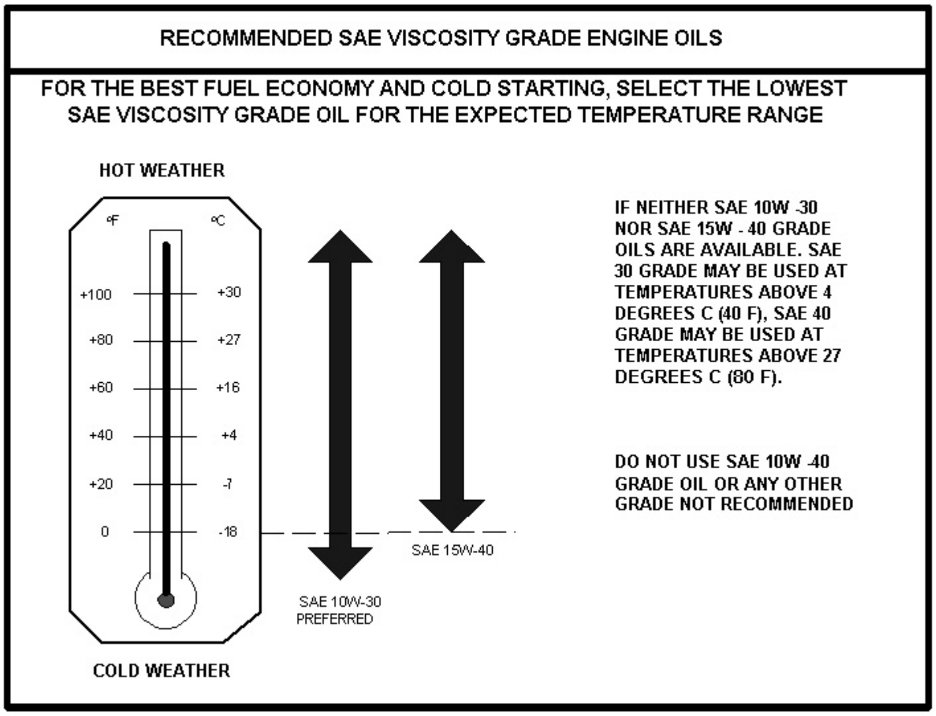
The engine electrical system incorporates computers to control certain functions of the fuel system and ignition system control. The electrical system connections and ground circuits require good connections. Follow the recommended maintenance schedule in this section to maintain optimum performance. When inspecting the electrical system check the following:

- Check battery connection clean and insure that connectors are tight
- Check battery for cracks or damage to the case replace if necessary
- Check Positive and Negative cables for corrosion, rubbing, chaffing and insure tight connections at both ends
- Check engine wire harness for rubbing, chaffing, pinching, and cracks or breaks in the wiring
- Check engine harness connectors, check to insure fitted and locked by pushing the connector together then pull on the connector halves to insure they are locked
- Check ignition coils and wire wiring for hardening, cracking, chaffing, separation, split boot covers and proper fit
- Replace spark plugs at the required intervals per the recommended maintenance schedule
- Check to insure all electrical components are securely mounted and retained to the engine or chassis
- Check to insure any additional electrical devices installed by the owner are properly installed in the system
- Check the Alternator charging light, and oil pressure lights for operation by starting the engine and checking that the light illuminates for the prescribed period of time before turning out.

ENGINE CRANKCASE OIL

Oil recommendation

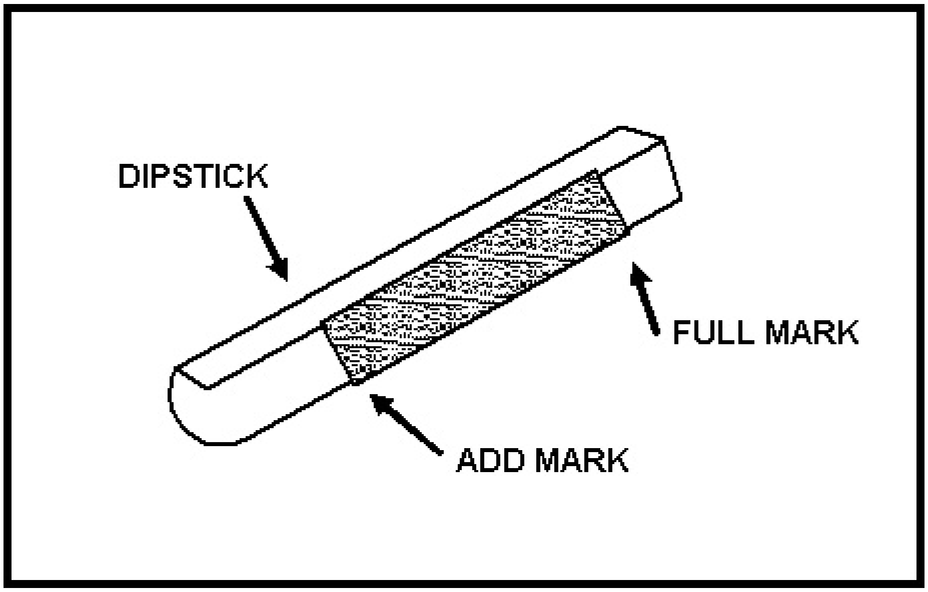
Prior to changing the oil, select oil based on the prevailing daytime temperature in the area in which the vehicle will be operated. The chart in figure 1 is a guide to selecting the proper crankcase oil.



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 the dipstick. Wipe with a clean cloth or paper towel and reinstall. Push the dipstick all the way into the dipstick tube.
4. Remove the dipstick and note the oil level.
5. Oil level must be between the "FULL" and "ADD" marks.



6. If the oil level is below the “ADD” mark, proceed to Step 7 and 8, and reinstall the dipstick into the dipstick tube.
7. Remove the oil filler cap from the valve rocker arm cover
8. Add the required amount of oil to bring the level up to but not over the “FULL” mark on the dipstick
9. Reinstall the oil filler cap to the valve rocker arm cover and wipe any excess oil clean.

CAUTION

Overfilled crankcase (oil level being to high) can cause a flucation or drop in the 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 aereated). The aereated oil cause the hydraulic lifters to "bleed down". This intrun, results in rocker are clatter and loss of engine performance due to valves not opening properly.

FUEL SYSTEM INSPECTION AND MAINTENANCE

LPG FUEL SYSTEM

The LPG fuel system installed on this vehicle has been designed to meet the emission standard applicable for this region. To ensure compliance to these standards follow the recommended maintenance schedule contained in this section.

Inspection and Maintenance of the Fuel Storage cylinder

The fuel storage cylinder should be inspected daily or at the beginning of each operational shift for leaks, external damage, adequate fuel supply and insure the manual service valve is open. Fuel storage cylinders should always be securely mounted, inspect the securing straps or retaining devices for damage insure that all locking devices are closed and locked.

IMPORTANT: When refueling the fuel cylinders, wipe clean both the female and male connection with a clean rag prior to filling. This will prevent dust, dirt and debris from being introduced to the fuel cylinders and prolong the life of the fuel filter.

Low Pressure Regulator maintenance and inspection

When inspecting the regulator check for the following items.

- Check for any fuel leaks at the inlet and outlet fittings
- Check for any fuel leaks in the regulator body
- Check the inlet and outlet fittings of the coolant supply lines for water leaks
- Check to ensure the regulator is securely mounted

Checking/draining oil build-up in the LPR

During the course of normal operation oil or “heavy ends” may build inside the secondary chamber of the LPR. These oils may be a result of poor fuel quality, contamination of the fuel supply chain, or regional variation of the fuel make up. If the build up of oil becomes significant this can affect the performance of the secondary diaphragm response. The Recommended Maintenance Schedule found in this section recommends that the oil be drained periodically.

IMPORTANT: Draining the regulator when the engine is warm will help the oils to flow freely from the regulator.

To drain the LPR use the following steps

1. Move the vehicle to a well ventilated area and insure all external ignition sources are not present.
2. Start the engine.
3. With the engine running close the manual valve.
4. When the engine runs out of fuel turn OFF the key and disconnect the negative battery cable.

IMPORTANT: A small amount of fuel may still be present in the fuel line, wear proper eye protection.

5. Slowly loosen the inlet fitting to the LPR and disconnect.
6. Loosen the hose clamp at the outlet hose fitting and remove the hose.
7. Remove the two LPR mounting bolts and retain.
8. Place a small receptacle in the engine compartment.
9. Rotate the LPR to 90° so that the outlet fitting is pointing down into the receptacle and drain the LPR.

10. Inspect the secondary chamber for any large dried particles and remove.
11. Remove the receptacle and reinstall the LPR with the two retaining bolts and tighten to specifications.
12. Reinstall the outlet fitting and secure
13. Reconnect the outlet hose and secure the hose clamp.
14. Reinstall the fuel inlet line and tighten connection to specification.
15. Slowly open the manual service valve.
16. Check for leaks at the inlet and outlet fittings using a soapy solution or an electronic leak detector, if leaks are detected make repairs.
17. Start engine recheck for leaks at the regulator.
18. Dispose of any drain material in safe and proper manner

Air Fuel Mixer/throttle control device maintenance and inspection

When inspecting the mixer check for the following items.

- Check for any fuel leaks at the inlet fitting.
- Check the fuel inlet hose for cracking, splitting or chaffing, replace if any of these condition exist.
- Check to ensure the mixer is securely mounted.
- Check air inlet hose connection and insure clamp is tight, check inlet hose for cracking, splitting or chaffing, replace if any of these condition exist.
- Check air cleaner element according to the Recommended Maintenance Schedule found in this section.
- Check Throttle body return action to ensure throttle shaft is not sticking repair if necessary.
- Check for leaks at the throttle body and intake manifold.
- Check Throttle cable for damage, rubbing, and kinking and free movement repair if necessary.

RECOMMENDED MAINTENANCE SCHEDULE

UNIT OF MEASURE	HOURS							
	Date	Daily	100	250	500	750	1000	1250
General Maintenance Section								
Visual check for leaks		X						
Check engine oil level		X						
Check coolant level		X						
Change engine oil and filter	REFER TO THE ENGINE MANUAL FOR SCHEDULED MANITENANCE							
Inspect electrical system				X		X		X
Check Fuel system for leaks				X		X		X
Inspect all vacuum lines and fitting				X		X		X
Inspect all fuel lines and fitting				X		X		X
Engine Coolant Section								
Check coolant level		X						
Clean Debris from Radiator				X		X		X
Change coolant							X	
Inspect coolant hoses for cracks, swelling or deterioration							X	
Engine Ignition System								
Inspect Battery case for damage							X	
Inspect battery cables							X	
Check all electrical connectors				X		X		X
Check ignition timing and adjust					X		X	
Replace spark plugs							X	
Check spark plug wires				X		X		X
Fuel System Maintenance								
Replace fuel filter						X		
Inspect lock off for leaks				X		X		X
Ensure lock if closing				X		X		X
Check manifold for vacuum leaks							X	
Inspect LPR for oil build up & Drain				X		X		X
Check air induction system for leaks				X		X		X
Inspect LPR for coolant leaks				X		X		X
Check throttle shaft for sticking				X		X		X
Inspect air cleaner				X		X		X
Engine Exhaust System								
Inspect exhaust manifold for leaks						X		
Inspect exhaust piping for leaks						X		

SECTION 0A

GENERAL INFORMATION

Notes, Cautions, And Warnings

Notes, Cautions, and Warnings are used in this manual to emphasize important and critical instructions. They are used for the following conditions:

NOTE

Denotes situations which could influence safety or proper performance of the vehicle or component and to highlight an essential operating procedure or condition.

⚠ CAUTION

Operating procedures or practices that will result in damage to or destruction of the engine if not strictly observed.

⚠ WARNING

Operating procedures or practices that will result in serious injury or loss of life if not correctly followed.

Fuel Systems Cautions

⚠ WARNING

Do not smoke, carry lighted tobacco, or use a lighted flame of any type when working on or near any fuel related component. Highly flammable air-fuel mixtures may be present and can be ignited causing personal injury.

⚠ WARNING

Do not allow propane to contact the skin. Propane is stored in the fuel tank as a liquid. When propane contacts the atmosphere, it immediately expands into a gas, resulting in refrigeration that can cause severe burns.

⚠ WARNING

Do not allow propane to accumulate in areas below ground level such as in a service pit or underground ventilation systems. Propane is heavier than air and can displace oxygen, creating a dangerous condition.

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 or fail to make the engine emissions compliant. 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 the warranty.

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 equivalent part. Do not use a replacement part of lesser quality. In the case of replacement parts for the emission control system use only genuine OEM replacement parts.

Before using a replacement part, service procedure, or a 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 the tool selected.

Special service tools shown in this service manaual that have tool product numbers beginning with “J” or “BT” are available for world wide distribution from:

- o Kent-Moore Tools
- o 28635 Mound Road
- o Warren, MI. 48092
- o 1-800-345-2233

Special Tools which are required to service the LPG fuel system are listed below:

- o Hand held diagnostic scanner
- o ITK-1 Fuel pressure test kit

The tools are available from:

IMPCO Engine System Division
7100 East 15 Mile Road
Sterling ‘Heights, MI. 48312
1-586-276-4333

English And Metric Fasteners

⚠ CAUTION

Late model engines use a combination of English and Metric fasteners. The components affected are the starter motor, engine mounts, and flywheel housing mounting. Other components may also have a combination of fasteners, always verify that the proper fasteners are used whenever removing or replacing any components.

Handling Electrostatic Discharge (ESD) Sensitive Parts

Many solid state electrical components can be damaged by electrostatic discharge (ESD). Some will display a label, but many will not.

In order to avoid possibly damaging any components, observe the following:

1. Body movement produces an electrostatic charge. To discharge personal static electricity, touch a ground point (metal) on the vehicle. This should be done any time you:
   - Slide across the vehicle seat.
   - Sit down or get up.
   - Do any walking.
2. Do not touch exposed electric terminals on components with your finger or any tools. Remember, the connector that you are checking might be tied into .a circuit that could be damaged ‘by electrostatic discharge.
3. When using a screwdriver or similar tool to disconnect a connector, never let the tool come in contact with or come between the exposed terminals.
4. Never jumper, ground, or use test equipment probes on any components or connectors unless specified in diagnosis. When using test equipment, always connect the ground lead first.
5. Do not remove the solid state component from its protective packaging until you are ready to install the part.
6. Always touch the solid state components package to a ground before opening. Solid state components can also be damaged if:
   - They are bumped or dropped.
   - They are laid on any metal work benches or components that operate electrically, such as a TV, radio, or oscilloscope.

GLOSSARY OF TERMS

Air Valve Vacuum (AVV): The vacuum signal taken from below the air valve assembly and above the throttle butterfly.

ADP: Adaptive Digital Processor.

Air/Fuel Ratio: The amount of air and fuel in the air fuel mixture, which enters the engine, shown in a ratio.

Analog Voltmeter: A meter that uses a needle to point to a value on a scale of numbers usually of the low impedance type; used to measure voltage and resistance.

Aromatics: Pertaining to or containing the six-carbon ring characteristic of the benzene series. Found in many crude oils.

Backfire: Combustion of the air/fuel mixture in the intake or exhaust manifolds. A backfire can occur if the intake or exhaust valves are open when there is a mis-timed ignition spark.

Benzene: An aromatic (C_6H_6). Sometimes blended with gasoline to improve antiknock value. Benzene is toxic and suspected of causing cancer.

Bi-Fueled: A vehicle equipped to run on two fuels at the same time such as a fumigated diesel.

Blow-By: Gases formed by the combustion of fuel and air, which ordinarily should exert pressure only against the piston crown and first compression ring. When rings do not seal, these gases (blowby) escape down the side of the piston into the crankcase.

BTU: British Thermal Unit. A measurement of the amount of heat required to raise the temperature of 1lb. of water 1 degree F.

Butane: An odorless, colorless gas, C_4H_{10} found in natural gas and petroleum. One of the five LP gases.

CAFE: Corporate Average Fuel Economy.

CARB: California Air Resources Board.

Carbon Monoxide (CO): A chemical compound of a highly toxic gas that is both odorless and colorless.

Carburetor: An apparatus for supplying an internal-combustion engine a mixture of vaporized fuel and air.

Cathode Ray Tube: A vacuum tube in which cathode rays usually in the form of a slender beam are projected on a fluorescent screen and produce a luminous spot.

Circuit: A path of conductors through which electricity flows before it returns to its source.

Closed Loop Operation: Applies to systems utilizing an oxygen sensor. In this mode of operation, the system uses oxygen sensor information to determine air/fuel ratio. Adjustments are made accordingly and checked by comparing the new oxygen sensor to previous signals. No stored information is used.

CNG: Compressed Natural Gas.

CKP: Crankshaft Position Sensor

CMP: Camshaft Position Sensor

Conductor: A material, normally metallic, that permits easy passage of electricity.

Contaminants: Impurities or foreign material present in fuel.

Control Module: One of several names for a solid state microcomputer which monitors engine conditions and controls certain engine functions; i.e. air/fuel ratio, injection and ignition time, etc.

Converter: A LPG fuel system component containing varying stages of fuel pressure regulation combined with a vaporizer.

Cryogen: A refrigerant used to obtain very low temperatures.

Current: The directed flow of electrons through a conductor. Measured in amps.

Dedicated Fuel System: A motor fuel system designed to operate on only one fuel type.

Diaphragm: A thin, flexible membrane that separates two chambers. When the pressure in one chamber is lower than in the other chamber, the diaphragm will move toward the side with the low pressure.

Diaphragm Port: The external port located at the fuel inlet assembly and connected to the vacuum chamber above the air valve diaphragm.

Digital Volt/Ohm Meter (DVOM): A meter that uses a numerical display in place of a gauge and is usually of the high impedance type.

DTC: Diagnostic Trouble Code

DST: Diagnostic Scan Tool.

DVOM: Digital volt/ohmmeter.

ECT: Engine Coolant Temperature.

ECM : Electronic Control module

EFI: Electronic Fuel Injection. A fuel injection system, which uses a microcomputer to determine and control the amount of fuel, required by, and injected into, a particular engine.

EGR: Exhaust gas recirculation.

EPA: Environmental Protection Agency: A regulating agency of the Federal government which, among other duties, establishes and enforces automotive emissions standards.

Ethanol: Grain alcohol (C2H5OH), generally produced by fermenting starch or sugar crops.

Evaporative Emissions Controls: An automotive emission control system designed to reduce hydrocarbon emissions by trapping evaporated fuel vapors from the fuel system.

Excess Flow Valve: A check valve that is caused to close by the fuel when the flow exceeds a predetermined rate.

Forced Idle: ECM commands electronic throttle controller to an idle position.

FTV: Fuel Trim Valve.

FFV: Flexible Fuel Vehicle.

Firing Line: The portion of an oscilloscope pattern that represents the total amount of voltage being expended through the secondary circuit.

FMVSS: Federal Motor Vehicle Safety Standards.

FPP: Foot Pedal Position Sensor

Fuel Injector:, a spring loaded, electromagnetic valve which delivers fuel into the intake manifold, in response to electrical from the control module.

Fuel Lock: A solenoid-controlled valve located in the fuel line to stop the flow when the engine stops or the ignition switch is off.

Gasohol: 10 percent ethanol, 90 percent gasoline. Often referred to as E-10.

Gasoline: A motor vehicle fuel that is a complex blend of hydrocarbons and additives. Typical octane level is 89.

Greenhouse Effect: A scientific theory that suggests that excessive levels of carbon dioxide from the burning of fossil fuels is causing the atmosphere to trap heat and cause global warming.

HD 10: A fuel of not less than 80% liquid volume propane and not more than 10% liquid volume propylene.

HD 5: A fuel of not less than 90% liquid volume propane and not more than 5% liquid volume propylene.

HDV: Heavy Duty Vehicle.

Hg: Chemical symbol for mercury. Used in reference to vacuum (in. of Hg).

Hydrocarbon: A chemical compound made up of hydrogen and carbon (HC). A major pollution emission of the internal combustion engine. Gasoline and almost all other fuels are hydrocarbons.

Hydrostatic Relief Valve: A pressure relief device installed in the liquid propane hose on a propane fuel system.

IAT: Intake Air Temperature

Ideal Mixture: The air/fuel ratio at which the best compromise of engine performance to exhaust emissions is obtained. Typically 14.7:1.

Ignition Reserve: The difference between available voltage and the required voltage.

ILEV: Inherently Low Emission Vehicle.

IMPCO: Imperial Machine Products Company. IMPCO Technologies, Inc. A manufacturer of both LPG and Gasoline fuel systems.

Impedance: A form of opposition of AC current flow (resistance) measured in ohms.

Insulation: A nonconductive material used to cover wires in electrical circuits to prevent the leakage of electricity and to protect the wire from corrosion.

Intercept: An electrical term for a type of splice where the original circuit is interrupted and redirected through another circuit.

ITK: IMPCO Test Kit

Knock: Sound produced when an engine's air/fuel mixture is ignited by something other than the spark plug, such as a hot spot in the combustion chamber. Can be caused by a

fuel with an octane rating that is too low or maladjusted ignition timing. Also called detonation or ping.

Lambda Sensor: A feedback device, usually located in the exhaust manifold, which detects the amount of oxygen present in exhaust gases in relation to the surrounding atmosphere.

LDV: Light Duty Vehicle.

Lean Mixture: An air to fuel ratio above the stoichiometric ratio; too much air.

LEV: Low Emission Vehicle.

Limp-in or Limp-home: This term is used to describe the drivability characteristics of a failed computer system

Liquified Petroleum Gas (LPG): A fuel commonly known as propane consisting mostly of propane (C3H8), derived from the liquid components of natural gas stripped out before the gas enters the pipeline, and the lightest hydrocarbons produced during petroleum refining. Octane level is 107.

Low Rev Limit Secondary engine speed control, only used to limit speed when throttle positioning is not maintaining desired speed

LPG: Liquified Petroleum Gas.

M85: A blend of gasoline and methanol consisting of 85% methanol and 15% gasoline.

Measurements of Pressure: 1 PSI=2.06 Hg (mercury) = 27.72" H2O (water column). At sea level atmospheric pressure is 29.92" Hg.

Methanol: Known as wood alcohol (CH3OH), a light, volatile, flammable alcohol commonly made from natural gas.

Misfire: Failure of the air/fuel mixture to ignite during the power stroke.

Mixer: Fuel introduction device that does not include a throttle plate.

MPFI: Multi-Point Fuel injection. A fuel injection system that uses one injector per cylinder mounted on the engine to spray fuel near the intake valve area of combustion chamber.

MTBE: Methyl Tertiary Butyl Ether. Oxygenate add to gasoline to reduce harmful emissions and to improve the octane rating.

Multi-fuel System: A motor fuel system designed to operate on two different fuels, such as LPG and gasoline.

Natural Gas: A gas formed naturally from buried organic material, composed of a mixture of hydrocarbons, with methane (CH4) being the dominant component.

NGV: Natural Gas Vehicle.

Nox: See Oxides of Nitrogen.

Octane Rating: The measurement of the antiknock value of a motor fuel.

OEM: Original Equipment Manufacturer, the vehicle manufacturer.

Open-Loop: An operational mode during which control module memory information is used to determine air/fuel ratio, injection timing, etc., as opposed to actual oxygen sensor input.

Orifice: A port or passage with a calibrated opening designed to control or limit the amount of flow through it.

Oscilloscope: An instrument that converts voltage and frequency readings into traces on a-cathode ray tube (also see Cathode Ray Tube).

Oxides of Nitrogen: Chemical compounds of nitrogen bonded to various amounts of oxygen (Nox). A chief smog forming-agent.

Oxygen Sensor: An automotive fuel system that produces a signal in accordance with the oxygen content of the exhaust gas. (See Lambda Sensor).

Oxygenate: MTBE, ethanol and methanol. Oxygenates are added to gasoline to increase the oxygen content and therefore reduce exhaust emissions.

Ozone: A radical oxygen module (O3) that is found in the upper atmosphere and filters out ultraviolet radiation from the sun. Ground level ozone is formed by Nox, during the formation of photochemical smog.

Particulates: Microscopic pieces of solid or liquid substances such as lead and carbon that are discharged into the atmosphere by internal combustion engines.

Positive Crankcase Ventilation (PCV): An automotive emission control system designed to reduce hydrocarbon emissions by routing crankcase fumes into the intake manifold rather than to the atmosphere.

Power Derate Level 1 ECM has detected condition in throttle control and limits throttle blade opening to 50%

Power Derate Level 2 ECM has detected condition in throttle control and limits throttle blade opening to 20%

Pressure Differential: The differential between atmospheric pressure and intake manifold (referred to as vacuum) pressure.

Pressure Regulator: A device to control the pressure of fuel delivered to the fuel injector(s).

Primary Circuit: The low-voltage or input side of the ignition coil.

Propane: An odorless, colorless gas, C3H8, found in natural gas and petroleum.

PTV: Pressure Trim Valve

Reactivity: Refers to the tendency of an HC in the presence of Nox and sunlight to cause a smog-forming reaction. The lighter the HC, the lower reactivity tends to be.

Regulator: An assembly used to reduce and control the pressure of a liquid or vapor.

Resistance: The opposition to the flow of current in an electrical circuit. Measured in ohms.

SECTION 0B

MAINTAINENCE

Maintenance

The maintenance of the engine and its related components is critical to the life of the engine and optimum performance during its useful life. All engines require a certain amount of maintenance. The suggested maintenance requirements are contained in this section. Industrial engines operate in various environments from extremely dusty environments, to hot and cold temperature environments and clean environments. The recommended schedule is a recommended guide line for the owner and servicing agency to follow, however certain environmental operating conditions may require more frequent inspection and maintenance. In addition the owner may have installed additional equipment to the equipment which may also increase the requirements for service on certain components. Therefore the owner and servicing agent should review the operating condition of the equipment and determine if more frequent inspections and maintenance cycles maybe required.

⚠ WARNING

The engine installed in this equipment may use one or both accessory drive belt configurations. The drive belt may be incorporated to drive the water pump, alternator and addition pumps or devices. It is important to note, the drive belt is an integral part of the cooling and charging system and should be inspected at a minimum according to the maintenance schedule in this section and in extremely hot and dirty environments more often.

When inspecting the belts check for:

- Cracks,
- Chunking of the belt,
- Splits
- Material hanging loose from the belt
- Glazing, hardening

If any of these conditions exist the belt should be replaced with an OEM replacement belt.

V-Belt Systems

Check the belt tension by pressing down on the midway point of the longest stretch between two pulleys. The belt should not depress beyond 13mm (1/2 inch). If the depression is more than allowable adjust the tension. Do not over tighten the tension of the belt. Over tightening may cause overload on the bearings and pulleys of the drive belt components.

Serpentine Belt System

Serpentine belts utilize a spring-loaded tensioner which keeps the belt properly adjusted. Serpentine belts should be checked according to the maintenance schedule in this section.

NOTE

The engine manufacturer does not recommend the use of "belt dressing" or "anti slipping agents" on either belt configuration.

Cooling System

⚠ WARNING

It is important to remember that the cooling system of this engine be maintained properly to insure the longevity of the engine. Maintenance of the cooling system is critical to not only the engine but the fuel system as well. Because the LPG vaporizer is connected into the cooling system low coolant levels and restricted or plugged radiator cores can impact the performance of the fuel system. Therefore proper maintenance of the cooling system should include removing dust, dirt and debris from the radiator core on regular intervals. To properly maintain the cooling system follow the recommend maintenance schedule in this section.

Cooling system inspections should be performed as prescribed when inspecting the cooling system check for the following:

- Plugged or restricted radiator core clean with compressed air, blow dust and debris from the core and the fan shroud
- Check the radiator cap to insure proper sealing if damage replace
- Check for coolant leaks at the radiator tank seams and inlet joints repair or replace as necessary
- Check for leaks at the radiator hose connections, tighten hose clamps if necessary
  - Check Radiator hoses for swelling,

separation, cracks deterioration in the hoses, or hardening, if any of these conditions exist the hose should be replaced with the OEM replacement parts

- Check coolant level if low add with 50/50 mixture, Do not add plain water
- Replace coolant per the recommended schedule at the end of this section

CHECKING THE COOLANT LEVEL

⚠ WARNING

Do not remove the cooling system pressure cap when the engine is hot. Allow the engine to cool and then remove the 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.

NOTE

The engine manufacturer and the fuel system supplier do not recommend the use of “stop leak” additives to repair leaks in the cooling system. If leaks are present the radiator should be removed and repaired.

If the radiator requires repair insure that the radiator core repairs did not result in a significant reduction in the cooling capacity of the radiator.

The engine manufacturer recommends the cooling system be filled with a 50/50 mixture of ethelyene glychol anitfreeze and water.

This GM industrial engine can utilize any type of permanent antifreeze or any brand antifreeze solution that meets GM Specification 1825M or 1899M which will not damage aluminum parts.

Engine Electrical System Maintenance

The engine electrical system incorporates computers to control certain functions of the equipment. The electrical system connections and ground circuits require good connections. Follow the recommended maintenance schedule in this section to maintain optimum performance. When inspecting the electrical system check the following:

- Check battery connection clean and insure that connectors are tight.
- Check battery for cracks or damage to the case replace if necessary.
- Check Positive and Negative cables for corrosion, rubbing, chaffing and insure tight connections at both ends.
- Check engine wire harness for rubbing, chaffing, pinching, and cracks or breaks in the wiring.
- Check engine harness connectors, check to insure fitted and locked by pushing the connector together then pull on the connector halves to insure they are locked.
- Check ignition coil wire for hardening, cracking, arcing, chaffing, separation, split boot covers and proper fit.
- Check spark plug wires for hardening, cracking, chaffing, separation, split boot covers and proper fit.
- Replace spark plugs at the required intervals per the recommended maintenance schedule
- Check to insure all electrical components are securely mounted and retained to the engine or chassis.
- Check to insure any additional electrical devices installed by the owner are properly installed in the system.
- Check the MIL, charging, and oil pressure lights for operation by starting the engine and checking that the light illuminates for the prescribe period of time before turning out.

Engine Crankcase Oil

Oil Recommendation

Prior to changing the oil, select oil based on the prevailing daytime temperature in the area in which the equipment will be operated. The chart in figure 1 is a guide to selecting the proper crankcase oil.

IMPORTANT: Oils containing “solid” additives, non-detergent oils, or low quality oils are not recommended by the engine manufacturer.

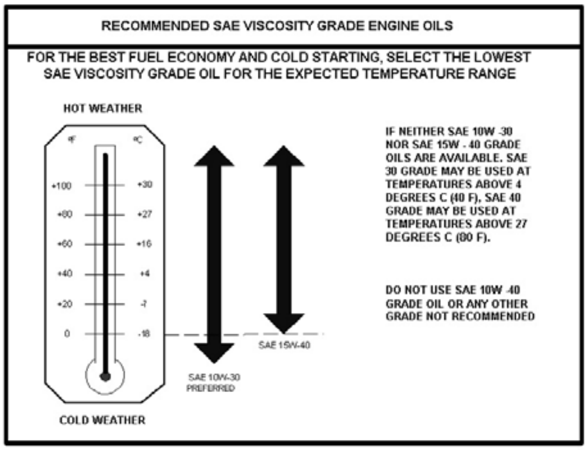


Figure 1 Engine Oil Viscosity Recommendation

Use Of Supplemental Additives

Use of the oils recommended by the engine manufacturer already contains a balanced additive treatment. The uses of supplemental additives which are added to the engine

oil by the customer are not necessary and may be harmful. The engine manufacturer, fuels system suppliers and engine distributors do not review, approve or recommend such products.

Synthetic Oils

Synthetic oils have been available for use in industrial engines for a relatively long period of time. Synthetic oils may offer advantages in cold temperature pumpability and high temperature oxidations resistance. However, synthetic oils have not proven to provide operational or economic benefits over conventional petroleum-based oils in industrial engines. Their use does not permit the extension of oil change intervals.

Checking/filling Engine Oil Level

NOTE

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 the dipstick. Wipe with a clean cloth or paper towel and reinstall. Push the dipstick all the way into the dipstick tube.
4. Remove the dipstick and note the oil level.
5. Oil level must be between the “FULL” and “ADD” marks.

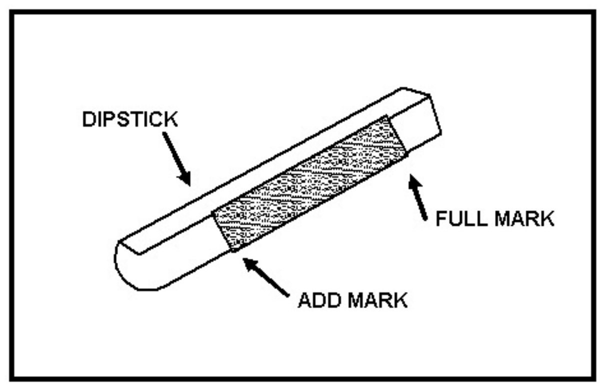


Figure 2 *Engine Oil Dip stick (Typical)*

6. If the oil level is below the “ADD” mark, proceed to Step 7 and 8, and reinstall the dipstick into the dipstick tube.
7. Remove the oil filler cap from the valve rocker arm cover
8. Add the required amount of oil to bring the level up to but not over the “FULL” mark on the dipstick
9. Reinstall the oil filler cap to the valve rocker arm cover and wipe any excess oil clean.\

Changing The Engine Oil

NOTE

When changing the oil, always change the oil filter.

1. Start the engine and run until it reaches normal operating temperature.

NOTE

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

2. Stop engine.

⚠ WARNING

Engine oil will be hot. Use protective gloves to prevent burns. Engine oil contains chemicals which may be harmful to your health avoid skin contact.

3. Remove drain plug and allow the oil to drain.
4. Remove and discard oil filter and it sealing ring.
5. Coat sealing ring on the new filter with clean engine oil, wipe the sealing surface on the filter mounting surface to remove any dust, dirt or debris. Tighten filter securely (follow filter manufacturers instructions). Do not overtighten.
6. Check sealing ring on drain plug for any damage, replace if necessary, wipe plug with clean rag, wipe pan sealing surface with clean rag and re-install plug into the pan. Tighten to specification.
7. Fill crankcase with oil.
8. Start engine and check for oil leaks.
9. Dispose of oil and filter in a safe manner.

Fuel System Inspection And Maintenance

Propane Fuel System

The Propane fuel system installed on this industrial engine has been designed to meet the emission standard applicable for this equipment for 2004 model year. To ensure compliance to these standards follow the recommended maintenance schedule contained in this section.

Inspection And Maintenance Of The Fuel Storage Cylinder

The fuel storage cylinder should be inspected daily or at the beginning of each operational shift for any leaks, external damage, adequate fuel supply and to insure the manual service valve is open. Fuel storage cylinders should always be securely mounted, inspect the securing straps or retaining devices for damage insure that all locking devices are closed and locked. Check to insure that the fuel storage cylinder is positioned with the locating pin in the tank collar on all horizontally mounted cylinders this will insure the proper function of the cylinder relief valve.

When refueling or exchanging the fuel cylinder check the quick fill valve for thread damage. Insure the o-ring is in place, check the o-ring for cracking, chunking or separation, replace if damaged before filling. Check the service line quick coupler for any thread damage. Insure the o-ring is in place, check the o-ring for cracking, hardening, chunking or separation. Replace if damaged.

NOTE

When refueling the fuel cylinder, wipe clean both the female and male connection with a clean rag prior to filling. This will prevent dust, dirt and debris from being introduced to the fuel cylinder and prolong the life of the fuel filter.

Inspection And Replacement Of The Fuel Filter

The Propane system on this emission certified engine utilizes an in-line replaceable fuel filter element. This element should be replaced, at the intervals specified in the recommended maintenance schedule. When inspecting the fuel filter check the following:

- Check for leaks at the inlet and outlet fittings, using a soapy solution or an electronic leak detector, if leaks are detected make repairs
- Check to make sure filter is securely mounted.
- Check filter housing for external damage or distortion, if damaged replace fuel filter

To replace the filter use the following steps:

1. Move the equipment to a well ventilated area and insure all external ignition sources are not present.
2. Start the engine.
3. With the engine running close the manual valve.
4. When the engine runs out of fuel turn OFF the key when the engine stops and disconnect the battery negative cable.

⚠ WARNING

A small amount of fuel may still be present in the fuel line, use gloves to prevent burns, wear proper eye protection. If liquid fuels continues to flow from the connections when loosened check to make sure the manual valve is fully closed.

5. Slowly loosen the inlet fitting and disconnect.
6. Slowly loosen the outlet fitting and disconnect.
7. Remove the filter housing form the equipment.
8. Check for contamination.
9. Tap the opening of the filter on a clean cloth.
10. Check for debris.
11. Check canister for proper mounting direction.
12. Reinstall the filter housing to the equipment.
13. Tighten the inlet and outlet fittings to specification.
14. Open the manual valve.

NOTE

The fuel cylinder manual valve contains an "Excess Flow Check Valve" open the manual valve slowly to prevent activating the "Excess Flow Check Valve".

15. Check for leaks at the inlet and outlet fittings, and the filter housing end connection using a soapy solution or an electronic leak detector, if leaks are detected make repairs.

Low Pressure Regulator Maintenance And Inspection

NOTE

The Low Pressure Regulator (LPR) components have been specifically designed and calibrated to meet the fuel system requirements of the emission certified engine. The regulator should not be disassembled or rebuilt. If the LPR fails to operate or develops a leak the LPR should be replaced with the OEM recommended replacement parts.

When inspecting the regulator check for the following items:

- Check for any fuel leaks at the inlet and outlet fittings.
- Check for any fuel leaks in the regulator body.
- Check the inlet and outlet fittings of the coolant supply lines for water leaks.
- Check the coolant supply lines for hardening, cracking, chaffing or splits. If any of these conditions exist replace coolant lines.
- Check coolant supply hose clamp connections, ensure they are tight.
- Check the to ensure the Pressure Trim Valve (PTV) mounting bolts are secure.
- Check PTV for external amage.
- Check PTV electrical connection to ensure the connector is seated and locked.
- Check to ensure the regulator is securely mounted.

Checking/draining Oil Build-up In The Low Pressure Regulator

During the course of normal operation oil or "heavy ends" may build inside the secondary chamber of the Low Pressure Regulator (LPR). These oil and heavy ends may be a result of poor fuel quality, contamination of the fuel supply chain, or regional variation of the fuel make up. If the build up of oil becomes significant this can affect the performance of the secondary diaphragm response. The Recommended Maintenance Schedule found in this section recommends that the oil be drained periodically.

NOTE

Draining the regulator when the engine is warm will help the oils to flow freely from the regulator.

To drain the LPR use the following steps:

1. Move the equipment to a well ventilated area and ensure no external ignition sources are present.
2. Start the engine.
3. With the engine running close the manual valve.
4. When the engine runs out of fuel turn OFF the key when the engine stops and disconnect the battery negative cable.

⚠ WARNING

A small amount of fuel may still be present in the fuel line, use gloves to prevent burns, wear proper eye protection. If liquid fuels continues to flow from the connections when loosened check to make sure the manual valve is fully closed.

5. Slowly loosen the inlet fitting and disconnect.
6. Loosen the hose clamp at the outlet hose fitting and remove the hose.
7. Remove and retain the locking pin in the outlet fitting and remove the outlet fitting from the LPR
8. Disconnect PTV connection and disconnect the vacuum hose.
9. Remove the two LPR mounting bolts and retain.
10. Place a small receptacle in the engine compartment.
11. Rotate the LPR to 90° so that the outlet fitting is pointing down into the receptacle and drain the LPR.
12. Inspect the secondary chamber for any large dried particles and remove.
13. Remove the receptacle and reinstall the LPR with the two retaining bolts and tighten to specifications.
14. Reinstall the outlet fitting and secure with the previously removed locking pin.
15. Reconnect the PTV electrical connection push connector until lock "Click", pull on the connector to ensure it is locked, connect the vacuum line.
16. Reconnect the outlet hose and secure the hose clamp.
17. Reinstall the fuel inlet line and tighten connection to specification.
18. Slowly open the manual service valve.

NOTE

The fuel cylinder manual valve contains an "Excess Flow Check Valve" open the manual valve slowly to prevent activating the "Excess Flow Check Valve".

19. Check for leaks at the inlet and outlet fittings using a soapy solution or an electronic leak detector, if leaks are detected make repairs. Check coolant line connections to ensure no leaks are present.
20. Start engine recheck for leaks at the regulator.
21. Dispose of any drained material in safe and proper manner.

Air Fuel Mixer/throttle Control Device Maintenance And Inspection

⚠ CAUTION

The Air Fuel Mixer components have been specifically designed and calibrated to meet the fuel system requirements of the emission certified engine. The mixer should not be disassembled or rebuilt. If the mixer fails to operate or develops a leak the mixer should be replaced with the OEM recommended replacement parts.

When inspecting the mixer check for the following items:

- Check for any fuel leaks at the inlet fitting.
- Check the fuel inlet hose for cracking, splitting or chaffing, replace if any of these condition exist.
- Check to ensure the mixer is securely mounted.
- Check air inlet hose connection and insure clamp is tight, check inlet hose for cracking, splitting or chaffing, replace if any of these condition exist.
- Check air cleaner element according to the *Recommended Maintenance Schedule* found in this section.
- Check fuel line to Throttle body mounted Fuel

Trim Valve (FTV) for cracking, splitting or chaffing, replace if any of these condition exist.

- Check Throttle body return action to ensure throttle shaft is not sticking repair if necessary.
- Check FTV electrical connection to ensure connector is fully seated and locked.
- Check for leaks at the throttle body and intake manifold.

Exhaust System And Catalytic Converter Inspection And Maintenance

NOTE

The exhaust system on this emission certified engine contains an Exhaust Gas Oxygen Sensor (EGO) which provides feed back to the ECM on the amount of oxygen present in the exhaust stream after combustion. The measurement of oxygen in the exhaust stream is measured in voltage and sent to the ECM. The ECM then makes corrections to the fuel air ratio to ensure the proper fuel charge and optimum catalytic performance. Therefore it is important that the exhaust connections remain secured and air tight.

⚠ CAUTION

The EGO sensor is sensitive to silicone or silicone based products. Do not use silicone sprays or hoses which are assembled using silicone lubricants. Silicone contamination can cause severe damage to the EGO.

When inspecting the Exhaust system check the following:

- Check the exhaust manifold at the cylinder head for leaks and that all retain bolts and shields (if used) are in place.
- Check the manifold to exhaust pipe fasteners to ensure they are tight and that there are no exhaust leaks repair if necessary.
- Check EGO electrical connector to ensure connector is seated and locked, check wires to ensure there is no cracking, splits chaffing or "burn through" repair if necessary.
- Check any exhaust pipe extension connector for leaks tighten if necessary
- Visually inspect converter to insure muffler is securely mounted and tail pipe is properly aimed.
- Check for any leaks at the inlet and outlet of the converter

leaks

- Check the base of the injector for leaks
- Check the injector wire connections to ensure sure they are fully seated and locked
- Check the fuel pressure sender electrical connection to ensure they are fully seated and locked

CERTIFIED ENGINE MAINTENANCE REQUIREMENTS										
	Install	Interval Hours								
	Date	Daily	250	500	750	1000	1250	1500	1750	2000
General Maintenance Section										
Visual check for leaks		**X**								
Check engine oil level		**X**								
Check coolant level		**X**								
Change engine oil and filter	**Every 200 hours or monthly**									
Check Fuel system for leaks	**Prior to any service or maintenance activity**									
Inspect Accessory Drive belts						**X**				**X**
Inspect electrical system										**X**
Inspect all vacuum lines and fitting										**X**
Inspect all fuel lines and fitting										**X**
Engine Coolant Section										
Check coolant level		**X**								
Clean debris from radiator core	**Every 100 hours or 60 days of operation**									
Change coolant						**X**				**X**
Inspect coolant hoses for cracks, swelling or deterioration						**X**				**X**
Engine Ignition System										
Inspect Battery case for damage						**X**				**X**
Inspect battery cables						**X**				**X**
Check all electrical connectors						**X**				**X**
Check ignition timing and adjust										**X**
Replace spark plugs										**X**
Check spark plug wires										**X**
Fuel System Maintenance										
Replace fuel filter						**X**				**X**
Inspect lock off for leaks										**X**
Ensure lock off closing										**X**
Test LPG/Gas regulator pressure										**X**
Inspect LPR for oil build up	**Annually or every 2000 hours**									
Inspect LPR for coolant leaks	**Annually or every 2000 hours**									
Check air induction system for leaks										**X**
Check manifold for vacuum leaks										**X**
Check FTV electrical connection										**X**
Check throttle shaft for sticking										**X**
Check injector & rails for leaks										**X**
Inspect air cleaner	**Every 200 hours, or every 100 hours in dusty environment**									
Replace filter element	**Annually, or Bi-annually in dusty environments**									
Engine Exhaust System										
Inspect exhaust manifold for leaks										**X**
Inspect exhaust piping for leaks										**X**
Inspect catalyst inlet and outlet										**X**
Check HEGO sensor connector										**X**

The maintenance schedule represents manufacturers recommended maintenance intervals to maintain proper engine/equipment function. Specific state and federal regulations may require equipment operators to conduct comprehensive engine/equipment inspections at more periodic intervals than those specified above. This maintenance schedule has no regulatory value and should not be considered representative of any state or federal engine/equipment maintenance requirement.

SECTION 1A1

LPG FUEL SYSTEM OPERATION

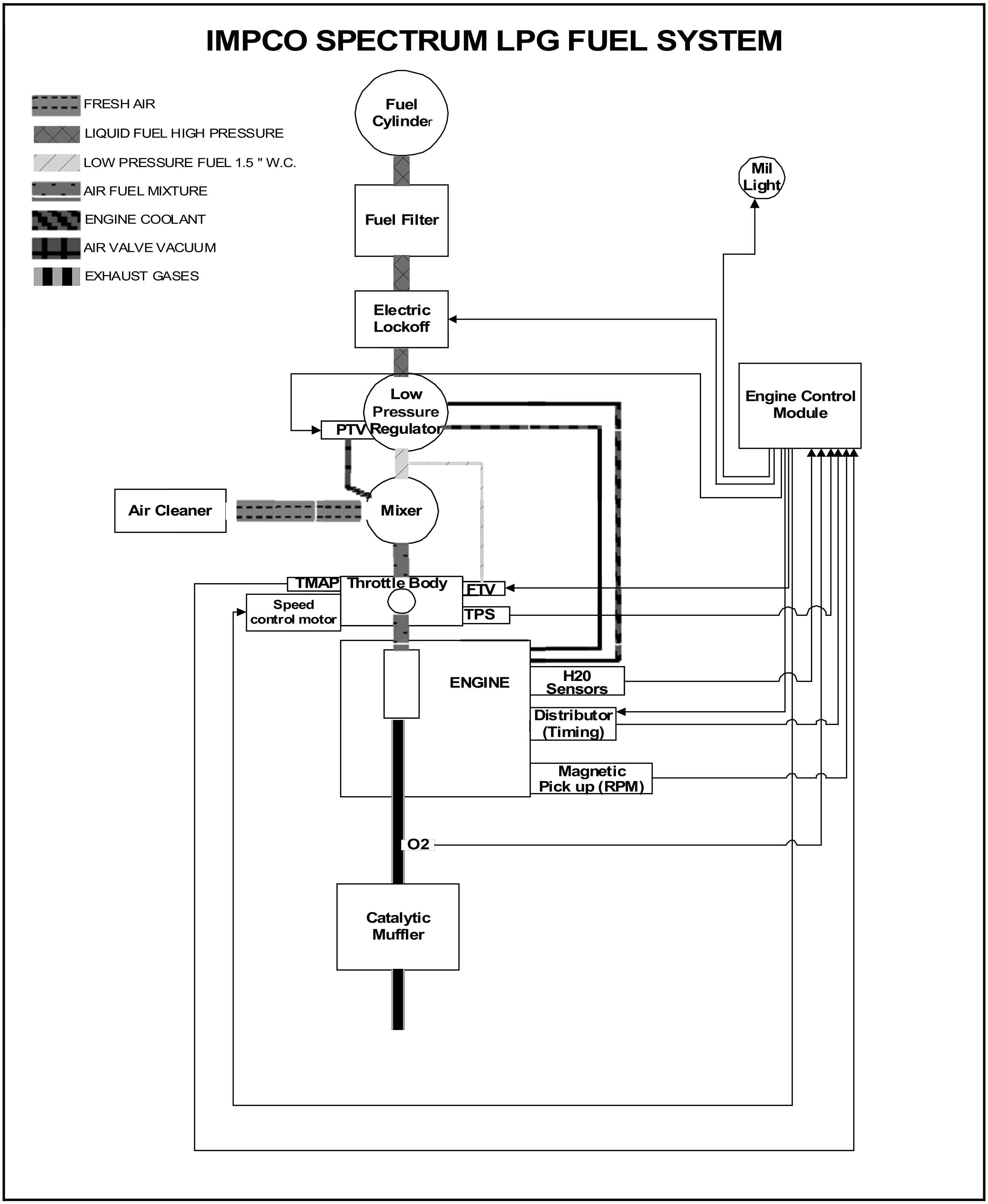


Figure 1 Typical Fuel System Schematic

Description and Operation of the Fuel Systems

Propane Fuel System

The primary components of the propane fuel system are the fuel storage tank, low pressure regulator (LPR), fuel mixer module with throttle control device, electric fuel lock-off solenoid, engine control unit (ECM) fuel trim valve (FTV) pressure trim valve (PTV) and three way catalytic (TWC) converter. The system operates at pressures which range from 355.60 mm (14.0 inches) of water column up to 21.5 BAR (312 psi).

LPG Fuel Tank

1. Liquid Outage valve w/quick disconnect coupling	11. Vapor Withdrawal Tube (when applicable)
2. Filler Valve	12. 80% Limiter Tube
3. Pressure Relief Valve	13. Fuel Level Float
4. Liquid Outage Fill Check Valve	14. Liquid Withdrawal Tube
5. Fuel Gauge	

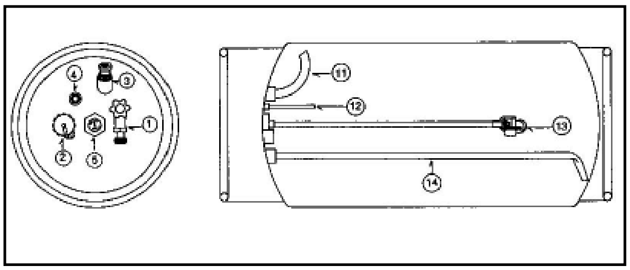


Figure 2 Typical Propane Fuel Tank

Propane is stored in the fuel tank as a liquid. The approximate pressure of the fuel in the tank is 16.5 bar (240 psi) when the tank is full at an ambient temperature of 27° C (81°F). The boiling point, (temperature at which the liquid fuel becomes vapor) is approximately -40° C (-40° F). When the fuel changes from liquid to vapor the fuel expands and creates pressure inside the tank. When the tank service valve is opened the pressure inside the tank forces the liquid fuel out though the pick up tube located near the bottom of the fuel cylinder. Because the propane is stored under pressure the tank is equipped with a safety valves which are normally set at 25.8 bar (375 psi) to prevent tank rupture due to over-pressurization of the cylinder. The service valve mounted in the end of the cylinder controls the flow of fuel from the tank. By turning the handle to its “open” position, fuel flows out of the tank and into the service line. The service valve is also equipped with a safety feature called an “excess flow check valve”. This feature reduces the flow from the service valve in the event of a rupture of the fuel line or any down stream component.

Service Line

Propane flows from the fuel tank to the electric lock via the service line. The service line is connected to the tank utilizing a quick coupler. The other end of the service line is connected to a “bulkhead connector” mounted on the equipment sheet metal. This bulkhead connector allows for a safe means of passing through the equipments engine compartment sheet metal and into the engine compartment. If a bulkhead connector is used a pressure relief device is mounted in the service line or the connector itself to prevent over pressurization of the service line. The service line is made of high pressure hose with special material or possibly tubing which is friendly to the LPG fuel and should always be replaced with an OEM supplied part.

⚠ **CAUTION**

The bulkhead assembly should never be removed and a service line run through the sheet metal.

Fuel Filter

Propane fuel like all other motor fuels is subject to contamination from outside sources. Refueling of the equipments tank and removal of the tank from the equipment can inadvertently introduce dirt and other foreign matter into the fuel system. It is therefore necessary to filter the fuel prior to entering the fuel system components down stream of the tank. An inline bulkhead fuel filter is utilized in the fuel system to remove the dirt and foreign matter from the fuel. The filter is replaceable. Maintenance of the filter is critical to proper operation of the fuel system and should be replaced as

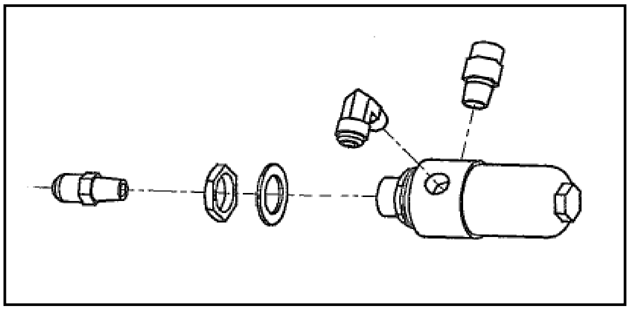


Figure 3 Inline Fuel Filter

defined in the Recommended Maintenance Schedule. In severe operating condition more frequent replacement of the filter may be necessary.

Electric Lock Off

The Electric Lock Off device is an integrated assembly. The electric lock assembly is a 12 volt normally closed valve. The solenoid is mounted to the valve body. When energized the solenoid opens the valve and allows the Propane fuel to flow through the device. The valve opens during cranking and run cycles of the engine. The lock off supply voltage is controlled by the engine module (ECM)

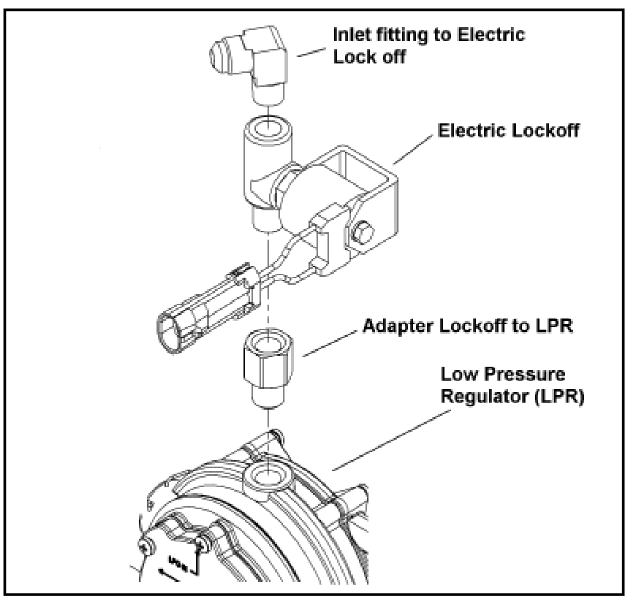


Figure 4 Electric Fuel Lock Off

Low Pressure Regulator (LPR)

The LPR is a combination vaporizer, pressure regulating device. The LPR is a negative pressure two stage regulator that is normally closed when the engine is not running. When the engine is cranking or running a partial vacuum is created in the fuel line which connects the regulator to the mixer. This partial vacuum opens the regulator permitting fuel to flow to the mixer.

Propane fuel enters the primary port of the LPR and passes through the primary jet and into the primary/exchanger chamber. As the propane passes through the heat exchanger the fuel expands and creates pressure inside the chamber. The pressure rises as the fuel expands when the pressure rises above 10.34 kpa (1.5 psi), sufficient pressure is exerted on the primary diaphragm to cause the diaphragm plate to pivot and press against the primary valve pin thus closing off the flow of fuel. This action causes the flow of fuel into the regulator to be regulated. When the engine is cranking, sufficient vacuum will be introduce into the secondary chamber from the mixer drawing the secondary diaphragm down onto the spring loaded lever and opening the secondary valve allowing vaporized fuel to pass to the mixer. Increased vacuum in the secondary chamber increases the downward action on the secondary lever causing it to open wider allowing more fuel to flow to the mixer.

The regulator utilized on this emission certified engine is equipped with a unique Pressure Trim Valve (PTV) which is directly mounted to the regulator. This solenoid is a 12 volt normally closed solenoid. The function of this solenoid is to regulate a specific amount of venture vacuum to the atmospheric side of the secondary diaphragm. By introducing vacuum to the top side of the secondary diaphragm during regulator operation the amount of fuel being delivered to the mixer can be “trimmed” or reduced to allow for correction to the air fuel ratio for closed loop fuel control. The solenoid receives a reference signal from the ECM which causes the solenoid to be pulsed fast or slow depending on the amount of fuel to be trimmed.

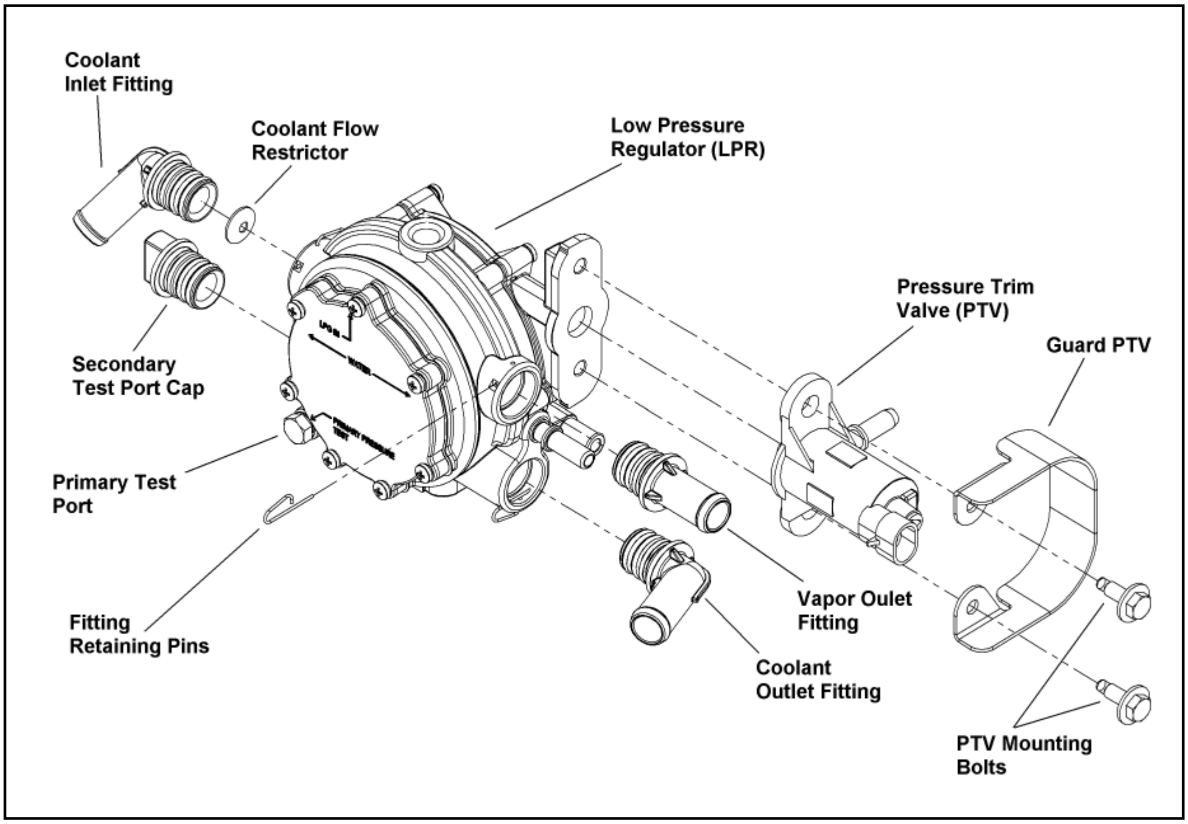


Figure 5 Low Pressure Regulator

⚠ **CAUTION**

The LPR is an emission control device. Components inside the regulator are specifically calibrated to meet the engine emissions requirements and should never be disassembled or rebuilt. If the LPR fails to operate, replace with an OEM replacement part.

⚠ **CAUTION**

When servicing the regulator use caution to insure the jet is replaced in the regulator. Failure to install the jet may cause damage to the regulator and cause fuel control and emission problems.

The process of pressure reduction within the regulator causes a refrigeration effect this requires that the regulator be heated with engine coolant to prevent the regulator from freezing and fail to function properly. The regulator is connected into the coolant system by hoses connected to the engines coolant circuit. The emission certified regulator contains an orifice or jet in the outet side of the regulator to maintain the proper amount of coolant flow during regular operation. The orifice is located between the inlet fitting and the housing of the regulator.

Air Fuel Mixer

The air valve mixer is an air-fuel metering device and is completely self-contained. The mixer is an air valve design, utilizing a relatively constant pressure drop to draw fuel into the mixer from cranking to full load. The mixer is mounted in the air stream ahead of the throttle control device.

⚠ **CAUTION**

The air/fuel mixer is an emission control device. Components inside the mixer are specifically calibrated to meet the engines emissions requirements and should never be disassembled or rebuilt. If the mixer fails to operate replace

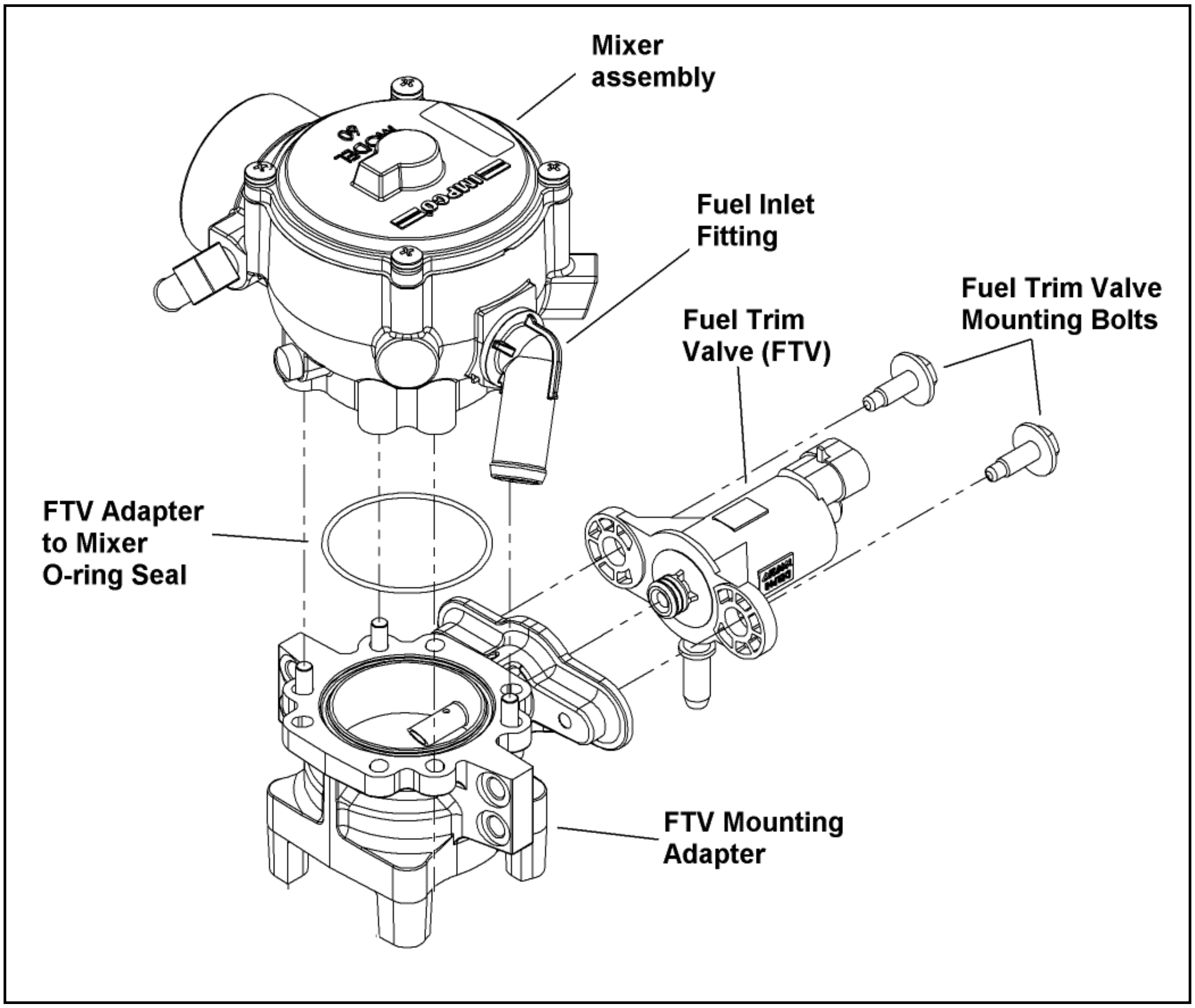


Figure 6 Air Fuel Mixer

with an OEM replacement part.

When the engine begins to crank it draws in air with the air valve covering the inlet, negative pressure begins to build. This negative pressure signal is communicated to the top of the air valve chamber through four vacuum ports in the air valve assembly. A pressure/force imbalance begins to build across the air valve diaphragm between the air valve vacuum chamber and the atmospheric pressure below the diaphragm. The air valve vacuum spring is calibrated to generate from 101.6 mm (4.0 inches) of water column at start to as high as 355.60 mm (14.0 inches) of water column at full throttle. The vacuum being created is referred to as Air Valve Vacuum (AVV). As the air valve vacuum reaches 101.6mm (4.0 inches) of water column, the air valve begins to lift against the air valve spring. The amount of AVV generated is a direct result of the throttle position. At low engine speed the air valve vacuum is low and the air valve position is low thus creating a small venturi for the fuel to flow. As the engine speed increase the AVV increases and the air valve is lifted higher thus creating a much larger venturi. This air valve vacuum is communicated from the mixer venture to the LPR secondary chamber via the low pressure fuel supply hose. As the AVV increases in the secondary chamber the secondary diaphragm is drawn further down forcing the secondary valve lever to open wider.

The mixer is equipped with a low speed mixture adjustment which is retained in a tamper proof housing. The mixer has been preset at the factory and should not require any adjustment. In the event that the idle adjustment should need to be adjusted refer to the Fuel System Repair section of this manual.

The mixer is mounted into the air stream utilizing an adapter which contains the Fuel Trim Valve (FTV). The FTV is utilized to assist with fuel control while the engine is operating. The FTV is a 12 volt normally closed electric valve and is connected to the LPR by a fuel line. The FTV normally receives a pulse from the ECM which causes the FTV to be cycled open and closed to allow additional fuel to be supplied to the air stream above the throttle plate. During normal closed loop operating condition the ECM provides a electrical pulse to both the FTV and the PTV which controls the amount of fuel being introduced into the air stream. The PTV is connected to the Air Valve Vacuum (AVV) which reduces the amount of fuel flow to the regulator; the FTV introduces additional fuel into the air stream. By cycling the PTV more frequently and the FTV less frequently the air fuel ratio can be leaned, by decreasing the PTV duty cycles and increasing the FTV duty cycles the air fuel ratio can be increased.

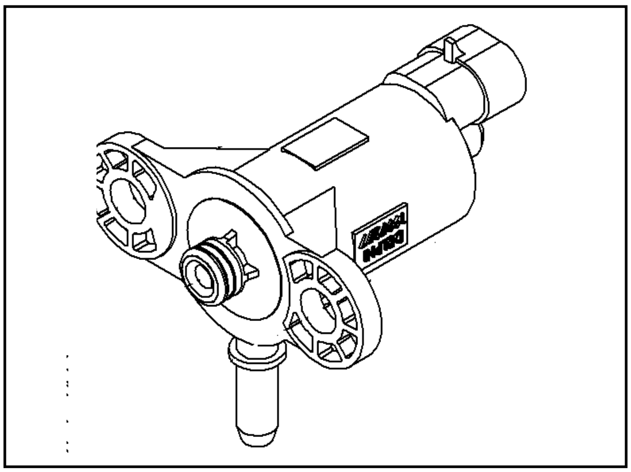


Figure 7 Pressure Trim Valve and Fuel Trim Valve

Throttle Control Device

Drive By Wire

Engine speed control is maintained by the amount of pressure applied to the foot pedal located in the engine compartment. In a Drive By Wire (DBW) application there is no direct connection between the operator pedal and the throttle shaft. Speed and load control are determined by the ECM. Defaults programmed into the ECM software and throttle position sensors allow the ECM to maintain safe operating control over the engine.

In a drive by wire application the Electronic Throttle Control device or “throttle body assembly” is connected to the intake manifold of the engine. The electronic throttle control device utilizes an electric motor connected to the throttle shaft. In addition a Foot Pedal Position sensor (FPP) is located in the operator’s compartment. When the engine is running electrical signals are sent from the foot pedal position sensor to the engine ECM when the operator depresses or release the foot pedal. The ECM then sends an electrical signal to the motor on the electronic throttle control to increase or decrease the angle of the throttle blade thus increasing or decreasing the air/fuel charge to the engine.

The electronic throttle control device incorporates two internal Throttle Position Sensors (TPS) which provide output signals to the ECM as to the location of the throttle shaft and blade. The TPS information is used by the ECM to correct for speed and load control as well as emission control.

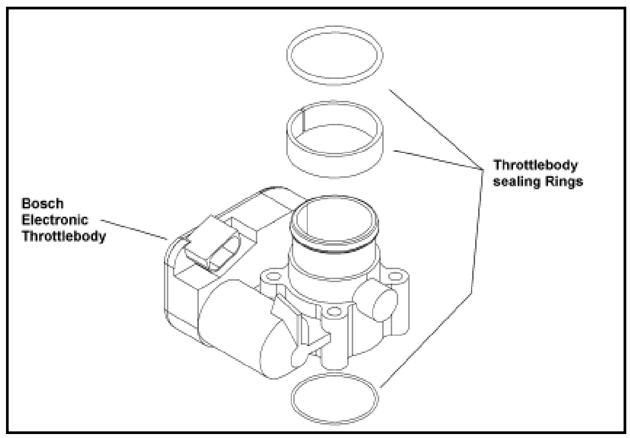


Figure 8 Electronic Throttle control device “Drive by Wire” throttle body assembly”

Three Way Catalytic Muffler

The emission certified engine has been designed and calibrated to meet the emission standards in effect for 2004. To help meet the emission requirements the vehicle has been equipped with a Three Way Catalytic (TWC) muffler. The catalyst muffler is a three way catalyst, sound damping and spark arresting unit. Besides controlling the noise created from the combustion process, and preventing sparks from escaping from the exhaust system the most important function is treating the exhaust gases which are created from the combustion process. The three-way catalyst consists of a honeycomb coated with a mixture of platinum, palladium, and rhodium. The hot gases flow through the catalyst sections where an oxidation and reduction reactions take place. These chemical reactions reduce the amount of CO, HC and NOX in the engines exhaust. The Exhaust gas then flows through the outlet

Figure 9 Three way catalytic converter

Engine Control Module

To obtain maximum effect from the catalyst and accurate control of the air fuel ratio the emission certified engine is equipped with an onboard computer or Engine control module (ECM). The ECM is a 32 bit controller which receives in-put data from sensors fitted to the engine and fuel system and then out-puts various signals to control engine operation.

One specific function of the controller is to maintain “closed loop fuel control”. Closed loop fuel control is accomplished when the exhaust gas oxygen sensor (EGO) mounted in the exhaust system sends a voltage signal to the controller. The controller then calculates any correction that may need to be made to the air fuel ratio. The controller then out-puts signals to PTV or the FTV or both mounted in the fuel system to change the amount of fuel being delivered from the regulator or mixer or to the engine.

The controller also performs diagnostic functions on the fuel system and notifies the operator of malfunctions by turning on a Malfunction Indicator Light (MIL) mounted in the dash. Malfunctions in the system are identified by a Diagnostic Code number. In addition to notifying the operator of the malfunction in the system the controller also stores the information about the malfunction in its memory. A technician can than utilize a computerized diagnostic tool to retrieve the stored diagnostic code and by using the diagnostic charts in this manual determine the cause of the malfunction. In the event a technician does not have the computerized diagnostic tool the MIL light can be used to identify the diagnostic code. By following specific steps the technician can activate the “blink” feature and count the number of blinks to determine the diagnostic code number to locate the fault in the system.

Heated Exhaust Gas Oxygen Sensor

The Heated Exhaust Gas Oxygen Sensor (HEGO) is mounted in the exhaust system downstream of the engine. The HEGO is used to measure the amount of oxygen present in the exhaust stream and communicate that to the ECM via an electrical signal. The amount of oxygen present in the exhaust stream indicates whether the fuel air ratio is to rich or to lean. If the HEGO sensor signal indicates that the exhaust stream is to rich the ECM will decrease or lean the fuel mixture during engine operation, if the mixture is to lean the ECM will richen the mixture. The ECM continuously monitors the HEGO sensor output if a rich or lean condition is present for an extended period of time and the ECM cannot correct the condition the ECM will set a diagnostic code and turn on the MIL light in the dash.

⚠ CAUTION

The Heated Exhaust Gas Oxygen Sensor (HEGO) is an emissions control component. If the HEGO fails to operate, replace only with

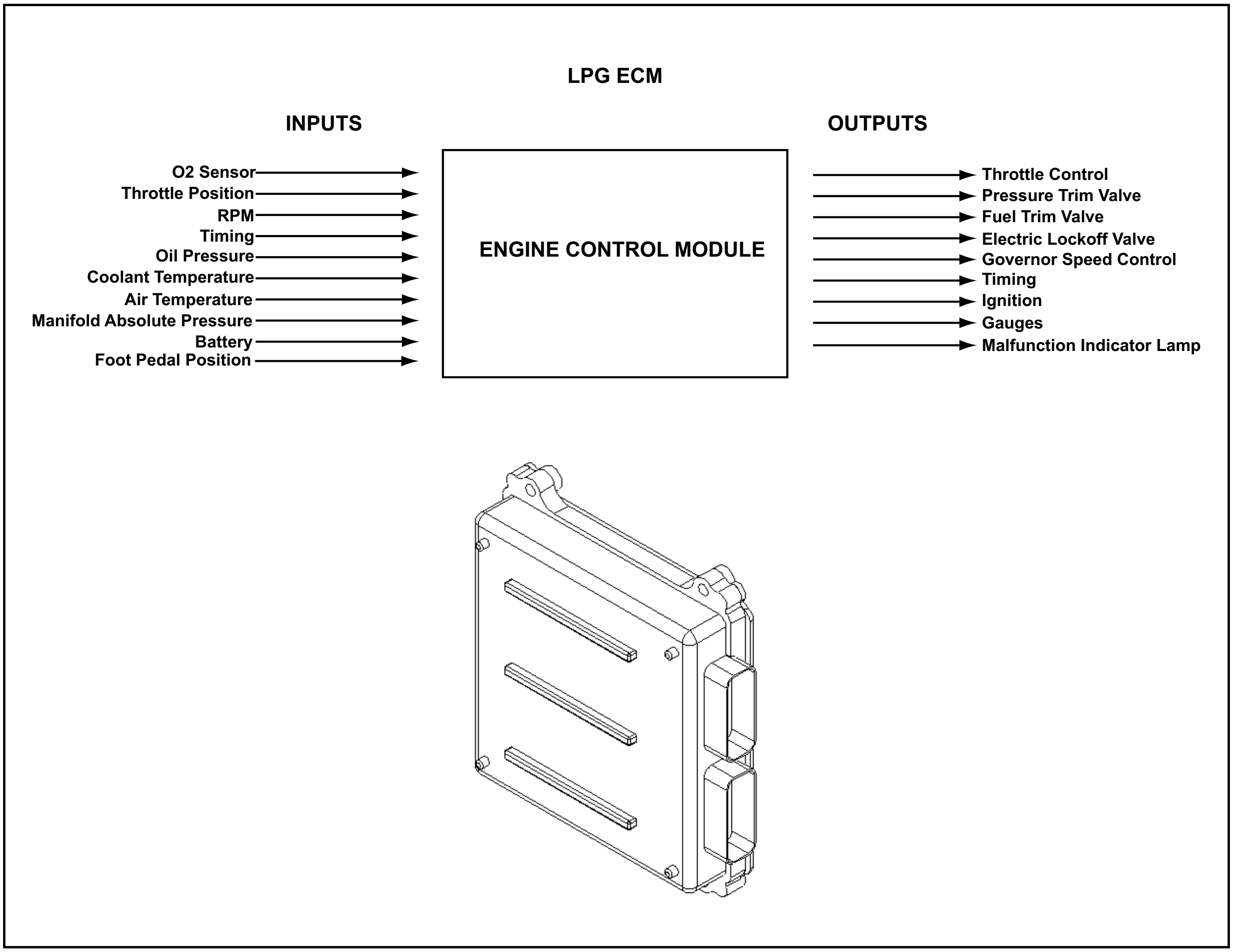


Figure 10 Engine control unit (ECM)

an OEM replacement part. The HEGO sensor is sensitive to silicone and silicone based products and can become contaminated. Avoid using silicone sealers or hoses treated with silicone lubricant in the air stream or fuel supply lines.

Figure 11 Exhaust Gas Oxygen Sensor (EGO)

Temperature Manifold Absolute Pressure Sensor (TMAP)

The ECM receives signal from sensors mounted to the engine and fuel system to control engine operation and emission control. The TMAP is a dual sensor mounted in the air stream of the fuel system. The TMAP provides the ECM with the temperature of the air charge entering the engine which the ECM utilizes to correct the air fuel ratio depending on the ambient air temperature the vehicle is operating in. It also provides the ECM with the Manifold Absolute Pressure (MAP) which allows to the ECM to adjust fuel air ratio based on barometric pressure as well provides the ECM with the load condition being introduce to the engine. The TMAP is mounted to the throttle body to manifold adapter.

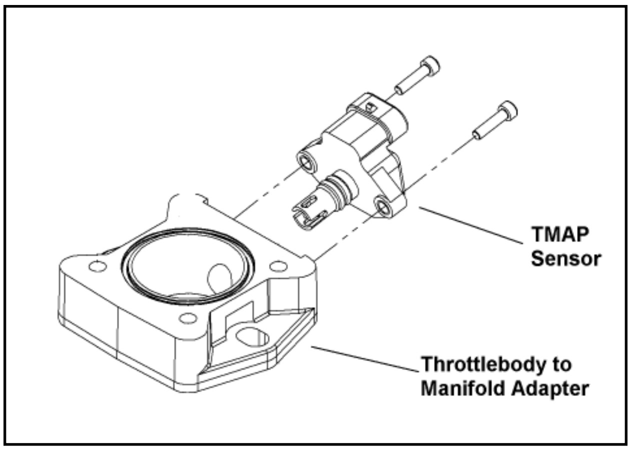


Figure 12 Temperature Manifold Absolute Pressure (TMAP) sensor

Engine RPM Sensor

The ECM relies on a Magnetic sensor to count the revolutions of the crankshaft to determine the engine speed. The Magnetic sensor is mounted to a bracket located directly above a timing whell which is machined with teeth to trip the magnetic sensor.. The timing wheel is mounted to the front pulley of the engine.

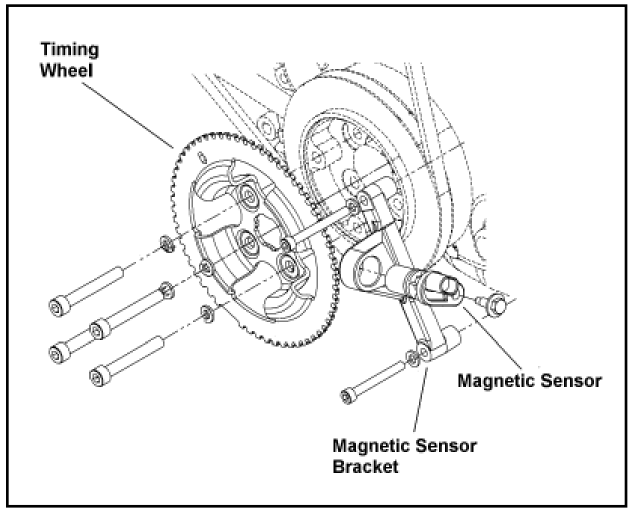


Figure 13 Magnetic Sensor & Timing Wheel

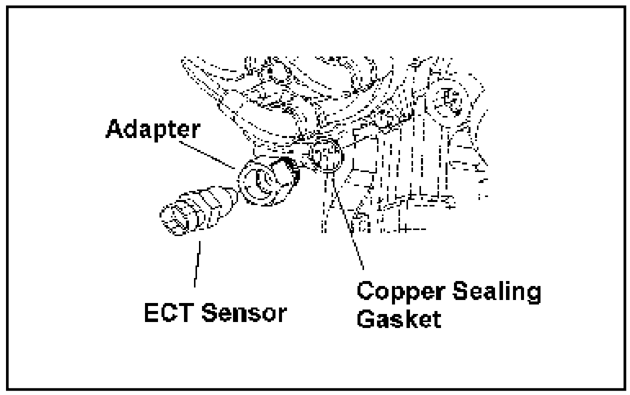


Figure 14 Engine Coolant Temperature Sensor (ECT)

Engine Coolant Tmeperature Sensor (ECT)

The ECM receives a signal from the Engine Coolant Temperature (ECT) sensor. The ECM will make correction to the air fuel ratio based on the engine operating temperature. The ECM has also been programmed with default settings which may result in a power reduction or shut down the engine in the event the engine overheats.

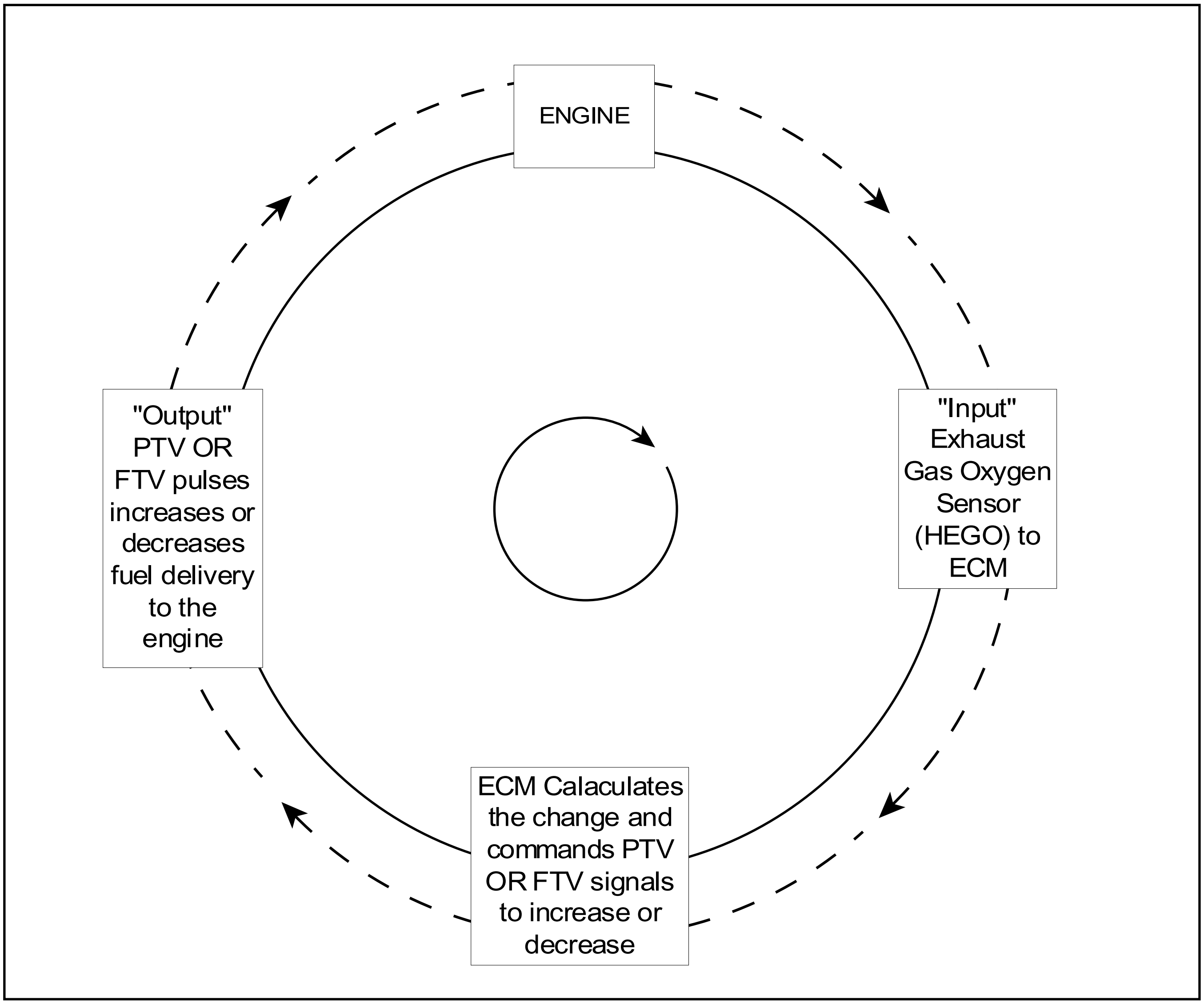


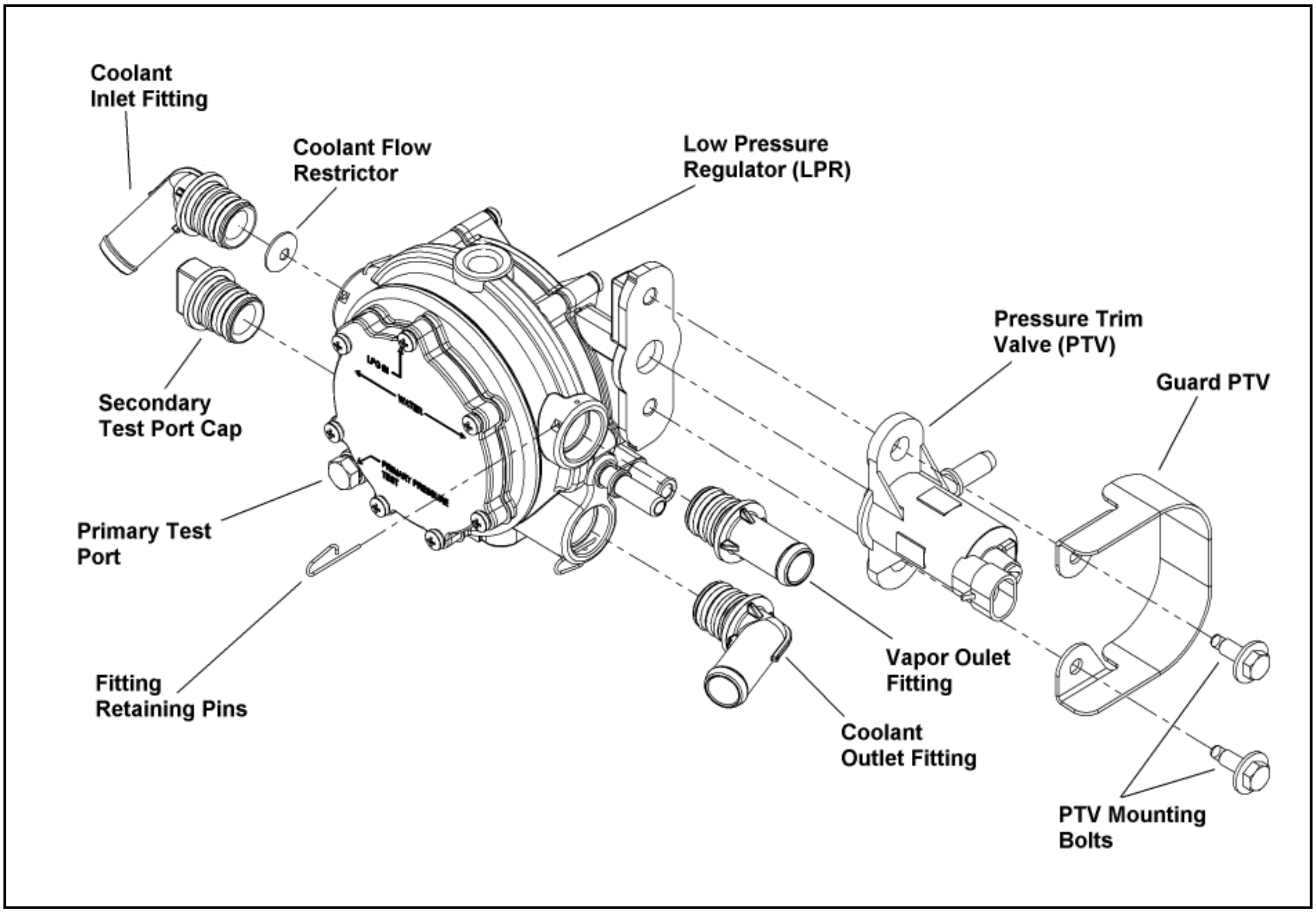
Figure 15 Propane Closed Loop Control Schematic

Closed Loop Control System

Closed Loop control is the term used to describe the strategy used by the ECM to maintain proper tail pipe emission. The ECM utilizes the input of the sensors in the system to adjust air fuel ratio. The HEGO provides a signal to the ECM which indicates the amount of oxygen present in the exhaust gases after combustion. The correct air fuel ratio is necessary to maintaining proper temperature in the catalyst for conversion of the unburned gases after combustion and supplying sufficient power for engine operation.

SECTION 1B1

LPG FUEL SYSTEM DIAGNOSTICS



LPG Fuel System Diagnosis

Fuel System Description

The Engine Control Module (ECM) receives information from various engine sensors in order to control the operation of the fuel control solenoid valves (FTV) and the low-pressure lock-off (LPL) solenoid. The LPL solenoids prevent fuel flow unless the engine is cranking or running. LPG is stored in the tank and delivered under pressure to the system as a liquid. During key on, the LPL receives a two (2) second prime pulse from the ECM which allows LPG to flow from the tank through fuel filter and fuel lines to the low pressure regulator (LPR) at pressures up to 312 psi.

In the (LPR) the fuel is vaporized and the pressure reduced in two stages. The first stage reduces the pressure to approximately 4.5 psi. The second stage reduces the pressure to approximately negative 1.5” of water column.

The fuel is then drawn from the secondary chamber of the LPR by the vacuum generated by air flowing through the mixer. This vacuum signal is also used to generate lift for the mixer air valve. This vacuum signal is most commonly referred to as air valve vacuum. In the mixer, the fuel mixes with the air entering the engine. This air/fuel mixture is then drawn into the engine for combustion.

Diagnostic Aids

This procedure is intended to diagnose a vehicle operating on LPG. If the vehicle will not continue to run on LPG, refer to Hard Start for preliminary checks. Before proceeding with this procedure, verify that the vehicle has a sufficient quantity of fuel and that liquid fuel is being delivered to the LPR. Also, ensure that the manual shut off valve on the LPG tank is fully opened and that the excess flow valve has not been activated.

Tools Required:

- 7/16 Open end wrench (for test port plugs)
- Straight Blade screw driver
- DVOM (GM J 39200, Fluke 88 or equivalent).

Duty Cycle Monitoring Tool

- IMPCO Fuel System Analyzer (FSA), or DVOM (GM J 39200, Fluke 88 or equivalent).

Diagnostic Scan Tool

- IMPCO hand held PDA or equivalent.

Pressure Gauges

- Water Column Gauge / Manometer (GM 7333-6 or equivalent).
- 0-10 PSI Gauge

Test Description

The numbers below refer to step numbers on the diagnostic table.

5. This step will determine if the fuel control solenoid (FCS) and fuel supply system are functioning properly. The vacuum on the secondary test port will be approximately –1.0 " to –2.0" w.c. If the vehicle has a hard start or poor idle, check for proper operation of the idle control solenoid (ICS).
6. This step checks the base mechanical LPR output pressure by disabling all fuel control devices.
9. This step checks for proper air valve operation.
19. This determines if fuel is available from the fuel tank supply system.

LPG Fuel System Diagnosis

Step	Action	Value(s)	Yes	No
1	Were you referred to this procedure by a DTC diagnostic chart?	—	Go to *Step 3*	Go to *Step 2*
2	Perform the On Board Diagnostic (OBD) System Check. Are any DTCs present in the ECM?	—	Go to the applicable DTC Table	Go to *Step 3*
3	Verify that the LPG fuel tank has a minimum of 1/4 tank of fuel, that the manual valve is open and the tank quick connect is fully engaged Does the vehicle have fuel?	—	Go to *Step 4*	—
4	1. Connect a water column gauge or a manometer to the secondary test port of the low pressure regulator (LPR). 2. Start the engine and allow it to reach operating temperature. Does the engine start and run?	—	Go to *Step 5*	Go to *Step 8*
5	With the engine idling, observe the pressure reading for the LPR secondary pressure. Does the fuel pressure fluctuate rhythmically **OUTSIDE** the specified range?	-1.0" to -2.0" w.c.	Go to *Step 25*	Go to *Step 6*

6	1. Disconnect the PTV electrical connectors. **Note:** This action may cause a DTC to be set by the ECM 2. With the engine idling observe the pressure reading on the secondary test port. Is the fuel pressure **WITHIN** the specified range?	-1.0" to -2.0" w.c.	Go to *Fuel Control System Diagnosis*	Go to *Step 7*
7	1. Inspect the air intake stream between the mixer assembly and the throttle body for leaks. 2. Inspect the fuel hose connection between the LPR and mixer assembly for damage or leakage. 3. Inspect the vacuum hoses to the FTV solenoid. Was a problem found and corrected?	—	Go to *Step 26*	Go to *Step 22*
8	1. Connect a water column gauge or a manometer to the secondary test port of the low pressure regulator (LPR). 2. Crank the engine and observe the pressure reading for the LPR secondary pressure. Does the fuel pressure indicate a vacuum is present?	—	Go to *Step 12*	Go to *Step 9*
9	1. Remove Air induction hose to the mixer 2. Observe the air valve for movement while the engine is cranking. **Note:** Movement of the air valve will be minimal at cranking speeds. Does the air valve move when the engine is cranked?	—	Go to *Step 11*	Go to *Step 10*

10	1. Inspect the air intake stream to the mixer assembly and the throttle body for vacuum leaks. 2. Inspect the vacuum hoses from the mixer to the PTV solenoids for proper connection and condition**.** Was a problem found and repaired?	—	Go to *Step 26*	Go to *Step 24*
11	Inspect the fuel hose connection between the LPR and the mixer assembly for damage or leakage. Was a problem found and repaired?	—	Go to *Step 26*	Go to *Step 12*
12	1. Connect a 0-10 psi gauge to the primary test port of the low pressure regulator (LPR). 2. Crank the engine and observe the pressure reading for the LPR primary pressure. Is the fuel pressure **ABOVE** the specified value?	2.0 – 4.0 psi	Go to *Step 22*	Go to *Step 13*
13	1. Turn OFF the ignition. 2. Disconnect the LPL connector. 3. Install a test light between the pins of the LPL connector. 4. Crank the engine. The test light should illuminate. Does the test light illuminate?	—	Go to *Step 14*	Go to *Step 16*
14	Using a DVOM, check the resistance of the low pressure lock-off (LPL). Is the resistance within the specified range?	12 - 24Ω	Go to *Step 15*	Go to *Step 23*

15	1. Turn the ignition OFF. 2. Close the manual shut-off valve on the LPG tank. **CAUTION: When disconnecting LPG fuel lines, liquid LPG may be present. Perform this step in a well ventilated area.** 3. Loosen the fuel inlet hose fitting at the inlet of the LPL. Was fuel present when the fitting was loosened?	—	Go to *Step 23*	Go to *Step 17*
16	1. Turn OFF the ignition. 2. Connect the test light to chassis ground and probe pin A of the LPL connector. 3. Crank the engine. The test light should illuminate. Does the test light illuminate?	—	Go to *Step 20*	Go to *Step 21*
17	1. Remove the LPG fuel filter / LPL. 2. Remove the filter from the LPL. 3. Empty the contents of the inlet side of the LPG fuel filter onto a clean surface. 4. Inspect the contents of the LPG fuel filter for an excessive amount of foreign material or water. If necessary, locate and repair the source of contamination. 5. Verify the LPG fuel filter is not restricted or plugged. Was a problem found?	—	Go to *Step 19*	Go to *Step 23*
18	The fuel supply system or hoses are plugged or restricted, locate and repair the problem. Is the action complete?	—	Go to *Step 26*	—
19	Replace the fuel filter. Refer to *Fuel Filter Replacement.* Is the action complete?	—	Go to *Step 26*	—

20	Repair the open in the lock-off ground circuit. Is the action complete?	—	Go to *Step 26*	—
21	Repair the open in the lock-off power (OEM fuel pump) circuit. Is the action complete?	—	Go to *Step 26*	—
22	Replace the low pressure regulator (LPR). Refer to *Low Pressure Regulator Replacement*. Is the action complete?	—	Go to *Step 26*	—
23	Replace the lock-off. Refer to *Low Pressure Lock-off (LPL) Replacement*. Is the action complete?	—	Go to *Step 26*	—
24	Replace the mixer assembly. Refer to *Fuel Mixer Replacement*. Is the action complete?	—	Go to *Step 26*	—
25	The fuel supply system is operating normally, if a failure of the control solenoids is suspected. Refer to *Fuel Control System Diagnosis.* 1. Install the test plug in the LPR secondary chamber. 2. If you were sent to this routine by another diagnostic chart, return to the previous diagnostic procedure. Is the action complete?	—	System OK	—

26	1. Disconnect all test equipment 2. Install the primary and secondary test port plugs. 3. Start the engine. 4. Using SNOOP® or equivalent, leak check the test port plugs. Is the action complete?	—	System OK	—

SECTION 1B4

SYMPTOM DIAGNOSIS

Symptom Diagnosis

Important Preliminary Checks

Checks	Action
Before Using This Section	Before using this section, you should have performed On Board Diagnostic Check and determined that: 1. The Control Module and MIL (Malfunction Indicator Lamp) are operating correctly. 2. There are no Diagnostic Trouble Codes (DTCs) stored, or a DTC exists but without a MIL. Several of the following symptom procedures call for a careful visual and physical check. The visual and physical checks are very important. The checks can lead to correcting a problem without further checks that may save valuable time.
LPG Fuel System Check	1. Verify the customer complaint. 2. Locate the correct symptom table. 3. Check the items indicated under that symptom. 4. Operate the vehicle under the conditions the symptom occurs. Verify HEGO switching between lean and rich. **IMPORTANT!** **Normal HEGO switching indicates the LPG fuel system is in closed loop and operating correctly at that time.** 5. If a scan tool is available, **take a snapshot** under the condition that the symptom occurs. Go to *Engine Scan Tool Data* List to verify normal sensor values and parameters.

Visual and Physical Checks	• Check all ECM system fuses and circuit breakers. • Check the ECM ground for being clean, tight and in its proper location. • Check the vacuum hoses for splits, kinks and proper connections. • Check thoroughly for any type of leak or restriction. • Check for air leaks at all the mounting areas of the intake manifold sealing surfaces. • Check for proper installation of the mixer module assembly. • Check for air leaks at the mixer assembly. • Check the ignition wires for the following conditions: − Cracking − Hardness − Proper routing − Carbon tracking • Check the wiring for the following items: − Proper connections, pinches or cuts. • The following symptom tables contain groups of possible causes for each symptom. The order of these procedures is not important. If the scan tool readings do not indicate the problems, then proceed in a logical order, easiest to check or most likely to cause first.

Intermittent

Checks	Action
DEFINITION: The problem may or may not turn ON the Malfunction Indicator Lamp (MIL) or store a Diagnostic Trouble Code (DTC).	
Preliminary Checks	• Refer to *Important Preliminary Checks.* • Do not use the DTC tables. If a fault is an intermittent, the use of the DTC tables may result in the replacement of good parts.
Faulty Electrical Connections or Wiring	• Faulty electrical connections or wiring can cause most intermittent problems. • Check the suspected circuit for the following conditions: − Faulty fuse or circuit breaker − Connectors poorly mated − Terminals not fully seated in the connector (backed out) − Terminals not properly formed or damaged − Terminal to wires poorly connected − Terminal tension insufficient. • Carefully remove all the connector terminals in the problem circuit in order to ensure the proper contact tension. If necessary, replace all the connector terminals in the problem circuit in order to ensure the proper contact tension. • Checking for poor terminal to wire connections requires removing the terminal from the connector body.
Operational Test	If a visual and physical check does not locate the cause of the problem, drive the vehicle with a scan tool. When the problem occurs, an abnormal voltage or scan reading indicates the problem may be in that circuit.
Intermittent Malfunction Indicator Lamp (MIL)	The following components can cause intermittent MIL and no DTC(s): • A defective relay, Control Module driven solenoid, or a switch that can cause electrical system interference. Normally, the problem will occur when the faulty component is operating. • The improper installation of electrical devices, such as lights, 2-way radios, electric motors, etc. • The ignition secondary voltage shorted to a ground. • The Malfunction Indicator Lamp (MIL) circuit or the Diagnostic Test Terminal intermittently shorted to ground. • The Control Module grounds.

Loss of DTC Memory	To check for the loss of the DTC Memory: 1. Disconnect the TMAP sensor. 2. Idle the engine until the Malfunction Indicator Lamp illuminates. The ECM should store a TMAP DTC. The TMAP DTC should remain in the memory when the ignition is turned OFF. If the TMAP DTC does not store and remain, the ECM is faulty.
Additional Checks	.

No Start

Checks	Action
DEFINITION: The engine cranks OK but does not start.	
Preliminary Checks	• Refer to *Important Preliminary Checks*.
Control Module Checks	• If a scan tool is available: • Check for proper communication with both the ECM • Check the 3A inline fuse in the ECM battery power circuit. Refer to *Engine Controls Schematics.* • Check battery power, ignition power and ground circuits to the ECM. Refer to *Engine Control Schematics.* Verify voltage and/or continuity for each circuit.
Sensor Checks	• Check the TMAP sensor. • Check the Magnetic pickup sensor (RPM). .
Fuel System Checks	**Important**: A closed LPG manual fuel shut off valve will create a no start condition. • Check for air intake system leakage between the mixer and the throttle body. • Verify proper operation of the low pressure lock-off solenoids. • Verify proper operation of the fuel control solenoids. • Check the fuel system pressures. Refer to the *LPG Fuel System Diagnosis*. • Check for proper mixer air valve operation.

Ignition System Checks	Note: LPG being a gaseous fuel requires higher secondary ignition system voltages for the equivalent gasoline operating conditions. • Check for the proper ignition voltage output with *J 26792* or the equivalent. • Verify that the spark plugs are correct for use with LPG (R46TS) • Check the spark plugs for the following conditions: − Wet plugs − Cracks − Wear − Improper gap − Burned electrodes − Heavy deposits • Check for bare or shorted ignition wires. • Check for loose ignition coil connections at the coil.
Engine Mechanical Checks	**Important:** The LPG Fuel system works on a fumigation principle of fuel introduction and is more sensitive to intake manifold leakage than the gasoline fuel supply system. • Check for the following: − Vacuum leaks − Improper valve timing − Low compression − Bent pushrods − Worn rocker arms − Broken or weak valve springs − Worn camshaft lobes.
Exhaust System Checks	• Check the exhaust system for a possible restriction: − Inspect the exhaust system for damaged or collapsed pipes − Inspect the muffler for signs of heat distress or for possible internal failure. • Check for possible plugged catalytic converter. Refer to *Restricted Exhaust System Diagnosis*

Hard Start

Checks	Action
DEFINITION: The engine cranks OK, but does not start for a long time. The engine does eventually run, or may start but immediately dies.	
Preliminary Checks	• Refer to *Important Preliminary Checks*. • Make sure the vehicle's operator is using the correct starting procedure.
Sensor Checks	• Check the Engine Coolant Temperature sensor with the scan tool. Compare the engine coolant temperature with the ambient air temperature on a cold engine. IF the coolant temperature reading is more than 5 degrees greater or less than the ambient air temperature on a cold engine, check for high resistance in the coolant sensor circuit. Refer to *DTC 111* • Check the Crankshaft Position (CKP) sensor. • Check the Throttle position (TPS) sensor.
Fuel System Checks	**Important**: A closed LPG manual fuel shut off valve will create an extended crank OR no start condition. • Verify the excess flow valve in the LPG manual shut-off valve is not tripped. • Check mixer module assembly for proper installation and leakage. • Verify proper operation of the low pressure lock-off solenoids. • Verify proper operation of the PTV and FTV. • Check for air intake system leakage between the mixer and the throttle body. • Check the fuel system pressures. Refer to the *Fuel System Diagnosis*.

Ignition System Checks	Note: LPG being a gaseous fuel requires higher secondary ignition system voltages for the equivalent gasoline operating conditions. • Check for the proper ignition voltage output with *J 26792* or the equivalent. • Verify that the spark plugs are correct for use with LPG (R46TS) • Check the spark plugs for the following conditions: − Wet plugs − Cracks − Wear − Improper gap − Burned electrodes − Heavy deposits • Check for bare or shorted ignition wires. • Check for moisture in the distributor cap if applicable. • Check for loose ignition coil connections. **Important**: 1. If the engine starts but then immediately stalls, Crankshaft Position (CKP). 2. Check for improper gap, debris or faulty connections.
Engine Mechanical Checks	**Important:** The LPF Fuel system works on a fumigation principle of fuel introduction and is more sensitive to intake manifold leakage than the gasoline fuel supply system. • Check for the following: − Vacuum leaks − Improper valve timing − Low compression − Bent pushrods − Worn rocker arms − Broken or weak valve springs − Worn camshaft lobes. Ref • Check the intake and exhaust manifolds for casting flash.

Exhaust System Checks	• Check the exhaust system for a possible restriction: − Inspect the exhaust system for damaged or collapsed pipes − Inspect the muffler for signs of heat distress or for possible internal failure. • Check for possible plugged catalytic converter. Refer to *Restricted Exhaust System Diagnosis* or *Exhaust System* in the GM MD Service Manual.
Additional Checks	•

Cuts Out, Misses

Checks	Action
DEFINITION: A surging or jerking that follows engine speed, usually more pronounced as the engine load increases which is not normally felt above 1500 RPM. The exhaust has a steady spitting sound at idle, low speed, or hard acceleration for the fuel starvation that can cause the engine to cut-out.	
Preliminary Checks	• Refer to *Important Preliminary Checks*.

Ignition System Checks	• Start the engine.
	• Wet down the secondary ignition system with water from a spray bottle, and look/listen for arcing or misfiring as you apply water.
	• Check for proper ignition output voltage with spark tester J 26792.
	• Check for a cylinder misfire.
	• Verify that the spark plugs are correct for use with LPG (R46TS)
	• Remove the spark plugs in these cylinders and check for the following conditions:
	  • Insulation cracks
	  • Wear
	  • Improper gap
	  • Burned electrodes
	  • Heavy deposits
	  • Visually/Physically inspect the secondary ignition for the following:
	  • Ignition wires for arcing, cross-firing and proper routing
	  • Ignition coils for cracks or carbon tracking

Engine Mechanical Checks	• Perform a cylinder compression check.
	• Check the engine for the following:
	  − Improper valve timing
	  − Bent pushrods
	  − Worn rocker arms
	  − Worn camshaft lobes.
	  − Broken or weak valve springs.
	• Check the intake and exhaust manifold passages for casting flash.

Fuel System Checks	• Check the fuel system - plugged fuel filter, low fuel pressure, etc. Refer to *LPG Fuel System Diagnosis*. • Check the condition of the wiring to the low pressure lock-off solenoid.
Additional Check	Check for Electromagnetic Interference (EMI). • EMI on the reference circuit can cause a missing condition. • Monitoring the engine RPM with a scan tool can detect an EMI. • A sudden increase in the RPM with little change in the actual engine RPM, indicates EMI is present. • If the problem exists, check the routing of the secondary wires and the ground circuit.

Hesitation, Sag, Stumble

Checks	Action
DEFINITION: The vehicle has a momentary lack of response when depressing the accelerator. The condition can occur at any vehicle speed. The condition may cause the engine to stall if it's severe enough.	
Preliminary Checks	Refer to *Important Preliminary Checks*.
Fuel System Checks	• Check the fuel pressure. Refer to *LPG Fuel System Diagnosis*. • Check for low fuel pressure during a moderate or full throttle acceleration. If the fuel pressure drops below specification, there is possibly a faulty low pressure regulator or a restriction in the fuel system. • Check the Manifold Absolute Pressure (MAP) sensor response and accuracy. • Check LPL electrical connection • Check the mixer air valve for sticking or binding. • Check the mixer module assembly for proper installation and leakage. • Check the PTV and FTV.
Ignition System Checks	Note: LPG being a gaseous fuel requires higher secondary ignition system voltages for the equivalent gasoline operating conditions. If a problem is reported on LPG and not gasoline, do not discount the possibility of a LPG only ignition system failure and test the system accordingly. • Check for the proper ignition voltage output with *J 26792* or the equivalent. • Verify that the spark plugs are correct for use with LPG (R46TS) • Check for faulty spark plug wires • Check for fouled spark plugs. •
Additional Check	1. Check for manifold vacuum or air induction system leaks • Check the generator output voltage.

Backfire

Checks	Action
DEFINITION: The fuel ignites in the intake manifold, or in the exhaust system, making a loud popping noise.	
Preliminary Check	• Refer to *Important Preliminary Checks*.
Ignition System Checks	**Important!** **LPG, being a gaseous fuel, requires higher secondary ignition system voltages for the equivalent gasoline operating conditions. The ignition system must be maintained in peak condition to prevent backfire.** • Check for the proper ignition coil output voltage using the spark tester *J26792* or the equivalent. • Check the spark plug wires by connecting an ohmmeter to the ends of each wire in question. If the meter reads over 30,000 ohms, replace the wires. • Check the connection at each ignition coil. • Check for deteriorated spark plug wire insulation. • Check the spark plugs. The correct spark plugs for LPG are (R46TS) • Remove the plugs and inspect them for the following conditions: − Wet plugs − Cracks − Wear − Improper gap − Burned electrodes − Heavy deposits

Engine Mechanical Check	**Important!** **The LPG Fuel system works on a fumigation principle of fuel introduction and is more sensitive to intake manifold leakage than a gasoline fuel supply system.** • Check the engine for the following: − Improper valve timing − Engine compression − Manifold vacuum leaks − Intake manifold gaskets − Sticking or leaking valves − Exhaust system leakage • Check the intake and exhaust system for casting flash or other restrictions.
Fuel System Checks	• Perform a fuel system diagnosis. Refer to *LPG Fuel System Diagnosis*.

Lack of Power, Sluggishness, or Sponginess

Checks	Action
DEFINITION: The engine delivers less than expected power. There is little or no increase in speed when partially applying the accelerator pedal.	
Preliminary Checks	• Refer to *Important Preliminary Checks.* • Refer to the *LPG Fuel system OBD System Check* • Compare the customer's vehicle with a similar unit. Make sure the customer has an actual problem. *Do not compare the power output of the vehicle operating on LPG to a vehicle operating on gasoline as the fuels do have different drive feel characteristics* • Remove the air filter and check for dirt or restriction. • Check the vehicle transmission Refer to the OEM transmission diagnostics.
Fuel System Checks	• Check for a restricted fuel filter, contaminated fuel, or improper fuel pressure. Refer to *LPG Fuel System Diagnosis*. • Check for the proper ignition output voltage with the spark tester *J 26792* or the equivalent. • Check for proper installation of the mixer module assembly. • Check all air inlet ducts for condition and proper installation. • Check for fuel leaks between the LPR and the mixer. • Verify that the LPG tank manual shut-off valve is fully open. • Verify that liquid fuel (not vapor) is being delivered to the LPR.
Sensor Checks	• Check the Heated Exhaust Gas Oxygen Sensor (HEGO) for contamination and performance. Check for proper operation of the MAP sensor. • Check for proper operation of the TPS sensor.
Exhaust System Checks	• Check the exhaust system for a possible restriction: − Inspect the exhaust system for damaged or collapsed pipes − Inspect the muffler for signs of heat distress or for possible internal failure. − Check for possible plugged catalytic converter.

Engine Mechanical Check	Check the engine for the following: • Engine compression • Valve timing • Improper or worn camshaft. Refer to *Engine Mechanical* in the Service Manual.
Additional Check	• Check the ECM grounds for being clean, tight, and in their proper locations. • Check the generator output voltage. • If all procedures have been completed and no malfunction has been found, review and inspect the following items: • Visually and physically, inspect all electrical connections within the suspected circuit and/or systems. • Check the scan tool data.

Poor Fuel Economy

Checks	Action
DEFINITION: Fuel economy, as measured by refueling records, is noticeably lower than expected. Also, the economy is noticeably lower than it was on this vehicle at one time, as previously shown by an by refueling records.	
Preliminary Checks	• Refer to *Important Preliminary Checks*. • Check the air cleaner element (filter) for dirt or being plugged. • Visually (Physically) check the vacuum hoses for splits, kinks, and proper connections. • Check the operators driving habits for the following items: − Is there excessive idling or stop and go driving? − Are the tires at the correct air pressure? − Are excessively heavy loads being carried? − Is their often rapid acceleration? • Suggest to the owner to fill the fuel tank and to recheck the fuel economy. • Suggest that a different operator use the equipment and record the results.
Fuel System Checks	• Check the LPR fuel pressure. Refer to *LPG Fuel System Diagnosis*. • Check the fuel system for leakage.
Sensor Checks	• Check the Temperature Manifold Absolute Pressure (TMAP) sensor.
Ignition System Checks	• Verify that the spark plugs are correct for use with LPG (R46TS) • Check the spark plugs. Remove the plugs and inspect them for the following conditions: − Wet plugs − Cracks − Wear − Improper gap − Burned electrodes − Heavy deposits • Check the ignition wires for the following items: − Cracking − Hardness − Proper connections
Cooling System Checks	• Check the engine thermostat for always being open or for the wrong heat range

Additional Check	• Check the transmission shift pattern. Refer to the OEM Transmission Controls section the Service Manual. • Check for dragging brakes.

Rough, Unstable, or Incorrect Idle, Stalling

Checks	Action
DEFINITION: The engine runs unevenly at idle. If severe enough, the engine or vehicle may shake. The engine idle speed may vary in RPM. Either condition may be severe enough to stall the engine.	
Preliminary Check	• Refer to *Important Preliminary Checks*.
Sensor Checks	• Check for silicon contamination from fuel or improperly used sealant. The sensor will have a white powdery coating. The sensor will result in a high but false signal voltage (rich exhaust indication). The ECM will reduce the amount of fuel delivered to the engine causing a severe driveability problem. • Check the Heated Exhaust Gas Oxygen Sensor (HEGO) performance: • Check the Temperature Manifold Absolute Pressure (TMAP) sensor response and accuracy.
Fuel System Checks	• Check for rich or lean symptom that causes the condition. Drive the vehicle at the speed of the complaint. Monitoring the oxygen sensors will help identify the problem. • Check for a sticking mixer air valve. • Verify proper operation of the PTV and FTV. • Perform a cylinder compression test. Refer to *Engine Mechanical* in the Service Manual. • Check the LPR fuel pressure. Refer to the *LPG Fuel System Diagnosis*. • Check mixer module assembly for proper installation and connection.

Ignition System Checks	• Check for the proper ignition output voltage using the spark tester *J26792* or the equivalent. • Verify that the spark plugs are correct for use with LPG (R46TS) • Check the spark plugs. Remove the plugs and inspect them for the following conditions: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Blistered insulators – Heavy deposits • Check the spark plug wires by connecting an ohmmeter to the ends of each wire in question. If the meter reads over 30,000 ohms, replace the wires.
Additional Checks	**Important:** The LPG Fuel system works on a fumigation principle of fuel introduction and is more sensitive to intake manifold leakage than the gasoline fuel supply system. • Check for vacuum leaks. Vacuum leaks can cause a higher than normal idle and low throttle angle control command. • Check the ECM grounds for being clean, tight, and in their proper locations. • Check the battery cables and ground straps. They should be clean and secure. Erratic voltage may cause all sensor readings to be skewed resulting in poor idle quality..
Engine Mechanical Check	• Check the engine for the following: – Broken motor mounts – Improper valve timing – Low compression – Bent pushrods – Worn rocker arms – Broken or weak valve springs – Worn camshaft lobes

Surges/Chuggles

Checks	Action
DEFINITION: The engine has a power variation under a steady throttle or cruise. The vehicle feels as if it speeds up and slows down with no change in the accelerator pedal.	
Preliminary Checks	• Refer to *Important Preliminary Checks*. • Be sure the driver understands the Torque Converter Clutch operation.
Sensor Checks	Check the Heated Exhaust Gas Oxygen Sensor (HEGO) performance.
Fuel System Checks	• Check for Rich or Lean symptom that causes the condition. Drive the vehicle at the speed of the complaint. Monitoring the oxygen sensors will help identify the problem. • Check the fuel pressure while the condition exists. Refer to *LPG Fuel System Diagnosis.* • Verify proper fuel control solenoid operation. • Verify that the LPG manual shut-off valve is fully open. • Check the in-line fuel filter for restrictions.

Ignition System Checks	• Check for the proper ignition output voltage using the spark tester J26792 or the equivalent.
	• Verify that the spark plugs are correct for use with LPG (R46TS)
	• Check the spark plugs. Remove the plugs and inspect them for the following conditions:
	  − Wet plugs
	  − Cracks
	  − Wear
	  − Improper gap
	  − Burned electrodes
	− Heavy deposits
	− Check the Crankshaft Position (CKP) sensor.

Additional Check	• Check the ECM grounds for being clean, tight, and in their proper locations. • Check the generator output voltage. • Check the vacuum hoses for kinks or leaks. • Check Transmission

SECTION 1C2

WIRING SCHEMATICS

ON-VEHICLE SERVICE WIRE HARNESS REPAIR

The ECM/PCM harness electrically connects the ECM/PCM to the various solenoids, electrically and sensors in vehicle engine and passenger compartment.

Wire harnesses should be replaced with proper part number harnesses. When signal wires are spliced, into a harness, use wire with high temperature insulation only.

With the low current and voltage levels found in the system, it is important that the best possible bond at all wire splices be made by soldering the splices, as shown in Figure 1.

Molded on connectors require complete replacement of the connector. This means splicing a new connector assembly into the harness.

Refer to Figure 1 for wiring diagrams.

CONNECTORS AND TERMINALS

Use care when probing a connector or replacing terminals in them. It is possible to short between opposite terminals. If this happens to the wrong terminal pair, it is possible to damage certain components. Always use jumper wires between connectors, for circuit checking. NEVER probe through the Weather-Pack seals. Use tachometer adapter J 35812, or equivalent, which provides an easy hook up of the tach lead. The connector test adapter kit J 35616, or equivalent, contains an assortment of flexible connectors, used to probe terminals during diagnosis. Fuse remover and test tool BT 8616, or equivalent, is used for removing a fuse and to adapt fuse holder, with a meter, for diagnosis.

When diagnosing, open circuits are often difficult to locate by sight, because oxidation, or terminal misalignment are hidden by the connectors. Merely wiggling a connector on a sensor, or in the wiring harness, may correct the open circuit condition. This should always be considered, when an open circuit, or failed sensor is indicated. Intermittent problems may, also, be caused by oxidized or loose connections.

Before making a connector repair, be certain of the type of connector. Weather-Pack and Meter Pack connectors look similar, but are serviced differently.

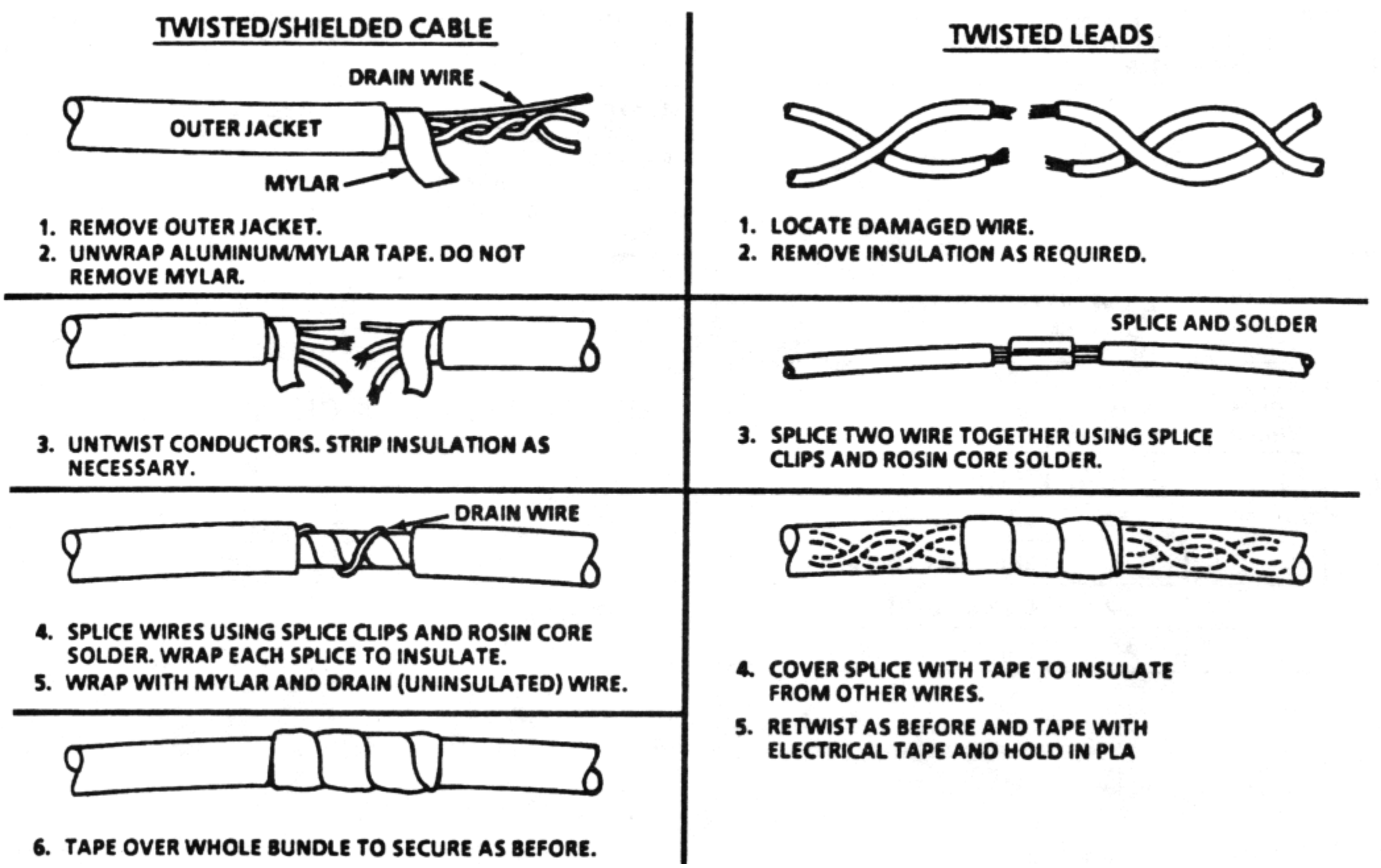


FIGURE 1 WIRE HARNESS REPAIR

Micro-Pack

Refer to Figure 2 and repair procedure for replacement of a :Micro-Pack terminal.

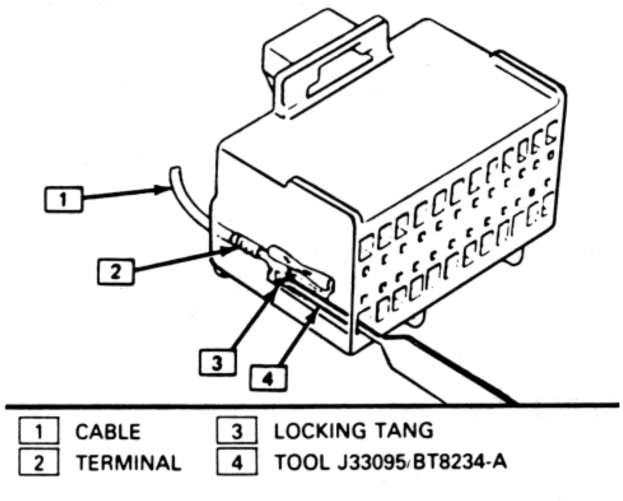


FIGURE 2 MICRO-PACK CONNECTOR

Metri-Pack

Some connectors use terminals called Metri-Pack Series 150. (Figure 3). ‘These may be used at the coolant sensor, as well as TBI units.

They are also called “Pull-To-Seat” terminals, because, to install a terminal on a wire, the wire is first inserted through the seal (5) and connector (4). The terminal is then crimped on the wire and the terminal pulled back into the connector to seat it in place.

To remove a terminal:

1. Slide the seal back on the wire.
2. Insert tool (3) BT-8518, or J 35689, or equivalent, as shown in insert “A” and “B,” to release the terminal locking tab (2).
3. Push the wire and terminal out through the connector.

If reusing the terminal, reshape the locking tang (2).

Weather-Pack

A Weather-Pack connector can be identified by a rubber seal, at the rear of the connector. This connector, which is used in the engine compartment, protects against moisture and dirt, which could create oxidation and deposits on the terminals. This protection is important, because of the very low voltage and current levels found in the electronic system.

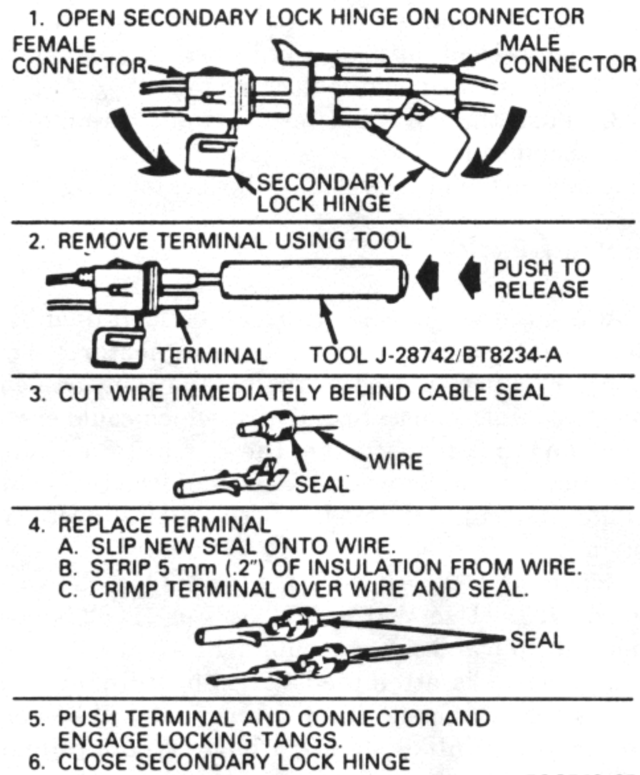
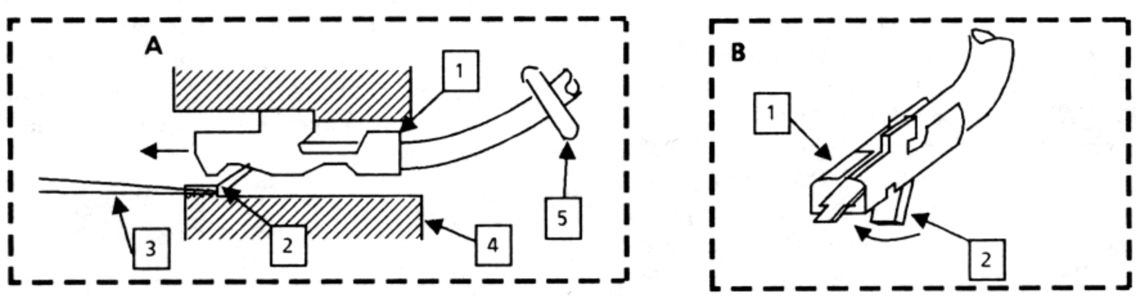


FIGURE 4 WEATHER PACK TERMINAL REPAIR



1. **METRI-PACK SERIES 150 FEMALE TERMINAL**
2. **LOCKING TANG**
3. **TOOL J35689 OR BT-8446**
4. **CONNECTOR BODY**
5. **SEAL**

FIGURE 3 METRI-PACK SERIES 150 TERMINAL REMOVAL

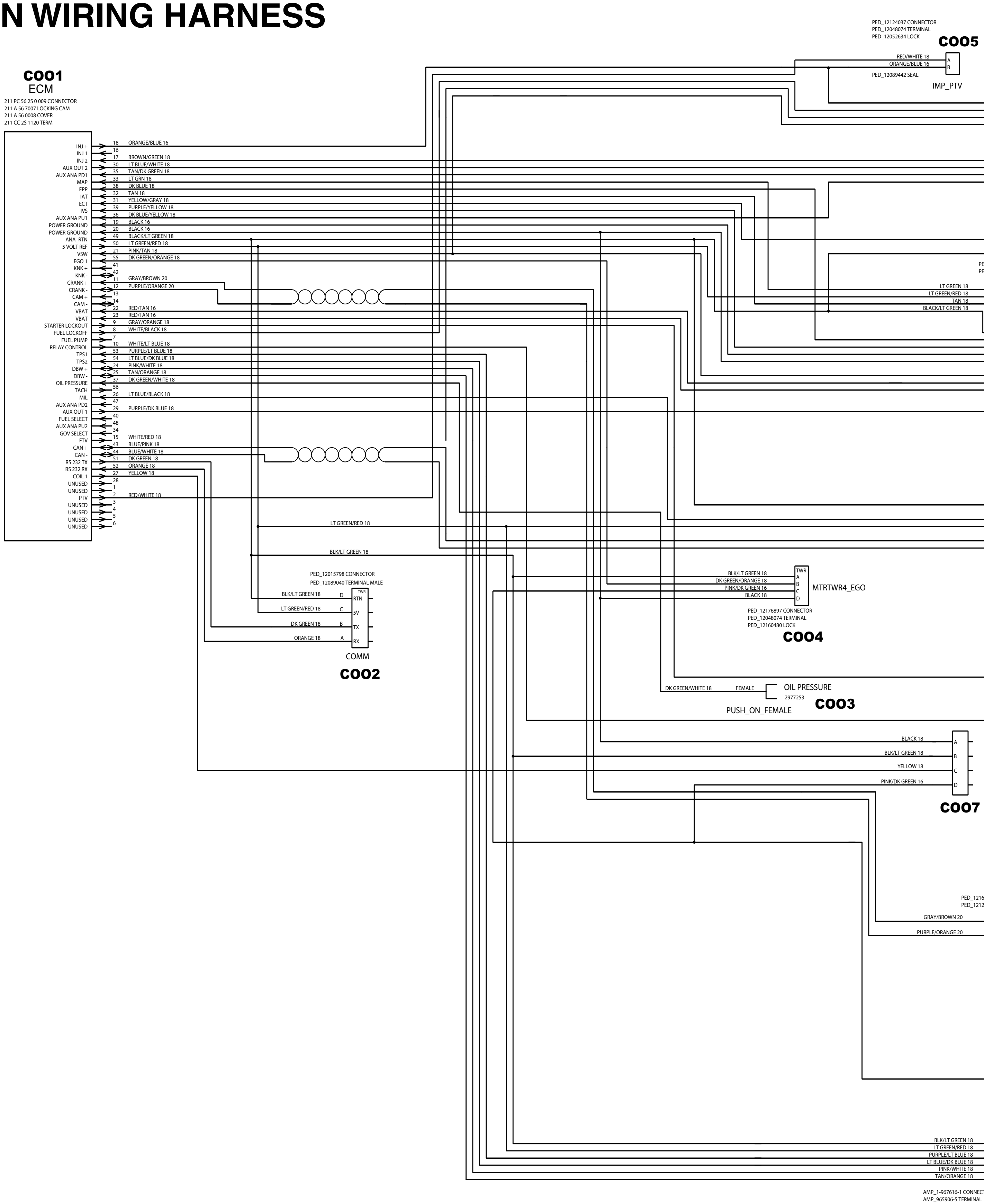
Repair of a Weather-Pack terminal is shown in Figure 3-23. Use tool J M28742, or BT8234-A to remove the pin and sleeve terminals.

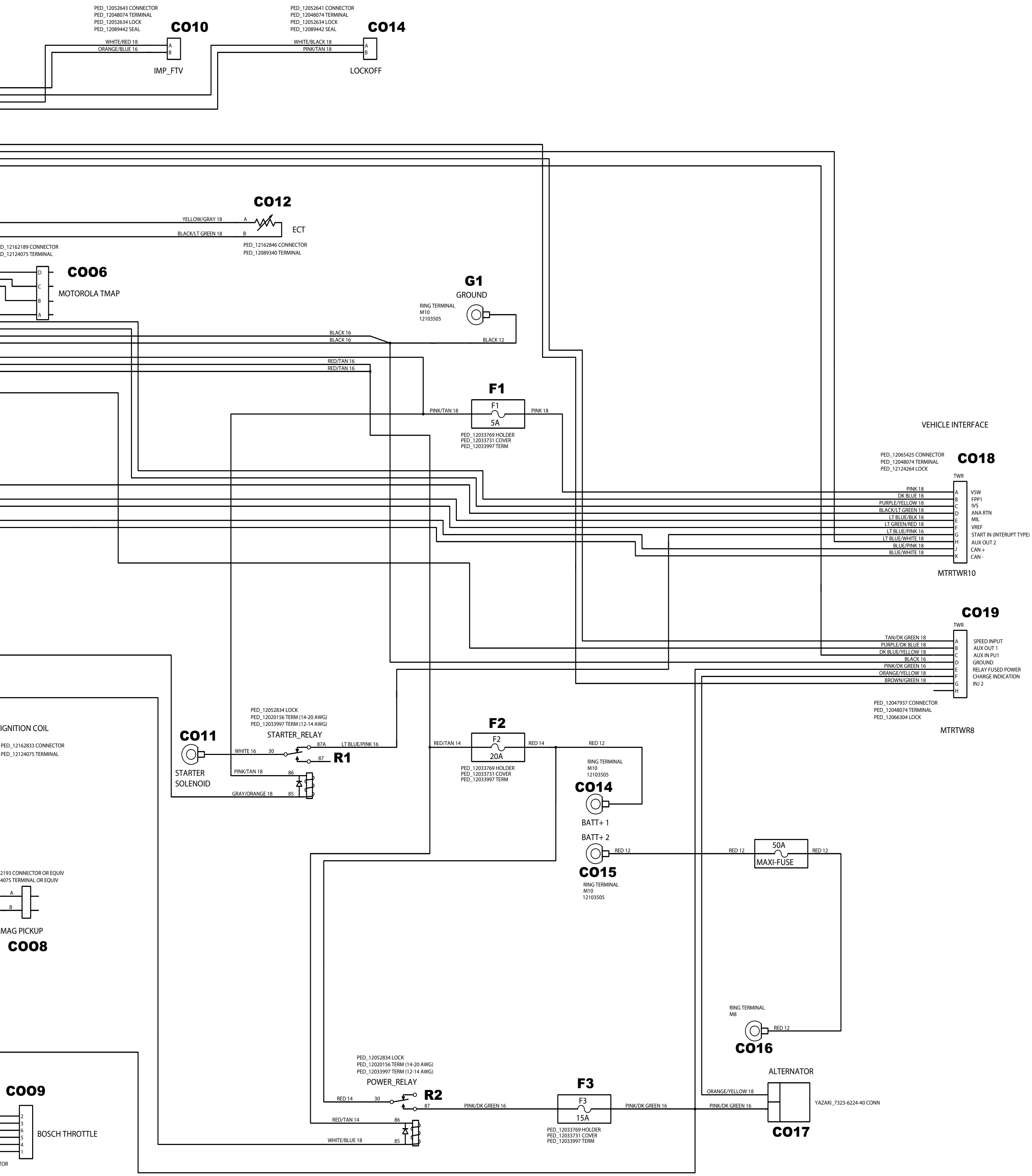
If removal is attempted with an ordinary pick, there is a good chance that the terminal will be bent, or deformed. Unlike standard blade type terminals, these terminals cannot be straightened once they are bent.

Make certain that the connectors are properly seated and all of the sealing rings in place, when connecting leads. The hinge type flap provides a backup, or secondary locking feature for the connector. They are used to improve the connector reliability by retaining the terminals, if the small terminal lock tangs are not positioned properly.

Weather-Pack connections cannot be replaced with standard connections. Instructions are provided with Weather-Pack connector and terminal packages.

MAIN WIRING HARNESS





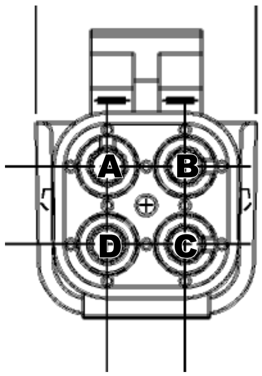
PED_12052643 CONNECTOR
PED_12048074 TERMINAL
PED_12052634 LOCK
PED_12089442 SEAL
CO10
WHITE/RED 18
ORANGE/BLUE 16
IMP_FTV
PED_12052641 CONNECTOR
PED_12048074 TERMINAL
PED_12052634 LOCK
PED_12089442 SEAL
CO14
WHITE/BLACK 18
PINK/TAN 18
LOCKOFF
CO12
YELLOW/GRAY 18
BLACK/LT GREEN 18
ECT
PED_12162846 CONNECTOR
PED_12089340 TERMINAL
PED_12162189 CONNECTOR
PED_12124075 TERMINAL
COO6
MOTOROLA TMAP
G1
GROUND
RING TERMINAL
M10
12103505
BLACK 16
BLACK 16
BLACK 12
RED/TAN 16
RED/TAN 16
F1
PINK/TAN 18
5A
PINK 18
PED_12033769 HOLDER
PED_12033731 COVER
PED_12033997 TERM
VEHICLE INTERFACE
PED_12065425 CONNECTOR
PED_12048074 TERMINAL
PED_12124264 LOCK
CO18
TWR
PINK 18
DK BLUE 18
PURPLE/YELLOW 18
BLACK/LT GREEN 18
LT BLUE/BLK 18
LT GREEN/RED 18
LT BLUE/PINK 16
LT BLUE/WHITE 18
BLUE/PINK 18
BLUE/WHITE 18
VSW
FPP1
IVS
ANA RTN
MIL
VREF
START IN (INTERUPT TYPE)
AUX OUT 2
CAN +
CAN -
MTRTWR10
CO19
TWR
TAN/DK GREEN 18
PURPLE/DK BLUE 18
DK BLUE/YELLOW 18
BLACK 16
PINK/DK GREEN 16
ORANGE/YELLOW 18
BROWN/GREEN 18
SPEED INPUT
AUX OUT 1
AUX IN PU1
GROUND
RELAY FUSED POWER
CHARGE INDICATION
INJ 2
PED_12047937 CONNECTOR
PED_12048074 TERMINAL
PED_12066304 LOCK
MTRTWR8
IGNITION COIL
PED_12162833 CONNECTOR
PED_12124075 TERMINAL
CO11
STARTER SOLENOID
PED_12052834 LOCK
PED_12020156 TERM (14-20 AWG)
PED_12033997 TERM (12-14 AWG)
STARTER_RELAY
WHITE 16
LT BLUE/PINK 16
PINK/TAN 18
GRAY/ORANGE 18
R1
F2
RED/TAN 14
20A
RED 14
RED 12
PED_12033769 HOLDER
PED_12033731 COVER
PED_12033997 TERM
RING TERMINAL
M10
12103505
CO14
BATT+ 1
BATT+ 2
RED 12
CO15
RING TERMINAL
M10
12103505
50A
MAXI-FUSE
RED 12
RED 12
2193 CONNECTOR OR EQUIV
4075 TERMINAL OR EQUIV
MAG PICKUP
COO8
RING TERMINAL
M8
RED 12
CO16
PED_12052834 LOCK
PED_12020156 TERM (14-20 AWG)
PED_12033997 TERM (12-14 AWG)
POWER_RELAY
R2
RED 14
PINK/DK GREEN 16
RED/TAN 14
WHITE/BLUE 18
F3
15A
PED_12033769 HOLDER
PED_12033731 COVER
PED_12033997 TERM
PINK/DK GREEN 16
ALTERNATOR
ORANGE/YELLOW 18
PINK/DK GREEN 16
YAZAKI_7323-6224-40 CONN
CO17
COO9
BOSCH THROTTLE

ENGINE CONTROL MODULE C001

211 PC 56 2S 0 009 CONNECTOR
211 A 56 7007 LOCKING CAM
211 A 56 0008 COVER
211 CC 2S 1120 TERM

INJ +	18	ORANGE/BLUE 16
INJ 1	16	
INJ 2	17	BROWN/GREEN 18
AUX OUT 2	30	LT BLUE/WHITE 18
AUX ANA PD1	35	TAN/DK GREEN 18
MAP	33	LT GRN 18
FPP	38	DK BLUE 18
IAT	32	TAN 18
ECT	31	YELLOW/GRAY 18
IVS	39	PURPLE/YELLOW 18
AUX ANA PU1	36	DK BLUE/YELLOW 18
POWER GROUND	19	BLACK 16
POWER GROUND	20	BLACK 16
ANA_RTN	49	BLACK/LT GREEN 18
5 VOLT REF	50	LT GREEN/RED 18
VSW	21	PINK/TAN 18
EGO 1	55	DK GREEN/ORANGE 18
KNK +	41	
KNK -	42	
CRANK +	11	GRAY/BROWN 20
CRANK -	12	PURPLE/ORANGE 20
CAM +	13	
CAM -	14	
VBAT	22	RED/TAN 16
VBAT	23	RED/TAN 16
STARTER LOCKOUT	9	GRAY/ORANGE 18
FUEL LOCKOFF	8	WHITE/BLACK 18
FUEL PUMP	7	
RELAY CONTROL	10	WHITE/LT BLUE 18
TPS1	53	PURPLE/LT BLUE 18
TPS2	54	LT BLUE/DK BLUE 18
DBW +	24	PINK/WHITE 18
DBW -	25	TAN/ORANGE 18
OIL PRESSURE	37	DK GREEN/WHITE 18
TACH	56	
MIL	26	LT BLUE/BLACK 18
AUX ANA PD2	47	
AUX OUT 1	29	PURPLE/DK BLUE 18
FUEL SELECT	40	
AUX ANA PU2	48	
GOV SELECT	34	
FTV	15	WHITE/RED 18
CAN +	43	BLUE/PINK 18
CAN -	44	BLUE/WHITE 18
RS 232 TX	51	DK GREEN 18
RS 232 RX	52	ORANGE 18
COIL 1	27	YELLOW 18
UNUSED	28	
UNUSED	1	
PTV	2	RED/WHITE 18
UNUSED	3	
UNUSED	4	
UNUSED	5	
UNUSED	6	

COMMUNICATION PORT CONNECTOR C002

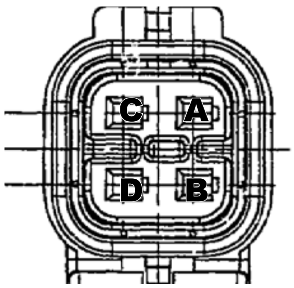


Pins	Wire Color	Function
A	Orange	RS232 RX
B	Dark Green	RS232 TX
C	Lt Green/Red	5 Volt Ref
D	Black/Lt Green	Analog Return

OIL PRESSURE CONNECTOR C003

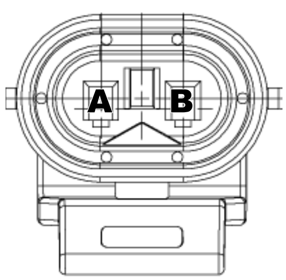
Pins	Wire Color	Function
A	Lt Green/Black	Oil Pressure Switch

HEATED OXYGEN SENSOR (HEGO) CONNECTOR C004



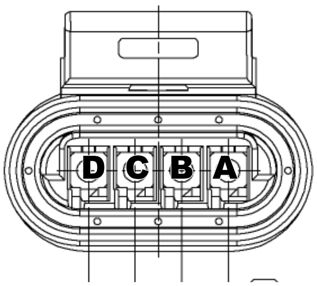
Pins	Wire Color	Function
A	Black/Lt Green	Analog Return
B	Dk Green/Orange	HEGO
C	Pink/Dk Green	Relay Fused Power
D	Black	Power Ground

FUEL TRIM VALVE (FTV) CONNECTOR C005



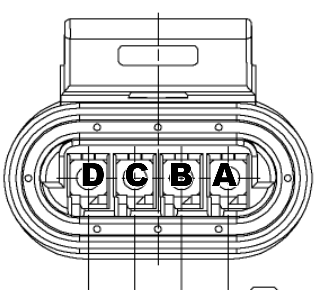
Pins	Wire Color	Function
A	Red/White	INJ 7
B	Orange/Blue	INJ +

TMAP CONNECTOR C006



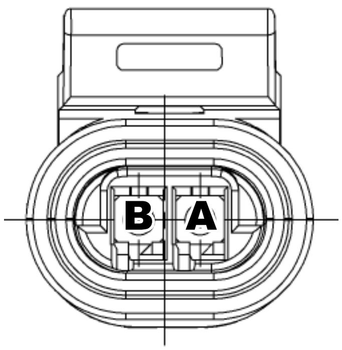
Pins	Wire Color	Function
A	Black/Lt Green	Analog Return
B	Tan	IAT
C	Lt Green/Red	5 Volt Reference
D	Lt Green	MAP

COIL CONNECTOR C007



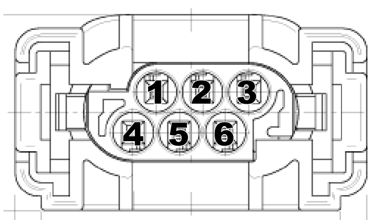
Pins	Wire Color	Function
A	Black	Power Ground
B	Black/Lt Green	Analog Return
C	Yellow	Coil 1
D	Pink/Dk Green	Relay Fused Power

MAGNETIC PICKUP CONNECTOR C008



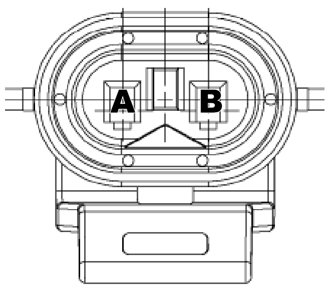
Pins	Wire Color	Function
A	Gray/Brown	Crank +
B	Purple/Orange	Crank –

THROTTLE CONNECTOR C009



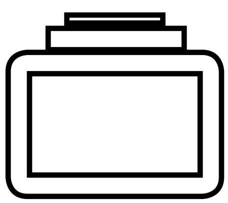
Pins	Wire Color	Function
1	Tan/Orange	DBW -
2	Black/Lt Green	Analog Return
3	Lt Green/Red	5 Volt Reference
4	Purple/Lt Blue	TPS 1
5	Lt Blue/Dk Blue	TPS 2
6	Pink/White	DBW +

PRESSURE TRIM VALVE (PTV) CONNECTOR C010



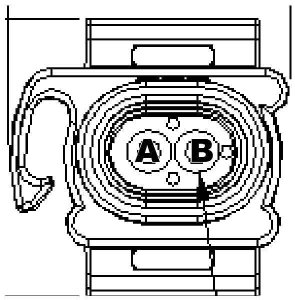
Pins	Wire Color	Function
A	White/Red	Gaseous Trim
B	Orange/Blue	INJ +

STARTER SOLENOID CONNECTOR C011



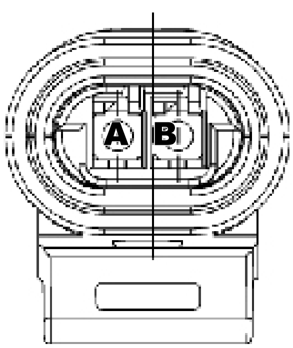
Pins	Wire Color	Function
A	White	Starter Relay R1

ENGINE COOLANT TEMPERATURE SENSOR (ECT) CONNECTOR C012



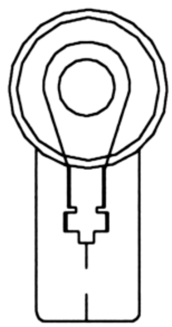
Pins	Wire Color	Function
A	Yellow/Gray	ECT
B	Black/Lt Green	Analog Return

FUEL LOCKOFF CONNECTOR CO13



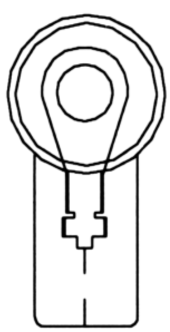
Pins	Wire Color	Function
A	White/Black	Fuel Lockoff
B	Pink/Tan	VSW

BATTERY POSITIVE CONNECTOR C014



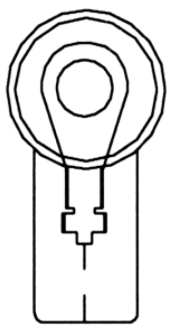
Pins	Wire Color	Function
A	Red	Power Relay R2

BATTERY POSITIVE CONNECTOR C015



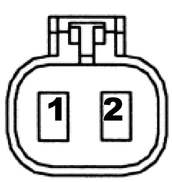
Pins	Wire Color	Function
A	Red	Alternator

ALTERNATOR CONNECTOR C016



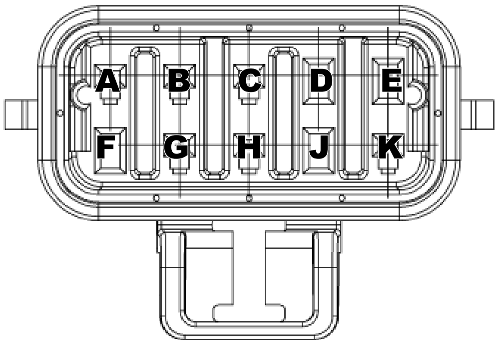
Pins	Wire Color	Function
A	Red	Battery

ALTERNATOR CONNECTOR C017



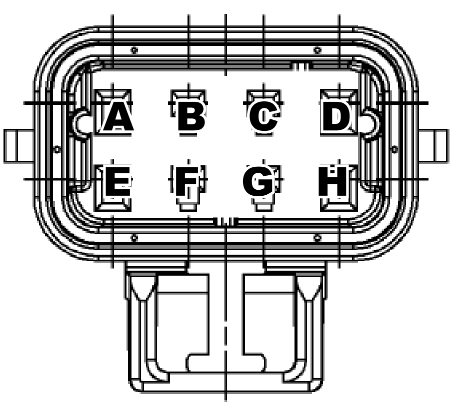
Pins	Wire Color	Function
A	Pink/Dk Green	Power Relay R2
B	Orange/Yellow	Charge Indicator

INSTRUMENT PANEL CONNECTOR C018



Pins	Wire Color	Function
A	Pink	VSW
B	Dk Blue	FPP1
C	Purple/Yellow	IVS
D	Black/Lt Green	ANA RTN
E	Lt Blue/Black	MIL
F	Lt Green/Red	VREF
G	Lt Blue/Pink	Start
H	Lt Blue/White	AUX Out 2
J	Blue/Pink	CAN +
K	Blue/White	CAN -

INSTRUMENT PANEL CONNECTOR C019



Pins	Wire Color	Function
A	Tan/Dk Green	Speed Input
B	Purple Dk Blue	AUX Out
C	Dk Blue/Yellow	AUX In
D	Black	Ground
E	Pink/Dk Green	Relay Fused Power
F	Orange/Yellow	Charge Indication
G	Brown/Green	INJ 2
H	(not used)	

SECTION 1C4

DIAGNOSTIC TROUBLE CODES

DESCRIPTION OF ECM BASED DIAGNOSTICS

DEFINITION OF TERMS

Active Gov Mode	Speed is governed by one of two modes. Isochronous, which maintains an exact speed, or Droop, which allows speed to drop a predetermined amount based on current engine load.
AL	Adaptive Learn
AL Mult	Adaptive Learn Multiplier. The adaptive learn multiplier is a correction to the fuel delivery which is expressed as a percentage (%) and stored in the ECM's RAM.
Analog	0 to 5 volt or 0 to 12 volt signals
Batt	Battery Voltage
BP	Barometric Pressure. The pressure of the outside air.
CHT	Cylinder Head Temperature
CL	Closed Loop
CL Mult	Closed Loop Multiplier. The closed loop multiplier is a fast acting adjustment to the fuel delivery based on feedback from the HEGO. The closed loop multiplier is expressed as a percentage (%) and is not stored in the ECM's memory.
Closed Loop	Fuel and timing modified based on feedback from the O2 sensor.
DBW	Drive by wire.
DTC	Diagnostic Trouble Code. A code which is stored in the ECM when an ECM initiated test fails.
ECT	Engine Coolant Temperature.
ECM	Engine Control Module. The computer, which controls the fuel and ignition system on the engine.
EGO	See HO2S
Forced Idle	ECM commands electronic throttle controller to an idle position.
FPP	Foot Pedal Position.
HO2S	Heated Oxygen Sensor
IAT	Intake Air Temperature
IVS	Idle Validation Switch
Low Rev Limit	Secondary engine speed control, only used to limit speed when throttle positioning is not maintaining desired speed
MAP	Manifold Absolute Pressure. The pressure of the air in the intake manifold.
MAT	Manifold Air Temperature. The temperature of the air in the intake manifold
MIL	Malfunction Indicator Light. A dash mounted light that illuminates when the ECM senses a system fault.
ms	Milli-seconds. 1/1000 of a second.
Open Loop	Fuel and timing based strictly on tables stored in the ECM.
Power Derate Level 1	ECM has detected condition in throttle control and limits throttle blade opening to 50%
Power Derate Level 2	ECM has detected condition in throttle control and limits throttle blade opening to 20%
PSIA	Pounds per square inch absolute. 14.7 psia = 0 psig
RAM	Random Access Memory. The portion of computer memory within the ECM, which changes as the engine is running and is stored while the engine is off.
TPS	Throttle Position Sensor. The throttle position sensor measures the opening of the throttle.

Spectrum Diagnostic Section

DIAGNOSTICS OVERVIEW OF THE SPECTRUM FUEL SYSTEM

The Spectrum Fuel system has built-in diagnostics for trouble shooting. The system has a dash mounted Malfunction Indicator Lamp (MIL) for indication of system problems.

MALFUNCTION INDICATOR LAMP (MIL)

Most engine control system related problems that affect emissions or driveability of the vehicle will set a (DTC) Diagnostic Trouble Code and illuminate the Malfunction Indicator Lamp.

The MIL has the following functions:

1. It notifies the driver of a problem with the fuel system, ignition system, or emission control system so the driver can arrange for service as soon as possible.
2. It will display DTC's that have been stored due to a system malfunction.

The lamp should come on when the key is in the ON position and the engine is not running. This feature verifies that the lamp is in proper working order. If the lamp does not come on with the vehicle key on/engine off, repair it as soon as possible. Once the engine is in start or run mode, the lamp should go off. If the lamp illuminates while the engine is in the start or run mode, there is a current Diagnostic Trouble Code.

SPECTRUM DIAGNOSTIC TROUBLE CODES (DTC)

Diagnostic Trouble Codes are set when the Spectrum ECM (Electronic Control Module) runs a diagnostic self-test and the test fails. When a DTC is set, the ECM will illuminate the Malfunction Indicator Lamp on the instrument panel and save the code in memory. The ECM will continue to run the self-test unless the DTC is an oxygen sensor lean, oxygen sensor rich, or an internal ECM related DTC. If the system continues to fail the test, the lamp will stay illuminated and the DTC is current (ACTIVE). All DTC's are stored as historical faults until they are cleared. All DTC's except the ECM related DTC's will automatically clear from memory if the DTC does not reset within 100 consecutive engine run cycles.

While a Diagnostic Trouble Code is current for a sensor, the ECM may assign a default "limp home" value and use that value in its control algorithms. All of the system diagnostic self-tests run continuously during normal vehicle operation.

The Diagnostic Trouble Codes can be read by using either the MIL lamp or a laptop computer. Refer to Using a Laptop Computer to Diagnose the Spectrum System and Using a Diagnostic Jumper to Diagnose the ECI System, located in this section. Diagnostic Trouble Codes can be cleared from memory with a laptop computer or by turning the ignition key to the OFF position and removing the system main power fuse (F3) for 15 seconds.

If more than one DTC is detected, always begin with the lowest number DTC and diagnose each problem to correction unless directed to do otherwise by the fault tree. The DTC's are numbered in order of importance. Having DTC 112 and DTC 122, both concerning the oxygen sensor, is possible. By repairing DTC 112 first, the problem causing the DTC 122 may also be corrected.

DIAGNOSTIC COMMUNICATION ERROR

The ECM 5 volt reference circuit powers the Spectrum diagnostic link cable. In the event that the 5 volt reference signal is open or shorted to ground, you will not be able to connect to the system. If you are unable to connect, follow the quick checks listed below:

Be sure you are using the correct password and latest software for the system you are connecting to.

Check the ECM system power and ground circuits. Refer to DTC 261 for the power schematic. Also check for +12 switched power at ECM pin 21 with the ignition key on.

Check for power at the DLC connector for +5 volts between pins C (LT GRN/RED) and pin D (BLK) with the ignition key in the on position.

You may still be able to retrieve a code using the blink code function if none of the above recommendations prove useful. In the event of a 5 volt reference signal malfunction, DTC 531 or 532 should set. If you find one of these codes using the blink code function, follow the DTC diagnostic chart recommendations in the DTC section of this manual.

USING A LAPTOP COMPUTER TO DIAGNOSE THE SPECTRUM SYSTEM

A laptop computer is the preferred tool for performing diagnostic testing of the Spectrum system. A laptop computer, with the system diagnostic cable and diagnostic software, is used to read and clear Diagnostic Trouble codes. It is also used to monitor sensor and actuator values. The diagnostic software also performs several special tests.

The following procedures will assist you in using a laptop computer to diagnose the Spectrum system:

INSTALLING THE SPECTRUM DIAGNOSTIC SOFTWARE

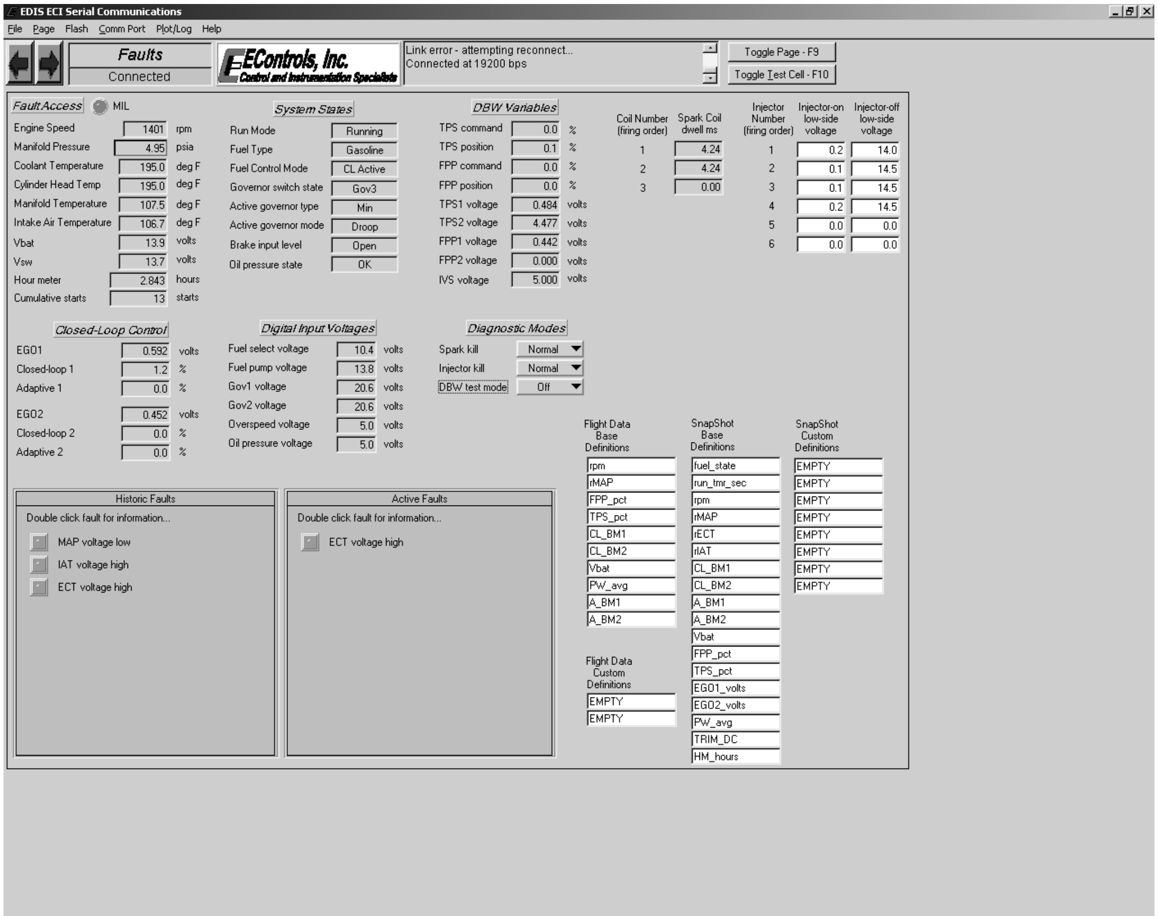
Loading Software and Connecting the Computer

- Start Windows
- Insert the Diagnostic Interface software CD.
- Click on the START button.
- From the Start menu, select RUN.
- In the command-line text box, type the letter of your CD-ROM drive, followed by: \setup (for example, e:\setup), then click OK.
- Follow the on screen instructions.

Connecting a Laptop Computer to the Spectrum System

- Connect the system diagnostic cable to the RS232 port on the back of the computer. If you do not have a RS232 port use the USB to RS232 adapter supplied in the IMPCO ITK-2 test kit.
- Connect the diagnostic cable to the diagnostic connector on the engine harness. The diagnostic connector is a square 4-pin connector located near the Spectrum system ECM.
- Turn the computer ON.
- Start Windows.
- From the Start menu select Programs.
- Select IMPCO Display.
- Place the ignition key in the ON position.
- The system Gauge screen should now appear and a green banner in the upper left hand will read “Connected”.

DIAGNOSTIC TROUBLE CODES



The System Fault screen is used to view and clear DTC's, which have been set.

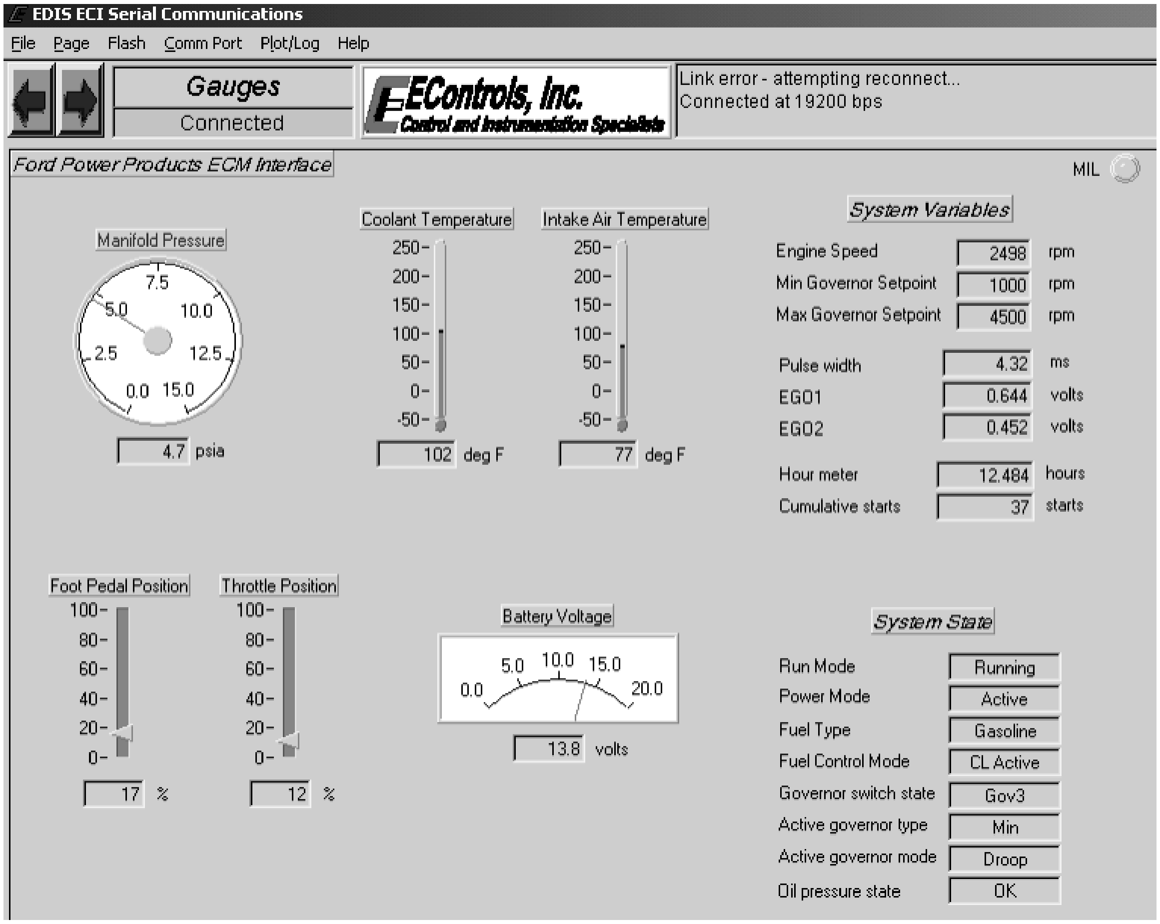
Checking Diagnostic Trouble Codes

The System Fault screen contains a listing of all of the Historic and Active DTC's set within the system. If a DTC is stored in memory, the screen will display that fault in the History column. If the fault is active it will also show up in that column.

Clearing Diagnostic Trouble Codes

To clear a DTC from memory use the arrow keys or mouse to move then Press the Enter key to clear the fault from memory. NOTE: Record faults before erasing them for reference during diagnostics.

DATA STREAM

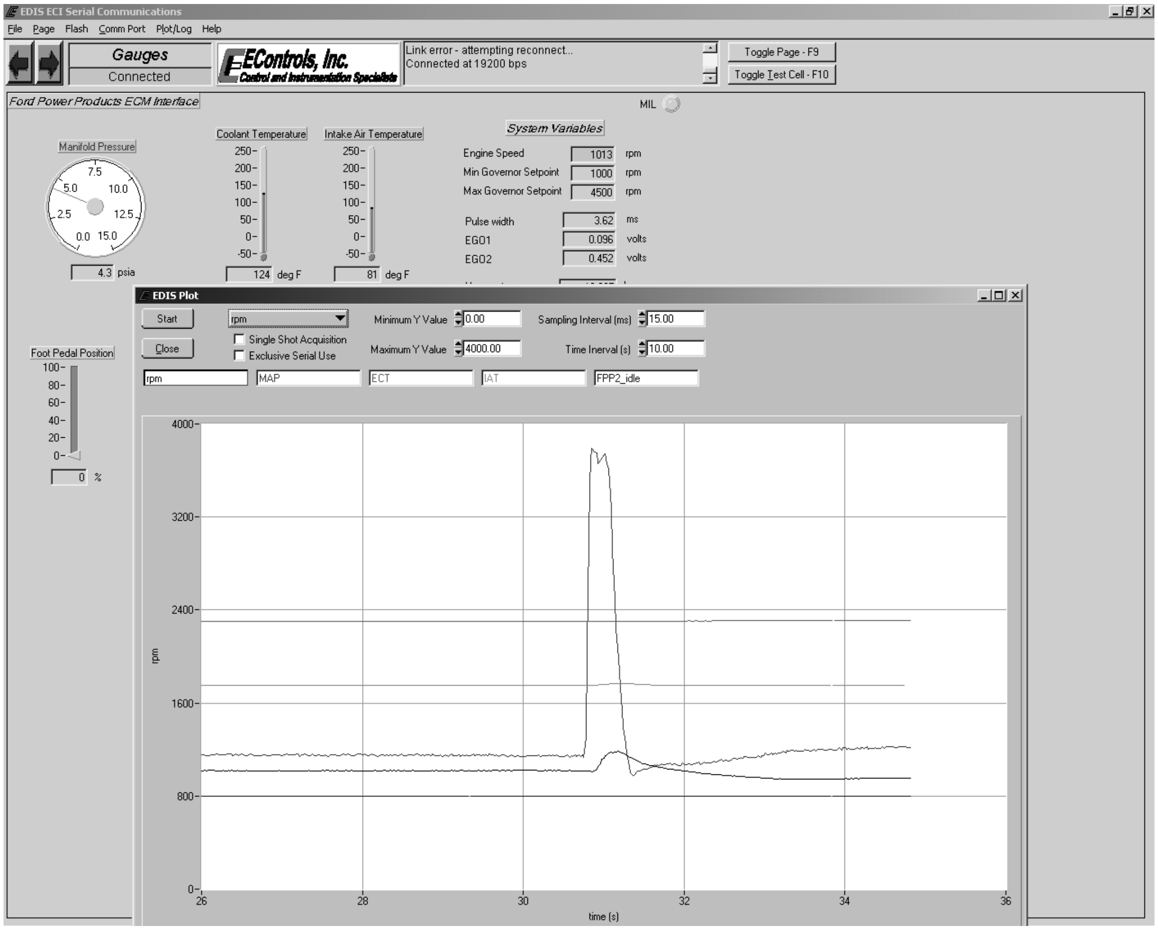


Reading Sensor and Actuator Values

Most applicable sensor and actuator values are displayed on the Gauges screen. The display shows the value for sensors, voltages and the sensor values in engineering units.

NOTE: If a DTC for a sensor is current, the engineering value for that sensor may be a default, limp home value and the voltage value will be the actual sensor voltage. Use the voltage value when performing diagnostics unless directed to do otherwise by the diagnostic chart.

GRAPHING AND DATA LOGGING



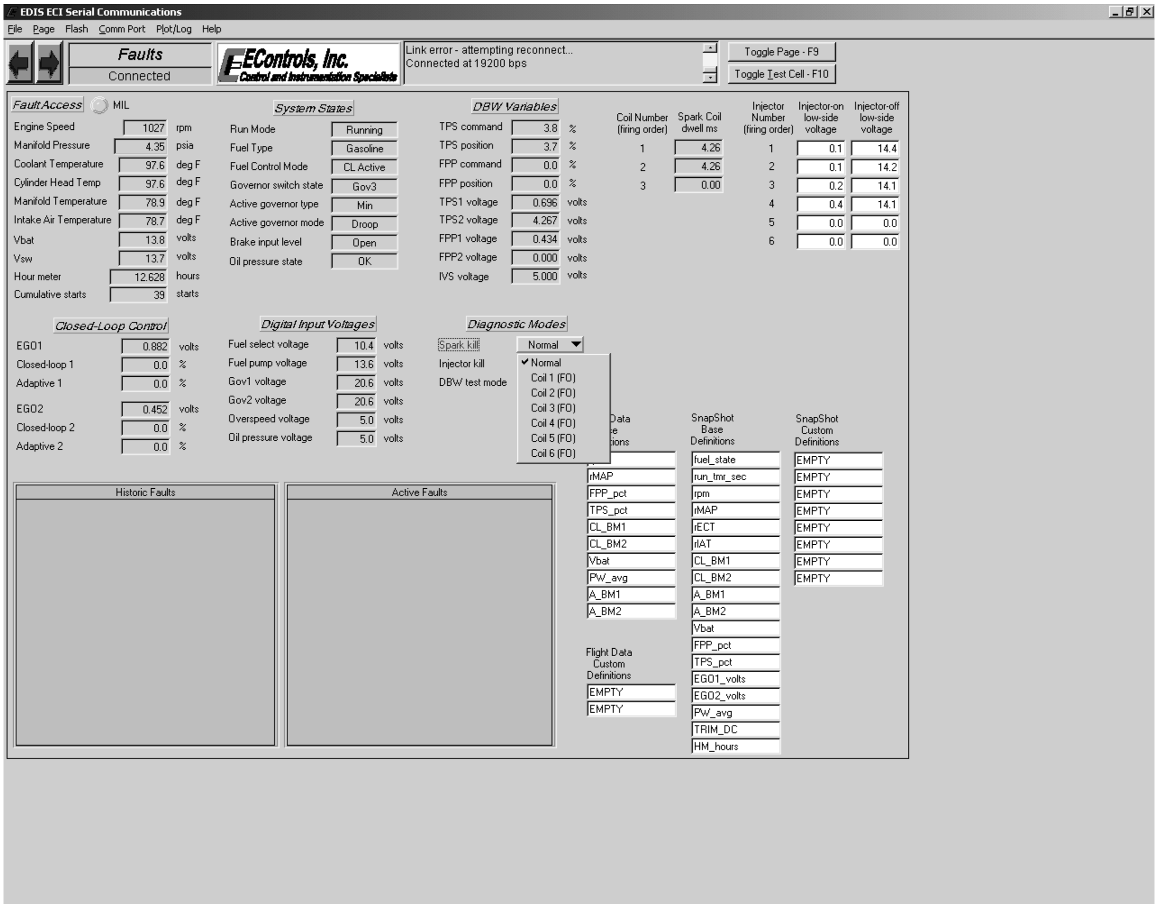
Graphing the values and voltages can be a very useful tool in doing intermittent diagnosis. The system diagnostic monitoring software includes graphing and data logging capability. These features enhance the ability to diagnose and repair possible problems with the system. The graphing feature allows sensor inputs and select control output variables to be plotted in real-time while the engine is running.

To plot a variable you must first “TAG” the variable you wish to plot. To do this, use the mouse to highlight the variable, and then right click.

Next press the “P” key or double click the Plot/Log button to invoke the plotting feature. You may change the desired time interval for each display screen. The default is 10 seconds. This can be increased or decreased as necessary to display the desired results. You can also change the sample rate.

You are now ready to plot. Simply click the “START” button to observe the plotted variables. The plot sweeps across the screen from left to right. To pause the display screen press the “SPACE BAR” at any time during plotting. To continue plotting simply press the “SPACE BAR” again. To stop the plotting feature simply click the “STOP” button. To exit the plotting screen click the “CLOSE” button. The range of each variable is listed along the left side of the display and the time is listed along the bottom of the screen.

Ignition System Test



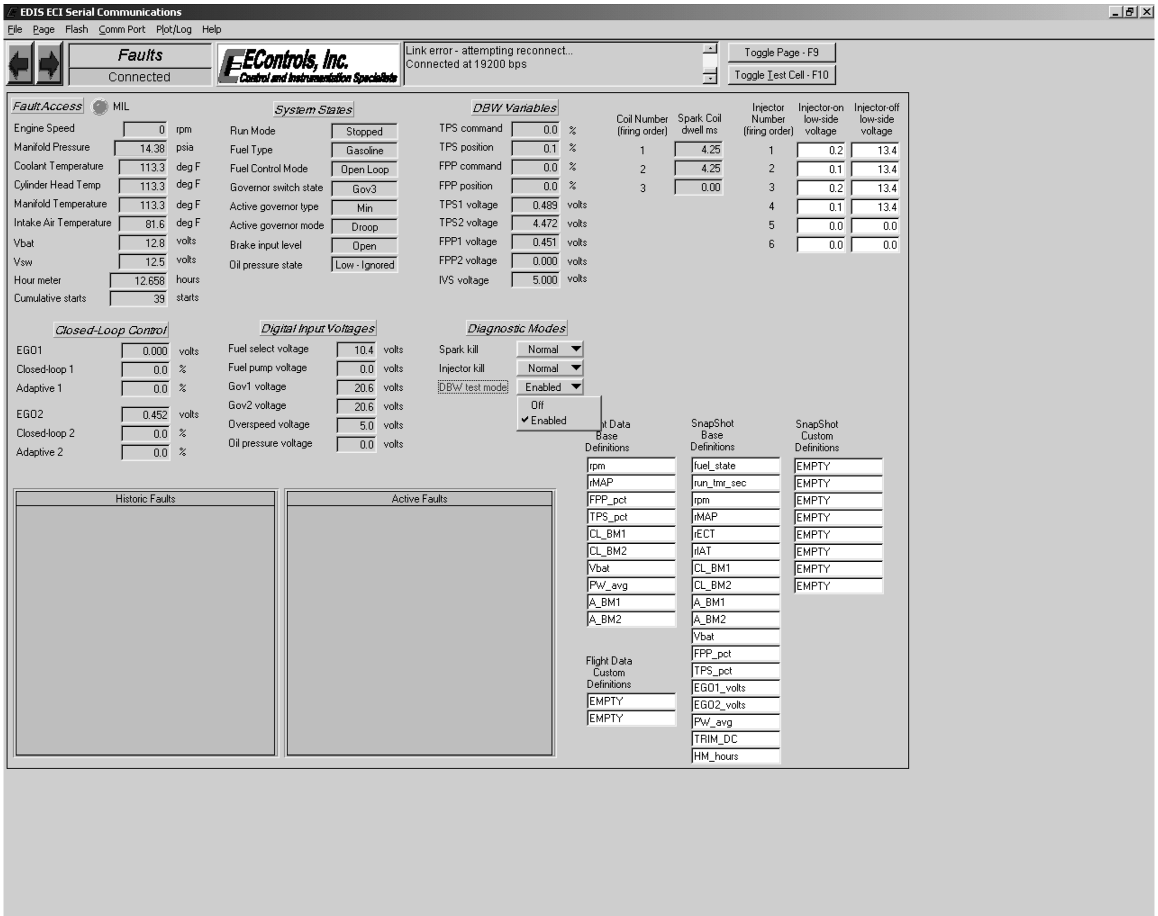
The Spark Kill diagnostic mode allows the technician to disable the ignition on individual cylinders. If the Spark Kill diagnostic mode is selected with the engine running below 1000 RPM, the minimum throttle command will lock into the position it was in when the test mode was entered. If the Spark System Test mode is selected with the engine running above 1000 RPM, the throttle will continue to operate normally.

Disabling Ignition Outputs

To disable the ignition system for an individual cylinder, use the mouse to highlight the “Spark Kill” button and select the desired coil. The spark output can be re-enabled by using the mouse to highlight the “Spark Kill” button and selecting “Normal”. If the engine is running below 1000 RPM, the spark output will stay disabled for 15 seconds and then re-set. If the engine is running above 1000 RPM, the spark output will stay disabled for 5 seconds and then re-set. This test mode has a timeout of 10 minutes. Record the rpm drop related to each spark output disabled.

The Spark outputs are arranged in the order which the engine fires, not by cylinder number.

THROTTLE TEST



To select this test mode the engine must be off but the key must be in the ON position.

The DBW (Drive By Wire) test mode allows the technician to control the throttle directly with the foot pedal or throttle input and is used during the diagnostic routines specified for FPP and TPS for Spectrum systems that use DBW.

FPP position displays the current position of the foot pedal as a percentage. FPP volts display the voltage which the ECM is reading from the FPP sensor.

TPS Command displays the commanded throttle position expressed as a percentage, which is being sent to the throttle. TPS Position is the actual percent of throttle opening being sent to the ECM from the throttle. TPS volts display the actual TPS signal voltage the ECM is receiving from the throttle.

Using a Diagnostic Jumper to Diagnose the ECI System

If you do not have access to a laptop computer, it is still possible to access the Diagnostic Trouble Codes stored in the memory of the Spectrum system ECM using a diagnostic jumper and the Malfunction Indicator Lamp. With the key off connect the diagnostic jumper to the ECI system diagnostic connector located near the ECM. Jumper diagnostic pins A and D. Turn the ignition on but do not start the vehicle. The Malfunction Indicator Lamp (MIL) will begin to flash.
The MIL displays three digit codes by flashing the first digit, pausing, then flashing the second digit, pausing, and then flashing the third digit. There will be a long pause between codes. For example, a code 143 would be

one flash followed by four flashes followed by three flashes.
The MIL will first display a 166 three times. Code 166 indicates that the ECM based diagnostic routines are functioning. Then, any Diagnostic Trouble Codes stored in memory will display three times each. The MIL will then start over with the code 166. If the vehicle is started while the diagnostic jumper is in place, the MIL will flash rapidly.
Diagnostic Trouble Codes may be cleared from the system ECM memory by moving the ignition key to the OFF position and removing the (F1) system battery fuse for at least 15 seconds. Note: This will erase all of the memory in the computer including the adaptive learn.

Diagnostic Communication Error

The ECM 5 volt reference circuit powers the Spectrum diagnostic link cable. In the event that the 5 volt reference signal is open or shorted to ground, you will not be able to connect to the system. If you are unable to connect, follow the quick checks listed below:

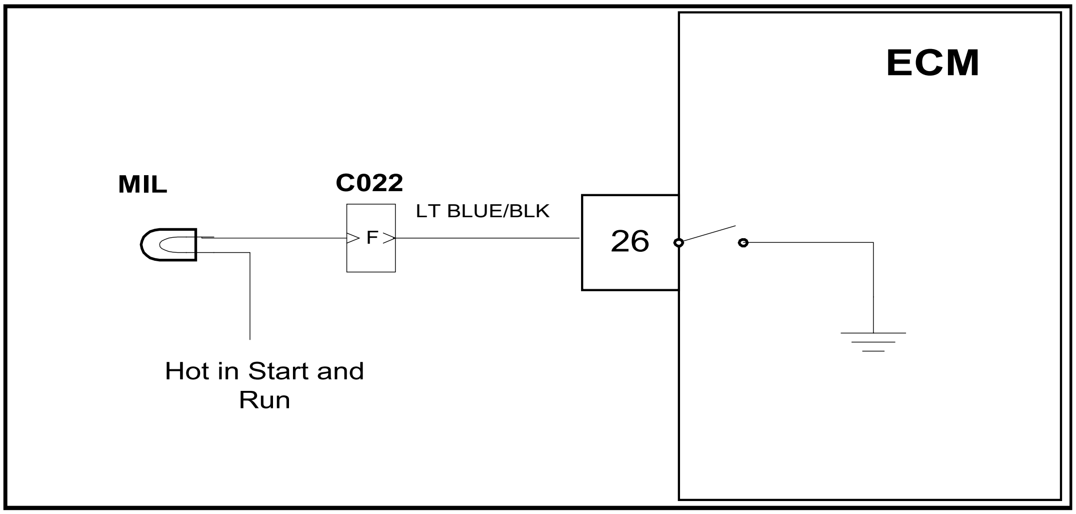
Be sure you are using the correct password and latest software for the system you are connecting to.

Check the ECM system power and ground circuits. Refer to DTC 261 for the power schematic. Also check for +12 switched power at ECM pin 21 with the ignition key on.

Check for power at the DLC connector for +5 volts between pins C (LT GRN/RED) and pin D (BLK) with the ignition key in the on position.

You may still be able to retrieve a code using the blink code function if none of the above recommendations prove useful. In the event of a 5 volt reference signal malfunction, DTC 531 or 532 should set. If you find one of these codes using the blink code function, follow the DTC diagnostic chart recommendations in the DTC section of this manual.

OBD System Check/Malfunction Indicator Lamp



Circuit Description

The Spectrum Fuel system is equipped with OBD (On-Board Diagnostics). The system has a dash mounted MIL (Malfunction Indicator Lamp) for the indication of system problems. Engine control system problems that affect emissions or driveability of the vehicle will set a DTC (Diagnostic Trouble Code). The ECM will then provide a path to ground and illuminate the MIL (Malfunction Indicator Lamp)

The MIL has the following functions:

1. It notifies the driver of a problem with the fuel system, ignition system, or emission control system so the driver can arrange for service as soon as possible.
2. It will display DTC's that have been stored due to a system malfunction.

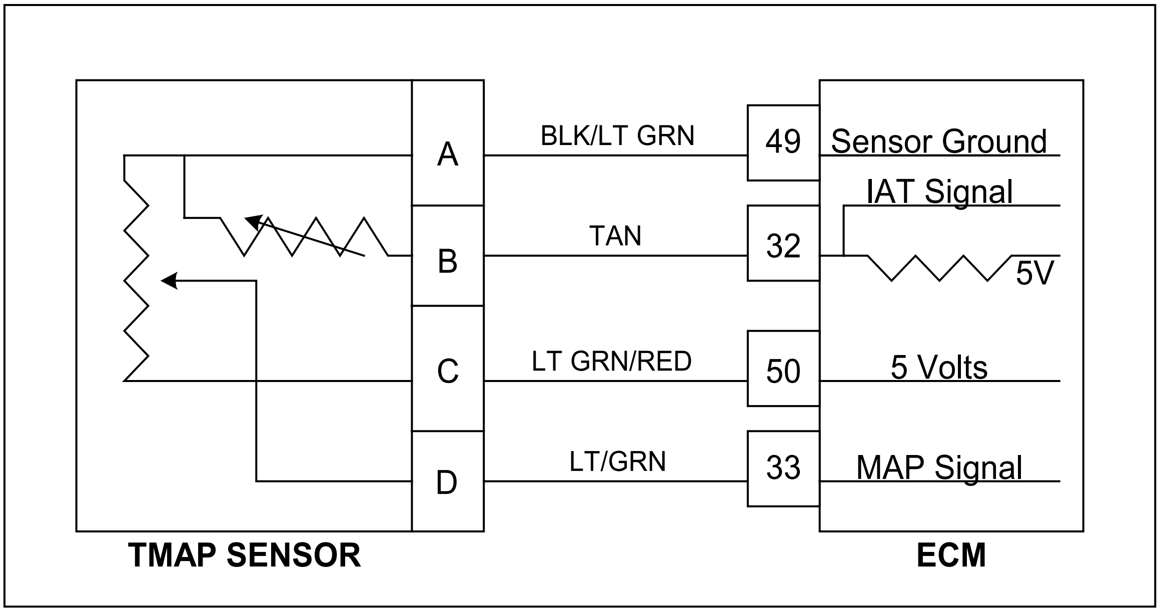
The lamp should illuminate when the key is in the ON position, and the engine is not running. This feature verifies that the lamp is in proper working order. If the lamp does not come on with the vehicle key on/engine off, repair it as soon as possible. Once the engine is in start or run mode, the lamp should go off. If the lamp illuminates while the engine is in the start or run mode, a current Diagnostic Trouble Code may be set. Always use the OBD System Check chart on the next page of this manual to verify proper MIL operation before proceeding with a DTC diagnostic code repair.

OBD System Check

Step	Action	Value(s)	Yes	No
1	• Key ON Engine OFF Does the MIL illuminate?		*Go to Step (2)*	*Go to Step (3)*
2	• Start the engine • Does the MIL lamp turn off?		*MIL is working properly. OBD System Check is complete*	Go to Step (10)
3	• Key ON engine OFF • Check for voltage between MIL power source and engine ground Do you have voltage?		*Go to Step (4)*	*Repair MIL voltage source. Refer to OEM body and chassis wiring diagrams*
4	Replace MIL lamp Did that solve the problem?		*Go to step (1)*	*Go to Step (5)*
5	• Key OFF • Disconnect ECM wire harness connector C001 • Using a DVOM check for continuity between MIL side of connector C022 and ECM terminal 26 Do you have continuity?		Go to Step (6)	*Go to Step (8)*
6	• Inspect the MIL lamp socket, connector C022 and ECM terminal 26 for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)
7	• Replace ECM Is the replacement complete?		Go to Step (1)	-

8	• Back probe both MIL and ECM side of terminal F in connector C022 • Using a DVOM check for continuity through connector C022 Do you have continuity?		*Go to Step (9)*	*Repair open circuit in connector C022*
9	• Inspect the MIL lamp socket, connector C022 and ECM terminal 26 for damage, corrosion or contamination Did you find a problem?		Repair the damaged socket or terminal as required. Refer to Wiring Repairs in Engine Electrical.	Repair the wire harness open circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
10	Active DTC (Diagnostic trouble code) is stored in memory. Proceed with DTC diagnosis. If no active DTC is found in ECM memory return to this page Step (11)		-	-
11	• Key OFF • Disconnect ECM wire harness connector C001 • Using a DVOM check for continuity between ECM terminal 26 and battery voltage • Do you have continuity?		Repair the shorted to ground circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)

DTC 111-IAT High Voltage



Conditions for Setting the DTC

- Intake Air Temperature
- Check Condition-Engine Running
- Fault Condition-IAT Sensor Voltage greater than 4.95
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled

Circuit Description

The TMAP is a combined IAT (Intake Air Temperature) and MAP (Manifold Absolute Pressure) sensor. A temperature sensitive resistor is used in the TMAP located in the intake manifold of the engine. It is used to monitor incoming air temperature, and the output in conjunction with other sensors is used to determine the airflow to the engine. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads higher voltage, and lower when warm.
The IAT is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT (Engine Coolant Temperature) at low airflow.

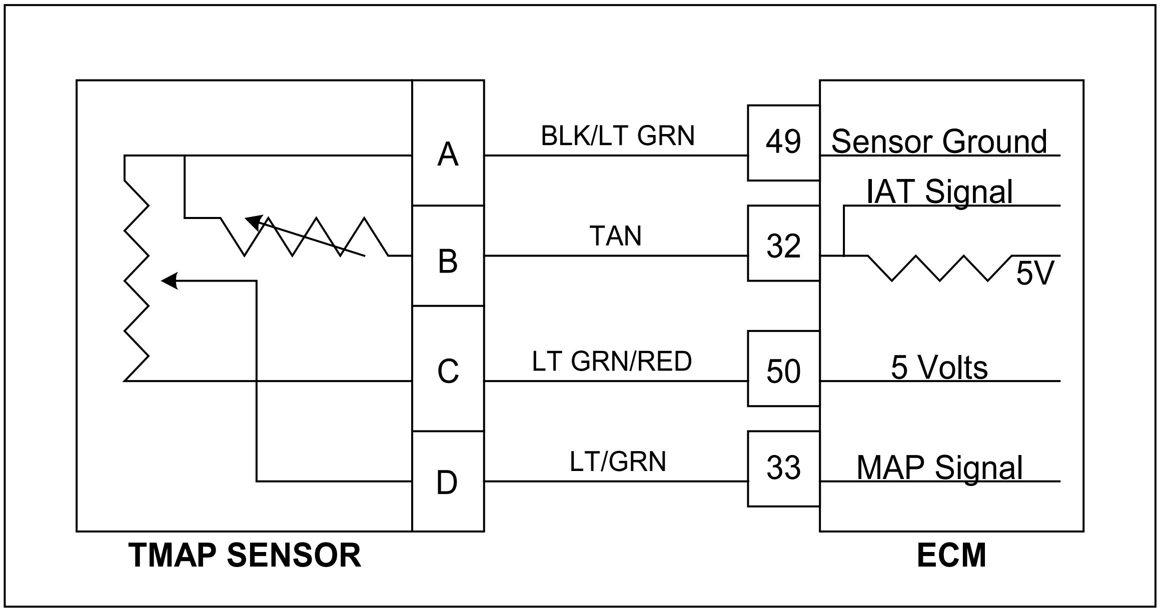
This fault will set if the signal voltage is more than 4.95 volts anytime the engine is running. The ECM will use the default value for the IAT sensor in the event of this fault.

DTC 111- IAT VOLTAGE HIGH

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display IAT voltage of 4.95 or greater?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Key Off • Disconnect the TMAP sensor connector from the wiring and harness and jumper pins A and B together • Key On Does the DST display IAT voltage of 0.1 volts or less?		Go to step (9)	Go to step (4)
4	• Key OFF • Jumper TMAP sensor connector signal pin B to engine ground • Key ON • Does DST display IAT voltage of 0.1 volts or less?		Go to Step (7)	Go to Step (6)
5	Replace TMAP sensor. Is the replacement complete?		Go to Step (11)	_
6	• Key OFF • Disconnect the ECM wire harness connector. • Check for continuity between TMAP sensor connector signal pin B and ECM IAT signal pin 32. Do you have continuity between them?	—	Go to step (10)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

7	• Check for continuity between TMAP sensor connector ground circuit pin A and ECM sensor ground circuit pin 49. Do you have continuity between them?	__	Go to step (10)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
8	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?	_	Go to step (11)	_
9	• Re-check wire harness and TMAP sensor connectors for damage corrosion or contamination Were any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical	Go to Step (5)
10	• Re-check wire harness and TMAP sensor connectors for damage corrosion or contamination Were any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical	Go to Step (8)
11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-111 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 112-IAT Low Voltage



Conditions for Setting the DTC

- Intake Air Temperature
- Check Condition Engine Cranking or Running
- Fault Condition-IAT Sensor Voltage less than 0.05
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled and allowed to stay at limit if required but will then also set the limiting fault.

Circuit Description

The TMAP is a combined IAT (Intake Air Temperature) and MAP (Manifold Absolute Pressure) sensor. A temperature sensitive resistor is used in the TMAP located in the intake manifold of the engine. It is used to monitor incoming air temperature, and the output in conjunction with other sensors is used to determine the airflow to the engine. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads higher voltage, and lower when warm.
The IAT is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT (Engine Coolant Temperature) at low airflow.

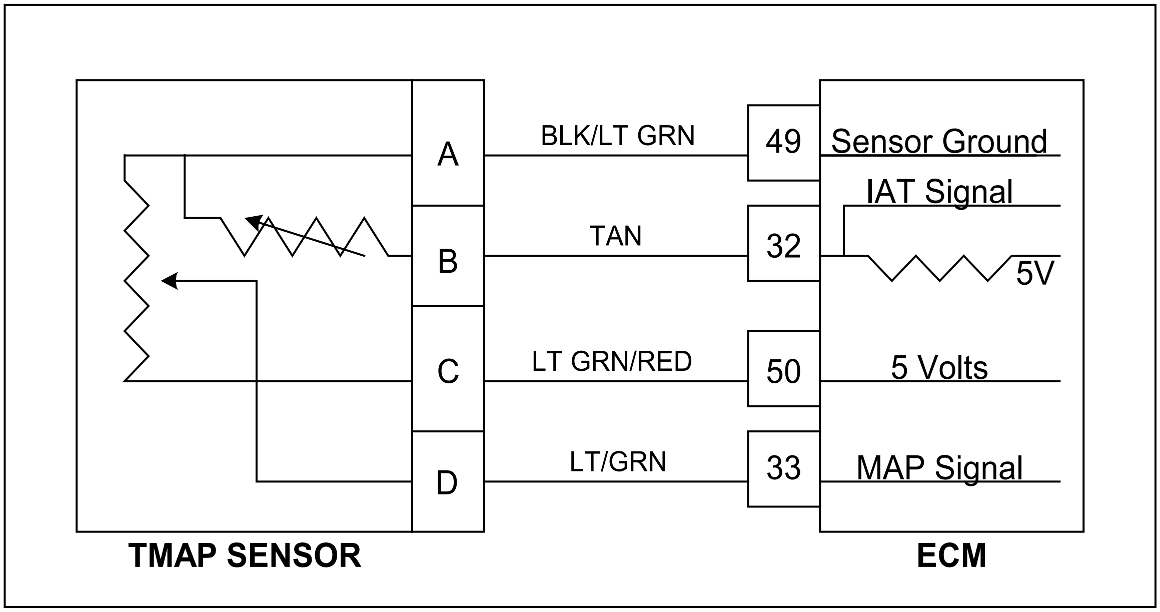
This fault will set if the signal voltage is less than 0.05 volts anytime the engine is cranking or running. The ECM will use the default value for the IAT sensor in the event of this fault.

DTC 112- IAT VOLTAGE LOW

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	_	Go to Step (2)	Go to OBD System Check Section
2	• Key On • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display IAT voltage of 0.05 or less?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Key Off • Disconnect the TMAP sensor wire harness connector • Key ON Does the DST display IAT voltage of 4.9 volts or greater?		Go to step (4)	Go to step (5)
4	Replace TMAP sensor. Is the replacement complete?		Go to Step (9)	_
5	• Key OFF • Disconnect ECM wire harness connector. • Check for continuity between TMAP sensor connector ground pin A and TMAP sensor connector signal pin B Do you have continuity between them?	__	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (6)
6	• Check for continuity between TMAP sensor connector signal circuit pin B and engine ground. Do you have continuity?	__	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (7)

7	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?	–	Go to step (8)	–
8	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-112 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 113-IAT Higher Than Expected 1



Conditions for Setting the DTC

- Intake Air Temperature
- Check Condition-Engine Running
- Fault Condition-Intake Air Temperature greater than 200 degrees F. and engine RPM greater than 1000
- MIL-On for active fault and for 15 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled
- Power Derate 1

Circuit Description

The TMAP is a combined IAT (Intake Air Temperature) and MAP (Manifold Absolute Pressure) sensor. A temperature sensitive resistor is used in the TMAP located in the intake manifold of the engine. It is used to monitor incoming air temperature, and the output in conjunction with other sensors is used to determine the airflow to the engine. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads higher voltage, and lower when warm.
The IAT is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT (Engine Coolant Temperature) at low airflow.

This fault will set if the Intake Air Temperature is greater than 200 degrees F. for 60 seconds or more and engine RPM is greater than 1000. Power Derate 1 will then be enforced. During this fault, maximum throttle position is 50% and the MIL will be on.

Diagnostic Aids

* This fault will set when inlet air is much hotter than normal. The most common cause of high inlet air temperature is a problem with the inlet air system. Ensure that the air inlet is not obstructed, modified or damaged.

* Inspect the air inlet system for cracks or breaks that may allow unwanted under hood air in to the air inlet system

DTC 113-IAT Higher Than Expected 1

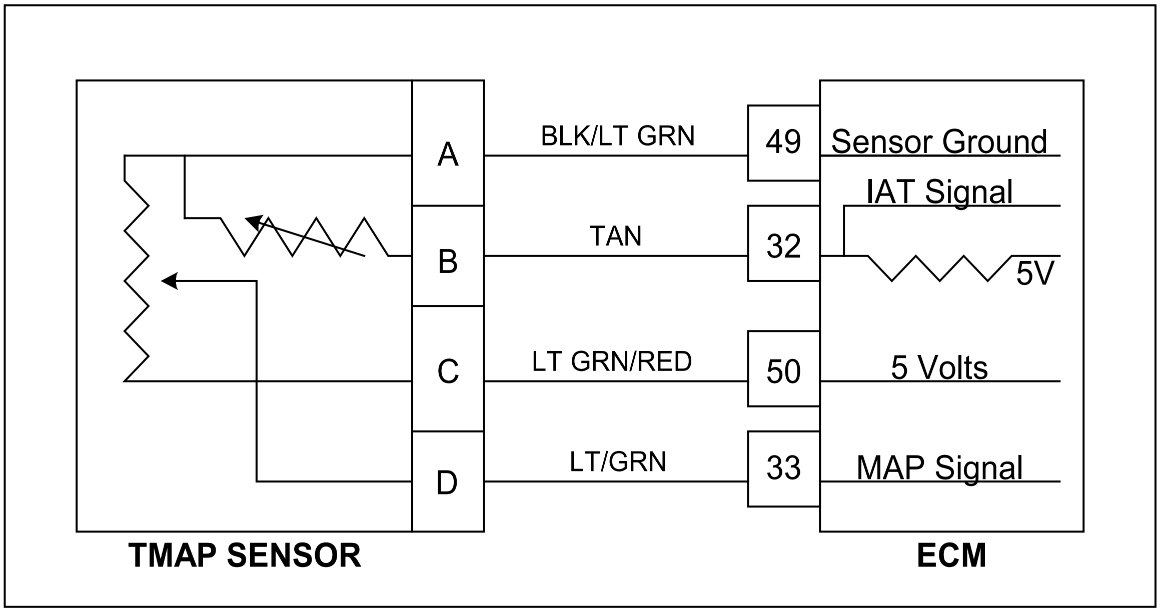
Diagnostic Aids

* This fault will set when inlet air is much hotter than normal. The most common cause of high inlet air temperature is a problem with the inlet air system. Ensure that the air inlet is not obstructed, modified or damaged.

* Inspect the air inlet system for cracks or breaks that may allow unwanted under hood air in to the air inlet system

* If none of the above can be found, Follow the diagnostic steps for DTC 112-IAT Low Voltage.

DTC 114-IAT Higher Than Expected 2



Conditions for Setting the DTC

- Intake Air Temperature
- Check Condition-Engine Running
- Fault Condition-Intake Air Temperature greater than 210 degrees F. and engine RPM greater than1000
- MIL-On for active fault and for 15 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled
- Engine Shut Down

Circuit Description

The TMAP is a combined IAT (Intake Air Temperature) and MAP (Manifold Absolute Pressure) sensor. A temperature sensitive resistor is used in the TMAP located in the intake manifold of the engine. It is used to monitor incoming air temperature, and the output in conjunction with other sensors is used to determine the airflow to the engine. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads higher voltage, and lower when warm.
The IAT is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT (Engine Coolant Temperature) at low airflow.

This fault will set if the Intake Air Temperature is greater than 210 degrees F. after 120 seconds and engine RPM is greater than 1000. The MIL light will be on during this active fault and the engine

DTC 114-IAT Higher Than Expected 2

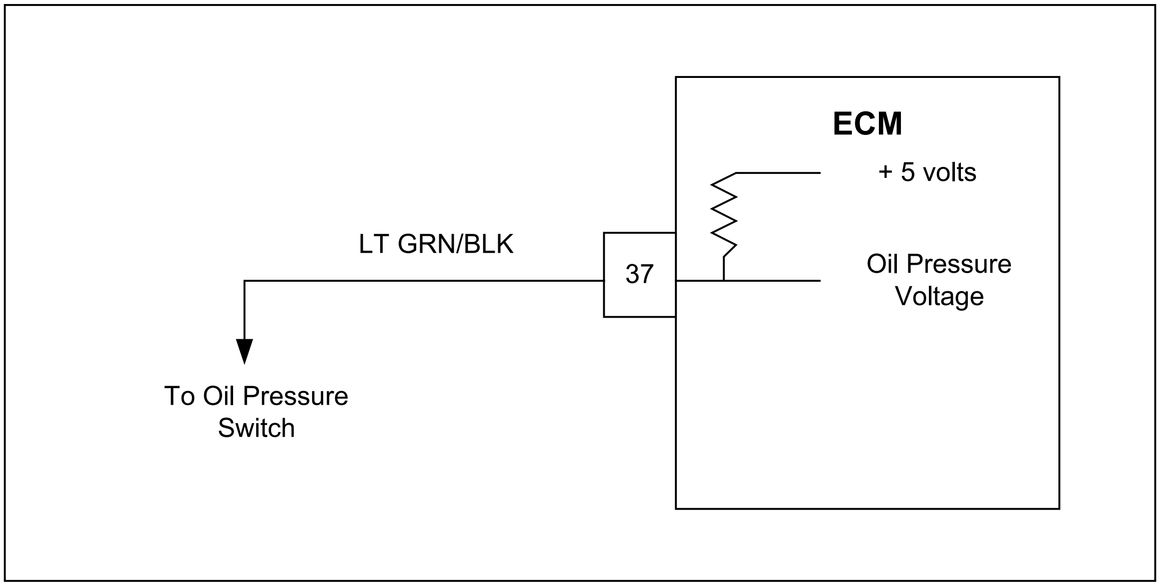
Diagnostic Aids

* This fault will set when inlet air is much hotter than normal. The most common cause of high inlet air temperature is a problem with the inlet air system. Ensure that the air inlet is not obstructed, modified or damaged.

* Inspect the air inlet system for cracks or breaks that may allow unwanted under hood air in to the air inlet system

* If none of the above can be found, Follow the diagnostic steps for DTC 112-IAT Low Voltage.

DTC 115-Oil Pressure Low



Conditions for Setting the DTC

- Engine Oil Pressure low
- Check Condition-Engine running for 15 seconds and RPM greater than 600
- Fault Condition- Open circuit/voltage high
- MIL-On during active fault and for 3 seconds after active fault
- Adaptive-Enabled
- Closed Loop-Enabled
- Engine Shut Down

Circuit Description

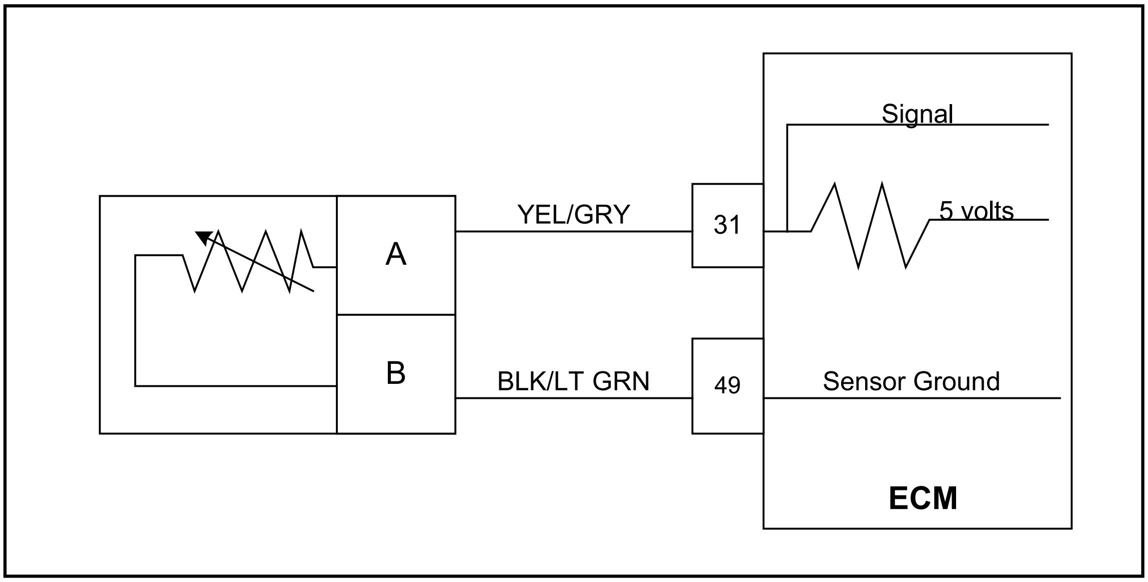
The Oil Pressure Switch is used to communicate a low oil pressure condition to the ECM. Engine damage can occur if the engine is operated with low oil pressure. The ECM uses an analog voltage input with an internal 5 volt reference. If the oil pressure circuit is grounded, the input voltage will be near zero. If it is open, the input will be near 5 volts. The switch is normally closed and the fault will set if the circuit becomes open. The engine will shut down in the event of this fault to help prevent possible damage.

DTC 115- Oil Pressure Low

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Verify that the engine has oil pressure using a mechanical oil pressure gauge before proceeding with this chart. See Engine Specifications Section 1F. Does the engine have oil pressure?	15 psi or greater	Go to Step (3)	Repair faulty Oiling System
3	• Key On, Engine Running DST connected in System Data Mode • Clear DTC 115 • Warm the engine by idling until the ECT temperature is above 160 degrees F. and has been running for at least one minute • Increase engine speed above 600 RPM Does DTC115 reset and cause the engine to shut down?	Greater than 600 rpm	Go to Step (4)	Intermittent problem Go to Intermittent section
4	• Key OFF • Disconnect oil pressure switch harness connector C005 • Jumper the pressure switch LG/BK wire to engine ground • Clear DTC 115 • Start engine, let idle for at least one minute with ECT over 160 degrees F. • Increase engine speed above 1300 RPM Does DTC 115 reset?		Go to Step (6)	Go to Step (5)
5	• Replace oil pressure switch Is the replacement complete?		Go to Step (9)	-
6	• Key OFF • Disconnect ECM harness connector C001 • Using a DVOM check for continuity between oil pressure switch connector LG/BK wire and ECM connector pin 37 • Do you have continuity between them?		Go to Step (7)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

7	• Inspect ECM connector pin 37 for damage corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (8)
8	• Replace ECM • Is the replacement complete?		Go to Step (9)	-
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-115 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 121-ECT / High Voltage



Conditions for Setting the DTC

- Engine Coolant Temperature
- Check Condition-Engine Running
- Fault Condition-ECT sensor voltage exceeds 4.95
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled

ECT Data:	
Temp (deg F)	**Ohms**
242.4	101
231.9	121
211.6	175
201.4	209
181.9	302
163.1	434
144.9	625
127.4	901
102.4	1,556
78.9	2,689
49.9	5,576
23.5	11,562
-5.7	28,770
-21.2	49,715
-30.8	71,589
-40.0	99,301

Circuit Description

The ECT (Engine Coolant Temperature) sensor is a temperature sensitive resistor located in the engine coolant. It is used for the engine airflow calculation, gasoline cold enrichment and to enable other temperature dependant features. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm. This fault will set if the signal voltage is greater than 4.95 volts anytime the engine is running. The ECM will use a default value for the ECT sensor in the event of this fault.

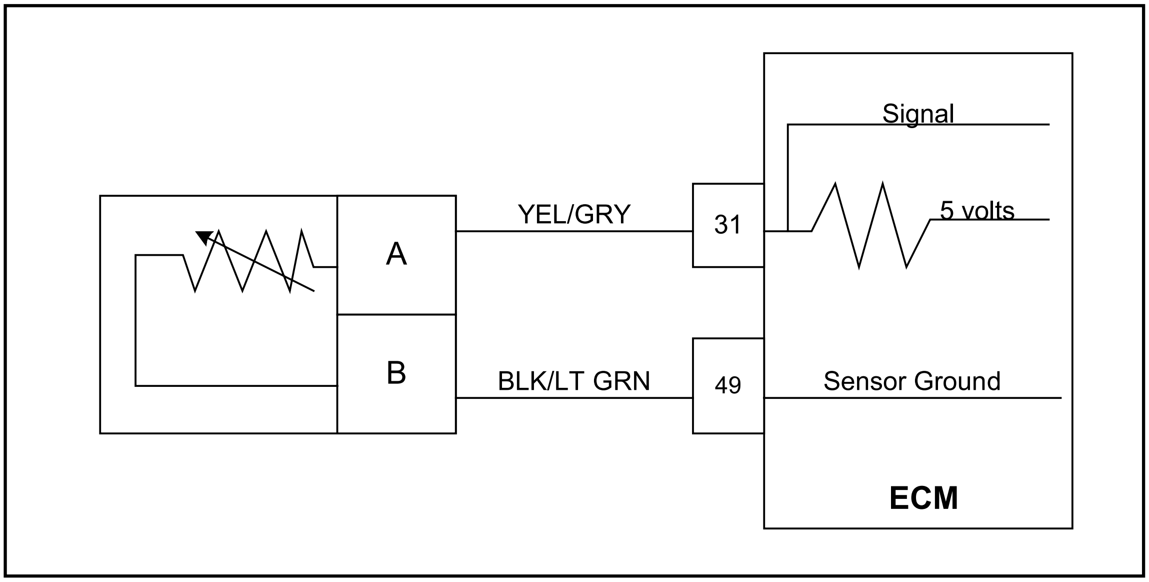
DTC 121- ECT VOLTAGE HIGH

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display ECT voltage of 4.95 or greater?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Key Off • Disconnect the ECT sensor from the wiring harness and Jumper connector terminals A and B together • Key On Does the DST display ECT voltage of 0.05 volts or less?		Go to step (4)	Go to Step (8)
4	• Using a DVOM check the resistance between the two terminals of the ECT sensor and compare the resistance reading to the chart Is the resistance value correct?	See resistance chart vs. temperature in the DTC 121 circuit description	Go to Step (6)	Go to step (5)
5	• Replace ECT sensor Is the replacement complete?		Go to Step (14)	-
6	• Inspect the ECT wire harness connector terminals for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)

7	• Key OFF • Disconnect ECM wire harness connector • Inspect ECM connector pins 31 and 49 for damage corrosion or contamination • Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Intermittent problem Go to Intermittent section
8	• Jumper the ECT signal pin A at the ECT connector to engine ground Does DST display ECT voltage of 0.05 or less?		Go to Step (9)	Go to Step (12)
9	• Key OFF • Disconnect ECM wire harness connector • Using a DVOM check for continuity between ECT sensor ground pin B and ECM connector pin 49 Do you have continuity between them?		Go to Step (10)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
10	• Inspect ECM connector pins 31 and 49 for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (11)
11	• Replace ECM Is the replacement complete?		Go to Step (14)	-
12	• Key OFF • Disconnect ECM wire harness connector • Using A DVOM check for continuity between ECT connector signal pin A and ECM connector terminal 31 Do you have continuity between them?		Go to Step (13)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
13	• Inspect ECM connector pins 31 and 49 for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (11)

14	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-121 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 122-ECT Low Voltage



Conditions for Setting the DTC

- Engine Coolant Temperature
- Check Condition-Engine Running
- Fault Condition- ECT sensor voltage less than 0.05
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled

Circuit Description

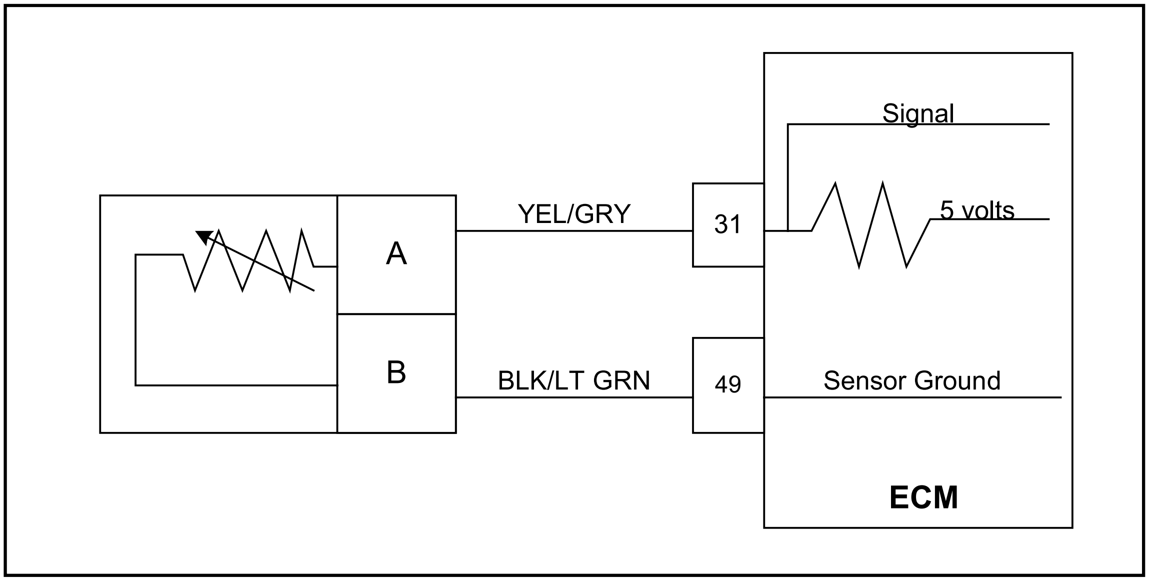
The ECT (Engine Coolant Temperature) sensor is a temperature sensitive resistor located in the engine coolant. It is used for the engine airflow calculation, gasoline cold enrichment and to enable other temperature dependant features. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm
This fault will set if the signal voltage is less than 0.05 volts anytime the engine is running. The ECM will use a default value for the ECT sensor in the event of this fault.

DTC 122- ECT VOLTAGE LOW

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	_	Go to Step (2)	Go to OBD System Check Section
2	• Key On • DST (Diagnostic Scan Tool) connected in • System Data Mode Does DST display ECT voltage of 0.05 or less?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Key Off • Disconnect the ECT wire harness connector • Key ON Does the DST display ECT voltage of 4.9 volts or greater?		Go to step (4)	Go to step (5)
4	Replace ECT sensor. Is the replacement complete?		Go to Step (8)	_
5	• Key OFF • Disconnect ECM wire harness connector • Check for continuity between ECT sensor connector signal pin A and ECT sensor ground pin B Do you have continuity between them?	__	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (6)
6	• Check for continuity between ECT sensor connector signal circuit pin A and engine ground. Do you have continuity?	__	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (7)

7	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?	–	Go to step (8)	–
8	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-122 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 123-ECT Higher Than Expected 1



Conditions for Setting the DTC

- Engine Coolant Temperature
- Check Condition-Engine Running
- Fault Condition-Engine Coolant Temperature reading or estimate greater than 220 degrees F. and engine RPM greater than 500 for 60 seconds
- MIL- On during active fault and for 15 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled
- Power Derate (level 1)

Circuit Description

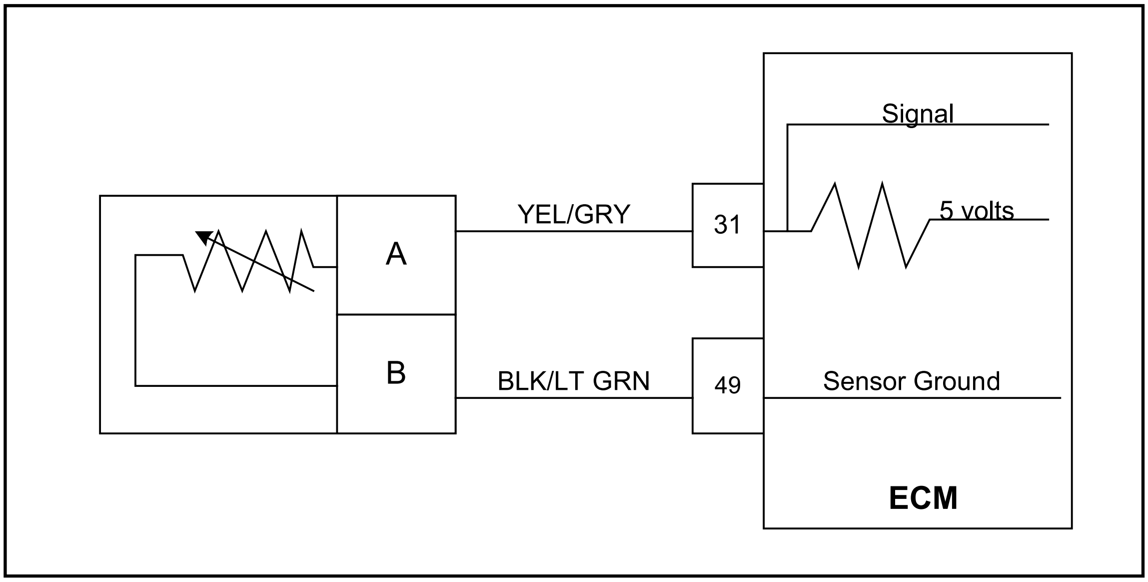
The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. The ECT (Engine Coolant Temperature) sensor that is located in the coolant near the thermostat. The ECT is used for engine airflow calculation, fuel enrichment, ignition timing control, to enable certain features, and for engine protection. The ECM provides a voltage divider circuit so when the sensor reading is cool the sensor reads higher voltage, and lower when warm.

This fault will help protect the engine in the event of over temperature. When the coolant exceeds 220 degrees F. and engine RPM exceeds 500 this fault will set and Power Derate 1 will be enforced. During this fault, maximum throttle position is 50% and the MIL light will turn on.

DTC 123- ECT Higher Than Expected 1

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On • DST (Diagnostic Scan Tool) connected in System Data Mode • Warm Engine to normal operating temperature, then run the engine above 500 rpm for 60 seconds Does DST display ECT temperature of 220 degrees F. or greater with the engine running over 500 rpm?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Verify with a temperature gauge that the engine coolant is over 220 degrees F. Does the temperature gauge indicate 220 degrees F. or greater?		Repair Cooling system.	Go to step (4)
4	Verify ECT circuit function. Follow diagnostic test procedure for DTC-122 ECT Low Voltage		-	-

DTC 124-ECT Higher Than Expected 2



Conditions for Setting the DTC

- Engine Coolant Temperature
- Check Condition-Engine Running
- Fault Condition-Engine Coolant temperature reading or estimate greater than 235 degrees F. and engine RPM greater than 500 for 60 seconds
- MIL-On for active fault and for 15 seconds after active fault
- Adaptive-Enabled
- Closed Loop-Enabled
- Engine Shut Down

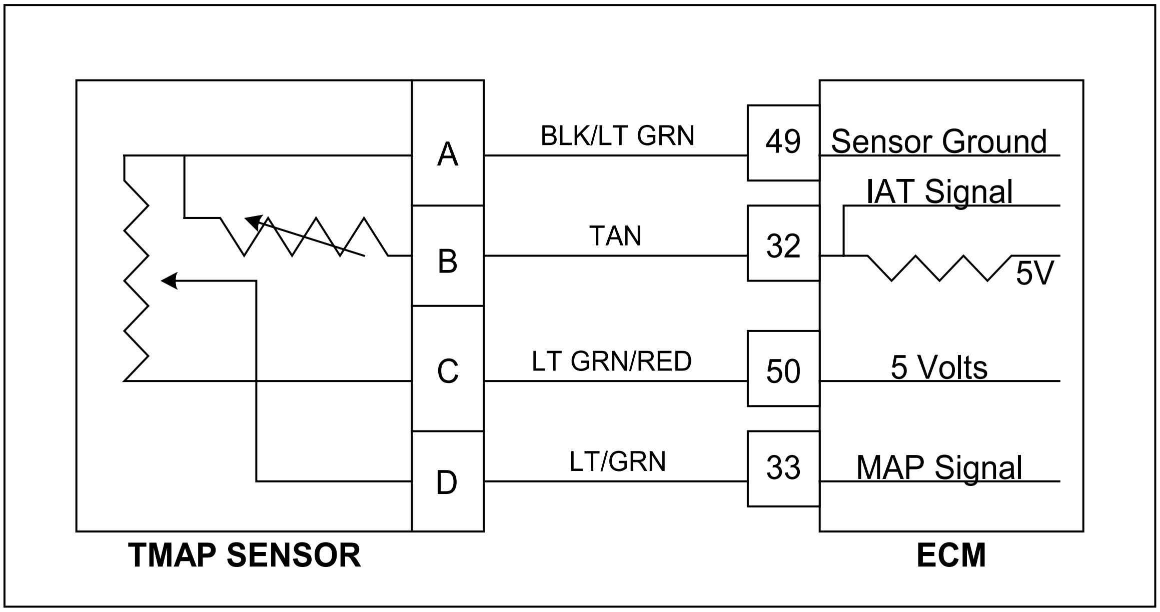
Circuit Description

The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. The ECT (Engine Coolant Temperature) sensor that is located in the coolant near the thermostat. The ECT is used for engine airflow calculation, ignition timing control, fuel enrichment, to enable certain features, and for engine protection. The ECM provides a voltage divider circuit so when the sensor reading is cool, the signal reads higher voltage, and lower when warm. This fault will set if coolant temperature reaches 235 degrees F. and engine RPM exceeds 500 rpm, then engine will shut down.

DTC 124 ECT Higher Than Expected 2

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On • DST (Diagnostic Scan Tool) connected in System Data Mode • Warm Engine to normal operating temperature, then run the engine above 500 rpm for 60 seconds • Does DST display ECT temperature of 235 degrees F. or greater with the engine running over 500 rpm?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Verify with a temperature gauge that the engine coolant is over 235 degrees F. Does the temperature gauge indicate 235 degrees F. or greater?		Repair Cooling system.	Go to step (4)
4	Verify ECT circuit function. Follow diagnostic test procedure for DTC-122 ECT Low Voltage		-	-

DTC 131-MAP High Pressure



Conditions for Setting the DTC

- Manifold Absolute Pressure
- Check Condition-RPM greater than 800, Throttle Command less than 10%, steady MAP and TPS
- Fault Condition-MAP greater than 17.8 psia, TPS less than 10% and engine RPM greater than 1800.
- MIL-On
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled and allowed to stay at limit
- Misc. Fueling is based on RPM and TPS Limp-Home Condition during this fault.

Circuit Description

The TMAP is a combined inlet manifold temperature and pressure sensor connected to the intake manifold. It is used to measure the pressure of air in the manifold prior to induction into the engine. The pressure reading is used in conjunction with other inputs to determine the airflow rate to the engine, which also determines the fuel flow rate. This fault will set when the MAP reading is higher than it should be for the given TPS, and RPM. When the fault is set, the Adaptive Learn will be disabled for the remainder of the key on cycle and the MIL will be on. The engine will operate on a default MAP during this active fault.

Diagnostic Aids

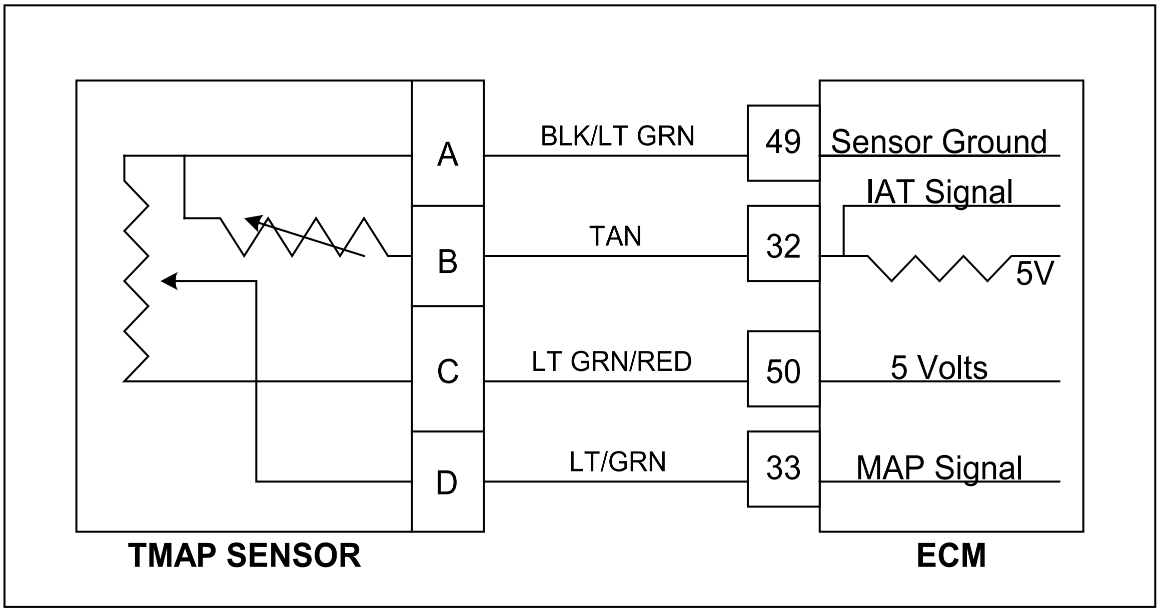
If the engine is running rough, unstable or missing due to a suspected mechanical problem, vacuum leak or other issue causing misfire these problems must be taken care before using the MAP diagnostic chart. Failure to follow this recommendation will result in a false MAP diagnostic and repair procedure.

DTC 131- MAP HIGH PRESSURE

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine running. • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display MAP pressure of 13.0 psia or greater with the engine idling?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect the TMAP sensor connector • Key ON Does the DST display MAP pressure less than 0.05 psia?		Go to step (4)	Go to step (6)
4	• Probe TMAP sensor ground circuit pin A with a test light connected to battery voltage. Does the test light come on?		Go to step (5)	Go to step (8)
5	• Check TMAP mechanical connection for correct mounting or possible damage causing leakage. Is the TMAP sensor mechanical connection Ok?		Go to step (6)	Go to Step (10)
6	• Key OFF • Disconnect ECM connector and inspect terminals for damage corrosion or contamination. Is the connection Ok?		Go to step (7)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
7	Replace TMAP sensor. Is the repair complete?	__	Go to step (11)	-

8	• Disconnect ECM connector and check for continuity between TMAP connector sensor ground pin A and ECM sensor ground PIN 49. Do you have continuity between them?		Go to step (9)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
9	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		Go to step (11)	-
10	• Correct TMAP mechanical connection Has TMAP mechanical connection been corrected?		Go to Step (11)	-
11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-131 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 132-MAP Low Voltage



Conditions for Setting the DTC

- Manifold Absolute Pressure
- Check Condition-Cranking or Running
- Fault Condition-MAP voltage less than 0.05,Throttle Position greater than 2% and engine RPM less than 7000.
- MIL-On
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled
- Misc.-Fueling is based on RPM and TPS Limp-Home Condition during this fault.

Circuit Description

The Manifold Absolute Pressure sensor is a pressure transducer connected to the intake manifold. It is used to measure the pressure of air in the manifold prior to induction into the engine. The pressure reading is used in conjunction with other inputs to determine the airflow rate to the engine, which determines the fuel flow rate. This fault will set when the MAP reading is lower than the sensor should normally produce. When this fault is set the Adaptive Learn will be disabled for the remainder of the key on cycle and the MIL will be on.

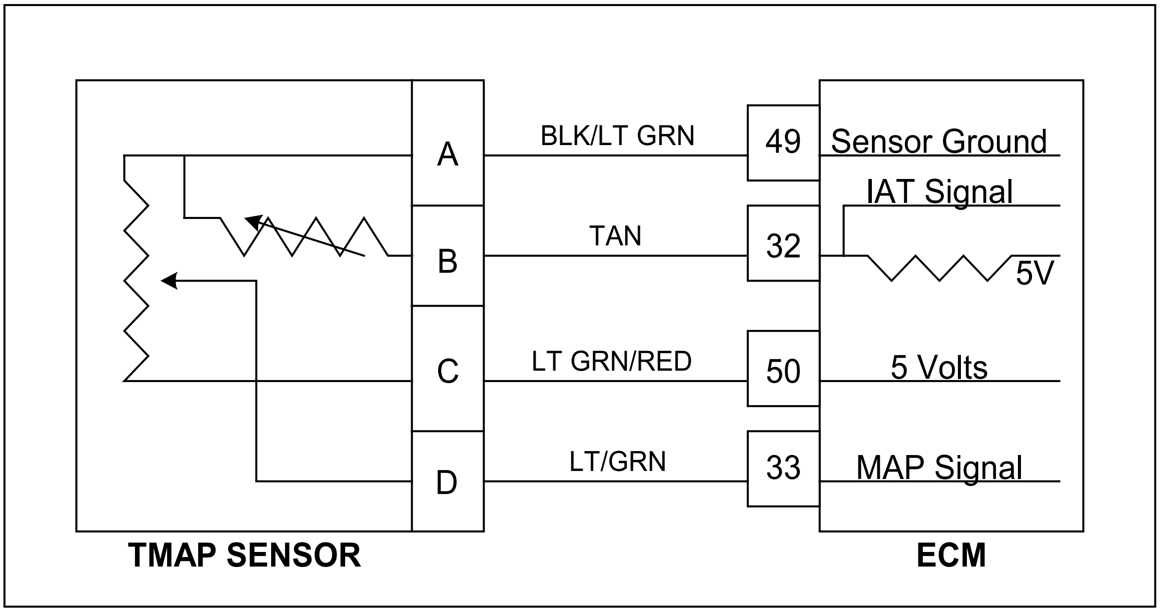
DTC 132- MAP Low Voltage

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine running. • DSC (Diagnostic Scan Tool) connected in System Data Mode Does DST display MAP voltage of 0.05 or less with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect the TMAP sensor from the wiring harness • Jumper the 5 volt reference pin C and MAP signal circuit pin D together • Key ON Does the DST display MAP voltage of 4.5 volts or greater?		Go to Step (4)	Go to step (8)
4	• Inspect TMAP connector pins for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (5)
5	• Key OFF • Disconnect ECM connector • Check for continuity between TMAP sensor connector signal pin D and ECM MAP signal pin 33. Do you have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Check for continuity between TMAP sensor connector 5 volt supply signal pin C and ECM 5 volt supply pin 50 Do you have continuity between them?		Go to step (7)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

7	• Check for continuity between TMAP sensor connector ground pin A and ECM sensor ground pin 49 Do you have continuity between them?		Go to step (17)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
8	• Probe MAP signal circuit with a test light connected to battery voltage Does the DST display MAP voltage of 4.0 or greater?		Go to Step (9)	Go to step (13)
9	• Key OFF • Disconnect ECM connector • Check for continuity between TMAP sensor connector and ECM 5 volt reference signal. Do you have continuity between them?		Go to step (10)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
10	• Check for continuity between TMAP sensor connector 5 volt reference pin C signal and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (11)
11	• Inspect ECM connector and wire harness connector terminals for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (16)
12	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		Go to step (17)	-
13	• Disconnect ECM connector • Check for continuity between TMAP sensor connector signal circuit pin D and ECM signal PIN 33 Do you have continuity between them?		Go to Step (14)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

14	• Check for continuity between TMAP sensor connector signal pin D and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (15)
15	• Inspect ECM connector and wire harness connector terminals for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (16)
16	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		Go to Step (18)	-
17	Replace TMAP sensor Is the replacement complete?		Go to step (18)	-
18	• Remove all test equipment except the DSC. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-132 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 134-BP High Pressure



Conditions for Setting the DTC

- Barometric Pressure
- Check Condition-Key On
- Fault Condition-BP greater than 16 psia
- MIL-On for active fault and for 2 seconds after active fault
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled

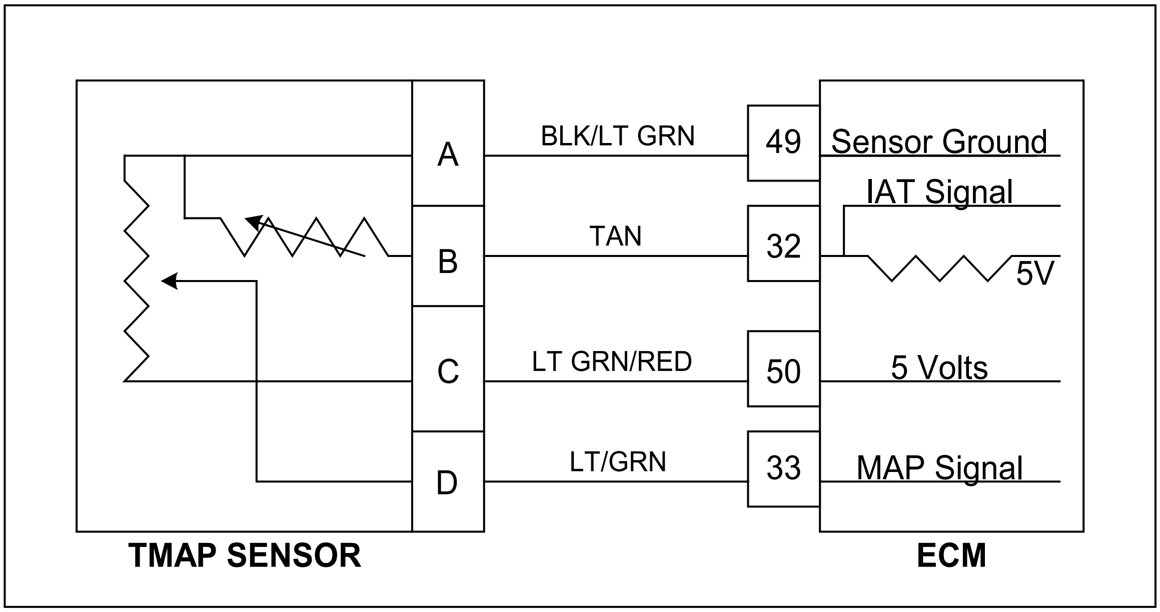
Circuit Description

The BP (Barometric Pressure) is estimated from the TMAP sensor. The barometric pressure value is used for fuel and airflow calculations. This fault sets in the event the BP value is out of the normal range.

DTC 134- BP High Pressure

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On • DST (Diagnostic Scan Tool) connected in • System Data Mode Does DST display MAP pressure of 16 psia or greater?		Go to step (3)	Intermittent problem Go to Intermittent section
3	Replace TMAP sensor. Is the repair complete?			-
	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-134 check for any stored codes. Does the engine operate normally with no stored codes?		System Ok	Go to OBD System Check

DTC 135-BP Low Pressure



Conditions for Setting the DTC

- Barometric Pressure
- Check Condition-Key On
- Fault Condition-BP less than 8.3 psia
- MIL-On for active fault and for 2 seconds after active fault
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled

Circuit Description

The BP (Barometric Pressure) is estimated from the TMAP sensor. The barometric pressure value is used for fuel and airflow calculations. This fault sets in the event the BP value is out of the normal range.

DTC 135- BP Low Pressure

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On. • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display BP pressure of 8.3 psia or less?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect the TMAP sensor from the wiring harness • Jumper the 5 volt reference pin C and MAP signal pin D together • Key ON Does the DST display BP pressure of 16.00 psia or greater?		Go to Step (4)	Go to step (8)
4	• Inspect TMAP connector and wire harness connector terminals for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (5)
5	• Key OFF • Disconnect ECM connector • Check for continuity between TMAP sensor connector pin D and ECM connector pin 33 Do you have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

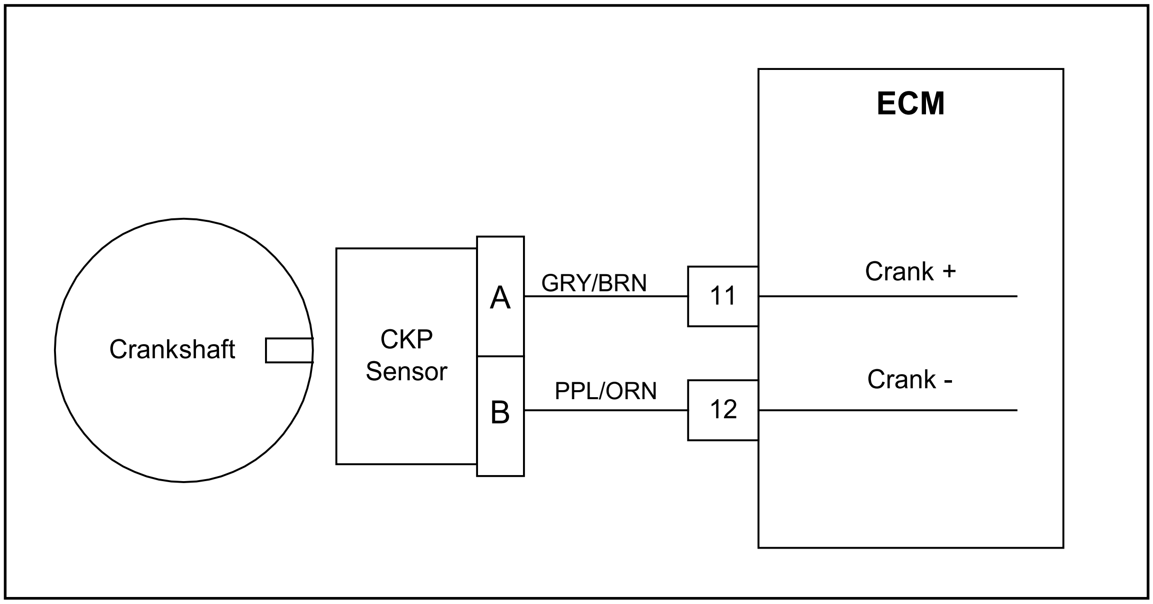
6	• Check for continuity between TMAP sensor connector 5 volt supply pin C and ECM connector pin 50 Do you have continuity between them?		Go to step (7)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
7	• Check for continuity between TMAP sensor connector ground pin A and ECM connector pin 49 Do you have continuity between them?		Go to step (17)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
8	• Remove Jumper that was installed during step 3 • Probe TMAP connector signal circuit D with a test light connected to battery voltage Does the DST display BP pressure of 16.00 psia or greater?		Go to Step (9)	Go to step (13)
9	• Key OFF • Disconnect ECM connector • Check for continuity between TMAP sensor connector pin C and ECM connector pin 50 Do you have continuity between them?		Go to step (10)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
10	• Check for continuity between TMAP sensor connector 5 volt reference signal pin C and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (11)

11	• Inspect TMAP AND ECM connectors pins for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (16)
12	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		Go to step(17)	-
13	• Disconnect ECM connector • Check for continuity between TMAP sensor connector pin D and ECM pin 33 Do you have continuity between them?		Go to Step (14)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
14	• Check for continuity between TMAP sensor connector pin D and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (15)
15	• Inspect ECM connector and wire harness connector pins for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (16)
16	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		Go to Step (18)	-
17	Replace TMAP sensor Is the replacement complete?		Go to step (18)	-

18	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-135 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

v

DTC 142-Crank Sync Noise



Conditions for setting the DTC

- Crankshaft Position sensor
- Check Condition- Engine running
- Fault Condition- 1 invalid crank re-sync
- MIL- On during active fault and for 10 seconds after active fault
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled

Circuit Description

The Crankshaft Position sensor is a magnetic transducer mounted on the engine block adjacent to a pulse wheel located on the crankshaft. It determines crankshaft position by monitoring the pulse wheel. The Crankshaft Position sensor is used to measure engine RPM and its signal is used to synchronize the ignition and fuel systems. The ECM must see a valid Crankshaft position signal while running. If no signal is present for 800ms or longer, this fault will set.

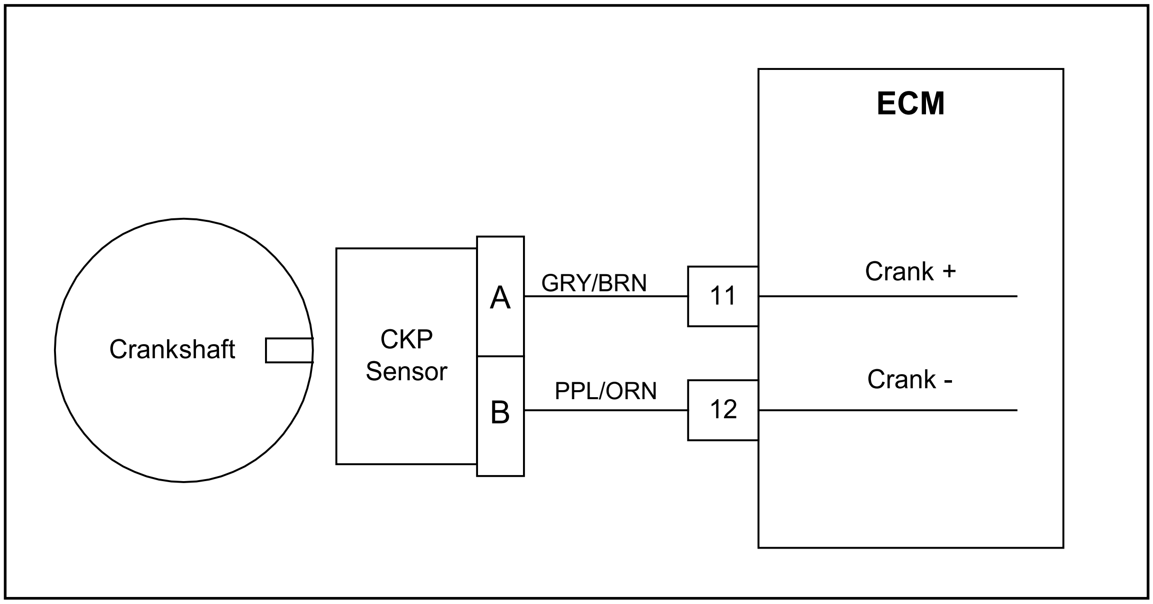
DTC 142 Crank Sync Noise

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Check to be sure that the ECM ground terminal G1 to engine ground is clean and tight. Is terminal G1 clean and tight?		Go to Step (3)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
3	• Key OFF • Disconnect the CKP sensor connector • Using a DVOM check for voltage output from the CKP sensor while cranking the engine • Do you have voltage output?	Over .5 volts	Go to Step (4)	Go to Step (11)
4	• Key OFF • Disconnect ECM connector C001 • Using a DVOM check for continuity between CKP connector pin A and ECM connector pin 11 • Do you have continuity between them?		Go to Step (5)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
5	• Using a DVOM check for continuity between CKP connector pin B and ECM connector pin 12 Do you have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Inspect the CKP connector C011 pins for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)

7	• Inspect the ECM connector C001 pins 11 and 12 for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (8)
8	• Using a DVOM check for continuity between ECM connector pins 11 and 12 to engine ground Do you have continuity?		Repair the shorted circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (10)
9	• Replace CKP sensor Is the replacement complete?		Go to Step (16)	-
10	• Replace ECM • Is the replacement complete?		Go to Step (16)	-
11	• Key OFF • Inspect the pulse wheel and CKP sensor for mechanical damage, corrosion or contamination. Did you find a problem?		Repair the distributor as necessary. Refer to Engine Repairs in Engine Section	Go to Step (12)
12	• Check the CKP pulse wheel to sensor air gap Is the air gap correct?	.030 to .040 inches	Go to step (13)	Go to Step (14)
13	• Check CKP for excessive movement or broken mounting bracket. Does the CKP show excessive movement on the bracket?		Go to Step (15)	Go to Step (9)
14	• Re set air gap to the correct specification Is the gap now set to the correct specification?	.030 to .040 inches	Go to Step (16)	-

15	• Replace CKP sensor bracket • Is the replacement complete?		Go to Step (16)	-
16	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-142 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 143-Never Crank Synced At Start



Conditions for setting the DTC

- Crankshaft Position sensor
- Check Condition- Engine running
- Fault Condition- 1 invalid crank re-sync
- MIL- On during active fault
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled

Circuit Description

The Crankshaft Position sensor is a magnetic transducer mounted on the engine block adjacent to a pulse wheel located on the crankshaft. It determines crankshaft position by monitoring the pulse wheel. The Crankshaft Position sensor is used to measure engine RPM and its signal is used to synchronize the ignition and fuel systems. The ECM must see a valid Crankshaft position signal while running. If no signal is present for 800ms or longer with rpm greater than 90, this fault will set.

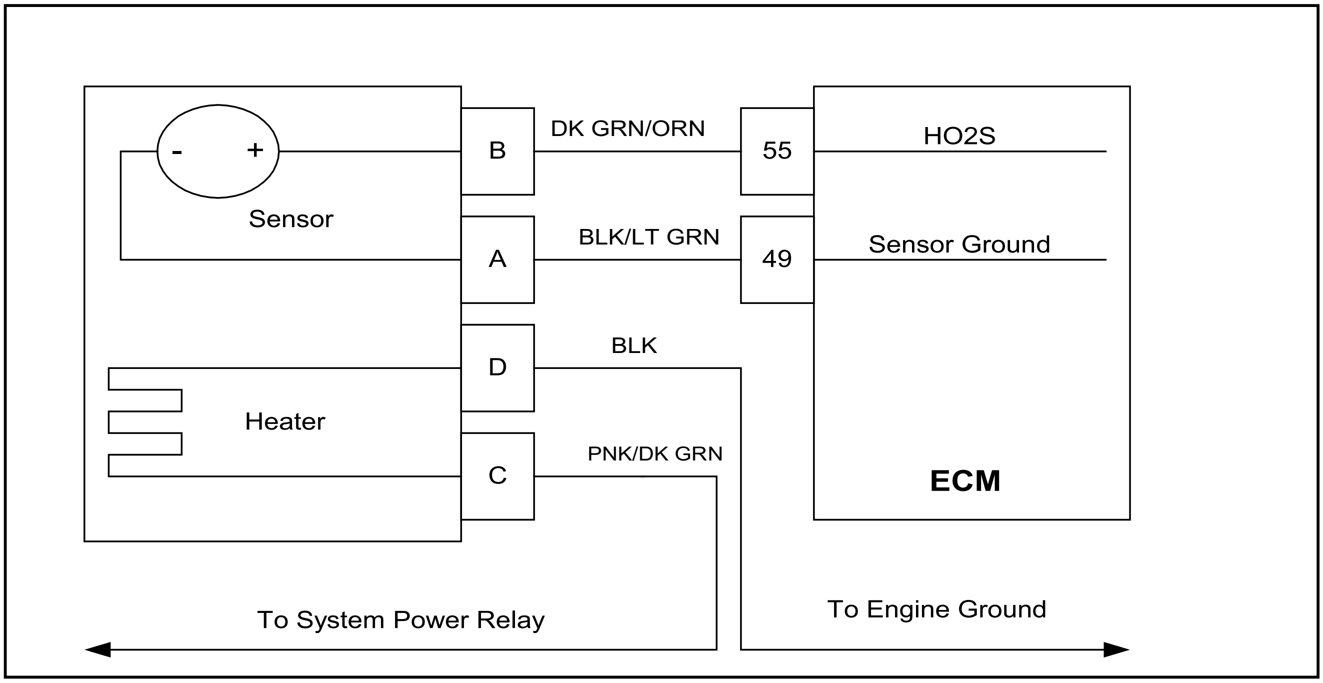
DTC 143 Never Crank Sync at Start

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Check to be sure that the ECM ground terminal G1 to engine ground is clean and tight. Is terminal G1 clean and tight?		Go to Step (3)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
3	• Key OFF • Disconnect the CKP sensor connector • Using a DVOM check for voltage output from the CKP sensor while cranking the engine • Do you have voltage output?	Over .5 volts	Go to Step (4)	Go to Step (11)
4	• Key OFF • Disconnect ECM connector C001 • Using a DVOM check for continuity between CKP connector pin A and ECM connector pin 11 • Do you have continuity between them?		Go to Step (5)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
5	• Using a DVOM check for continuity between CKP connector pin B and ECM connector pin 12 Do you have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Inspect the CKP connector C011 pins for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)

7	• Inspect the ECM connector C001 pins 11 and 12 for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (8)
8	• Using a DVOM check for continuity between ECM connector pins 11 and 12 to engine ground Do you have continuity?		Repair the shorted circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (10)
9	• Replace CKP sensor Is the replacement complete?		Go to Step (16)	-
10	• Replace ECM • Is the replacement complete?		Go to Step (16)	-
11	• Key OFF • Inspect the pulse wheel and CKP sensor for mechanical damage, corrosion or contamination. Did you find a problem?		Repair the distributor as necessary. Refer to Engine Repairs in Engine Section	Go to Step (12)
12	• Check the CKP pulse wheel to sensor air gap Is the air gap correct?	.030 to .040 inches	Go to step (13)	Go to Step (14)
13	• Check CKP for excessive movement on the bracket. Does the CKP show excessive movement on the bracket		Go to Step (15)	Go to Step (9)
14	• Re set air gap to the correct specification Is the gap now set to the correct specification?	.030 to .040 inches	Go to Step (16)	-
15	• Replace CKP sensor bracket • Is the replacement complete?		Go to Step (16)	-

16	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-143 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 211- Closed Loop Multiplier High (LPG)



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Check Condition- Engine running
- Fault Condition- Closed Loop multiplier out of range (greater than 35%)
- MIL- Disabled
- Adaptive- Enabled but not updated when Closed Loop is at limit
- Closed Loop- Enabled

Circuit description

The HO2S sensor is used to determine if the fuel flow to the engine is correct by measuring the oxygen content in the exhaust gas. The ECM uses this information to correct the fuel flow with the Closed Loop multiplier and the adaptive multiplier. This fault sets if the Closed Loop multiplier exceeds the limits of normal operation and cannot correctly modify the fuel flow within its limits.

Diagnostic Aids

Always diagnose any ECM codes that are present before beginning this diagnostic procedure.

- Heated Oxygen sensor wires may be mis-routed and contacting the exhaust manifold.
- Vacuum leaks can cause a lean exhaust condition, especially at light load and idle conditions.
- Exhaust leaks can cause a lean exhaust condition, especially at light load and idle conditions
- A poor ECU ground to the engine block or battery negative
- Problems with the fuel system causing lean fuel mixtures such as low fuel pressure, faulty mixture control solenoid or damaged fuel mixer assembly.

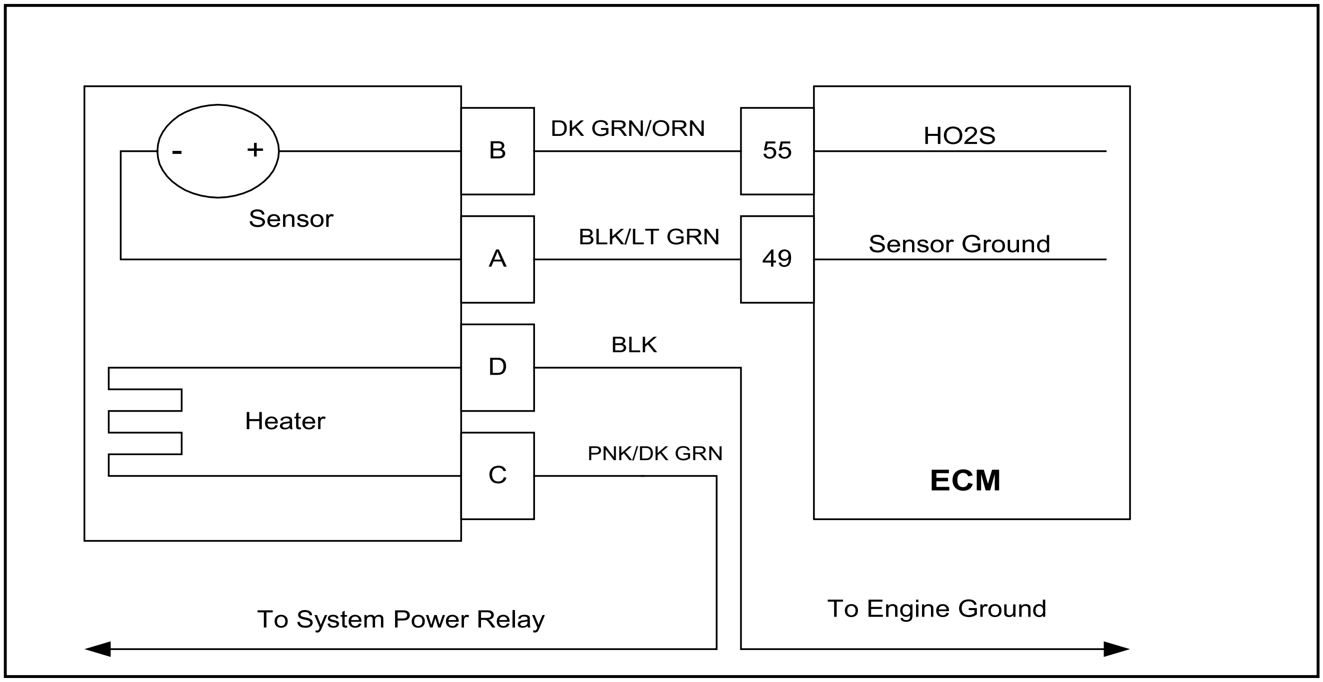
Never solder HO2S wires. For the correct repair procedure refer to Wiring Repairs in the Engine Electrical Section.

DTC 211- Closed Loop Multiplier High (LPG)

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode • Run engine to full operating temperature and then idle for a minimum of 2 minutes Does DST display HO2S voltage fixed below 0.35 volts after 2 minutes of idle run time?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect ECM connector • Disconnect HO2S wire harness connector • Using a high impedance DVOM check for continuity between HO2S connector signal pin B and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (4)
4	• Using a high impedance DVOM check for continuity between HO2S connector signal pin B and HO2S connector sensor ground pin A • Do you have continuity between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (5)
5	• Refer to Diagnostic aids for DTC 211 Did you check the diagnostic Aids for DTC 211?		Go to Step (6)	
6	• Replace HO2S sensor Is the replacement complete?		Go to Step (7)	

7	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-211 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

212-HO2S Open/Inactive



Conditions for Setting the DTC

- Heated Oxygen Sensor
  - Check condition- Engine running
  - Fault condition- HO2S cold persistently more than 120 seconds
  - MIL- On during active fault and for 1 second after active fault
  - Adaptive- Disabled during active fault
  - Closed Loop- Disabled during active fault

Circuit Description

The HO2S sensor is used to determine if the fuel flow to the engine is correct by measuring the oxygen content in the exhaust gas. The ECM uses this information to correct the fuel flow with the Closed Loop multiplier and the Adaptive multiplier.

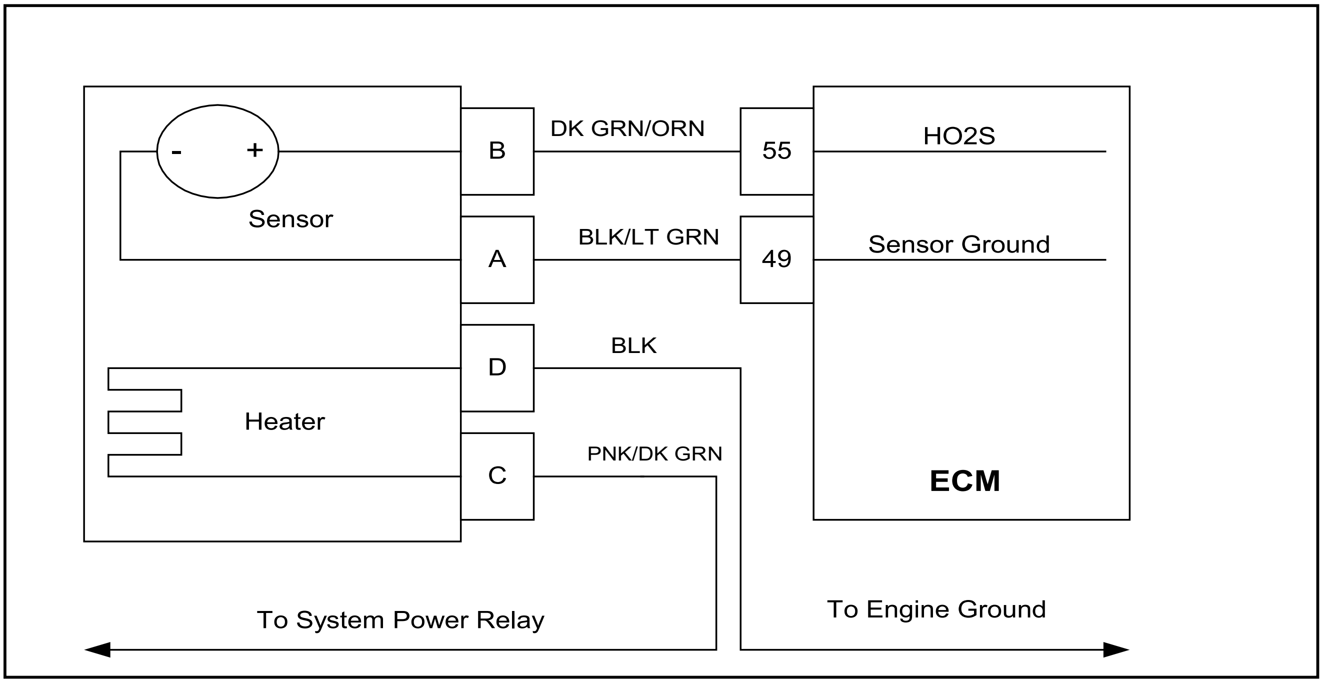
This fault will set if HO2S is cold, non-responsive, or inactive for 120 seconds or longer.

DTC 212- HO2S Open/Inactive

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode • Run engine to full operating temperature and then idle for a minimum of 2 minutes Does DST display HO2S voltage fixed between 0.4 and 0.5 volts after 2 minutes of idle run time?		Go to Step (5)	Go to Step (3)
3	• Back probe HO2S wire harness connector and check for voltage between HO2S connector heater ground pin D and battery voltage positive. Do you have power?		Go to step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Back probe HO2S wire harness connector and check for voltage between HO2S connector heater power pin C and engine ground. Do you have power?		Go to step (7)	Repair the circuit as necessary. **Check System Power Relay** circuit. Refer to Wiring Repairs in Engine Electrical.

5	• Key OFF • Disconnect HO2S connector and ECM connector. • Key ON • Check for continuity between HO2S sensor connector ground pin A and ECM HO2S sensor ground PIN 49. Do you have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Check for continuity between HO2S sensor connector signal pin B and ECM connector HO2S signal pin 55 Do you have continuity between them?		Go to Step (8)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
7	Replace HO2S Sensor Is the replacement complete?		Go to Step (9)	-
8	• Inspect ECM connector pins 49 and 55 for damage, corrosion or contamination • Inspect HO2S connector terminals A, B, C and D for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-212 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 224- Closed Loop Multiplier Low (LPG)



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Functional Fault-Closed Loop multiplier out of range (at limit of -35%)
- MIL- on during active fault

Circuit Description

The HO2S (Heated Oxygen Sensor) sensor is used to determine if the fuel flow to the engine is correct by measuring the oxygen content in the exhaust gas. The ECM uses this information to correct the fuel flow with the Closed Loop multiplier and the adaptive multiplier. This fault sets if the Closed Loop multiplier exceeds the limits of normal operation. When the multiplier cannot correctly modify the fuel flow within its limits, it is limited at -35%.

Diagnostic Aids

Always diagnose any other ECM codes that are present before beginning this diagnostic procedure.

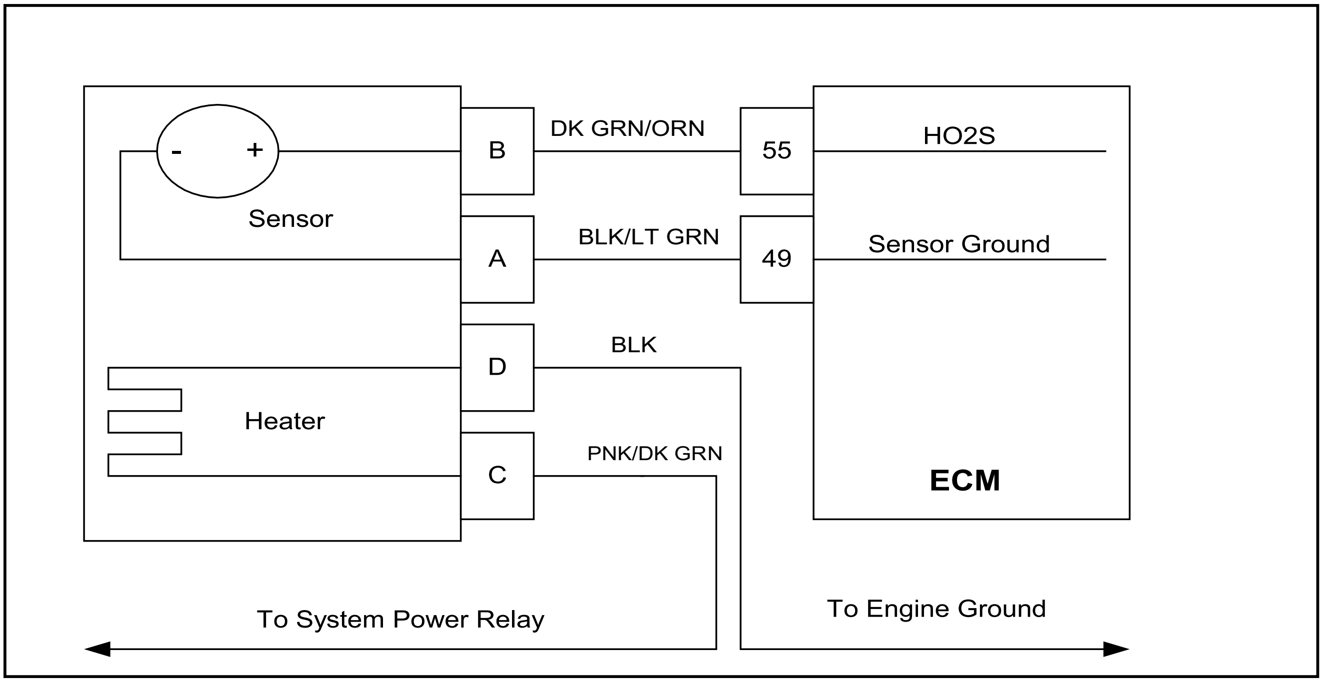
Fuel System High secondary fuel pressure can cause the system to run rich. A worn fuel mixer, faulty PTV (pressure trim valve) or FTV (fuel trim valve) can also cause the system to run rich.

Fuel Quality A drastic variation in fuel quality (very high butane content) may cause the system to run rich. Be sure that the specified HD-5 or HD-10 motor fuel grade propane is used.

DTC 224- Closed Loop Multiplier Low (LPG)

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode • Run engine to full operating temperature and then idle for a minimum of 2 minutes Does DST display HO2S voltage fixed above 0.7 volts after 2 minutes of idle run time?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect HO2S wire harness connector • Disconnect ECM wiring harness connector • Key ON • Using a high impedance DVOM check for voltage between HO2S connector signal pin B and engine ground Do you have voltage?		Repair wire harness shorted signal to voltage Refer to Wiring Repairs in Engine Electrical.	Refer to Diagnostic Aids for DTC 224

DTC 243-Adaptive Learn High (LPG)



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Check Condition- Engine Running
- Fault Condition- Adaptive multiplier out of range (greater than +30%)
- MIL- Disabled
- Adaptive- Enabled
- Closed Loop- Enabled

Circuit Description

The HO2S sensor is used to determine if the fuel flow to the engine is correct by measuring the oxygen content in the exhaust gas. The ECM uses this information to correct the fuel flow with the Closed Loop multiplier and Adaptive multiplier. This fault will set if the adaptive multiplier exceeds the limits of normal operation.

Diagnostic Aids

If any other DTCs are present, diagnose those first

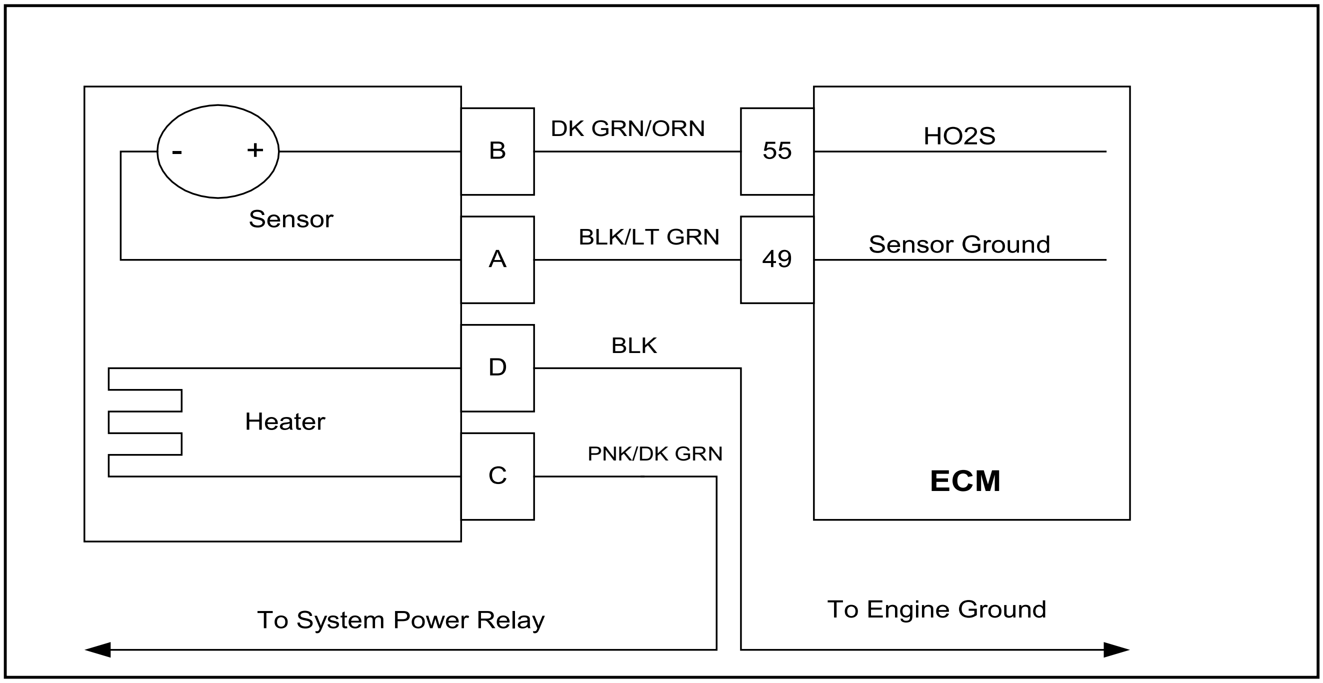
Oxygen Sensor Wire Heated Oxygen sensor wires may be mis-routed and contacting the exhaust manifold.
Vacuum Leaks Large vacuum leaks and crankcase leaks can cause a lean exhaust condition at especially at light load.
Injectors System will be lean if an injector driver or driver circuit fails open. The system will also be lean if an injector fails in a closed manner.
Fuel Pressure Low fuel pressure, faulty fuel injector or damaged fuel pump assembly can cause fuel system to run lean
Exhaust Leaks If there is an exhaust leak, outside air can be pulled into the exhaust and past the 02 sensor causing a false lean condition.
Fuel Quality Contaminated or spoiled fuel can cause the fuel system to be lean.
Ground Problem ECM grounds must be good battery or engine ground.

DTC 243 Adaptive Learn High (LPG)

Step	Action	Value(s)	Yes	No
1	• Perform the On-Board (OBD) System Check? Are any other DTCs present?		Go to Step (3)	Go to Step (2)
2	Visually and physically check the following items: • The air intake duct for being collapsed or restricted • The air filter for being plugged • The HO2S sensor installed securely and the wire leads not contacting the exhaust manifold or ignition wires • ECM grounds for being clean and tight. Refer to Section 1C Engine Electrical Power and Ground Distribution • Fuel System Diagnostics. Refer to Section 1B Fuel System Diagnostics Was a repair made?		Go to Step (7)	Go to Step (4)
3	• Diagnose any other DTC codes before proceeding with this chart. Have any other DTC codes been detected, diagnosed and repaired?		Go to Step (7)	Go to step (4)
4	• Key ON Engine running • Using a DVOM back probe the HO2S sensor connector heater circuit pin C for positive and D for negative. check for voltage • Do you have voltage?	Battery voltage	Go to Step (5)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
5	• Key OFF • Disconnect HO2S sensor wire harness connector • Disconnect ECM wire harness connector • Key ON • Using a DVOM check for voltage at HO2S connector signal pin B and engine ground Do you have voltage?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (6)
6	• Replace HO2S sensor Is the replacement complete?		Go to Step (7)	-

7	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-243 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 244-Adaptive Learn Low (LPG)



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Check Condition- Engine running
- Fault Condition- Adaptive multiplier out of range (at limit of -30%)
- MIL-Disabled
- Adaptive- Enabled
- Closed Loop- Enabled

Circuit Description

The HO2S sensor is used to determine if the fuel flow to the engine is correct by measuring the oxygen content in the exhaust gas. The ECM uses this information to correct the fuel flow with the Closed Loop multiplier and Adaptive multiplier. This fault will set if the adaptive multiplier exceeds the limits of normal operation.

Diagnostic Aids

Always diagnose any other ECM codes that are present before beginning this diagnostic procedure.

Fuel System High secondary fuel pressure will cause the system to run rich. A worn fuel mixer, faulty PTV (pressure trim valve) or FTV (fuel trim valve) can also cause the system to run rich.

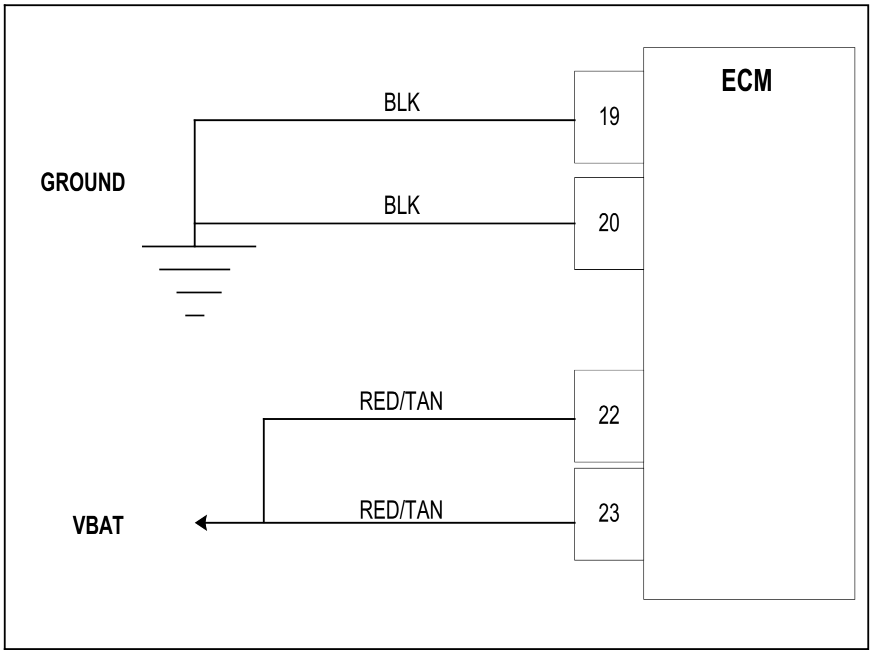
Fuel Quality A drastic variation in fuel quality (very high butane content) may cause the system to run rich. Be sure that the specified HD-5 or HD-10 motor fuel grade propane is used.

DTC 244 Adaptive Learn Low (LPG)

Step	Action	Value(s)	Yes	No
1	• Perform the On-Board (OBD) System Check? Are any other DTCs present?		Go to Step (3)	Go to Step (2)
2	Visually and physically check the following items: • The air intake duct for being collapsed or restricted • The air filter for being plugged • ECM grounds for being clean and tight. Refer to Section 1C Engine Electrical Power and Ground Distribution • Fuel System Diagnostics. Refer to Section 1B Fuel System Diagnostics Was a repair made?		Go to Step (7)	Go to Step (4)
3	• Diagnose any other DTC codes before proceeding with this chart. Have any other DTC codes been detected, diagnosed and repaired?		Go to Step (7)	Go to step (4)
4	• Key OFF • Disconnect HO2S sensor wire harness connector • Disconnect ECM wire harness connector • Key ON • Using a DVOM check for voltage at HO2S connector signal pin B and engine ground Do you have voltage?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (5)
5	• Replace HO2S sensor Is the replacement complete?		Go to Step (7)	-

7	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-244 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 261-System Voltage Low



Conditions for Setting the DTC

- System Voltage to ECM
- Check Condition-Key on and RPM greater than 1500
- Fault Condition-Battery voltage at ECM less than 9.0 volts continuously for 5 seconds
- MIL-On for active fault and for 10 seconds after active fault
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled

Circuit Description

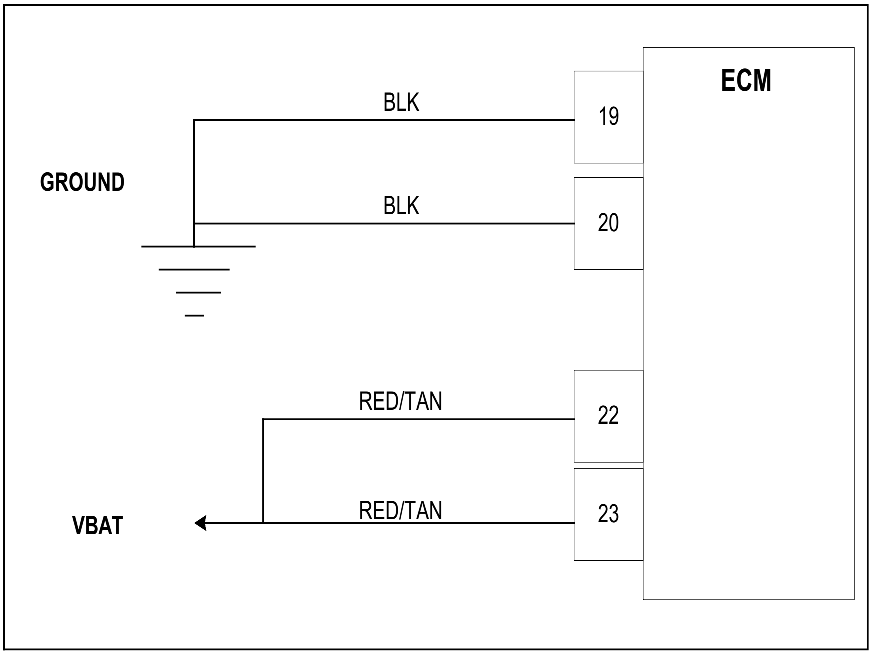
The battery voltage powers the ECM and must be measured to correctly operate injector drivers, fuel trim valves and ignition coils. This fault will set if the ECM detects system voltage less than 9.0 for 5 seconds or longer while the alternator should be charging. The adaptive learn is disabled.

DTC 261- System Voltage Low

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display system voltage greater than 9.0 volts?	-	Intermittent problem Go to Engine Electrical Intermittent section	Go to Step (3)
3	• Check battery condition Is it OK?	-	Go to Step (4)	Replace Battery
4	• Check charging system Is it Ok?	-	Go to Step (5)	Repair charging System
5	• Back probe ECM connector pins 22 and 23 • Measure voltage with DVOM between each pin and engine ground Is the voltage greater than 9.0 volts?	-	Repair ECM Ground circuit. Go to Power and Ground section in engine Electrical	Go to Step (6)
6	• Back probe ECM connector pins 19 and 20 • Measure voltage with DVOM between each pin and battery voltage Is the voltage greater than 9.0 volts?	-	Repair ECM power circuit. Go to Power and Ground section in engine Electrical	Go to step (7)
7	Replace ECM Is the replacement complete?	-	Go to Step (8)	-

8	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-261 check for any stored codes. Does the engine operate normally with no stored codes?	-	System OK	Go to OBD System Check

DTC 262-System Voltage High



Conditions for Setting the DTC

- System Voltage to ECM
- Check Condition-Cranking or Running
- Fault Condition-Switched battery voltage at ECM greater than 18 volts for 3 seconds
- MIL-On for active fault and for 5 seconds after active fault
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled

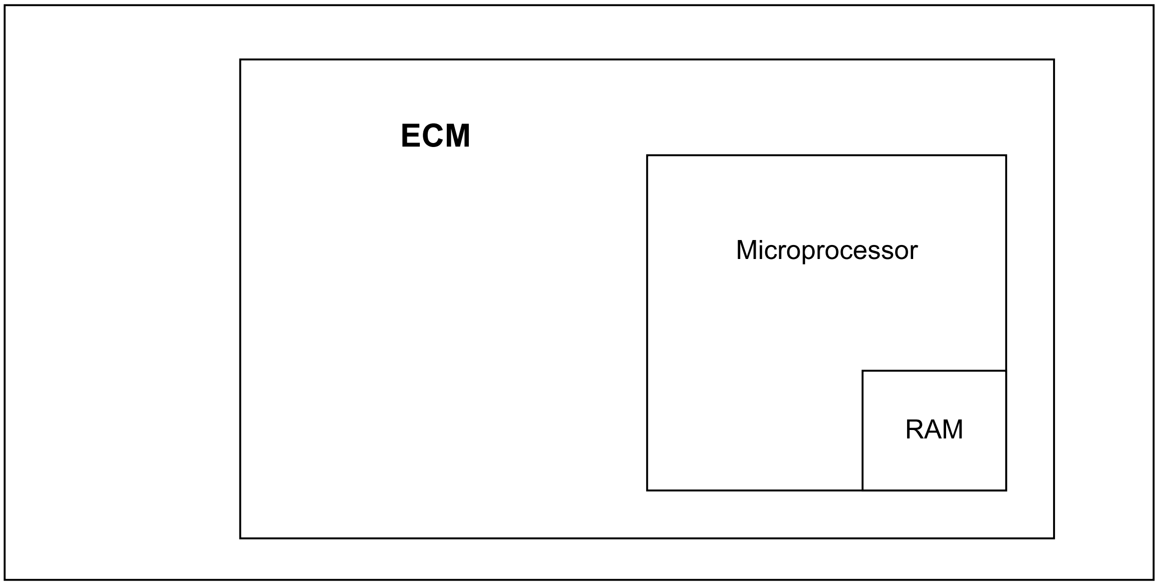
Circuit Description

The battery voltage powers the ECM and must be measured to correctly operate injector drivers, trim valves and ignition coils. This fault will set if the ECM detects voltage greater than 18 volts for 3 seconds at anytime the engine is cranking or running. The adaptive learn is disabled. The ECM will shut down with internal protection if the system voltage exceeds 26 volts.

DTC 262- System Voltage High

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode • Run engine greater than 1500 rpm. Does DST display system voltage less than 18 volts?	-	Intermittent problem Go to Engine Electrical Intermittent section	Go to Step (3)
3	• Check voltage at battery terminals with DVOM with engine speed greater than 1500 rpm Is it greater than 18 volts?	-	Go to Step (4)	Go to Step (5)
4	• Repair the charging system Has the charging system been repaired?	-	Go to Step (6)	-
5	• Replace ECM Is the replacement complete?		Go to Step (6)	-
6	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-262 check for any stored codes. Does the engine operate normally with no stored codes?	-	System OK	Go to OBD System Check

DTC 511-COP Failure



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

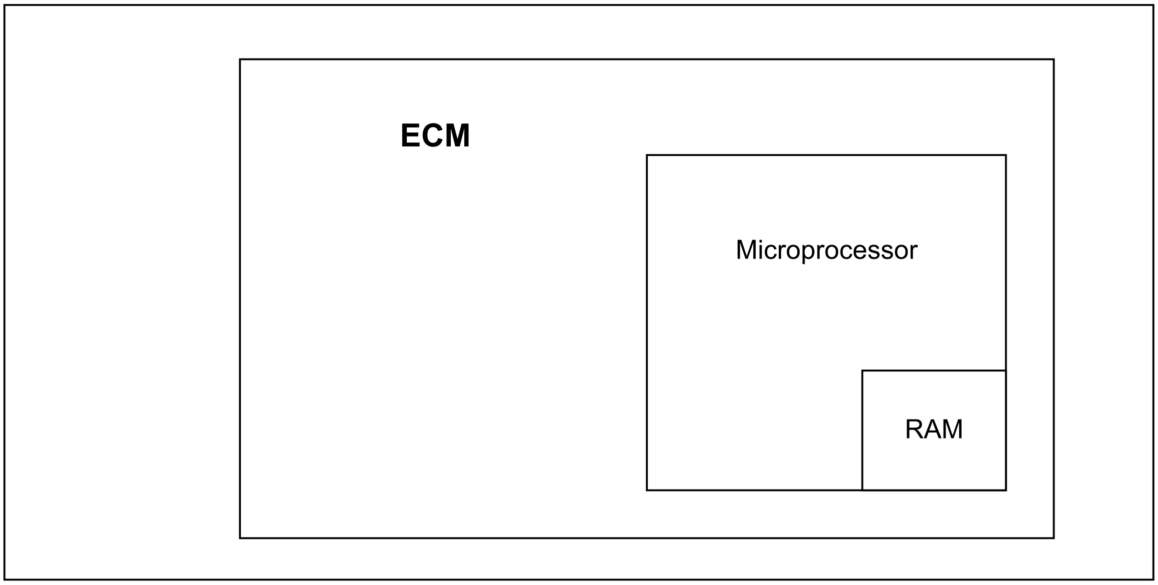
Circuit Description

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 511 COP Failure

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 511 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		Go to Step (5)	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-511 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 512-Invalid Interrupt



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

Circuit Description

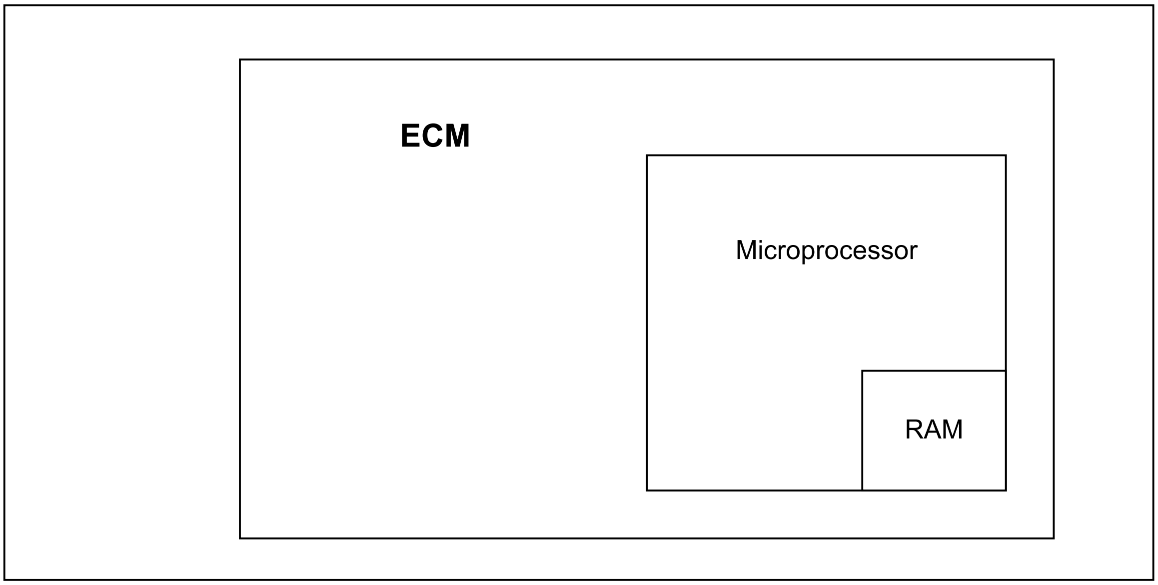
The ECM has checks that must be verified each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 512 Invalid Interrupt

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 512 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		Go to Step (5)	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-512 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 513-A/D Loss



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

Circuit Description

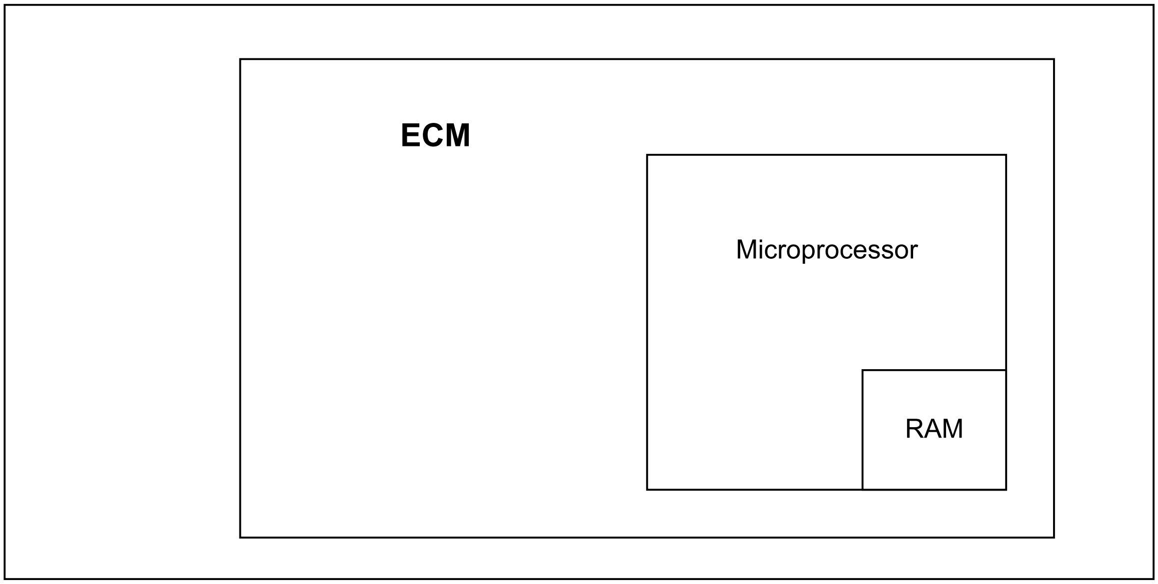
The ECM has checks that must be verified each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 513 A/D Loss

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 513 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		Go to Step (5)	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-513 check for any stored codes. Does the engine normally with no stored codes?		System OK	Go to OBD System Check

DTC 514-RTI 1 Loss



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

Circuit Description

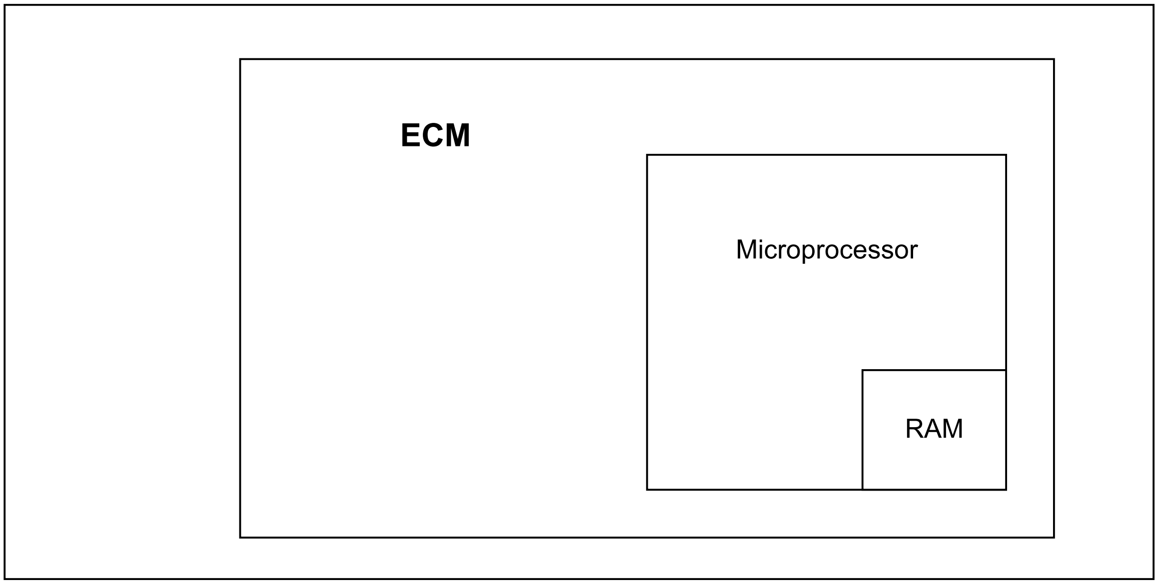
The ECM runs checks that must be verified each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 514 RTI 1 Loss

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 514 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		Go to Step (5)	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-514 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 515-Flash Checksum Invalid



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

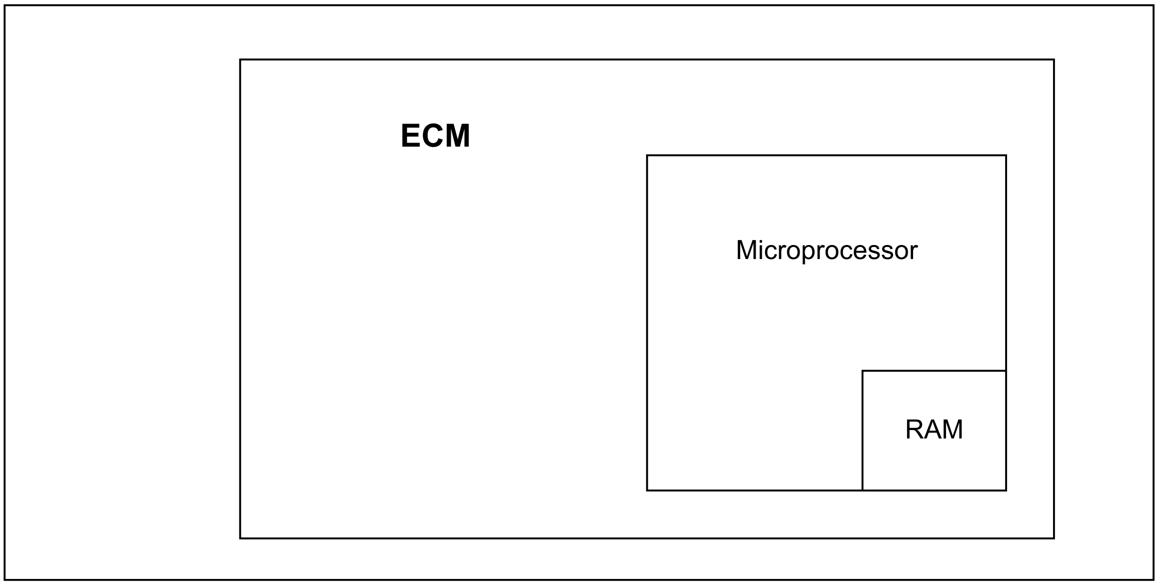
Circuit Description

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase. During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 515 Flash Checksum Invalid

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 515 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		Go to Step (5)	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-515 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 516-Ram Failure



Conditions for Setting the DTC

- Random Access Memory
- Check Condition- Key-On
- Fault Condition- Internal ECM memory access failure
- MIL- On until fault is cleared
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2) enforced

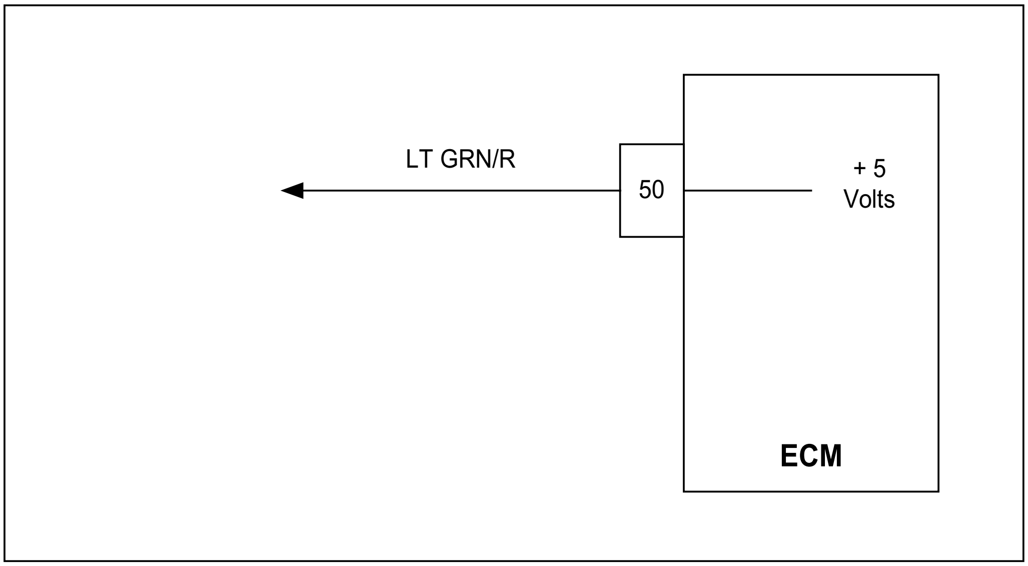
Circuit Description

Random Access Memory is located within the microprocessor that can be read from or written to at any time. The System Fault Codes and the Adaptive Learn Table are among the data stored in RAM. This fault will set if the ECM detects a problem accessing or writing information to RAM. This fault will not self erase and must be cleared manually.

DTC 516 Ram Failure

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 516 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		Go to Step (5)	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-516 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 531-External 5V Ref Lower Than Expected



Conditions for Setting the DTC

- External 5V reference
- Check Condition-Cranking with battery voltage greater than 8 volts and engine running
- Fault Condition-5V reference voltage lower than 4.6 volts
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled

Circuit Description

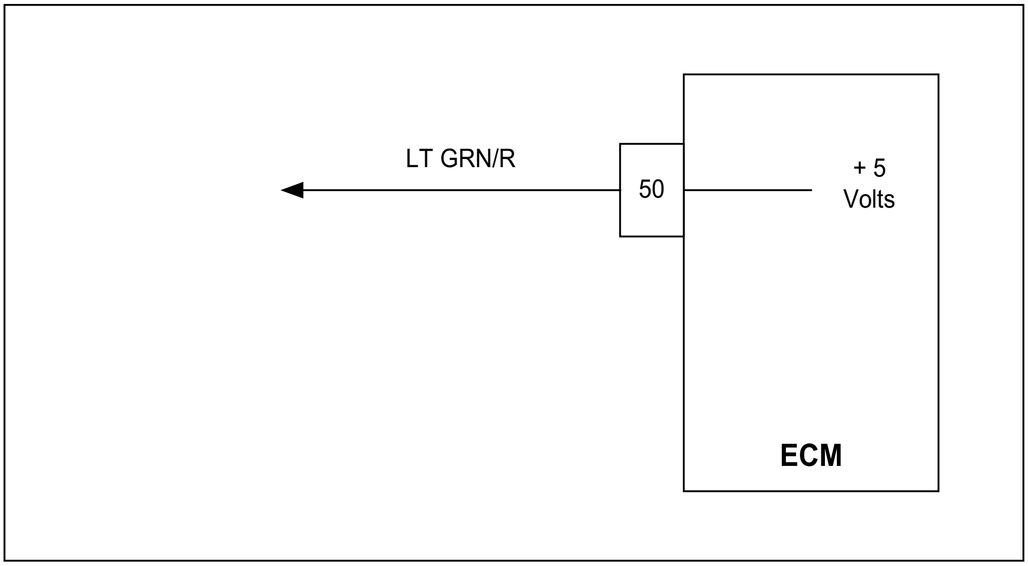
The External 5 Volt supply powers some of the sensors and other components in the system. The accuracy of the 5 Volt supply is very important to the accuracy of the sensors and therefore controlled by the ECM. The ECM monitors the 5 volt supply to determine if it is overloaded, shorted, or otherwise out of specification. This fault will set if the 5 Volt reference is below 4.6 volts.

DTC 531 External 5V Reference Lower Than Expected

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine Running • DST (Diagnostic Scan Tool) connected in System Fault Mode Does DST display DTC 531?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect ECM connector • Using DVOM check for continuity between ECM 5 volt reference LT GRN/R pin 50 and engine ground Do you have continuity?		Go to Step (5)	Go to Step (4)
4	• Replace ECM Is the replacement complete?		Go to Step (7)	-
5	• While monitoring DVOM for continuity between ECM 5 volt reference and engine ground disconnect each sensor (below) one at a time to find the shorted 5 volt reference. When continuity to ground is lost the last sensor disconnected is the area of suspicion. Inspect 5volt reference supply wire leads for shorts before replacing the sensor. • IAT • ECT/CHT • TMAP • FPP • TPS 1 • TPS 2 • Crankshaft Sensor • Camshaft Sensor While disconnecting each sensor one at a time did you loose continuity?		Go to Step (6)	-

6	• Replace Sensor Is the replacement complete?		Go to step (7)	-
7	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-531 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 532-External 5 V Ref Higher Than Expected



Conditions for Setting the DTC

- External 5V reference
- Check Condition-Cranking with battery voltage greater than 8 volts or engine running
- Fault Condition-5V reference voltage higher than 5.4 volts
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled

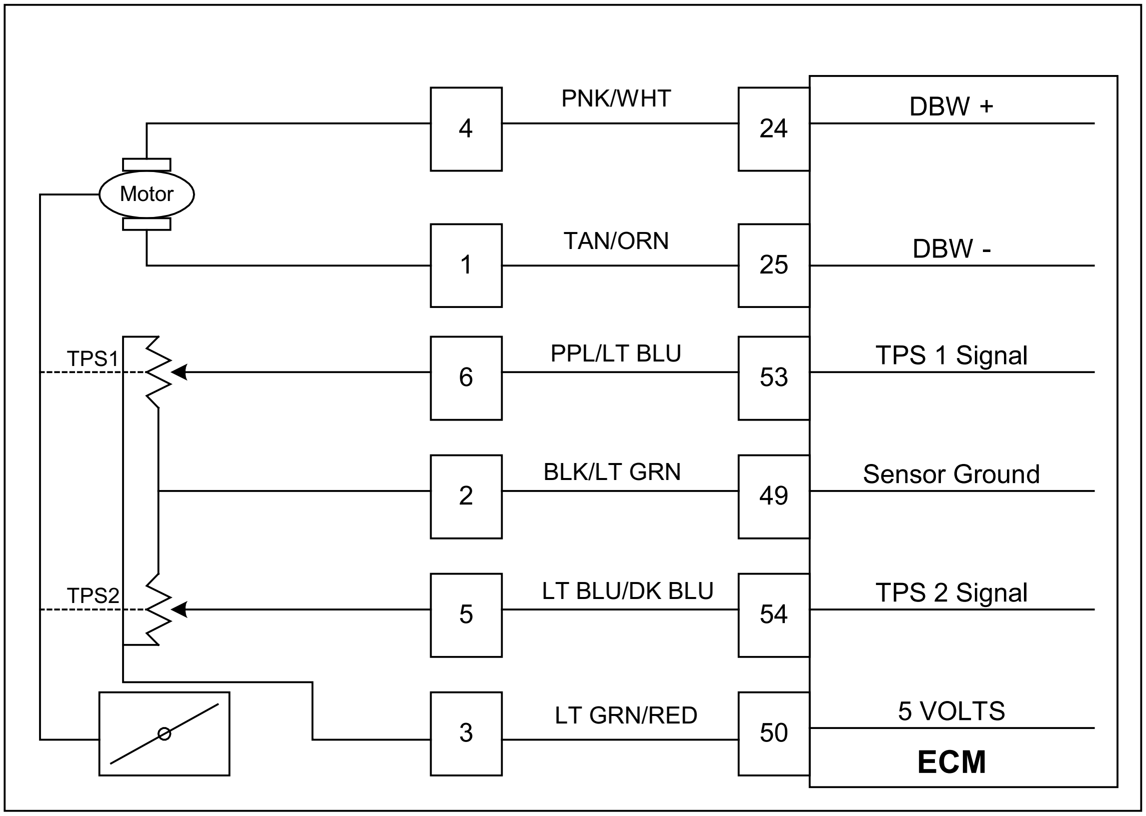
Circuit Description

The External 5 Volt supply powers some of the sensors and other components in the system. The accuracy of the 5 Volt supply is very important to the accuracy of the sensors and therefore control by the ECM. The ECM to determine if they are overloaded, shorted, or otherwise out of specification monitors the 5 Volt supply. This fault will set if the 5 Volt reference is above 5.4 volts.

DTC 532 External 5V Reference Higher Than Expected

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine running • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display DTC 532?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check all ECM ground connections Refer to Engine electrical power and ground distribution. Are the ground connections Ok?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Key OFF • Disconnect ECM connector • Key ON • Using DVOM check for Voltage between ECM harness wire LT GRN/R pin 50 and engine ground Do you have voltage?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (5)
5	• Replace ECM Is the replacement complete?		Go to Step (6)	-
6	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-532 check for any stored codes. Does the vehicle engine normally with no stored codes?		System OK	Go to OBD System Check

DTC 554-Gaseous Fuel Lo Rev Overun



Conditions for Setting the DTC

- TPS or FPP Code set
- Check Condition- Engine running in LPG mode
- Fault Condition- unable to enforce low rev limit of 1300 to 1500 rpm
- MIL- On during active fault
- Adaptive- Enabled
- Closed Loop- Enabled
- Engine Shut Down

Circuit description

This fault may set if the engine is running in the LPG fuel mode with one ore more codes relating to the throttle control system. If the ECM has been commanded to enforce low rev limit and the governor control system is unable to achieve low rev limiting the engine will shut down.

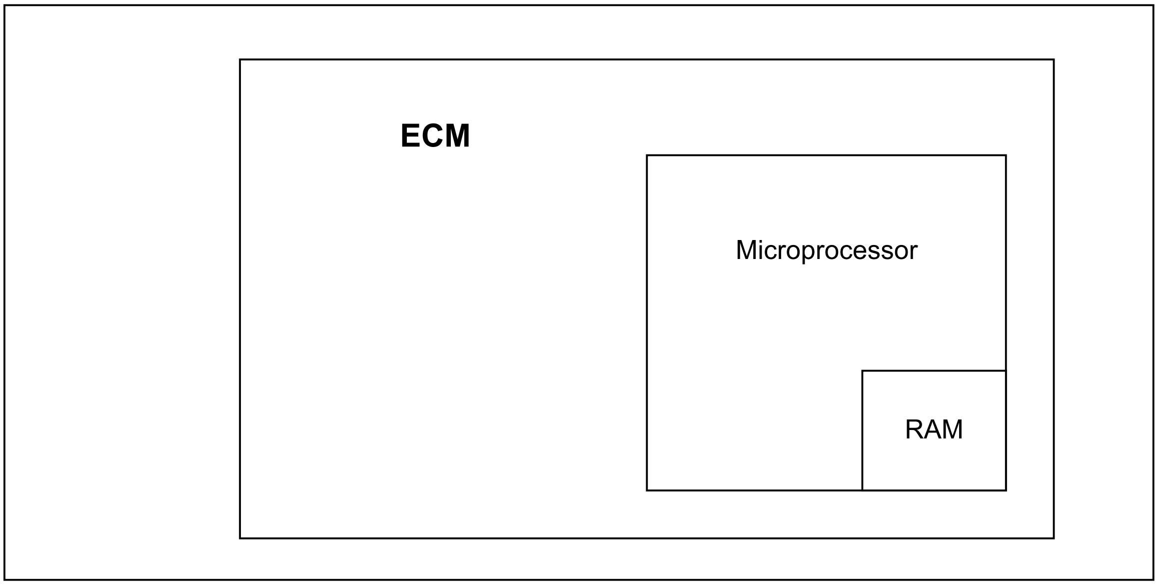
Diagnostic Aids

In the event of multiple DTC codes present in the ECM control system, always work to resolve the lowest numerical DTC code first. This code may have been set as a result of another throttle control system DTC. In the event this does

DTC 554-Gaseous Fuel Flow Rev Limit

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Check for other DTC codes that may be stored in ECM memory Did you find other DTC codes stored in the ECM memory?		Go to Step (3)	Go to Step (4)
3	• Repair DCT codes starting with the lowest code first. Have the other codes been diagnosed and repaired?		Go to Step (5)	-
4	Follow the diagnostic chart recommendations for DTC 637		-	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-554 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 555-RTI 2 Loss



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

Circuit Description

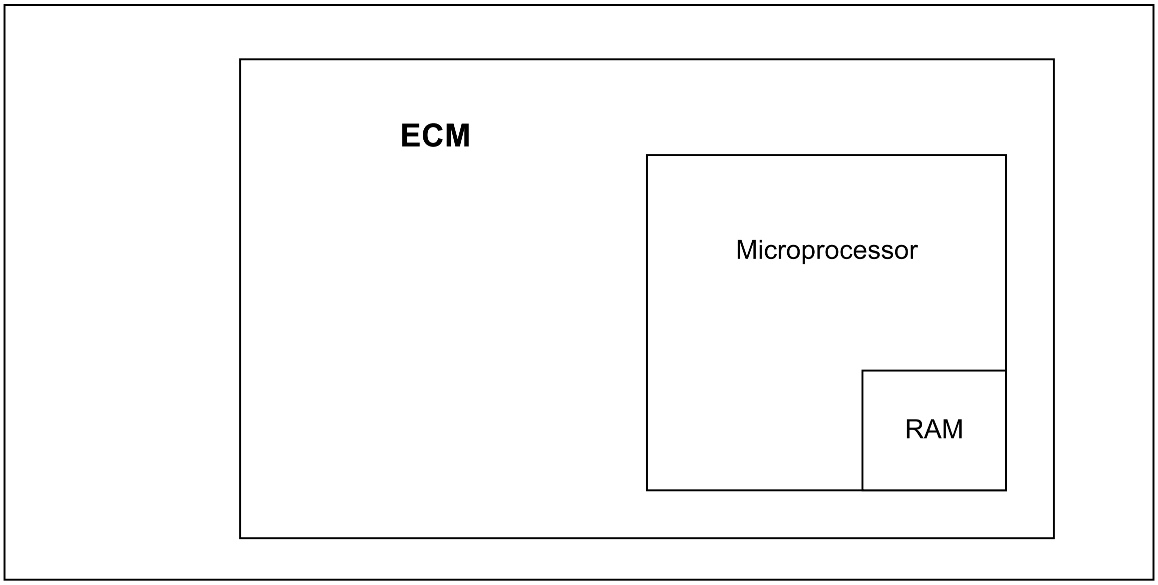
The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 555 RTI 2 Loss

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 555 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		Go to Step (5)	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-555 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 556-RTI 3 Loss



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

Circuit Description

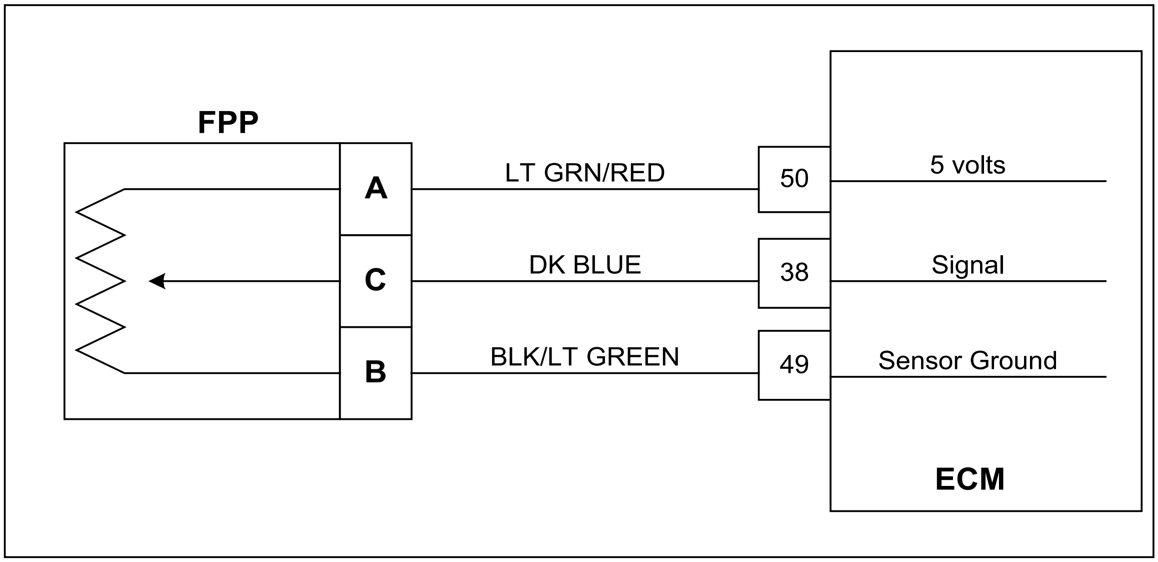
The ECM runs checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 556 RTI 3 Loss

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 555 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		Go to Step (5)	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-556 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 611-FPP High Voltage



Conditions for Setting the DTC

- Foot Pedal Position
- Check Condition-Key On
- Fault Condition-FPP1 sensor voltage exceeds 4.8
- MIL-On during active fault
- Low Rev Limit enforced 1300
- Forced Idle700 rpm
- Power Derate 1

Circuit Description

The Foot Pedal Position sensor uses a variable resistor to determine signal voltage based on pedal position. Less depression of pedal results in lower voltage, and greater depression results in higher voltage.

This fault will set if voltage is over 4.8 volts at any operating condition while the key is on. If the voltage exceeds 4.8, then FPP is considered to be out of specifications. At this point the ECM does not have a valid signal, and must therefore enforce the low rev limit and Power Derate (level 1). When these are enforced the maximum throttle position is 50% and the maximum engine speed is 1300 RPM. The Low Rev Limit is enforced for the remainder of the key-on cycle to 700 rpm. Rev limit is still enforced if the active fault is no longer present

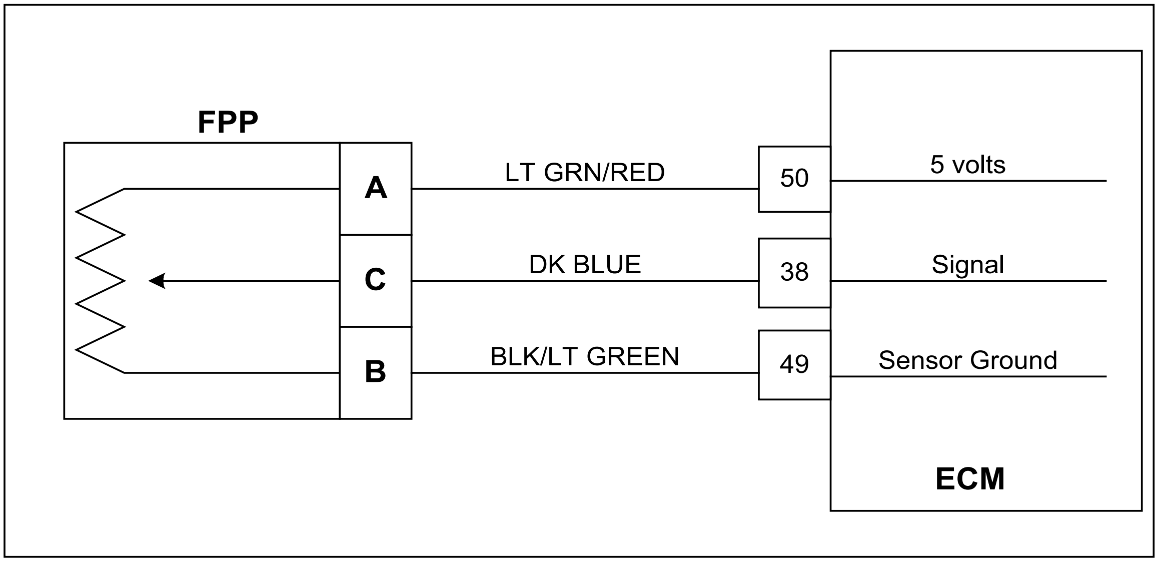
DTC 611 FPP Voltage High

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in System Data Mode Does the DST display FPP voltage of 4.8 volts or greater with the foot pedal in the idle position?		Go to Step (8)	Go to Step (3)
3	• Slowly increase FPP while observing FPP voltage Does DST FPP voltage ever exceed 4.8 volts?		Go to step (4)	Intermittent problem Go to Intermittent section
4	• Key OFF • Disconnect FPP sensor connector • Inspect connector and wire terminals for damage, corrosion or contamination Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (5)
5	• Disconnect ECM connector C001 • Check continuity between FPP sensor connector ground pin B and ECM connector FPP sensor ground pin 49 Do have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Key ON • Using a DVOM check for voltage at ECM wire harness connector FPP signal pin 38 and ECM sensor ground terminal pin 49 Do you have voltage between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)

Step	Action	Value(s)	Yes	No
7	• Using a DVOM check for voltage at ECM wire harness connector between ECM FPP signal pin 38 and engine ground Do you have voltage between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Intermittent problem Go to Intermittent section
8	• Key OFF • Disconnect FPP sensor from wire harness • Key ON Does DSC display FPP voltage less than 0.2 volts?		Go to Step (11)	Go to Step (9)
9	• Disconnect ECM wire harness connector C001 • Using a DVOM check for voltage between the ECM FPP signal pin 38 and engine ground Do you have voltage between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (10)
10	• Replace ECM Is the replacement complete?		Go to Step (15)	-
11	• Probe FPP sensor connector ground circuit pin B with a test light connected to battery voltage Does the test light come on?		Go to Step (12)	Go to Step (14)
12	• Key OFF • Disconnect ECM wire harness connector • Inspect the ECM wire harness connector terminals for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (13)
13	• Replace FPP sensor Is the replacement complete?		Go to step (15)	-

Step	Action	Value(s)	Yes	No
14	• Key OFF • Disconnect ECM connector • Check continuity between FPP sensor connector ground pin B and ECM connector FPP sensor ground pin 49 Do have continuity between them?		Go to Step (10)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
15	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-611 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 612-FPP Low Voltage



Conditions for Setting the DTC

- Foot Pedal Position
- Check Condition-Key On
- Fault Condition-FPP sensor voltage less than 0.200
- MIL-On during active fault
- Power Derate 1
- Low rev limit 1300 rpm
- Force Idle 700 rpm

Circuit Description

The Foot Pedal Position sensor uses a variable resistor to determine signal voltage based on pedal position. Less depression of pedal results in lower voltage, and greater depression results in higher voltage.

This fault will set if voltage is less than 0.2 volts at any operating condition while the key is on. If the voltage is less than 0.2, then FPP is considered to be out of specifications. At this point the ECM does not have a valid signal, and must therefore enforce the low rev limit and Power Derate (level 1). When these are enforced the maximum throttle position is 50% and the maximum engine speed is 1300 RPM. The Low Rev Limit is enforced for the remainder of the key-on cycle to 700 rpm. Rev limit is still enforced if the active fault is no longer present

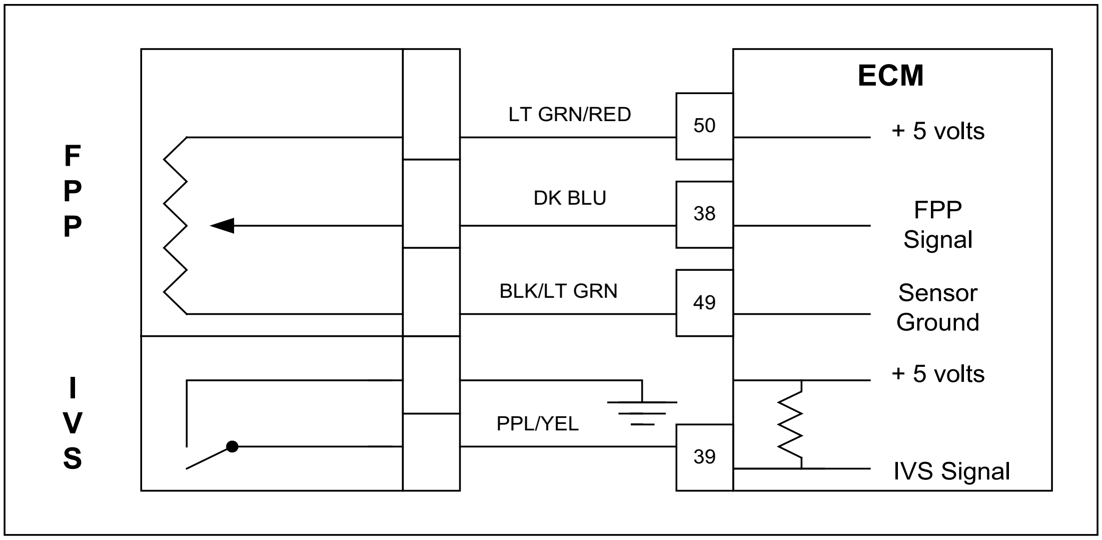
DTC 612 FPP Voltage Low

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in System Data Mode Does the DST display FPP voltage of 0.2 volts or less with the foot pedal in the idle position?		Go to Step (7)	Go to Step (3)
3	• Slowly depress FP while observing FPP voltage Does DST FPP voltage ever drop below 0.2 volts?		Go to step (4)	Intermittent problem Go to Intermittent section
4	• Key OFF • Disconnect FPP sensor connector • Inspect connector and wire terminals for damage, corrosion or contamination Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (5)
5	• Key ON • Using A DVOM check for voltage at the FPP sensor connector between 5 volt reference pin A and FPP sensor ground pin B Do you have voltage between them?	5.0 Volts	Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Replace FPP Sensor Is the replacement complete?		Go to Step (18)	-
7	• Key OFF • Disconnect FPP Sensor from wire harness • Jumper 5 volt reference circuit pin A and FPP signal circuit pin C together • Key ON Does DST display FPP voltage of 4.8 volts or greater?		Go to Step (8)	Go to Step (9)

8	• Check FPP connector wire terminals for damage, corrosion or contamination? Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (6)
9	• Probe FPP connector signal circuit pin C with a test light connected to battery voltage Does the DST display FPP voltage of 4.8 volts or greater?		Go to Step (10)	Go to Step (14)
10	• Key OFF • Disconnect ECM wire harness connector • Using a DVOM check for continuity between FPP sensor connector 5 volt reference pin A and ECM connector 5 volt reference pin 50 Do you have continuity between them?		Go to Step (11)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
11	• Using A DVOM check for continuity between ECM 5 volt reference pin 50 and engine ground Do you have continuity between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (12)
12	• Using a DVOM check for continuity between ECM connector 5 volt reference pin 50 and ECM sensor ground pin 49 Do you have continuity between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (13)
13	• Inspect FPP and ECM connector terminal terminals for damage, corrosion or contamination Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (17)

14	• Key OFF • Disconnect ECM wire harness connector C001 • Using a DVOM check for continuity between FPP connector signal pin C and ECM connector FPP signal pin 38 Do you have continuity between them?		Go to Step (15)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
15	• Using a DVOM check for continuity between ECM connector FPP signal pin 38 and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (16)
16	• Using a DVOM check for continuity between ECM FPP signal pin 38 and ECM connector FPP sensor ground pin 49 Do you have continuity between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (13)
17	• Replace ECM Is the replacement complete?		Go to Step (18)	-
18	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-612 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 613-FPP Higher Than IVS Limit



Conditions for Setting the DTC

- Foot Pedal Position/Idle Validation Switch
- Check Condition-Engine Cranking or Running
- MIL-On during active fault
- Fault Condition-IVS at idle and FPP voltage greater than 1.12 volts
- Power Derate 1 50% maximum throttle
- Low rev Limit 1300 rpm
- Force Idle 700 rpm

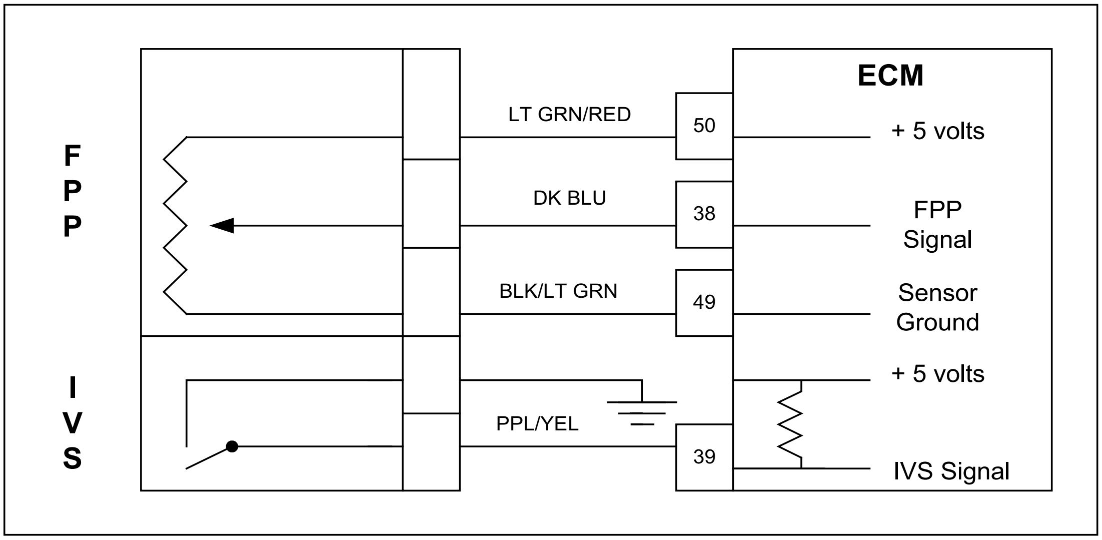
Circuit Description

The engine load command to the ECM is determined by operator depression of the electronic foot pedal. The ECM monitors the foot pedal position and controls the throttle to maintain the commanded power level. Because a problem with the foot pedal signal can result in a higher or lower power than intended by the operator, the pedal used with this control system incorporates a sensor with an idle validation switch. Checks and cross checks are constantly conducted by the ECM to determine the validity of the signals. The Idle Validation Switch (IVS) is a normally closed contact (idle) that opens the IVS circuit to the ECM when the pedal is depressed more than the idle position.

DTC 613 FPP Higher Than IVS Limit

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in System Data Mode Does the DST display IVS "idle" with the foot pedal fully depressed?		Go to Step (3)	Go to Step (7)
3	• Key OFF • Disconnect foot pedal from harness • Key ON Does DST display IVS "idle"?		Go to Step (4)	Go to Step (5)
4	• Replace foot pedal Is the replacement complete?		Go to Step (8)	-
5	• Key OFF • Disconnect ECM wire harness connector • Using a DVOM check for continuity between IVS signal and engine ground Do you have continuity between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (6)
6	• Replace ECM Is the replacement complete?		Go to Step (8)	-
7	• Depress foot pedal until DST reads FPP voltage between 1.1 and 1.3 volts Does DST display IVS "idle"	1.1 to 1.3 volts	Go to Step (4)	Intermittent problem Go to Intermittent section
8	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-613 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go OBD System Check

DTC 614-FPP Lower Than IVS Limit



Conditions for Setting the DTC

- Foot Pedal Position/Idle Validation Switch
- Check Condition-Engine Cranking or Running
- MIL-On during active fault
- Fault Condition-IVS off idle and FPP voltage less than .880 volts
- Power Derate 1 50% maximum throttle
- Low rev Limit 1300 rpm
- Force Idle 700 rpm

Circuit Description

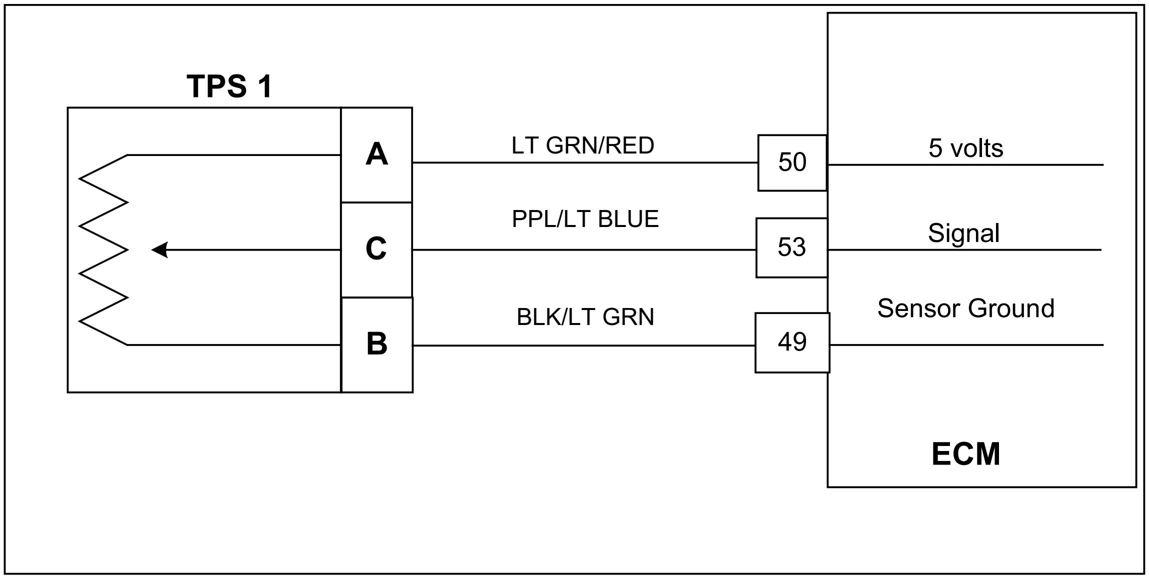
The engine load command to the ECM is determined by operator depression of the electronic foot pedal. The ECM monitors the foot pedal position and controls the throttle to maintain the commanded power level. Because a problem with the foot pedal signal can result in a higher or lower power than intended by the operator, the pedal used with this control system incorporates a sensor with an idle validation switch. Checks and cross checks are constantly conducted by the ECM to determine the validity of the signals. The Idle Validation Switch (IVS) is a normally closed contact (idle) that opens the IVS circuit to the ECM when the pedal is depressed more than the idle position.

This fault will set if the IVS is off-idle (open) and the FPP voltage is less than 0.880 volts. During this fault, Power Derate (level 2) and the Low Rev Limit are enforced. When these are enforced the maximum throttle position is 20% and the maximum engine speed is 1300 RPM. These are enforced for the remainder of the key-on cycle. If the active fault is no longer present, the MIL light will be on for the remainder of the key-on cycle. This is a reminder that the Power Derate and Low Rev Limits are still enforced.

DTC 614 FPP Lower Than IVS Limit

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in System Data Mode Does the DST display IVS "OFF IDLE" with the foot pedal in the idle position?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Jumper IVS signal and IVS ground together at wire harness connector • Key ON Does DST display IVS "ON"		Go to step (4)	Go to Step (5)
4	• Replace Foot Pedal Is the replacement complete?		Go to Step (7)	-
5	• Key OFF • Disconnect ECM wire harness connector • Using a DVOM check for continuity between IVS signal and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (6)
6	• Replace ECM Is the replacement complete?		Go to Step (7)	-
7	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-614 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go OBD System Check

DTC 631-TPS 1 Signal Voltage High



Conditions for Setting the DTC

- Throttle Position Sensor #1
- Check Condition-Cranking or Running
- Fault Condition-TPS sensor voltage exceeds 4.8
- MIL-On during active fault
- Power Derate 1
- Low rev limit 1300 rpm
- Forced idle 700 rpm

Circuit Description

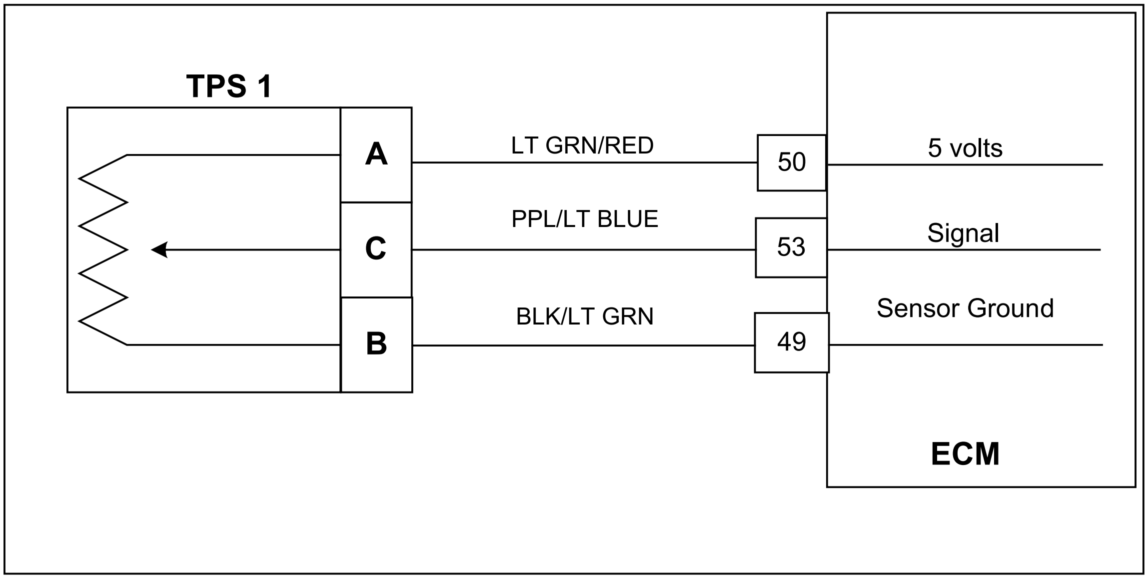
The Electronic Throttle has two counter acting Throttle Position Sensors. Two sensors are used for improved safety and redundancy. The Throttle Position sensor uses a variable resistor to determine signal voltage based on throttle plate position, and is connected to the throttle shaft. Less opening results in lower voltage, and greater opening in higher voltage. The TPS value is used by the ECM to determine if the throttle is opening as commanded. This fault will set if voltage is above 4.8 volts at any operating condition while the engine is cranking or running.
Power derate 1 will be enforced limiting the throttle to 50% maximum. Low rev limit and forced idle will also be enforced during this fault.

DTC 632 TPS 1 Signal Voltage Low

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in DBW (Drive by Wire) throttle test mode Does the DST display TPS 1 voltage of 0.2 volts or less with the throttle closed		Go to Step (4)	Go to Step (3)
3	• Slowly depress Foot Pedal while observing TPS 1 voltage Does TPS 1 voltage ever fall below 0.2 volts?		Go to Step (4)	Intermittent problem Go to Intermittent section
4	• Key OFF • Disconnect the TPS 1 electrical connector • Jumper the 5 volt reference circuit pin A and TPS 1 signal circuit pin C together at the throttle connector • Key ON Does DST display TPS 1voltage of 4.0 volts or greater?		Go to Step (7)	Go to Step (5)
5	• Key OFF • Disconnect ECM wire harness connector Using a DVOM check continuity between TPS 1 connector signal pin C and ECM connector TPS 1 signal pin 53 Do have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Replace ECM Is the replacement complete?		Go to Step (9)	-
7	• Inspect the throttle wire harness connector terminals for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (8)

8	• Replace the TPS 1 Is the replacement complete?		Go to Step (9)	-
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-632 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 632-TPS 1 Signal Voltage Low



Conditions for Setting the DTC

- Throttle Position Sensor #1
- Check Condition-Cranking or Running
- Fault Condition-TPS sensor voltage less than 0.2
- MIL-On during active fault
- Power Derate 1
- Low rev limit 1300 rpm
- Forced idle 700 rpm

Circuit Description

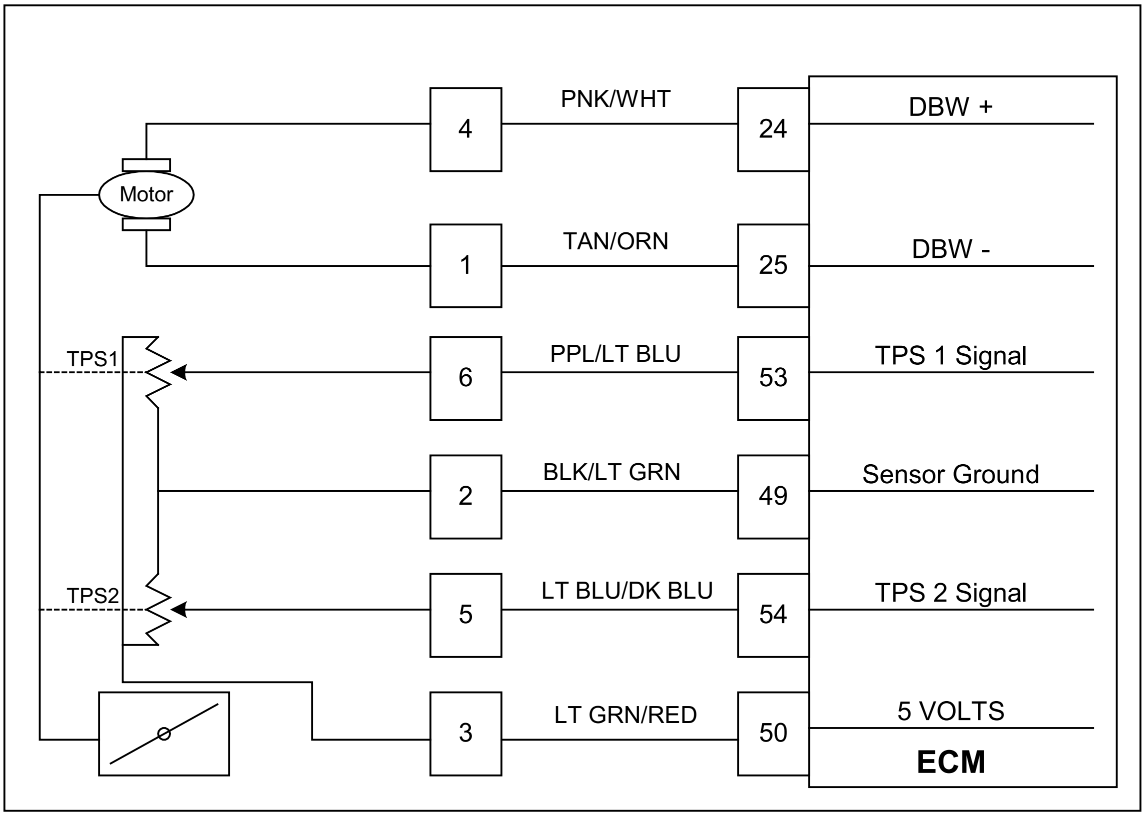
The Electronic Throttle has two counter acting Throttle Position Sensors. Two sensors are used for improved safety and redundancy. The Throttle Position sensor uses a variable resistor to determine signal voltage based on throttle plate position, and is located within the throttle. Less opening results in lower voltage, and greater opening in higher voltage. The TPS value is used by the ECM to determine if the throttle is opening as commanded. This fault will set if voltage is less than 0.2 volts at any operating condition while the engine is cranking or running. Power derate 1 will be enforced limiting the throttle to 50% maximum and low rev limit and forced idle will also be enforced during this fault.

DTC 632 TPS 1 Signal Voltage Low

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in DBW (Drive by Wire) throttle test mode Does the DST display TPS 1 voltage of 0.2 volts or less with the throttle closed		Go to Step (4)	Go to Step (3)
3	• Slowly depress Foot Pedal while observing TPS 1 voltage Does TPS 1 voltage ever fall below 0.2 volts?		Go to Step (4)	Intermittent problem Go to Intermittent section
4	• Key OFF • Disconnect the TPS 1 electrical connector • Jumper the 5 volt reference circuit pin A and TPS 1 signal circuit pin C together at the throttle connector • Key ON Does DST display TPS 1voltage of 4.0 volts or greater?		Go to Step (7)	Go to Step (5)
5	• Key OFF • Disconnect ECM wire harness connector Using a DVOM check continuity between TPS 1 connector signal pin C and ECM connector TPS 1 signal pin 53 Do have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Replace ECM Is the replacement complete?		Go to Step (9)	-
7	• Inspect the throttle wire harness connector terminals for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (8)
8	• Replace the TPS 1 Is the replacement complete?		Go to Step (9)	-

9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-632 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 633-TPS 2 Signal Voltage High



Conditions for Setting the DTC

- Throttle Position Sensor #2
- Check Condition-Cranking or Running
- Fault Condition-TPS 2 sensor exceeds 4.8 volts
- MIL-On during active fault
- Power Derate 1
- Low rev limit 1300 rpm
- Forced idle 700 rpm

Circuit Description

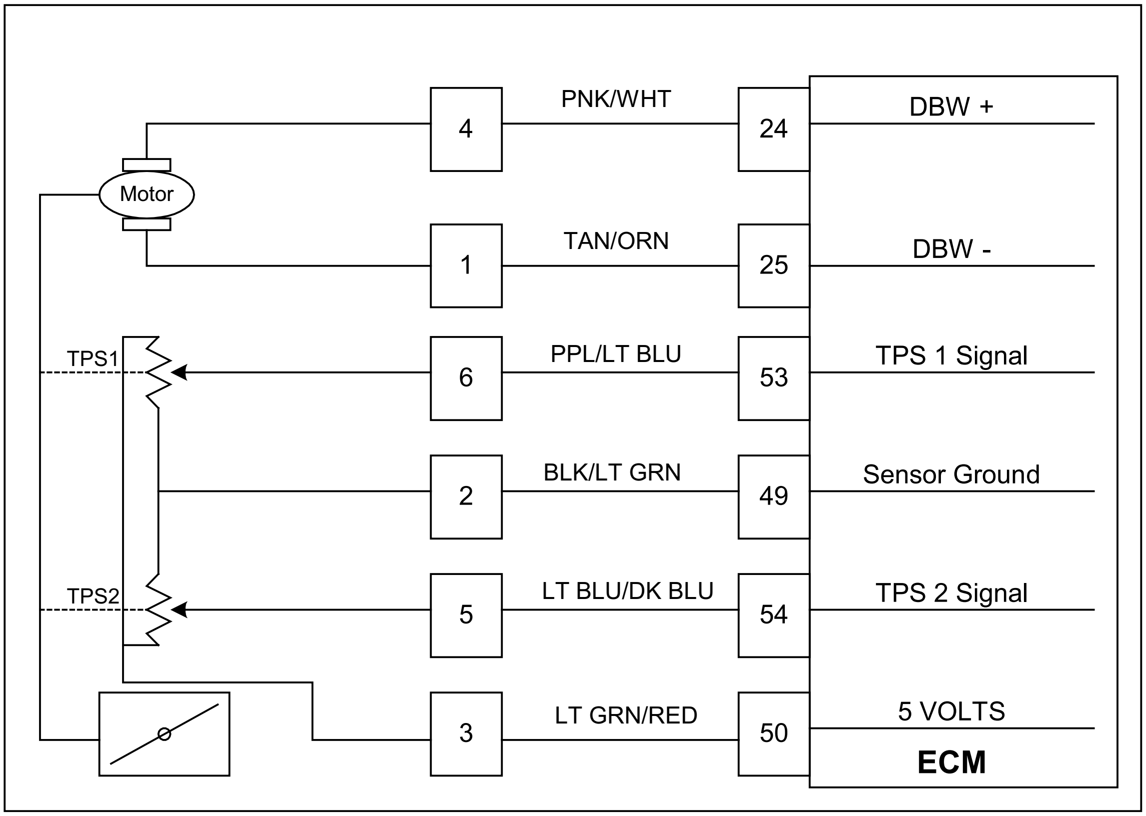
The Electronic Throttle has two counter acting Throttle position Sensors. Two sensors are used for improved safety and redundancy. The Throttle Position sensor (TPS2) uses a variable resistor to determine signal voltage based on throttle plate position, and is located within the throttle. Less opening results in higher voltage and greater opening in lower voltage. The TPS value is used by the ECM to determine if the throttle is opening as commanded. This fault will set if voltage is above 4.8 volts at any operating condition while the engine is cranking or running. Power derate 1 will be enforced limiting the throttle to 50% maximum. Low rev limit and forced idle will also be enforced during this fault.

DTC 633 TPS 2 Signal Voltage High

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in DBW (Drive by Wire) throttle test mode Does the DST display TPS 2 voltage of 4.8 volts or greater with the throttle closed		Go to Step (4)	Go to Step (3)
3	• Slowly depress Foot Pedal while observing TPS 2 voltage Does TPS 2 voltage ever exceed 4.8 volts?		Go to Step (4)	Intermittent problem Go to Intermittent section
4	• Key OFF • Disconnect electronic throttle connector • Key ON Does DST display TPS 2 voltage less than 0.2 volts?		Go to Step (7)	Go to Step (5)
5	• Key OFF • Disconnect ECM wire harness connector C001 • Key ON • Using a DVOM check for voltage between electronic throttle connector TPS 2 signal pin 5 and engine ground Do you have voltage?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (6)
6	• Replace ECM Is the replacement complete?		Go to Step (11)	-
7	• Back probe sensor ground circuit at the ECM side of the wire harness pin 49 with a test light connected to battery voltage Does the test light come on?		Go to Step (8)	Go to Step (10)
8	• Inspect the electronic throttle wire harness connector and terminals for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (9)

9	• Replace electronic throttle Is the replacement complete?		Go to Step (11)	-
10	• Key OFF • Disconnect ECM connector • Using a DVOM check for continuity between throttle connector sensor ground pin 2 and ECM connector sensor ground pin 49 Do have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-633 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 634-TPS 2 Signal Voltage Low



Conditions for Setting the DTC

- Throttle Position Sensor #2
- Check Condition-Cranking or Running
- Fault Condition-TPS 2 sensor voltage less than 0.2
- MIL-On during active fault
- Power Derate 1
- Low rev limit 1300 rpm
- Forced idle 700 rpm

Circuit Description

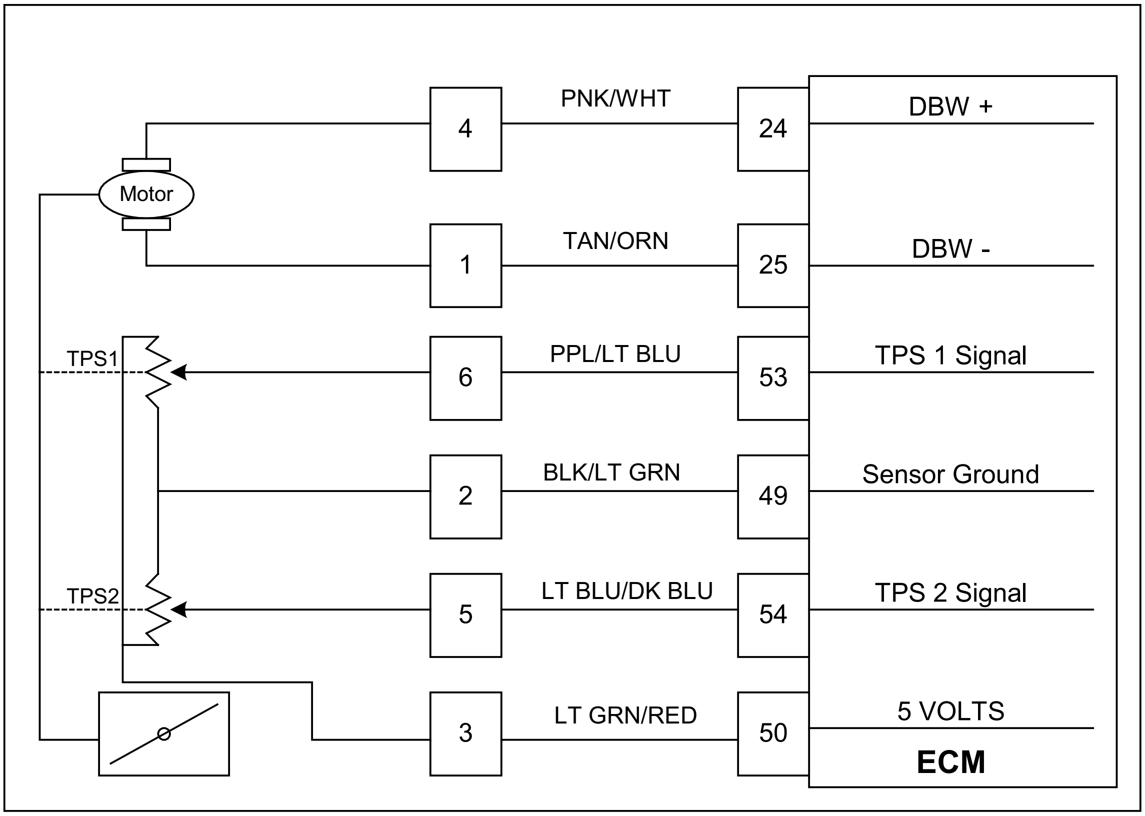
The Electronic Throttle has two counter acting Throttle Position sensors. Two sensors are used for improved safety and redundancy. The Throttle Position Sensor (TPS2) uses a variable resistor to determine signal voltage based on throttle plate position, and is located within the throttle. Less opening results in higher voltage and greater opening in lower voltage. The TPS value is used by the ECM to determine if the throttle is opening as commanded. This fault will set if voltage is below 0.2 volts at any operating condition while the engine is cranking or running. Power derate 1 will be enforced limiting the throttle to 50% maximum. Low rev limit and forced idle will also be enforced during this fault.

DTC 634 TPS 2 Signal Voltage Low

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in DBW (Drive by Wire) throttle test mode Does the DST display TPS 2 voltage of 0.2 volts or less with the throttle closed		Go to Step (4)	Go to Step (3)
3	• Slowly depress Foot Pedal while observing TPS 2 voltage Does TPS 2 voltage ever fall below 0.2 volts?		Go to Step (4)	Intermittent problem Go to Intermittent section
4	• Key OFF • Disconnect electronic throttle connector • Jumper the 5 volt reference circuit and TPS 2 signal circuit together at the throttle connector • Key ON Does DST display TPS 2 voltage of 4.0 volts or greater?		Go to Step (7)	Go to Step (5)
5	• Key OFF • Disconnect ECM wire harness connector Using a DVOM check continuity between TPS 2 connector signal and ECM connector TPS 2 signal terminals Do have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Replace ECM Is the replacement complete?		Go to Step (9)	-
7	• Inspect the throttle wire harness connector terminals for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (8)
8	• Replace throttle Is the replacement complete?		Go to Step (9)	-

9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-634 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 635-TPS1 Higher Than TPS 2



Conditions for Setting the DTC

- Throttle Position Sensor 1 & 2
- Check Condition-Key On
- Fault Condition-TPS1 higher than TPS2
- MIL-On for remainder of key on cycle
- Power Derate 1
- Low rev limit 1300 rpm
- Forced idle 700 rpm

Circuit Description

There are 2 Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS1 will read low voltage when closed and TPS2 will read high voltage when closed. The TPS1 and TPS2 percentages are calculated from these voltages. Although the voltages are different, the calculated values for the throttle position percentages should be very close to the same. The TPS values are used by the ECM to determine if the throttle is opening as commanded. This fault will set if TPS1 is 20% (or more) higher than TPS2. At this point the throttle is considered to be out of specification, or there is a problem with the TPS signal circuit. Power derate 1 will be enforced limiting the throttle to 50% maximum. Low rev limit and forced idle will also be enforced during this fault.

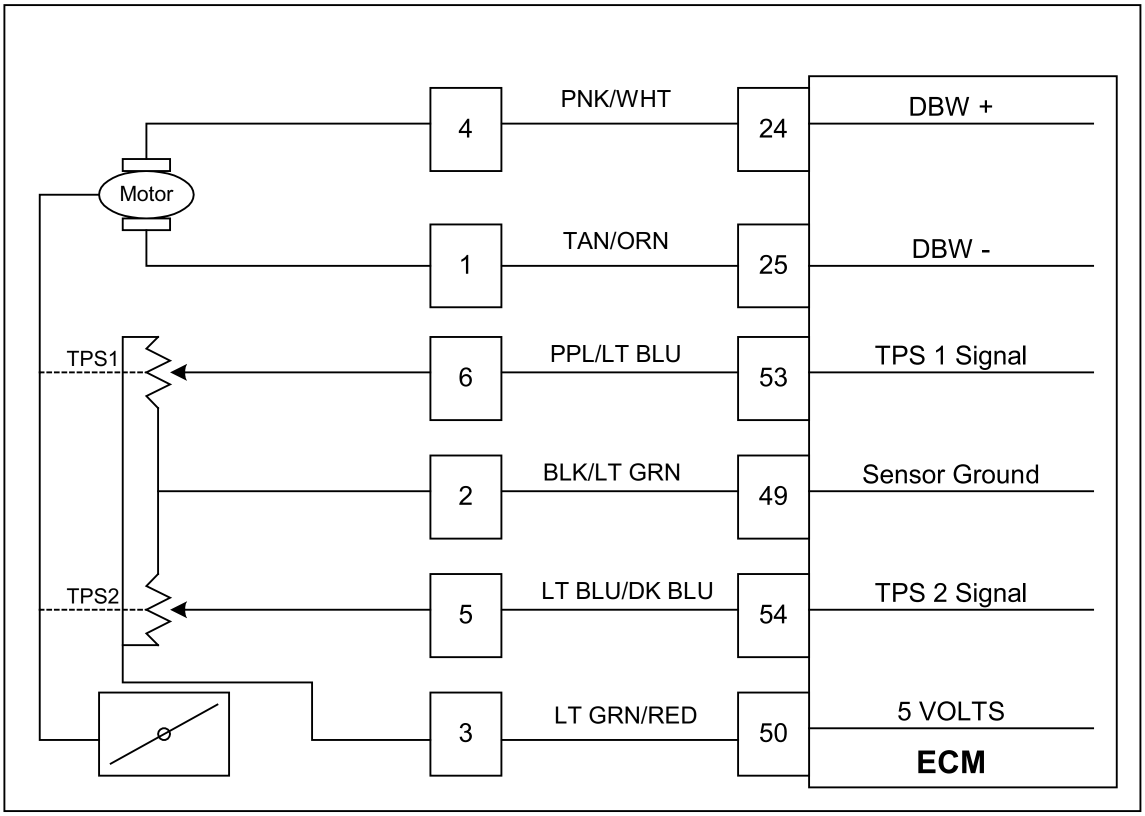
DTC 635 TPS 1 Higher Than TPS 2

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in System Data Mode Does the DST display more than a 20% difference between TPS 1 and TPS 2?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect wiring harness connector to throttle • Key ON • Change DST mode to DBW (drive by wire) test mode Is the voltage for TPS 1 and TPS 2 less than 0.1 volts?		Go to Step (5)	Go to Step (4)
4	• Key OFF • Disconnect ECM wiring harness connector • Key ON • Using a DVOM check for voltage between TPS 1 or TPS 2 (the one that is over 0.1 volts) and engine ground Do you have voltage?		Repair the TPS 1 or TPS 2 circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (13)
5	• Jumper TPS 1 and TPS 2 signal to the 5 volt reference at the throttle connector Does DST display TPS 1 and TPS 2 voltage over 4.95 volts		Go to Step (6)	Go to Step (8)
6	• Inspect wire terminals at throttle connector for damage corrosion or contamination Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)
7	• Replace Throttle Is the replacement complete?		Go to Step (14)	-

8	• Key OFF • Disconnect ECM wire harness connector from ECM • Using a DVOM check for continuity between throttle connector TPS 1 signal and ECM connector TPS 1 signal terminal Do you have continuity between them?		Go to Step (9)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
9	• Using a DVOM check for continuity between throttle connector TPS 2 signal and ECM connector TPS 2 signal terminal Do you have continuity between them?		Go to Step (10)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
10	• Using a DVOM check for continuity between throttle connector TPS 1 signal and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (11)
11	• Using a DVOM check for continuity between throttle connector TPS 2 signal and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (12)
12	• Inspect ECM connector terminals for damage corrosion or contamination. Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical	Go to Step (13)
13	• Replace ECM Is the replacement complete?		Go to Step (14)	-

14	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-635 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 636-TPS1 Lower Than TPS2



Conditions for Setting the DTC

- Throttle Position Sensor 1 & 2
- Check Condition-Key On
- Fault Condition-TPS1 lower than TPS2
- MIL-On for remainder of key on cycle
- Power Derate 1
- Low rev limit 1300 rpm
- Forced idle 700 rpm

Circuit description

There are 2 Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS1 will read low voltage when closed and TPS2 will read high voltage when closed. The TPS1 and TPS2 percentages are calculated from these voltages. Although the voltages are different, the calculated values for the throttle position percentages should be very close to the same. The TPS values are used by the ECM to determine if the throttle is opening as commanded. This fault will set if TPS1 is 20% (or more) lower than TPS2. At this point the throttle is considered to be out of specification, or there is a problem with the TPS signal circuit. Power derate 1 will be enforced limiting the throttle to 50% maximum. Low rev limit and forced idle will also be enforced during this fault.

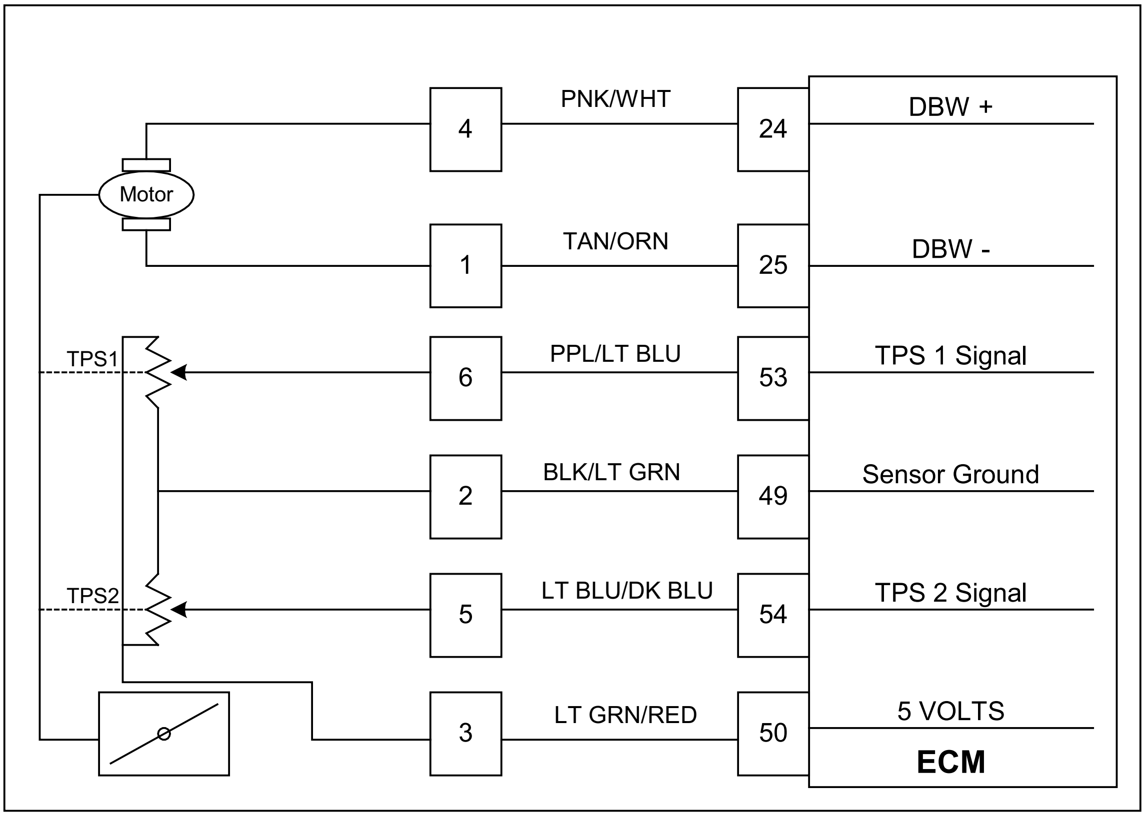
DTC 636 TPS 1 Lower Than TPS 2

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in System Data Mode Does the DST display more than a 20% difference between TPS 1 and TPS 2?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect wiring harness connector to throttle • Key ON • Change DST mode to DBW (drive by wire) test mode Is the voltage for TPS 1 and TPS 2 less than 0.1 volts?		Go to Step (5)	Go to Step (4)
4	• Key OFF • Disconnect ECM wiring harness connector • Key ON • Using a DVOM check for voltage between TPS 1 or TPS 2 (the one that is over 0.1 volts) and engine ground Do you have voltage?		Repair the TPS 1 or TPS 2 circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (13)
5	• Jumper TPS 1 and TPS 2 signal to the 5 volt reference at the throttle connector Does DST display TPS 1 and TPS 2 voltage over 4.95 volts		Go to Step (6)	Go to Step (8)
6	• Inspect wire terminals at throttle connector for damage corrosion or contamination Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)
7	• Replace Throttle Is the replacement complete?		Go to Step (14)	-

8	• Key OFF • Disconnect ECM wire harness connector from ECM • Using a DVOM check for continuity between throttle connector TPS 1 signal and ECM connector TPS 1 signal terminal Do you have continuity between them?		Go to Step (9)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
9	• Using a DVOM check for continuity between throttle connector TPS 2 signal and ECM connector TPS 2 signal terminal Do you have continuity between them?		Go to Step (10)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
10	• Using a DVOM check for continuity between throttle connector TPS 1 signal and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (11)
11	• Using a DVOM check for continuity between throttle connector TPS 2 signal and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (12)
12	• Inspect ECM connector terminals for damage corrosion or contamination. Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical	Go to Step (13)
13	• Replace ECM Is the replacement complete?		Go to Step (14)	-

14	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-636 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 637-Throttle Unable To Open



Conditions for Setting the DTC

- Throttle Position Sensor
- Check Condition-Cranking or Running
- Fault Condition-Throttle command is 20% more than throttle position
- MIL-On during active fault
- Engine Shut Down

Circuit Description

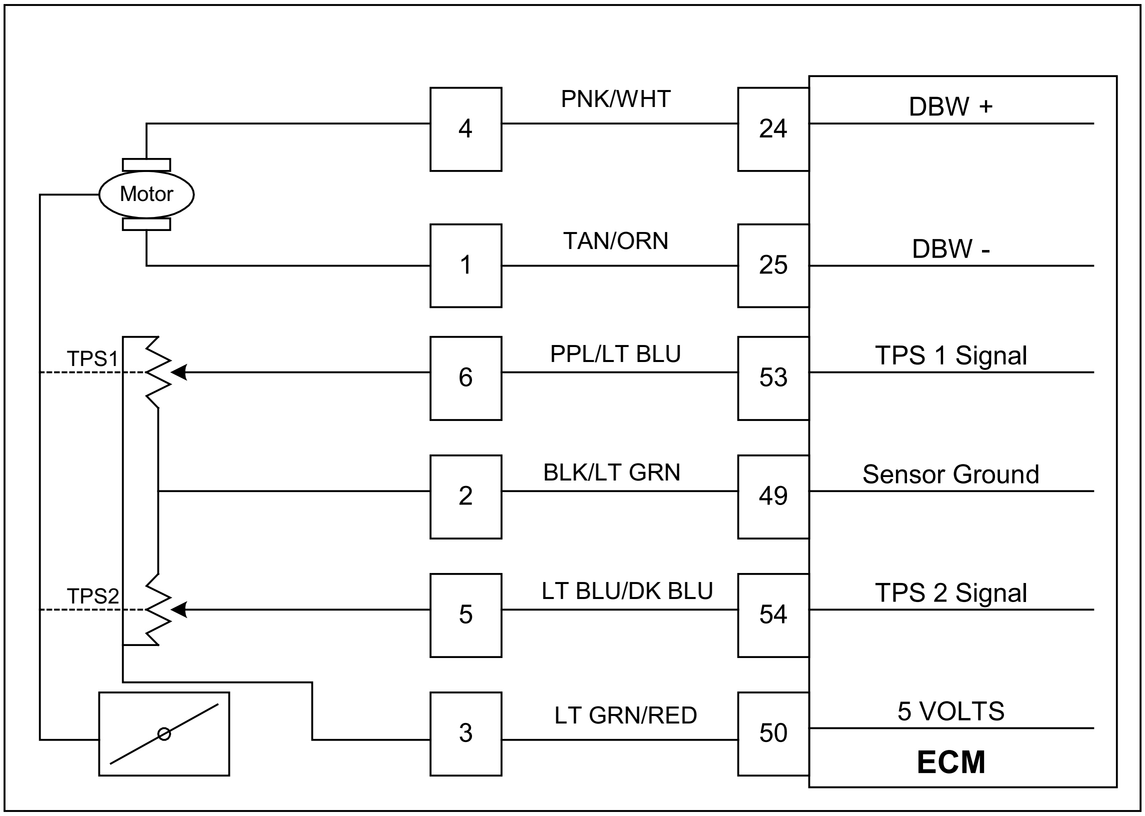
There are 2 Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS1 will read low voltage when closed and TPS2 will read high voltage when closed. The TPS1 and TPS2 percentages are calculated from these voltages. Although the voltages are different, the calculated values for the throttle position percentages should be very close to the same. The TPS values are used by the ECM to determine if the throttle is opening as commanded. This fault will set if the throttle command is 20% or more than the actual throttle position. During this active fault the MIL light will turn on and the engine will shut down.

DTC 637 Throttle Unable to Open

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in DBW (Drive By Wire) test mode • Depress Foot Pedal until theThrottle Command is 63%-68% Is the TPS voltage less than 2.0 volts?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect wire harness connector from throttle • Probe TPS 1 signal circuit with test light connected to battery voltage • Key ON Is TPS voltage 4.0 volts or greater?		Go to Step (4)	Go to Step (8)
4	• Check throttle bore for foreign object Did you find a problem?		Go to Step (5)	Go to step (6)
5	• Remove the foreign object Has the object been removed?		Go to Step (11)	-
6	• Check throttle connector terminals for damage corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)
7	• Replace throttle Is the replacement complete?		Go to Step (11)	-
8	• Key OFF • Disconnect ECM wire harness connector • Using a DVOM check for continuity between throttle connector TPS 1 signal terminal and ECM TPS 1 signal terminal Do you have continuity between them?		Go to Step (9)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

9	• Using a DVOM check for continuity between throttle connector TPS 1 signal and engine ground Do you have continuity between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (10)
10	• Replace ECM Is the replacement complete?		Go to step (11)	-
11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-637 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 638-Throttle Unable To Close



Conditions for Setting the DTC

- Throttle Position Sensor
- Check Condition-Cranking or Running
- Fault Condition-Throttle position is 20% greater than throttle command
- MIL-On during active fault
- Engine Shut Down

Circuit Description

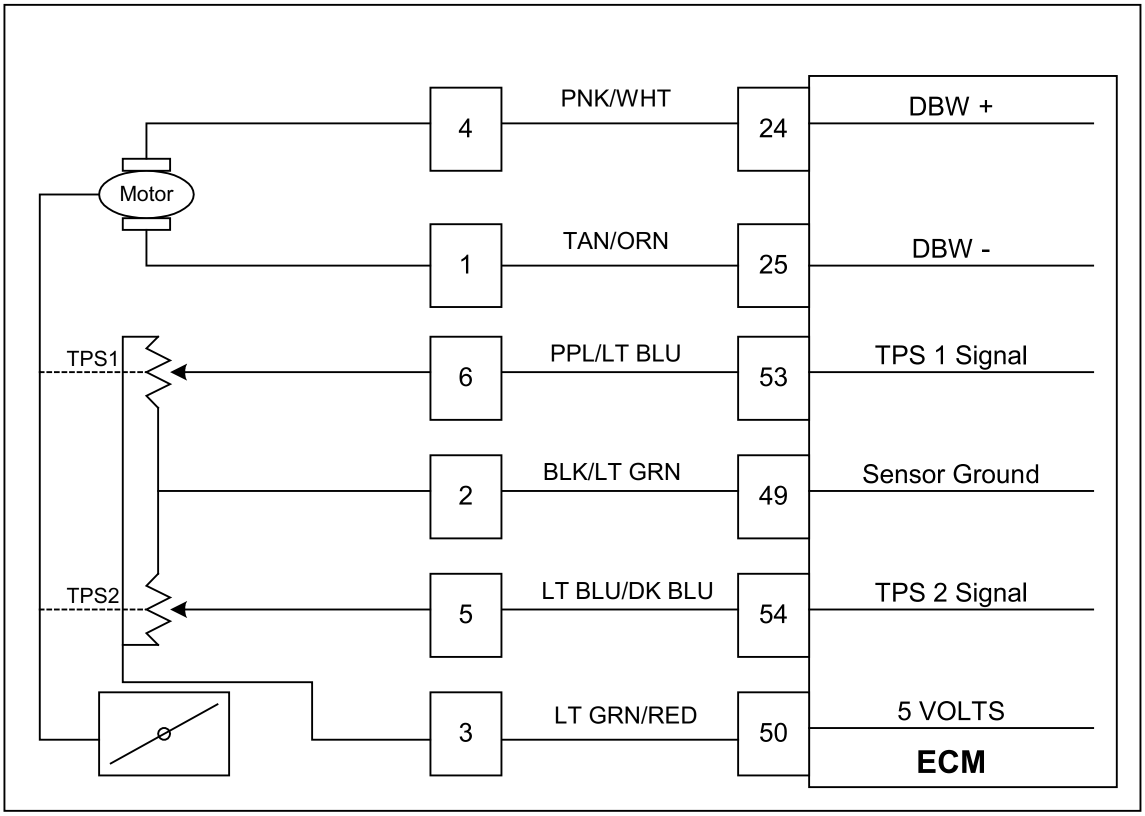
There are 2 Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS1 will read low voltage when closed and TPS2 will read high voltage when closed. The TPS1 and TPS2 percentages are calculated from these voltages. Although the voltages are different, the calculated values for the throttle position percentages should be very close to the same. The TPS values are used by the ECM to determine if the throttle is opening as commanded. This fault will set if the throttle command is 20% less than the actual throttle position. During this active fault the MIL light will turn on and the engine will shut down.

DTC 638 Throttle Unable to Close

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in DBW (Drive By Wire) test mode • Depress Foot Pedal until theThrottle Command is between 63%-68% Is the TPS 1 voltage greater than 2.0 volts?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect wire harness connector from throttle • Probe TPS 1 signal circuit with test light connected to battery voltage • Key ON Does DST display TPS 1 voltage less than 0.2 volts		Go to Step (6)	Go to Step (4)
4	• Key OFF • Disconnect ECM wire harness connector • Key ON • Using a DVOM check for voltage between throttle connector signal terminal and engine ground Do you have voltage?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (5)
5	• Replace ECM Is the replacement complete?		Go to Step (13)	-
6	• Back probe sensor ground circuit at ECM connector with test light connected to battery voltage Does the test light come on?		Go to Step (9)	Go to Step (7)
7	• Key OFF • Disconnect ECM wire harness connector • Using a DVOM check for continuity between throttle connector signal ground and ECM signal ground circuit terminals Do you have continuity between them?		Go to Step (8)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
8	• Replace ECM • Is the replacement complete?		Go to Step (13)	-

9	• Check throttle for foreign object in bore Did you find a foreign object in the bore?		Go to Step (10)	Go to Step (11)
10	• Remove foreign object Is the removal complete?		Go to Step (13)	-
11	• Inspect the throttle wire harness connector terminals for damage, corrosion or contamination Did you find the problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (12)
12	• Replace throttle Is the replacement complete?		Go to Step (13)	-
13	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-638 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 651-Max Govern Speed Override



Conditions for Setting the DTC

- Max Govern Speed Override
- Check Condition- Engine Running
- Fault Condition- Engine RPM greater than 3800 for 2 seconds continuously
- MIL- On during active fault
- Adaptive- Enabled
- Closed Loop- Enabled

Circuit description

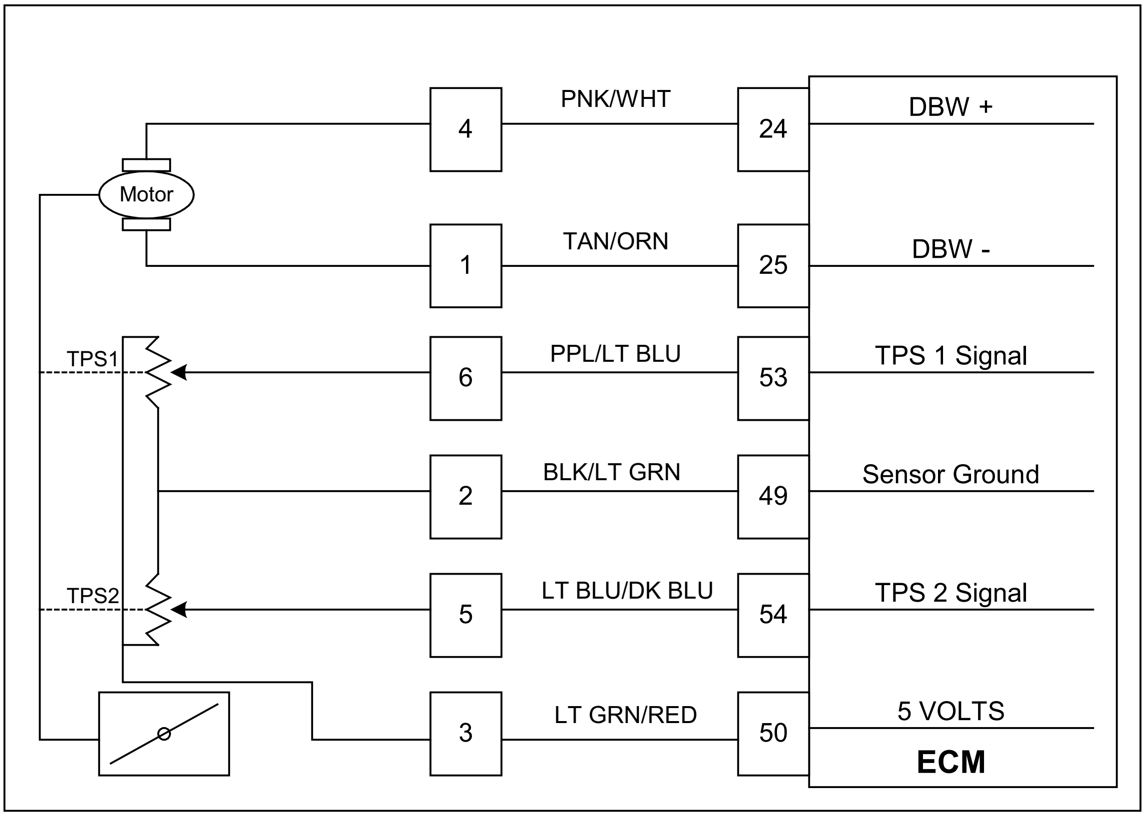
This fault will set anytime the engine RPM exceeds 3800 for 2 seconds or more continuously. This speed overrides any higher max governor speeds programmed by the user. This is to help prevent engine or equipment damage. The MIL will be on during this active fault.

DTC 651 Max Govern Speed Override

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST in Active Fault Mode Are any other DTC codes present with DTC 651?		Go to Step (3)	Go to Step (4)
3	• Diagnose any other DTC codes before proceeding with this chart. Have any other DTC codes been diagnosed and repaired?		Go to step (4)	-
4	• Check the Service Part Number on the ECM to ensure correct calibration is in use Is the Service Part Number Correct?		Go to Step (6)	Go to Step 5
5	• Replace ECM with correct Service Part Number Is the replacement complete?		Go to Step (9)	-
6	• Check the mechanical operation of the throttle Is the mechanical operation of the throttle OK?		Go to Step (8)	Go to Step (7)
7	• Correct mechanical operation of the throttle. Refer to Engine & Component R&R Section 1E Has the mechanical operation of the throttle been corrected?		Go to step (9)	-
8	• Check engine for large manifold vacuum leaks. Refer to Fuel Systems Section 1B Symptom Diagnostics Did you find and correct the vacuum leak?		Go to Step (9)	Go to OBD System Check Section

9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-651 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 652-Fuel Rev Limit



Conditions for Setting the DTC

- Fuel Rev Limit
- Check Condition- Engine Running
- Fault Condition- Engine RPM greater than 4000 for 2 seconds continuously
- MIL- On during active fault
- Adaptive- Enabled
- Closed Loop- Enabled

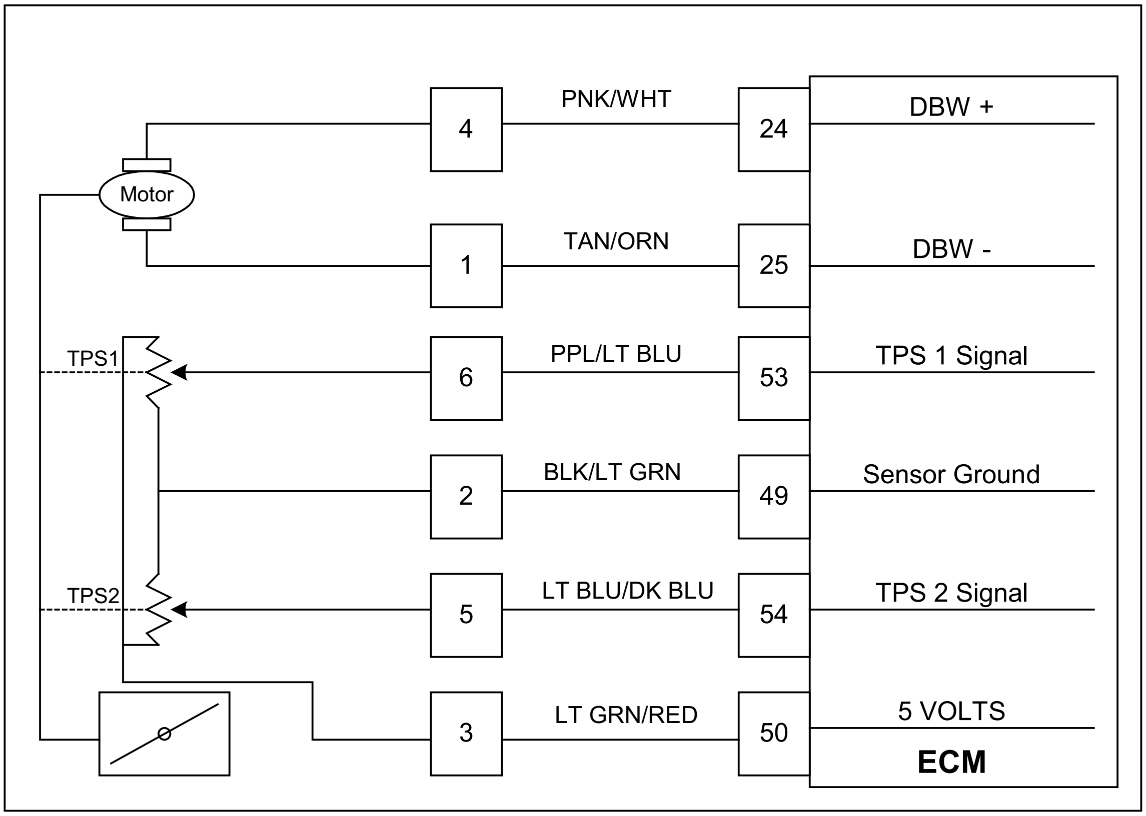
Circuit Description

This fault will set anytime engine RPM exceeds 4000 for 2 seconds or more continuously. When these conditions are met, the ECM shuts off the fuel injectors. This is to help prevent engine or equipment damage. The MIL will be on during this active fault.

DTC 652 Fuel Rev Limit

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST in Active Fault Mode Are any other DTC codes present with DTC 651?		Go to Step (3)	Go to Step (4)
3	• Diagnose any other DTC codes before proceeding with this chart. Have any other DTC codes been diagnosed and repaired?		Go to step (4)	-
4	• Check the Service Part Number on the ECM to ensure correct calibration is in use Is the Service Part Number Correct?		Go to Step (6)	Go to Step 5
5	• Replace ECM with correct Service Part Number Is the replacement complete?		Go to Step (9)	-
6	• Check the mechanical operation of the throttle Is the mechanical operation of the throttle OK?		Go to Step (8)	Go to Step (7)
7	• Correct mechanical operation of the throttle. Refer to Engine & Component R&R Section 1E Has the mechanical operation of the throttle been corrected?		Go to step (9)	-
8	• Check engine for large manifold vacuum leaks. Refer to Fuel Systems Section 1B Symptom Diagnostics Did you find and correct the vacuum leak?		Go to Step (9)	Go to OBD System Check Section

DTC 653-Spark Rev Limit



Conditions for Setting the DTC

- Spark Rev Limit
- Check Condition- Engine running
- Fault Condition- Engine RPM greater than 4100
- MIL- On during active fault
- Adaptive- Enabled
- Closed Loop- Enabled
- Engine Shut Down

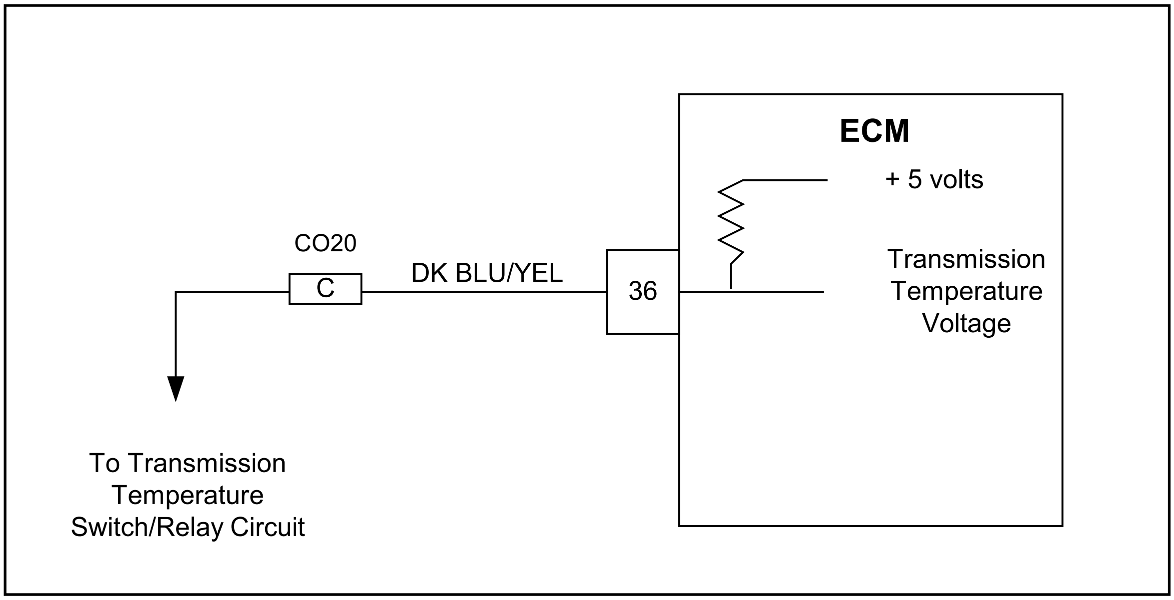
Circuit description

This fault will set anytime the engine RPM exceeds 4100 for 2 seconds or more continuously. When these conditions are met, the ECM will shut off spark to the engine. This is to help prevent engine or equipment damage. The MIL will be on during this active fault and the engine will shut down.

DTC 653 Spark Rev Limit

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST in Active Fault Mode Are any other DTC codes present with DTC 651?		Go to Step (3)	Go to Step (4)
3	• Diagnose any other DTC codes before proceeding with this chart. Have any other DTC codes been diagnosed and repaired?		Go to step (4)	-
4	• Check the Service Part Number on the ECM to ensure correct calibration is in use Is the Service Part Number Correct?		Go to Step (6)	Go to Step 5
5	• Replace ECM with correct Service Part Number Is the replacement complete?		Go to Step (9)	-
6	• Check the mechanical operation of the throttle Is the mechanical operation of the throttle OK?		Go to Step (8)	Go to Step (7)
7	• Correct mechanical operation of the throttle. Refer to Engine & Component R&R Section 1E Has the mechanical operation of the throttle been corrected?		Go to step (9)	-
8	• Check engine for large manifold vacuum leaks. Refer to Fuel Systems Section 1B Symptom Diagnostics Did you find and correct the vacuum leak?		Go to Step (9)	Go to OBD System Check Section

DTC 721-Transmission Over Temperature



Conditions for Setting the DTC

- Check Condition-Engine running
- Transmission Temperature High
- Fault Condition- closed circuit/voltage low
- MIL-On during active fault
- Power Derate 2

Circuit Description

The transmission temperature switch is used to communicate a high temperature condition to the ECM. Transmission damage can occur if the transmission is operated at high temperature. The ECM uses an analog voltage input with an internal 5 volt reference. If the transmission temperature circuit is grounded, the input voltage will be near zero. If it is open the input will be near 5 volts. The temperature switch is normally open and should close at 122C and remain closed until the temperature drops to 115C. The fault will set if the switch becomes closed with the engine running for longer than 10 seconds. Power derate 2 will be enforced to a maximum throttle position of 20%.

Diagnostic Aids

Before performing any electrical diagnostics be sure to check the transmission fluid levels and cooling systems for proper operation. Also verify that the truck is being operated to the manufactures specifications in regards to load, speed and environmental conditions. Failure to follow this recommendation may result in a false DTC diagnosis.

DTC 721- Transmission Over Temperature

Step	Action	Value(s)	Yes	No
1	Did you perform the On Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	Did you perform the Diagnostic Aids check for DTC 721?		Go to step (3)	Perform the Diagnostic Aids check for DTC 721
3	• Key Off • Disconnect ECM connector C001 • Disconnect transmission temperature switch connector CO20 • Using a high impedance DVOM check for continuity between ECM pin 36 and engine ground Do you have continuity?		Repair the shorted circuit to ground as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (4)
4	• Verify transmission relay lamp circuit is in proper working order and not shorted to ground. Is the transmission relay lamp circuit ok?		Go to Step (5)	Repair the circuit as required. See chassis electrical system section.
5	• Replace transmission temperature switch Is the replacement complete?		Go to Step (6)	-

6	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature, running the transmission to similar conditions where the DTC 721 previously set. • Observe the MIL • Observe engine performance and drive ability • After operating the engine within the test parameters of DTC-721 check for any stored codes. Does the engine operate normally without setting DTC 721?		System OK	Go to Step (7)
7	• Replace the ECM Is the replacement complete?		Go to Step (8)	-
8	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature, running the transmission to similar conditions where the DTC 721 previously set. • Observe the MIL • Observe engine performance and drive ability • After operating the engine within the test parameters of DTC-721 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

SECTION 1E1
FUEL SYSTEM

REPAIR INSTRUCTIONS

PROPANE FUEL SYSTEM PRESSURE RELIEF

⚠ WARNING

The propane fuel system operates at pressures up to 21.5 BAR (312 psi). To minimize the risk of fire and personal injury, relieve the propane fuel system pressure (where applicable) before servicing the propane fuel system components.

To relieve propane fuel system pressure:

1.Close the manual shut-off valve (MSV) on the propane fuel tank.

2.Start and run the vehicle until the engine stalls.

3.Turn the ignition switch OFF.

⚠ WARNING

Residual vapor pressure will be present in the fuel system. Ensure the work area is well ventilated before disconnecting any fuel line.

PROPANE FUEL SYSTEM LEAK TEST

⚠ WARNING

Never use an open flame of any type to check for propane fuel system leaks.

Always inspect the propane fuel system for leaks after performing service. Check for leaks at the fittings of the serviced or replaced component. Use a commercially available liquid leak detector or an electronic leak detector. When using both methods, use the electronic leak detector first to avoid contamination by the liquid leak detector.

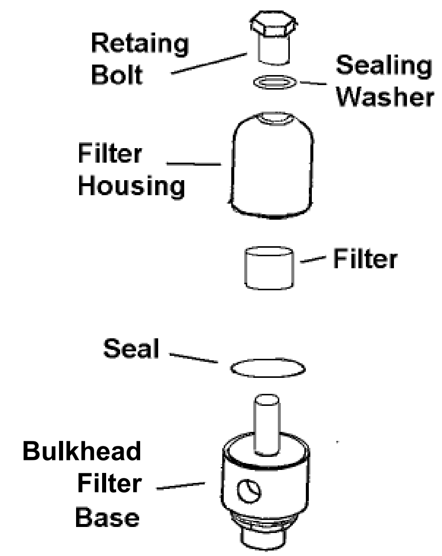


Figure 1 Fuel Filter

PROPANE FUEL FILTER REPLACEMENT (Figure 1)

Removal Procedure

1. Relieve the propane fuel system pressure. Refer to Propane Fuel System Pressure Relief.
2. Disconnect the negative battery cable.
3. Slow loosen the fuel inlet hose fitting to relieve any residual fuel pressure.
4. Remove the filter housing retaining bolt and sealing washer discard washer.
5. Remove the filter housing from the bulkhead filter base discard the filter and the sealing ring.
6. Clean and inspect the filter base for any debris.

Installation Procedure

NOTE

Be sure to install new sealing washer and seals

Do Not use Teflon tape on the pipe fittings use only a liquid pipe sealant

7. Install the housing seal to the bulkhead base.

8. Install the filter to the bulkhead base.
9. Install the filter housing to the bulkhead base.
10. Install sealing washer and retaining bolt and tighten to specification.

    Tighten
    27 Nm (20 ft lbs)
11. Tighten the fuel inlet hose fitting to specification.

    Tighten
    27 Nm (20 ft lbs)
12. Reconnect the negative battery cable.
13. Open manual shut-off valve.
14. Start the vehicle and leak check the propane fuel system at each serviced fitting Refer to *Propane Fuel System Leak Test.*

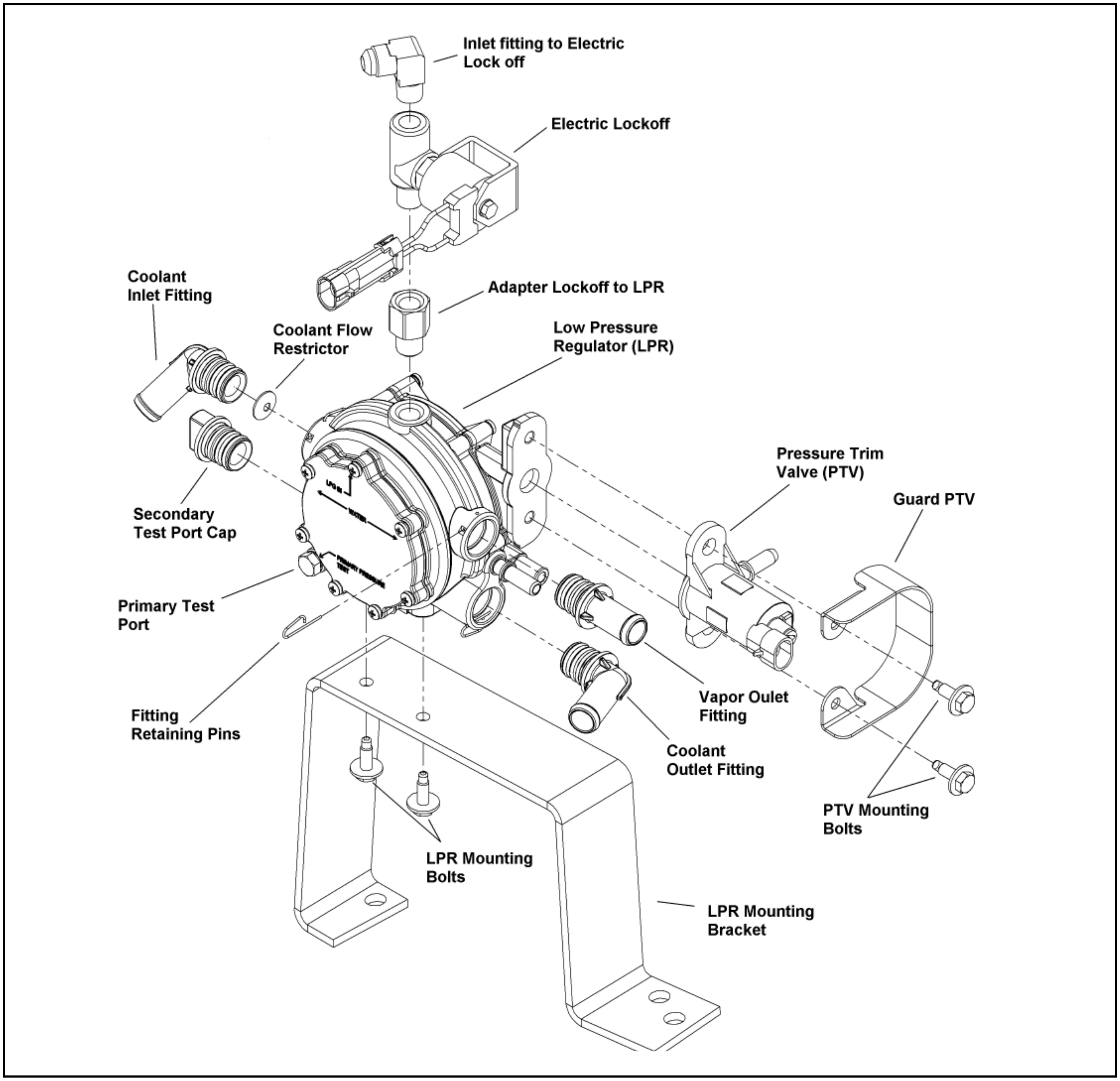


Figure 2 Low Pressure Regulator

LOW PRESSURE LOCK-OFF (LPL)

REPLACEMENT
(Figure 2)

Removal Procedure

1. Relieve the propane fuel system pressure. Refer to *Propane Fuel System Pressure Relief.*
2. Disconnect the negative battery cable.
3. Disconnect the LPL electrical connector.
4. Disconnect the LPG fuel inlet line from the LPL inlet fitting.
5. Unscrew the LPL from the LPR inlet fitting.

Installation Procedure

NOTE

Do not use Teflon tape on any fuel fitting. Use a liquid pipe thread sealant when installing fittings.

6. Apply pipe thread sealant to the LPR inlet fitting.
7. Install the LPL to the LPR. Tighten the LPL finger tight plus 1 to 2 turns and place the LPL in the correct position.
8. Install the fuel inlet line.
9. Tighten the fuel line fitting to the LPL

   Tighten
   27 Nm (20 ft lbs)

10. Connect the LPL electrical connector.
11. Connect the negative battery cable.
12. Slowly open the tank manual shut off valve.
13. Start the vehicle and leak check the propane fuel system at each serviced fitting.

PRESSURE TRIM VALVE (PTV) REPLACEMENT
(Figure 2)

1. Disconnect the PTV electrical connection.
2. Remove the vacuum hose from the PTV.
3. Remove and retain the two (2) retaining bolts and PTV guard.
4. Remove the PTV.

Installation Procedure

NOTE

Apply a small amount of O-ring lubricant to the PTV O-ring before installation

5. Install the PTV and guard using the two mounting bolts.
6. Tighten retaining bolts.

   Tighten
   9 N•m (80 lb-in)

7. Connect the PTV vacuum line.
8. Connect the PTV electrical connector.
9. Start the vehicle.
10. Connect the diagnostic service tool and verify the engine is operating in closed loop and no MIL light is present.

LOW PRESSURE REGULATOR (LPR) REPLACEMENT
(Figure 2)

Removal Procedure

1. Relieve the propane fuel system pressure. Refer to *Propane Fuel System Pressure Relief.*
2. Disconnect the negative battery cable.
3. Clamp the coolant hoses to the LPR or drain the radiator.
4. Remove the LPL. Refer to *Low Pressure Lock-off Replacement.*
5. Remove the PTV Refer to *Pressure Trim Valve Replacement.*
6. Disconnect the supply and return coolant lines from the LPR.
7. Remove the retaining pin from the water inlet and outlet fittings and retain
8. Remove the coolant inlet and outlet fitting retaining pins and retain.

9. Remove the outlet fitting locate the orifice in the housing or attached to the fitting and retain.
10. Remove the inlet fitting retain.
11. Disconnect the FTV supply line.
12. Remove the two LPR mounting bolts and retain.
13. Lift LPR assembly and remove.
14. Loosen the fuel vapor hose clamp at the LPR fuel outlet fitting.
15. Disconnect the fuel vapor hose from the LPR outlet fitting and remove the LPR.
16. Remove the retaining pin from the vapor outlet fitting and retain.
17. Remove and retain the vapor outlet fitting from the LPR.
18. Remove the LPR.

Installation Procedure

⚠ **CAUTION**

Do not use Teflon tape on any fuel fitting. Use a liquid pipe thread sealant when installing fittings.

Lubricate the o-ring of the PTV before installing into the LPR.

Lubricate the o-rings on each of the fitting.

Be sure to reinstall regulator coolant line orifice into the outlet side of the LPR before installing the coolant line hose fitting.

19. Install the outlet water fitting insure orifice is in place and secure with retaining pin.
20. Install the inlet water fitting and secure with retaining pin.
21. Install vapor outlet fitting and secure with retaining pin.
22. Insert the vapor hose to the fuel outlet fitting and place clamp.
23. Install the FTV supply line and secure.
24. Secure the LPR to the mounting bracket using the two (2) retaining bolts and tighten to specification.

    Tighten
    14 Nm (10 ft lbs)
25. Install the water inlet line to the fittings and place clamps.
26. Install the water outlet line to the fittings and place clamps.
27. Install LPL. Refer to *Low Pressure Lock-off Replacement.*
28. Install the PTV Refer to *Pressure Trim Valve Replacement.*
29. Tighten fuel line fitting.

    Tighten
    27 Nm (20 ft lbs)
30. Replace the drained coolant.
31. Start the vehicle and leak check the propane fuel system at each serviced fitting.
32. Connect the diagnostic service tool and verify the engine is operating in closed loop and no MIL light is present.

FUEL TRIM VALVE (FTV) SOLENOID REPLACEMENT
(Figure 3)

Removal Procedure

1. Disconnect the FTV electrical connection.
2. Remove the fuel supply hose from the FTV.
3. Remove the two (2) retaining bolts and retain.
4. Remove the FTV.

Installation Procedure

NOTE

Apply a small amount of O-ring lubricant to the PTV o-ring before installation

5. Install FTV to the throttle body
6. Install the and two bolts
7. Tighten retaining bolts

    Tighten
    9 N•m (80 lb-in)
8. Connect Fuel supply hose.

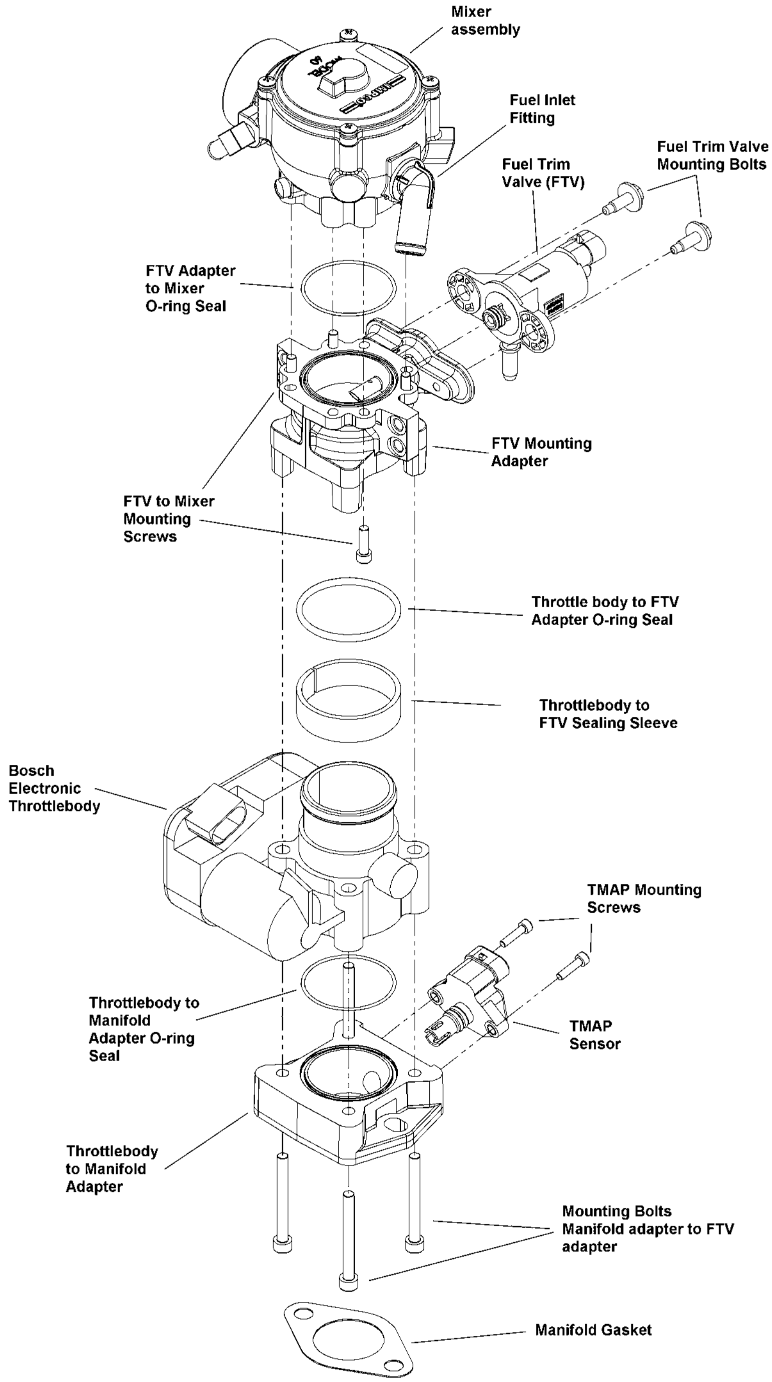


Figure 3 Mixer Assembly

9. Connect electrical connection.
10. Start the vehicle.
11. Connect the diagnostic service tool and verify the engine is operating in closed loop and no MIL light is present.

TEMPERATURE MANIFOLD ABSOLUTE PRESSURE (TMAP)
(Figure 3)

Removal Procedure

1. Disconnect the TMAP electrical connector.
2. Remove the two retaining bolts.
3. Remove the TMAP.

Installation Procedure

- Apply a small amount of O-ring lubricant to the TMAP o-ring before installation.

4. Install the TMAP.
5. Tighten retaining bolts.

   Tighten
   7 N•m (62 lb-in)

6. Connect the TMAP electrical connection.
7. Start engine.

THROTTLE BODY ASSEMBLY REPLACEMENT
(Figure 3)

Removal Procedure

1. Disconnect the negative battery cable.
2. Remove the air intake duct.
3. Disconnect the electronic throttle electrical connector.
4. Disconnect the FTV supply line.
5. Disconnect the PTV vacuum line.
6. Disconnect the balance line to the LPR.
7. Release mixer fuel inlet hose clamp and remove hose from mixer inlet.
8. Remove the two (2) manifold retaining and remove the throttle body assembly.
9. Remove gasket, and discard .
10. Remove the four (4) throttle body to adapter bolts and retain.
11. Remove the throttle body from the FTV adapter.
12. Remove the O-ring gasket and discard.

Installation Procedure

NOTE

Lightly Lubricate the both the o-rings of the electronic throttle control device to manifold adapter and FTV adapter.

Cover Throttle body adapter opening to prevent debris from entering engine until reassembly.

13. Install both the o-ring and sleeve to the throttle body.
14. Insert the throttle body to the FTV adapter.
15. Install the adapter O-ring seal.
16. Install throttle body assembly to the throttle body to manifold adapter and secure with four (4) screws.

    Tighten
    9 N•m (80 lb-in)

17. Install the manifold gasket.
18. Secure the assembly with the two (2) retaining bolts.

    Tighten
    12 N•m (106 lb-in)

19. Install balance line to the LPR.
20. Install the PTV vacuum line.
21. Install the fuel supply line to the FTV.
22. Install fuel supply line to the mixer and reset clamp.
23. Connect the FTV electrical connector.
24. Connect the electronic throttle body electrical connection.
25. Connect the air inlet duct.
26. Start engine.
27. Start the vehicle and leak check the propane fuel system at each serviced fitting.
28. Connect the diagnostic service tool and verify system is operating closed loop and no MIL light is present.

MIXER REPLACEMENT

Figure 3

Removal Procedure

1. Disconnect the negative battery cable.
2. Remove the air intake duct.
3. Remove the Throttle body assembly *Refer to Throttle Body Assembly Replacement.*
4. Remove the four (4) screws in the throttle body to FTV adapter and retain.
5. Remove and discard the mixer to FTV adapter O-ring.

Installation Procedure

NOTE

Lightly Lubricate the o-ring of the Mixer to FTV adapter before installing

Cover Throttle body adapter opening to prevent debris from entering engine until reassembly

1. Install Mixer to FTV adapter and secure with the four (4) screws.

   Tighten
   9 N•m (80 lb-in)

2. Install Throttle body Refer to Electronic Throttle Body Assembly Replacement.

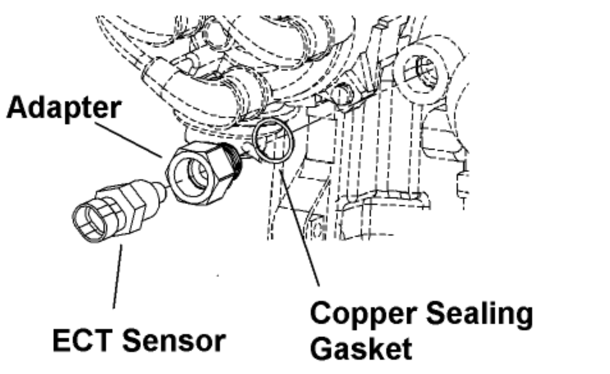


FIGURE 4

ENGINE COOLANT TEMPERATURE SENSOR REPLACEMENT

Figure 4

1. Disconnect the ECT electrical connect.
2. Remove ECT from the adapter, do not remove the adapter.
3. Remove the ECT and discard.

Installation Procedure

- If the ECT adapter to the block is removed locate the brass washer and replace.
- If the ECT adapter is replaced with a new adapter **remove the O-ring supplied with the adapter** before installing the brass sealing washer.

4. Apply liquid pipe sealant to the ECT.
5. Install the ECT to the adapter and tighten to finger tight.
6. Tighten to specification.

   Tighten
   1 to 2 turns after finger tight

COOLANT HOSE REPLACEMENT

1. Drain coolant.
2. Using a hose clamp pliers disconnect both hose clamps on each hose.
3. Remove the coolant inlet hose form each fitting.
4. Remove the coolant outlet hose.

Installation Procedure

⚠ CAUTION

Coolant hose are specifically designed, DO NOT use hose material or length other than the OEM specified parts.

DO NOT mix the inlet or outlet hoses when re-installing.

1. Install hose clamps and set back on each hose.
2. Reinstall the coolant inlet hose to each fitting.
3. Reinstall the coolant outlet hose to each fitting.

4. Reset clamps.
5. Refill with coolant.
6. Start engine and check for coolant leaks.

VAPOR HOSE REPLACEMENT

1. Using a hose clamp pliers disconnect both hose clamps.
2. Remove the vapor hose form each fitting.

Installation Procedure

NOTE

Vapor supply hose is specifically designed, DO NOT use hose material or length other than the OEM specified parts.

3. Install hose clamps and set back on each hose.
4. Reinstall the vapor hose to each fitting.
5. Reset clamps.
6. Start engine and check for leaks.

BALANCE LINE HOSE REPLACEMENT

1. Remove the clamp to the fitting at the mixer.
2. Remove small hose to check valve.
3. Remove and retain check valve.
4. Remove clamp at the LPR connection.

Installation Procedure

⚠ CAUTION

Balance line hoses are specifically designed, DO NOT use hose material or length other than the OEM specified parts.

DO NOT mix the hoses when reinstalling.

Install check valve in correct direction. (Arrow on check valve pointing toward mixer).

7. Install hose clamps and set back on each hose.
8. Reinstall the LPR hose end to the LPR fitting and set clamp.
9. Install Check valve and set clamp. (Directional part arrow pointing to mixer).
10. Reinstall the small hose section and set clamps.
11. Start engine and check for leaks.

PTV HOSE REPLACEMENT

1. Using a hose clamp pliers disconnect the clamps on the hose fitting at the mixer.
2. Using a small screw driver push locking clip back on PTV connection.
3. Remove the hose and discard.

Installation Procedure

⚠ CAUTION

PTV hoses are specifically designed, DO NOT use hose material or length other than the OEM specified parts

4. Install hose clamps and set back on the mixer hose end.
5. Reinstall hose at the PTV and push lock in place.
6. Reinstall hose at the mixer and set clamp.
7. Start engine and check for leaks.

FTV HOSE REPLACEMENT

1. Using a small screw driver push locking clips back on FTV connection at FTV and LPR.
2. Remove the hose and discard.

Installation Procedure

⚠ CAUTION

FTV hoses are specifically designed, DO NOT use hose material or length other than the OEM specified parts

3. Reinstall hose at the FTV and LPR and push locks in place.
4. Start engine and check for leaks.

ENGINE CONTROL MODULE REPLACEMENT

1. Disconnect Negative battery cable.
2. Remove controller from mounting bracket.
3. Push connector lock back to unlock connector.
4. Unplug controller and remove.

Installation Procedure

NOTE

Controller is calibrated for each engine verify you have the correct controller

.

5. Plug connector into controller.
6. Push lock into place.
7. Mount controller into mounting bracket.
8. Reconnect the battery cable.
9. Install Diagnostic service tool.
10. Start engine.
11. Check for any DTC codes and clear.
12. Verify engine is in closed loop and no MIL lights are present.

HEATED EXHAUST GAS OXYGEN SENSOR REPLACEMENT

1. Disconnect the O-2 sensor electrical connector.
2. Using a O-2 Sensor socket remove the O-2 Sensor and discard.

Installation Procedure

NOTE

Before install the O-2 sensor lubricate threads with anti-seize compound GM P/N 5613695 or equivalent. Avoid getting compound on the sensor tip.

3. Install O-2 sensor.
   Tighten
   41 N•m (30 lb-ft)
4. Start engine.
5. Check for any DTC codes and clear.
6. Verify engine is in closed loop and no MIL lights are present.

THREE WAY CATALYTIC CONVERTER MUFFLER REPLACEMENT

1. Remove the TWC muffler using the OEM end product processes.

Installation Procedure

NOTE

The Three Way Catalytic converter is specifically designed to meet the emission control of the certified engine. Use only the OEM specified parts.

2. Install the TWC muffler using the OEM end product processes.
3. Start engine.
4. Check for any DTC codes and clear
5. Verify engine is in closed loop and no MIL lights are present.

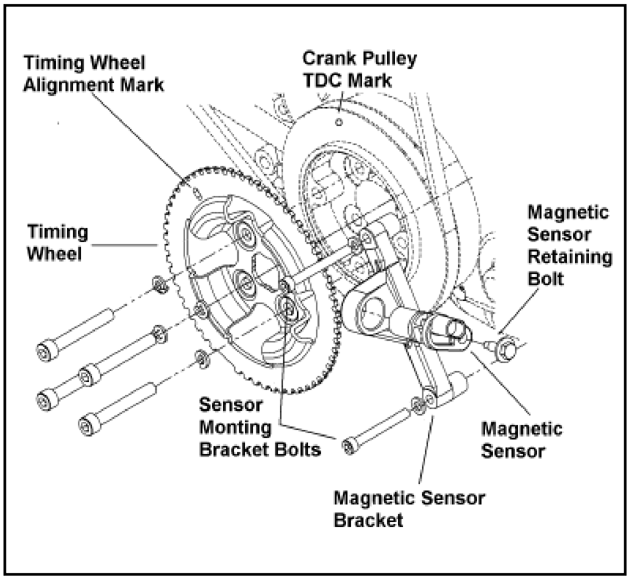


Figure 5 Timing Wheel

MAGNETIC SENSOR REPLACEMENT
Figure 5

1. Disconnect the Magnetic Pickup sensor electrical connector.
2. Remove the one (1) retaining bolt and retain.
3. Remove sensor.

Installation Procedure

NOTE

Remove any debris from the timing wheel.

4. Install the Magnetic pickup into the bracket.
5. Secure using one retaining bolt and tighten to specification.

   Tighten
   9 N•m (80 lb-in)

6. Adjust air gap of Magnetic Pickup, Refer to *Magnetic Pickup Air Gap Adjustment.*
7. Start engine.
8. Check for any DTC codes and clear.
9. Verify engine is in closed loop and no MIL lights are present.

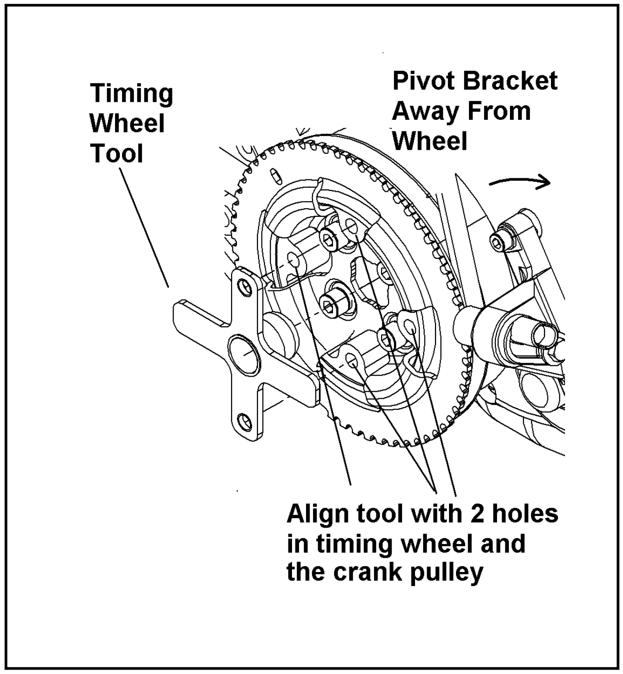


Figure 6 Removing Timing Wheel

TIMING WHEEL REPLACEMENT
Figure 6

1. Remove the four retaining bolts and lock washer and retain.
2. Remove the timing wheel.

Installation Procedure

NOTE

Remove any debris from the magnetic sensor.

3. Loosen the top and bottom Sensor Bracket bolts slightly and pivot the bracket away from the timing wheel.
4. Locate the timing wheel to the pulley by aligning the slot in the timing wheel with the TDC mark on the crankshaft pulley.
5. Re-install the 4 retaining bolt and lockwashers. Install hand tight only.
6. Insert the timing wheel installation tool into the timing wheel. Hold tool against the face of the crank pulley. Bolts can be used to

hold the tool in place if necessary. Center the timing wheel to the pulley.

7. Timing wheel should have very little.
8. Install the four (4) bolts and tighten to specification.

    Tighten
    9 N•m (80 lb-in)

9. Remove the timing wheel tool.
10. Adjust air gap of Magnetic Pickup, Refer to *Magnetic Pickup Air Gap Adjustment.*
11. Start engine.
12. Check for any DTC codes and clear.
13. Verify engine is in closed loop and no MIL lights are present.

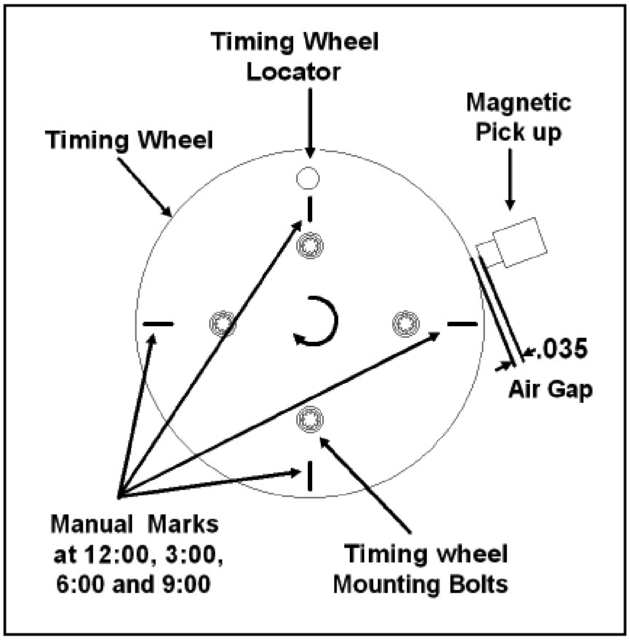


Figure 7 Installing Timing Wheel

TIMING WHEEL REPLACEMENT WITHOUT SPECIAL TOOL

Figure 6

1. Remove the four retaining bolts and lock washer and retain.
2. Remove the timing wheel.

Installation Procedure

NOTE

Remove any debris from the magnetic sensor.

3. Rotate crankshaft to position the TDC mark at 12:00.
4. Align the locator mark on the timing wheel with the TDC mark on the crankshaft pulley.
5. Install the four securing bolts and hand tighten.
6. Using a marker mark the timing wheel at 12:00, 3:00, 6:00, and 9:00 positions.
7. Place a .035 Brass feeler gauge between the sensor and the timing wheel with the crankshaft at 12:00 and insure feeler gauge moves in and out freely.
8. Rotate the crankshaft to each of the marked positions and insure feeler gauge moves in out freely.
9. If the gauge does not move freely at each of four marks loosen the four timing wheel retaining bolts and reposition the timing wheel and re secure hand tight and re-check air gap.
10. Recheck air gap at all mark positions and tighten the four (4) retaining bolts to specification.

    Tighten
    9 N•m (80 lb-in)

MAGNETIC PICKUP SENSOR AIR GAP ADJUSTMENT

Figure 7

1. Loosen the top and bottom Sensor Bracket bolts slightly and pivot the bracket away from the timing wheel.

Installation Procedure

NOTE

Remove any debris from the magnetic sensor.

2. Place a .035 Brass feeler gauge between the Magnetic pickup and the timing wheel and pivot the bracket to the timing wheel.
3. Secure the two bracket bolts and tighten to specification.

    Tighten
    9 N•m (80 lb-in)
4. Remove the feeler gauge.
5. Start engine.
6. Check for any DTC codes and clear.
7. Verify engine is in closed loop and no MIL lights are present.

HIGH MOUNT FAN PULLEY REPLACEMENT

Figure 8

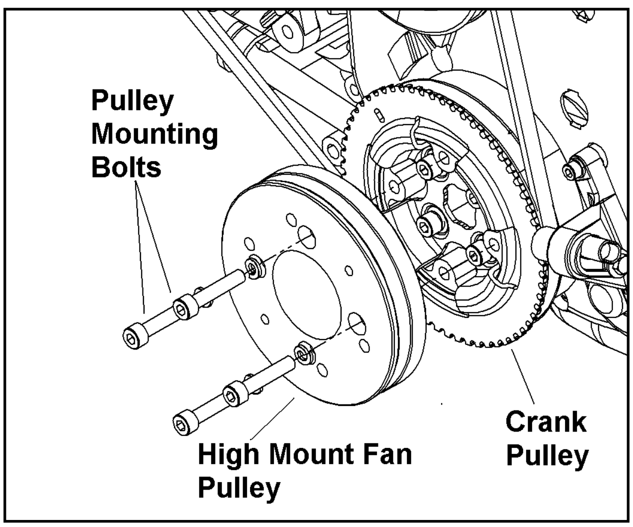


Figure 8 Fan Pulley

1. Loosen Fan belt and remove.
2. Remove the four retaining bolts and lock washers and retain.
3. Remove the Pulley.

Installation Procedure

NOTE

Check Fan belt for wear, checking, and cracks.

4. Install pulley to crank shaft pulley with the four bolts and lock washers and tighten to specification.

    Tighten
    9 N•m (80 lb-in)
5. Install fan belt and adjust to proper tension and tighten.