



The following contains the Service Manual for the current Hyundai Construction Equipment Forklift.

In order to effectively access and view this manual, please use Adobe Acrobat 7.0 or later software. The latest version of Adobe Reader can be found and downloaded at no cost at <http://get.adobe.com/reader/>. While viewing the manual, a window may pop-up requesting download of a Korean plug-in to run the program properly. Download this application to ensure compatibility of the PDF.

This software uses Bookmarks to help quickly access each section of the manual. Click on the Bookmarks tab located on the left and click on the plus sign (+) to expand the desired section. Alternatively click on the minus sign (-) to contract a section. Once a section is expanded, you may click on a Section or Group to go directly to that page.

Another method of quickly accessing each page in the manual is going to the 'Table of Contents' and clicking on the desired Section or Group. This will directly take you to that page.

If any part of the manual needs to be printed, press the printer icon, or click on the FILE menu and select print. This will open up the printing options window where you may choose how to print the document.



Forklift Service Manual

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

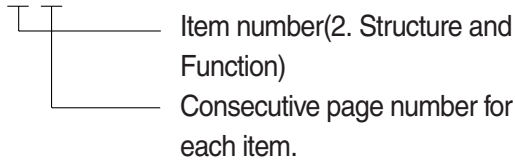
1. See the page number on the bottom of the page.

File the pages in correct order.

2. Following examples shows how to read the page number.

Example 1

2 - 3



3. Additional pages : Additional pages are indicated by a hyphen(-) and number after the page number. File as in the example.

10 - 4

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Added pages

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 50 in the vertical column at the left side, take this as ①, then draw a horizontal line from ①.
- (2) Locate the number 5 in the row across the top, take this as ②, then draw a perpendicular line down from ②.
- (3) Take the point where the two lines cross as ③. This point ③ 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

②

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
① 50	1.969	2.008	2.047	2.087	2.126	③ 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
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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	6.076	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	7.699	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

1 kgf · m = 7.233 lbf · 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	296.6	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/cm² to lbf/in²

1 kgf / cm² = 14.2233 lbf / in²

	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

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

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SECTION 1 GENERAL

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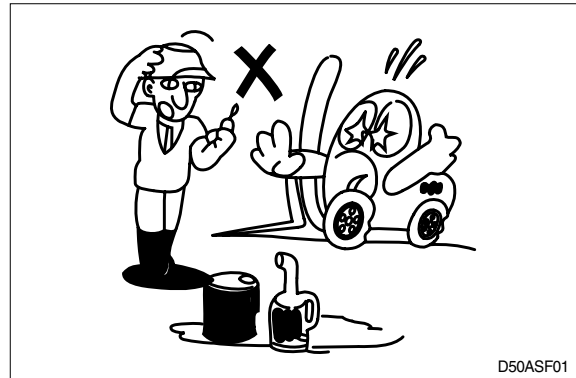
GROUP 1 SAFETY HINTS

Careless performing of the easy work may cause injuries.

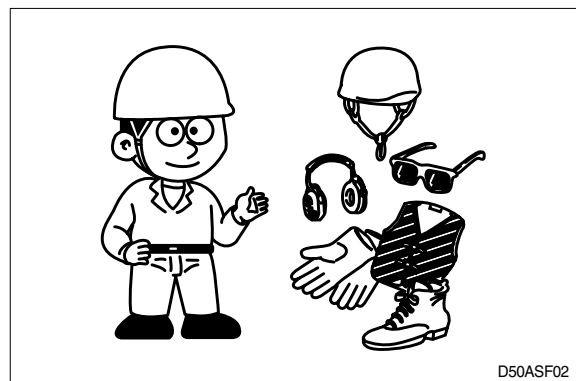
Take care to always perform work safely, at least observing the following.

- Oil is a dangerous substance. Never handle oil, grease or oily clothes in places where there is any fire or flame.

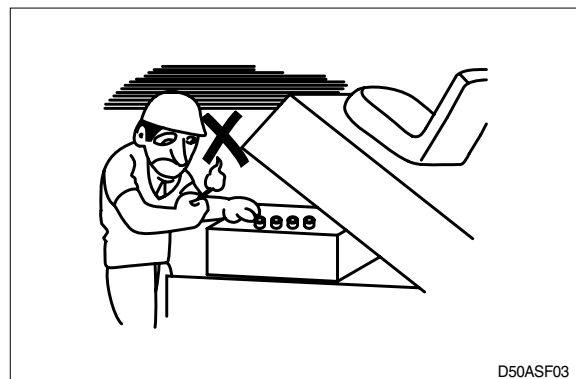
As preparation in case of fire, always know the location and directions for use of fire extinguishers and other fire fighting equipment.



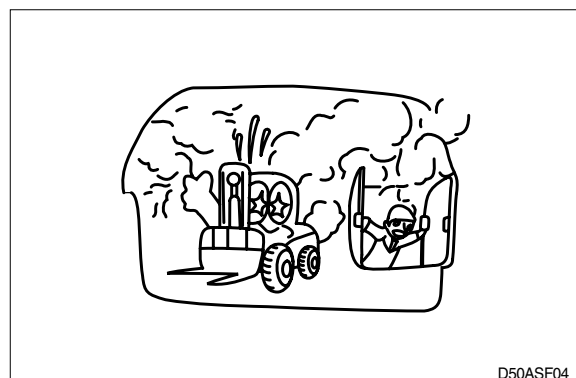
- Wear well-fitting helmet, safety shoes and working clothes. When drilling, grinding or hammering, always wear protective goggles. Always do up safety clothes properly so that they do not catch on protruding parts of machines. Do not wear oily clothes. When checking, always release battery plug.



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

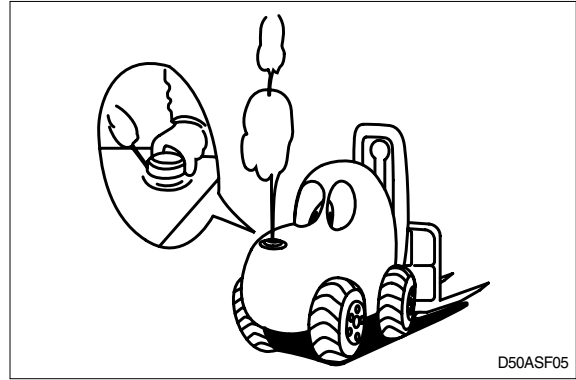


- Exhaust gas is dangerous. Provide adequate ventilation when working a closed space.



⚠ 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.



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



- 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.

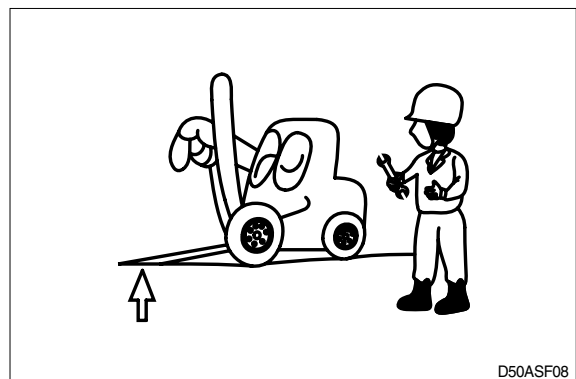
⚠ It is extremely dangerous to try to check the fan belt tension while the engine is running.



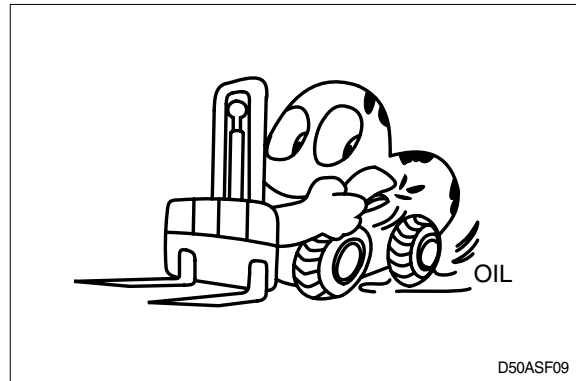
When inspecting the engine is running parts, or near such parts, always stop the engine first.

Before checking or servicing accumulator or piping, depress brake pedal repeatedly to release pressure.

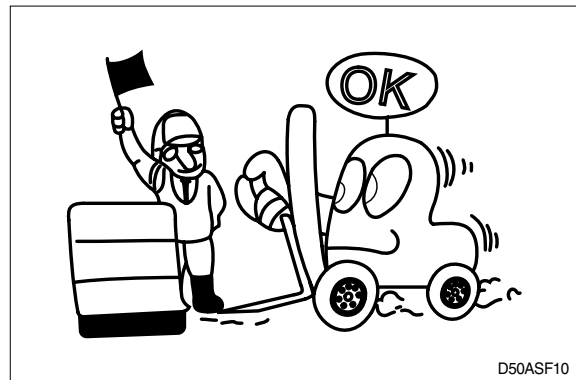
- Park the machine on firm, flat ground.
Lower the fork to the ground and stop the engine.
Return each lever to **NEUTRAL** and apply the brake lock.



- 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.



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



- 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.



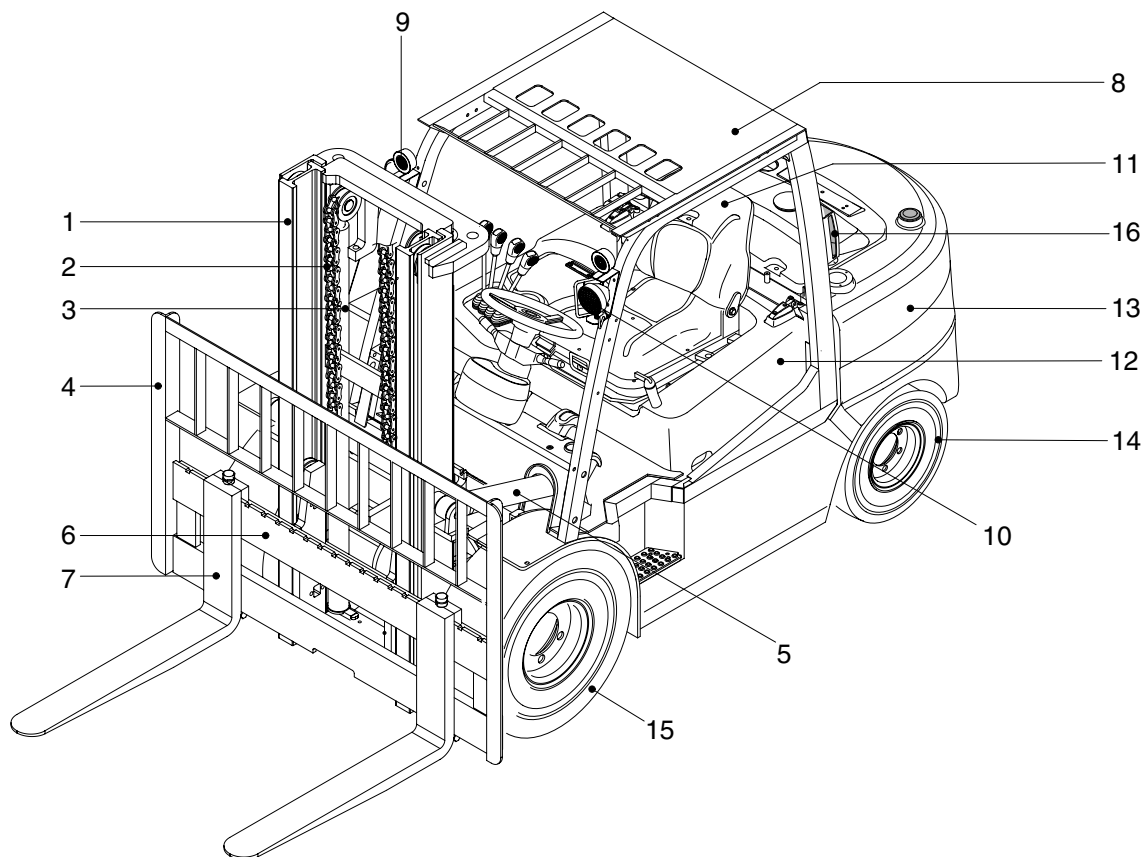
- Unless you have special instructions to the contrary, maintenance should always be carried out with the engine stopped. If maintenance is carried out with the engine running, there must be two men present : one sitting in the operator's seat and the other one performing the maintenance. In such a case,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

- 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

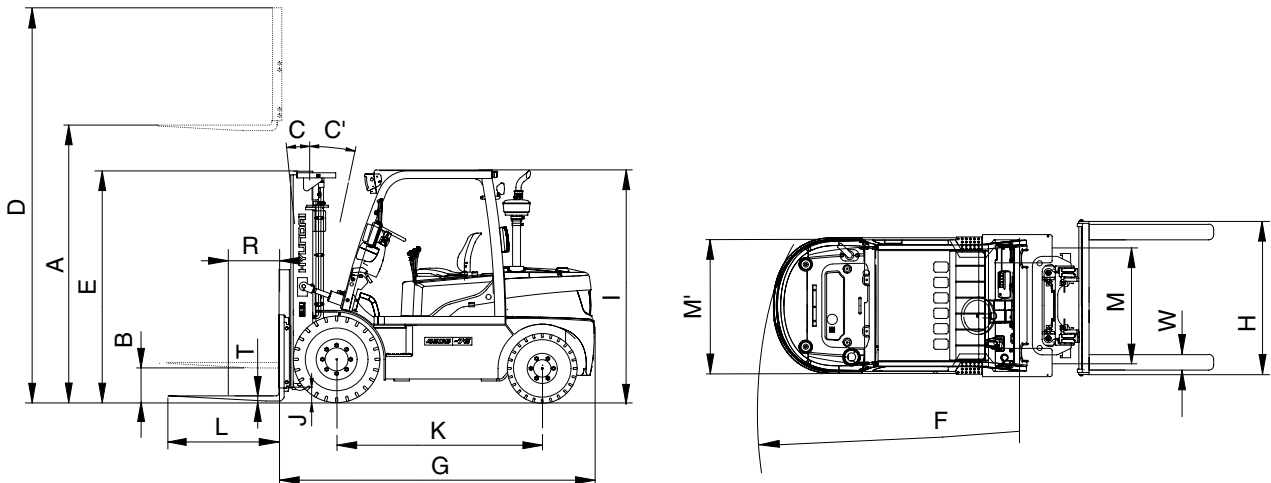
1. MAJOR COMPONENTS



D357OM54

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

2. SPECIFICATIONS



35DS7ESP01

Model			Unit	35DS-7E	40DS-7E	45DS-7E	50DA-7E
Capacity			kg	3500	4000	4500	5000
Load center		R	mm	600	←	←	←
Weight(Unloaded)			kg	5894	6464	6880	7302
Fork	Lifting height	A	mm	3000	←	←	←
	Free lift	B	mm	120	←	←	←
	Lifting speed(Unload/Load)		mm/sec	580/520	←	←	470/450
	Lowering speed(Unload/Load)		mm/sec	500/500	←	←	←
	L × W × T	L,W,T	mm	1070 × 122 × 50	1070 × 150 × 50	1220 × 150 × 50	1220 × 150 × 60
Mast	Tilt angle (forward/backward)	C/C'	degree	8/10	←	←	←
	Max height	D	mm	4236	←	4246	4134
	Min height	E	mm	2235	←	2220	←
Body	Travel speed		km/h	27.1	26.3	26.2	←
	Gradeability		degree	21.2	18.5	17.0	16.4
	Min turning radius(Outside)	F	mm	2770	2830	2890	2950
ETC	Max hydraulic pressure		kgf/cm ²	210	←	←	←
	Hydraulic oil tank		ℓ	66	←	←	←
	Fuel tank		ℓ	100	←	←	←
Overall length		G	mm	3070	3125	3185	3245
Overall width		H	mm	1400	1776	←	←
Overhead guard height		I	mm	2240	←	←	←
Ground clearance		J	mm	170	155	←	←
Wheel base		K	mm	2000	←	←	←
Wheel tread front/rear		M, M'	mm	1162/1140	1312/1140	←	←

3. SPECIFICATION FOR MAJOR COMPONENTS

1) ENGINE

Item	Unit	Specification
Model	-	MITSUBISHI S6S-T
Type	-	4-cycle, in-line, Vertical OHV
Cooling Method	-	Water cooling
Number of cylinders and arrangement	-	6 cylinders, in line
Firing order	-	1-5-3-6-2-4
Combustion chamber type	-	Indirect injection
Cylinder bore X stroke	mm(in)	94 × 120(3.7 × 4.7)
Piston displacement	cc(cu in)	4996(305)
Compression ratio	-	22
Rated gross horse power	ps/rpm	92/2300
Maximum gross torque at rpm	kgf · m/rpm	29.9/1700
Engine oil quantity	ℓ (U.S.gal)	16.5(4.3)
Dry weight	kg(lb)	360(792)
High idling speed	rpm	2570
Low idling speed	rpm	820
Rated fuel consumption	g/ps.hr	180
Starting motor	V-kW	24-5.0
Alternator	V-A	24-50
Battery	V-AH	12-96 × 2
Fan belt deflection	mm(in)	10~12(0.4~0.5)

(2) MAIN PUMP

Item	Unit	Specification
Type	-	Fixed displacement gear pump
Capacity	cc/rev	46±7
Maximum operating pressure	bar	250
Rated speed (Max/Min)	rpm	3000/600

(3) MAIN CONTROL VALVE

Item	Unit	Specification
Type	-	Semi - mono block
Operating method	-	Sectional
Main relief valve pressure	bar	210/150
Flow capacity	lpm	130

4) POWER TRAIN DEVICES

Item			Specification	
Torque converter	Model		DE 280 (KAPEC)	
	Type		3 Element, 1 stage, 2 phase	
	Stall ratio		2.25 : 1	
Transmission	Type		Power shift	
	Gear shift(FR/RR)		2/2	
	Control		Electrical single lever type	
	Overhaul ratio	FR	1 : 2.550	2 : 1.151
		RR	1 : 2.550	2 : 1.151
Axle	Type		Front-wheel drive type, fixed location	
	Gear ratio		11.692	
Wheels	Q'ty(FR/RR)		Single : 2/2	Double : 4/2
	Front(drive)	Single	3.5 ton : 8.25-15-14 PR	4.0/4.5 ton : 300-15-18 PR
		Double	7.5-16-12 PR	
	Rear(steer)		7.0-12-12 PR	
Brakes	Travel		Front wheel, wet disc brake	
	Parking		Toggle, internal expanding mechanical type	
Steering	Type		Full hydraulic, power steering	
	Steering angle		74.8° to both right and left angle, respectively	

4. TIGHTENING TORQUE FOR MAJOR COMPONENTS

NO	ITEMS		SIZE	kgf · m	lbf · ft
1	Engine	Engine mounting bolt, nut	M16 × 2.0	7.5	54
2		Radiator mounting bolt, nut	M10 × 1.5	6.9 ± 1.4	50 ± 10
3	Hydraulic system	MCV mounting bolt, nut	M14 × 2.0	19.6 ± 2.9	142 ± 21
4		Steering unit mounting bolt	M10 × 1.5	6.9 ± 1.4	50 ± 10
5		Hydraulic pump mounting bolt	M14 × 1.5	19.6 ± 1.3	142 ± 10
6	Power train system	Transmission mounting bolt, nut	M10 × 1.5	6.9 ± 1.4	50 ± 10
7		Torque converter mounting bolt	M10 × 1.5	6.9 ± 1.4	50 ± 10
8		Drive axle mounting bolt, nut	M22 × 2.5	77.4 ± 11.6	560 ± 84
9		Steering axle mounting bolt, nut	M14 × 2.0	19.6 ± 2.9	142 ± 21
10		Front wheel mounting nut	M22 × 1.5	61.2 ± 9.2	448 ± 67
11		Rear wheel mounting nut	M20 × 1.5	60.0 ± 5.0	434 ± 36
12	Others	Counterweight mounting bolt	M30 × 3.5	120 ± 15	1555 ± 239
13		Operator's seat mounting nut	M 8 × 1.25	2.5 ± 0.5	18.1 ± 3.6
14		Head guard mounting bolt	M12 × 1.75	12.8 ± 3.0	93 ± 22

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	2.73 ~ 4.12	19.7 ~ 29.8
M10 × 1.5	4.0 ~ 6.0	28.9 ~ 43.4	5.5 ~ 8.3	39.8 ~ 60
M12 × 1.75	7.4 ~ 11.2	53.5 ~ 79.5	9.8 ~ 15.8	71 ~ 114
M14 × 2.0	12.2 ~ 16.6	88.2 ~ 120	16.7 ~ 22.5	121 ~ 167
M16 × 2.0	18.6 ~ 25.2	135 ~ 182	25.2 ~ 34.2	182 ~ 247
M18 × 2.5	25.8 ~ 35.0	187 ~ 253	35.1 ~ 47.5	254 ~ 343
M20 × 2.5	36.2 ~ 49.0	262 ~ 354	49.2 ~ 66.6	356 ~ 482
M22 × 2.5	48.3 ~ 63.3	350 ~ 457	65.8 ~ 98.0	476 ~ 709
M24 × 3.0	62.5 ~ 84.5	452 ~ 611	85.0 ~ 115	615 ~ 832
M30 × 3.5	124 ~ 168	898 ~ 1214	169 ~ 229	1223 ~ 1655
M36 × 4.0	174 ~ 236	1261 ~ 1703	250 ~ 310	1808 ~ 2242

(2) Fine thread

Bolt size	8T		10T	
	kgf · m	lbf · ft	kgf · m	lbf · ft
M 8 × 1.0	2.17 ~ 3.37	15.7 ~ 24.3	3.04 ~ 4.44	22.0 ~ 32.0
M10 × 1.25	4.46 ~ 6.66	32.3 ~ 48.2	5.93 ~ 8.93	42.9 ~ 64.6
M12 × 1.25	7.78 ~ 11.58	76.3 ~ 83.7	10.6 ~ 16.0	76.6 ~ 115
M14 × 1.5	13.3 ~ 18.1	96.2 ~ 130	17.9 ~ 24.1	130 ~ 174
M16 × 1.5	19.9 ~ 26.9	144 ~ 194	26.6 ~ 36.0	193 ~ 260
M18 × 1.5	28.6 ~ 43.6	207 ~ 315	38.4 ~ 52.0	278 ~ 376
M20 × 1.5	40.0 ~ 54.0	289 ~ 390	53.4 ~ 72.2	386 ~ 522
M22 × 1.5	52.7 ~ 71.3	381 ~ 515	70.7 ~ 95.7	512 ~ 692
M24 × 2.0	67.9 ~ 91.9	491 ~ 664	90.9 ~ 123	658 ~ 890
M30 × 2.0	137 ~ 185	990 ~ 1338	182 ~ 248	1314 ~ 1795
M36 × 3.0	192 ~ 260	1389 ~ 1879	262 ~ 354	1893 ~ 2561

2) PIPE AND HOSE(FLARE TYPE)

Thread size	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
1"	41	21	152
1-1/4"	50	35	253

3) PIPE AND HOSE(ORFS TYPE)

Thread size	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
1-7/16-12	41	21	152
1-11/16-12	50	35	253

4) FITTING

Thread size	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
1"	41	21	152
1-1/4"	50	35	253

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)	Ambient temperature °C (°F)						
			-20 (-4)	-10 (14)	0 (32)	10 (50)	20 (68)	30 (86)	40 (104)
Engine oil pan	Engine oil	16.5(4.3)				SAE 30			
			SAE 10W						
			SAE 10W-30						
			SAE 15W-40						
Torque converter transmission	T/M oil	12 (3.2)	AFT DEXRON III						
Axle	Gear oil	10.5 (2.8)	Mobilfluid 424						
Hydraulic tank	Hydraulic oil	66 (17.4)	ISO VG32						
			ISO VG46						
			ISO VG68						
Fuel tank	Diesel fuel	100 (26.4)	ASTM D975 No.1						
			ASTM D975 No.2						
Fitting (Grease nipple)	Grease	-	NLGI No.1						
			NLGI No.2						
Brake reservoir tank	Hyd oil	-	Azola ZS10 (Hydraulic oil SAE 10W)						
Radiator	Antifreeze:Water 50:50	21.5 (5.7)	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 CF is used instead of class CH4 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 degree 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).

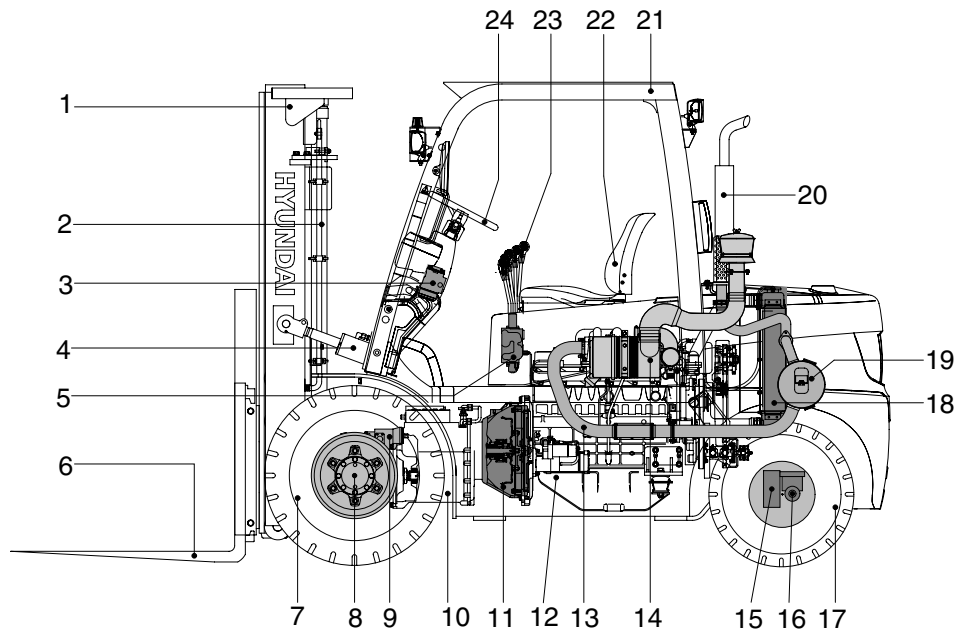
Note that periodic replacement has nothing to do with guarantee service.

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 & INSTALLATION OF UNIT

Group 1 Structure	2-1
Group 2 Removal and installation of unit	2-2

GROUP 1 STRUCTURE



D357OM21

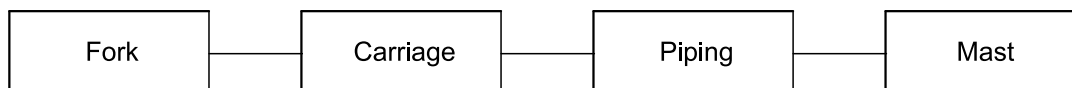
- | | | |
|-----------------|----------------------|-------------------|
| 1 Mast | 9 Hydraulic pump | 17 Rear wheel |
| 2 Lift cylinder | 10 Transmission | 18 Radiator |
| 3 Steering unit | 11 Torque converter | 19 Muffler |
| 4 Tilt cylinder | 12 Engine | 20 Silencer |
| 5 Control valve | 13 Exhaust pipe | 21 Overhead guard |
| 6 Fork | 14 Air cleaner | 22 Seat |
| 7 Front wheel | 15 Steering axle | 23 Control lever |
| 8 Drive axle | 16 Steering cylinder | 24 Steering wheel |

GROUP 2 REMOVAL AND INSTALLATION OF UNIT

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

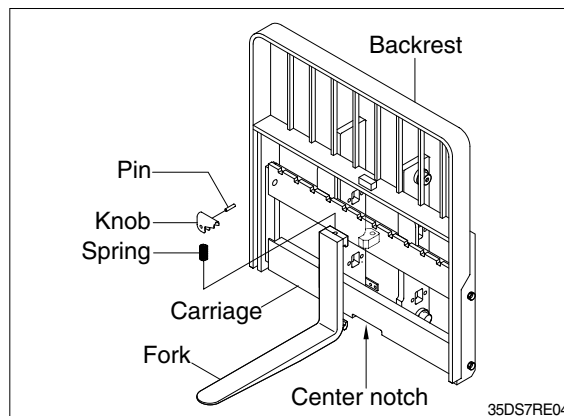
1. MAST

1) REMOVAL



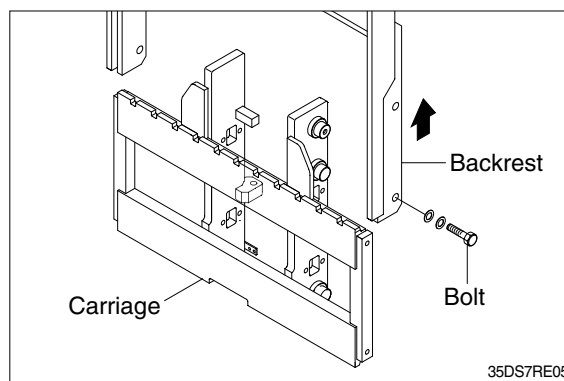
(1) Forks

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



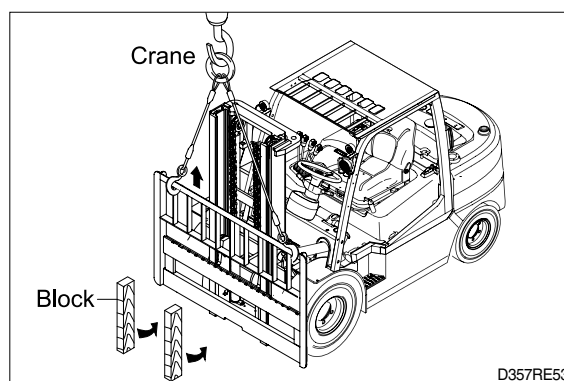
(2) Backrest(If necessary)

- ① Remove bolts securing backrest to fork carriage, lift backrest straight up and remove it from carriage.

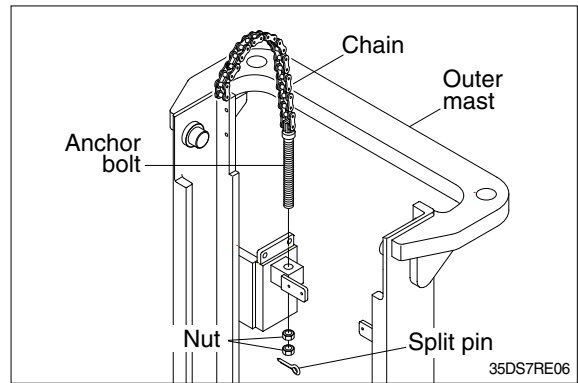


(3) Carriage

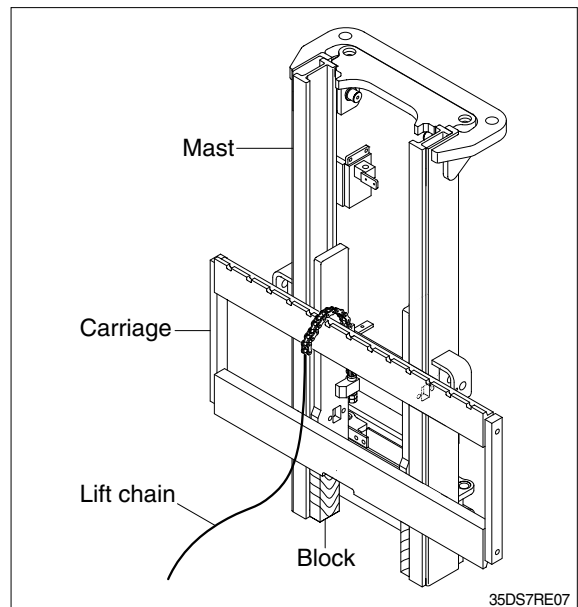
- ① With the mast vertical, raise the carriage high enough to place blocks under the load forks. This is done to create slack in the load chains when the carriage is lowered. Lower the carriage all the way down to the floor. Make sure the carriage is level, this will prevent any binding when the mast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



- ② While supporting lift chains, remove the split pin and nuts from the anchor bolt.



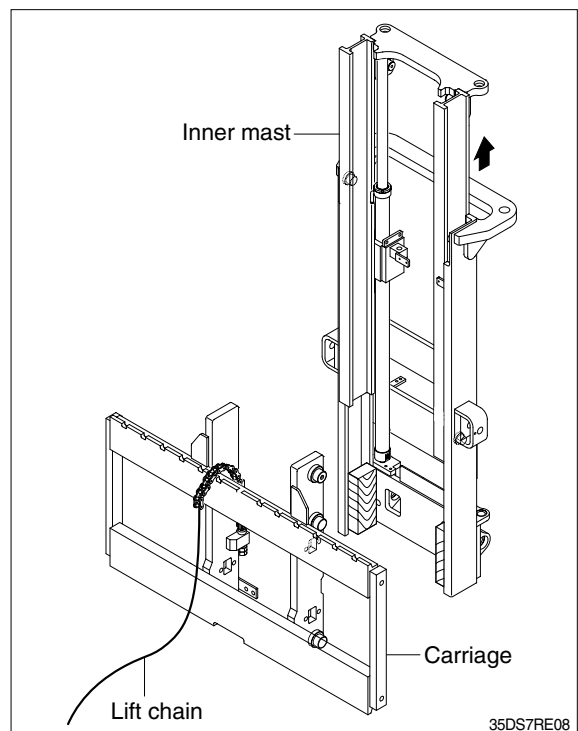
- ③ Pull the chains out of the sheaves and drape them over the front of the carriage.



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

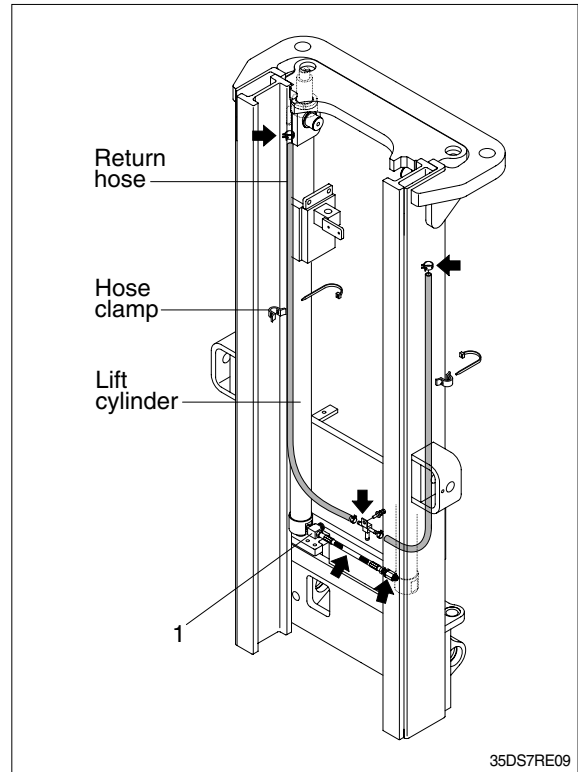
▲ Make sure that carriage remains on floor and does not bind while mast is being raised.

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



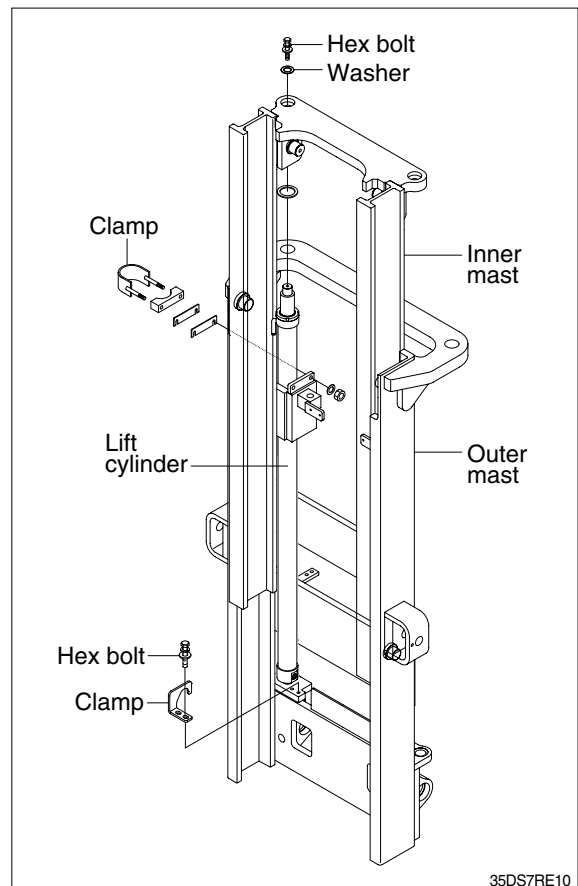
(4) Piping

- ① Remove the return hoses and clamps attached to the cylinder.
 - ② Remove the return hose from the tee.
 - ③ Remove hose assembly, tee and down safety valve(1).
- ※ Put blind plugs in the piping immediately after removing hoses.
This prevents the hydraulic oil from flowing out and also prevents dust and dirt from getting in.



(5) Lift cylinder

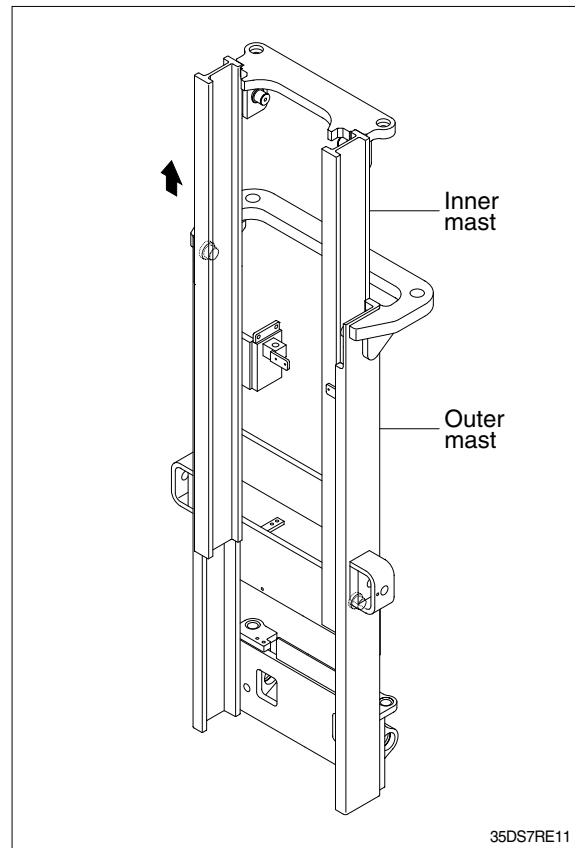
- ① Loosen and remove hexagon bolts and washers securing lift cylinders to inner mast.
 - ② Bind the lift cylinder with overhead hoist rope and pull up so that the rope has no slack or binding.
- ▲ Make sure the lift cylinder be tightened firmly for safety.**
- ③ Loosen and remove hexagon bolts, nuts and clamp securing lift cylinders 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.

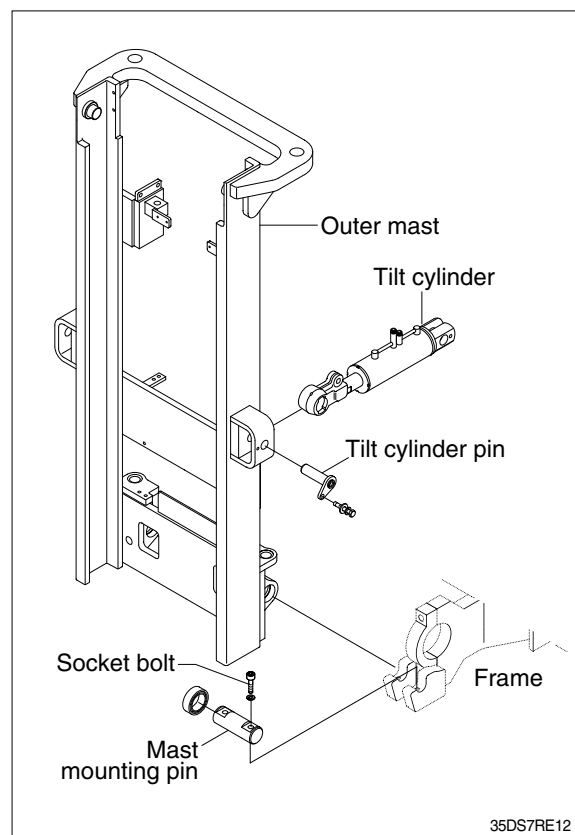
▲ Be careful the mast not to swing or fall.



(7) Tilt cylinder pin

(8) Mast mounting pin

- 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 under the machine, so use a pit, or if there is no pit, jack up the machine and loosen with an impact wrench.
- ② Loosen the mounting socket bolts and remove the mast mounting pins. Then slowly raise the outer mast.



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 mounting pin

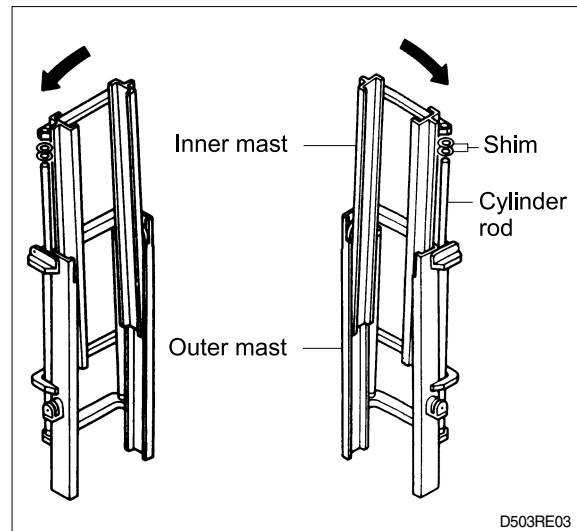
- ① Check the mast mounting pins for wear, then install pins into the mast support bracket.
- ② Jack up the machine so that the front is raised and then using an overhead hoist assemble outer mast to frame.
- ③ Tighten mounting socket bolts to frame.
 - Tightening torque : 35.1~47.5kgf · m(254~344lbf · ft)

(2) Tilt cylinder pin

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

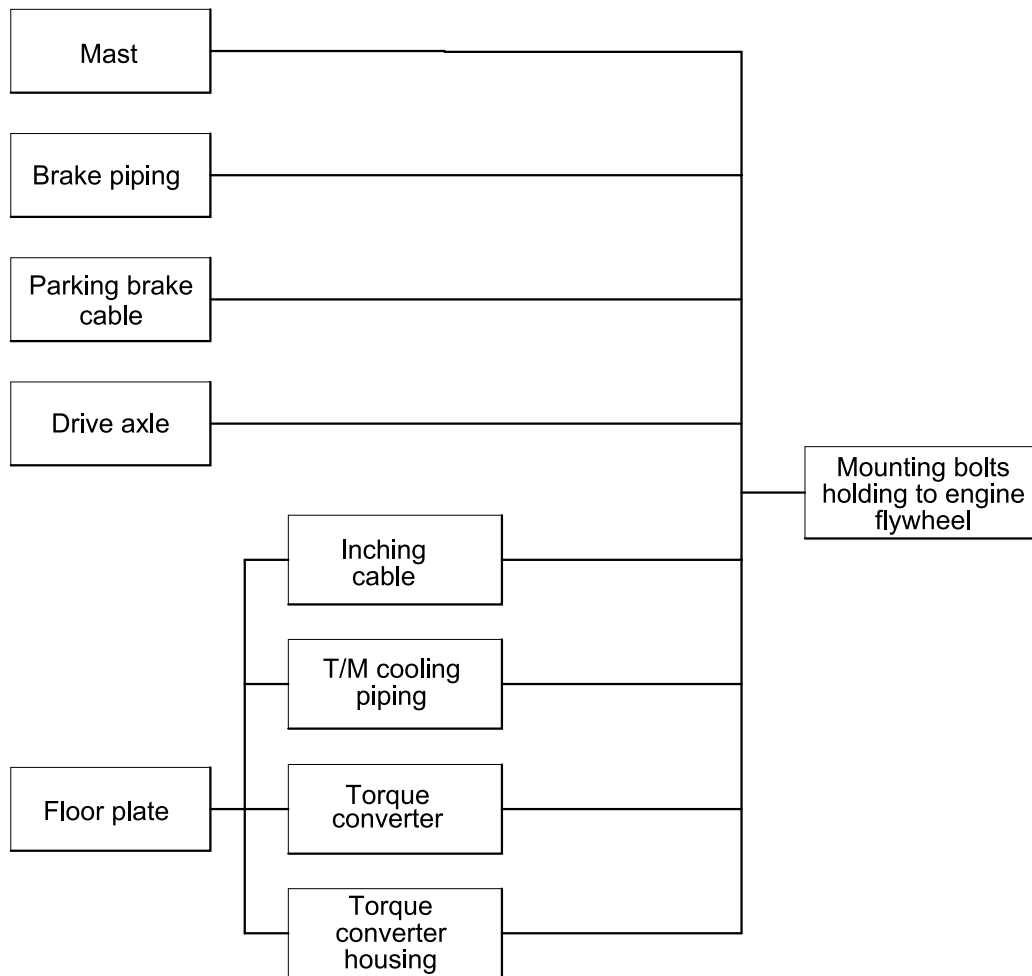
(3) Lift cylinder installation and adjustment

- 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



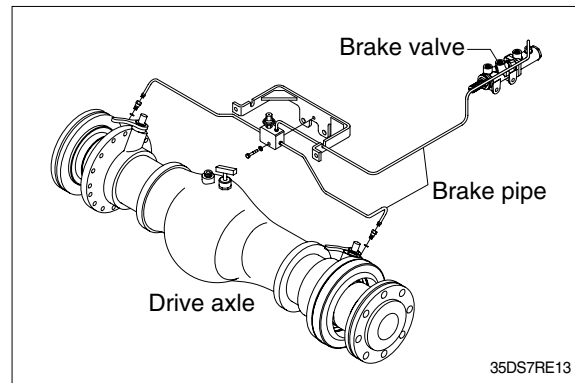
D503RE04

(1) Mast

Refer to section on mast(Page 2-2)

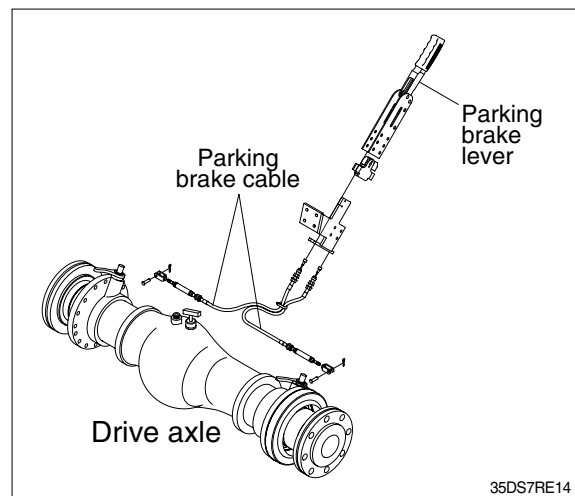
(2) Brake piping

Disconnect the brake piping from the brake housing of drive axle unit.



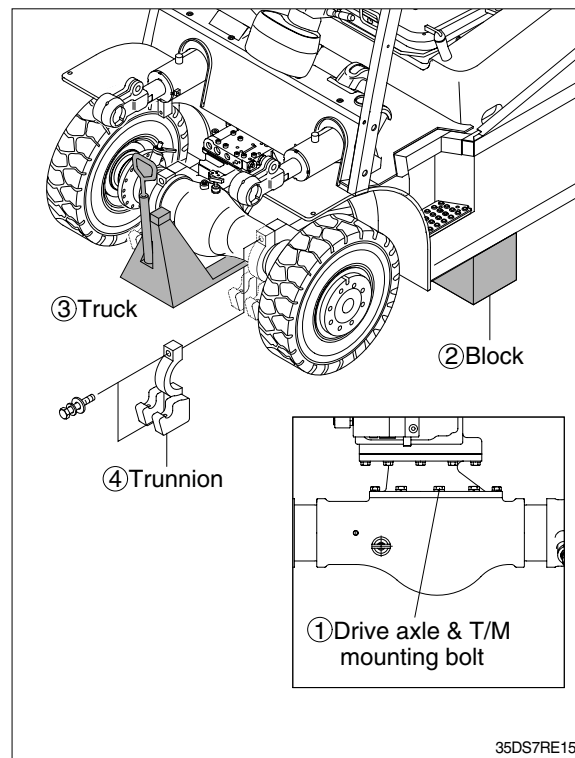
(3) Parking brake cable

Disconnect parking brake cable from the brake housing of drive axle unit.



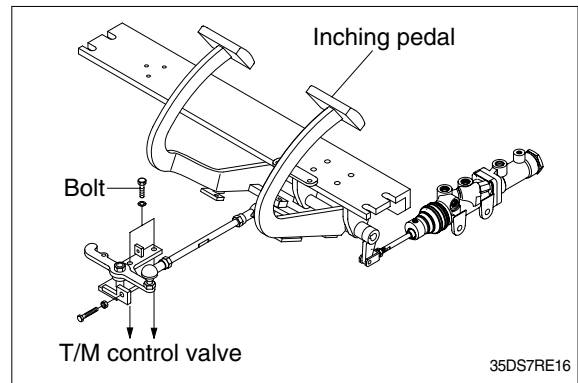
(4) Drive axle

- ※ Before removing the drive axle unit, drain all of the oil from the axle.
- ① Loosen hexagonal bolts connecting drive axle to the transmission.
- ※ If there is a pit, use the pit for safety.
- ② Jack up the machine and then put the block under the frame.
- ③ Prepare the truck under the drive axle unit to support it.
- ④ Remove trunnion fixing the axle to the frame and then carefully draw the truck out of the vehicle with the drive axle unit.



(5) Inching linkage

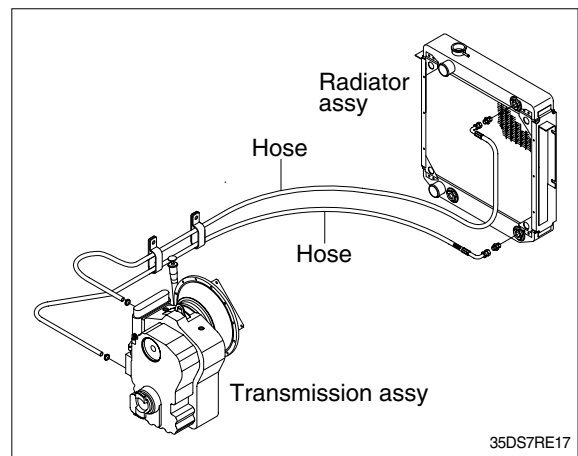
Remove the bolt fixing the linkage assembly to T/M control valve.



(6) Transmission cooling piping

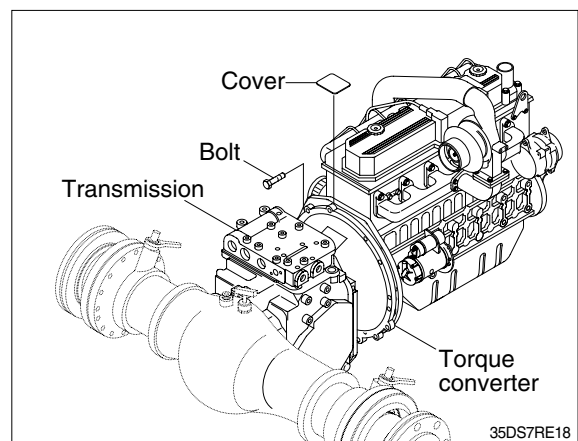
① Disconnect cooling hose and connector from the transmission.

※ Make sure that the coolant be drained from the hose.



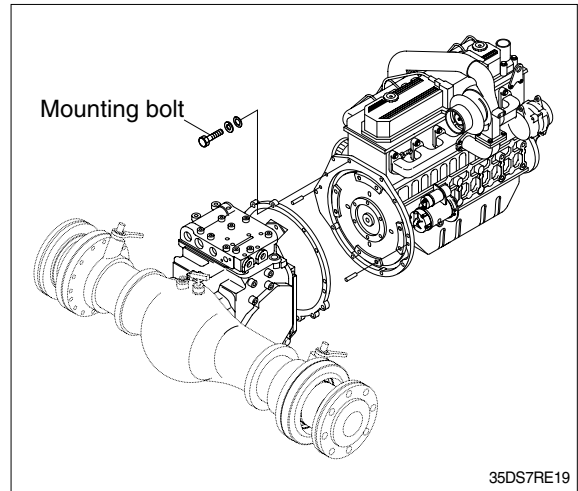
(7) Torque converter

① Remove the cover on top face of the torque converter housing then remove the 4 mounting bolts installed on 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.

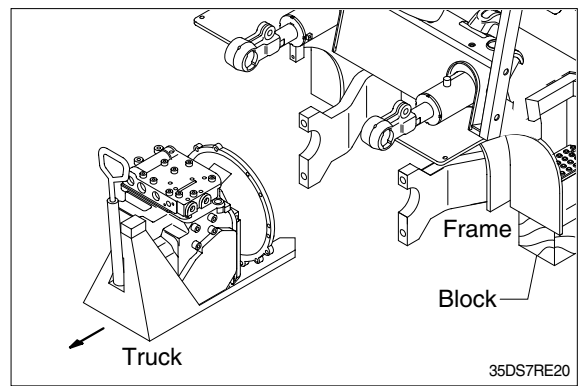


(8) Mounting bolts holding to flywheel housing

- ① Remove the transmission assembly from the engine flywheel by loosening the mounting bolts.



- ② Using a moving truck slowly pull out transmission assembly to the front.

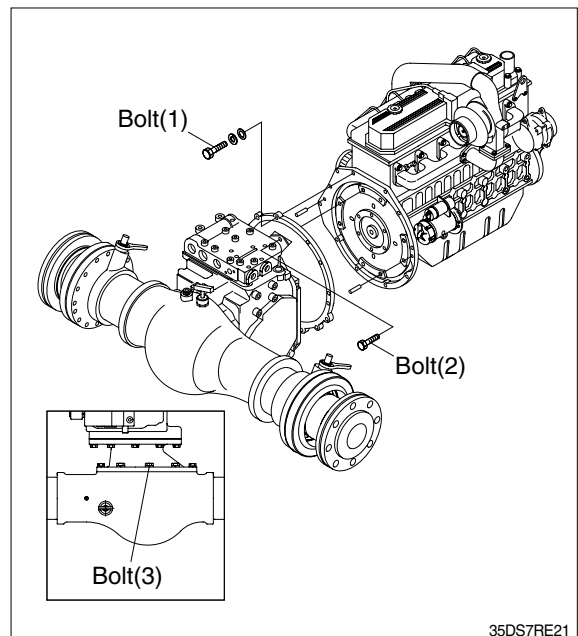


2) INSTALLATION

- (1) Installation is the reverse order to removal, but be careful of the following points.

(2) Tightening torque

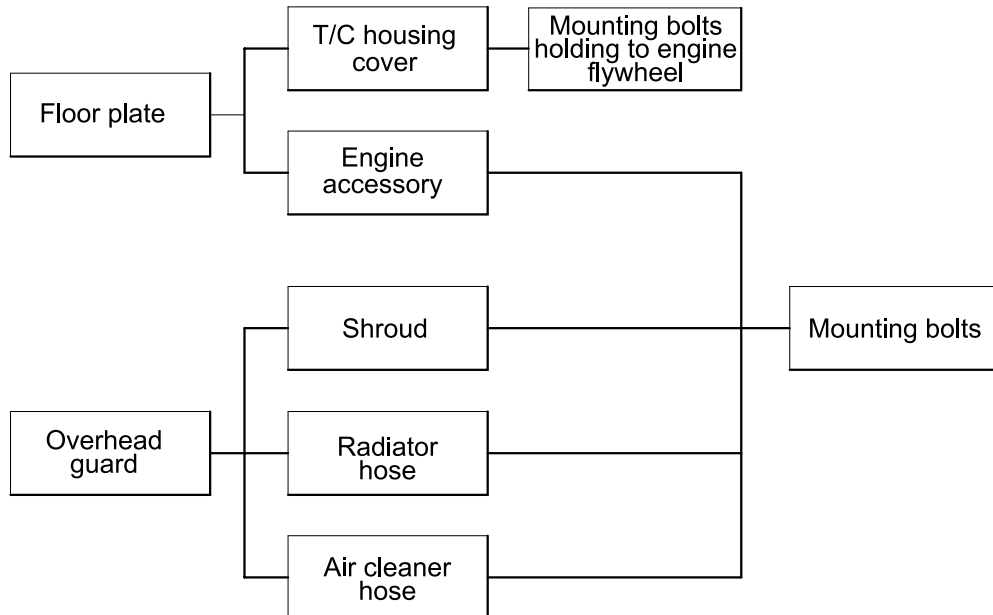
- Bolt(1) : 6.0~8.9kgf · m(49.2~64.4lbf · ft)
- Bolt(2) : 6.0~8.9kgf · m(49.2~64.4lbf · ft)
- Bolt(3) : 65.8~89kgf · m(476~644lbf · ft)



3. ENGINE

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

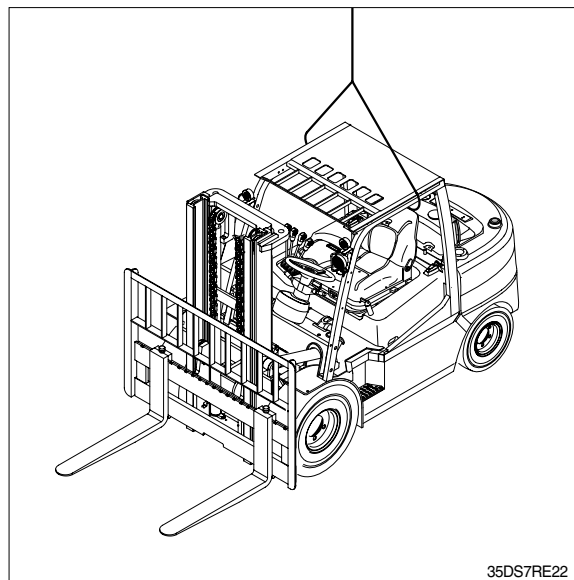
1) REMOVAL



D503RE25

(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.



35DS7RE22

- (2) Remove the torque converter housing cover, mounting bolts installed to flywheel housing.

For details, see page 2-9.

(3) Engine accessory

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

- ① Wiring harness to alternator and starter.
- ② Wiring harness for oil pressure and engine water temperature gauges.
- ③ Cables for meters, buttons and accelerator pedal.
- ④ Hoses to fuel tank and air cleaner.
- ⑤ Exhaust pipe.

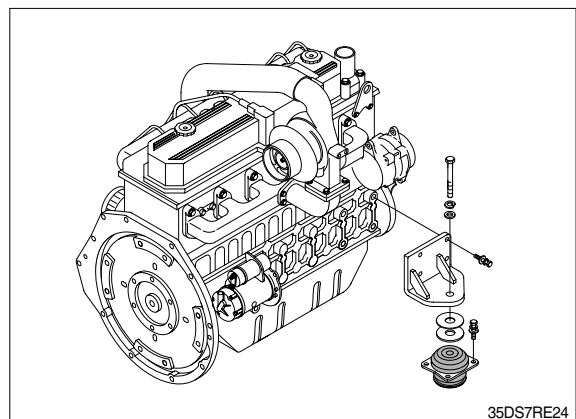
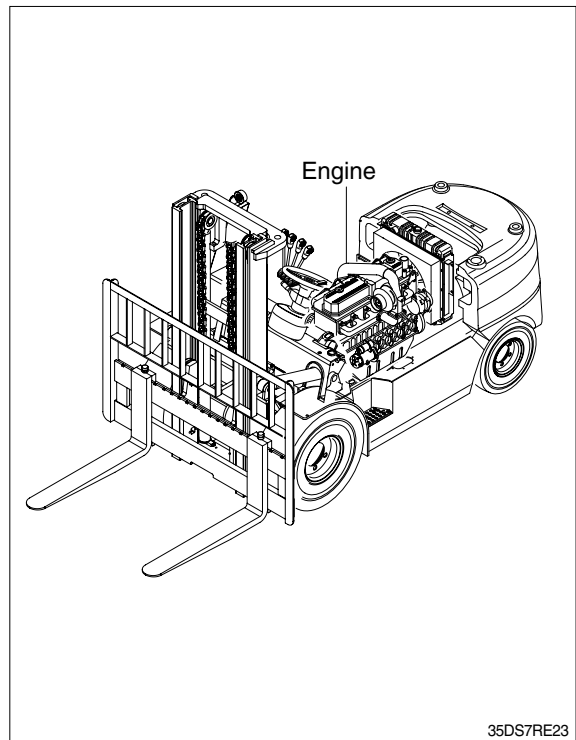
(4) Radiator hose

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 mounting bolts. Raise the engine slightly, slide towards the radiator, then lift up.

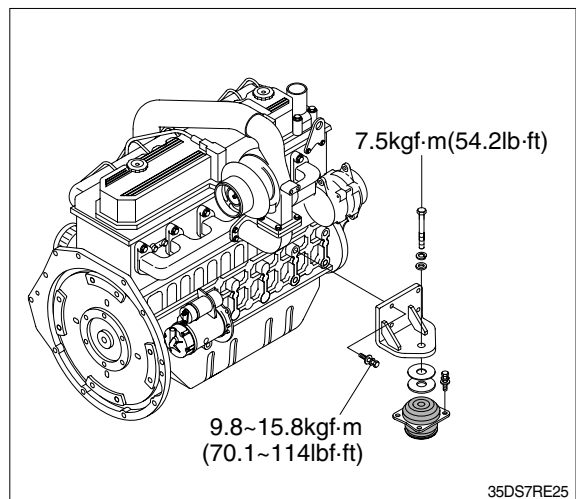
- ※ When sliding the engine, be careful of the collision engine and radiator.



2) INSTALLATION

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

- (1) Tighten the engine mounting bolts and nuts.
 - (2) Tighten the engine mounting bracket bolts.
- ※ Do not remove the bolts unless necessary. Loctite is coated over the threads of bolt. So, once the bolts were removed, coat them with loctite(#243) when installing.
- ※ Before installing the bolts, loctite in the holes should be removed by a tap.



- (3) Tightening torque of mounting bolt installing to torque converter housing.
- 6.0~8.9kgf · m(43~64lbf · ft)

(4) Radiator hoses

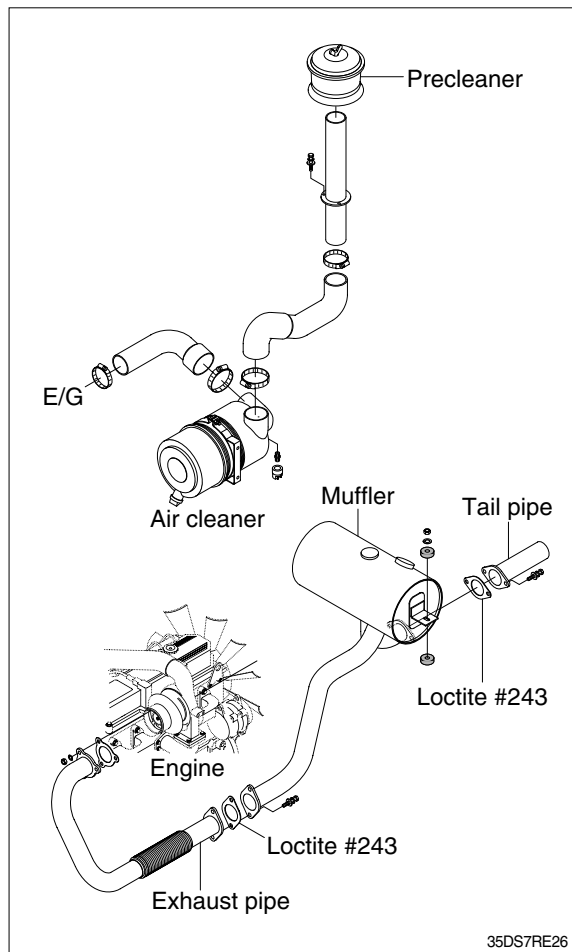
- Distance to insert hose : 42mm(1.65in)

(5) Air cleaner hose

- ① Insert the air cleaner hose securely and fit a clamp.

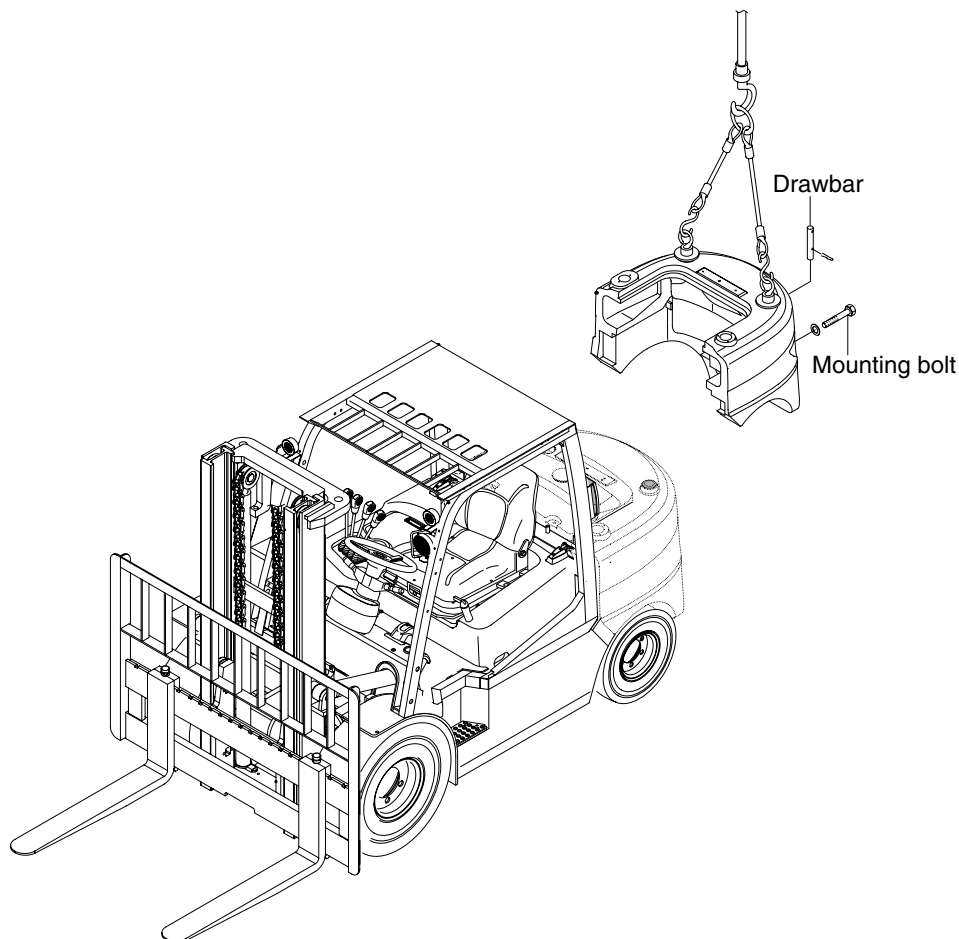
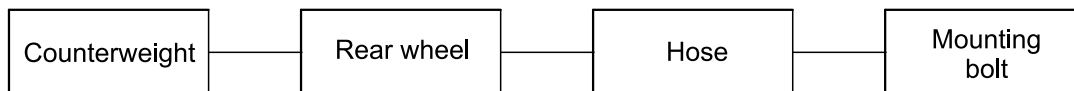
② **Distance to insert hose**

- Air cleaner hose : 89mm(3.5in)
- Engine end : 60mm(2.36in)



5. STEERING AXLE

1) REMOVAL



35DS7RE27

(1) Counterweight

Hold the counterweight with hoist bars, and raise it with a crane.

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

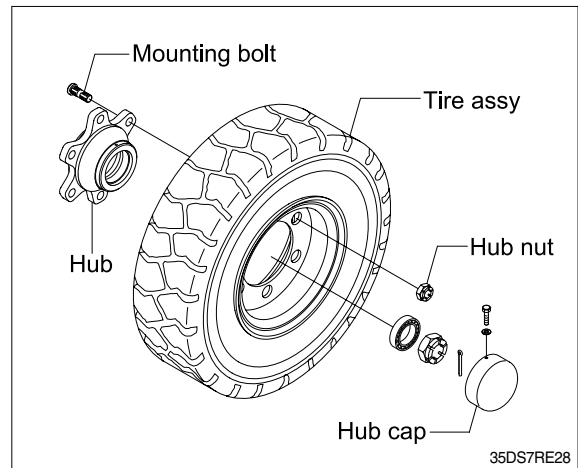
• Weight of counterweight(standard)

35DS-7E	1820kg (4010lb)	45DS-7E	2550kg (5620lb)
40DS-7E	2200kg (4850lb)	50DA-7E	2900kg (6390lb)

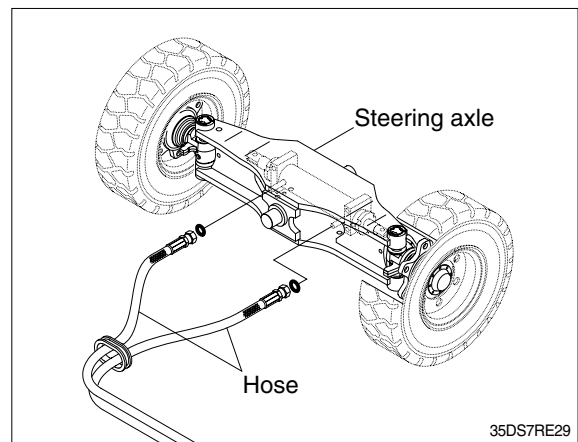
• Tightening torque : 199 ± 29.9 kgf · m (1440 ± 216 lbf · ft)

(2) Rear wheel

Remove mounting bolt and hub nut with socket wrench and then carefully take out the tire assembly.



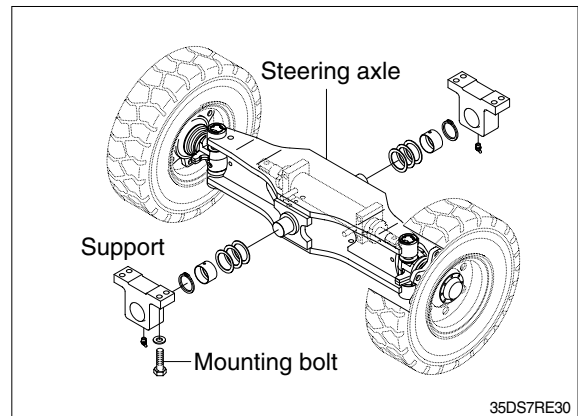
(3) Hose



(4) Mounting bolt

Put a block under the steering axle, support on a truck, and raise the frame with a crane. Remove the mounting bolts installing to the frame, and pull out to the rear.

There are shims between the support and steering axle to prevent play.



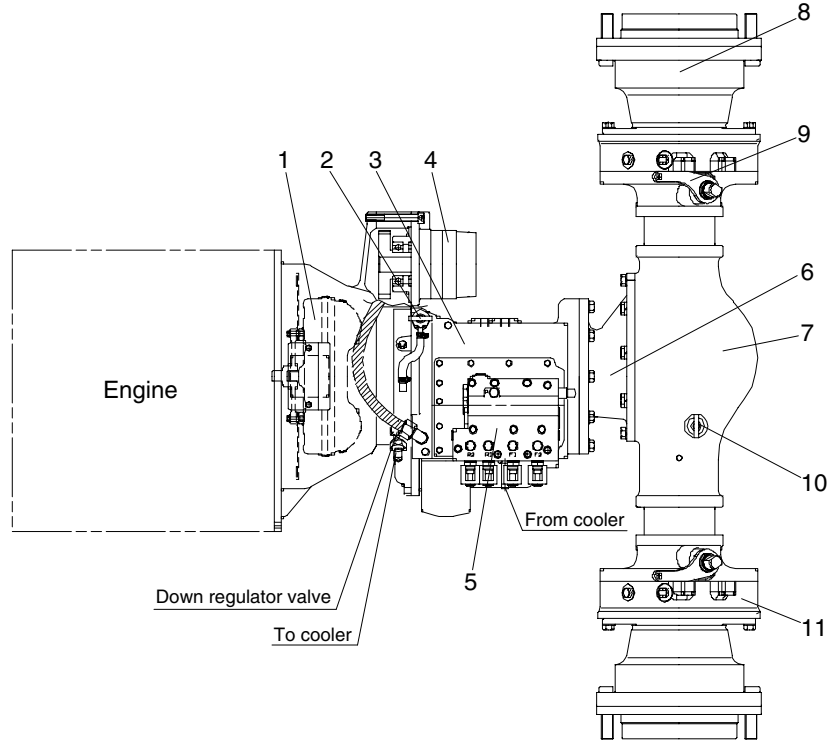
SECTION 3 POWER TRAIN SYSTEM

Group 1	Structure and operation	3-1
Group 2	Inspection and troubleshooting	3-13
Group 3	Disassembly and assembly	3-19

GROUP 1 STRUCTURE AND OPERATION

1. POWER TRAIN COMPONENT OVERVIEW

1) STRUCTURE



D357TA01

- | | | |
|-----------------------|---------------------|-------------------------------|
| 1 Torque converter | 5 T/M control valve | 9 Parking lever |
| 2 T/M oil level gauge | 6 Differential | 10 Drive axle oil level gauge |
| 3 Transmission | 7 Drive axle | 11 Disk brake |
| 4 T/M oil pump | 8 Drive wheel | |

2) OPERATION

Power train system consists of engine , torque converter(1) , transmission(3) , drive axle(7) , drive wheel(8).

Engine power is transmitted to the transmission(3) through the torque converter(1).

Transmission(3) which operates as a type of regularly and continuously engaged counter shaft shifting by 2 stage both forward and reverse consists of 4 hydraulic clutch packs.

Clutch piston is released by tension of spring.

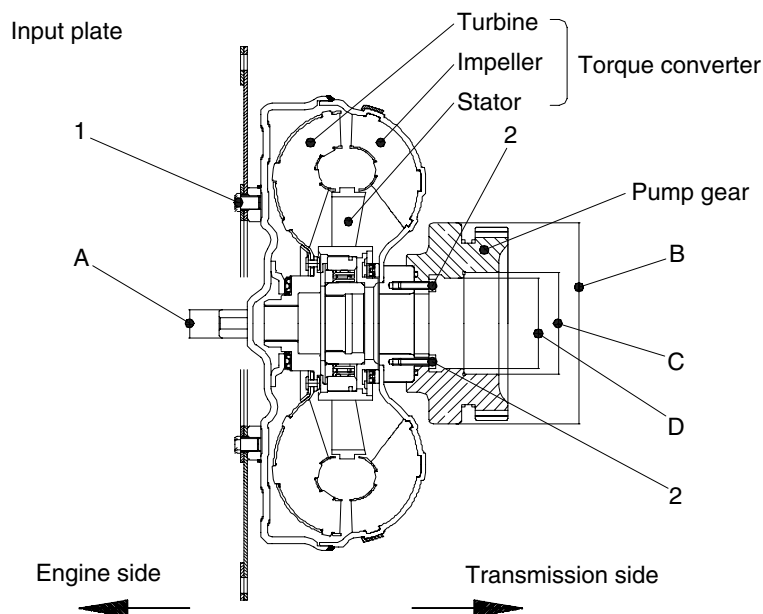
The power is transmitted to spiral gear and bevel gear set of differential through the output gear and then goes to the drive wheel via drive axle.

2. SPECIFICATION

Item			Unit	Specification
Torque converter	Type		-	3 elements 2 phase 1 stage
	Power transmit		-	Torque converter
Transmission	Type/Gear shift		-	POWER SHIFT / F2 : R2
	Gear ratio	FR/RR 1 stage	-	2.550
		FR/RR 2 stage	-	1.151
	P.T.O system		-	Included
	T/M oil		-	DEXRON 3
	Oil quantity		l	12
T/M valve	Type		-	Electric
Charging pump	Displacement		cc/rev	20.6
Drive axle	Gear ratio	Differential	-	2.923
		Planetary	-	4
		Total	-	11.692
	Axle oil		-	MOBILFLUID 424
	Oil quantity		l	10.5
	Brake type		-	WET DISC BRAKE (Include parking brake)
Differential	Gear type		-	Spiral bevel gear
	Differential type		-	4 pinions
Total gear ratio	FR.RR 1 stage		-	29.815
	FR.RR 2 stage		-	13.457

2. TORQUE CONVERTER

1) STRUCTURE



D357TA02

No	Item	Specification
1	Torque converter input plate	$4.5 \pm 0.3 \text{ kg} \cdot \text{m}$ ($32.5 \pm 2.2 \text{ lbf} \cdot \text{ft}$)
2	Torque converter pump gear	$2.0 \pm 0.3 \text{ kg} \cdot \text{m}$ ($14.5 \pm 2.2 \text{ lbf} \cdot \text{ft}$)
A	Pilot boss outer diameter	19.959 - 19.980mm (0.786 - 0.787in)
B	Oil seal outer diameter	134.9 - 135.0mm (5.311 - 5.315in)
C	Needle bearing outer diameter	68.000 - 68.019mm (2.677 - 2.678in)
D	Seal ring inner diameter	60.333 - 60.363mm (2.375 - 2.376in)

2) OPERATION

The torque converter is working according to the Trilok-system, i.e. it assumes at high turbine speed the characteristics, and therefore the favorable efficiency of a hydraulic clutch.

The converter will be defined according to the engine power so that the most favorable operating conditions for each installation case are given.

The Torque converter is composed of 3 main components :

Pump wheel - turbine wheel - stator(Reaction member)

These 3 impeller wheels are arranged in such a ring-shaped system that the fluid passes through the circulating components in the indicated order.

Pressure oil is constantly pressing out of the transmission pump through the converter. In this way, the converter can fulfill its task to multiply the torque of the engine, and at the same time, the heat created in the converter is absorbed through the escaping oil.

The oil, escaping out of the pump wheel, enters the turbine wheel and where the direction of flow is inversed.

According to the rate of inversion, the turbine wheel and with it also the output shaft, receives a more or less high reaction moment. The stator(Reaction member), following the turbine, has the task to inverse again the oil which is escaping out of the turbine and to delivery it under the suitable discharge direction to the pump wheel.

The stator receives a reaction moment, due to the inversion.

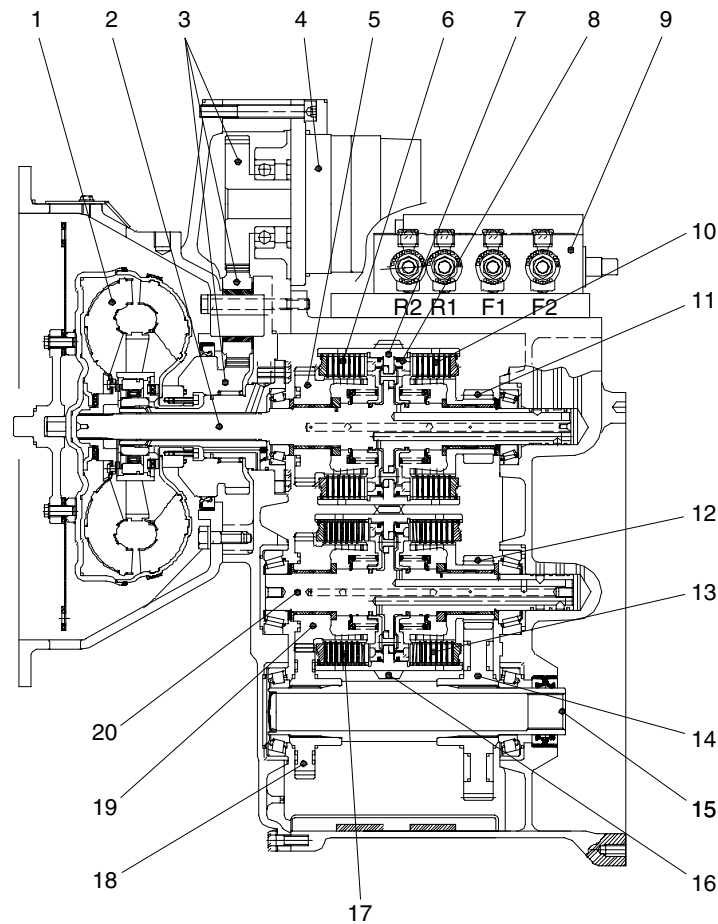
The relation between turbine and pump moment is called torque conversion. The conversion is increasing in correspondence with the speed difference of the pump and the turbine wheel.

Finally the maximum conversion will be broken down at turbine wheel.

With increasing output speed, the torque conversion is decreasing. The adoption of the output speed to a certain required output moment is infinitely variable and automatically achieved by the torque converter.

3. TRANSMISSION

1) STRUCTURE



D357TA03

1 Torque converter	8 Clutch piston	15 Output shaft
2 Input shaft	9 Valve assembly	16 Clutch drum (FR)
3 3 P.T.O gears	10 Clutch (RR, 1 stage)	17 Clutch (FR, 2 stage)
4 Pump assembly	11 Gear (RR, 1 stage)	18 Gear (Output, 2 stage)
5 Gear (RR, 2 stage)	12 Gear (FR, 1 stage)	19 Gear (FR, 2 stage)
6 Clutch (RR, 2 stage)	13 Clutch (FR, 1 stage)	20 Counter shaft
7 Clutch drum(RR)	14 Gear (Output, 1 stage)	

2) OPERATION

Transmission enables to a power transmission and a gearshift by the operation of hydraulic friction clutch pack which is controlled through the torque converter.

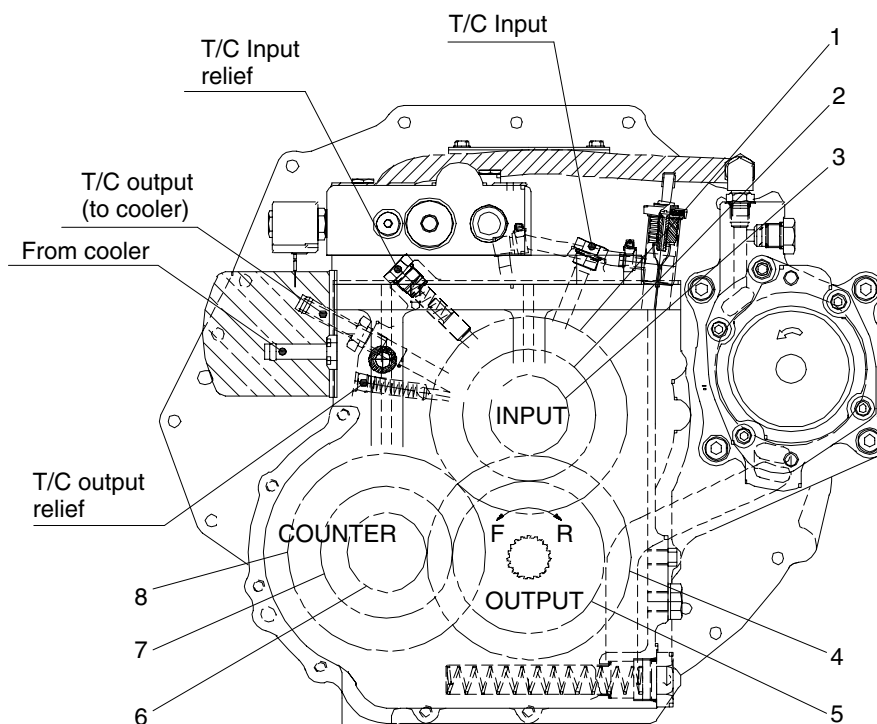
In accordance with the drive speed of vehicle, transmission shifts the gear to the optimal stage for a stable drive.

T/M transmits the power to drive axle by 2 stage each of forward and reverse gear selections.

T/M consists of 4 hydraulic clutches and it is released by spring tension.

Direction and gear stage are electrically changed. The power from the transmission is transmitted to all of the powertrain components.

3) TRANSMISSION GEAR ARRAY

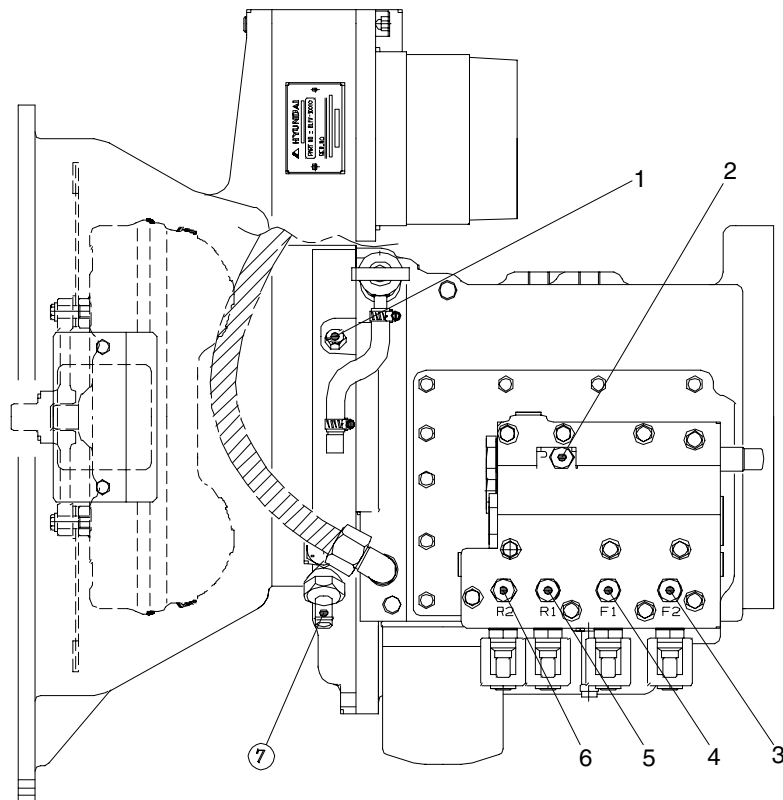


D357TA04

- | | | | | | |
|---|----------------------|---|-------------------------|---|---------------------|
| 1 | Cylinder clutch (RR) | 4 | Gear(Output, 1st stage) | 7 | Gear(FR, 2nd stage) |
| 2 | Gear(RR, 2nd stage) | 5 | Gear(Output, 2nd stage) | 8 | Gear clutch(FR) |
| 3 | Gear(RR, 1st stage) | 6 | Gear(FR, 1st stage) | | |

※ Selection of either forward or reverse gear makes all of the parts inside the T/M operate.

4) TRANSMISSION INPUT PORT



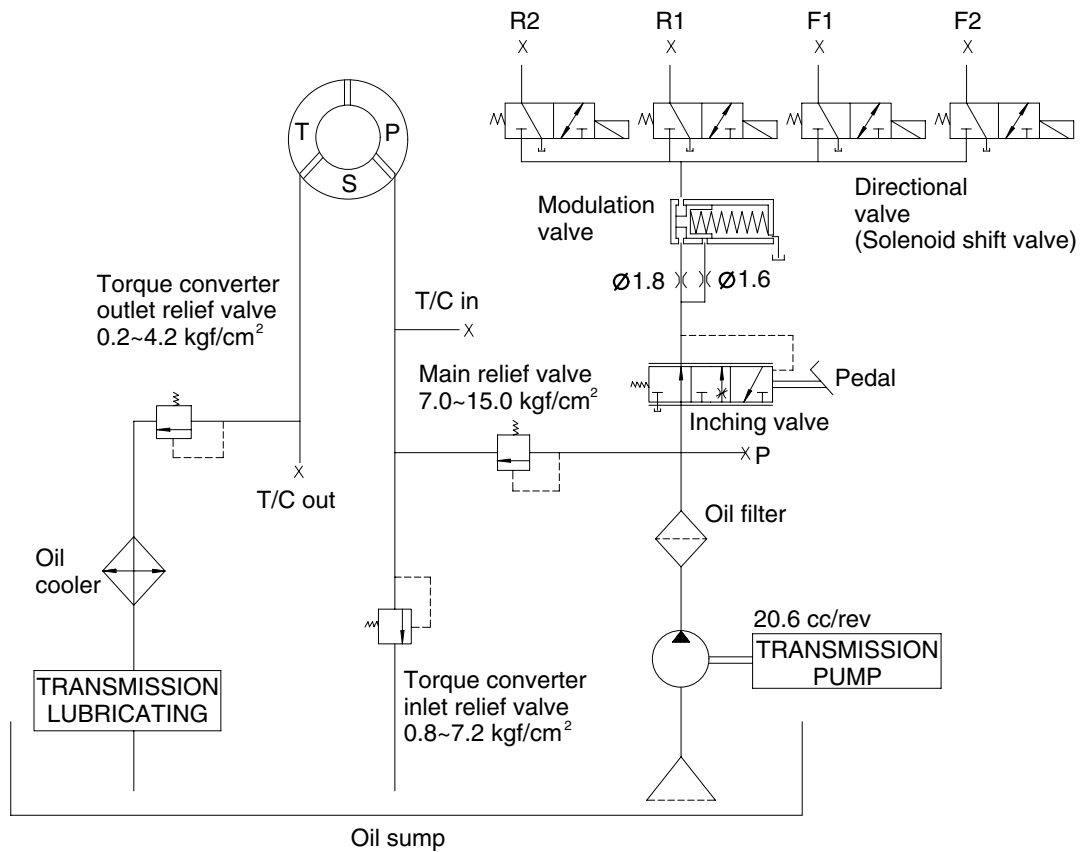
D357TA05

- | | |
|---------------------------|----------------------------|
| 1 T/C input port pressure | 5 RR 1st stage pressure |
| 2 Main line pressure | 6 RR 2nd stage pressure |
| 3 FR 2nd stage pressure | 7 T/C output port pressure |
| 4 FR 1st stage pressure | |

· Transmission pressure

Engine rpm	Unit	Main line (Neutral)	T/C input port (Neutral)	T/C output port (Neutral)	FR 1,2 stage clutch	RR 1,2 stage clutch
Idle	kgf/cm ² (psi)	7.0~13.2 (99.6~187.7)	0.8~4.2 (11.4~59.7)	0.2~1.2 (2.8~17.1)	7.0~13.2 (99.6~187.7)	7.0~13.2 (99.6~187.7)
1300	kgf/cm ² (psi)	7.5~14.5 (106.7~206.2)	2.5~6.1 (35.6~86.8)	0.7~2.5 (10.0~35.6)	7.5~14.5 (106.7~206.2)	7.5~14.5 (106.7~206.2)
2400	kgf/cm ² (psi)	7.5~15.0 (106.7~213.4)	4.2~7.2 (59.7~102.4)	1.0~4.2 (14.2~59.7)	7.5~15.0 (106.7~213.4)	7.5~15.0 (106.7~213.4)

3. TRANSMISSION HYDRAULIC CIRCUIT



D357TA06

(1) Specification

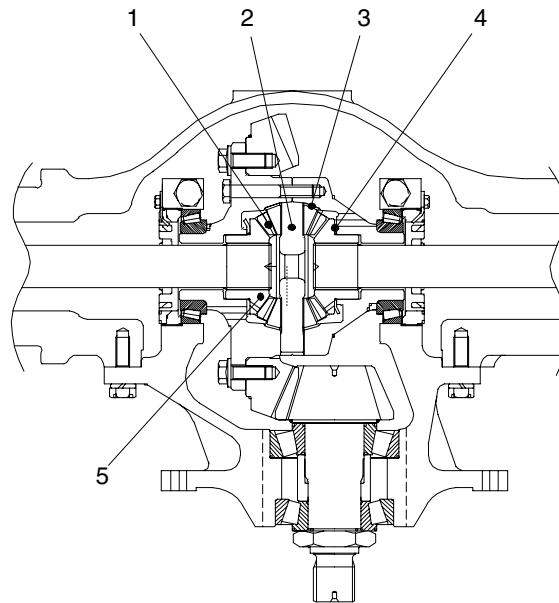
Item	Unit	Specification
Rated flow	l /rpm	37.4 / 2200
Main relief pressure	kgf/cm²(psi)	7.0 ~ 15.0(99.6~213.4)
T/C relief pressure	kgf/cm²(psi)	0.8 ~ 7.2(11.4~102.4)
Clutch pressure	kgf/cm²(psi)	7.0 ~ 15.0(99.6~213.4)
Residual pressure (Clutch release condition)	kgf/cm²(psi)	Max. 0.3(4.3)

(2) Electric input data

Item	Unit	Specification
Initial coil current at 20°C	A / VDC	0.7/24
Resistance at 20°C	Ω	39.3
Shifting time	sec	1.0 ~ 1.6
Connector	-	DR/D Models With Diode

4. DIFFERENTIAL CARRIER ASSEMBLY

1) STRUCTURE



D357TA07

No	Item	Unit	Specification
1	Differential pinion gear inner diameter	mm(in)	20.000 - 20.021(0.787~0.788)
2	Spider outer diameter	mm(in)	19.959 - 19.980(0.786~0.787)
3	Pinion gear washer	mm(in)	1.92 - 2.08(0.076~0.082)
4	Side gear washer	mm(in)	1.95 - 2.05(0.077~0.081)
5	Side gear	-	-

2) OPERATION

Differential transmits the power from the transmission to drive wheel.

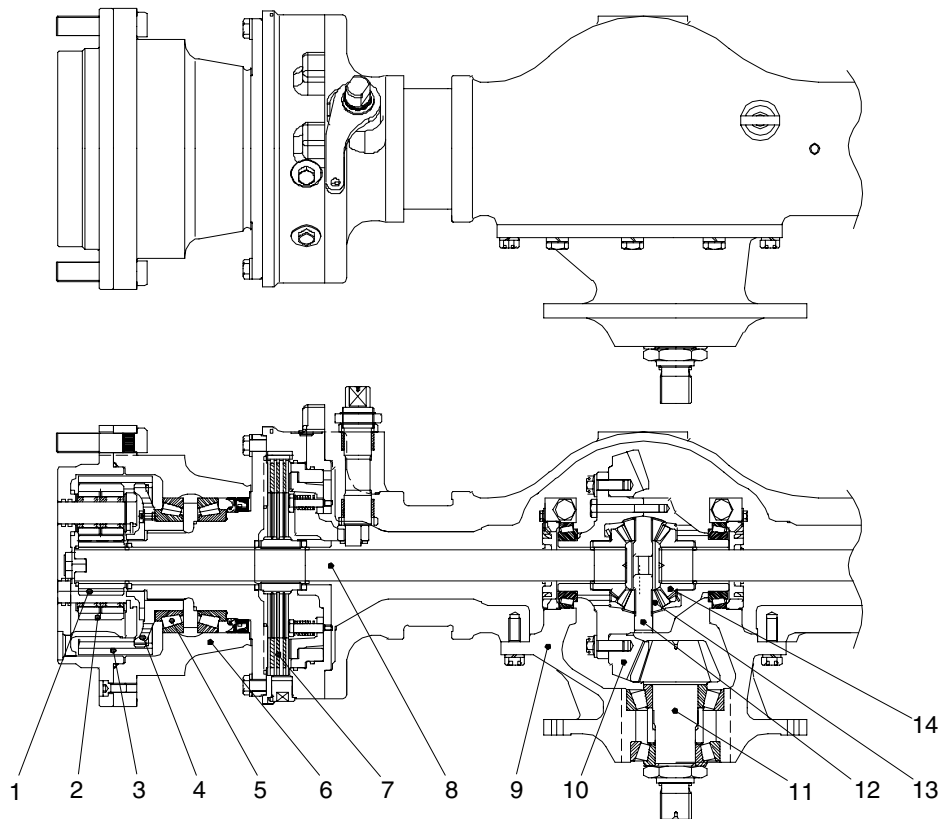
When the vehicle is running one side wheel rotates slower than the other side wheel.

Differential is composed of 4 pinions(1), 2 side gears(5) and 1 spider(2).

The spider is meshed vertically between 4 pinions(1) and 2 side gear(5), so the engagement become a right angle.

5. DRIVE AXLE

1) STRUCTURE



D357TA08

1 Sun gear	6 Hub assy	11 Pinion shaft
2 Planetary gear	7 Disk brake	12 Spider
3 Inner gear	8 Drive shaft	13 Differential pinion gear
4 Inner gear carrier	9 Differential carrier assy	14 Differential side gear
5 Tapered bearing	10 Ring gear	

2) OPERATION

Drive axle which consists of differential carrier assembly(9), drive shaft(8) and hub assembly(6) transmits the drive force from transmission to drive wheel.

Pinion shaft(11) is connected to transmission output shaft and spline.

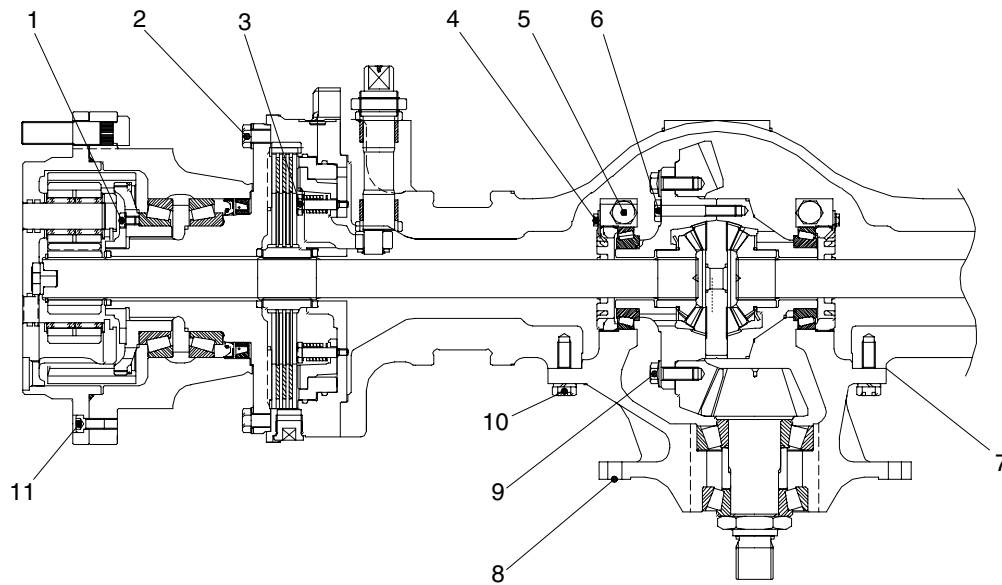
The power of transmission is transmitted to differential which consists of pinion shaft(11) and ring gear(10) and the differential rotates the drive shaft.

The differential transmits the drive force from transmission to wheels and one wheel's rotation speed is differ from the other.

The differential consists of 4 pinions(13) , 2 side gears(14) and spider and the engagement between 4 pinions(13) and side gear(14) makes a right angle.

Side gear(14) and drive shaft(8) are connected with spline and the drive shaft(8) consists of planetary gear(2), inner gear(3), wheel hub(6) and drive wheels.

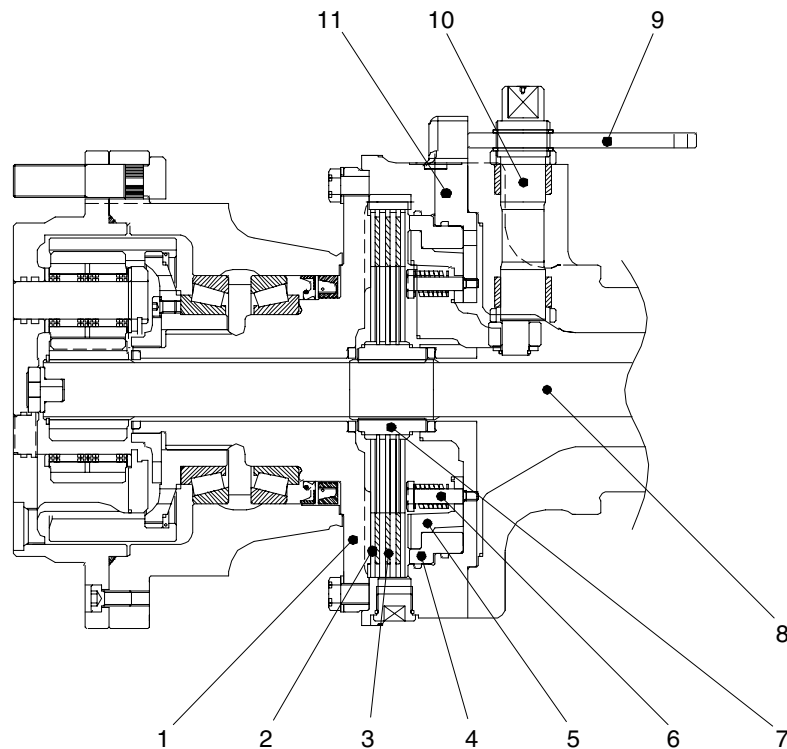
3) DRIVE AXLE TIGHTENING TORQUE



D357TA09

No	Item	Specification
1	Inner carrier	$2.2 \pm 0.3 \text{ kgf} \cdot \text{m}$ ($15.9 \pm 2.2 \text{ lbf} \cdot \text{ft}$)
2	Spindle	$12 \pm 0.5 \text{ kgf} \cdot \text{m}$ ($86.8 \pm 3.6 \text{ lbf} \cdot \text{ft}$)
3	Parking piston	$1.5 \pm 0.1 \text{ kgf} \cdot \text{m}$ ($10.8 \pm 0.7 \text{ lbf} \cdot \text{ft}$)
4	Adjuster nut	$1.0 \pm 0.2 \text{ kgf} \cdot \text{m}$ ($7.2 \pm 1.4 \text{ lbf} \cdot \text{ft}$)
5	Differential cap	$16 \pm 0.5 \text{ kgf} \cdot \text{m}$ ($115.7 \pm 3.6 \text{ lbf} \cdot \text{ft}$)
6	Differential case	$6 \pm 0.5 \text{ kgf} \cdot \text{m}$ ($43.4 \pm 3.6 \text{ lbf} \cdot \text{ft}$)
7	Connection between differential carrier and drive axle	LOCTITE #5127
8	Connection between differential carrier and T/M	LOCTITE #17430
9	Ring gear	$13.5 \pm 0.5 \text{ kgf} \cdot \text{m}$ ($97.6 \pm 3.6 \text{ lbf} \cdot \text{ft}$)
10	Differential carrier assembly	$11.5 \pm 0.5 \text{ kgf} \cdot \text{m}$ ($83.2 \pm 3.6 \text{ lbf} \cdot \text{ft}$)
11	Wheel hub	$3.0 \pm 0.3 \text{ kgf} \cdot \text{m}$ ($21.7 \pm 2.2 \text{ lbf} \cdot \text{ft}$)

4) DISK BRAKE



D357TA10

- | | | |
|------------------|--------------------------------|------------------------|
| 1 Spindle | 5 Service piston | 9 Parking lever |
| 2 Steel plate | 6 Parking piston mounting bolt | 10 Parking lever shaft |
| 3 Disk plate | 7 Spline collar | 11 Brake housing |
| 4 Parking piston | 8 Drive shaft | |

Sealed up structure of hydraulic disk brake system secures good brake performance even in the high humid or dusty area.

Because it is possible to use the brake semi-permanently, there is no need to replace or change the lining as drum type brake do.

Parking brake's lever system is the serration type, so it is possible to adjust the play.

Because it is easy to maintain the gap of both brakes, high brake efficiency and minimum disproportional braking deviation is acquired.

Major components are 3 disk plates(3), 4 steel plates(2), service piston(4), parking piston(5), parking lever(9) and brake housing(11).

Braking force is applied by restricting the driving force from drive shaft(8) and spline collar(7).

GROUP 2 INSPECTION AND TROUBLESHOOTING

1. INSPECTION

To check the problems of transmission, operate the machine and test its performance.

Check and record the abnormal noise and if the machine doesn't operate perfectly, refer to problem and possible cause in the troubleshooting table.

1) VISUAL CHECK

- (1) Start engine and check T/M oil level at the neutral gear shift.
- (2) Check any kind of damage or leakage on the oil piping, hose, connection, etc.
- (3) Operate the Forward/Reverse lever to both of directions.
- (4) Check the contamination in the strainer and filter inside the transmission.
 - ① If rubbed paper particles detected, check clutch defects.
 - ② If metal particles detected inside the filter, check metallic friction inside the T/M or mechanical faults.
 - ③ If rubber particles detected, check seal or hose defects.
 - ④ If Aluminum particles detected, check converter or control valve damage.
- (5) If metal or rubber particles found, clean all of the T/M hydraulic parts.
- (6) Replace damaged parts with the new one.

2) DRIVE CHECK

Fill T/M oil to the proper level before starting the machine.

Improper oil level can cause the damages on the components.

- (1) After starting engine, step on the brake pedal and then operate the Forward/Reverse lever to both of directions.
- (2) If the machine moves to each of directions, it will operates normally but check noise and cause and then note them.

In case of abnormal operation, refer to troubleshooting table.

2. TROUBLESHOOTING

1) GENERAL INSPECTION WHILE DRIVING

No	Problem	Cause
1	Failure at the specific gear stage	- Low oil pressure or no pressure. - No oil, low level or high oil viscosity. - Loose inching control valve connection, incorrect adjustment or damage. - Inching valve spool stuck or open. - Oil pump damage or defect. - T/C pump gear side bolt breakage or gear not meshing with pump. - Main regulator valve stuck or open. - Oil circuit clogged or strainer contaminated. - T/M inside leakage. - Control valve gasket damage. - Clutch shaft metal sealing wear or damage. - Clutch piston seal damage or wear. - Control valve gasket wear cause oil leakage. - Abnormal connection of outer line of cooler. - Mechanical defect inside the T/M
2	Gear shift failure	- Low oil pressure. - Main regulator valve does not move. - Malfunctioning of solenoid or relative electric components.
3	T/M overheating	- Clogged cooling line. - Oil level is too high or too low. - Low pump pressure, pump wear or defect. - Partial clutch wear or slip - Air mixed with oil, air leakage at the pump input port. - Insufficient oil flow through the T/C. - Overload on the machine. - Too excessive inching operation. - Too excessive stall operation of T/C. - Cooler bypass valve stick or open. Oil flow insufficient through oil cooler.

No	Problem	Cause
4	Slow clutch meshing or failure	1. Low oil pressure. 2. Low converter oil pressure. 3. Air mixed with oil 1) Air mixed through the pump input port. 2) Low oil level 4. Abnormal adjustment of inching valve linkage.
5	Reverse gear shift failure	1. Excessive wear of disk and plate at reverse clutch. 2. Oil leakage from seal. 3. Reverse clutch components defect. 1) Metal sealing wear or defect. 2) Clutch piston seal wear or defect. 3) Another components damaged. 4. Malfunction of solenoid or related electric parts.
6	Forward gear shift failure	1. Excessive wear of disk and plate at forward clutch. 2. Oil leakage from seal. 3. Forward clutch components defect. 1) Metal sealing wear or defect. 2) Clutch piston seal wear or defect. 3) Another components damaged. 4. Malfunction of solenoid or related electric parts.
7	Low stall speed	1. Incorrect engine performance. 2. Torque converter stator failure.
8	High stall speed at all of gear stage	1. Low oil level. 2. Air mixed with oil. 3. Clutch slip. 4. T/C malfunctioning.
9	High stall speed at partial direction or speed	1. Clutch line leakage. 2. Clutch defect.
10	Slow clutch meshing and rough gear shift	1. Incorrect adjustment of inching valve. 2. Inching valve not closed or clogged orifice. 3. Low main pressure. 4. Low pressure of direction clutch. 5. Oil leakage. 6. Valve spool spring weakened or damaged.
11	Abnormal movement to the specified direction at neutral	1. Clutch defect, clutch disk and plate damaged. 2. Valve spool defect or spool stucked.

2) ABNORMAL NOISE CHECK LIST

No	Problem	Cause
1	Noise only at neutral	1. Gear or bearing wear inside the pump. 2. Torque converter stator wear. 3. Low oil level. 4. Gear parts of engine and T/M pump's misalignment with that of converter housing and pump.
2	Pump noise	1. Loud noise irregularly repeats if there's contaminants in the T/M hydraulic components. 2. Regular noise means pump defect.
3	T/M noise	1. Converter housing and pump gear misalignment with engine or T/M 2. T/M components wear or damage. 1) Gear damage. 2) Clutch plate and disk slip noise. 3) Thrust washer defect. 4) Another components wear or damage.
4	Control valve noise	1. Air mixed into hydraulic system. 1) Air leakage from the pump input port. 2. Clogged oil passage. 3. Abnormal spool movement.

3) PRESSURE TEST CHECK LIST

No	Problem	Cause
1	FR/RR clutch low pressure	Incorrect adjustment of inching valve linkage
		Inching spool stucked and open.
		Clutch and piston oil leakage.
		Regulator spring defect.
		Low oil pressure.
		Incorrect connection of cooler external line.
2	High clutch and main pressure	Pressure regulation valve does not move smoothly.
		Clogged hydraulic line.
3	Low clutch pressure	Oil leakage due to incorrect assembly of clutch piston seal.
		Damage or wear of clutch piston seal and shaft seal.
		Valve contact surface not flat or gasket damage.
4	Low main pressure	Low oil quantity
		Pressure regulation valve does not move smoothly.
		Pump wear
		Internal leakage
		Low oil pressure
5	High converter pressure	Main regulation valve stucked and open, oil overflow to converter.
		Clogged internal passage of converter assembly.
		Clogged oil line.
6	Low converter pressure	Clogged main regulator valve.
7	Low converter output pressure, cooler input pressure.	Low oil pressure
		Cooler bypass valve stucked and open.
8	High converter output pressure, cooler input pressure	Clogged or restricted cooler line.

4) DIFFERENTIAL

No	Problem	Cause
1	Regular noise	1. Lubricating oil shortage. 2. Incorrect oil specification. 3. Wheel bearing adjustment failure or defect. 4. Drive gear and pinion adjustment failure. 5. Drive gear or pinion gear damage or wear. 6. Large or small gear backlash. 7. Pinion bearing wear or loosening. 8. Side bearing wear or loosening.
2	Irregular noise	1. Irregular rotation of ring gear. 1) Loosened drive gear fixing bolt. 2) Drive gear defect. 2. Differential bearing damage.
3	Noise only at the rotation	1. Differential drive gear and pinion shaft or spider are tightly meshed. 2. Side gear and differential case are tightly meshed. 3. Differential pinion and side gear defect. 4. Thrust washer wear or damage. 5. Too large backlash (between side gear and pinion)
4	Lubricating oil leakage	1. Oil leakage at the axle hub carrier side. 1) Too high oil level. 2) Incorrect oil specification. 3) Clogged axle housing breather. 2. Pinion axle leakage. 1) Too high oil level. 2) Incorrect oil specification. 3) Clogged breather. 4) Wear or incorrect assembly of oil seal.
5	Drive wheel stopping	1. Axle shaft damaged. 1) Wheel bearing loosening. 2) Short length of shaft. 3) Stud and nut loosening. 2. Drive gear teeth damaged. 3. Pinion gear of differential side gear is damaged. 4. Spider of differential pinion is damaged.

GROUP 3 DISASSEMBLY AND ASSEMBLY

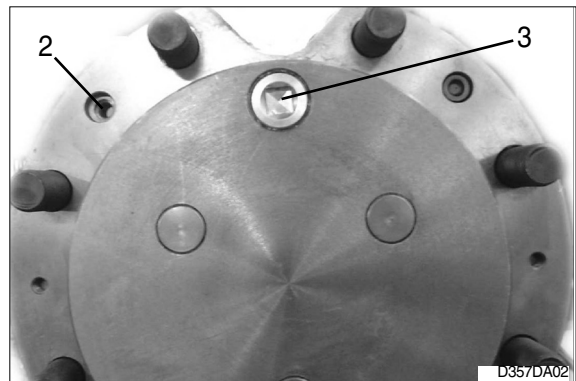
1. DISASSEMBLY OF DRIVE AXLE

1) REMOVAL AND DISASSEMBLY OF WHEEL HUB

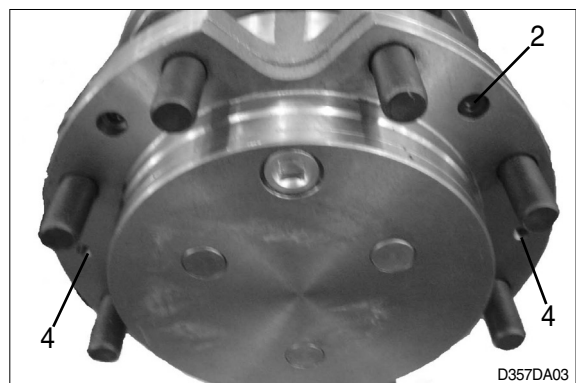
- (1) Loosen drain plug with a torque wrench(1) and drain oil.



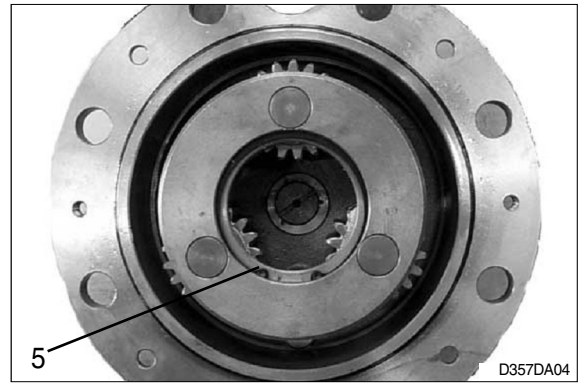
- (2) Loosen 4 socket head bolts(2) and a plug(3) from the housing of planetary.



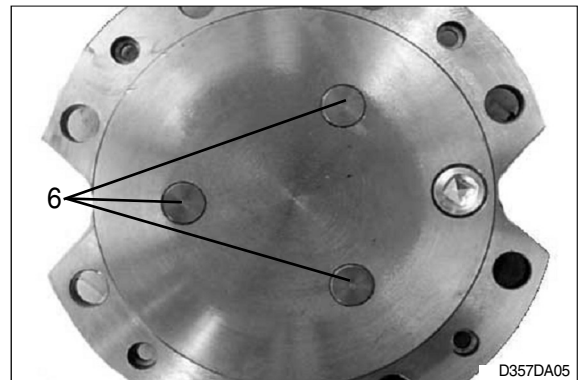
- (3) Fit socket head bolt(2) into the 2 tap holes(4) and remove housing of planetary.



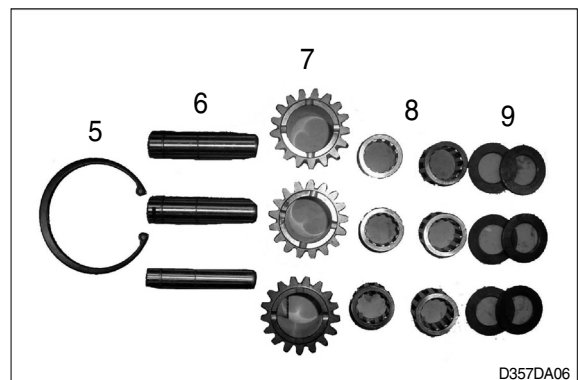
- (4) Remove snap ring(5) from the housing of planetary.



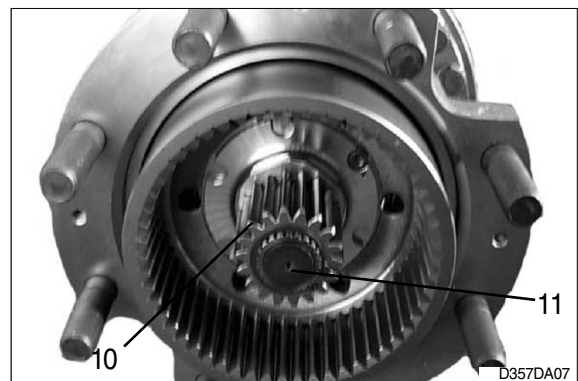
- (5) Remove 3 pins(6) with a plastic hammer.



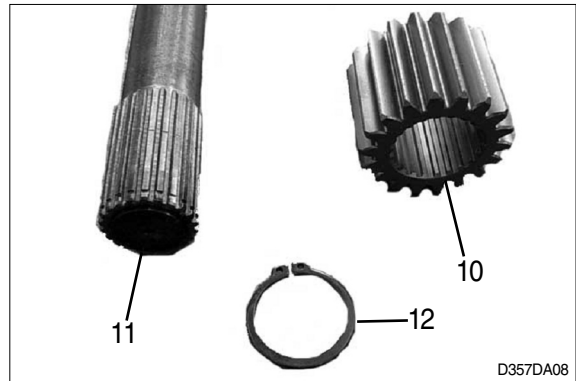
- (6) Remove needle bearing(8), planet gear(7) and thrust washer(9).



- (7) Remove sun gear(10) and drive shaft(11).



- (8) Remove snap ring(12) and then remove sun gear(10) from the shaft(11).



- (9) After removing bolt(13), remove ring gear(14) and torque plate assembly from the axle tube.



- (10) Remove snap ring from the ring gear(14) and disassemble internal gear carrier.

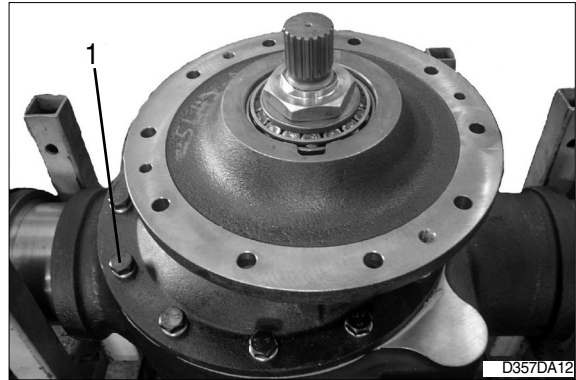


- (11) Remove bearing cup from the wheel hub by using jig and hammer. Shaft seal will be damaged.

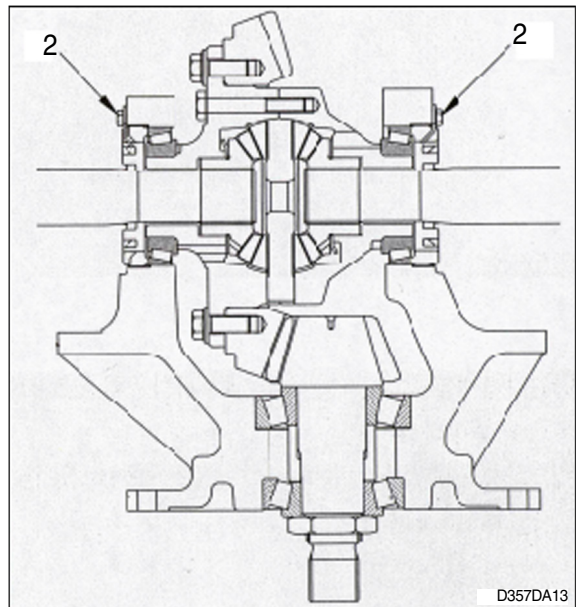


2) REMOVAL AND DISASSEMBLY OF AXLE HOUSING

(1) Loosen 12 bolts(1) and then remove carrier from the housing by using a lifting machine.

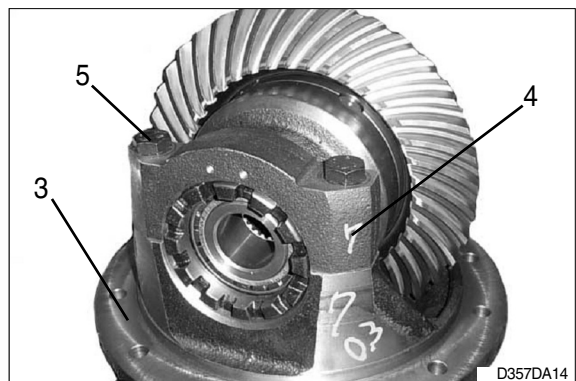


(2) For the reassembly, check rolling resistance and record it. Remove backing plate(2).

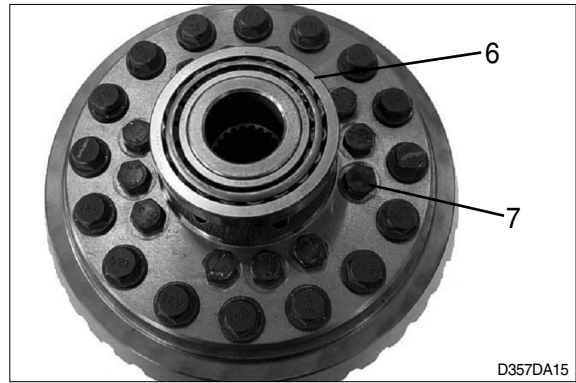


(3) Before removing differential assembly from carrier(3), check the location of cap(4) and mark it for reassembly.

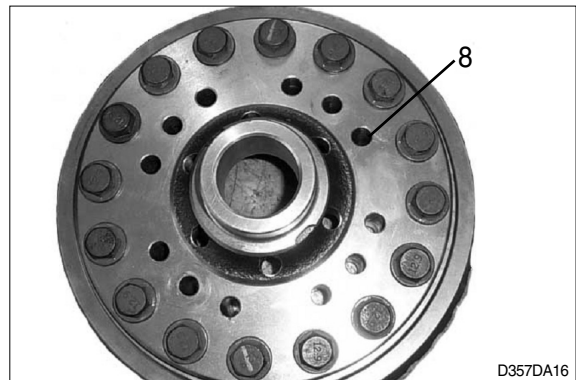
(4) Remove 4 hexagon bolts(5) and cap(4).



- (5) Disassemble bearing(6) from the differential housing and remove 12 bolts (7).



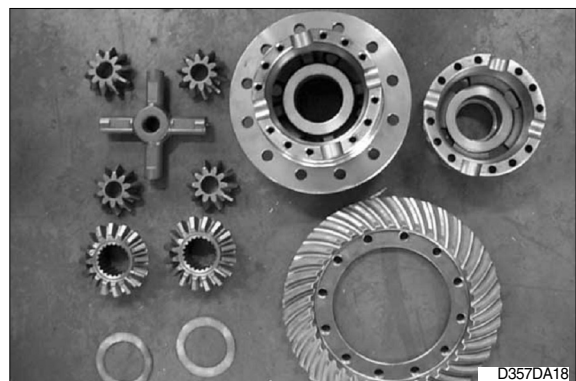
- (6) Remove differential assembly from the carrier.
- (7) After removing 12 mounting bolts(8) from the housing and then disassemble ring gear.



- (8) Check the mark on the housing and separate the housing from the differential. If there is no mark, be sure to mark on the housing. When reassembling, it must be placed at the same position as before.



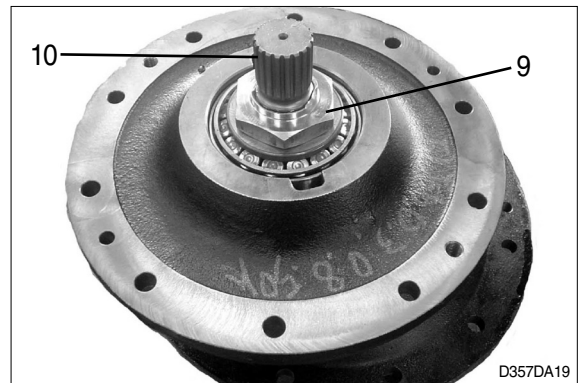
- (9) Remove thrust washer, side gear, pinion gear and spider and then place them on the clean bench.



(10) Remove lock nut(9).

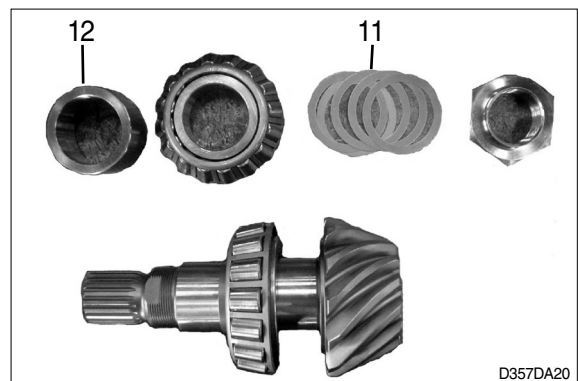
(11) Remove drive bevel pinion shaft (10) by using a plastic hammer.

※ **Be careful not to damage bevel pinion shaft.**



(12) Remove shim(11) and spacer(12) from pinion shaft.

Using a bearing puller, disassemble inner race of taper roller bearing from the pinion shaft.



(13) Remove outer race of taper roller bearing and shim from the housing by using a jig and hammer.

※ **Do not reuse damaged shims.**



(14) Remove outer race of taper roller bearing from the opposite side.



2. REASSEMBLY OF DRIVE AXLE

Clean all of the parts with cleaner and then remove remained loctite.

- ※ Be careful not to spill cleaner on your body.
- Avoid drinking cleaner or breathing its fumes.
- Wear protective clothing, glasses and gloves.
- If spilled on the skin, flush your skin with water immediately.
- If swallowed, get medical attention immediately.
- Please observe safety regulations.

- Check wear, damage or crack for all the parts and replace if needed.
- If the teeth of gear are damaged, replace it as a set.
- Replace damaged tapered roller bearing.
- Do not reuse deformed shims or worn thrust washers.
- Rasp off the seal contacted surface.

1) ADJUSTMENT OF BEVEL PINION SHAFT

Adjusting shim of bevel pinion shaft.

- (1) Adjust shim thickness and bevel pinion shaft with following method.

- ① Measure "E" at the housing.
- ② By the equation " $X = E - B - T \pm C$ ", define the the shim thickness(1).

B : Mounting dimension of bevel pinion shaft , 133.20mm (5.2 in)

T : Height of bearing.

C : Dimension of carved seal on the pinion. If there's no carved seal **C**=0.

EX) : From the housing

"E" = 162.95mm (6.4in)

B is factory dimension

"B" = 133.20mm (5.2in)

From the bearing

"T" = 29.25mm (1.2in)

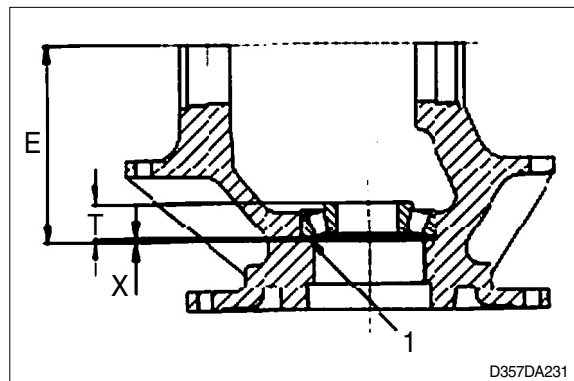
Carved seal on the pinion

"C" = 0.05mm (0.002in)

Shim thickness :

"X" = $162.95 - 133.20 - 29.25 + 0.05$
= 0.55mm (0.022in)

- ※ If teeth are damaged, replace bevel gear and shaft



- (2) Using different kinds of shims, adjust shim thickness as measured by previous equation. Place shims at the bearing place.

Using a jig, assemble drive bearing so that the outer race contact with the bearing place.



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- (3) Heat inner race of bearing to max 100°C and then assemble it to the pinion shaft. Also inner race should contact with bearing place.

- Measuring play of bevel pinion shaft end
Measure shim thickness by following method.

Dimension "Q" : Distance from bearing outer race surface to spacer surface.

Dimension "P" : Distance from bearing outer race surface to inner race surface.

From the below equation, define required shim thickness Z.

$$Z = P - Q$$

EX) : From the bearing

$$P = 2.25\text{mm (0.09in)}$$

From the housing

$$Q = 1.85\text{mm (0.07in)}$$

Required shim thickness Z :

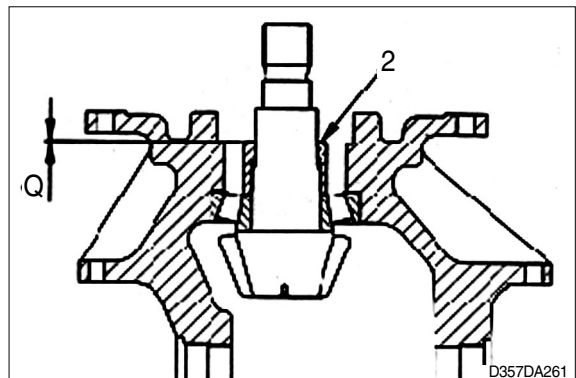
$$Z = 2.25 - 1.85 = 0.40\text{mm (0.02in)}$$

Unit : mm(in)

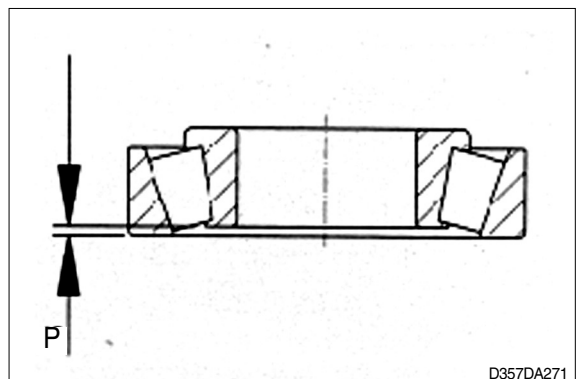
P	Q	Z
2.15(0.085)	1.85(0.073)	0.30(0.012)
2.20(0.087)	1.85(0.073)	0.35(0.014)
2.25(0.089)	1.85(0.073)	0.40(0.016)
2.30(0.091)	1.85(0.073)	0.45(0.018)
2.35(0.093)	1.85(0.073)	0.50(0.020)



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2) ADJUSTMENT OF PINION SHAFT

(1) Assemble bearing cup.

Assemble spacer to the pinion shaft and then install measured shims onto the spacer.



(2) Insert pinion shaft into the carrier.

Assemble bearing cone and lock nut.
Apply grease on the outer bearing(1).
Apply loctite #271 or #277 on the thread of pinion and then tighten lock nut.

- Tightening torque : 45~51kgf · m
(325~369lbf · ft).

Measure rolling resistance of pinion shaft.
Adjust shim thickness.

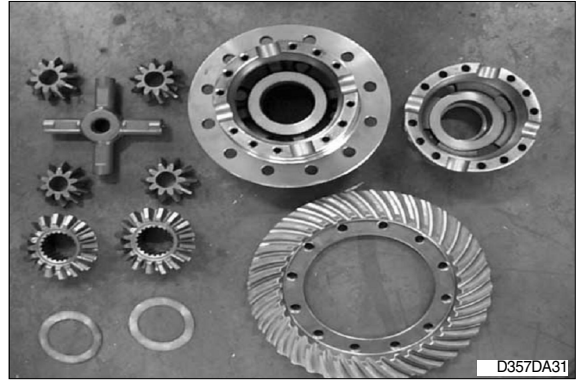
- Rolling resistance : 0.20~0.41kgf · m
(1.4~2.9lbf · ft).

Coke lock nut into the pinion shaft slot.



3) ASSEMBLY OF DIFFERENTIAL ASSEMBLY

- (1) Assemble thrust washer, side gear and spider with gear and then install them to the differential housing.
Apply grease on the bevel gear and thrust washer.



- (2) Assemble differential housing.

※ Check marks on the housing.
Match two marks at the same position.



- (3) Tighten 12 bolts(7) to the differential housing.
Apply loctite #271 or #277 on the thread of bolt.

• Tightening torque : 5.5~6.5kgf · m
(40~47lbf · ft)



- (4) Assemble ring gear by tightening 12 bolts(6).
Apply loctite #271 or #277 on the thread of bolt.

• Tightening torque : 13~14kgf · m
(94~101lbf · ft)



- (5) Install differential assembly onto the carrier. Place the bearing cup and screw into the housing. At this moment, using a screw adjust rotation backlash. Install the dial gauge on the gear tooth and measure the backlash while rotating bevel gear.

- Rotation backlash : 0.18~0.23mm
(0.007~0.009in)



- (6) Assemble bearing cap.

※ **Fix bearing cap with hexagon bolt.**

- Tightening torque : 15.5~16.5kgf · m
(112~119lbf · ft)

Measure rolling resistance of tapered roller bearing.

The right table shows the relation between preload(P) of bevel pinion shaft and rolling resistance(Z) calculated at 1).

Unit : kgf · m (lbf · ft)

P	Z
0.20(1.45)	0.35~0.41(2.53~2.95)
0.25(1.81)	0.40~0.46(2.89~3.33)
0.30(2.17)	0.45~0.49(3.25~3.54)
0.35(2.53)	0.50~0.56(3.62~4.05)
0.408(2.95)	0.56~0.62(4.05~4.48)
0.50(3.62)	0.62~0.70(4.48~5.06)

- (7) Confirm that the screw contacts with bearing.

- (8) After complete assembly of bearing, measure rotation backlash once more and readjust with a screw if needed.

- (9) Apply loctite #271 to the thread of bearing cap bolt.

- Tightening torque : 15.5~16.5kgf · m(112~119lbf · ft).

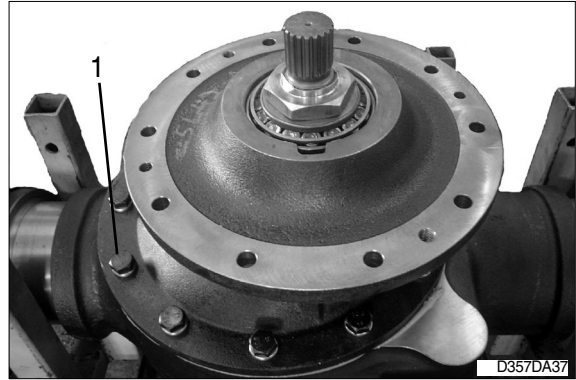
- (10) Assemble plate with hexagon bolts. Apply loctite #271 or #277 to the thread of bolt and then assemble at the tightening torque of 0.80~2.10 kgf · m(5.8~15.2lbf · ft).

※ **Assemble opposite side with the same methods.**

- (11) Apply marking liquid to 3~4 teeth of crown gear and then bring bevel pinion gear contact with the crown gear several times. Check out the contacted shape.

4) ASSEMBLY OF CARRIER

- (1) Assemble carrier assembly into the axle housing.
- (2) Apply loctite #271 or #277 to thread of bolt and then assemble at the tightening torque of 11~12kgf · m(79.6~86.8lbf · ft).

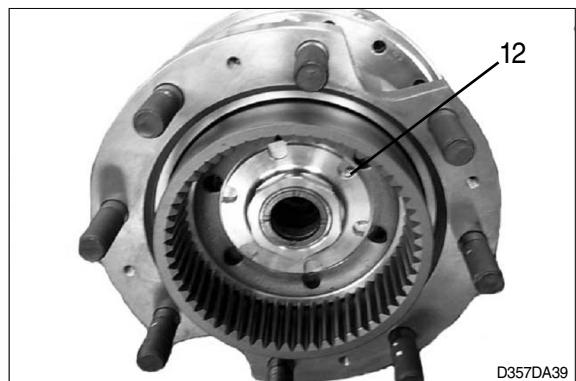


5) ASSEMBLY OF WHEEL HUB

- (1) Insert bearing into wheel hub.
Confirm that the bearing and wheel hub contact completely.
※ **Apply grease or oil to shaft seal and then assemble it from the direction of outer side of wheel hub.**
- (2) Install wheel hub assembly to the tube flange of axle completely.
Install bearing cone.



- (3) Insert shim, fix the torque plate and ring gear with snap ring and assemble them to the axle tube.
Apply loctite #271 or #277.
Apply grease on the bushing.

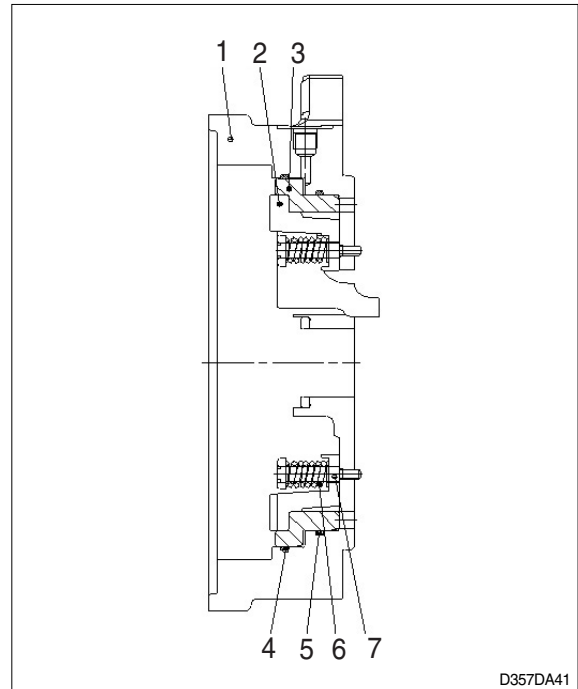


(3) Assemble square ring(4, 5) with oil(MOBIL #424) to the brake housing.

Assemble piston(3) after applying oil sufficiently and apply loctite #271 to spring(6) and 4 bolts(4).

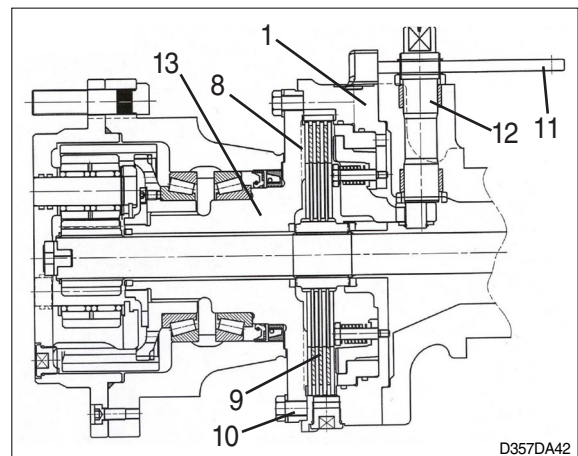
- Tightening torque : 1.4~1.6kgf · m
(10.1~11.6lbf · ft)

※ Check the status of square ring and replace if damaged.



Assembling plate and inspection

- ① Assemble 4 plates(8) and 3 disks(9) into the brake housing(1).
- ② Before assembling, clean all of the parts completely and remove burrs.
- ③ Disk must be assembled after 12 hours of infiltrate.(MOBIL #424)
- ④ After assembling plate and disk, confirm that the tolerance with brake housing surface is 1.8~2.3mm(0.07~0.09in).
(Spindle protrusion is 1mm(0.04in) and operation stroke of plate(8) and disk(9) assembly is 0.8~1.3mm(0.03~0.05in))
- ⑤ After tightening the bolt(10), confirm that parking lever(11) stroke is 18~28mm (0.71~1.10in) when pulling lever at the operation force of 25kgf.m(181lbf · ft).
· In case that the parking lever(11) distance is wrong, disassemble lever shaft(12) to rotate spline by 1 pitch and then reassemble it.
- ⑥ Apply loctite #5127 to spindle side of brake housing(1)



Unit : mm(in)

Spline	Parking lever operation distance
1 pitch	21(0.8)

- (5) Assemble sun gear to axle shaft and fix it with snap ring.

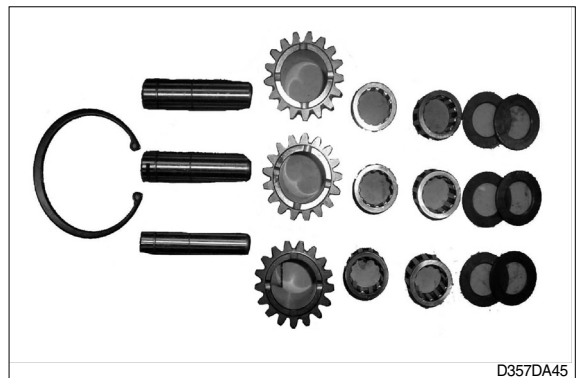
Assemble axle shaft to the axle assembly.

Apply grease on the shaft where bushing contacts.

Apply grease to teeth parts of planetary gear.

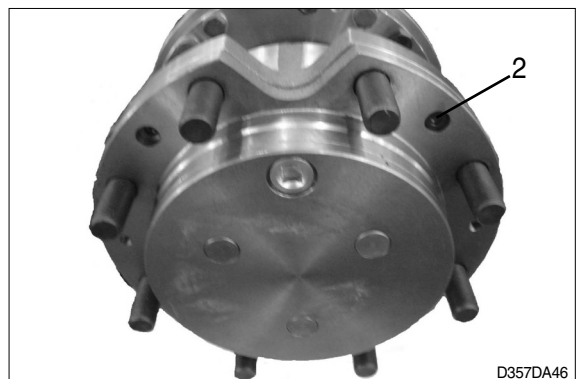


- (6) Assemble internal components of planetary carrier in the reverse order to disassembly.



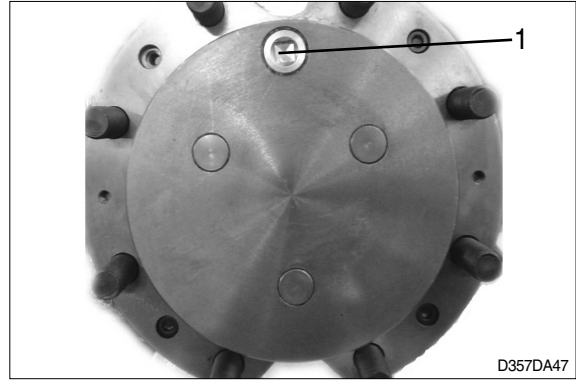
- (7) Install planetary carrier assembly to wheel hub and tighten bolt(2).

- Tightening torque : 2.7~3.3kgf · m
(19.5~23.9lbf · ft)



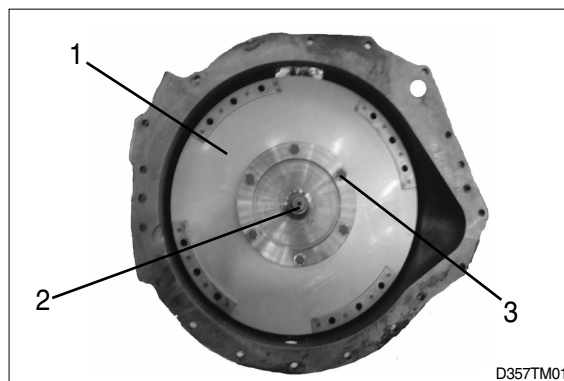
(8) Assemble wheel hub and tighten plug(1).

- Tightening torque : 4~5kgf · m
(28.9~36.1lbf · ft)

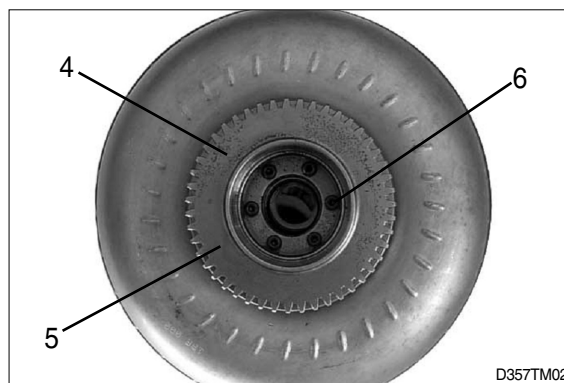


3. DISASSEMBLY OF TRANSMISSION

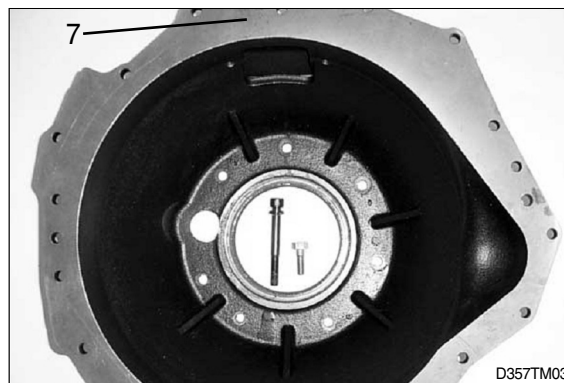
- 1) Remove torque converter from the housing.
Loosen 6 bolt(3) from torque converter and then remove adaptor(2) and flexible plate(1).



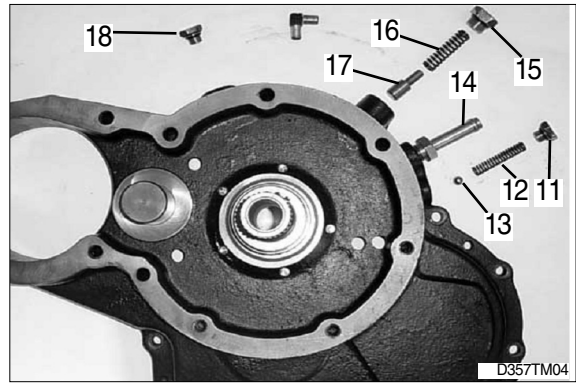
- 2) Loosen 6 socket bolts(6) and remove Gear P.T.O Input(5).



- 3) Remove oil seal(8), 4 bolts(9, 10) and washer individually, from the housing(7).

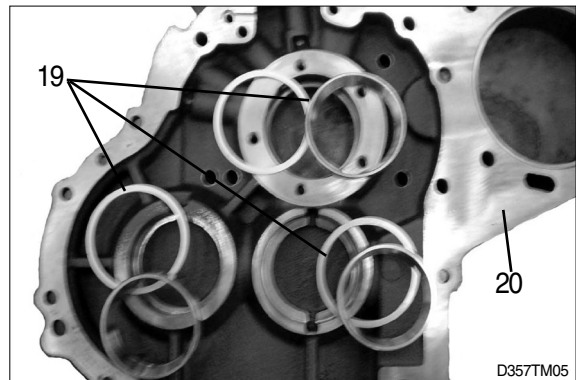


- 4) Remove plug(11), O-ring, spring(12) and ball(13) from cover.
- 5) Remove nipple(14) from the housing.
- 6) Remove plug(15), O-ring, spring(16) and valve(17).
- 7) Remove plug(18).



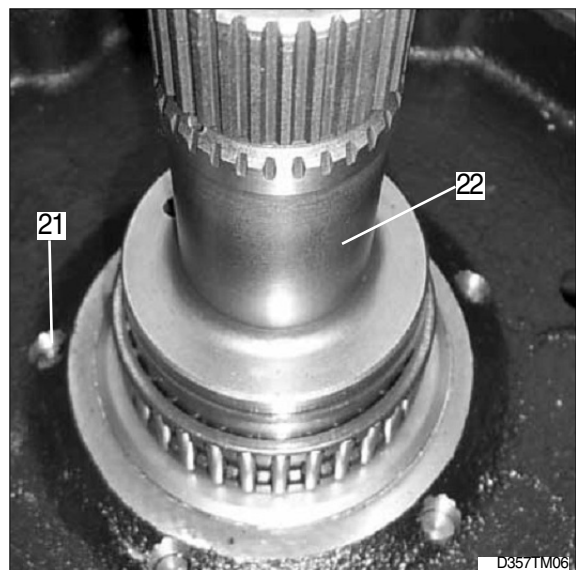
※ **Bearing cup(19) and shim(20) are located in the cover or at the shaft in the transmission case.**

※ **Mark the location of the bearing cup(19) and shim(20) on the transmission cover or shaft in the transmission case.**



- 8) Loosen 5 bolts of stator hub(22) fixed at bearing plate(20) and remove stator hub(22) from bearing plate(20).

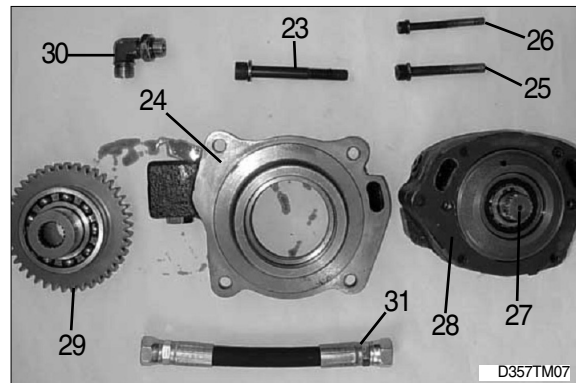
Use plastic hammer in order not to damage stator hub.



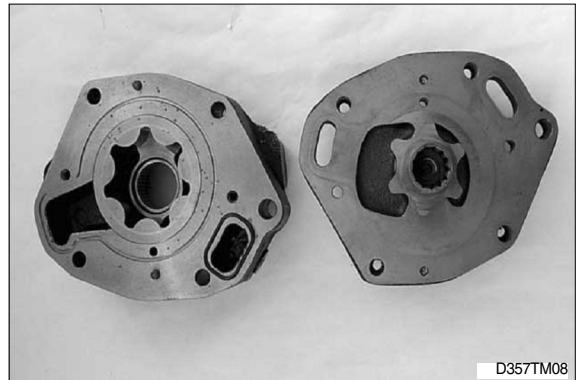
9) Remove 4 socket bolts(23) from the bearing plate(14) and disassemble flange pump(24).

Remove 1 socket bolt(25) and 4 socket bolts(26) from the flange pump to remove charging pump(27) and pump gasket(27) and then disassemble gear P.T.O output(29) and ball bearing.

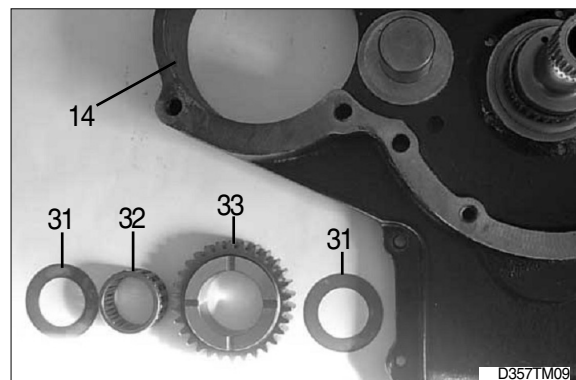
Remove elbow(30).



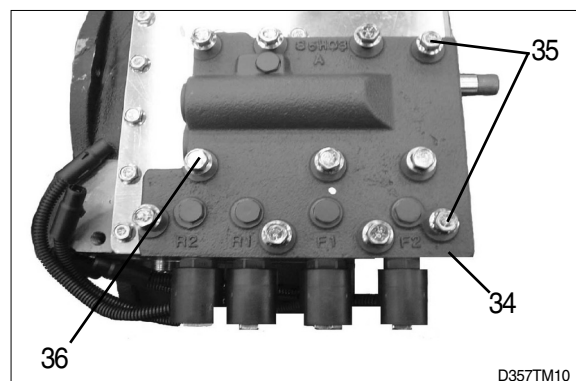
10) Loosen 2 socket bolts from charging pump(27) and then remove pump case and pump cover.



11) Remove 2 thrust washers(31), needle bearing(32) and gear P.T.O idle(33) individually from the bearing plate(14).



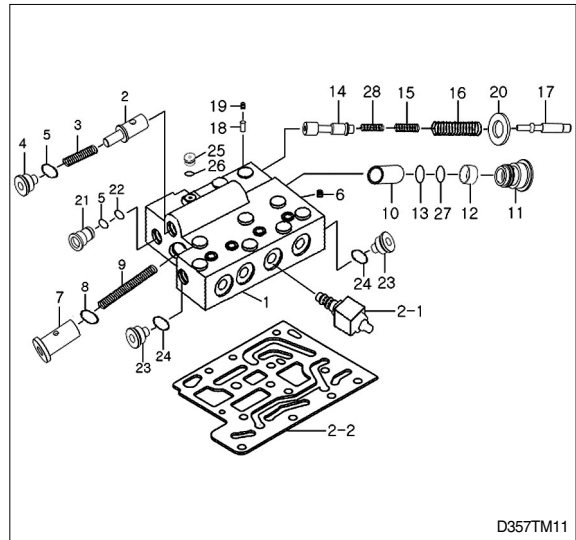
12) Remove 2 bolts(35) and 9 bolts(36) and then disassemble control valve gasket(34).



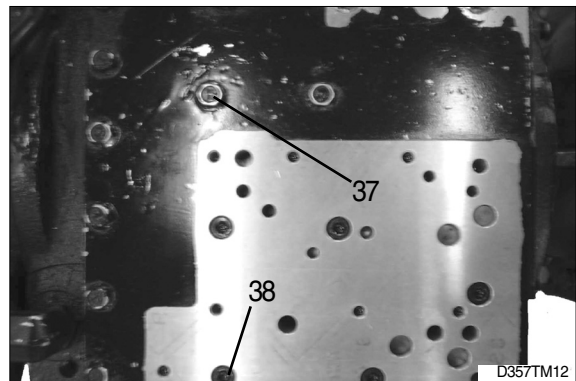
• Disassembly of transmission control valve

Remove transmission control valve

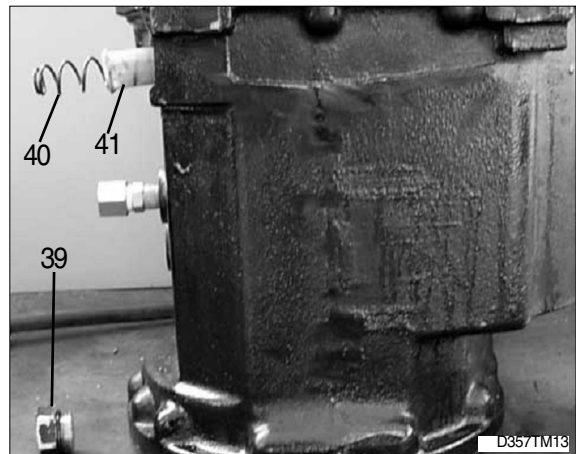
- ① Remove valve gasket(2-2).
- ② Remove stop bolt(19) and pin(18) from the valve body(1).
- ③ Remove spool(14), spring(18), spring (16), plunger(17), oil seal(20) and plug(21).
- ④ Remove plug(4), spring(3) and spool(2).
- ⑤ Remove plug(7), spring(9) and then remove plug(11), filter(12), O-ring(13, 27) and piston(10).
- ⑥ Remove both side of plug(23).



- 13) Remove 11 bolts(37) and 5 socket bolt(38) from transmission and remove valve plate carefully.

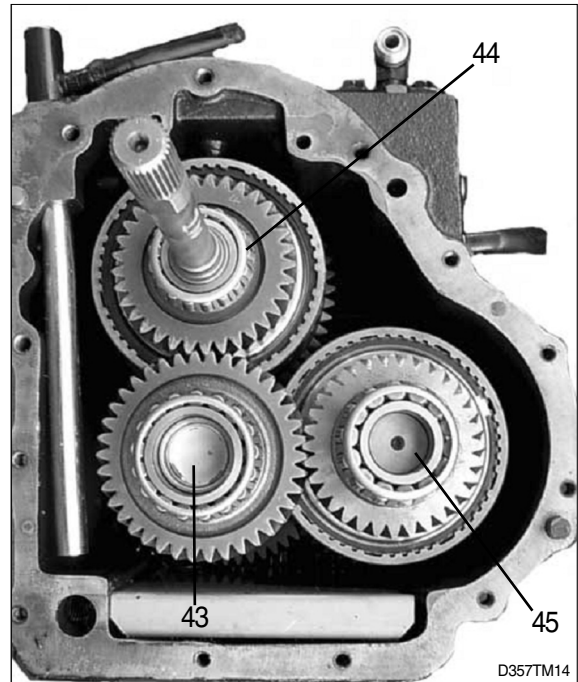


- 14) Remove plug(39) and O-ring and then remove spring(40) and oil screen(41) from the case.

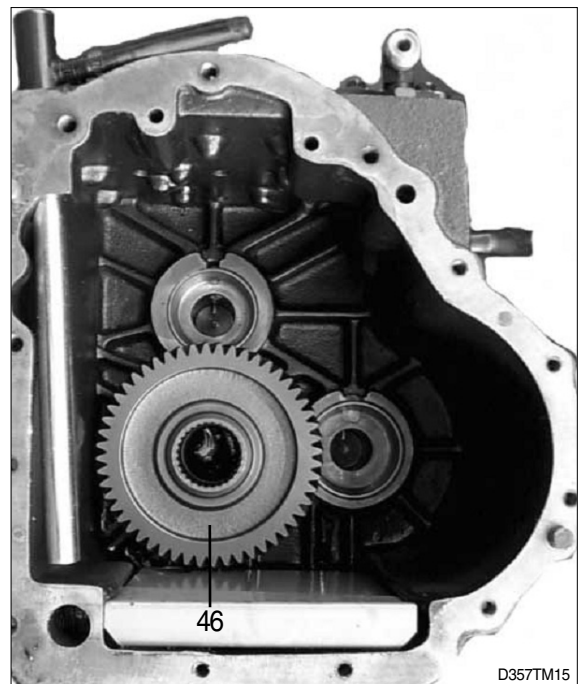


15) Using a plastic hammer push out tube(45) from transmission case.

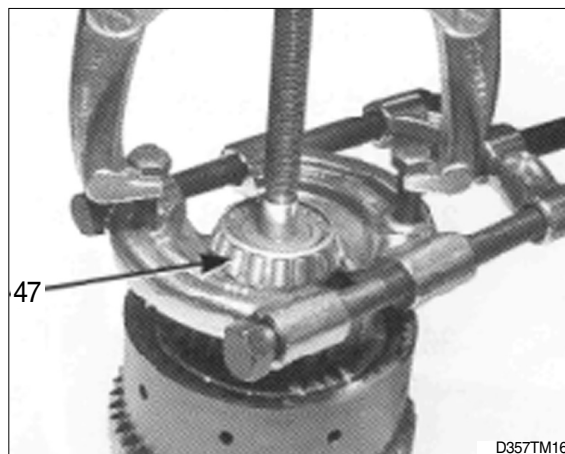
16) Remove output shaft assembly(43), input shaft assembly(44) and counter shaft assembly(45).



17) Disassemble output gear(46) from the transmission case.

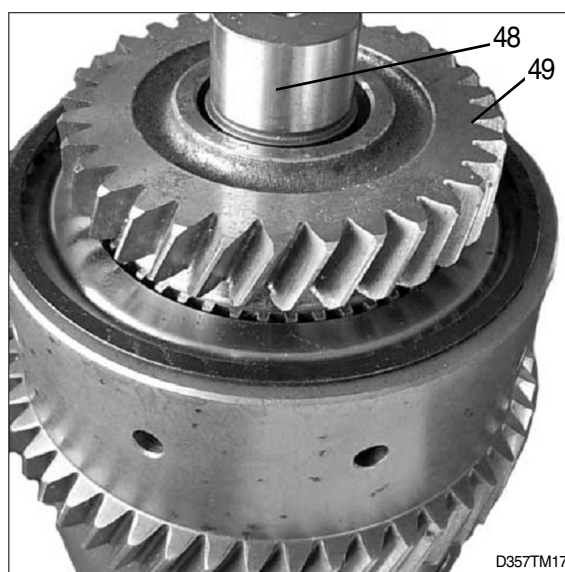


18) Disassemble bearing cone(47) for high speed which locates in front side of clutch assembly with a gear puller.



19) Remove 2 thrust washers(48) and gear(49).

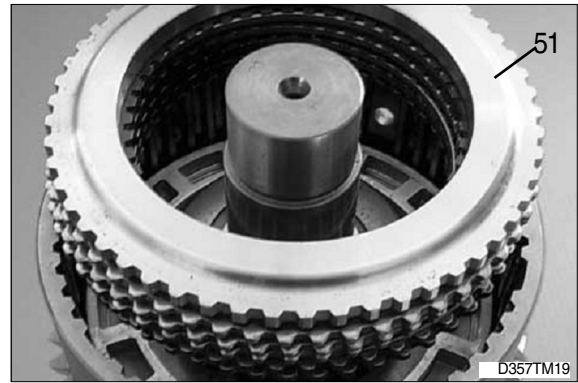
20) Remove needle bearing and washer from the shaft in front side of high speed clutch.



21) Using a driver remove snap ring(50) from the cylinder.



- 22) Remove clutch pressure plate, 7 clutch disks and 7 clutch plates(51) from the cylinder.



- 23) Pressing the retainer(52) downward and then remove snap ring(53) with a driver while reducing the tension of spring assembly.

- 24) Remove retainer(52) and spring assembly from the cylinder.

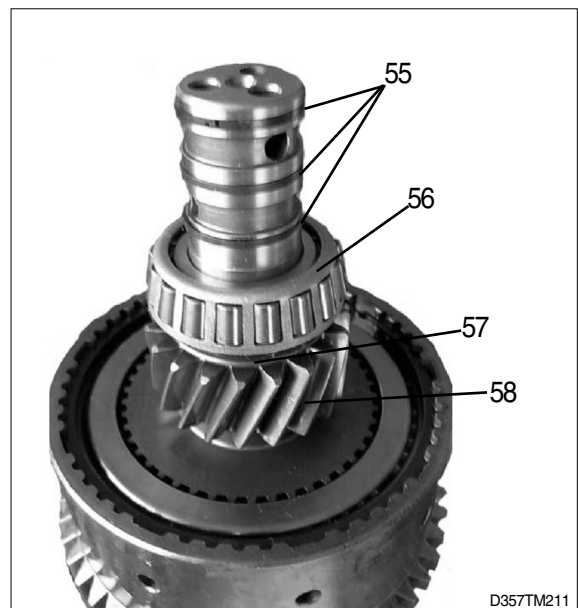
- 25) Remove piston(54) using pressurized air and remove O-ring from the shaft.



- 26) Remove seal ring from low speed forward clutch.

Remove 3 seal rings(55), bearing(56), thrust washer(57) and gear(58).

Remove needle bearing and spacer.



- 27) After removing snap ring(50) and then disassemble 7 disks and 7 plates from the cylinder.



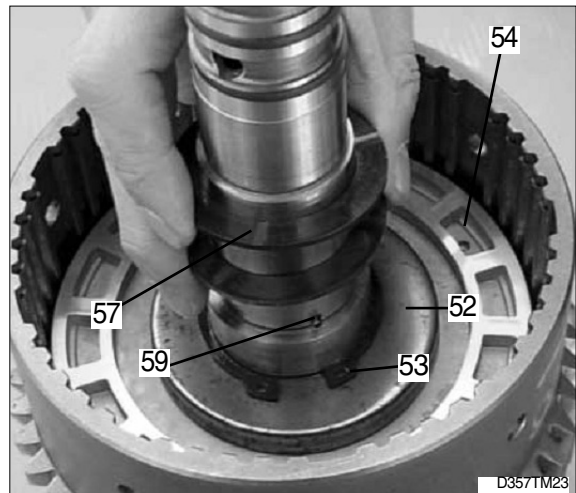
- 28) Remove 2 thrust washers(57) and a pin(59).

- 29) By pressing the retainer(52), remove snap ring(53).

Carefully reducing tension of spring assembly, remove retainer and spring.

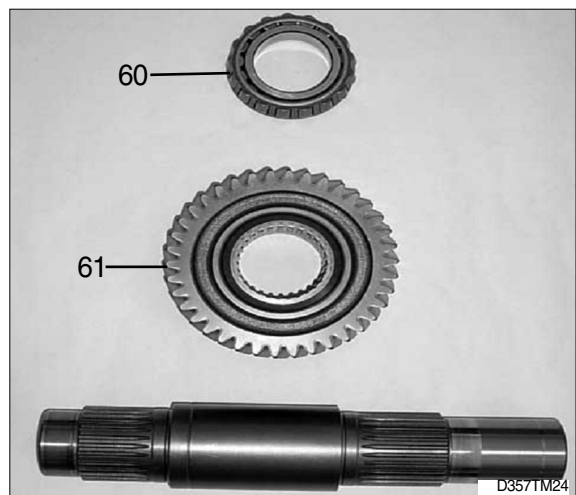
- 30) Using a air compressor, remove piston(54) and pull out O-ring.

※ **Disassembling procedure of Input shaft assembly is same as that of counter shaft assembly.**



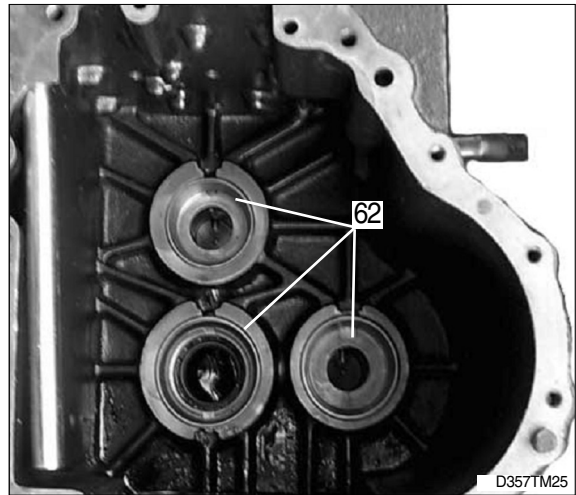
- 31) Disassemble input shaft assembly.

- 32) Remove bearing(60) and gear(61) from the output shaft assembly.

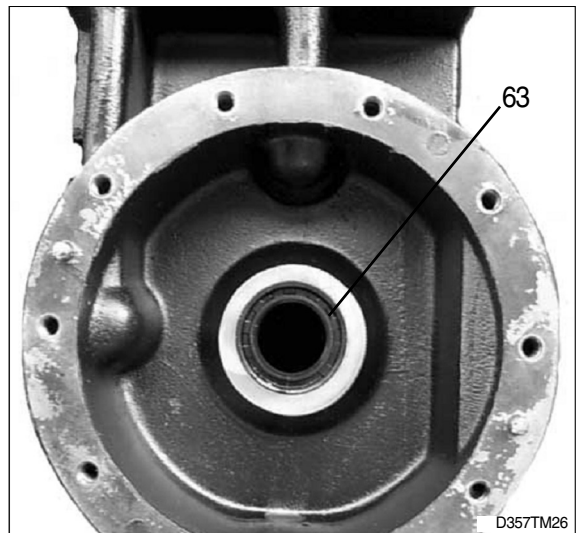


33) Remove 3 kinds of bearings(62) from the transmission case.

※ Mark on the bearing.

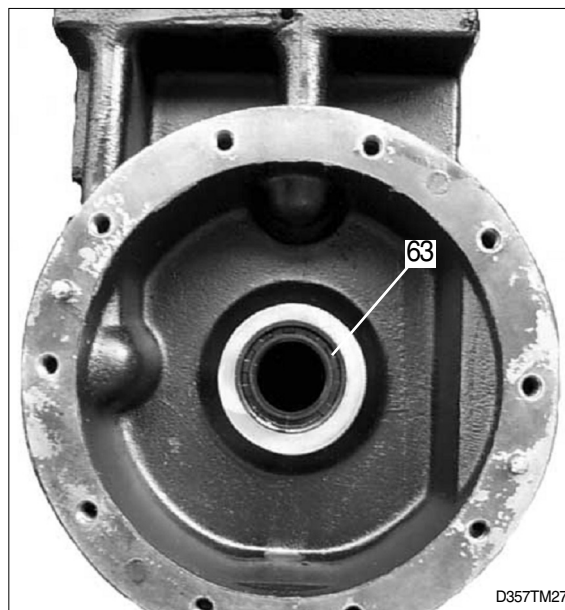


34) Remove lip shaped oil seal (63) from the transmission.

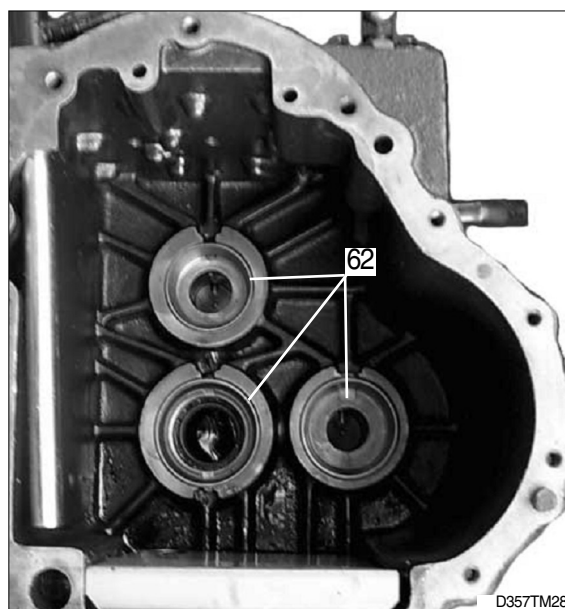


4. ASSEMBLY OF TRANSMISSION

- 1) After cleaning all of the parts completely, apply T/M oil.
- 2) Install inner seal(63) in order lip side to face the inner side and outer seal to face the outer side.



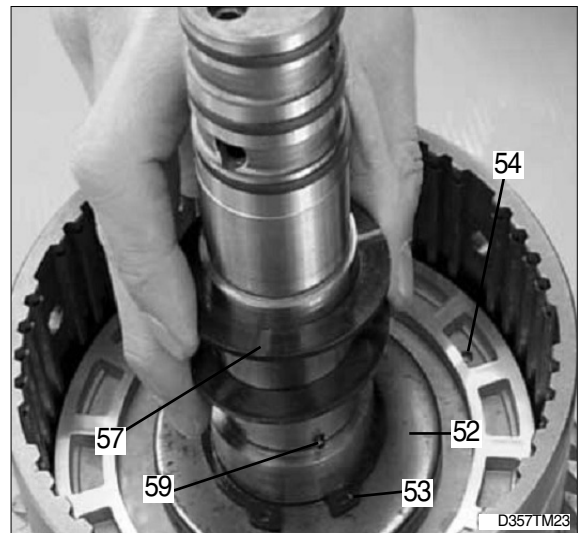
- 3) Assemble 3 kinds of bearing cups(62) into the transmission case at their original positions.



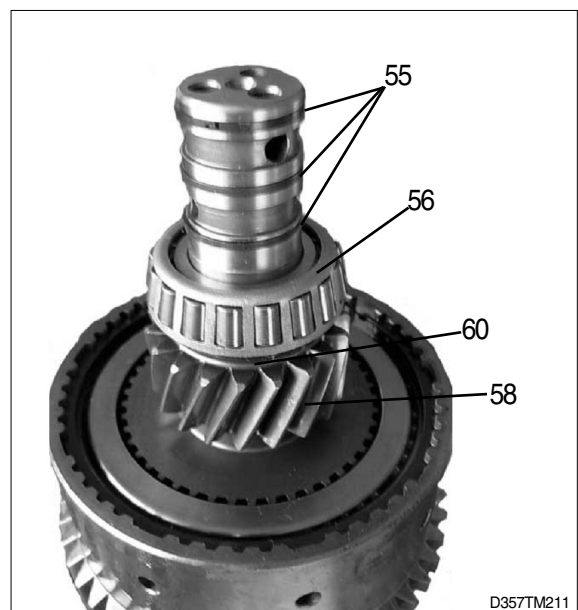
- 4) Assemble gear(61) and bearing(60) to the output shaft.



- 5) Install seal ring on the piston(54).
Apply T/M oil to seal ring.
- 6) Assemble seal ring and piston into the cylinder.
- ※ **Be careful not to damage seal ring when assembling piston.**



- 7) Install spring assembly and retainer(52) inside the cylinder.
- 8) Fix axle assembly in a vise and then pressurize the retainer downward to assemble snap ring with a screw driver.
- 9) Assemble pin(59) and 2 thrust washers(57) inside the counter shaft of low speed clutch.
- 10) Assemble needle bearing, spacer, gear(58), thrust washer(60) and bearing(56).



11) Apply clean T/M oil to the clutch disk and plate and then assemble 7 clutch disks and plates in the order of ;

- (1) At first, install clutch plate which has teeth on the outer race.
- (2) Install clutch disk which has teeth on the inner race.
- (3) Repeat (1) and (2) until all of the clutch plates and disks are assembled.

12) Install pressure plate inside the cylinder.

13) Assemble the pressure plate in the right position and then install snap ring(50) with a screw driver.

14) Assemble 3 seal rings(55) on the shaft.

※ **Be careful not to damage seal ring inside the counter shaft.**



15) Refer to 5) ~ 8) for assembling another side of counter shaft assy.

16) Apply clean T/M oil to the clutch disk and plate and then assemble clutch disks and plates in the order of ;

- (1) At first, install clutch plate which has teeth on the outer race.
- (2) Install clutch disk which has teeth on the inner race.
- (3) Repeat (1) and (2) until all of the clutch plates and disks are assembled.



17) Install pressure plate inside the cylinder.

18) Assemble snap ring(50) fixing the pressure plate inside the cylinder with a screw driver.

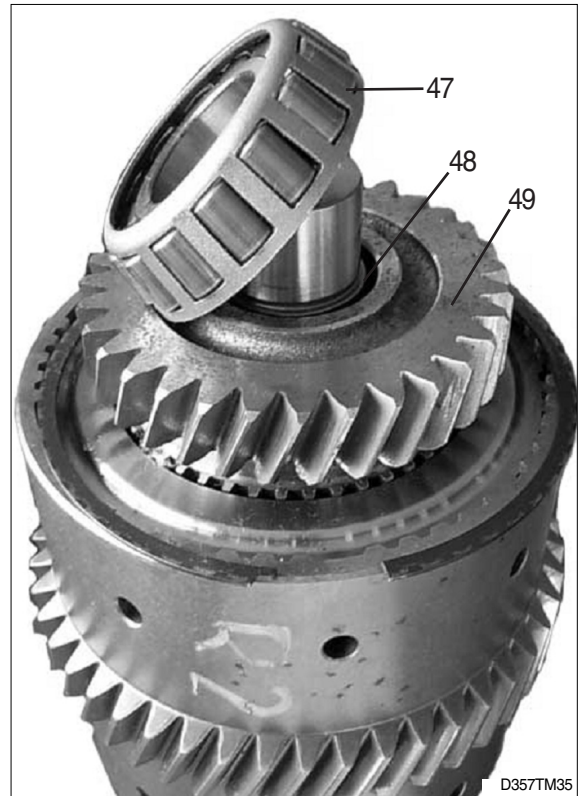
19) Assemble thrust washer and needle bearing to the high speed clutch counter shaft.



20) Assemble gear(49), thrust washer(48) and install bearing cone(47).

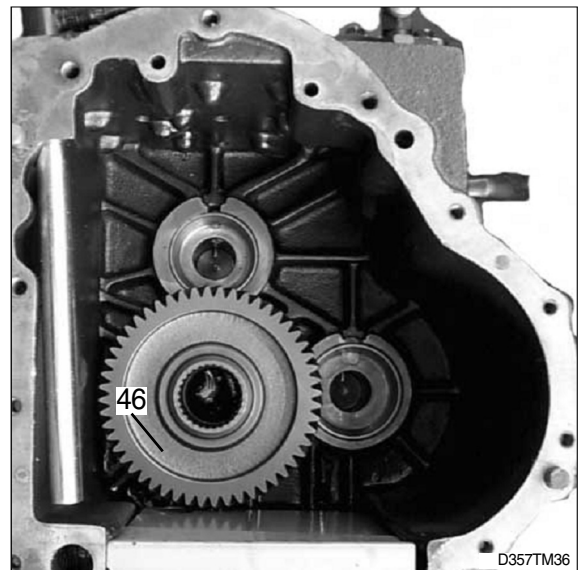
※ Do not apply compulsory force when assembling gears.

Move gear forward and backward until spline of gear and teeth side of clutch disk mesh with each other.



21) Assembly order of input shaft is the same as that of counter shaft assembly.

22) Install gear assembly(46) into the transmission.

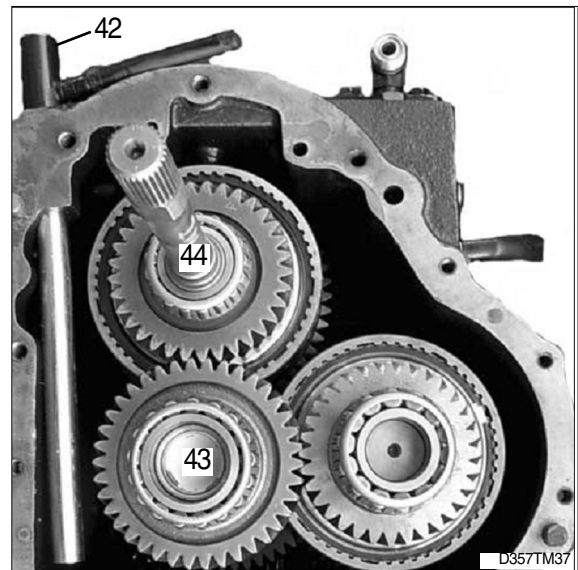


23) Place the T/M case in the right position and then install counter shaft assembly(45) carefully.

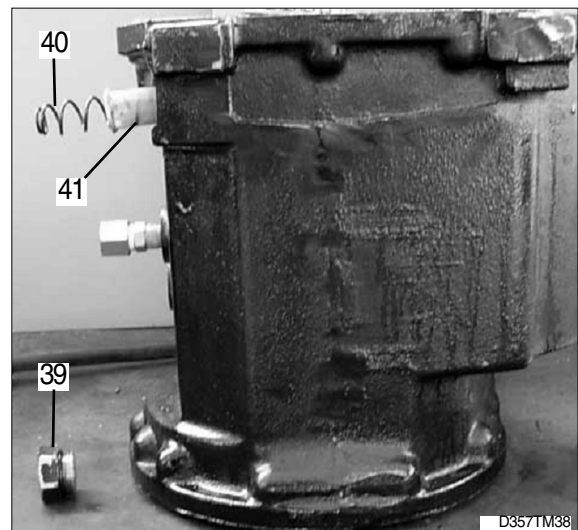
24) Install input shaft(44) carefully on its own place.

Assemble output shaft assembly(43) into the output gear assembly(46) and then rotate the gear until teeth meshed.

25) Install tube(42) into the case with a plastic hammer.



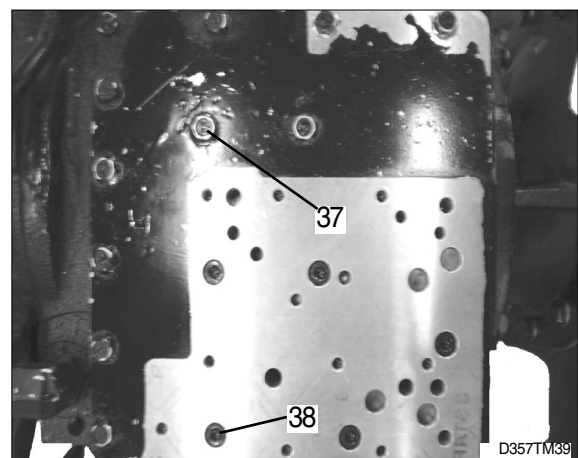
26) Assemble oil screen(41), spring(40), plug(39) and O-ring into the transmission case.



27) Apply loctite #5172 on the gasket adhering surface of case and then fix it.

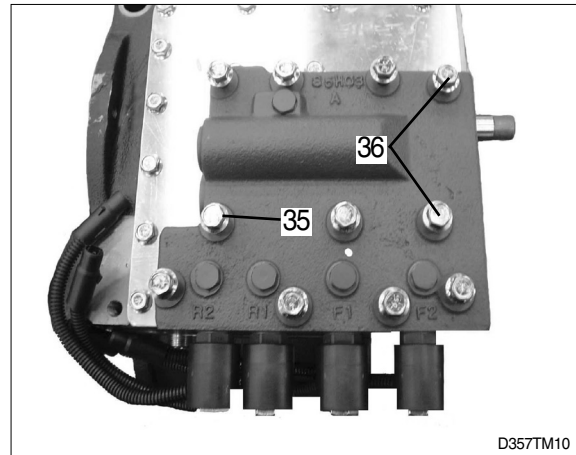
Tighten bolt(37) and 5 socket bolts(38) to assemble valve plate.

· Tightening torque (37, 38)
: 2.8kgf · m(20.3lbf · ft)



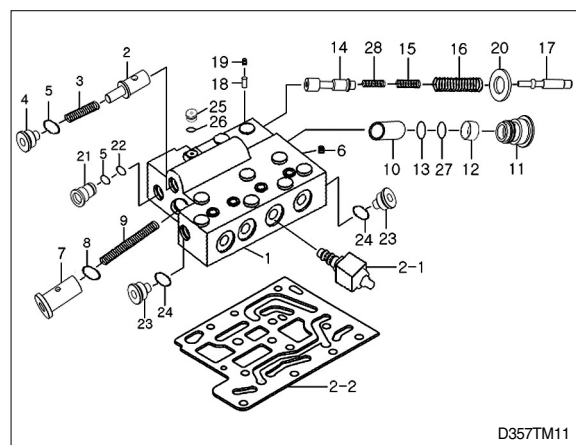
28)After adhering valve gasket(34), assemble valve plate with 9 bolts(35) and 2 bolts(36).

- Tightening torque (35) : 1.4kgf · m
(10.1lbf · ft)
- Tightening torque (36) : 2.8kgf · m
(20.3lbf · ft)

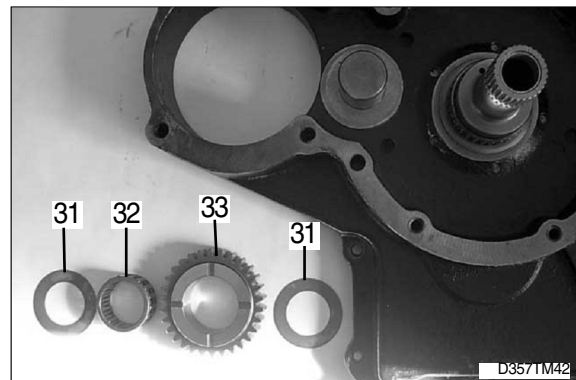


29)T/M control valve assembly

- ① Adhere valve gasket on the control valve body.
- ② Assemble plug(23) on the both sides.
- ③ After assembling spring(9) and plug(7) and then install piston(10), O-ring(13, 27), filter(12) and plug(11).
- ④ Assemble plug(21), spool(14), spring (28,15,16), oil seal(20) and plunger(17).
- ⑤ Assemble pin(18) and stop bolt(19).
- ⑥ Assemble spool(2), spring(3)and plug(4).



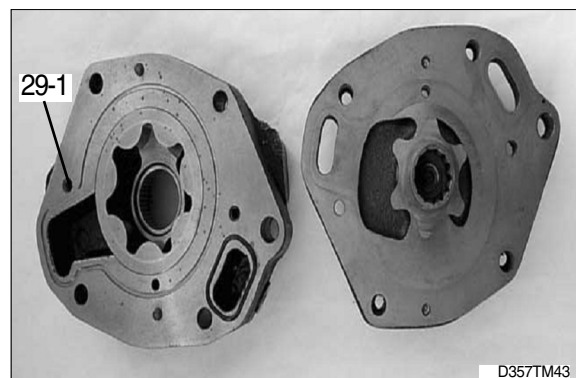
30)Assemble 2 thrust washers(31), needle bearing(32), Gear-P.T.O Idle(33) to the bearing plate(14) individually.



• Charging pump assembly

31)Assemble pump case and pump cover with 2 socket bolts (29-1).

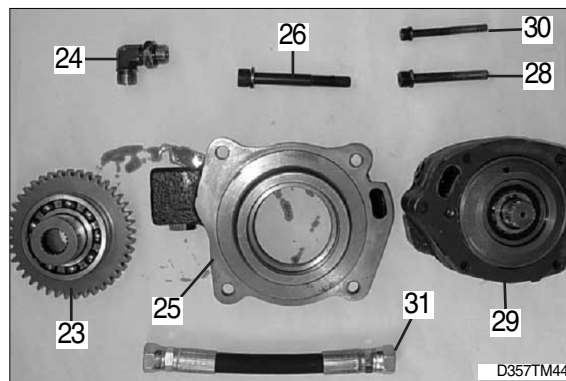
- Tightening torque (29-1) : 0.48~0.55kgf · m
(3.5~4.0lbf · ft)



32) Assemble the gear P.T.O output(23) and 2 ball bearings to the flange pump(25) with a jig and then assemble them to bearing plate with 4 bolts(26). Install charging pump(29) and gasket (27) to the flange pump(25) with bolts(28, 30x4).

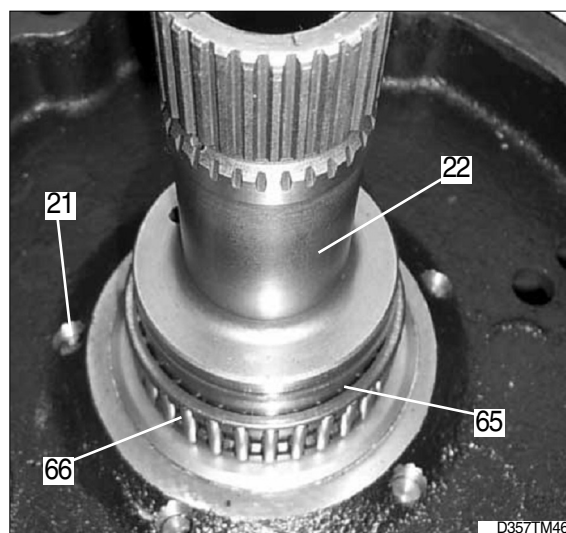
Assemble elbow(24) and then connect tube(31) to the elbow(24).

- Tightening torque(26) : 11~12kgf · m
(79.6~86.8lbf · ft)
- Tightening torque(28) : 4.9~5.5kgf · m
(35.4~39.8lbf · ft)
- Tightening torque(30) : 3.5~4.1kgf · m
(25.3~29.7lbf · ft)



33) Assemble Stator Hub (22) with a bushing(64), a seal ring(65) and a needle bearing(66) on the bearing plate by fastening with 5 bolts(21).

- Tightening torque (21) : 6.5~7.1kgf · m
(47.0~51.4lbf · ft)



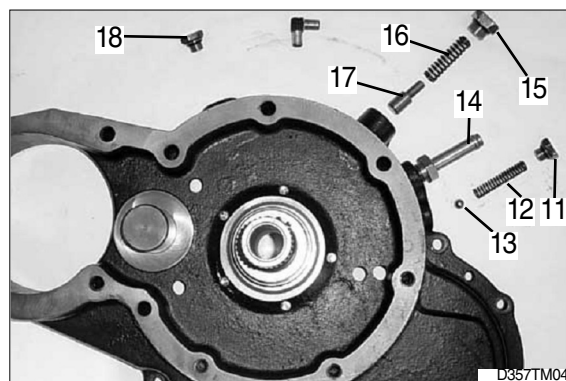
34) Assemble plug(18) and O-ring into the bearing plate.

35) Assemble valve(17), spring(16), plug(15) and O-ring into the bearing plate.

36) Assemble nipple(14).

37) Fit ball(13), spring(12), plug(11) and O-ring into the bearing plate.

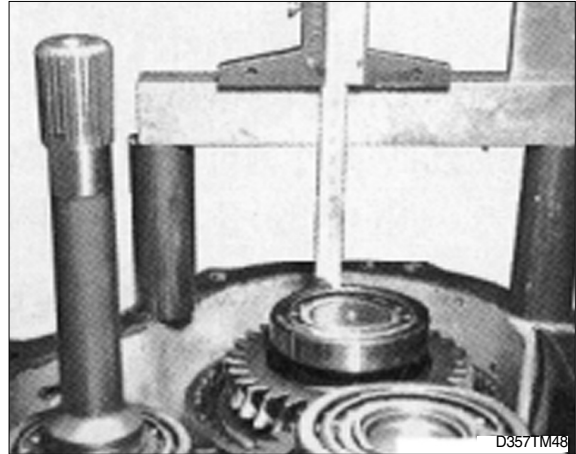
38) Install bearing cup and shim into the T/M cover.



※ Install bearing cup and shim on their own position of the transmission case to align the shaft and the transmission case.

39) In case of using new items calculate the shim thickness as below.

- (1) Shaft assembly. (Including tapered bearing cone and cup)
- (2) Install shaft assembly into the T/M case.
- (3) Measure distance from the surface of bearing cup to that of T/M case, "X".
- ※ **The height of bearing cup should be higher than the height of T/M case so that depth gauge and block gauge can be used.**
- (4) Measure distance from the beneath of bore fitted with bearing cup to the transmission cover surface, "Y".



(5) Shim thickness can be acquired by ;

• **Measuring shim thickness**

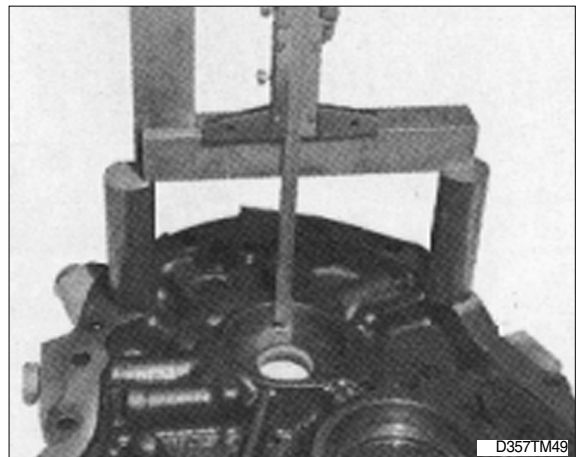
T/M cover depth - Protrusion of shaft bearing.

Item	Shim thickness
Input shaft	Y-X-0.01
Counter shaft	Y-X-0.05
Output shaft	Y-X-0.05

- (6) Choose 0~0.5mm(0.002in) required shim.
- (7) Assemble cover on the T/M case.
- (8) Turn the T/M assembly vertically.
- (9) Check shim adjustment
- (10) In case that output shaft doesn't rotate smoothly, remove shim of 0.025~0.05mm (0.001~0.002in).

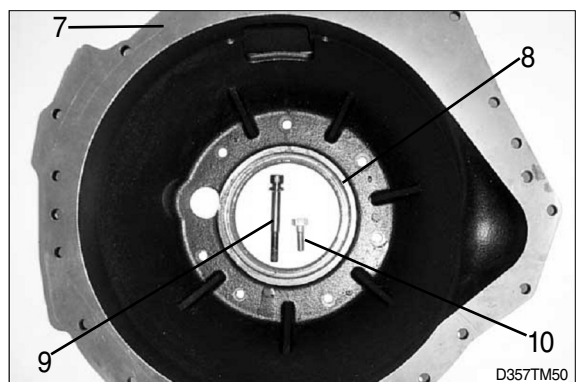
※ **Do not tilt the T/M assembly while assembling the cover.**

Seal ring of input shaft may be damaged.



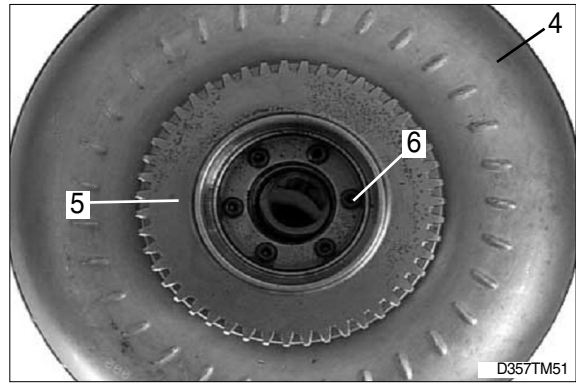
40) Assemble oil seal(8), 4 bolts(9, 10) and washers into housing.

- Tightening torque (9, 10): 6.6~7.2kgf · m
(47.7~52.1lbf · ft)



41) Install Gear P.T.O Input(5) on the torque converter(4) and fasten with 6 socket bolts(6).

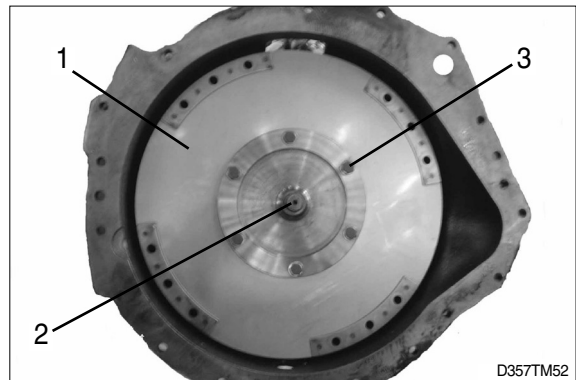
- Tightening torque : $1.7 \sim 2.3 \text{ kgf} \cdot \text{m}$
($12.3 \sim 16.6 \text{ lbf} \cdot \text{ft}$)



42) With 6 bolts(3) and 6 washers, assemble adaptor(2) and flexible plate(1) into torque converter.

And then put together torque converter and housing.

- Tightening torque : $4.2 \sim 4.8 \text{ kgf} \cdot \text{m}$
($30.4 \sim 34.7 \text{ lbf} \cdot \text{ft}$)



SECTION 4 BRAKE SYSTEM

Group 1	Structure and function	4-1
Group 2	Operational checks and troubleshooting	4-9
Group 3	Tests and adjustments	4-11

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 (parking) 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 disk brake assembly.

2. SPECIFICATION

1) DISK BRAKE

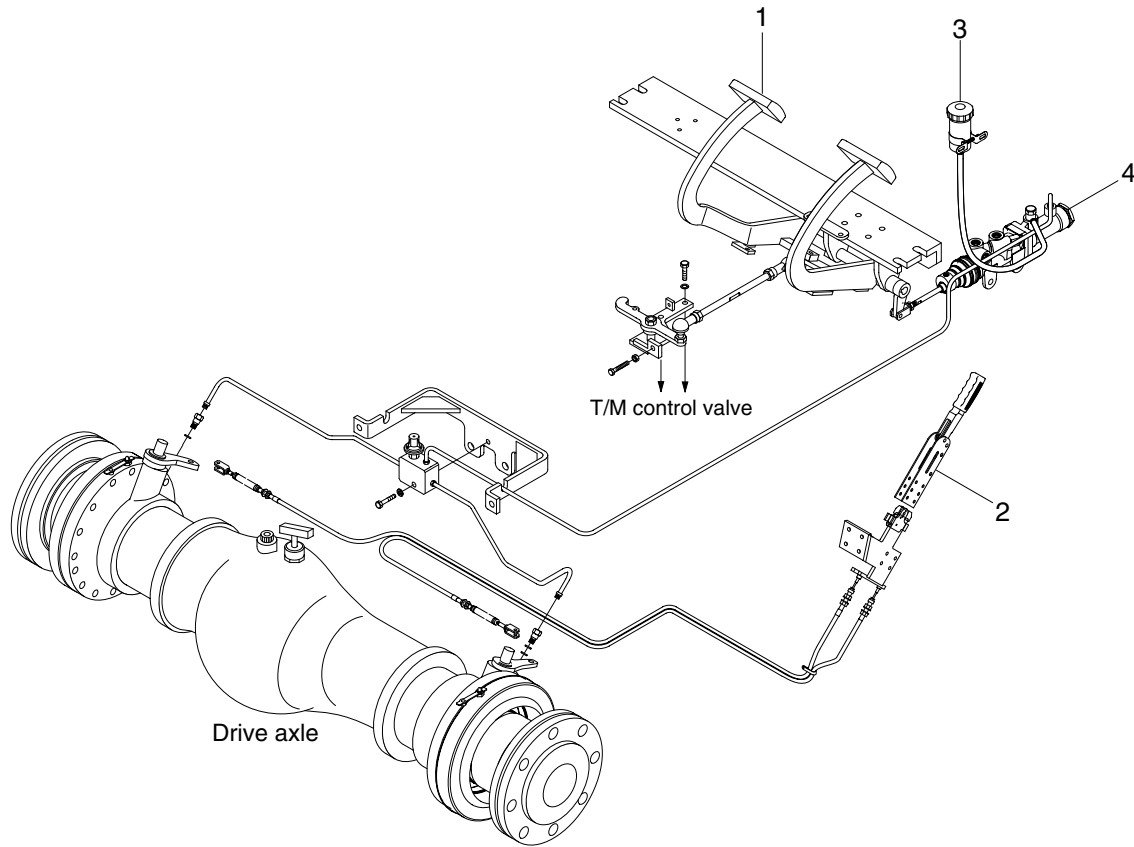
Item		Specification
Type		Wet disk brake
Brake valve step/bore piston diameter		40mm (1.6in) / 30mm (1.2in)
Pedal adjustment	Pedal height	153~157mm (6.0~6.2in)
	Play	5~8mm (0.2~0.31in)
Brake oil		Azola ZS10 (SAE 10W hydraulic oil)

2) PARKING BRAKE

Item		Specification
Type		Ratchet, internal expanding mechanical type
Parking lever stroke		295mm(11.6in)
Parking cable stroke		28mm(1.1in)

3. BRAKE PEDAL AND PIPING

1) STRUCTURE



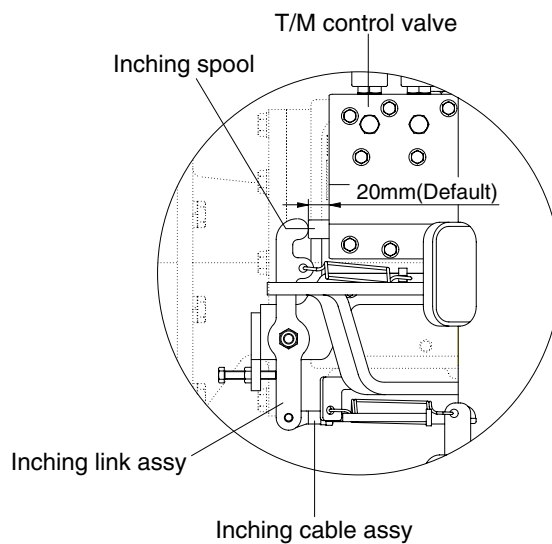
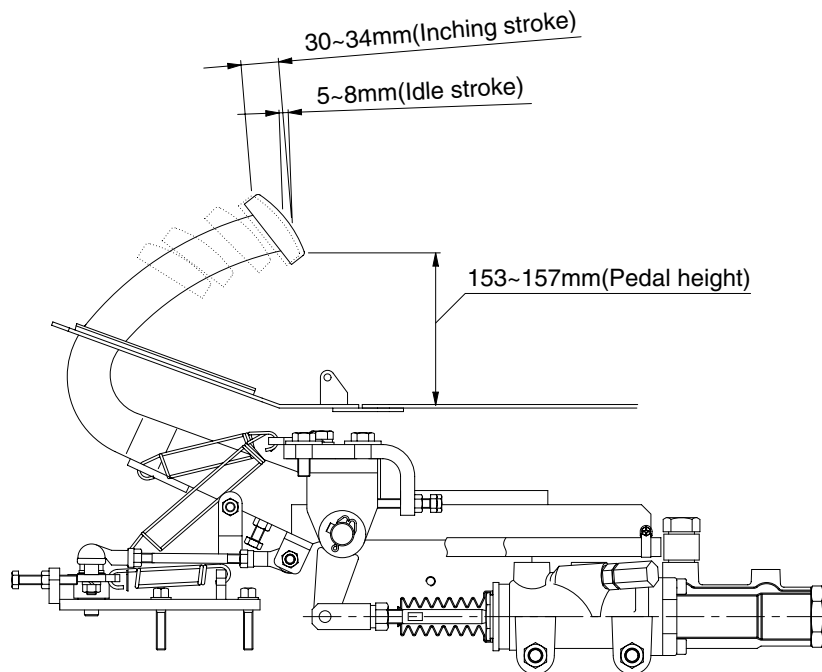
35DS7BS03

- 1 Brake pedal & bracket assembly
- 2 Parking lever assembly

- 3 Reservoir tank assembly
- 4 Brake valve

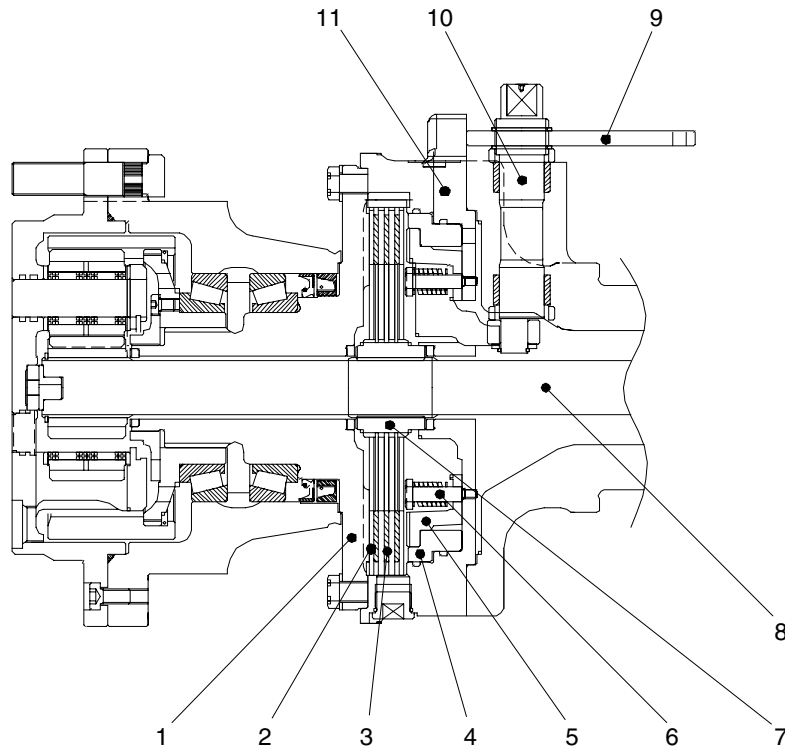
4. INCHING PEDAL AND LINKAGE

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 is applied.



5. WET DISK BRAKE

1) STRUCTURE



D357TA10

- | | | |
|------------------|------------------------------|------------------------|
| 1 Spindle | 5 Service piston | 9 Parking lever |
| 2 Steel plate | 6 Parking piston fixing bolt | 10 Parking lever shaft |
| 3 Disk plate | 7 Spline collar | 11 Brake housing |
| 4 Parking piston | 8 Drive shaft | |

2) OPERATION

Sealed up structure of hydraulic disk brake system secures good brake performance even in the high humid or dusty area.

Because it is possible to use the brake semi-permanently, there is no need to replace or change the lining as drum type brake do.

Parking brake's lever system is the serration type, so it is possible to adjust the play.

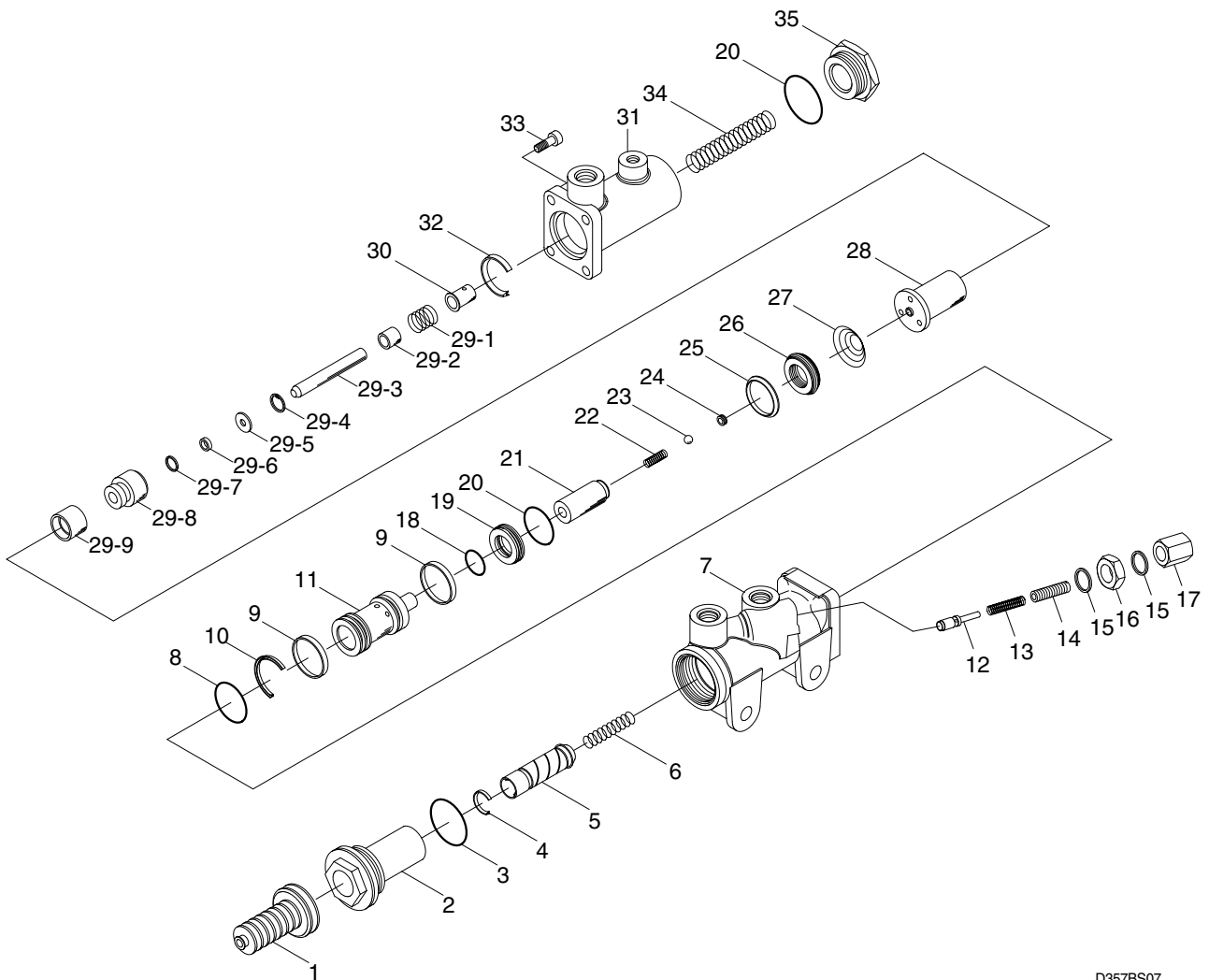
Because it is easy to maintain the gap of both brakes, high brake efficiency and minimum disproportional braking deviation is acquired.

Major components are 3 disk plates(3), 4 steel plates(2), service piston(4), parking piston(5), parking lever(9) and brake housing(11).

Braking force is applied by restricting the driving force from drive shaft(8) and spline collar(7).

6. BRAKE VALVE

1) STRUCTURE



D357BS07

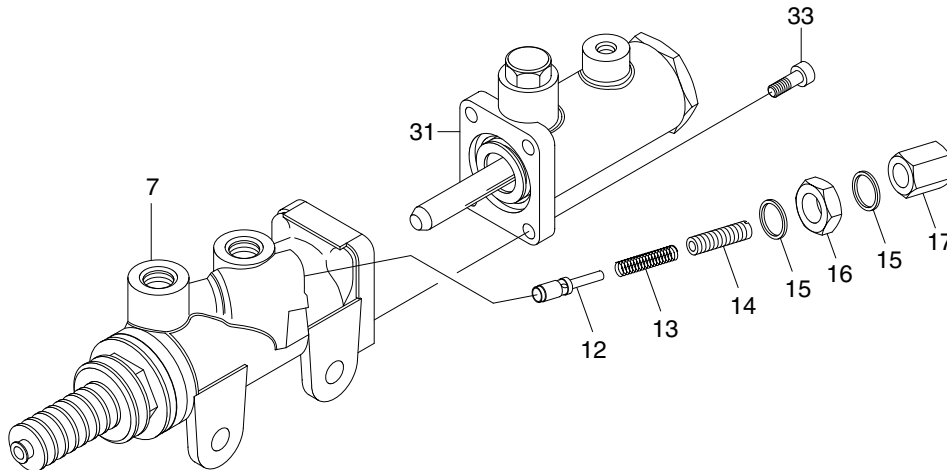
1	Dust cover	16	Nut	29-2	Spool plug
2	Guide plug	17	Plug	29-3	Spool
3	Seal	18	Seal	29-4	Stop ring
4	Seal	19	Ring	29-5	Washer
5	Push rod	20	Seal	29-6	Seal
6	Push rod spring	21	Auxiliary piston	29-7	Seal
7	Booster housing	22	Spring	29-8	Valve housing
8	Seal	23	Ball	29-9	Seal
9	Sliding guide	24	Seal	30	Spring guide
10	Seal	25	Ring	31	Brake cylinder housing
11	Booster piston	26	Seal	32	Seal
12	Relief valve body	27	Spring	33	Fixing screw
13	Spring	28	Piston	34	Spring
14	Adjusting screw	29	Valve	35	Plug
15	Washer	29-1	Spring		

2) DISASSEMBLY

▲ All operations must be carried out with the greatest care, following the instructions carefully. The disassembly instructions are being provided in chronological.

- (1) Unscrew the 4 screws(33), in order to be able to separate the front housing(7) from the rear housing(31).

Then disassemble the check valve and the limiting pressure valve composed of parts(12~17).



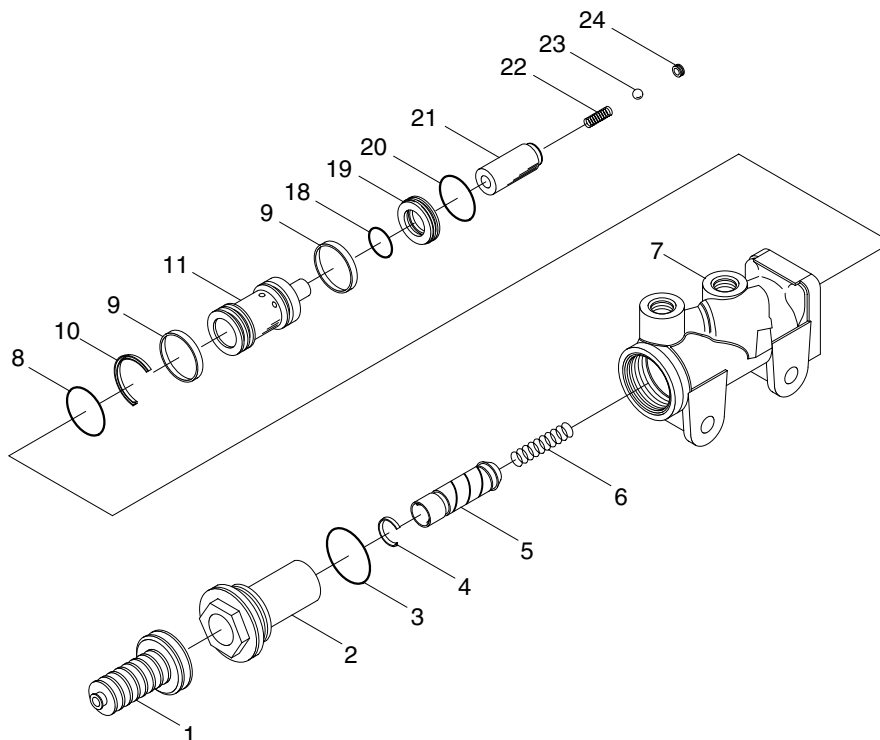
D357BS08

- (2) Remove dust cover(1) and then unscrew guide plug(2) with O-ring(3).

- (3) Extract push rod(5) and spring(6).

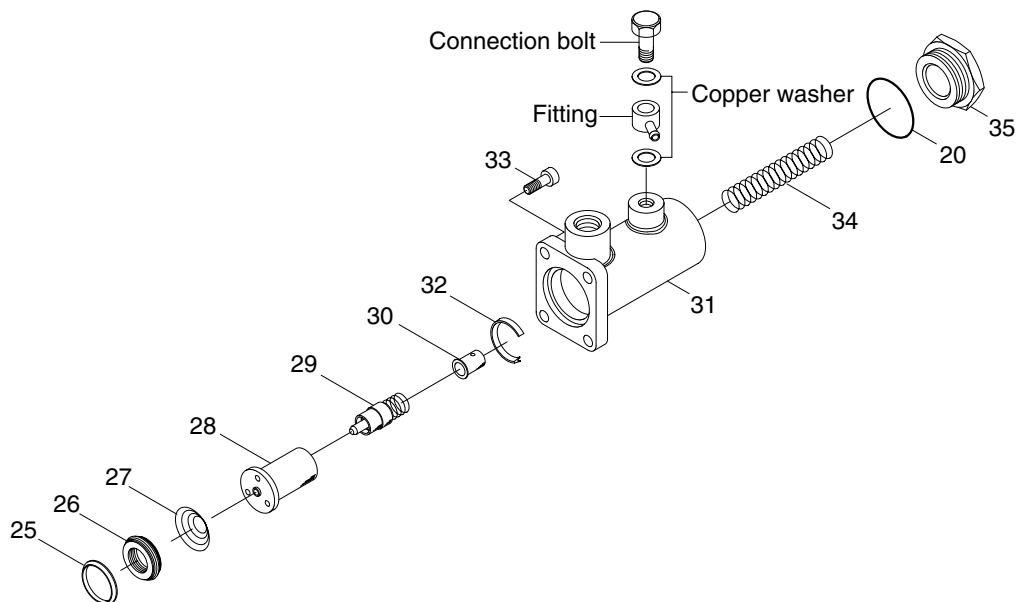
Disassemble booster piston(11) with seal(8,10) and guide sliding(9) and then remove seal(18,20) and ring(19).

- (4) Extract auxiliary piston(21) with auxiliary spring(22), ball(23) and seal(24).



D507BS09

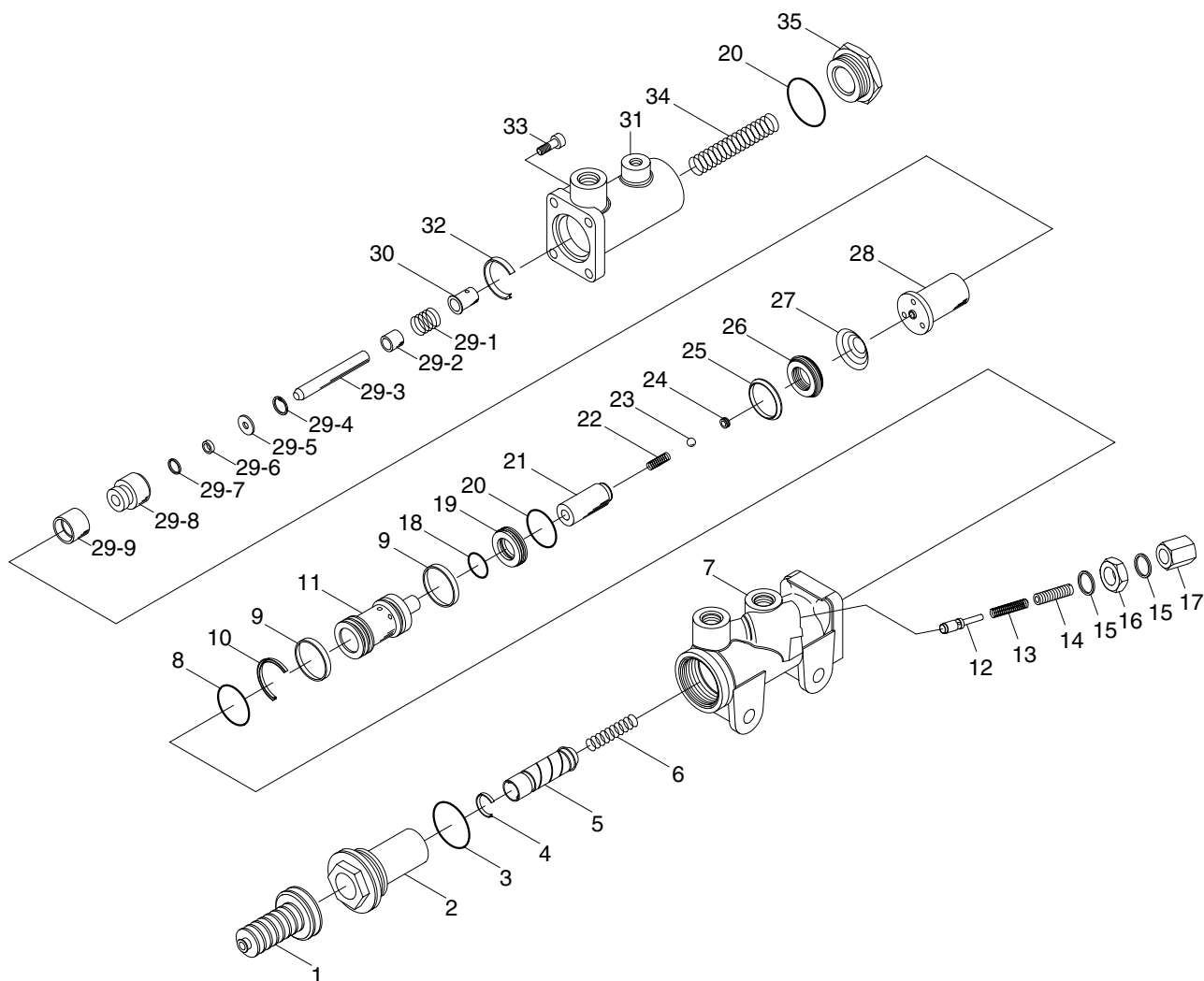
- (5) Remove ring(25), seal(26), spring(27) and piston(28).
- (6) Disassemble valve assembly(29), spring guide(30) and seal(32).
- (7) Remove the O-ring and the lip seal still inside the pump body with the aid of an "L" iron.
Remove all of the other gaskets from the disassembled components, namely the push rod(5), the piston(11).
- (8) Clean all the components thoroughly and check that there is no ribbing inside the piston slide cylinder(11) of the pump body; smooth if necessary.
Lubricate the components either with mineral or with hydraulic oil, according to their use destination.



D357BS10

3) ASSEMBLY

※ The assembly must be carried out by following the so far described sequence but in reverse order, taking great care not to assemble the new gaskets back to front or upside down.



D357BS07

· SEAL KIT : ZTAX-00077

▲ Use only brake fluid (Azola ZS10) in the compensation reservoirs.

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

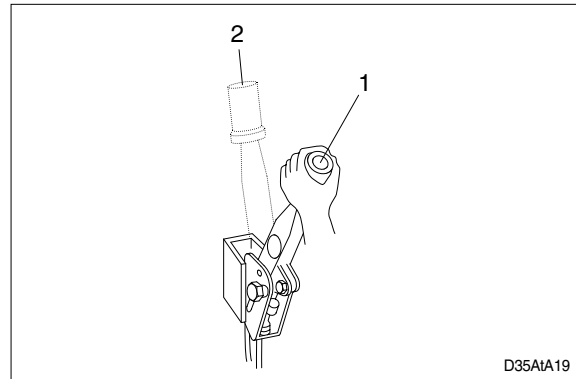
1. OPERATIONAL CHECKS

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) PARKING BRAKE

- (1) Operating force of parking lever is 35 - 40 kgf · m (253 - 290 lbf · ft).
- (2) Check that parking brake can hold machine in position when loaded on 20% slope. If there is no slope available, travel at low speed and check braking effect of parking brake.



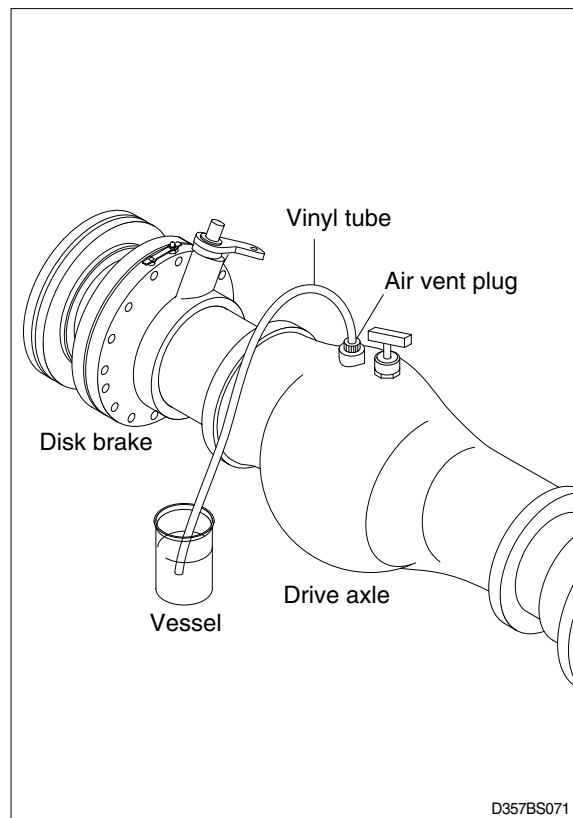
2. TROUBLESHOOTING

Problem	cause	Remedy
Insufficient braking force	- Hydraulic system leaks oil. - Hydraulic system leaks air. - Disk worn. - Brake valve malfunctioning. - Hydraulic system clogged.	- Repair and add oil. - Bleed air. - Replace. - Repair or replace. - Clean.
Brake acting unevenly. (Machine is turned to one side during braking.)	- Tires unequally inflated. - Brake out of adjustment. - Disk surface roughened. - Wheel bearing out of adjustment. - Hydraulic system clogged.	- Adjust tire pressure. - Adjust. - Repair by polishing or replace. - Adjust or replace. - Clean.
Brake trailing.	- Pedal has no play. - Piston cup faulty. - Brake valve return port clogged. - Hydraulic system clogged. - Wheel bearing out of adjustment.	- Adjust. - Replace. - Clean. - Clean. - Adjust or replace.
Brake chirps	- Brake trailing. - Piston fails to return. - Disk worn. - Disk surface roughened.	- See above. Brake trailing. - Replace. - Replace. - Repair by polishing or replace.
Brake squeaks	- Disk surface roughened. - Disk worn. - Excessively large friction between disk plate.	- Repair by polishing or replace. - Replace. - Clean and apply brake grease.
Large pedal stroke	- Brake out of adjustment. - Hydraulic line sucking air. - Oil leaks from hydraulic line, or lack of oil. - Disk worn.	- Adjust. - Bleed air. - Check and repair or add oil. - Replace.
Pedal dragging.	- Twisted push rod caused by improperly fitted brake valve. - Brake valve seal faulty.	- Adjust. - Replace.

GROUP 3 TESTS AND ADJUSTMENTS

1. 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.



2. ADJUSTMENT OF PEDAL

1) BRAKE PEDAL

(1) Pedal height from floor plate

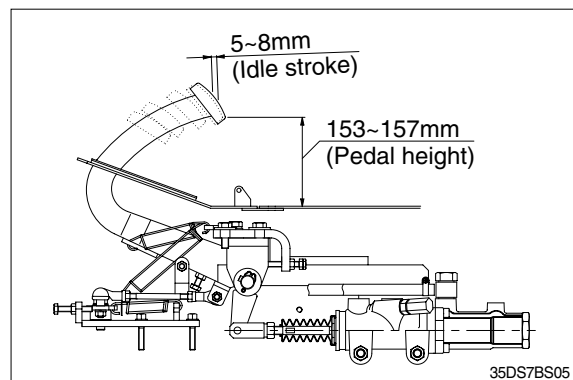
Adjust with stopper bolt.

- Pedal height : 153~157mm(6.0~6.2in)

(2) Idle stroke

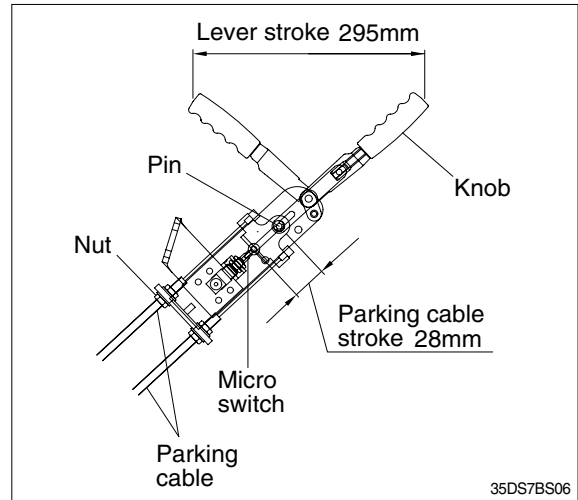
Adjust with rod of brake valve

- Play : 5~8mm(0.2 ~ 0.31in)



(3) Micro switch for parking brake (if equipped)

- ① After assembling parking brake and parking cable, put the parking brake lever released.
- ② Loosen the nut for parking brake plate to play up and down.
- ③ Move up the plate so that the stopper can be contacted with the pin and then reassemble nut.
 - Micro switch stroke when parking brake is applied : 2~3mm(0.08 ~ 0.1in)



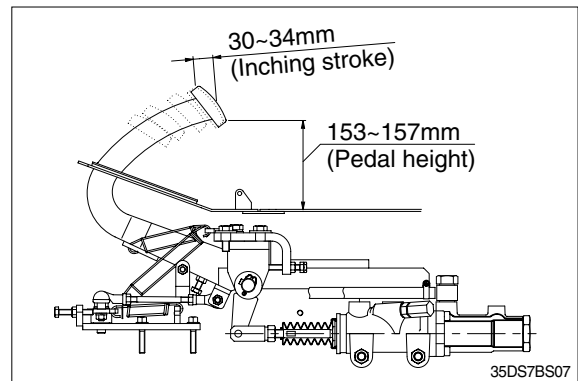
2) INCHING PEDAL

(1) Pedal height from floor plate

Adjust with stopper bolt.

- Pedal height : 153~157mm(6.0~6.2in)

- (2) Adjust bolt so that brake pedal interconnects with inching pedal at inching pedal stroke 30~34mm(1.2~1.3in).



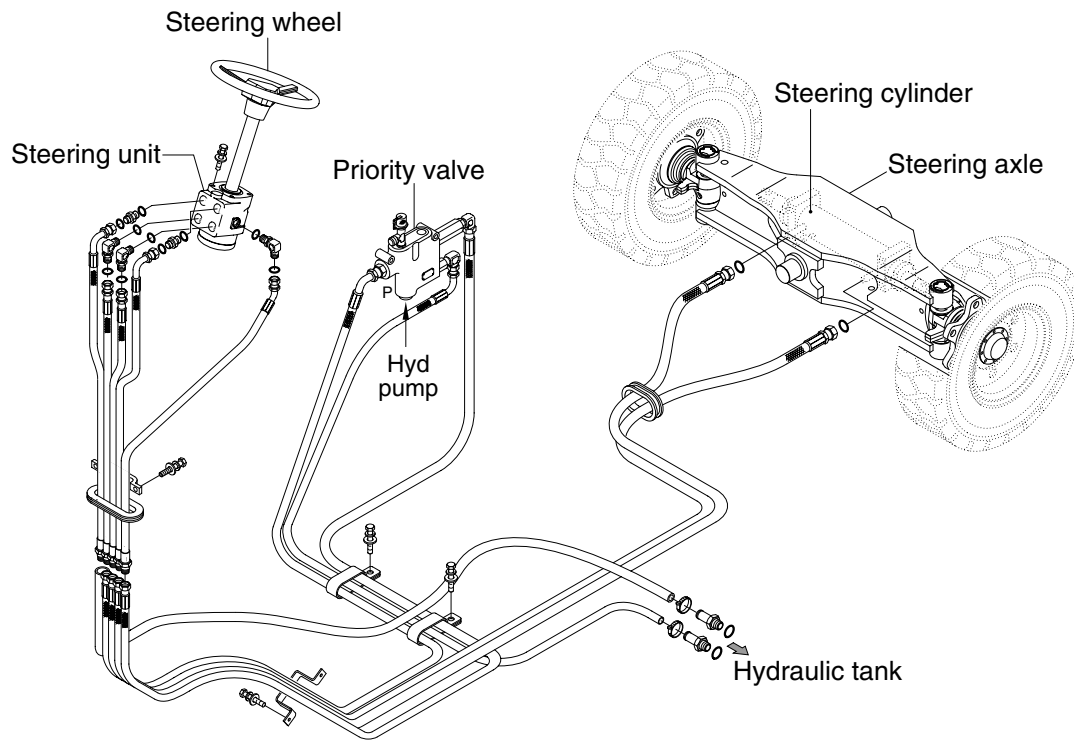
SECTION 5 STEERING SYSTEM

Group 1	Structure and function	5-1
Group 2	Operational checks and troubleshooting	5-10
Group 3	Disassembly and assembly	5-12

SECTION 5 STEERING SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. OUTLINE

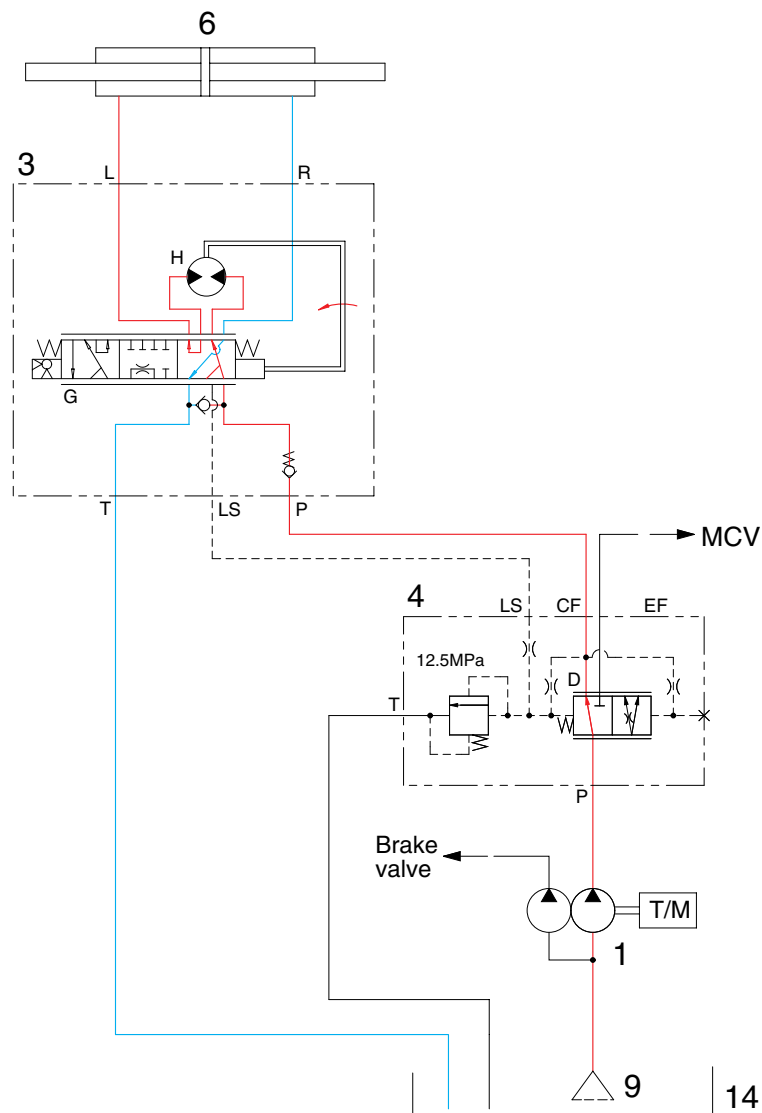


35DS7SE01

The steering system for this machine is composed of steering wheel assembly, steering unit, priority valve steering cylinder, steering axle and piping. 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) LEFT TURN



35DS7SE04

When the steering wheel is turned to the left, the spool(G) within the steering unit(3) 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(3) through the spool(D) of priority valve(4) and flows the gerotor(H).

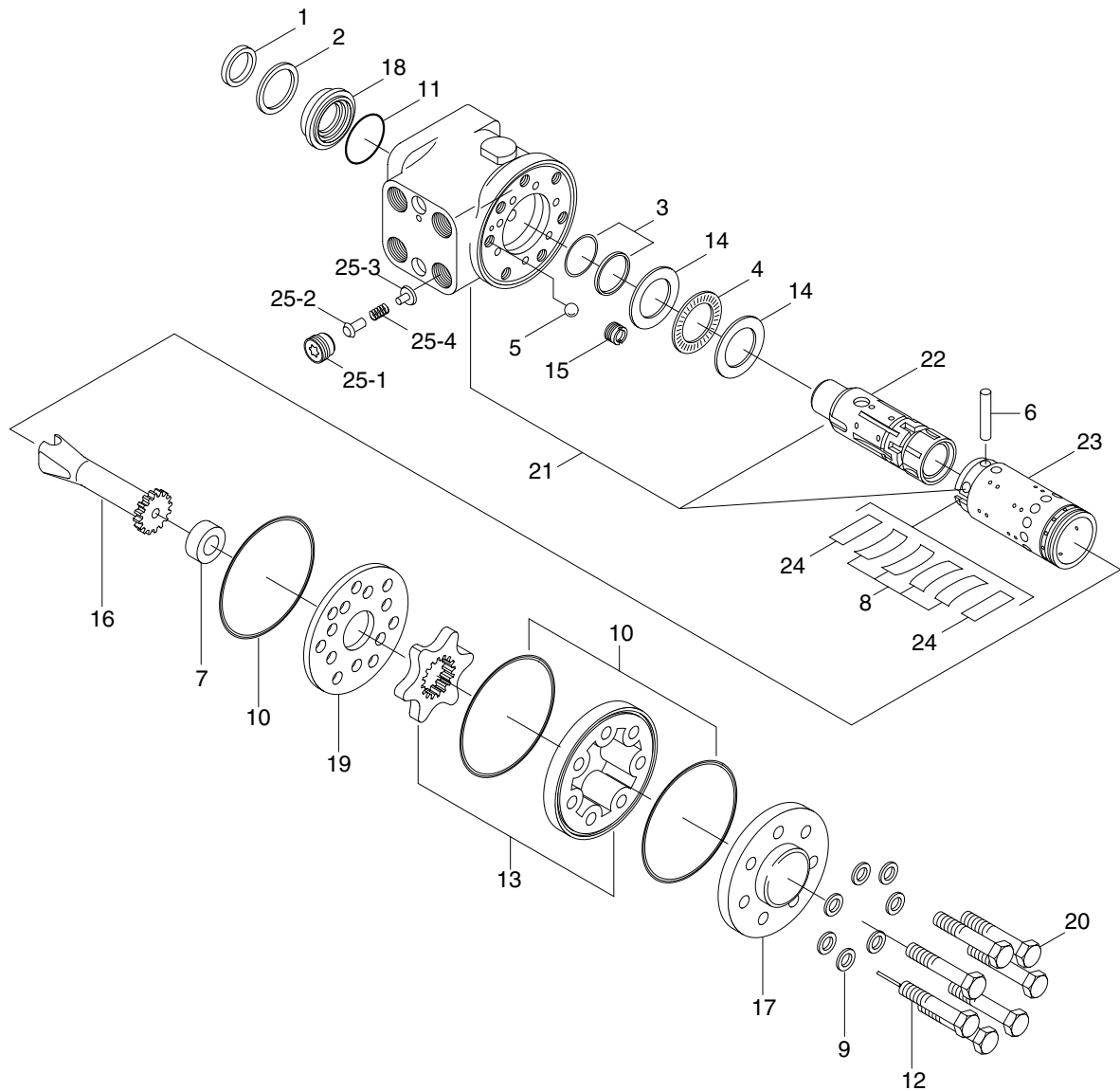
Oil flow from the gerotor(H) flows back into the spool(G) where it is directed out the left work port(L).

Oil returned from cylinder returns to hydraulic tank(14).

When the above operation is completed, the machine turns to the left.

3. STEERING UNIT

1) STRUCTURE



20D7SS06

- | | | |
|------------------|------------------|-----------------------|
| 1 Dust seal | 11 O-ring | 21 Housing |
| 2 Retaining ring | 12 Rolled screw | 22 Spool |
| 3 Cap seal | 13 Gerotor set | 23 Sleeve |
| 4 Thrust bearing | 14 Bearing race | 24 Plate spring |
| 5 Ball | 15 Bore screw | 25 P-port check valve |
| 6 Pin | 16 Drive | 25-1 Plug |
| 7 Spacer | 17 End cap | 25-2 Poppet |
| 8 Center spring | 18 Gland bushing | 25-3 Spring seat |
| 9 Washer | 19 Plate | 25-4 Spring |
| 10 O-ring | 20 Cap screw | |

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.

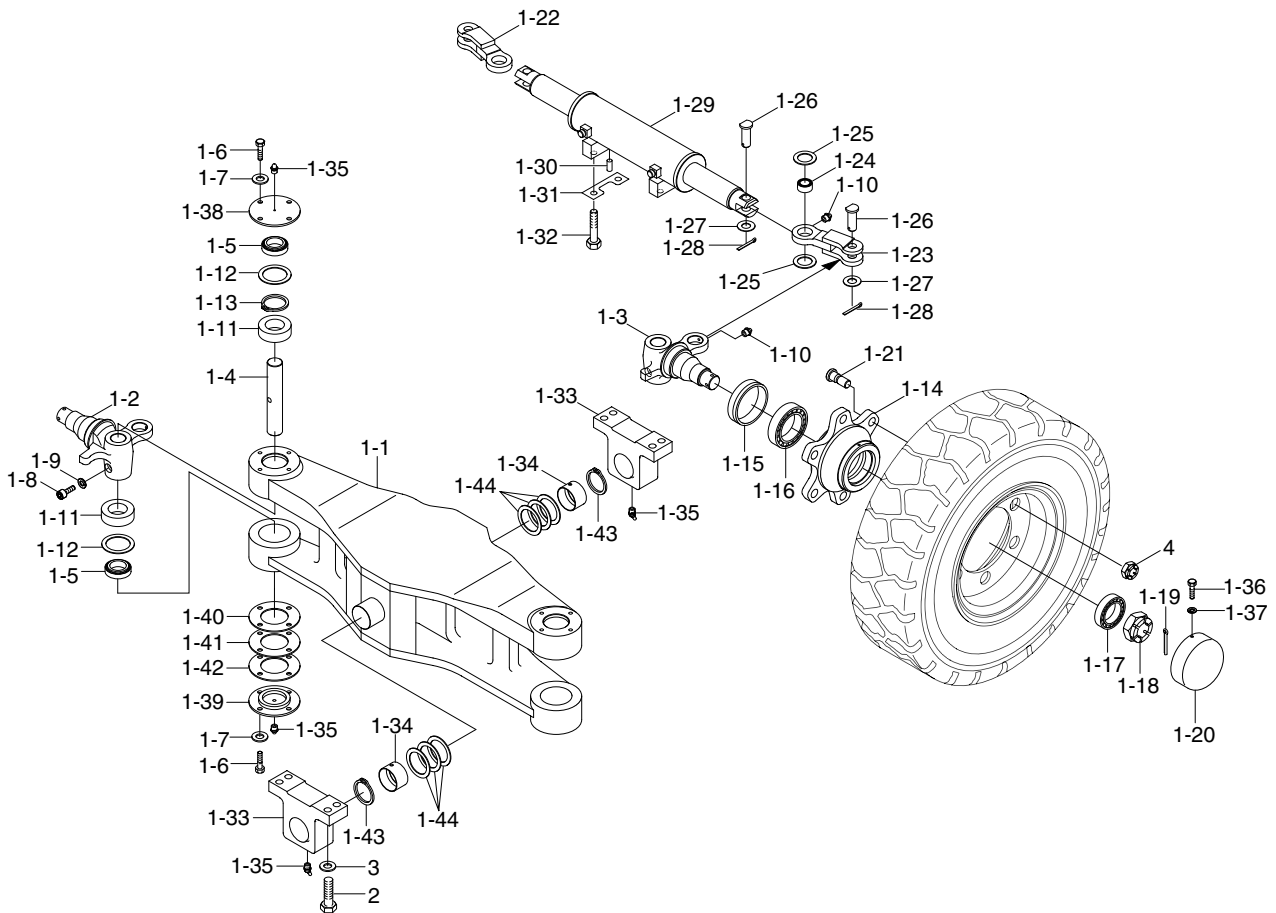
▲ If the hoses of the steering system are incorrectly connected, the steering wheel can turn very rapidly when the engine is started. Keep clear of the steering wheel when starting the engine.

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

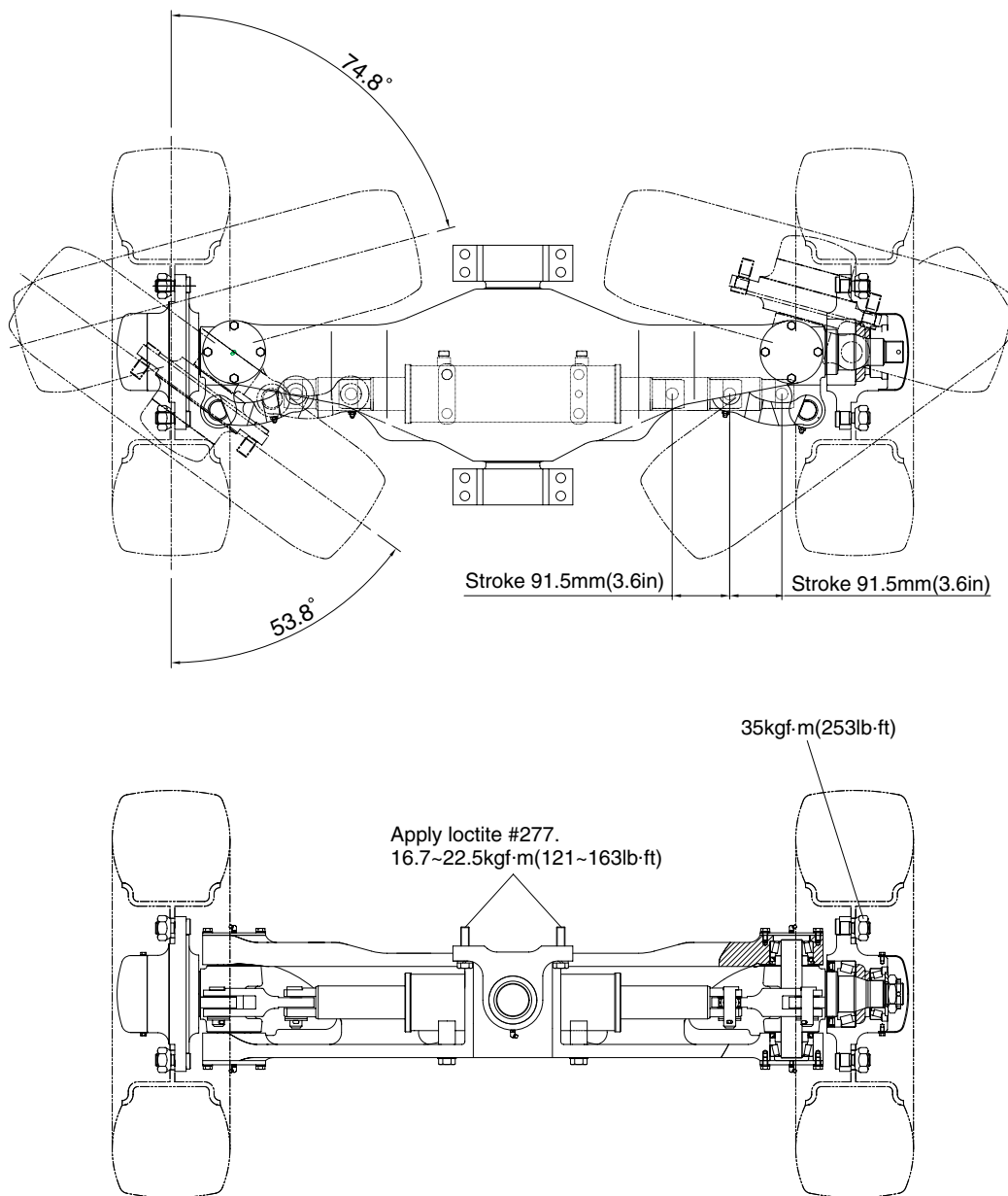
※ Do not remove the stopper bolt unless necessary.



35DS7SE06

1-1 Steering axle	1-12 Dust seal	1-23 Link-LH	1-34 Bushing
1-2 Knuckle-RH	1-13 Snap ring	1-24 SPH plain bearing	1-35 Grease nipple
1-3 Knuckle-LH	1-14 Hub	1-25 Thrust washer	1-36 Hexagon bolt
1-4 King pin	1-15 Oil seal	1-26 Clevis pin	1-37 Spring washer
1-5 Taper roller bearing	1-16 Taper roller bearing	1-27 Plain washer	1-38 Upper cover
1-6 Hexagon bolt	1-17 Taper roller bearing	1-28 Split pin	1-39 Lower cover
1-7 Spring washer	1-18 Slotted nut	1-29 Steering cylinder	1-40 Shim(0.1t)
1-8 Special bolt	1-19 Split pin	1-30 Pin	1-41 Shim(0.15t)
1-9 Spring washer	1-20 Hub cap	1-31 Lock plate	1-42 Shim(0.3t)
1-10 Grease nipple	1-21 Serration bolt	1-32 Hexagon bolt	1-43 Snap ring
1-11 Collar	1-22 Link-RH	1-33 Support	1-44 Shim

2) GREASING AND SPECIFICATION

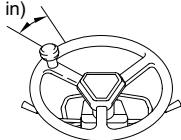


35DS7SE07

Type	Unit	Center pin support single shaft
Structure of knuckle	-	Elliott type
Toe-in	degree	0
Camber	degree	0
Caster	degree	0
King pin angle	degree	0
Max steering angle of wheels(Inside/Outside)	degree	74.8/53.8
Tread	mm(in)	1140(45)

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

Check item	Checking procedure								
Steering wheel 30-60mm (1.2-2.4 in) 	- 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 rin of steering wheel. If play is too large, adjust at gear box. - Test steering wheel play with engine at idling.								
Knuckle	Check knuckle visually or use crack detection method. If the knuckle is bent, the tire wear is uneven, so check tire wear.								
Steering axle	- Put camber gauge in contact with hub and measure camber. If camber is not within $0\pm0.5^{\circ}$; 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 $\pm 100\text{mm}$ ($\pm 4\text{in}$)of specified value, adjust turning angle stopper bolt. Min turning radius(Outside) <table><tr><td>35DS-7E</td><td>2770mm(109in)</td><td>45DS-7E</td><td>2890mm(114in)</td></tr><tr><td>40DS-7E</td><td>2830mm(111in)</td><td>50DA-7E</td><td>2950mm(116in)</td></tr></table>	35DS-7E	2770mm(109in)	45DS-7E	2890mm(114in)	40DS-7E	2830mm(111in)	50DA-7E	2950mm(116in)
35DS-7E	2770mm(109in)	45DS-7E	2890mm(114in)						
40DS-7E	2830mm(111in)	50DA-7E	2950mm(116in)						
Hydraulic pressure of power steering	Remove screw coupling from CF port of priority valve and install oil pressure gauge. Turn steering wheel fully and check oil pressure. ※ Oil pressure : 125kgf/cm² (1780psi)								

2. TROUBLESHOOTING

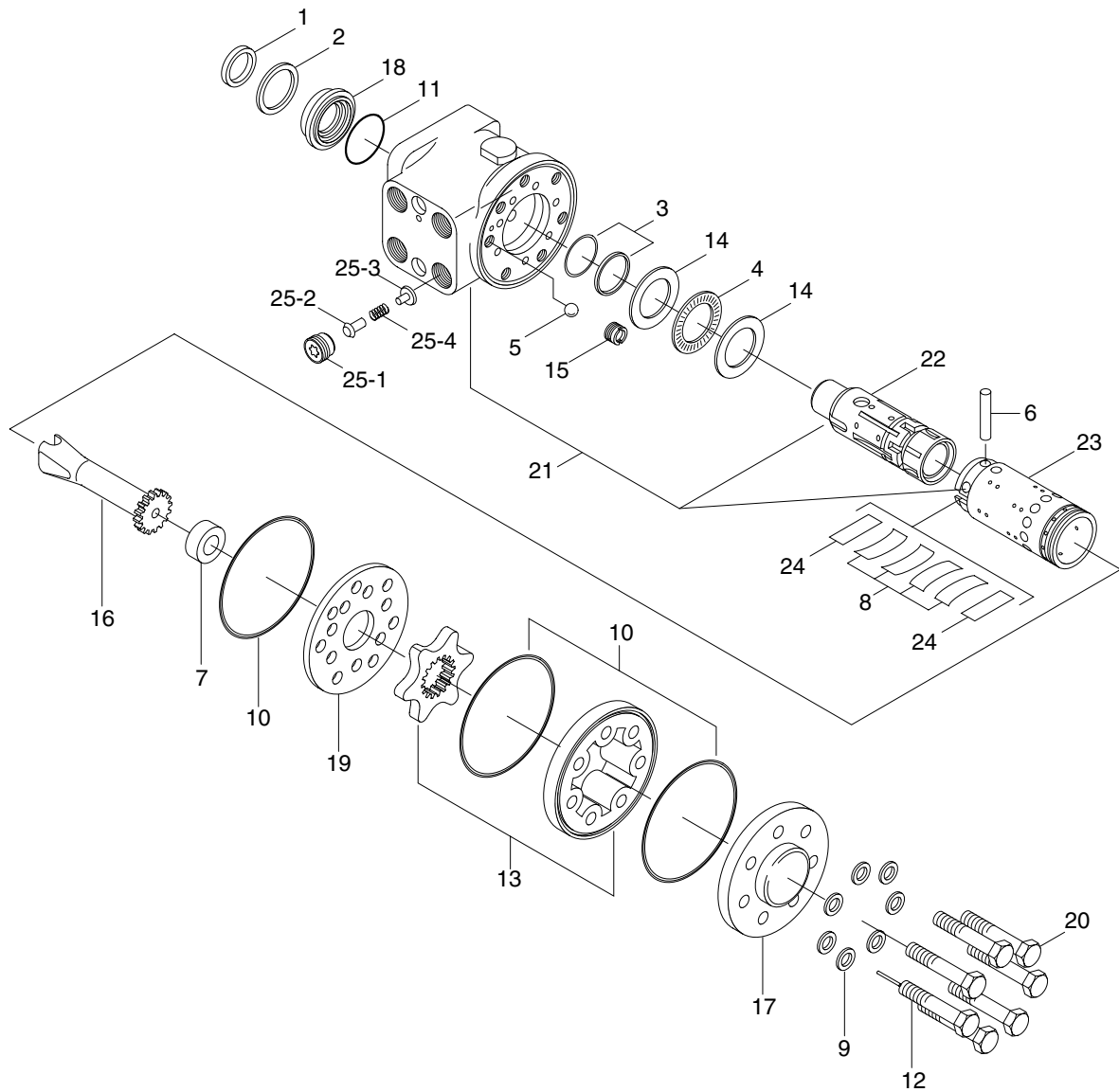
Problem	cause	Remedy
Steering wheel drags.	- Low oil pressure. - Bearing faulty. - Spring spool faulty. - Reaction plunger faulty. - Ball-and-screw assembly faulty. - Sector shaft adjusting screw excessively tight. - Gears poorly meshing. - Flow divider coil spring fatigued.	- Check lockout. Repair. - 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 material. • 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

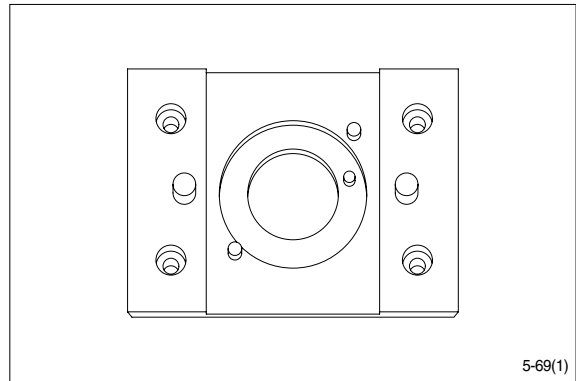


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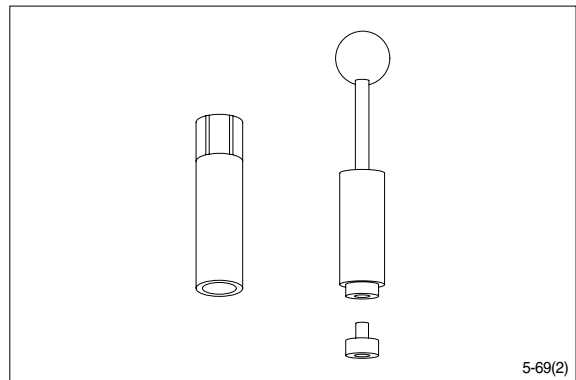
- | | | |
|------------------|------------------|-----------------------|
| 1 Dust seal | 11 O-ring | 21 Housing |
| 2 Retaining ring | 12 Rolled screw | 22 Spool |
| 3 Cap seal | 13 Gerotor set | 23 Sleeve |
| 4 Thrust bearing | 14 Bearing race | 24 Plate spring |
| 5 Ball | 15 Bore screw | 25 P-port check valve |
| 6 Pin | 16 Drive | 25-1 Plug |
| 7 Spacer | 17 End cap | 25-2 Poppet |
| 8 Center spring | 18 Gland bushing | 25-3 Spring seat |
| 9 Washer | 19 Plate | 25-4 Spring |
| 10 O-ring | 20 Cap screw | |

2) TOOLS

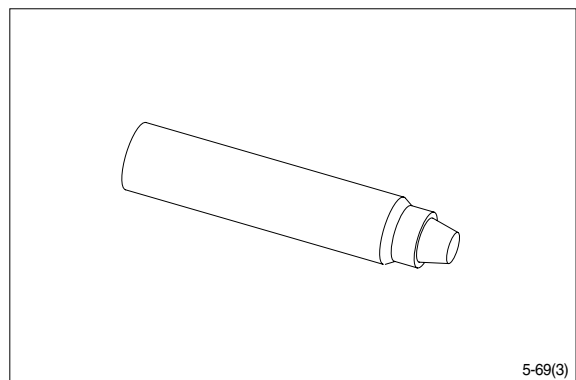
(1) Holding tool.



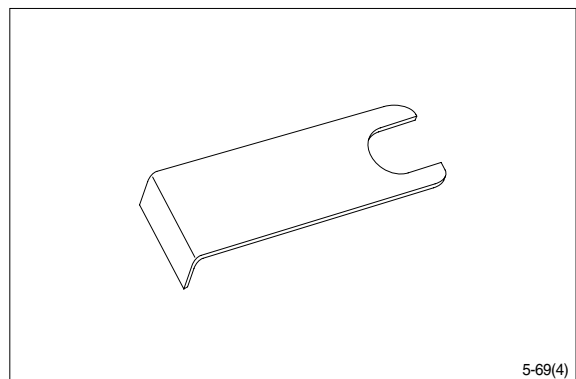
(2) Assembly tool for O-ring and kin-ring.



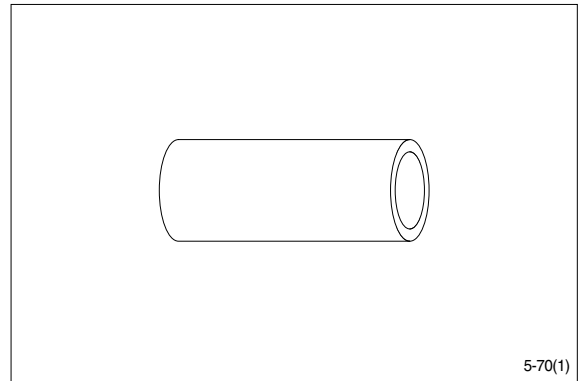
(3) Assembly tool for lip seal.



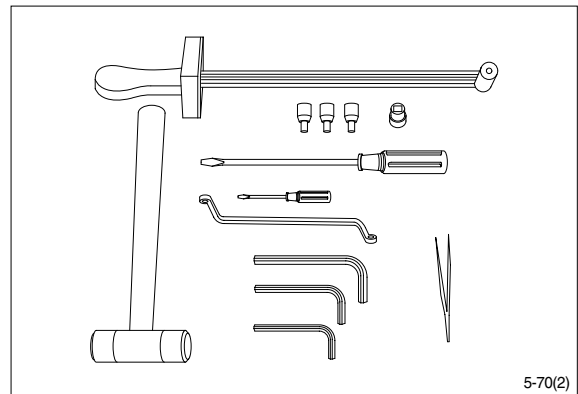
(4) Assembly tool for cardan shaft.



(5) Assembly tool for dust seal.

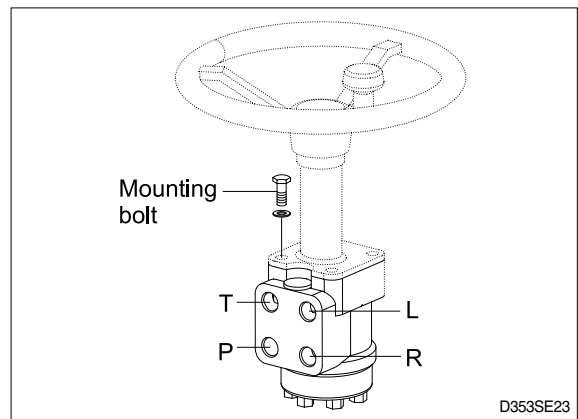


(6) Torque wrench 0~7.1kgf · m
(0~54.4lbf · ft)
13mm socket spanner
6, 8mm and 12mm hexagon sockets
12mm screwdriver
2mm screwdriver
13mm ring spanner
6, 8 and 12mm hexagon socket spanners
Plastic hammer
Tweezers



3) TIGHTENING TORQUE

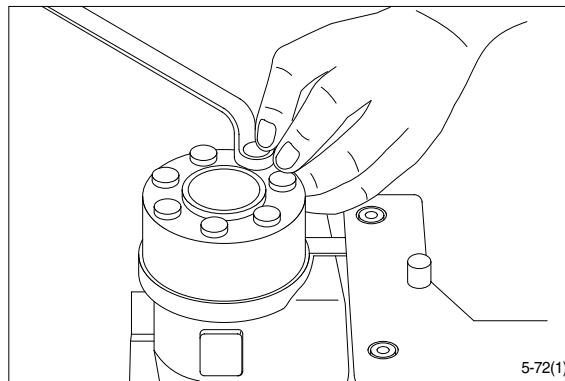
L : Left port
R : Right port
T : Tank
P : Pump



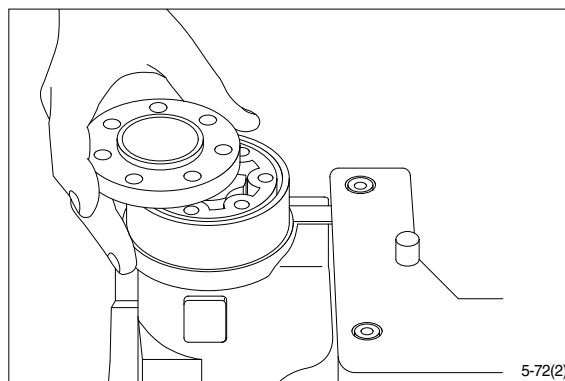
Port	Size	Torque [kgf · m(lbf · ft)]
L	3/4 - 16UNF	6.1 ± 0.6 (44 ± 4.3)
R	3/4 - 16UNF	6.1 ± 0.6 (44 ± 4.3)
T	3/4 - 16UNF	6.1 ± 0.6 (44 ± 4.3)
P	3/4 - 16UNF	6.1 ± 0.6 (44 ± 4.3)
Mounting bolt	M10 × 1.5	4.0 ± 0.5 (29 ± 3.6)

4) DISASSEMBLY

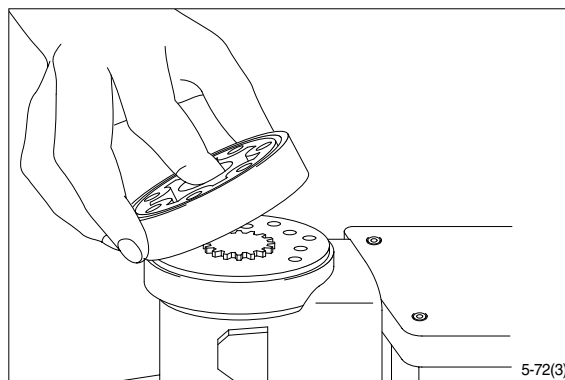
- (1) Disassemble steering column from steering unit and place the steering unit in the holding tool.
Screw out the screws in the end cover(6-off plus one special screw).



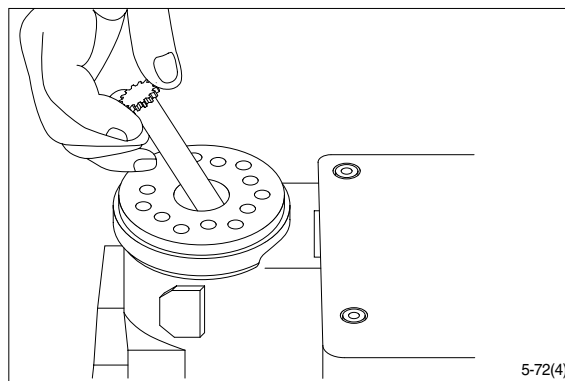
- (2) Remove the end cover, sideways.



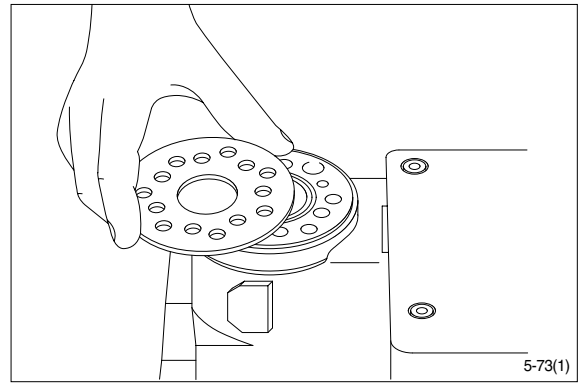
- (3) Lift the gearwheel set(With spacer if fitted) off the unit.
Take out the two O-rings.



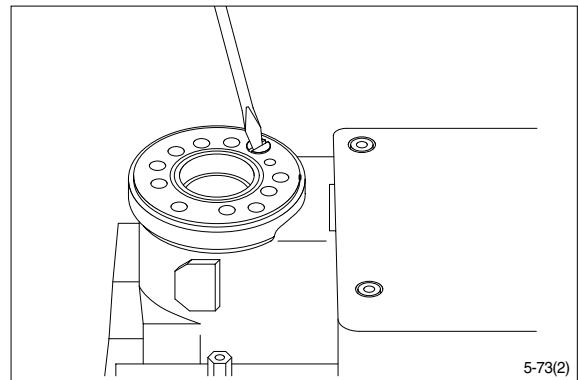
- (4) Remove cardan shaft.



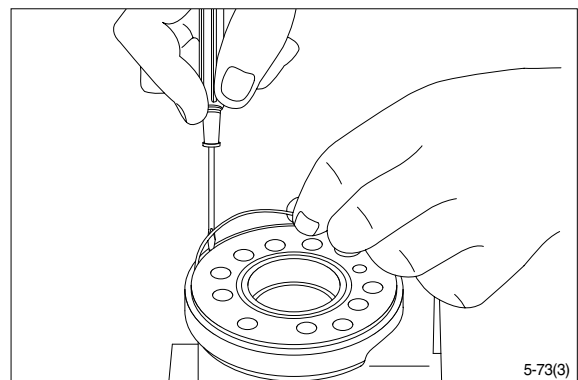
(5) Remove distributor plate.



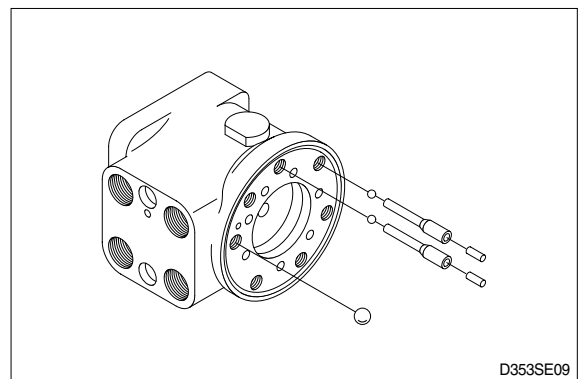
(6) Screw out the threaded bush over the check valve.



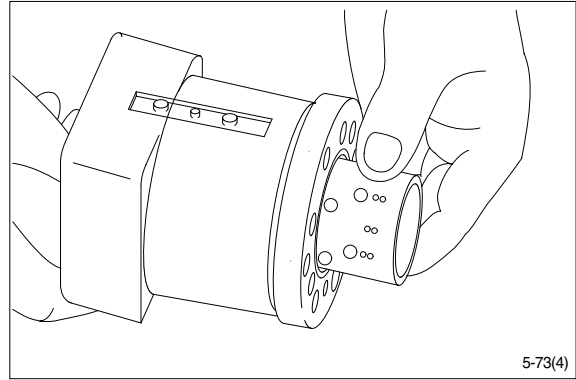
(7) Remove O-ring.



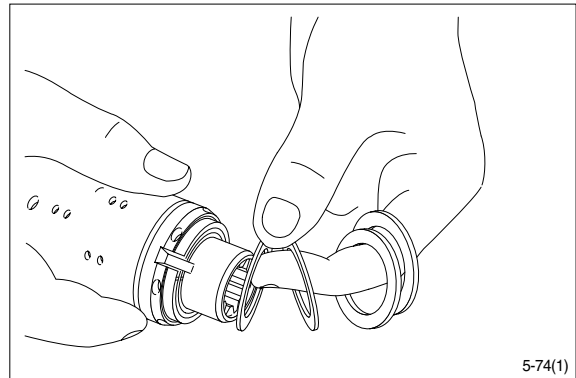
(8) Shake out the check valve ball and suction valve pins and balls.



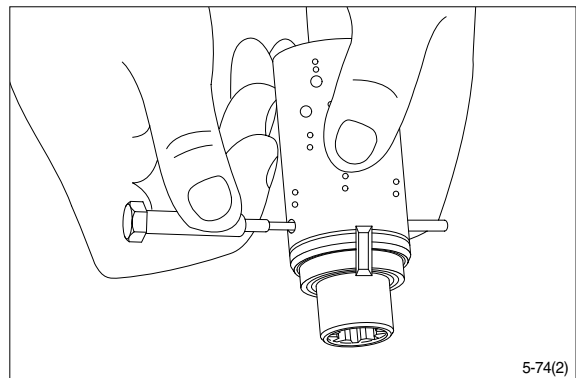
- (9) Take care to keep the cross pin in the sleeve and spool horizontal. The pin can be seen through the open end of the spool. Press the spool inwards and the sleeve, ring, bearing races and thrust bearing will be pushed out of the housing together.



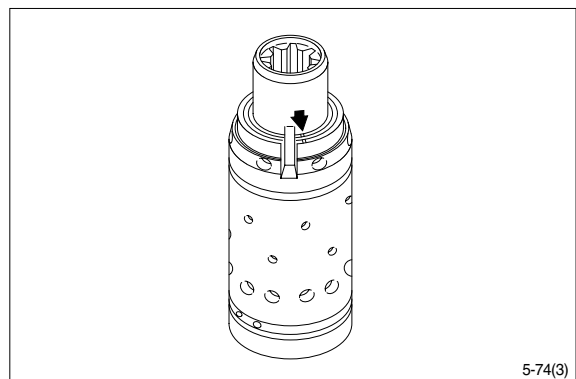
- (10) Take ring, bearing races and thrust bearing from sleeve and spool. The outer (Thin) bearing race can sometimes "stick" in the housing, therefore check that it has come out.



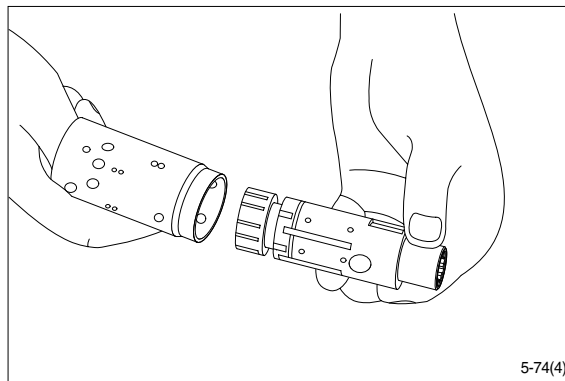
- (11) Press out the cross pin. Use the special screw from the end cover.



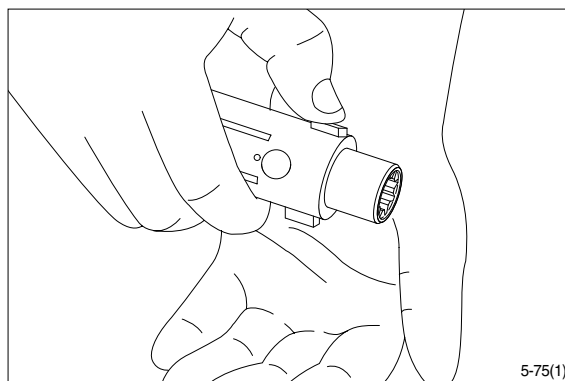
- ※ A small mark has been made with a pumice stone on both spool and sleeve close to one of the slots for the neutral position springs (See drawing). If the mark is not visible, remember to leave a mark of your own on sleeve and spool before the neutral position springs are disassembled.



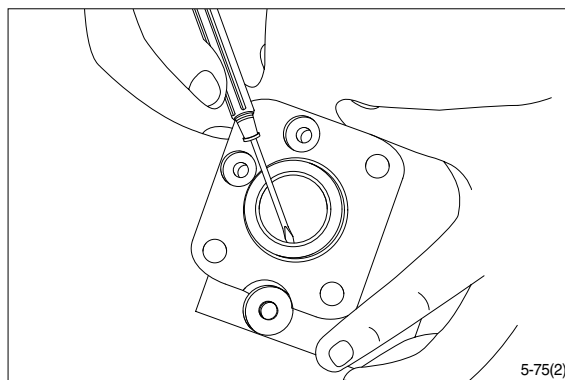
(12) Carefully press the spool out of the sleeve.



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

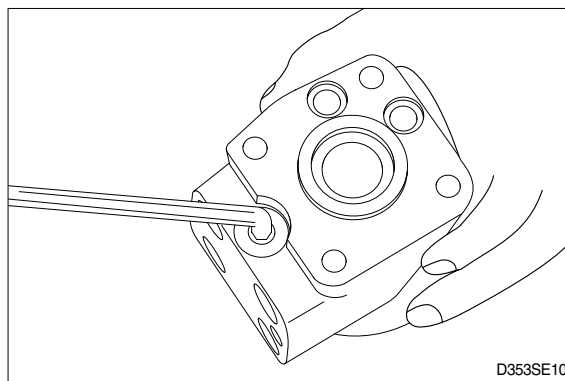


(14) Remove dust seal and O-ring.

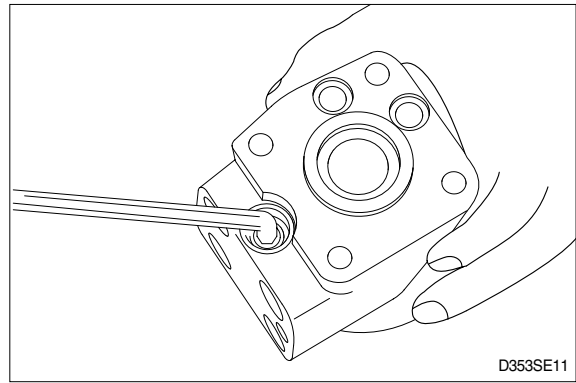


Disassembling the pressure relief valve

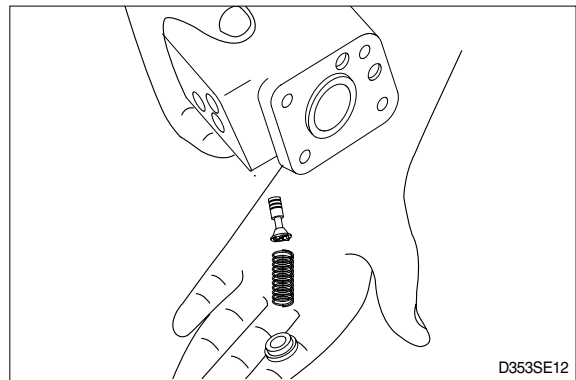
(15) Screw out the plug using an 8mm hexagon socket spanner.
Remove seal washers.



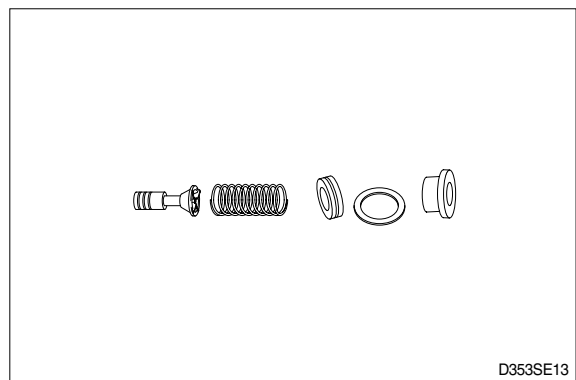
- (16) Unscrew the setting screw using an 8mm hexagon socket spanner.



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



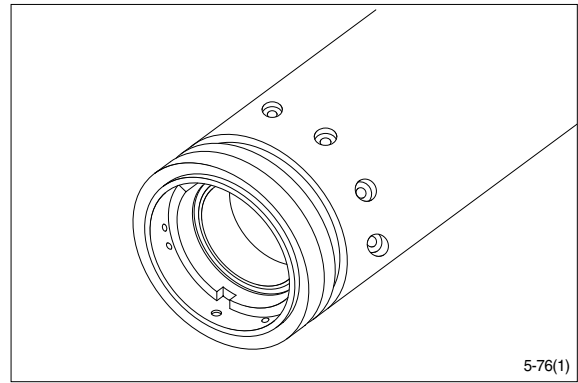
- (18) The pressure relief valve is now disassembled.



5) ASSEMBLY

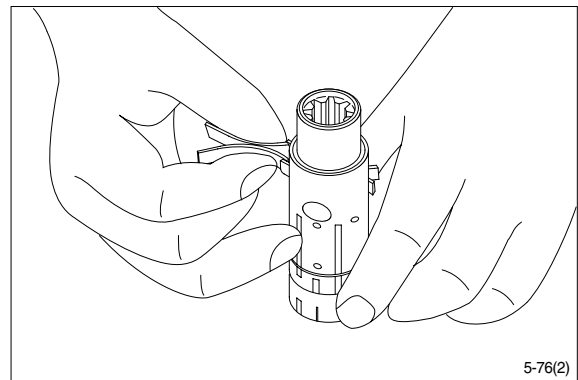
(1) Assemble spool and sleeve.

※ 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.

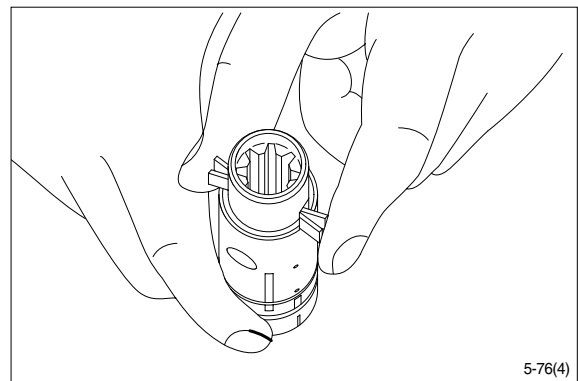


(2) Place the two flat neutral position springs in the slot.

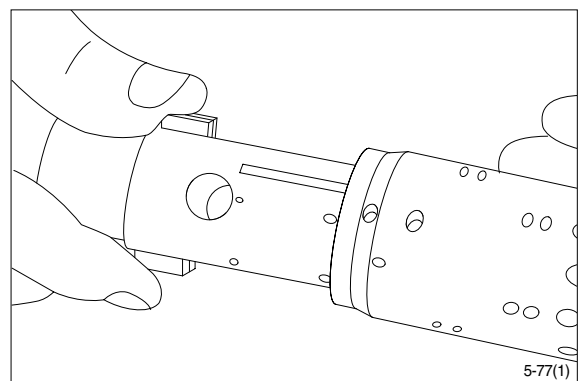
Place the curved springs between the flat ones and press them into place (see assembly pattern).



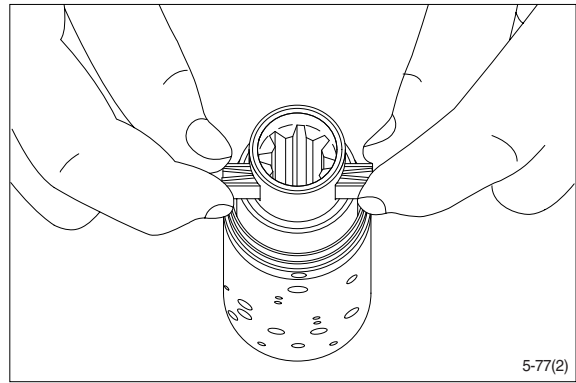
(3) Line up the spring set.



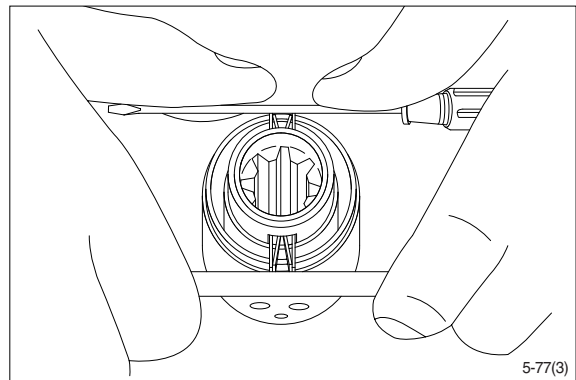
(4) Guide the spool into the sleeve. Make sure that spool and sleeve are placed correctly in relation to each other.



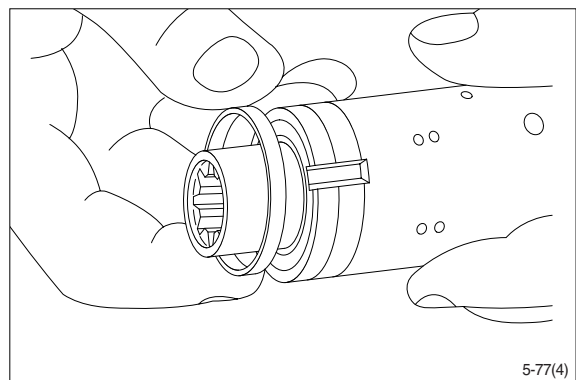
- (5) Press the springs together and push the neutral position springs into place in the sleeve.



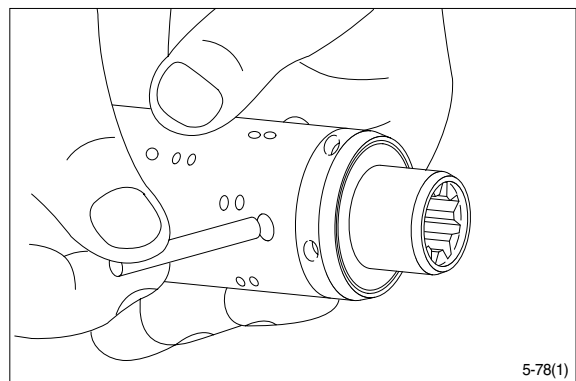
- (6) Line up the springs and center them.



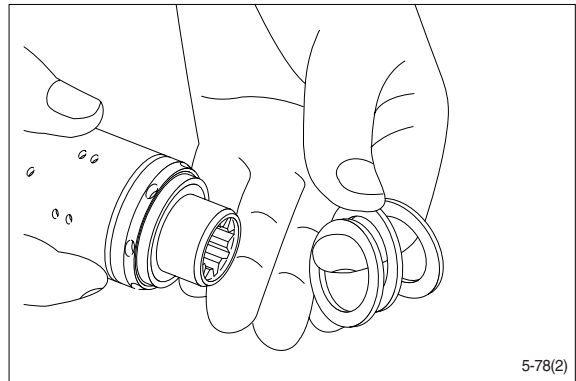
- (7) Guide the ring down over the sleeve.
※ The ring should be able to rotate free of the springs.



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

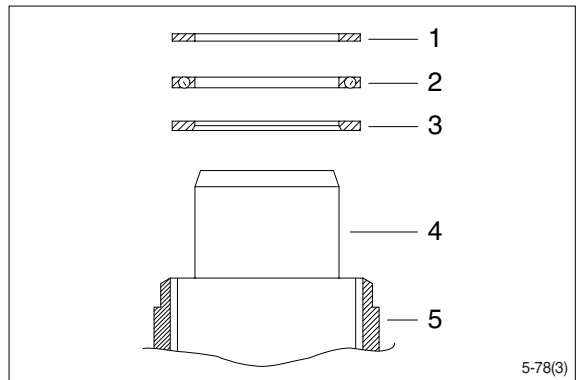


- (9) Fit bearing races and needle bearing as shown on below drawing.



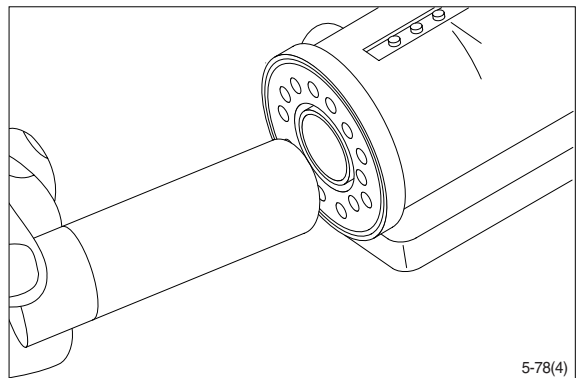
※ **Assembly pattern for standard bearings**

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

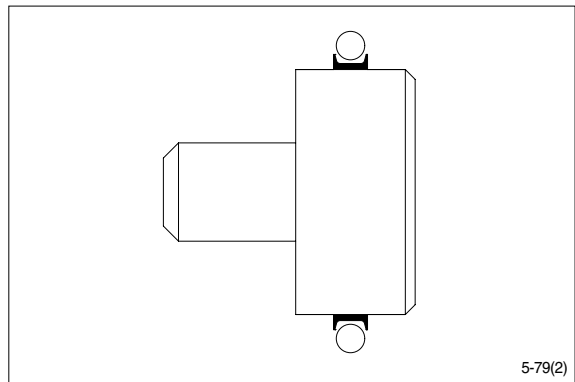
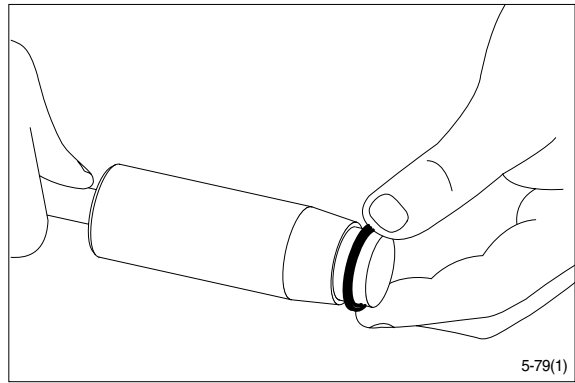


Installation instruction for O-ring

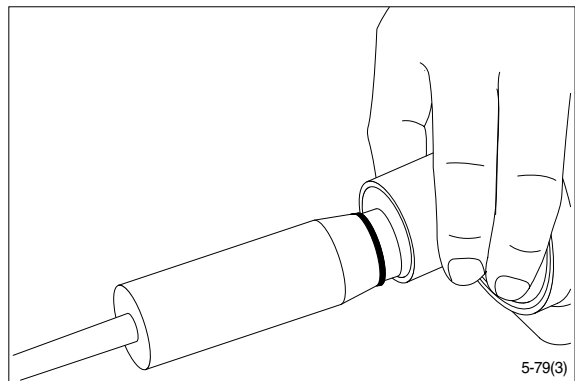
- (10) Turn the steering unit until the bore is horizontal. Guide the outer part of the assembly tool into the bore for the spool / sleeve.



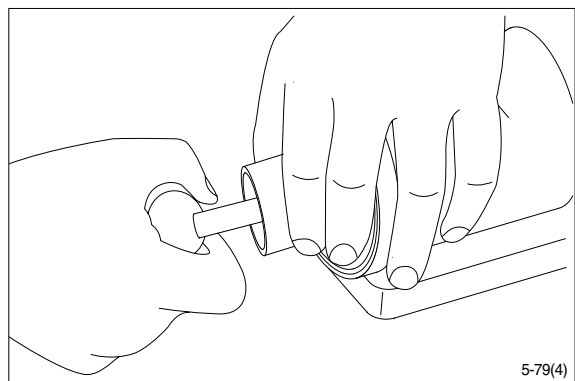
- (11) Grease O-ring with hydraulic oil and place them on the tool.



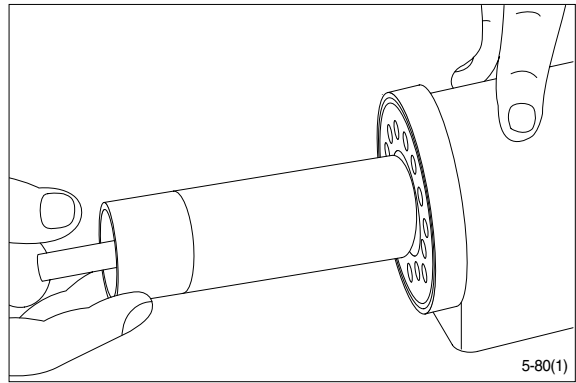
- (12) Hold the outer part of the assembly tool in the bottom of the steering unit housing and guide the inner part of the tool right to the bottom.



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

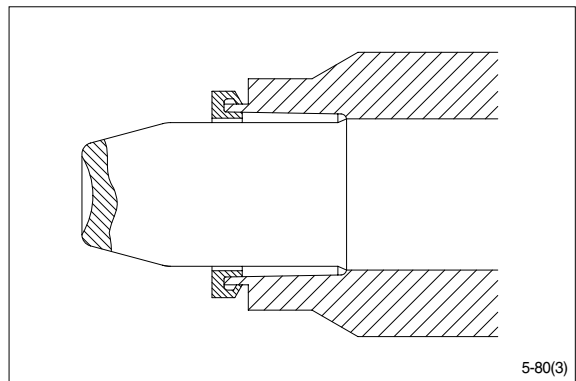
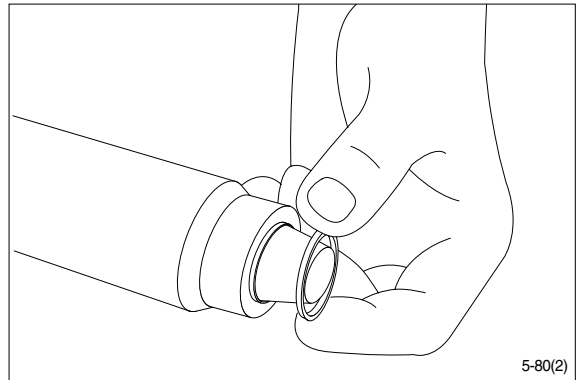


- (14) Draw the inner and outer parts of the assembly tool out of the steering unit bore, leaving the guide from the inner part in the bore.

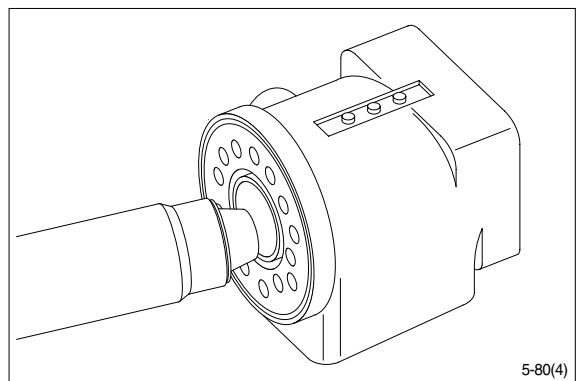


Installation instructions for lip seal

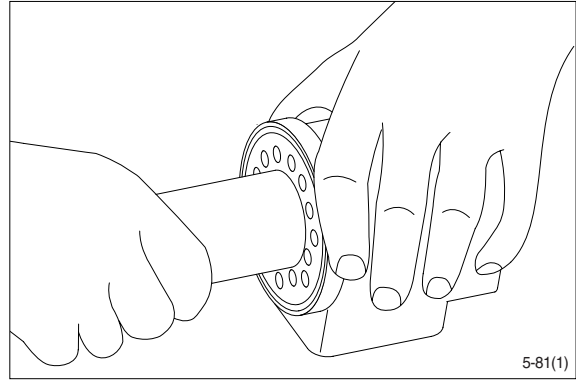
- (15) Lubricate the lip seal with hydraulic oil and place it on the assembly tool.



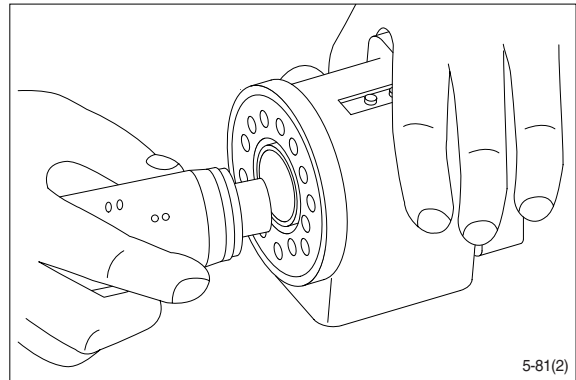
- (16) Guide the assembly tool right to the bottom.



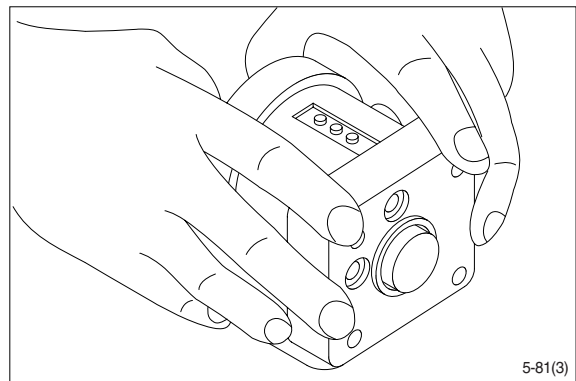
- (17) Press and turn the lip seal into place in the housing.



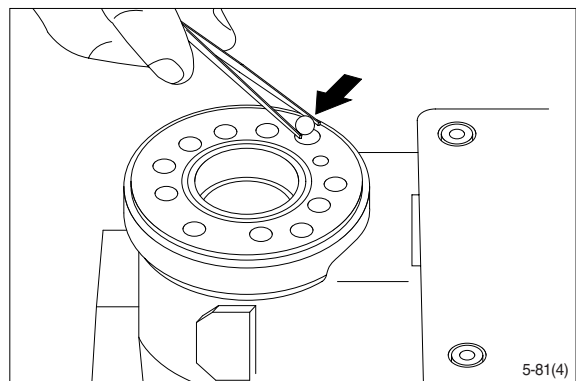
- (18) With a light turning movement, guide the spool and sleeve into the bore.
※ Fit the spool set holding the cross pin horizontal.



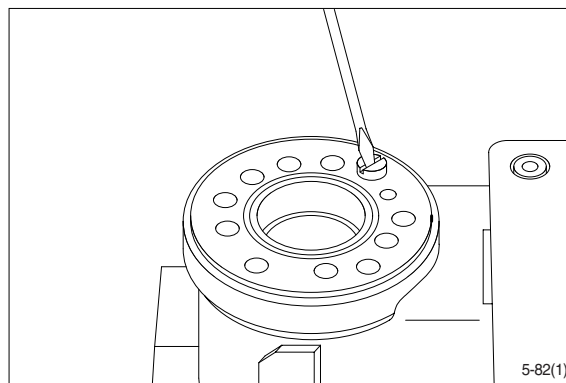
- (19) The spool set will push out the assembly tool guide. The O-ring are now in position.



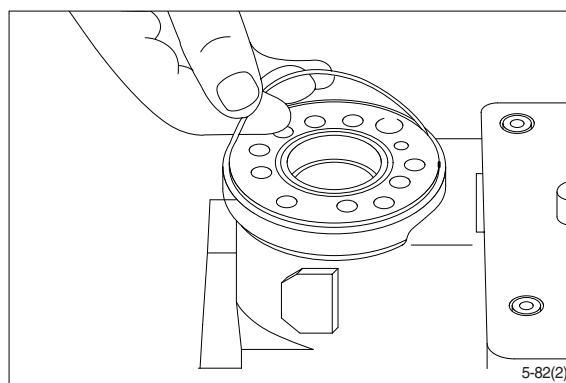
- (20) Turn the steering unit until the bore is vertical again. Put the check valve ball into the hole indicated by the arrow.



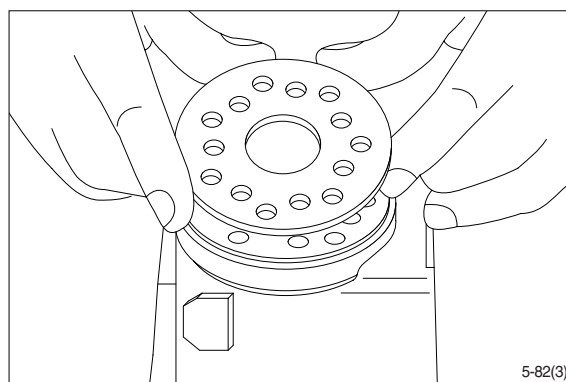
- (21) Screw the threaded bush lightly into the check valve bore. The top of the bush must lie just below the surface of the housing.



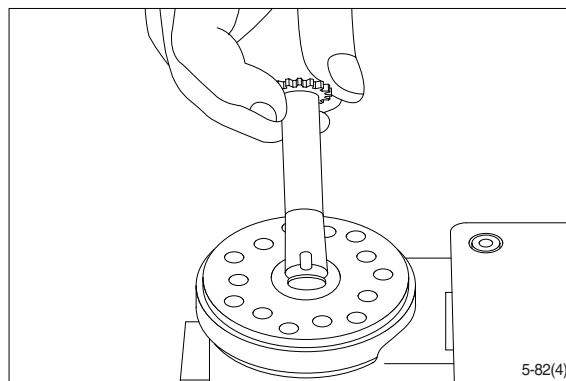
- (22) Grease the O-ring with mineral oil approx. viscosity 500 cSt at 20°C.



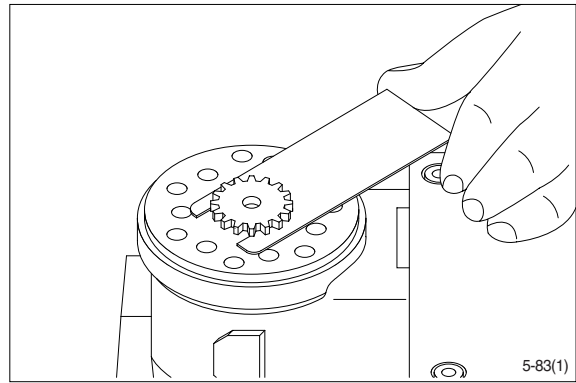
- (23) Place the distributor plate so that the channel holes match the holes in the housing.



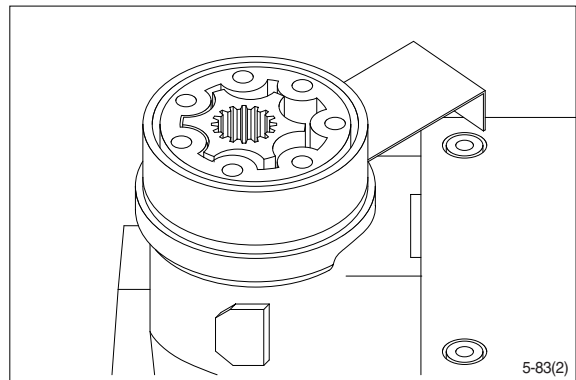
- (24) Guide the cardan shaft down into the bore so that the slot is parallel with the connection flange.



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



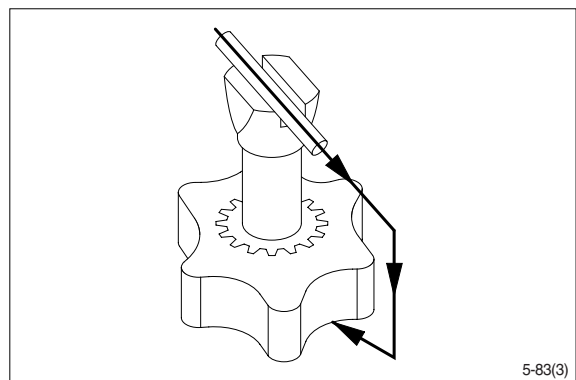
- (26) Grease the two O-rings with mineral oil approx. viscosity 500 cSt at 20°C and place them in the two grooves in the gear rim. Fit the gearwheel and rim on the cardan shaft.



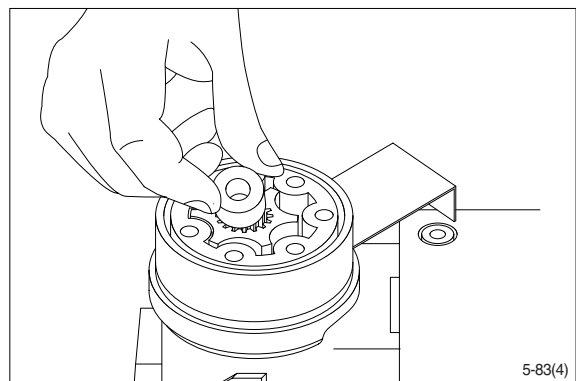
(27) Important

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.

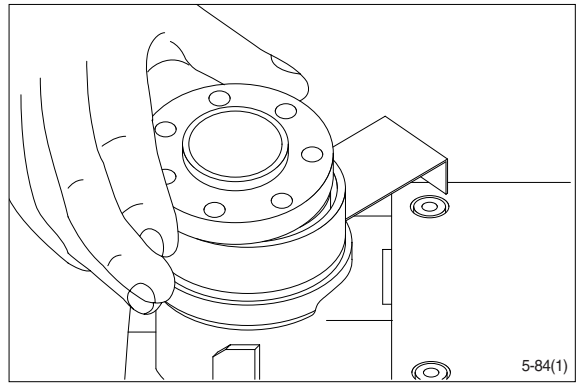
Turn the gear rim so that the seven through holes match the holes in the housing.



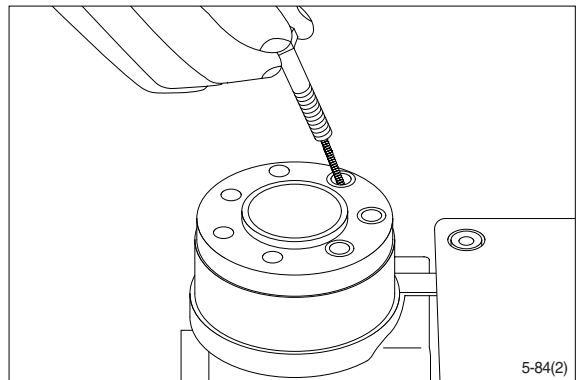
- (28) Fit the spacer, if any.



(29) Place the end cover in position.

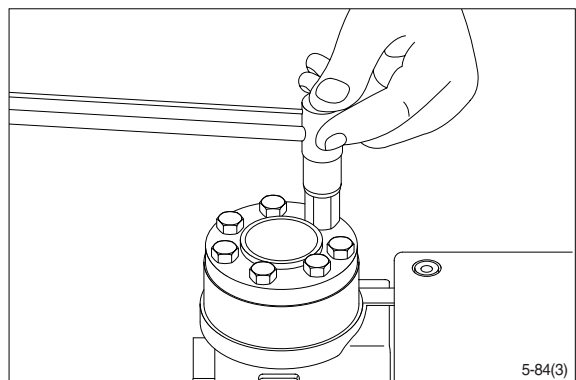


(30) Fit the special screw with washer and place it in the hole shown.

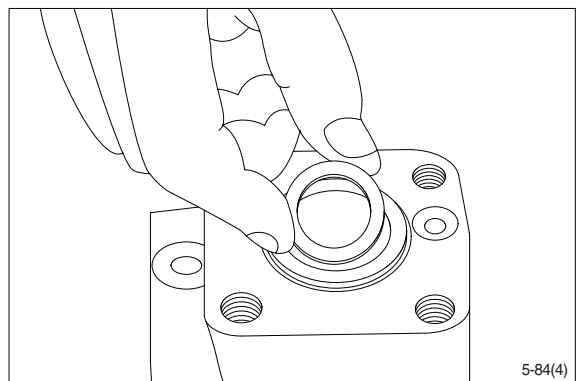


(31) Fit the six screws with washers and insert them. Cross-tighten all the screws and the rolled pin.

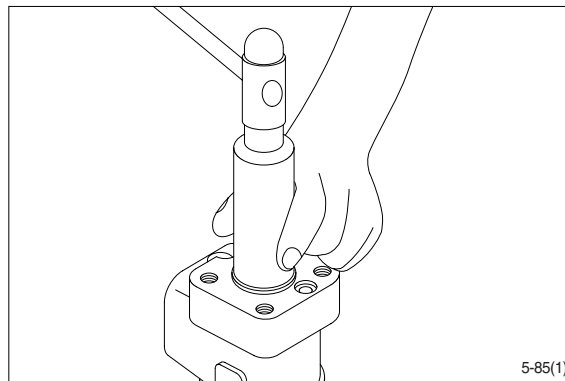
- Tightening torque : $4.0 \pm 0.5 \text{ kgf} \cdot \text{m}$
($28.9 \pm 3.6 \text{ lbf} \cdot \text{ft}$)



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

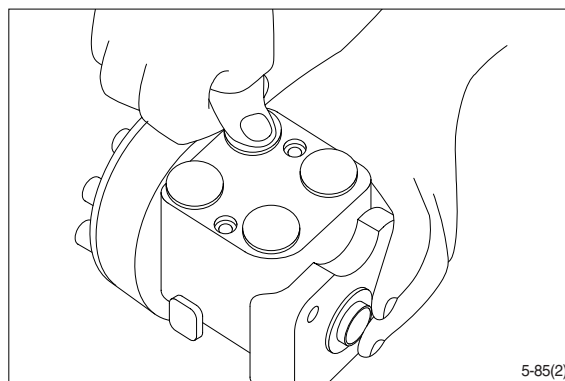


(33) Fit the dust seal ring in the housing.



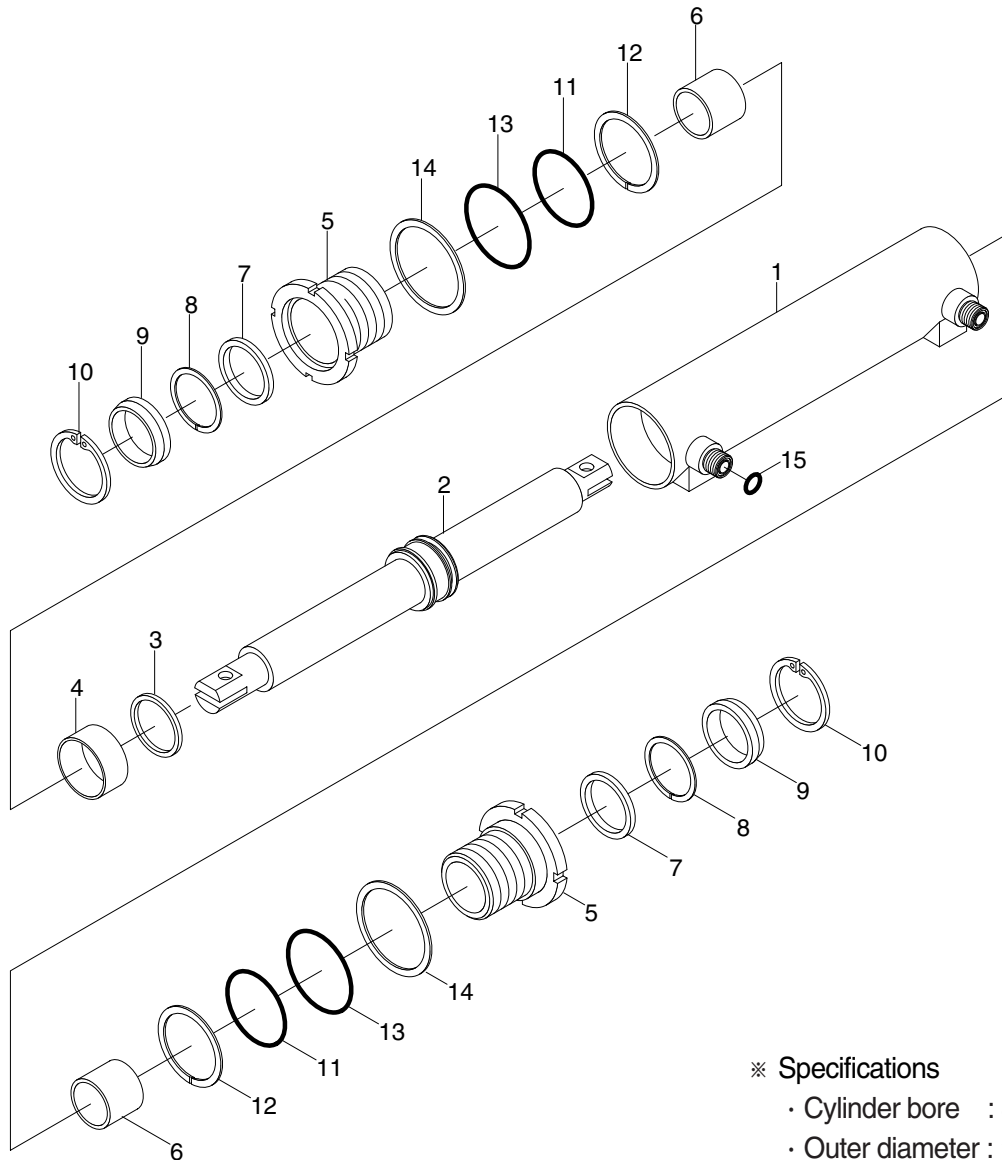
(34) Press the plastic plugs into the connection ports.

※ Do not use a hammer!



2. STEERING CYLINDER

1) STRUCTURE



※ Specifications

- Cylinder bore : 80mm
- Outer diameter : 94mm
- Stroke(half) : 180mm
- Rod diameter : 55mm

D357SE21

- | | | |
|---------------|----------------|-----------------|
| 1 Tube assy | 6 DU bushing | 11 O-ring |
| 2 Rod assy | 7 Rod seal | 12 Back up ring |
| 3 Piston seal | 8 Back up ring | 13 O-ring |
| 4 Wear ring | 9 Dust wiper | 14 Lock washer |
| 5 Gland | 10 Snap ring | 15 O-ring |

2) DISASSEMBLY

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

- (1) Put wooden blocks against the cylinder tube, then hold in & vice.
- (2) Remove the cover 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(O-ring, oil seal, dust seal, U-packing, bush). If there are some damage, replace with new parts.

3) CHECK AND INSPECTION

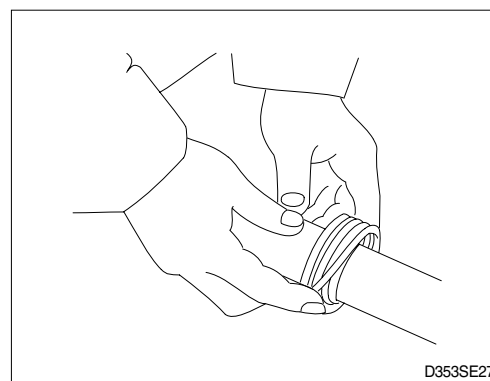
mm(in)

Check item	Criteria		Remarks
	Standard size	Repair limit	
Clearance between piston & cylinder tube	0.05~0.25 (0.002~0.01)	0.4 (0.02)	Replace piston seal
Clearance between cylinder rod & bushing	0.05~0.18 (0.002~0.007)	0.3 (0.01)	Replace bushing
Seals, O-ring	Damage		Replace
Cylinder rod	Dents		Replace
Cylinder tube	Biting		Replace

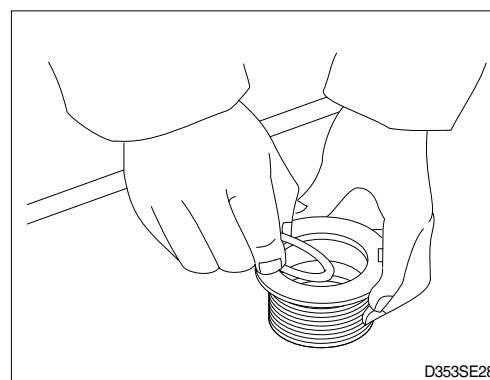
4) ASSEMBLY

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

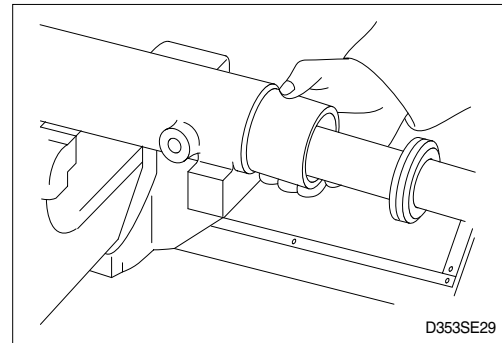
※ Be careful not to scratch the seal too much during installation or it could not be seated properly.



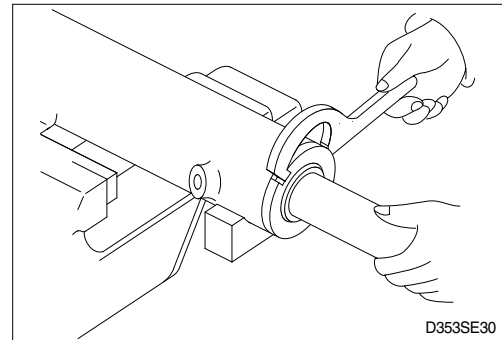
- (2) Install the rod seal to the position in the gland applying a slight coat with grease prior to install.



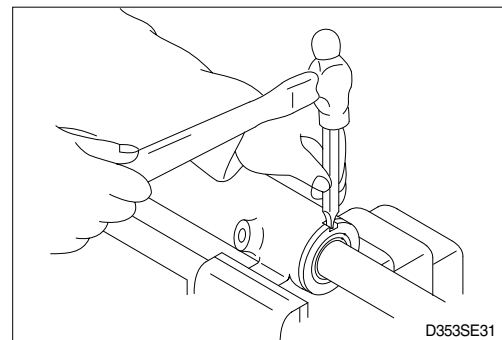
- (3) Install the dust wiper to the gland using a special installing tool. Coat the dust wiper with grease slightly before installing.
- (4) Using a special tool, install gland assembly into the cylinder tube.



- (5) Using a hook spanner, install the gland assembly, and tighten it with torque $60 \pm 6 \text{ kgf} \cdot \text{m}$ ($434 \pm 43 \text{ lbf} \cdot \text{ft}$).



- (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 is needed to calk again, never calk on the same place.

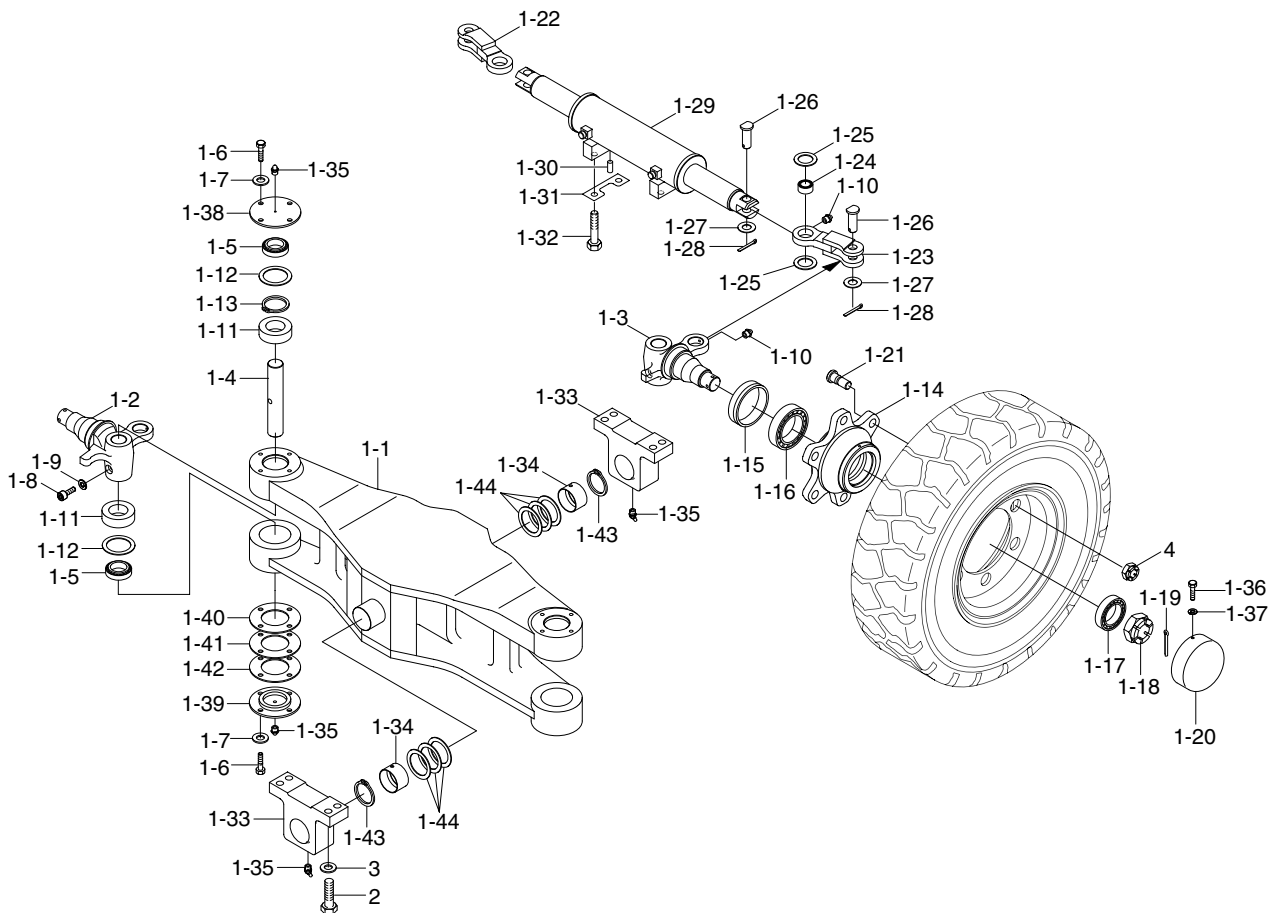


- (7) Move the piston rod back and forth several times for the full distance of its stroke. This helps to seat the ring and seals before applying full hydraulic pressure to the cylinder.
- (8) Install cylinder into trail axle.
- (9) While idling the engine with the rear wheels off the ground, operate 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

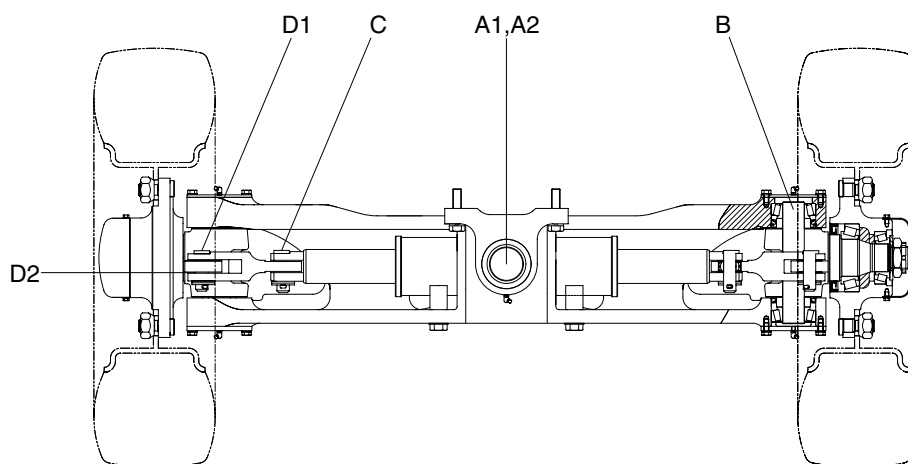
※ Do not remove the stopper bolt unless necessary.



35DS7SE06

1-1 Steering axle	1-12 Dust seal	1-23 Link-LH	1-34 Bushing
1-2 Knuckle-RH	1-13 Snap ring	1-24 SPH plain bearing	1-35 Grease nipple
1-3 Knuckle-LH	1-14 Hub	1-25 Thrust washer	1-36 Hexagon bolt
1-4 King pin	1-15 Oil seal	1-26 Clevis pin	1-37 Spring washer
1-5 Taper roller bearing	1-16 Taper roller bearing	1-27 Plain washer	1-38 Upper cover
1-6 Hexagon bolt	1-17 Taper roller bearing	1-28 Split pin	1-39 Lower cover
1-7 Spring washer	1-18 Slotted nut	1-29 Steering cylinder	1-40 Shim(0.1t)
1-8 Special bolt	1-19 Split pin	1-30 Pin	1-41 Shim(0.15t)
1-9 Spring washer	1-20 Hub cap	1-31 Lock plate	1-42 Shim(0.3t)
1-10 Grease nipple		1-32 Hexagon bolt	1-43 Snap ring
1-11 Collar		1-33 Support	1-44 Shim

2) CHECK AND INSPECTION



35DS7SE08

unit : mm(in)

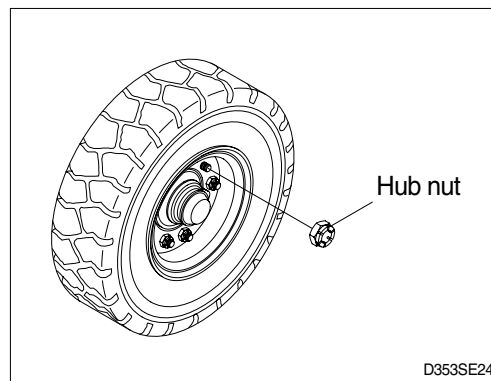
No.	Check item			Criteria		Remarks
				Standard size	Repair limit	
A	Shaft	A1	OD of shaft	55(2.2)	54.5(2.1)	Replace
		A2	ID of bushing	55(2.2)	55.5(2.2)	
B	OD of king pin			35(1.4)	34.5(1.4)	
C	OD of steering cylinder pin			20(0.8)	19.5(0.8)	
D	Knuckle	D1	OD of pin	20(0.8)	19.5(0.8)	Adjust with shims
		D2	Vertical play	-	-	

- OD : Outer diameter
- ID : Inner diameter

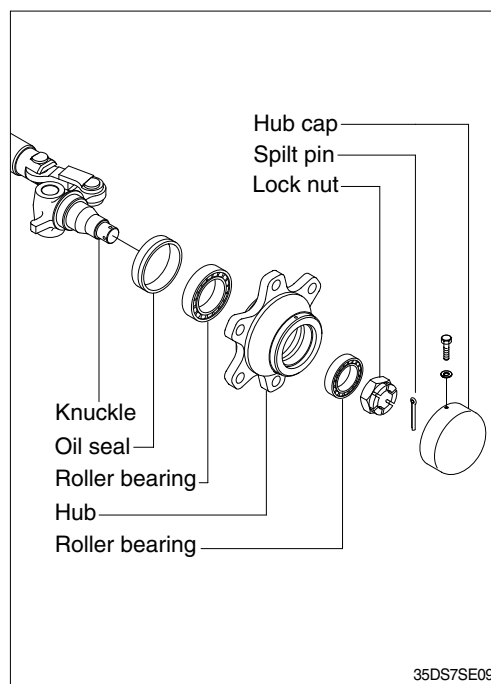
3) DISASSEMBLY

※ 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 counter weight part of the truck.

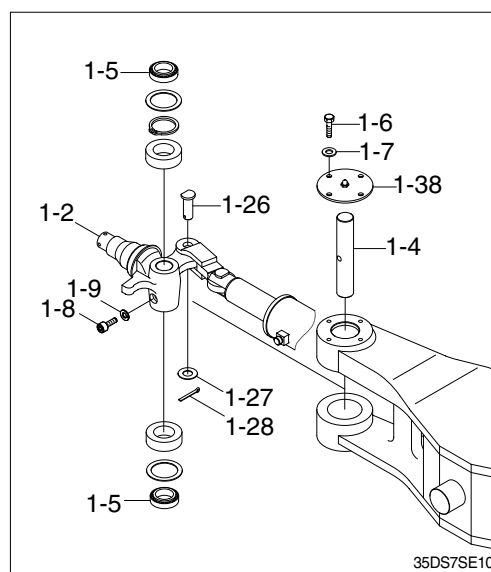
- (1) Loosen the hub nut and take off the steering wheel tire.



- (2) Remove Hub cap.
- (3) Pull out split pin and remove lock nut.
- (4) Using the puller, take off the hub together with the roller bearing.
 - ※ Be very careful because just before the hub comes off, tapered roller bearing will fall out.
- (5) After hub is removed take off the inner race of roller 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 lock nut in the knuckle to protect the threaded portion.



- (8) Loosen special bolt(1-8) and spring washer(1-9).
- (9) Remove hexagon bolt(1-6) and upper cover(1-38).
- (10) Push out the king pin(1-4) without damaging the knuckle arm(1-2).
- (11) If defect is observed in taper roller bearing(1-5), pull it out by using extractor.
- (12) Remove spilt pin(1-28), plain washer(1-27) and clevis pin(1-26).



4) ASSEMBLY

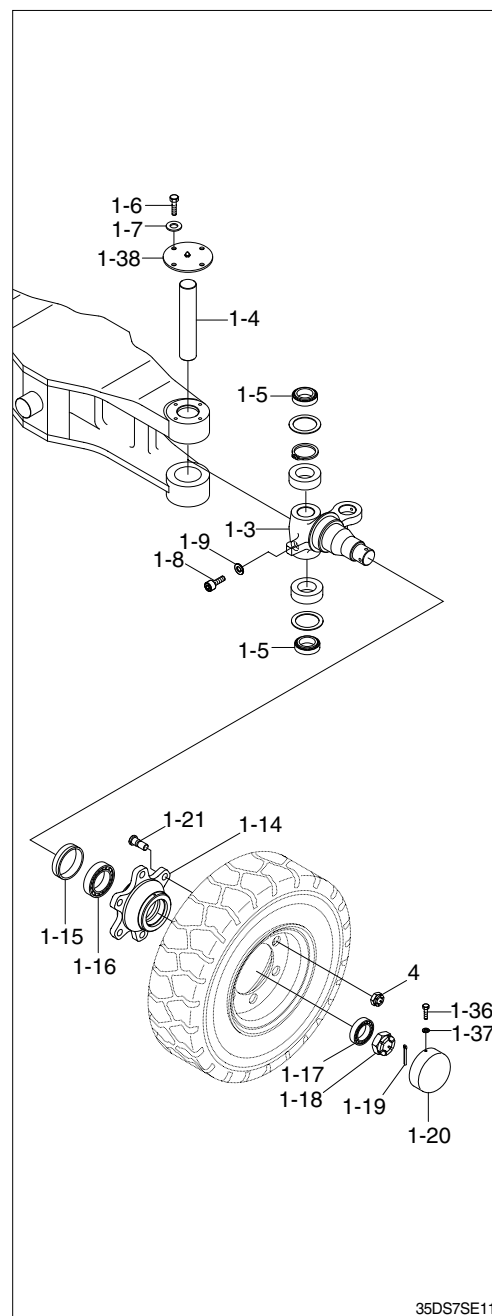
※ In reassembling, have all parts washed, grease applied to lubricating parts, and all expendable items such as oil seal and spring washers replaced by new ones.

Perform the disassembly in reverse order.

- (1) Tighten the special bolt(1-8) and washer(1-9) of king pin(1-3).
- (2) There is a notch in the middle of the king pin(1-4), make sure that this notch is on the special bolt side.
- (3) Do not hammer to drive in taper roller bearing(1-5) 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(1-3).

(4) Hub

- ① Mount oil seal(1-15) and inner race of taper roller bearing(1-16) on the knuckle. The bearing should be well greased before assembling.
- ② Install the outer race of the taper roller bearing(1-17) in the wheel center and assemble to the knuckle.
- ③ Tighten nut(1-18) and lock with split pin(1-19). 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(1-20) and tighten with bolt (1-36).
Bearing should be well greased before assembling.



SECTION 6 HYDRAULIC SYSTEM

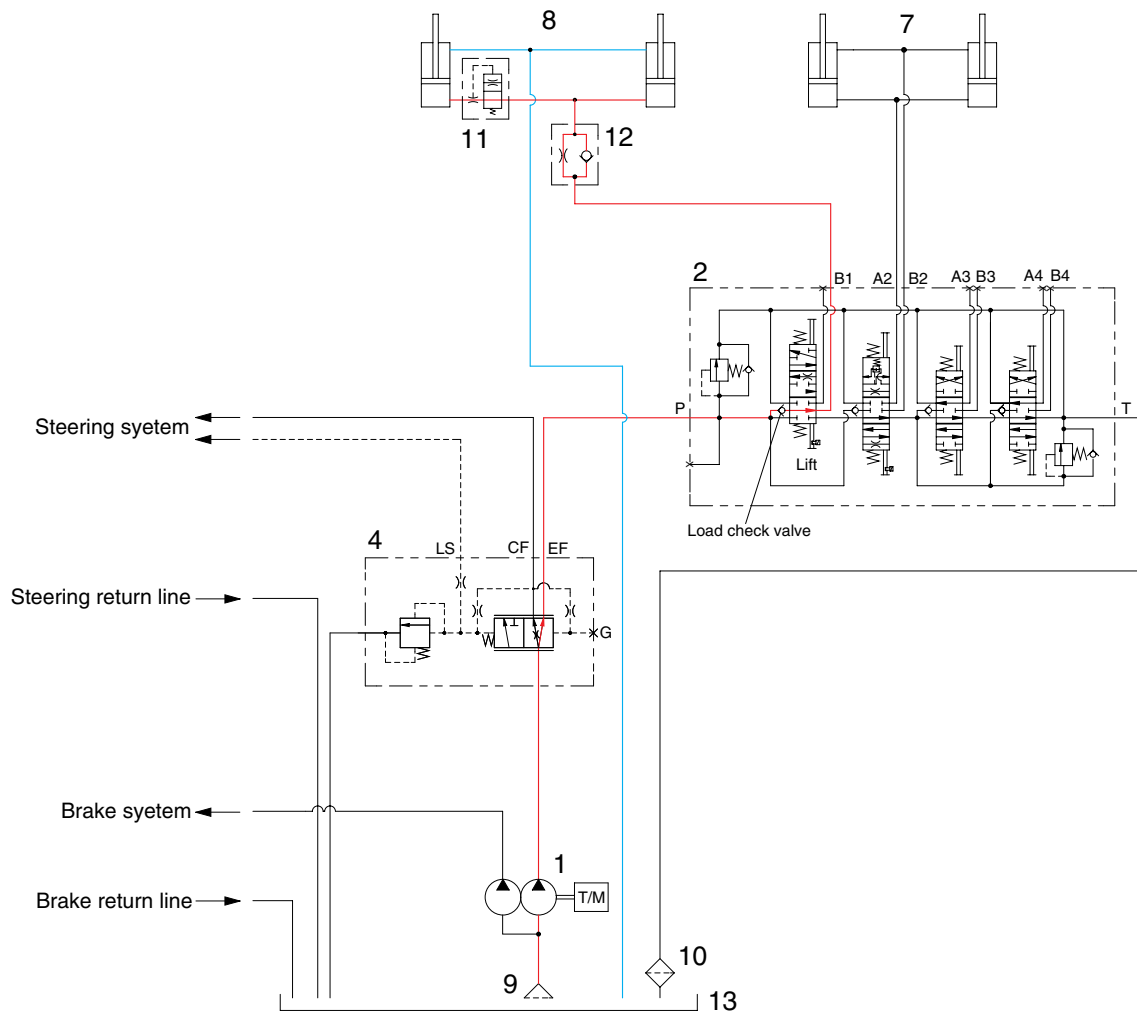
Group 1	Structure and function	6-1
Group 2	Operational checks and troubleshooting	6-17
Group 3	Disassembly and assembly	6-22

1. HYDRAULIC CIRCUIT



- 6-1

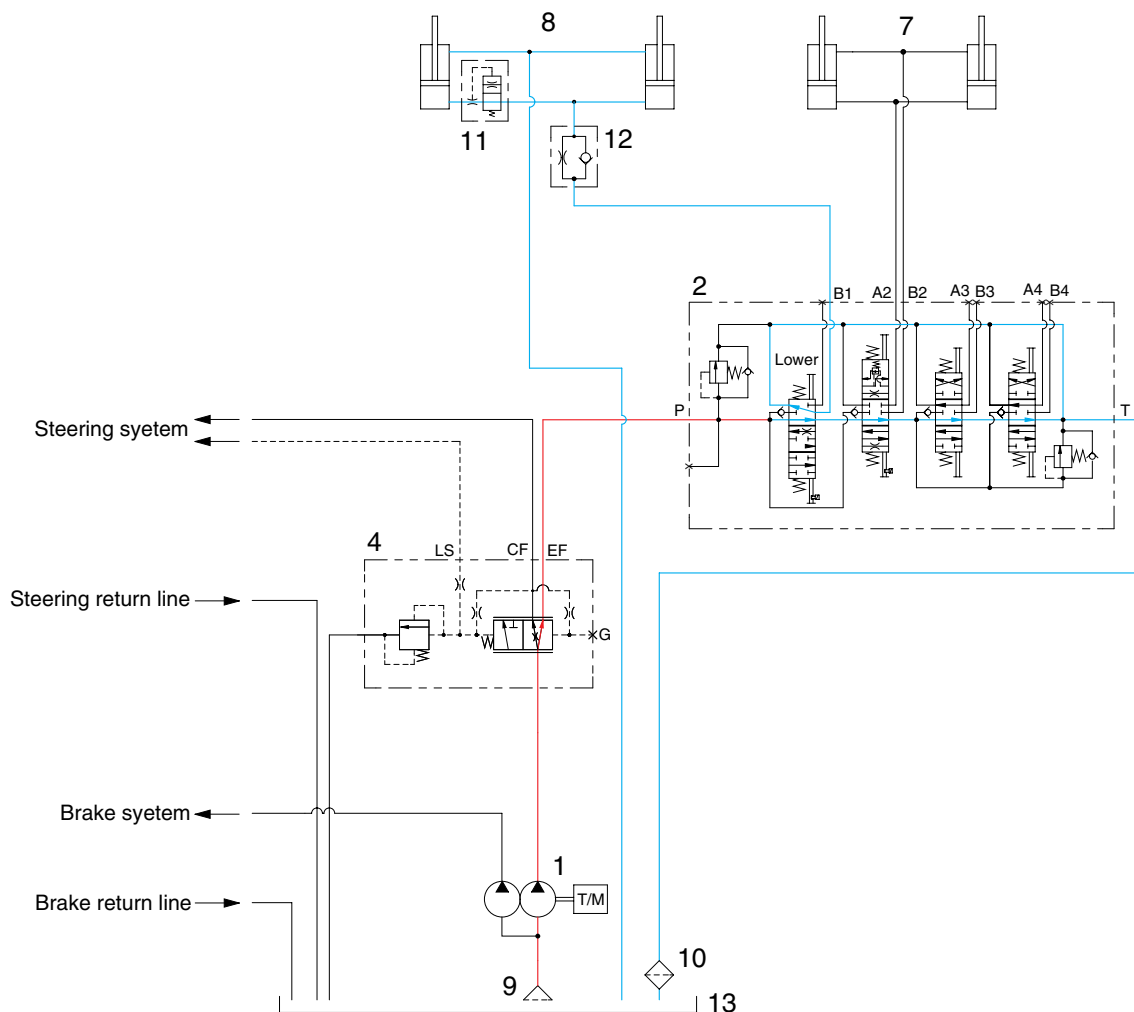
1) WHEN THE LIFT CONTROL LEVER IS IN THE LIFT POSITION



35DS7HS02

When the lift control lever is pulled back, the spool on the first block is moves to lift position. The oil from hydraulic gear pump(1) flows into main control valve(2) through the priority valve(4) and then goes to the large chamber of lift cylinder(8) by pushing the load check valve of the spool. The oil from the small chamber of lift cylinder(8) returns to hydraulic oil tank(13) at the same time. When this happens, the forks go up.

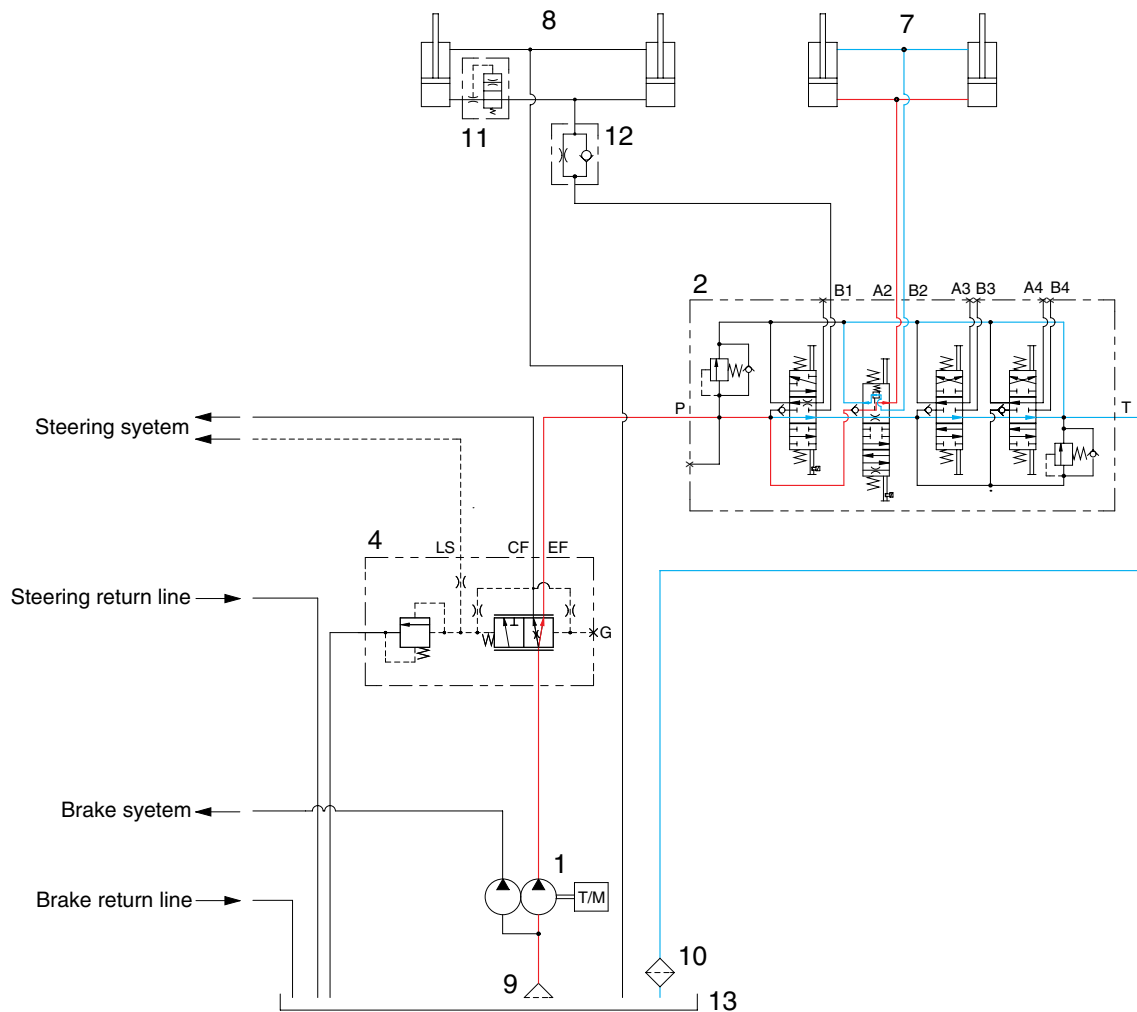
2) WHEN THE LIFT CONTROL LEVER IS IN THE LOWER POSITION



35DS7HS03

When the lift control is pushed forward, the spool on the first block is moved to lower position. The work port(B1) and the small chamber and the large chamber are connected to the return passage, so the lift will be lowered due to its own weight.

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



35DS7HS04

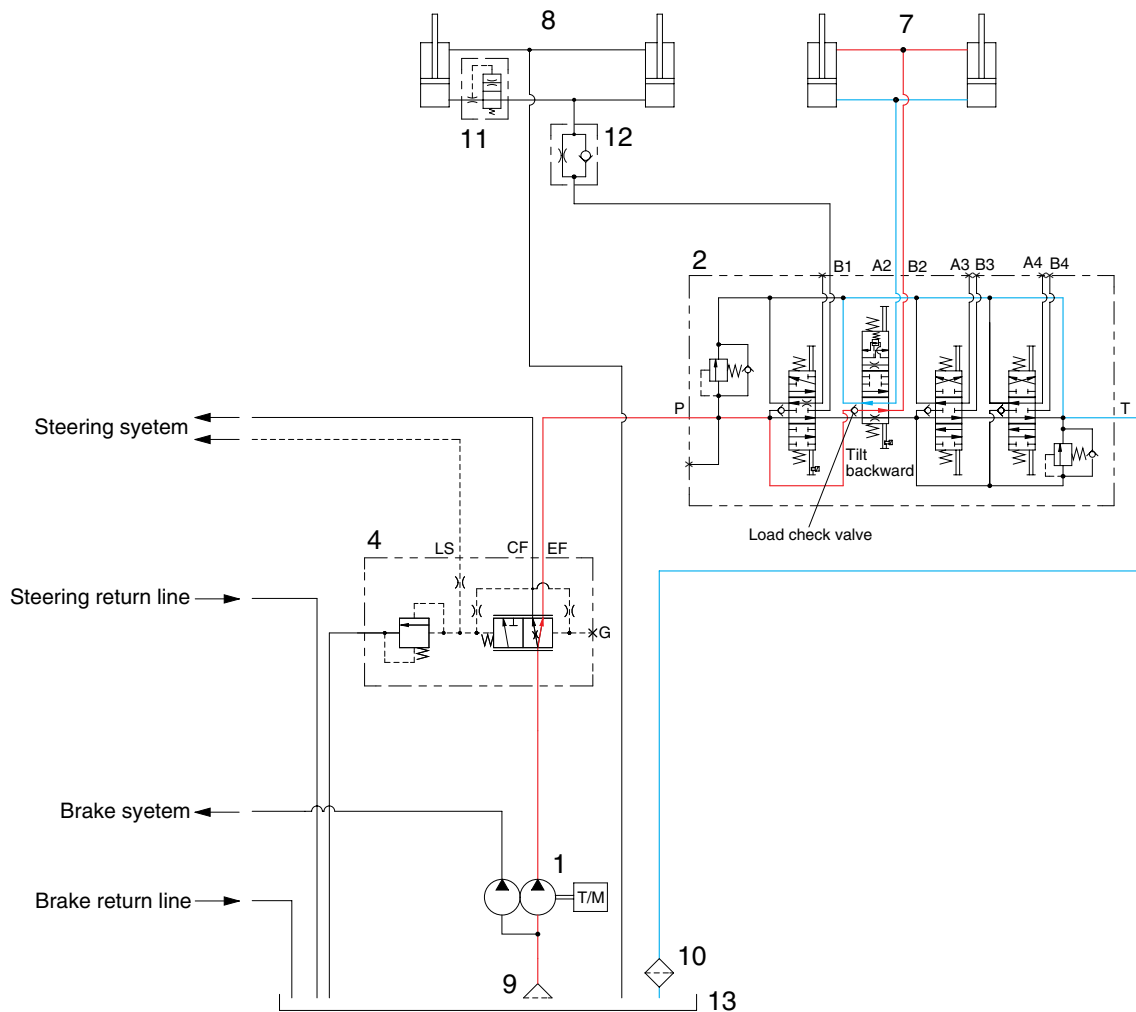
When the tilt control lever is pushed forward, the spool on the second block is moved to tilt forward position.

The oil from hydraulic gear pump(1) flows into main control valve(2) through the priority valve(4) 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(13) at the same time.

When this happens, the mast tilt forward.

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



35DS7HS05

When the tilt control lever is pulled back, the spool on the second block is moved to tilt backward position.

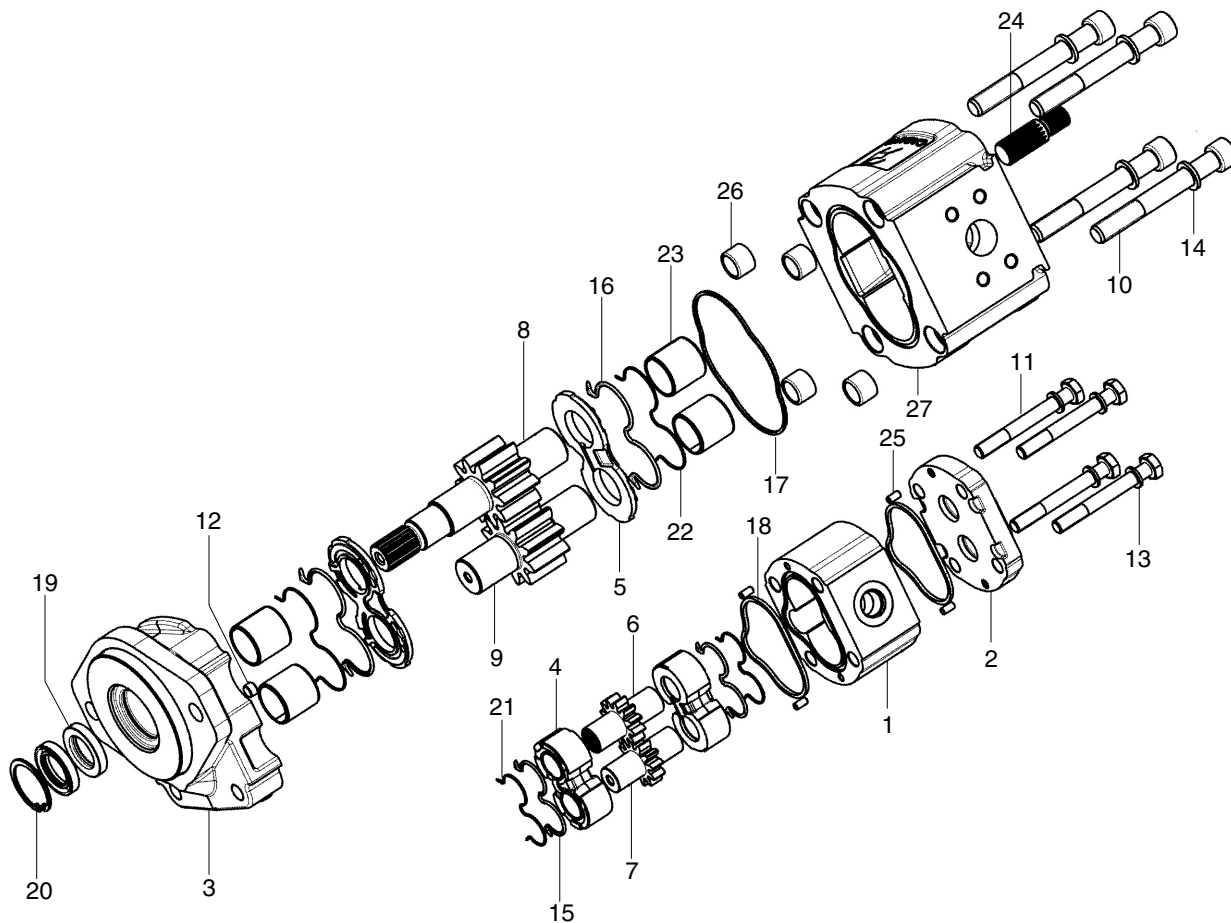
The oil from hydraulic gear pump(1) flows into main control valve(2) through the priority valve(4) and then goes to the small chamber of tilt cylinder(7) by pushing the load check valve of spool.

The oil at the large chamber of tilt cylinder(7) returns to hydraulic tank(13) at the same time.

When this happens, the mast tilt backward.

2. HYDRAULIC GEAR PUMP

1) STRUCTURE



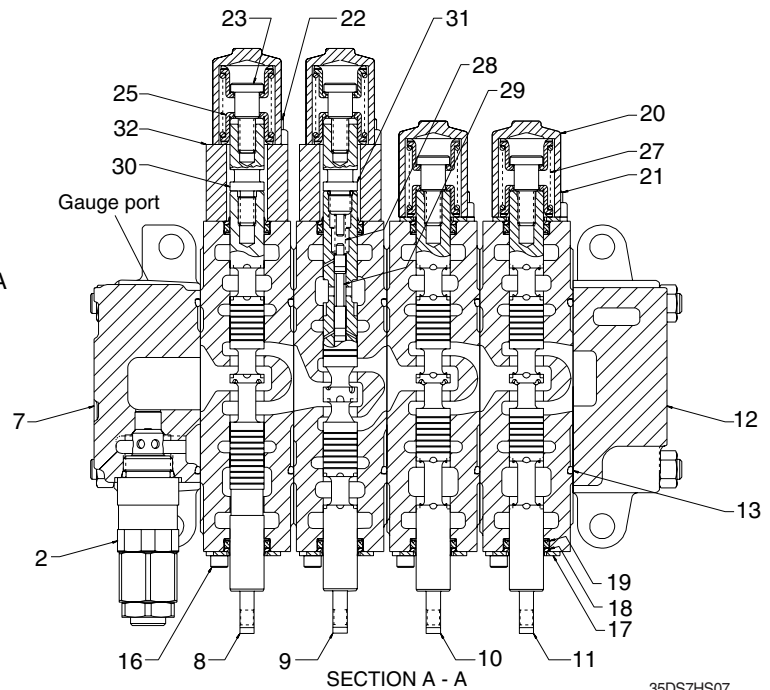
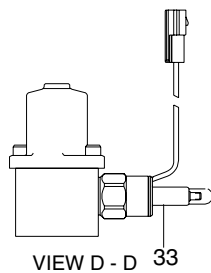
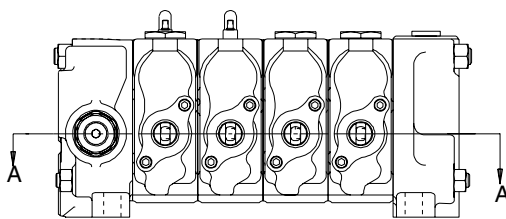
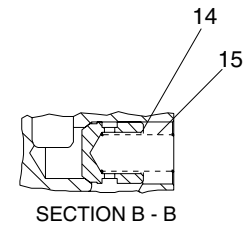
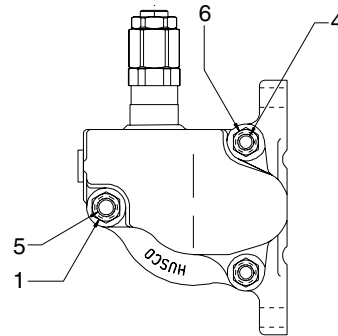
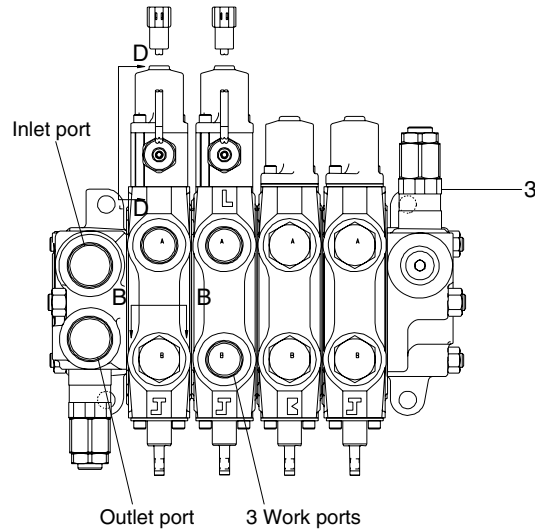
35DS7HS06

- | | | | | | |
|---|--------------|----|------------|----|----------------|
| 1 | Body | 10 | Screw | 19 | Shaft seal |
| 2 | Rear cover | 11 | Screw | 20 | Ring |
| 3 | Front cover | 12 | Grub screw | 21 | Back-up ring |
| 4 | Thrust plate | 13 | Washer | 22 | Antiextrusion |
| 5 | Thrust plate | 14 | Washer | 23 | Sleeve bearing |
| 6 | Drive gear | 15 | Seal | 24 | Hub |
| 7 | Driven gear | 16 | Seal | 25 | Dowel pin |
| 8 | Drive shaft | 17 | Seal | 26 | Steel bushing |
| 9 | Driven gear | 18 | Seal | 27 | Body |

3. MAIN CONTROL VALVE

1) STRUCTURE (2 Spool)

Port name	Size
Inlet port	1-5/16-12UN
Outlet port	1-5/16-12UN
Gauge port	PF1/4
3 Work port	1-1/16-12UN

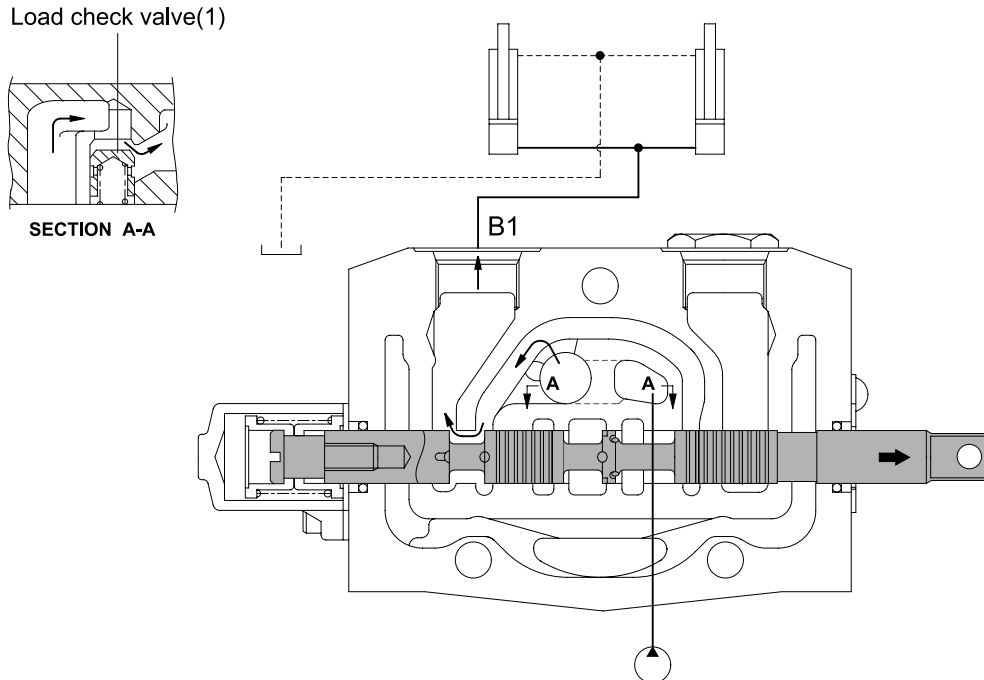


35DS7HS07

- | | | |
|----------------------|------------------------|-------------------|
| 1 Special nut | 12 Outlet section assy | 23 Spool end |
| 2 Main relief valve | 13 O-ring | 25 Spring seat |
| 3 Aux relief valve | 14 Poppet | 27 Spring |
| 4 Tie rod | 15 Spring | 28 Spring |
| 5 Tie rod | 16 Screw | 29 Piston |
| 6 Special nut | 17 Seal plate | 30 Spool end |
| 7 Inlet section assy | 18 Wiper | 31 Spool end |
| 8 Spool section-lift | 19 Spool seal | 32 Spool cap |
| 9 Spool section-tilt | 20 Spool cap | 33 Solenoid valve |
| 10 Spool section-A1 | 21 Screw cap | |
| 11 Spool section-A2 | 22 Screw cap | |

2) LIFT SECTION OPERATION

(1) Lift position



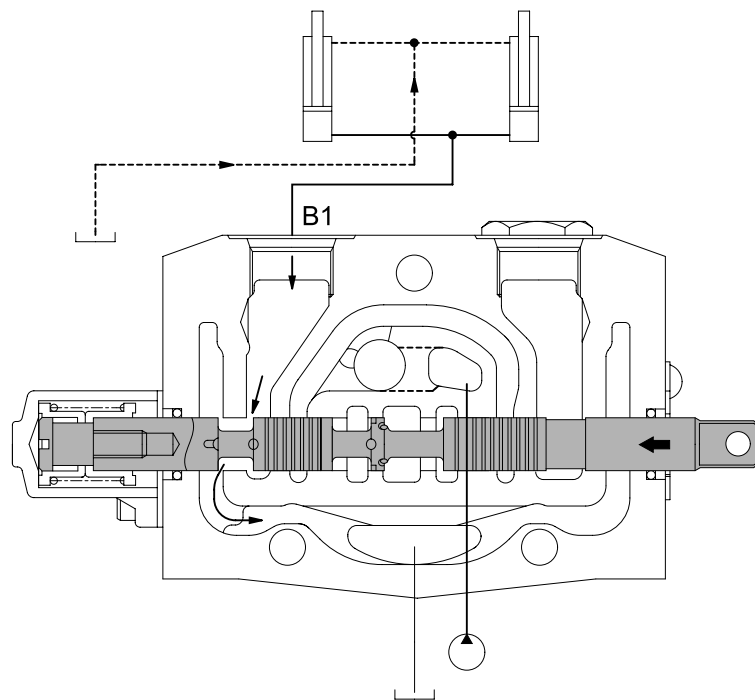
D353HS08

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(1) and flow into lift cylinder port(B1). 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



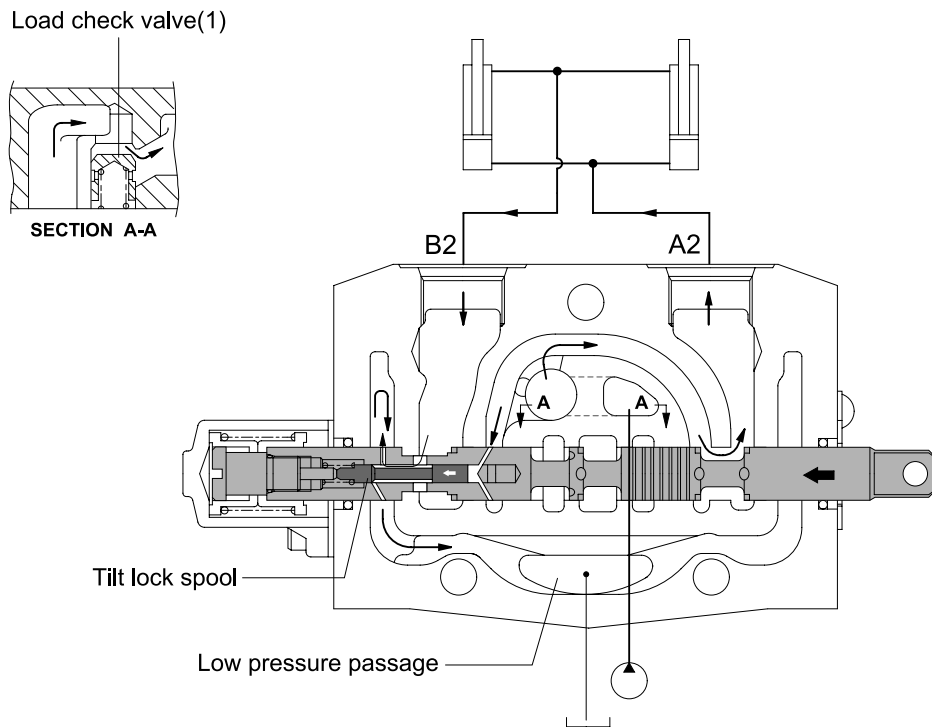
D353HS09

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 (B1)→T.
In lift lower position the fork drops due to its own weight.

3) TILT SECTION OPERATION

(1) Tilt forward position



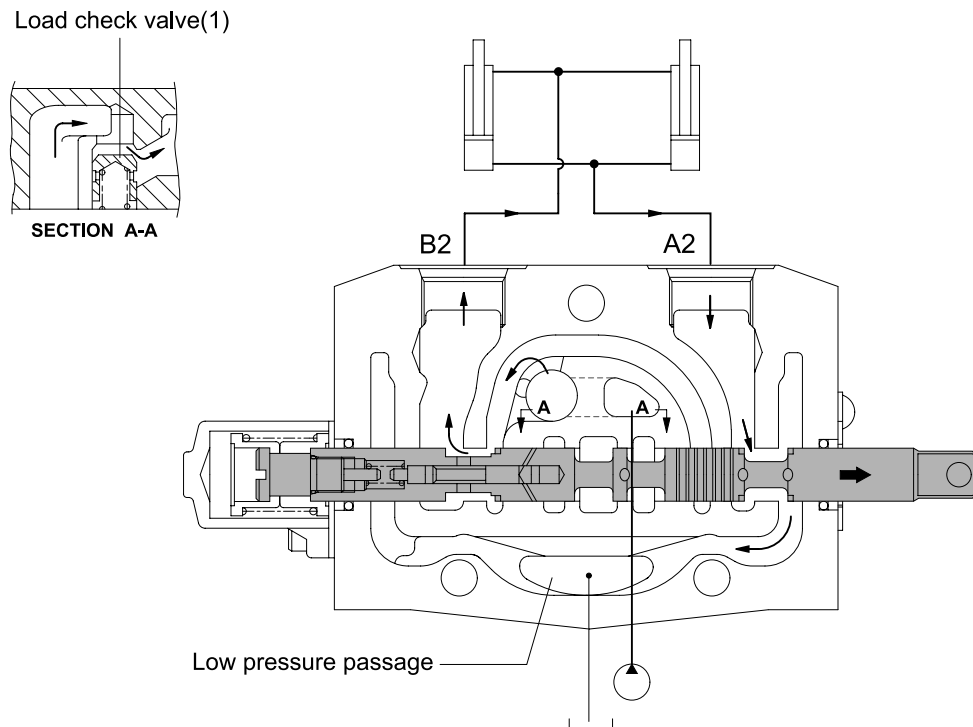
D353HS10

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(1) and flow into tilt cylinder port(A2). The pump pressure reaches proportionally the load of cylinders and fine control finished by closing the neutral passage.

The return oil from cylinder port(B2) flows into the tank through the hole of the tilt lock spool.

(2) Tilt backward position



D353HS11

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(1) and flows into tilt cylinder port(B2). 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(A2) flows into the tank via the low pressure passage.

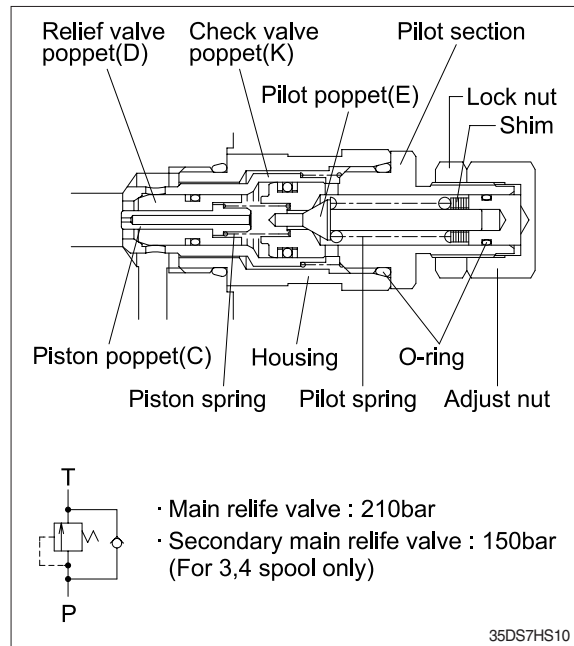
4) MAIN RELIEF VALVE

(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

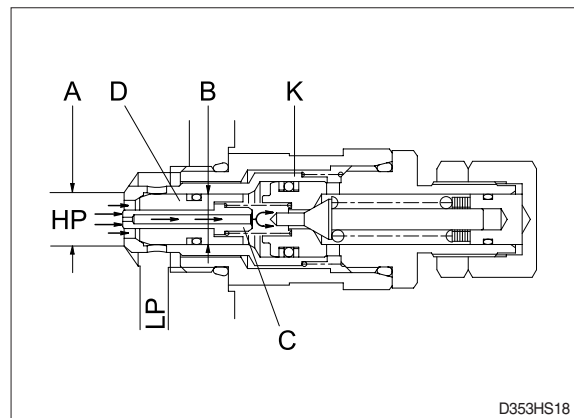
- ① Loosen lock nut.
- ② Set adjusting nut to desired pressure setting.
- ③ If desired pressure setting cannot be achieved, add or remove shims as required.
- ④ Tighten lock nut.
- ⑤ Retest in similar manner as above.



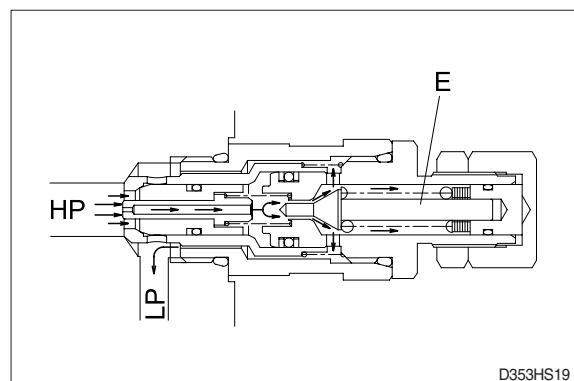
(2) Function

① As work port relief

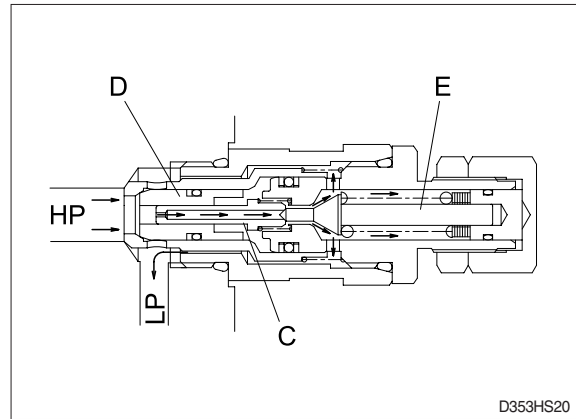
The relief valve is in communication between the high pressure port HP and low pressure LP. Oil is admitted through the hole in poppet C and because of the differential area between diameters A and B relief valve poppet D and check valve poppet K are tightly seated as shown.



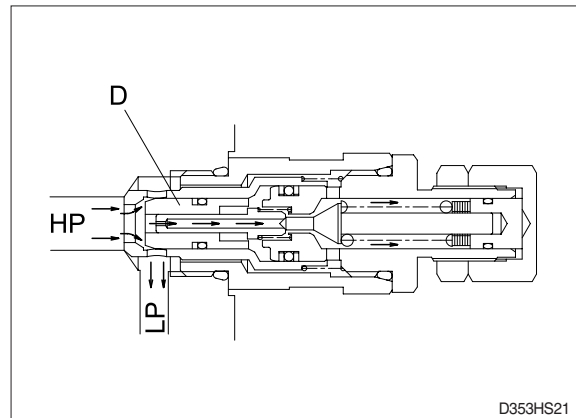
The oil pressure in the high pressure port HP has reached the setting of the pilot poppet spring force and unseats the pilot poppet E and oil flows around the poppet through the cross drilled holes and to the low pressure area LP.



The loss of oil behind poppet C, effected by the opening of pilot poppet E, causes poppet C to move back and seat against pilot puppet E. This shuts off the oil flow to the area behind relief valve poppet D, and causes a low pressure area internally.

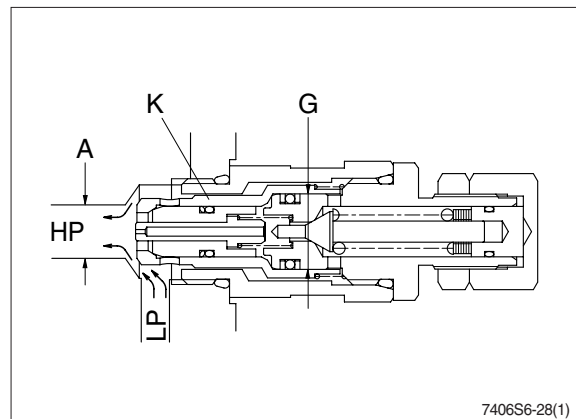


The imbalance of pressure on the inside as compared to that of the high pressure port HP, forces the relief valve poppet D to open and relieve the oil directly to the low pressure chamber LP in the valve.

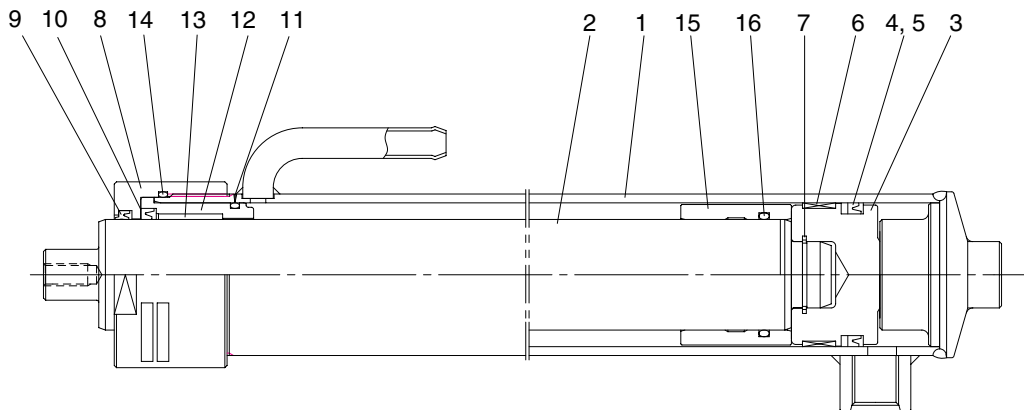


② As anti void

The anti-void unit supplies oil to the high pressure port HP when cavitation has occurred. A lower pressure exists in the port HP compared to the low pressure chamber LP. The difference between the effective area of diameter A and G causes imbalance of the check valve poppet K which unseats, thus allowing oil from the low pressure chamber LP to enter the port HP and fill the void.



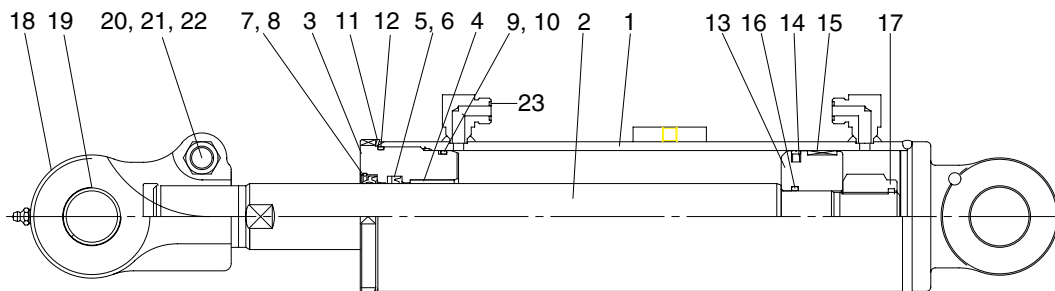
4. LIFT CYLINDER



D357HS12

- | | | |
|----------------|------------------|---------------|
| 1 Tube assy | 7 Retaining ring | 13 DU bushing |
| 2 Rod | 8 Gland | 14 O-ring |
| 3 Piston | 9 Dust wiper | 15 Spacer |
| 4 Piston seal | 10 Rod seal | 16 O-ring |
| 5 Back up ring | 11 O-ring | |
| 6 Wear ring | 12 Guide | |

5. TILT CYLINDER



D357HS13

- | | | |
|----------------|-----------------|------------------|
| 1 Tube assy | 9 O-ring | 17 Nylon nut |
| 2 Rod | 10 Back up ring | 18 Rod eye |
| 3 Gland | 11 Lock washer | 19 DU bushing |
| 4 DU bushing | 12 O-ring | 20 Hexagon bolt |
| 5 Rod seal | 13 Piston | 21 Hexagon nut |
| 6 Back up ring | 14 Glyd ring | 22 Spring washer |
| 7 Dust wiper | 15 Wear ring | 23 O-ring |
| 8 Snap ring | 16 O-ring | |

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

1) CHECK ITEM

- (1) Check visually for deformation, cracks or damage of rod.
- (2) Load maximum load, set mast vertical and raise 1m from ground. Wait for 10 minutes and measure hydraulic drift (amount forks move down and amount mast tilts forward).

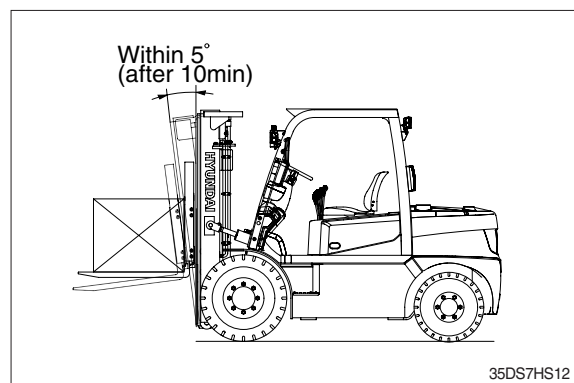
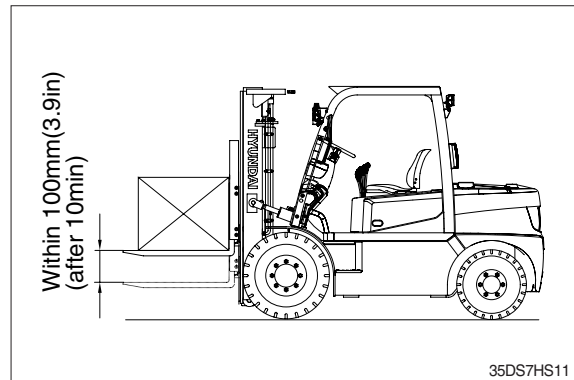
· Hydraulic drift

- Down (Downward movement of forks)
: Within 100mm (3.9in)
- Forward (Extension of tilt cylinder)
: Within 5°

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

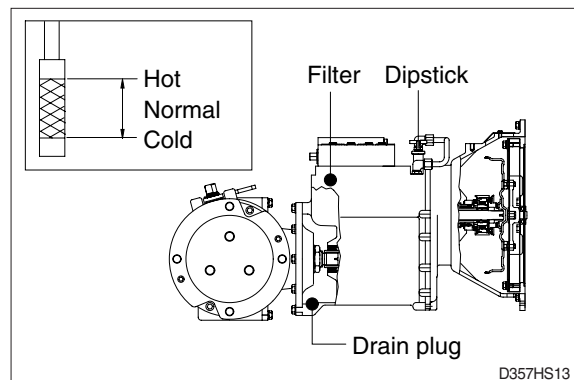
- (3) Check that clearance between tilt cylinder bushing and mounting pin is within standard range.

	mm (in)
Standard	Under 0.6 (0.02)



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)



3) CONTROL VALVE

- (1) Raise forks to maximum height and measure oil pressure.
Check that oil pressure is 210kgf/cm².
(2990psi)

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 CD 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 CD engine oil. • Clean filter.

Problem	Cause	Remedy
Actuator(cylinder or motor) works slowly or does not operate.	• Shortage of oil in oil tank. • Decrease of relief valve pressure. • Spool got stuck. • Shortage of oil flow to the valve.	• Check the oil level in the oil tank. • Install pressure gauge on the circuit, and check the pressure with it by handling the lever. • Check that manual lever moves smoothly. • Check that lever stroke is enough. • Check that oil flow of the pump is within specified rate.
Cylinder lowers considerably under normal circumstance.	• Internal leakage of cylinder happens frequently. • Excessive leakage from spool of the valve. • Spool got stuck. • Leakage in a part of the circuit.	• Fit the stop valve on the pipe between valve and cylinder, observe the internal leakage of cylinder. • Check the oil viscosity is not too low. • Check that manual lever moves smoothly. • Check the circuit. • Observe leakage from pipes.
Pressure does not increase sufficiently.	• Defect of relief valve. • Leakage in a part of the circuit.	• Check the relief valve. • Check the circuit. • Observe leakage from pipes.
Temperature rising of the hydraulic oil.	• Working with higher pressure than rated pressure. • Low viscosity of oil. • Leakage from a part of the circuit. • Oil leakage in the pump. • Insufficient suction of the pump.	• Check the flow pressure. • Check the sort of oil and viscosity. • Check if the circuit is relieved at all times. • Check if the temperature of pump surface higher 30°C than oil temperature. • Check the oil tank volume. • Check if the suction strainer is blocked.
Steering force is heavy.	• Defect of steering relief valve.	• Check the steering relief valve.

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. • Poppet C sticking in D.	• Replace the relief valve. • Clean and remove surface marks for free movement.
Pressure setting not correct	• Normal wear. Lock nut & adjust screw loose.	• See *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.

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

Then, follow these steps:

- Loosen lock nut.
- Set adjusting nut to desired pressure setting.
- If desired pressure setting cannot be achieved, add or remove shims as required.
- Tighten lock nut.
- Retest in similar manner as above.

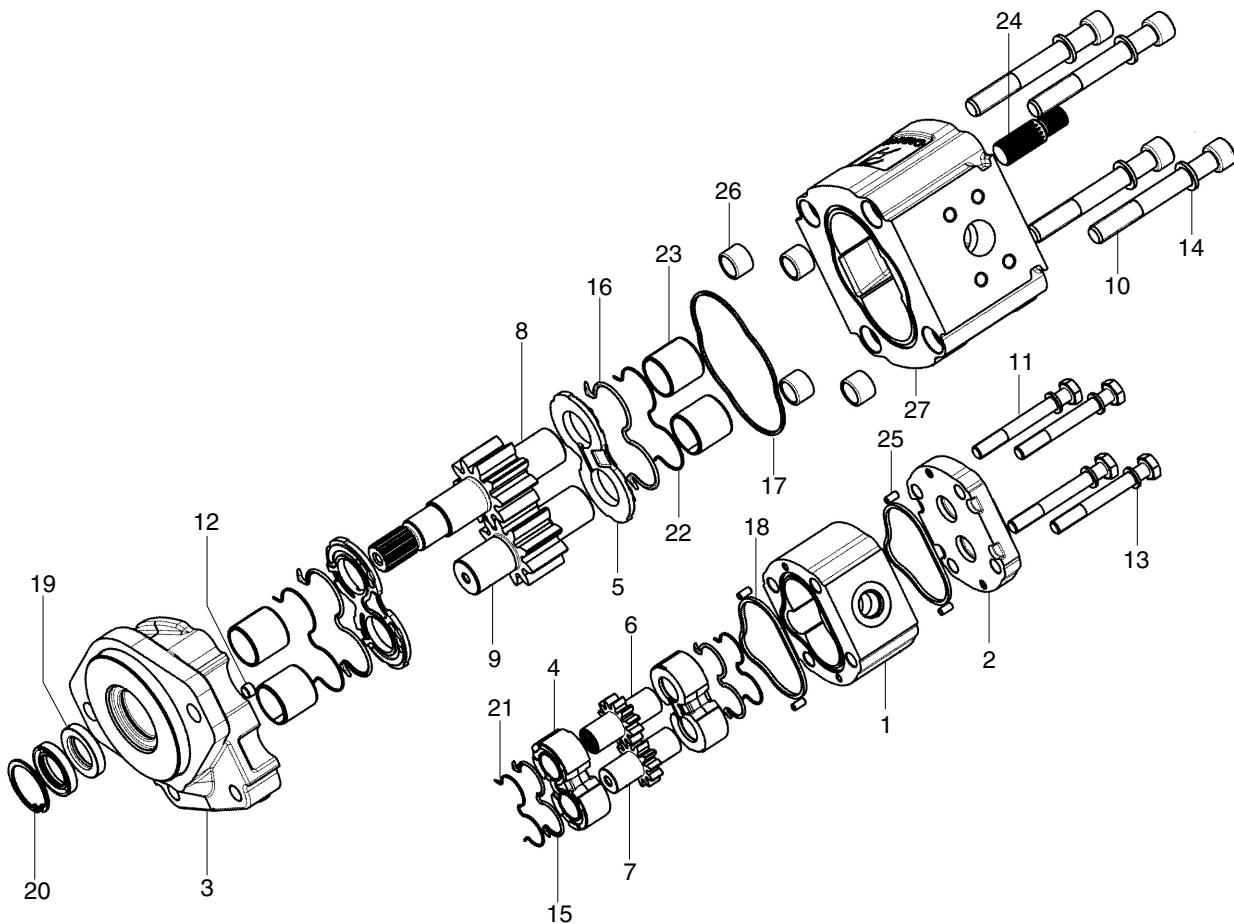
4) LIFT CYLINDER

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 surface 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. MAIN PUMP

1) STRUCTURE



35DS7HS06

- 1 Body
- 2 Rear cover
- 3 Front cover
- 4 Thrust plate
- 5 Thrust plate
- 6 Drive gear
- 7 Driven gear
- 8 Drive shaft
- 9 Driven gear

- 10 Screw
- 11 Screw
- 12 Grub screw
- 13 Washer
- 14 Washer
- 15 Seal
- 16 Seal
- 17 Seal
- 18 Seal

- 19 Shaft seal
- 20 Ring
- 21 Back up ring
- 22 Antiextrusion
- 23 Sleeve bearing
- 24 Hub
- 25 Dowel pin
- 26 Steel bushing
- 27 Body

2) GENERAL INSTRUCTION

(1) Cleanliness

- ① Cleanliness is the primary means of assuring satisfactory hydraulic pump life.

Components such as flanges and covers are best cleaned in soap and hot water, then air dried.

Gears should be washed in solvent, air dried, and oiled immediately.

▲ Certain cleaning solvents are flammable. Do not allow sources of ignition in the area when using cleaning solvents.

- ② Protect all exposed surfaces and open cavities from damage and foreign material.

※ Gear journals and gear faces are super finished. Take care not to touch these surfaces after oil and solvent.

(2) Lubrication of moving parts

During assembly, all running surfaces(Bearing and wear plate) must be lightly lubricated with a clean oil or aerosol lubricant.

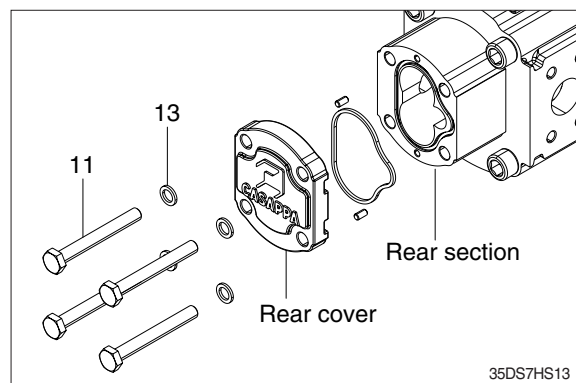
(3) Tools required for assembly

- ① Socket set(1/2" drive)
- ② Internal snap ring pliers
- ③ Shaft seal sleeve or clear tape
- ④ Torque wrench(200lbf · ft capacity)
- ⑤ Plastic hammer
- ⑥ Torque wrench box end adapters

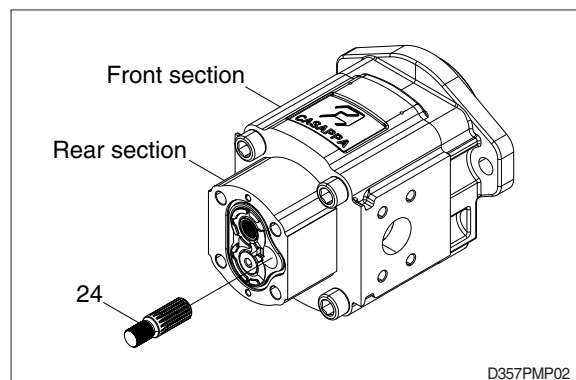
3) DISASSEMBLY

(1) Rear section

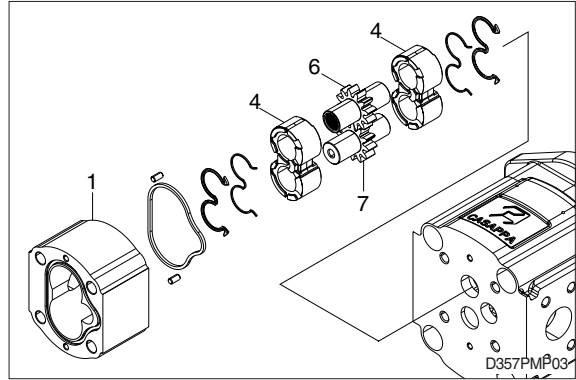
- ① Loosen and remove the screw(11) of second pump.



- ② Remove hub(24) and ease the drive gear up to facilitate removal the thrust plate.

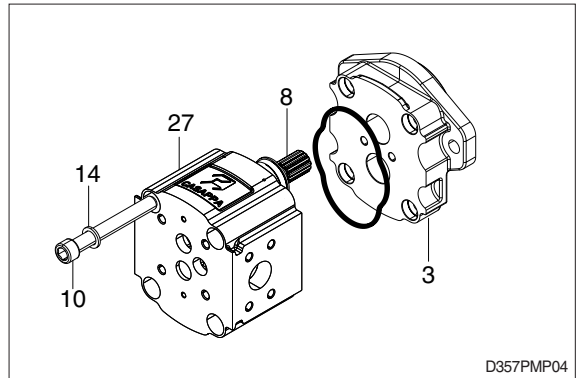


- ③ And remove drive gear(6), driven gear(7), thrust plate(4), keeping gears as straight as possible, and body(1) also.

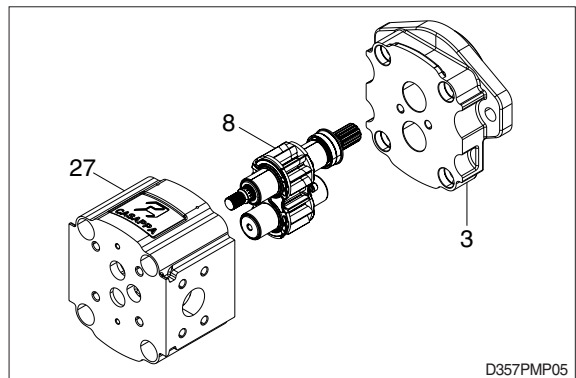


(1) Front section

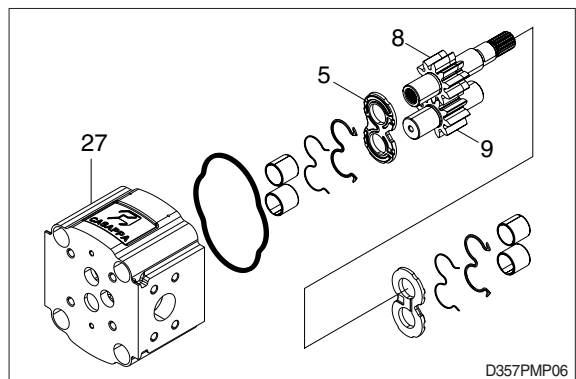
- ① Loosen and remove the screw(10) from the body(27).
- ※ Coat the sharp edges of the drive shaft (8) with adhesive tape and smear a clean grease on the shaft end extension to avoid any damaging lip of the shaft seal when removing the cover(3).



- ② Remove the cover(3) taking care to keep the cover as straight as possible during removal. If cover is stuck, tap around the edge with rubber mallet in order to break away from the body(27).
- ※ Ensure that while removing cover(3) shaft and other components remain position.

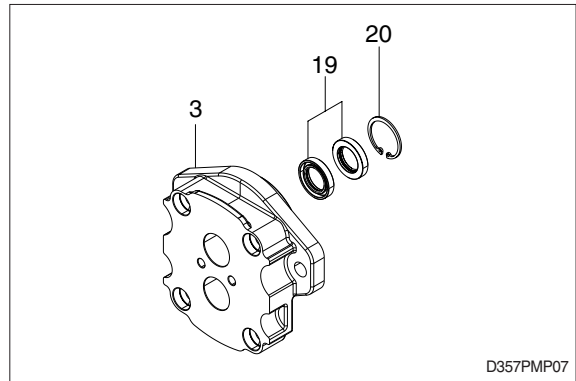


- ③ Ease the drive gear(8) up to facilitate removal the thrust plate(5).
- ④ Remove drive gear(8), driven gear(9), thrust plate(5), keeping gears as straight as possible, and body(27) also.



(3) Cover assembly

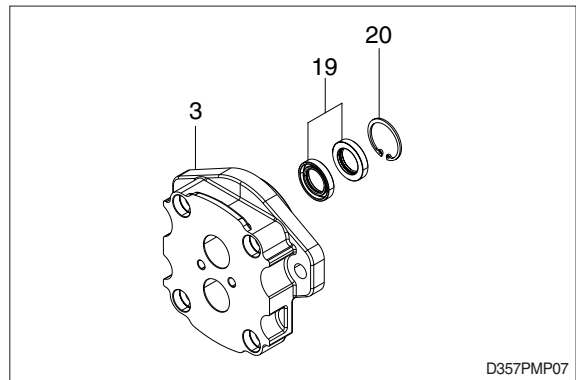
- ① Remove snap ring(20) with proper tool(Only when it is needed to replace shaft seal).
- ② Remove the shaft seal(19) taking care not to give any damage on the surface of shaft hole(Only when it is needed to replace shaft seal).



4) REASSEMBLY

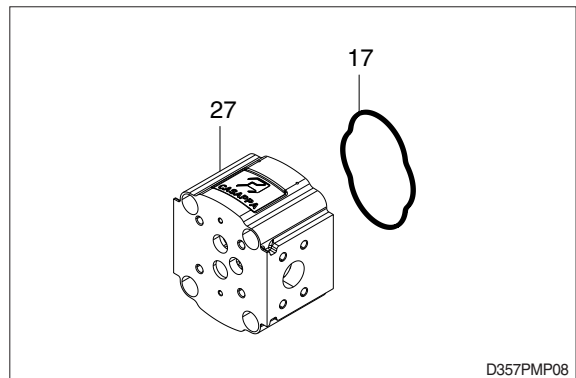
(1) Cover assembly

- ① Insert the shaft seal(19) carefully and fit it inside of cover with proper tool.
- ② Fit the snap ring(20) in pre-arranged position with proper tool.

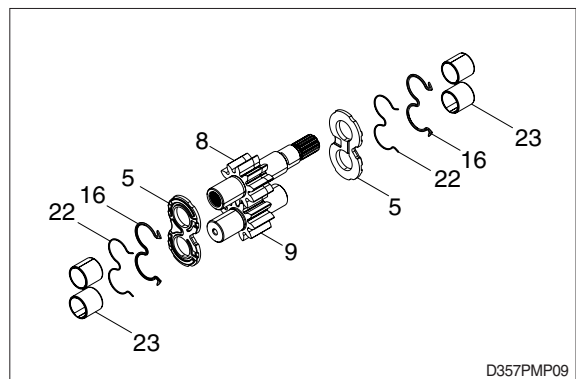


(2) Front section

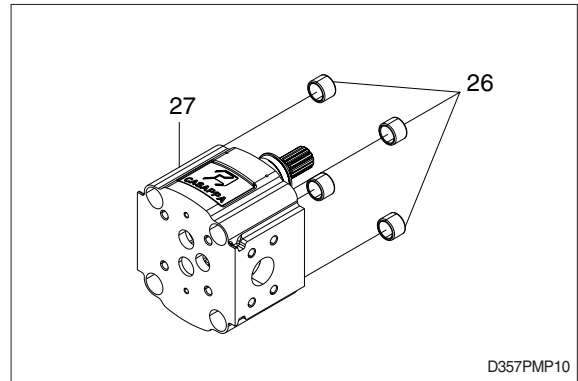
- ① Fit the seal(17) on the pre-arranged groove of the body(27).
- ※ Smear clean grease on the parker ring to avoid drifting away of parker ring from the body.



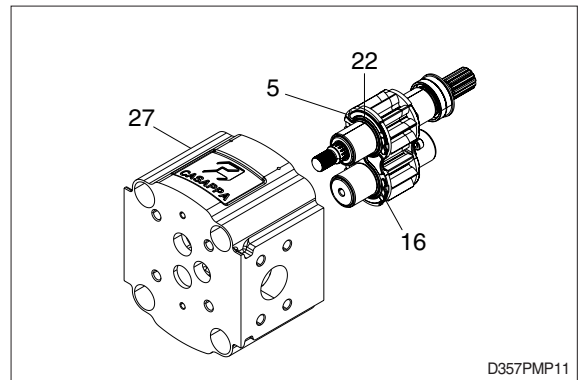
- ② Locate the seals(16) on the groove pre-arranged on the thrust plate(5). Then, locate antiextrusion(22) on the groove pre-arranged on the seals(16). Smear clean grease on the seals(16, 22). (The front and rear thrust plates and seals and back-up rings are same).



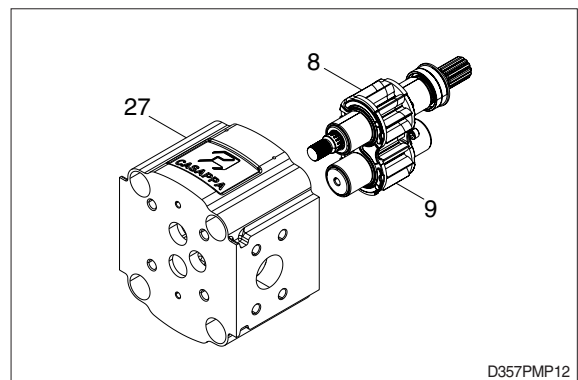
- ③ Insert the steel bushing(26) into body(27).



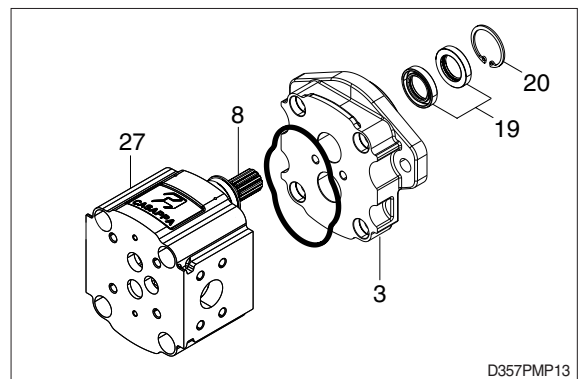
- ④ Insert the complete pressure plate (5+16+22) into body(27) while keeping the plate straight.
- ※ Seal side should face to the rear side, opposite side of gears.
 - ※ Pay attention to the direction of seal. (opened side should face suction side always)



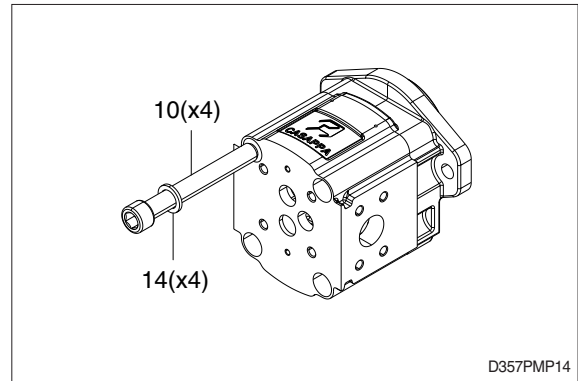
- ⑤ Locate driving gear(8) and driven gear(9) while keeping the gears straight.
- ※ Locate pressure plate(5+16+22) with care for the direction.



- ⑥ Locate complete cover(3+19+20) while taking care not to give any damage on the shaft seal by edge of shaft.
- And tap around the cover(3) with rubber mallet.

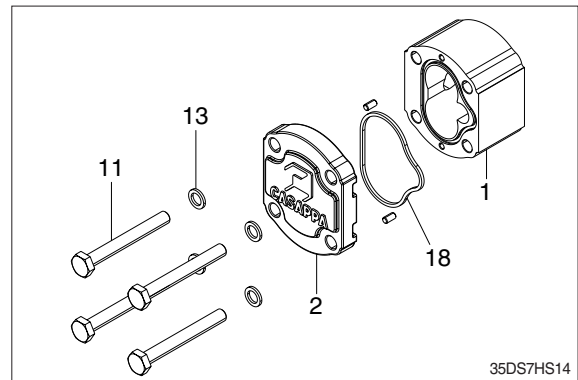


- ⑦ Tighten the bolts(10) with washer(14) in a crisscross pattern to torque value of 14.3kgf · m(103lbf · ft).



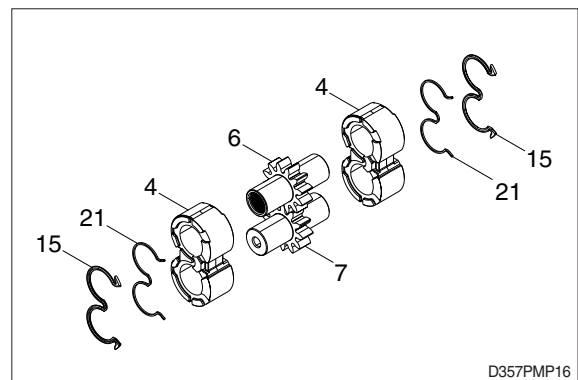
(3) Rear section

- ① Smear clean grease on the seal(18) to avoid drifting away of seal from the body(1) and assemble temporarily rear cover(2).



- ② Locate the seals(15) on the groove pre-arranged on the thrust plates(4). Then, locate back-up ring(21) on the groove pre-arranged on the seals(15).

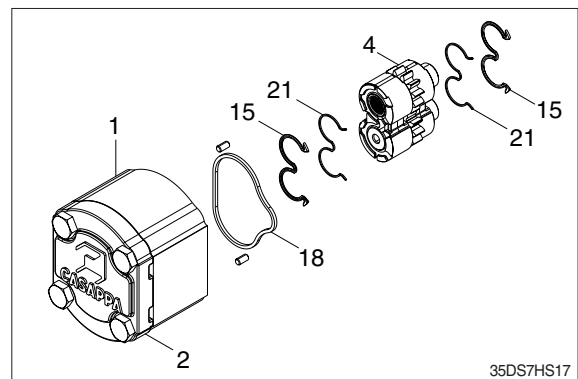
※ Smear clean grease on the seals (21+15).
(The front and rear thrust plates and seals and back-up rings are same)



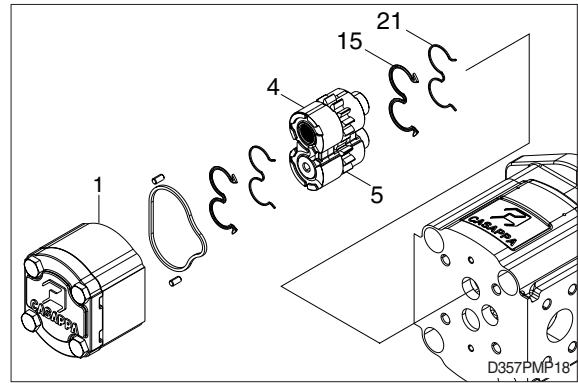
- ③ Insert the complete pressure plate (4+21+15) into body while keeping the plate straight.

※ Seal side should face to the rear cover (2), opposite side of gears.

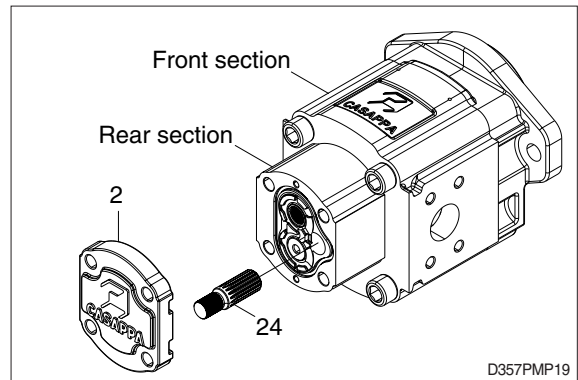
※ Pay attention to the direction of seal. (opened side should face suction side always)



- ④ Locate driving gear(4) and driven gear(5) while keeping the gears straight. Locate pressure plate(4+21+15) with care for the direction.

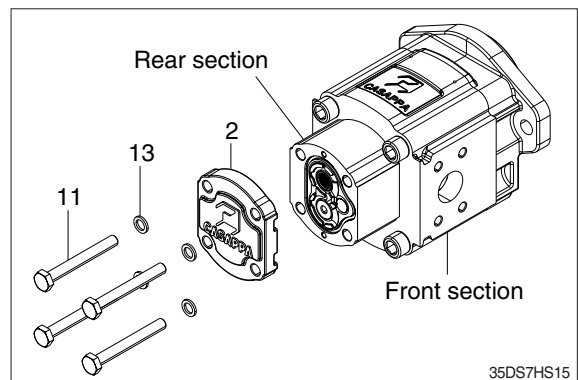


- ⑤ Open rear cover(2) to locate hub(24) into rear section.



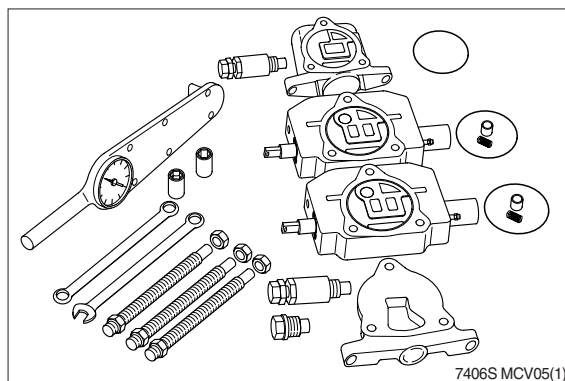
- ⑥ Tighten the bolts(11) with washer(13) in a crisscross pattern to torque value of 4.6kgf · m(33.3lbf · ft).

※ Check that the pump rotate freely when the drive shaft is turned by hand. If not a thrust plate seal may be pinched.

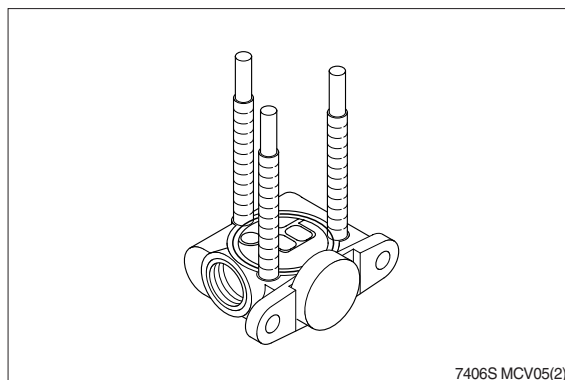


2. MAIN CONTROL VALVE

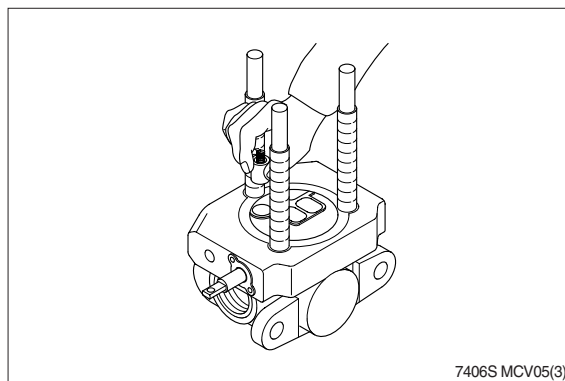
- 1) Lay out valve components on a clean, flat working surface. The inlet assembly will include an O-ring, and the spool section(s) include an O-ring, a load check poppet and a load check spring. Tools required for basic valve assembly include 3/4 and 11/16 open or box end wrenches and a torque wrench with thin wall sockets.



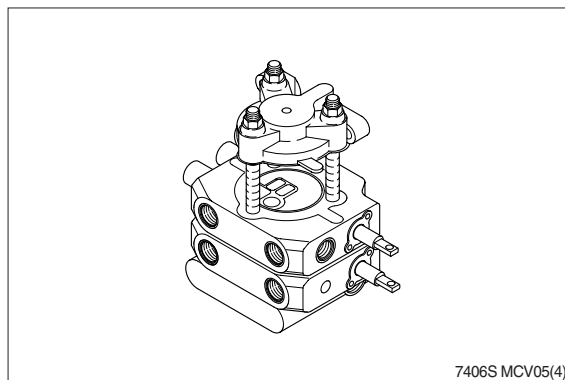
- 2) Assemble tie rod nuts to one end of each tie rod with one or two threads showing. Insert tie rods through tie rod holes of inlet (Large tie rod at top). Lay inlet on end with tie rods up, place O-ring into position.



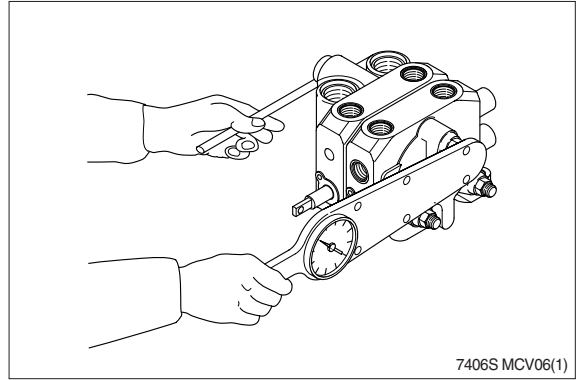
- 3) Place first spool section(O-ring side up) on inlet section, position O-ring and insert load check poppet(Nose down) and spring (Behind poppet) into load check cavity as shown. Repeat this procedure for each spool section ; The load check springs are compressed by the following sections during assembly.



- 4) Position end section on last spool section as shown and hand tighten tie rod nuts. The end section on picture is a "turn around" section without ports. Universal outlet /power beyond section and power beyond and closed center sections are also used as end sections. These end sections do not have O-ring grooves.



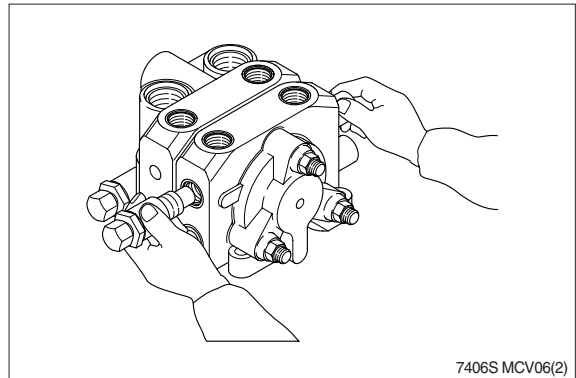
- 5) Position valve assembly with the mounting pads of the end sections on a flat surface. To obtain proper alignment of end sections relative to the spool sections apply downward pressure to the end sections ; Snug tie rod nuts to about $10\text{ lbf} \cdot \text{ft}$. Final torque the two $11/16$ nuts to $48 \pm 5\text{ lbf} \cdot \text{ft}$; Final torque the $3/4$ nut to $74 \pm 8\text{ lbf} \cdot \text{ft}$. Check for proper spool movement.



- 6) Install auxiliary valves and plugs and torque to proper specifications.

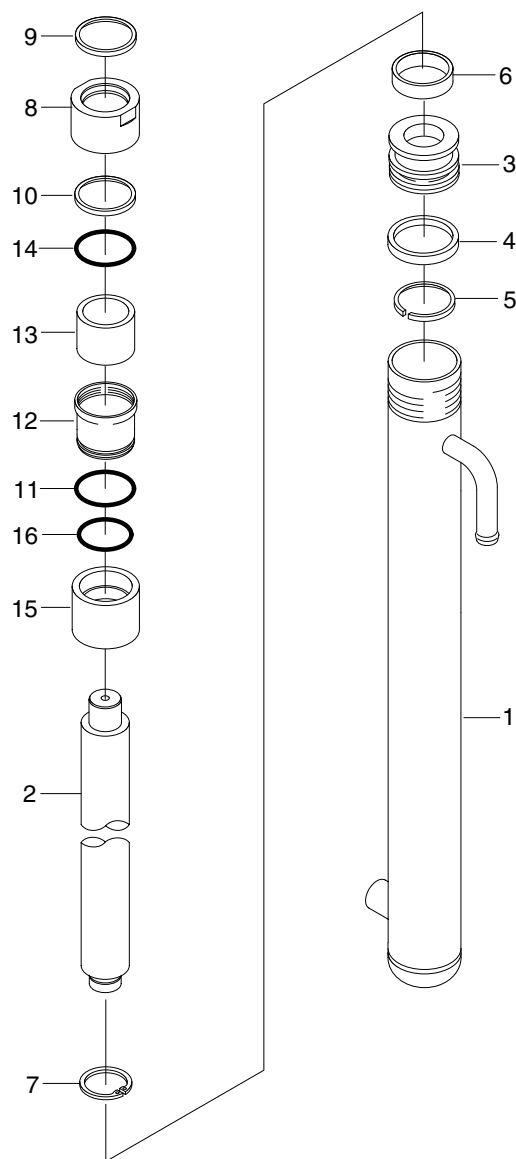
※ **General assembly notes:**

- A. Lever assemblies can be installed on section before or after complete valve assembly.
- B. The load check and spring may be omitted from assembly in certain circuit conditions(i.e., motor spools).



4. LIFT CYLINDER

1) STRUCTURE



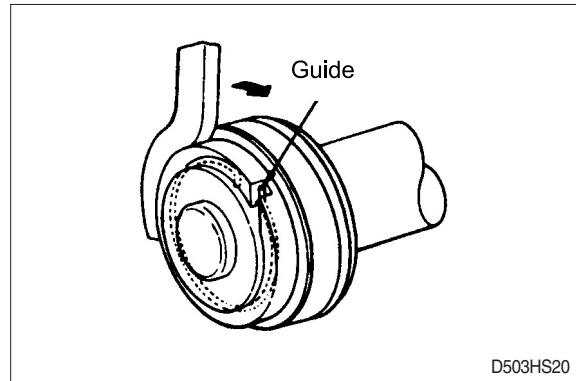
- I.D × O.D × stroke(standard)
73 × 65 × 1335mm
(2.9 × 2.6 × 52.6in)
- Rod O.D : 50mm(2.0in)

D357HS19

- | | | | |
|---|----------------|----|------------|
| 1 | Tube assy | 9 | Dust wiper |
| 2 | Rod | 10 | Rod seal |
| 3 | Piston | 11 | O-ring |
| 4 | Piston seal | 12 | Guide |
| 5 | Back up ring | 13 | DU busing |
| 6 | Wear ring | 14 | O-ring |
| 7 | Retaining ring | 15 | Spacer |
| 8 | Gland | 16 | 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.



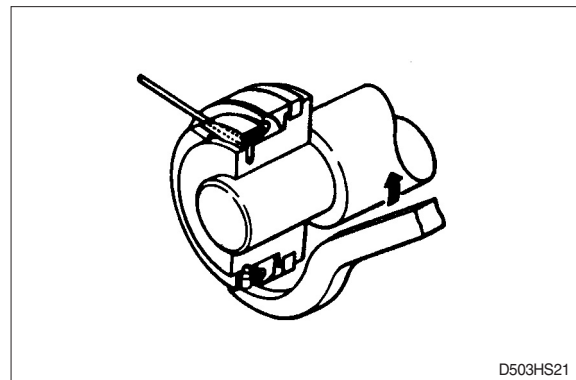
2) CHECK AND INSPECTION

mm(in)

Check item	Standard size	Repair limit	Remedy
Clearance between cylinder rod & bushing	0.05~0.25 (0.002~0.01)	0.4 (0.0015)	Replace bushing
Clearance between piston ring & tube	0.05~0.35 (0.002~0.013)	0.5 (0.02)	Replace piston ring

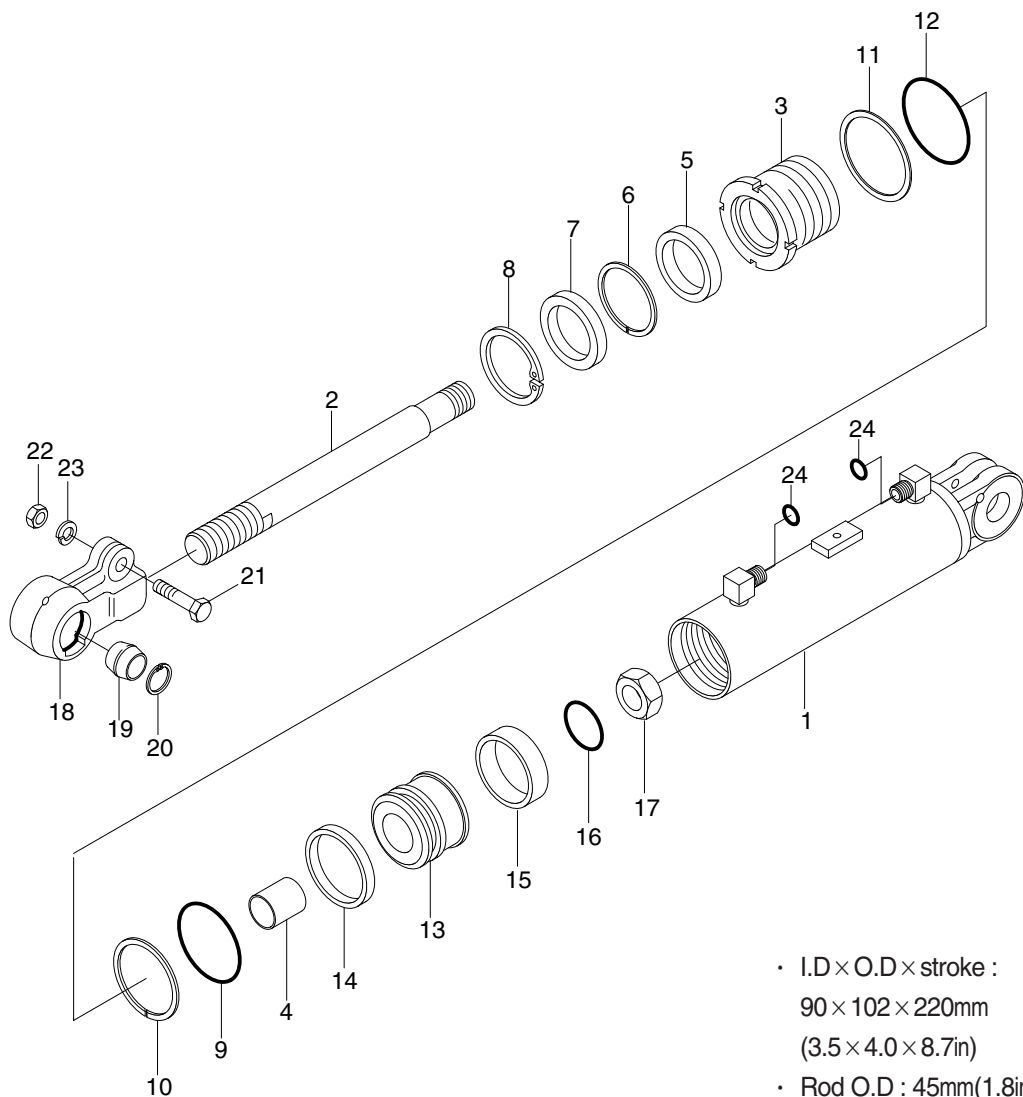
3) ASSEMBLY

- (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.



5. TILT CYLINDER

1) STRUCTURE



- I.D × O.D × stroke :
90 × 102 × 220mm
(3.5 × 4.0 × 8.7in)
- Rod O.D : 45mm(1.8in)

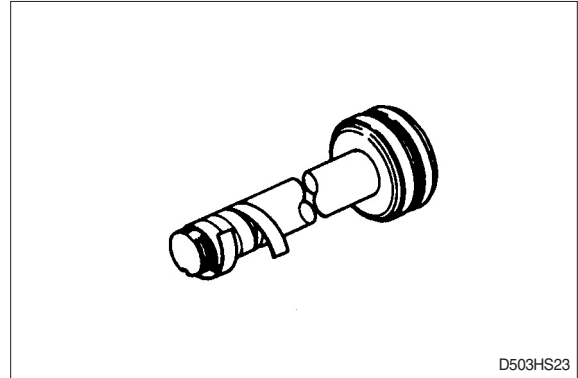
35DS7HS16

- | | | |
|----------------|-----------------|----------------------|
| 1 Tube assy | 9 O-ring | 17 Nylon nut |
| 2 Rod | 10 Back up ring | 18 Rod eye |
| 3 Gland | 11 Lock washer | 19 Spherical bearing |
| 4 DU bushing | 12 O-ring | 20 Retaining ring |
| 5 Rod seal | 13 Piston | 21 Hexagon bolt |
| 6 Back up ring | 14 Glyd ring | 22 Hexagon nut |
| 7 Dust wiper | 15 Wear ring | 23 Spring washer |
| 8 Snap ring | 16 O-ring | 24 O-ring |

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.



3) CHECK AND INSPECTION

mm(in)

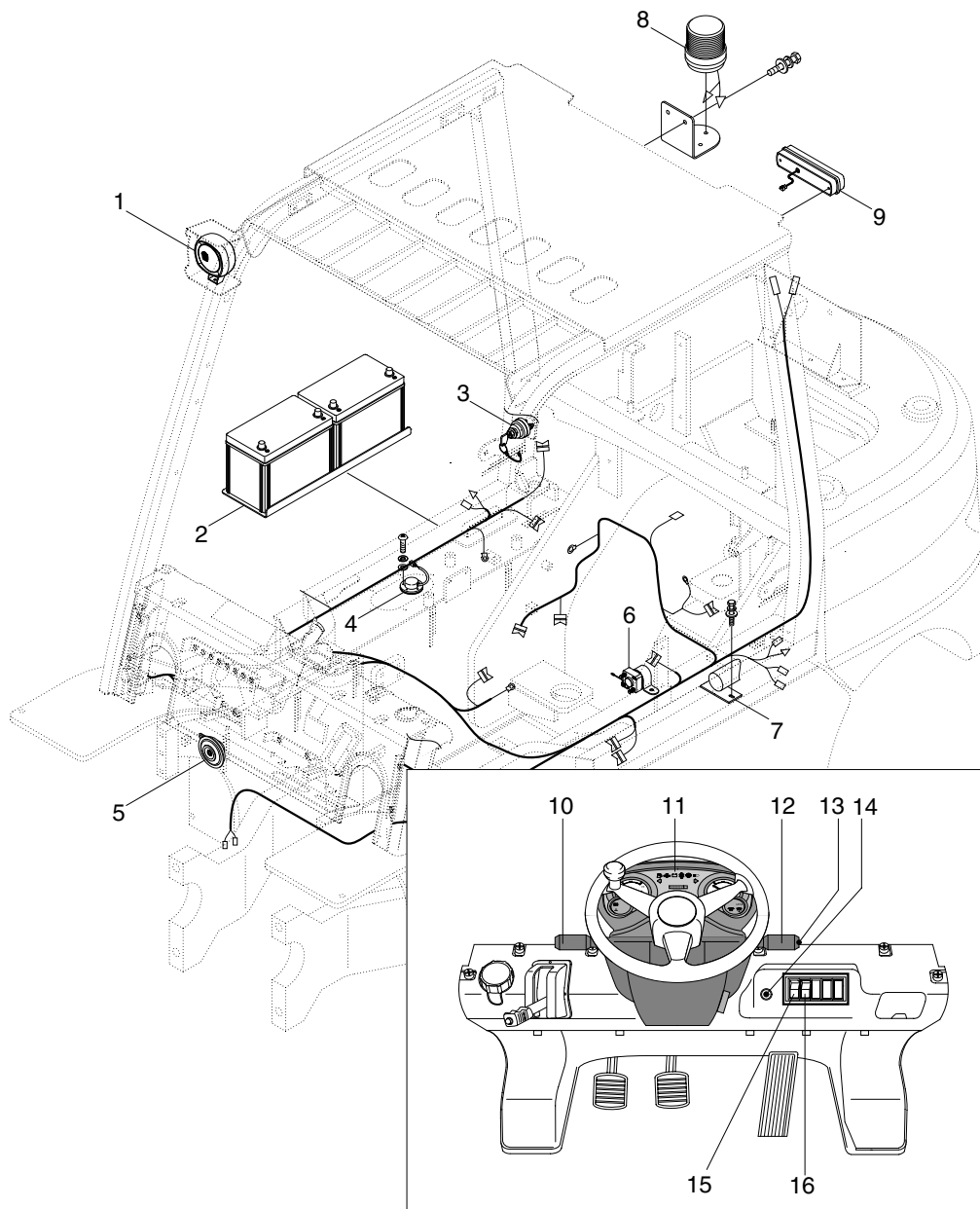
Check item	Standard size	Repair limit	Remedy
Clearance between cylinder rod & bushing	0.072~0.288 (0.003~0.011)	0.5 (0.020)	Replace bushing
Clearance between rod head bushing & pin	0.10~0.35 (0.004~0.014)	0.6 (0.024)	Replace bushing

SECTION 7 ELECTRICAL SYSTEM

Group 1	Component location	7-1
Group 2	Electrical circuit	7-2
Group 3	Component specification	7-12
Group 4	Connector destination	7-13
Group 5	Troubleshooting	7-15

SECTION 7 ELECTRICAL SYSTEM

GROUP 1 COMPONENT LOCATION



35DS7EL01

- | | | | | | |
|---|---------------|----|-----------------------|----|-------------------------|
| 1 | Work lamp | 8 | Beacon lamp | 13 | Horn button |
| 2 | Battery | 9 | Combination lamp | 14 | Start switch |
| 3 | Master switch | 10 | Forward-reverse lever | 15 | Work lamp switch(opt) |
| 4 | Fuel sender | 11 | Operating panel | 16 | Hazard lamp switch(opt) |
| 5 | High horn | 12 | Head lamp switch | | |
| 6 | Glow relay | | Illumination lamp | | |
| 7 | Back buzzer | | Turn signal switch | | |



MEMORANDUM

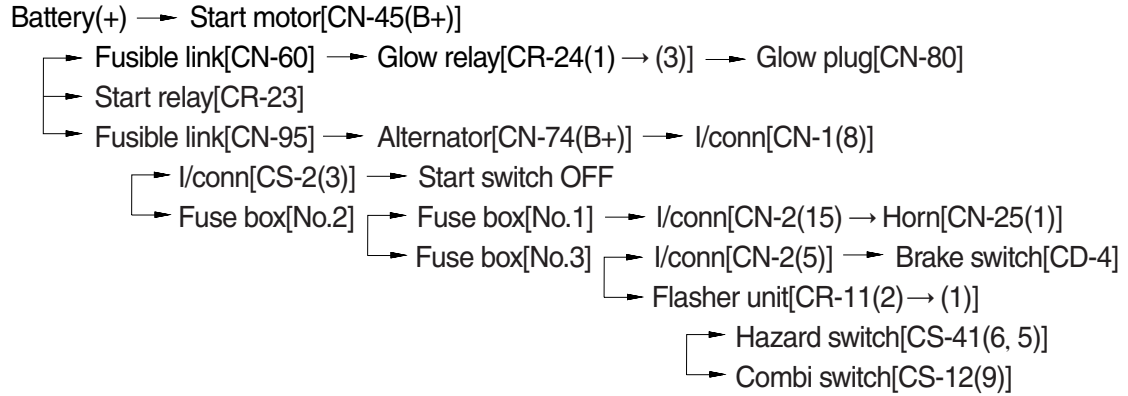


1. POWER CIRCUIT

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

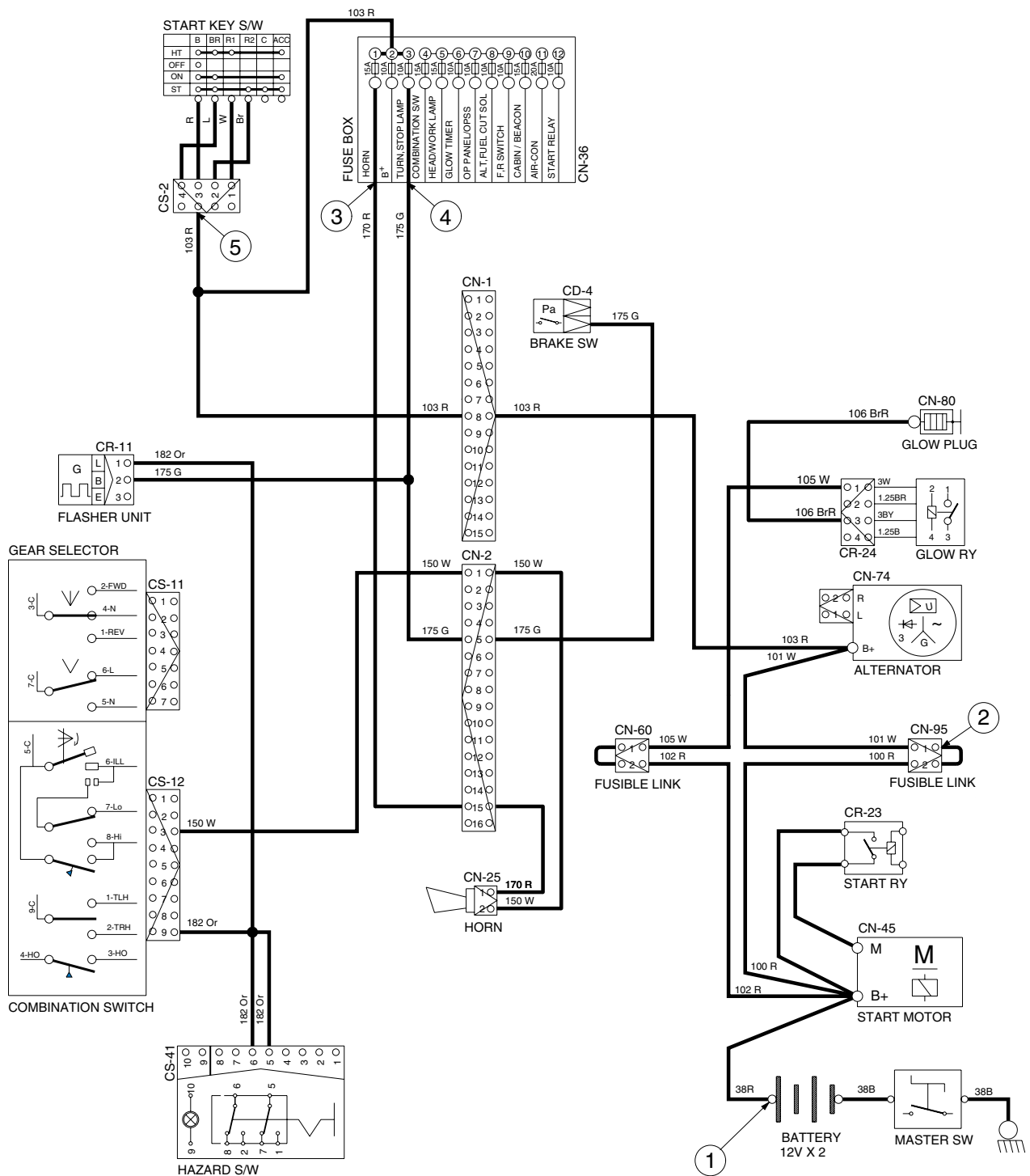


2) CHECK POINT

Engine	Key switch	Check point	Voltage
OFF	OFF	① - GND (Battery(+)) ② - GND (Fusible link) ③ - GND (Fuse No.1) ④ - GND (Fuse No.3) ⑤ - GND (Start key)	24V

※ GND : Ground

POWER CIRCUIT



35DS7EL03

2. STARTING CIRCUIT

1) OPERATING FLOW

Battery(+) terminal → Start motor[CN-45(B+)] → Fusible link[CN-95] → Start switch[CS-2(3)]
 ↳ Start relay[CR-23]

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

(1) When start key switch is in ON position

Start switch ON [CS-2(4)] → Fuse box[No.6 →4] → Combi switch[CS-12(5)]

(2) When start key switch is START position

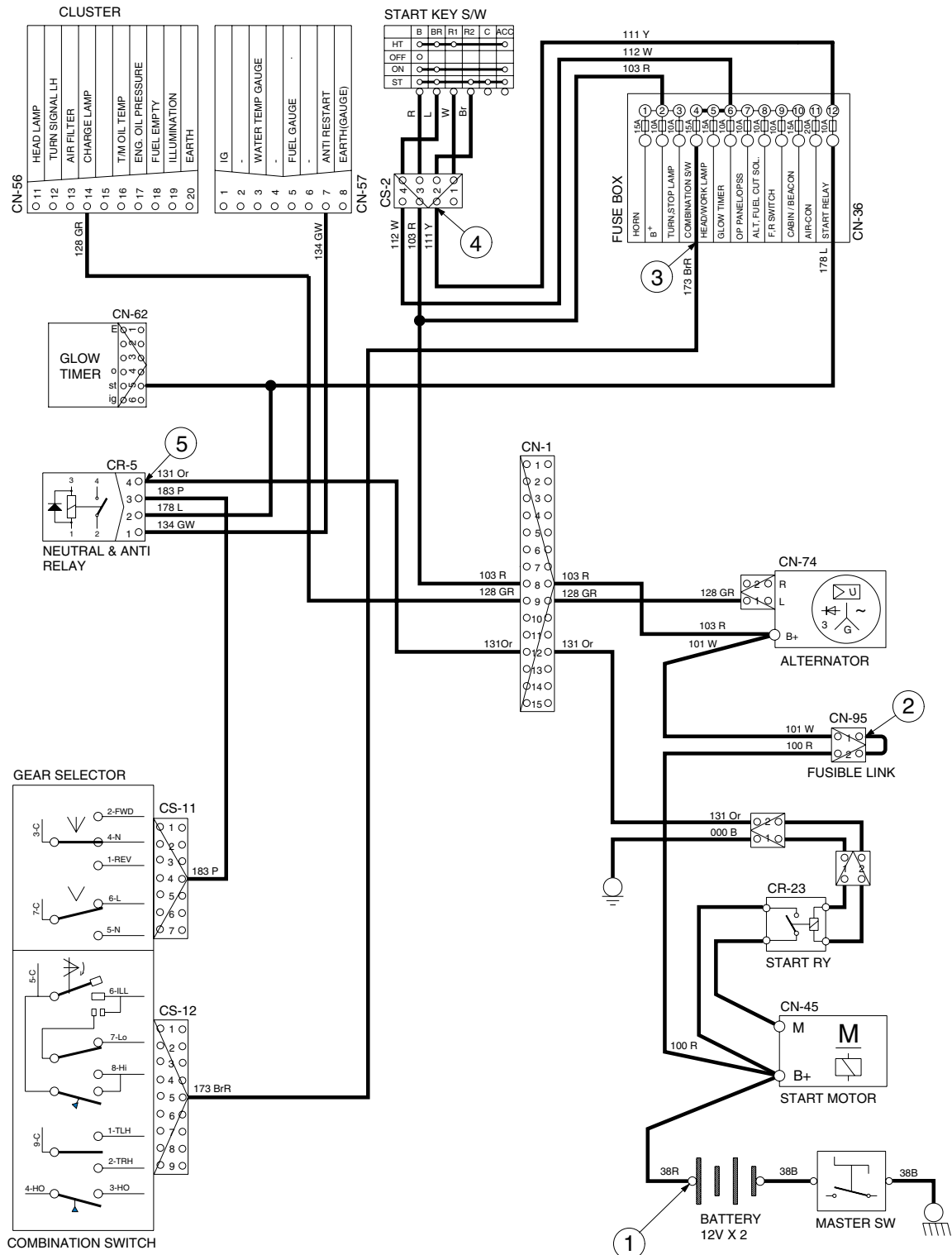
Start switch START[CS-2(2)] → Fuse box[No. 12] → Neutral & anti restart relay[CR-5(2) → (4)]
→ I/conn[CN-1(12)] → Start relay[CR-23]

2) CHECK POINT

Engine	Key switch	Check point	Voltage
Running	ON	① - GND (Battery B+) ② - GND (Fusible link) ③ - GND (Fuse box No.4, 11) ④ - GND (Start key) ⑤ - GND (Anti restart relay)	24V

※ GND : Ground

STARTING CIRCUIT



35DS7EL04

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-60) and the fuse box.

1) OPERATING FLOW

(1) Warning flow

Alternator[CN-74(L)] → I/conn[CN-1(9)] → Cluster charging warning lamp ON [CN-56(14)]

(2) Charging flow

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

2) CHECK POINT

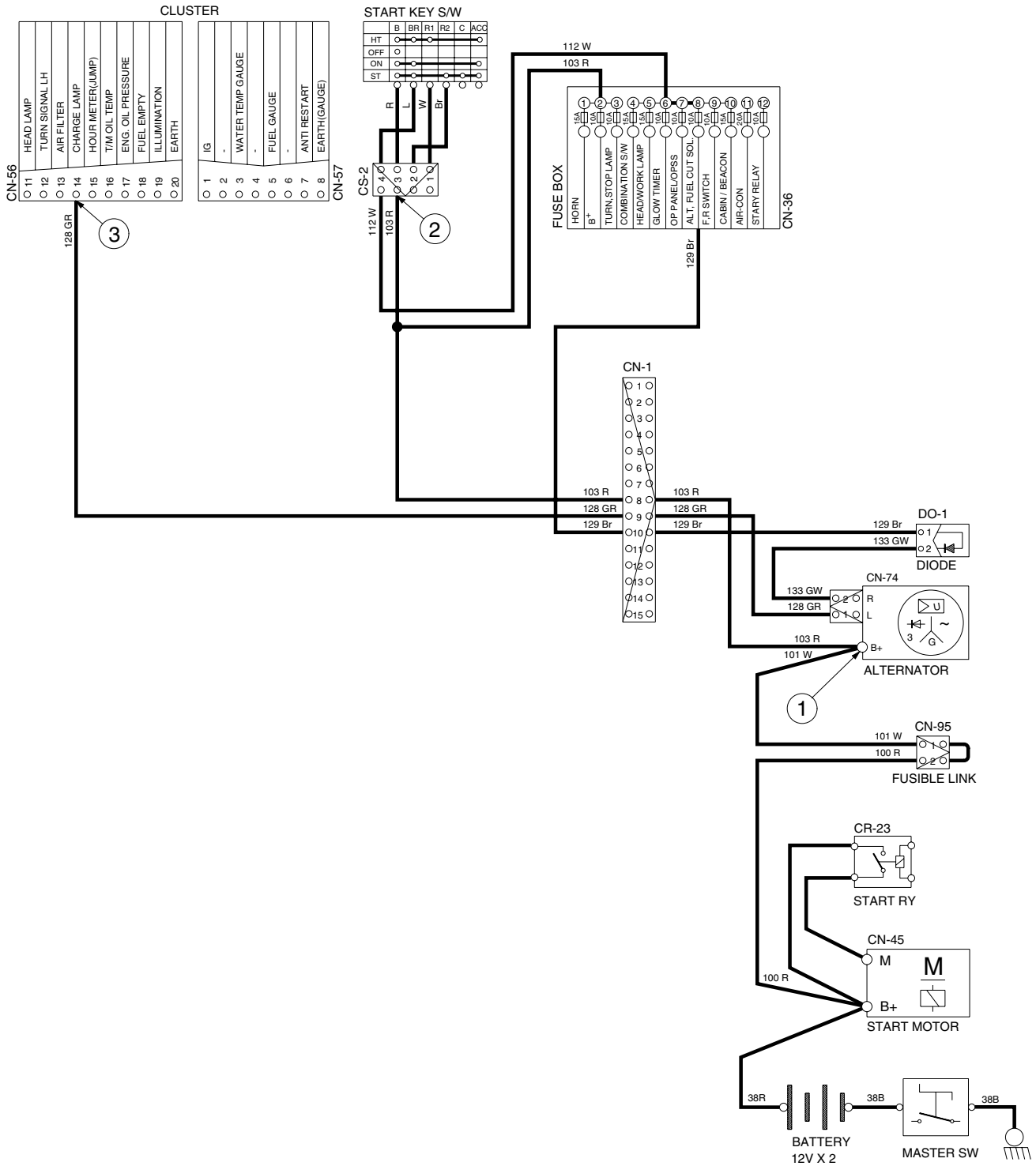
Engine	Key switch	Check point	Voltage
ON	ON	① - GND (Alternator B+) ② - GND (Start switch) ③ - GND (Cluster)	24V

※ 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



35DS7EL05

4. PREHEATING CIRCUIT

Combustion chamber glow plugs are used in order to give satisfactory starting of low ambient temperatures.

1) OPERATING FLOW

Battery(+) terminal
 → Fusible link[CN-95] → I/conn[CS-2(3)] → Start switch(B)
 → Fusible link[CN-60] → Glow relay[CR-24(1)]

※ When you turn the start switch to the ON position, the glow relay makes the glow plugs operated and the glow lamp of the cluster turned ON.

Start switch ON [CS-2(4)] → Fuse box [NO.6]

- Glow timer [CN-62(6)]
- Glow aux relay [CR-45(2) → (4)]
 - I/conn [CN-2(11)] → Glow relay ON [CR-24(2)]
→ Glow plug operating [CN-80]
 - Cluster [CN-56(2)] → Glow lamp ON

2) CHECK POINT

Engine	Key switch	Check point	Voltage
Stop	HEAT	① - GND (Battery B+) ② - GND (Fusible link) ③ - GND (Glow plug) ④ - GND (Glow relay) ⑤ - GND (Start switch) ⑥ - GND (Glow lamp)	24V

GROUP 3 COMPONENT SPECIFICATION

No	Part name	Qty	Specification														
1	Battery	2	12V × 96AH × 2EA RC : 130min CCA : 630A														
2	Working lamp	1	24V, 70W														
3	License lamp	1	24V, 3W × 2														
4	Rear Combination lamp	2	24V, 25/10W (Stop/Tail) 24V, 21W (Turn) 24V, 10W (Back Up)														
5	Head lamp	2	24V, 70W														
6	Flasher lamp	2	24V, 25/10W														
7	Glow relay	1	24V, 300A														
8	Relay (4P)	3	24V, 20A														
9	Relay (5P)	3	24V, 6A														
10	Flasher Unit	1	85 ± 10CM, (21W + 21W) × 2 + 3W × 2														
11	Back buzzer	1	24V, 90 ± 5dB, 60 ± 10C/M														
13	Horn	1	24V, MAX 1.5A, 100 ~ 115 dB														
14	Fuel level sender	1	<table border="1"> <tr> <td>Float indicator</td><td>E</td><td>1/2</td><td>F</td></tr> <tr> <td>Resistance(Ω)</td><td>105</td><td>32.5</td><td>5</td></tr> <tr> <td rowspan="2">Tolerance(Ω)</td><td>+0</td><td rowspan="2">±2.5</td><td>+0.5</td></tr> <tr> <td>-5</td><td>-0</td></tr> </table>	Float indicator	E	1/2	F	Resistance(Ω)	105	32.5	5	Tolerance(Ω)	+0	±2.5	+0.5	-5	-0
Float indicator	E	1/2	F														
Resistance(Ω)	105	32.5	5														
Tolerance(Ω)	+0	±2.5	+0.5														
	-5		-0														
15	Master switch	1	24V, 180A														
16	Combination switch	1	Direction 4.5A, Tail 5A Head 6A, Horn 4A														
17	Brake switch	1	24V, 50W														
18	Working lamp switch	1	24V, 8A														
19	Hazard switch	1	24V, 8A														
20	Start switch	1	24V, 30A														

GROUP 4 CONNECTOR DESTINATION

Connector number	Type	No. of pin	Destination	Connector part No.	
				Female	Male
CN-1	AMP	15	l/conn(Frame harness-dashboard harness)	2-85262-1	368301-1
CN-2	AMP	16	l/conn(Dashboard harness-frame harness)	368047-1	368050-1
CN-4	KET	4	LH support harness	S810-004201	-
CN-5	KET	4	RH support harness	S810-004201	-
CN-7	AMP	6	l/conn(RR support harness-frame harness)	174262-2	174264-2
CN-8	AMP	2	l/conn(RR support harness-frame harness)	S816-002002	-
CN-11	KET	6	Travel cut	-	S810-106201
CN-17	KET	4	For cabin	-	S816-104002
CN-25	MOLEX	2	Horn	35825-0211	-
CN-36	-	-	Fuse box	21HF-10500	-
CN-45	RING TERM	2	Start motor	S820-308000	-
CN-55	KET	14	OPSS unit	S814-014100	-
CN-56	AMP	20	Cluster	368511-2	-
CN-57	AMP	8	Cluster	368540-2	-
CN-60	KET	2	Fusible link	-	21N4-01311
CN-62	AMP	6	Glow timer	S810-006202	-
CN-65	KET	2	Back buzzer	S822-014000	S822-114000
CN-74	KET	2	Alternator	MG640188-4	-
CN-79	YAZAKI	1	Fuel cut off solenoid	7211-2215	-
CN-80	RING TERM	1	Glow plug	S820-204000	-
CN-95	KET	2	Fusible link	-	21N4-01311
CN-113	KET	2	OPSS buzzer	S814-002100	-
CN-122	DEUTSCH	2	Forward solenoid 1	DT06-2S	-
CN-123	DEUTSCH	2	Reverse solenoid 1	DT06-2S	-
CN-132	DEUTSCH	2	Forward solenoid 2	DT06-2S	-
CN-133	DEUTSCH	2	Reverse solenoid 2	DT06-2S	-
Switch					-
CS-2	KET	4	Start switch	S810-004201	-
CS-11	AMP	7	Gear selector switch	S811-007002	-
CS-12	AMP	9	Combination switch	S811-009002	-
CS-17	KET	3	Parking switch	S810-003201	-
CS-21	KET	10	Work lamp switch	593757	-
CS-41	KET	10	Hazard switch	593757	-
CS-73	KET	2	Seat switch	S810-002201	-

Connector number	Type	No. of pin	Destination	Connector part No.	
				Female	Male
Lamp					
CL-15	DAEDONG	6	Combination lamp-LH	110-6PR	-
CL-16	DAEDONG	6	Combination lamp-RH	110-6PR	-
CL-21	KET	2	License lamp	S822-014000	S822-114000
Relay					
CR-5	KET	4	Neutral relay	S810-004201	-
CR-11	-	3	Flasher unit relay	S810-003702	-
CR-13	KET	4	Head lamp relay	S810-004201	-
CR-23	KET	2	Start relay	S814-002100	S814-102100
CR-24	KET	4	Glow relay	S810-004201	-
CR-45	KET	4	Glow auxiliary	S810-004201	-
CR-50	AMP	6	Travel cut relay	S810-006202	-
CR-51	AMP	6	Attach cut relay	S810-006202	-
Sensor and pressure switch					
CD-2	KET	3	Fuel sendor	S810-003201	-
CD-4	AMP	1	Brake switch	S819-010122	-
CD-8	KET	1	Water temperature sensor	S822-014000	-
CD-10	KET	1	Air cleaner switch	ST730057-2	-
CD-18	AMP	1	Engine oil pressure switch	S819-010122	-
CD-29	AMP	1	T/M temperature sensor	S819-010122	-
CD-38	-	2	Water separator	S816-102003	-

GROUP 5 TROUBLESHOOTING

Trouble symptom	Probable cause	Remedy
Lamps dimming even at maximum 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

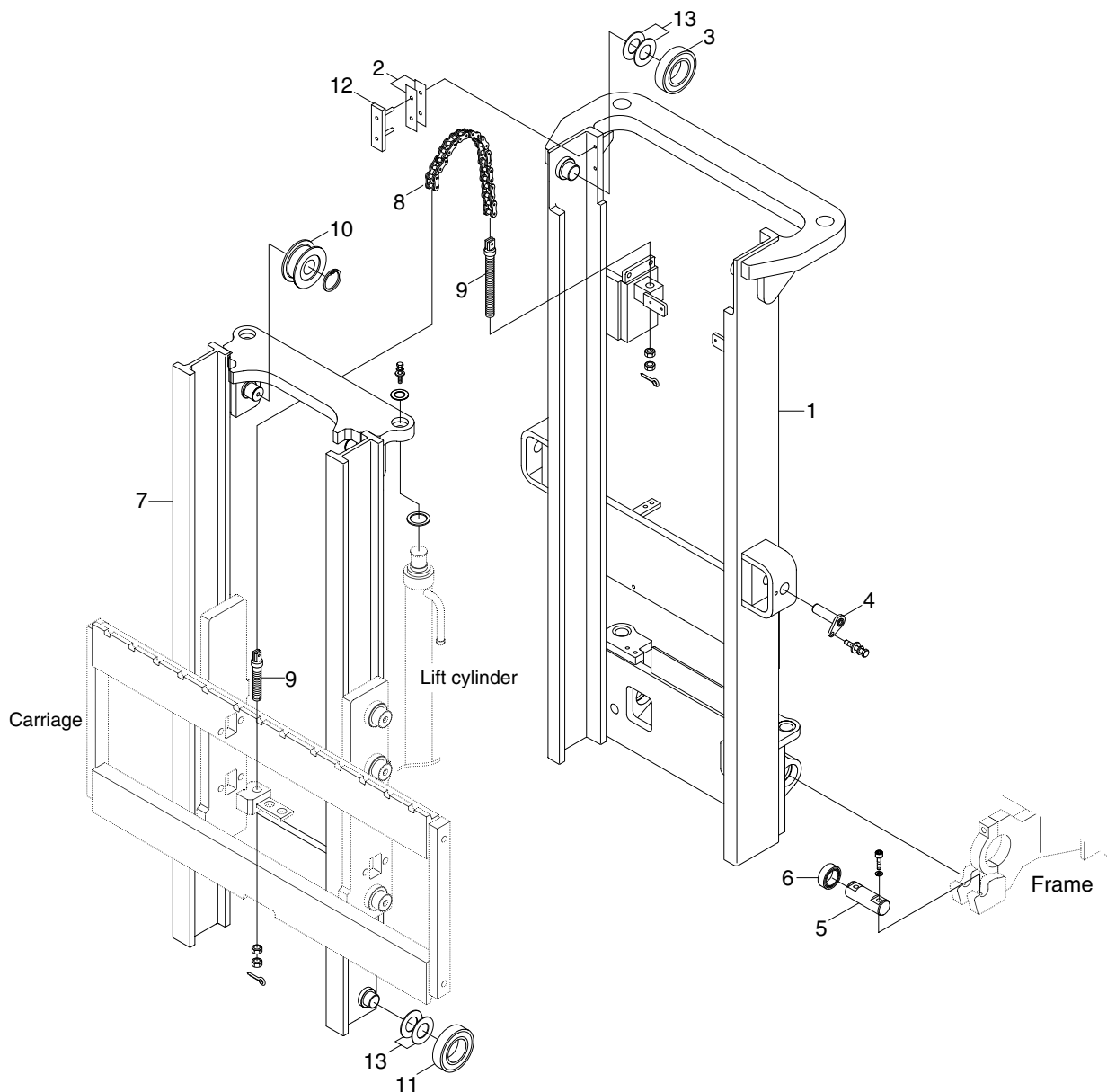
SECTION 8 MAST

Group 1 Structure	8-1
Group 2 Operational Checks and Troubleshooting	8-5
Group 3 Adjustment	8-8
Group 4 Removal and Installation	8-11

SECTION 8 MAST

GROUP 1 STRUCTURE

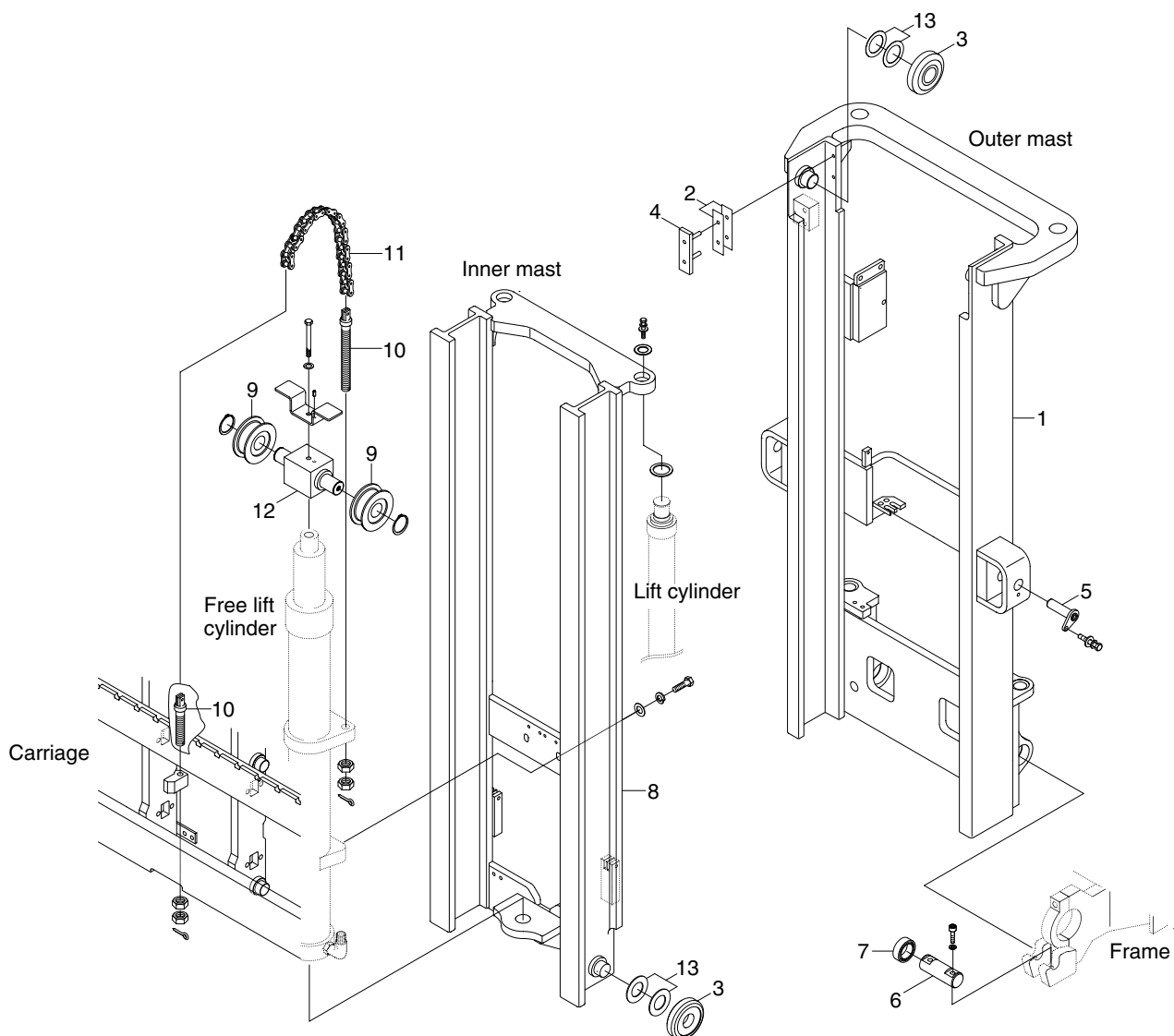
1. 2 STAGE MAST(V MAST)



35DS7MS01

- | | | | | | |
|---|-------------------|----|----------------------|----|-----------------|
| 1 | Outer mast | 6 | Bearing | 11 | Roller bearing |
| 2 | Shim(0.5, 1.0t) | 7 | Inner mast | 12 | Back up liner |
| 3 | Roller bearing | 8 | Lift chain | 13 | Shim(0.5, 1.0t) |
| 4 | Tilt cylinder pin | 9 | Anchor bolt | | |
| 5 | Mast mounting pin | 10 | Chain sheave bearing | | |

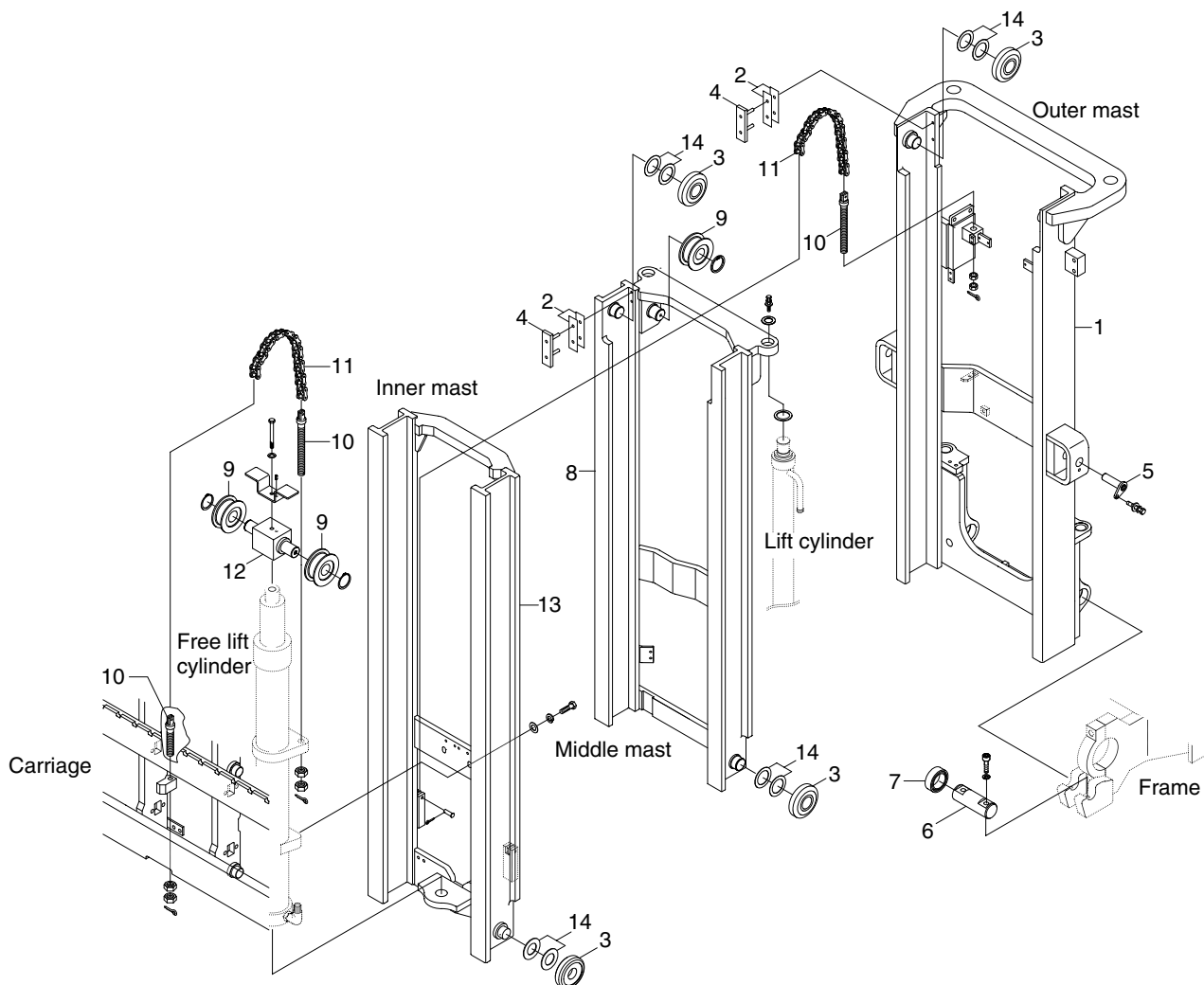
2. 2 STAGE MAST(VF MAST)



D357MS02

- | | | | | | |
|---|-------------------|----|----------------------|----|-----------------|
| 1 | Outer mast | 6 | Mast mounting pin | 11 | Chain |
| 2 | Shim(0.5, 1.0t) | 7 | Bearing | 12 | Sheave bracket |
| 3 | Roller bearing | 8 | Inner mast | 13 | Shim(0.5, 1.0t) |
| 4 | Backup liner | 9 | Chain sheave bearing | | |
| 5 | Tilt cylinder pin | 10 | Anchor bolt | | |

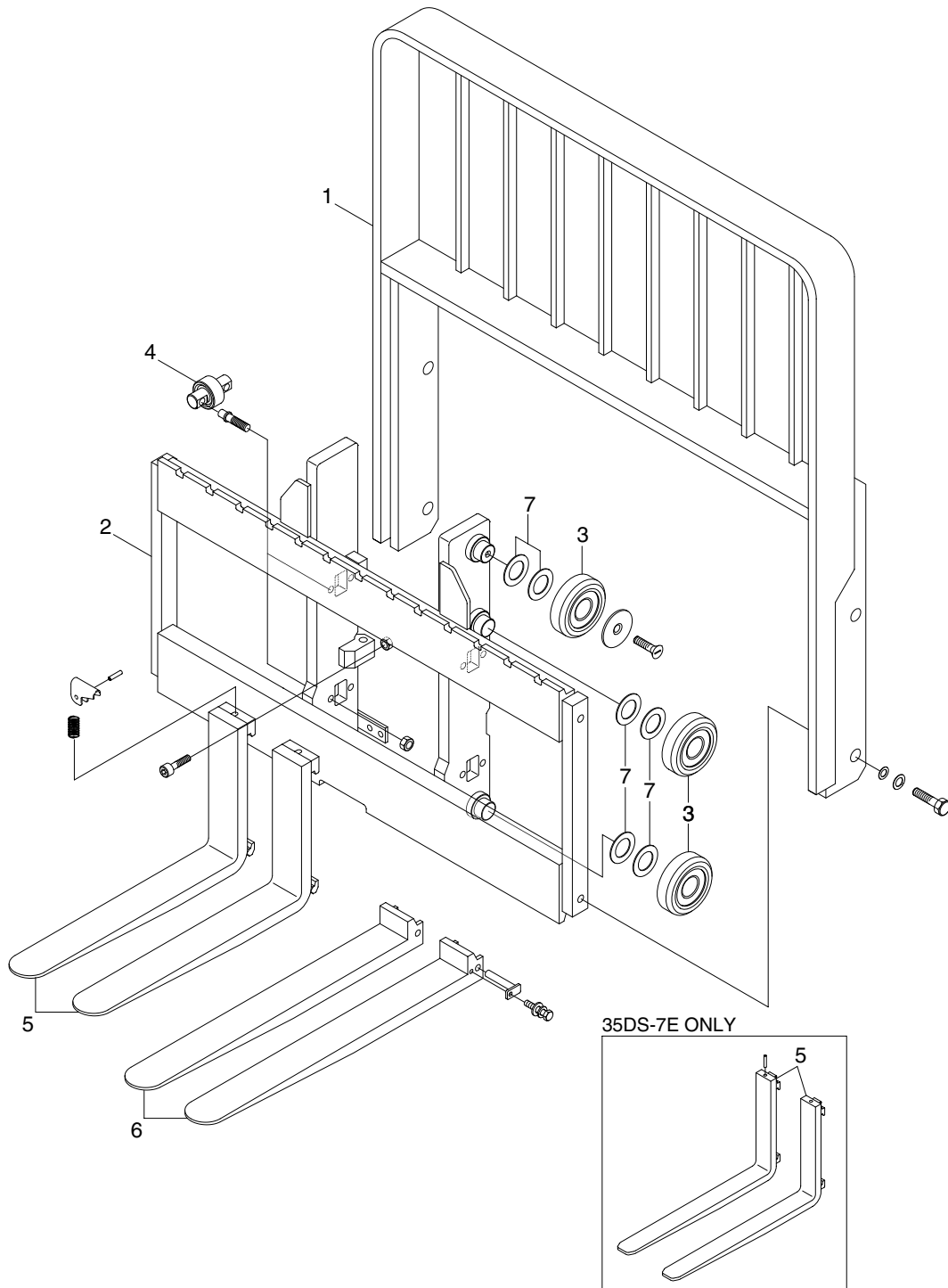
3. 3 STAGE MAST(TF MAST)



D357MS03

- | | | | | | |
|---|-------------------|----|----------------------|----|-----------------|
| 1 | Outer mast | 6 | Mast mounting pin | 11 | Chain |
| 2 | Shim(0.5, 1.0t) | 7 | Bearing | 12 | Sheave bracket |
| 3 | Roller bearing | 8 | Middle mast | 13 | Inner mast |
| 4 | Backup liner | 9 | Chain sheave bearing | 14 | Shim(0.5, 1.0t) |
| 5 | Tilt cylinder pin | 10 | Anchor bolt | | |

3. CARRIAGE, BACKREST AND FORK



35DS7MS04

- 1 Backrest
- 2 Carriage
- 3 Roller
- 4 Side roller

- 5 Fork
- 6 Extension fork
- 7 Shim(0.5, 1.0t)

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

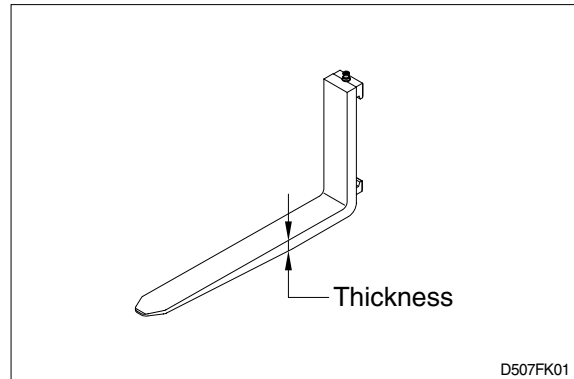
1) FORKS

- (1) Measure thickness of root of forks and check that it is more than specified value.

EX : $l = 1200\text{mm}(47\text{in})$

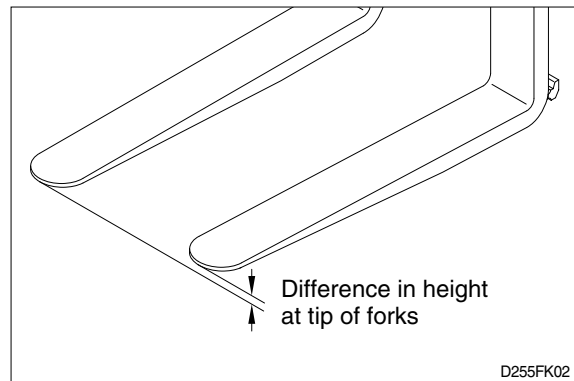
mm(in)

STD Fork assy	Applicable model	Standard	Limit
S173896-02	35DS-7E	50(2.0)	45(1.7)
F13710010	40DS-7E	50(2.0)	45(1.7)
F18393603	45DS-7E	50(2.0)	45(1.7)
F14710011	50DA-7E	60(2.4)	54(2.1)



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

Model	Fork length	Height difference
35DS/40DS/45DS-7E	1070~1970	6mm
50DA-7E	below 1500	3mm
	above 1500	6mm



- 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

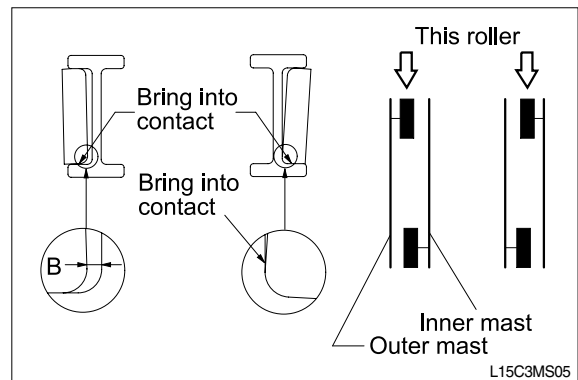
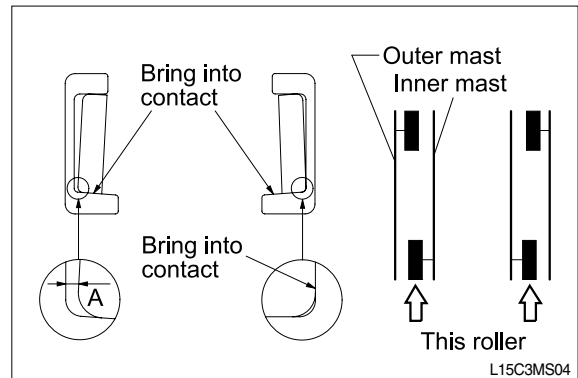
Problem	cause	Remedy											
Abrasion	Long-time operations causes the fork to wear and reduces the thickness of the fork. Inspection for thickness is needed. Wear limit : Must be 90% of fork thickness	If the measured value is below the wear limit, replace fork.											
Distortion	Forks are bent out of shape by a number of reasons such as overloading, glancing blows against walls and objects, and picking up load unevenly. Difference in height at tip of forks <table border="1"> <thead> <tr> <th>Model</th><th>Fork length</th><th>Height difference</th></tr> </thead> <tbody> <tr> <td>35DS/40DS/45DS-7E</td><td>1070~1970</td><td>6mm</td></tr> <tr> <td rowspan="2">50DA-7E</td><td>below 1500</td><td>3mm</td></tr> <tr> <td>above 1500</td><td>6mm</td></tr> </tbody> </table>	Model	Fork length	Height difference	35DS/40DS/45DS-7E	1070~1970	6mm	50DA-7E	below 1500	3mm	above 1500	6mm	If the measured value exceeds the allowance, replace fork.
Model	Fork length	Height difference											
35DS/40DS/45DS-7E	1070~1970	6mm											
50DA-7E	below 1500	3mm											
	above 1500	6mm											
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, VF MAST)

1) INNER/OUTER MAST ROLLER CLEARANCE ADJUSTMENT

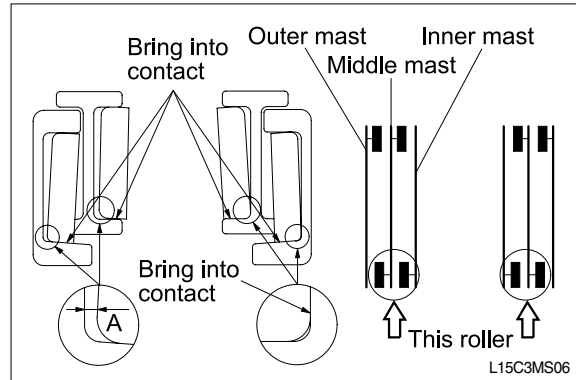
- (1) Measure the clearance with the mast overlap at near 480mm.
- (2) Shift the inner mast to one side to bring the roller into contact with the outer mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting 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)

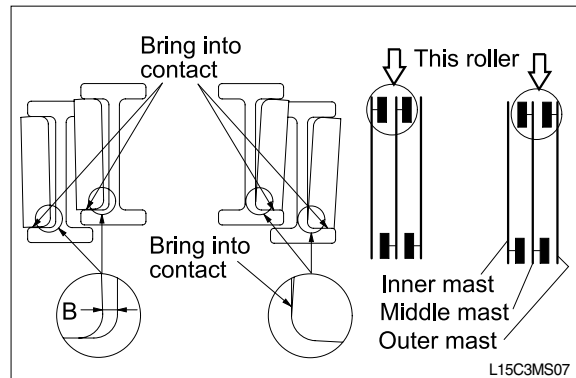
1) INNER AND MIDDLE MAST ROLLER CLEARANCE ADJUSTMENT

- (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.



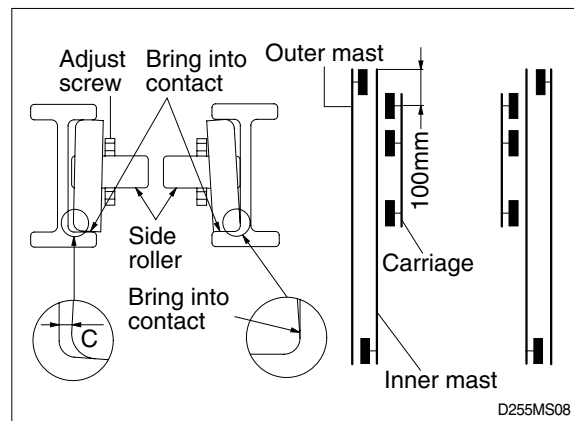
2) OUTER AND MIDDLE MAST UPPER ROLLER CLEARANCE ADJUSTMENT.

- (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.



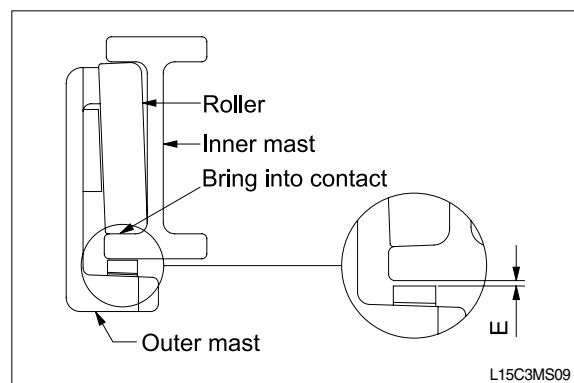
3) CARRIAGE LOAD ROLLER

- (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 $C = 0 \sim 0.6\text{mm}$
 - 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.



4) MAST BACK UP LINER

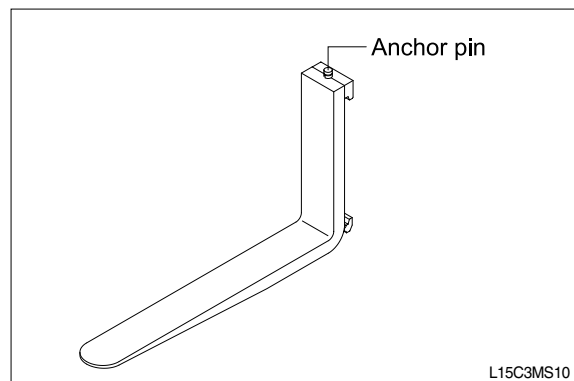
- (1) Measure the clearance with the middle mast at the bottom position.
- (2) With the middle mast in contact with the outer mast roller, adjust the clearance between the mast back up liner and middle mast to the following value by inserting the back up liner shim.
 - Standard clearance $E = 0.2 \sim 0.6\text{mm}$
 - Shim thickness 0.5, 1.0mm
- (3) After the adjustment, the mast should move smoothly.



GROUP 4 REMOVAL AND INSTALLATION

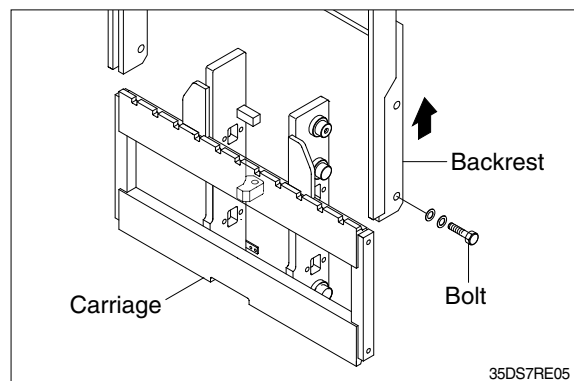
1. FORKS

- 1) Lower the fork carriage until the forks are approximately 25mm(1in) 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 parts.
- (6) Reverse the above steps to reinstall.

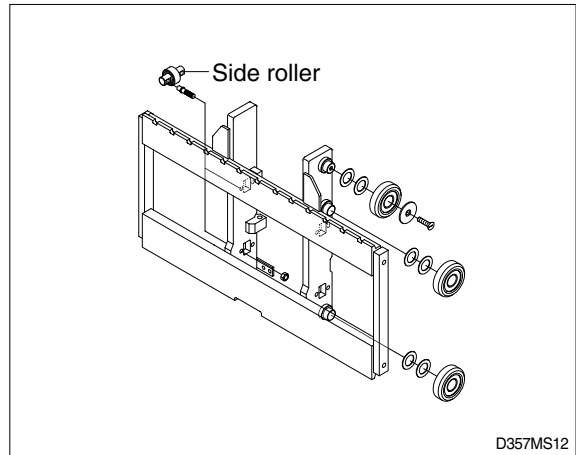
▲ Replace the split pin of chain anchor with new one.

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 plate.
- (3) Thoroughly clean, inspect and replace all worn or damaged parts.
- (4) Reverse the above procedure to assembly.

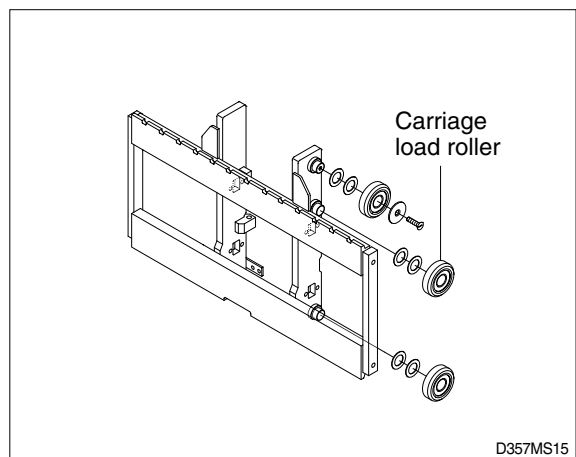
※ Adjustment

- 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

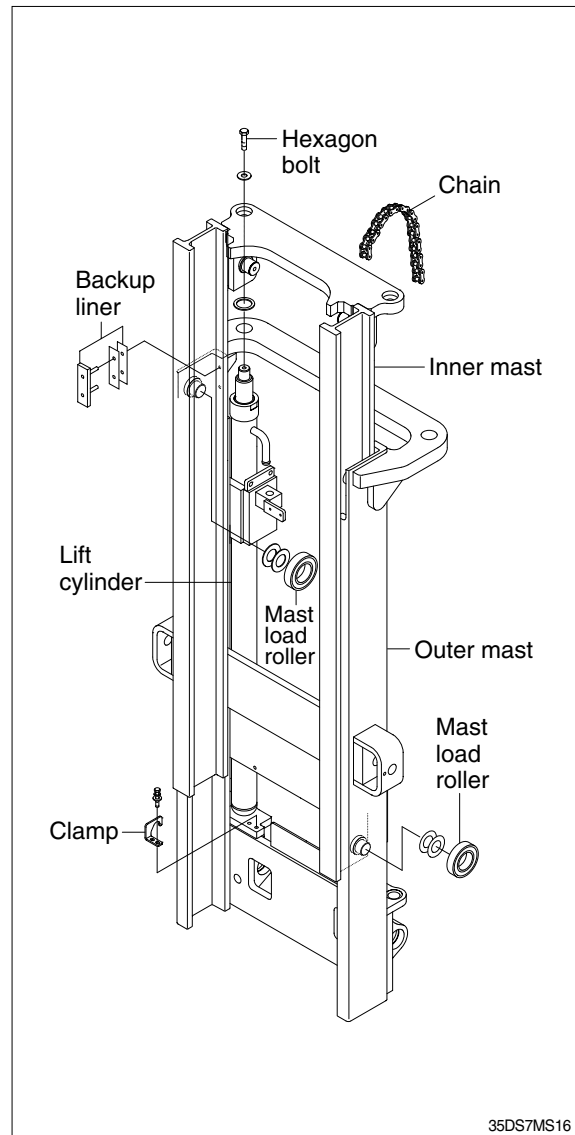
- (1) Remove carriage as outlined in the carriage assembly removal paragraph.
- (2) Loosen and remove flat head bolts and plain washers from top load roller bracket.
- (3) Using a pryer, remove load rollers from load roller bracket.
- (4) Reverse the above procedure to assemble. Refer to MAST ROLLER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



4) MAST LOAD ROLLER AND BACK UP LINER

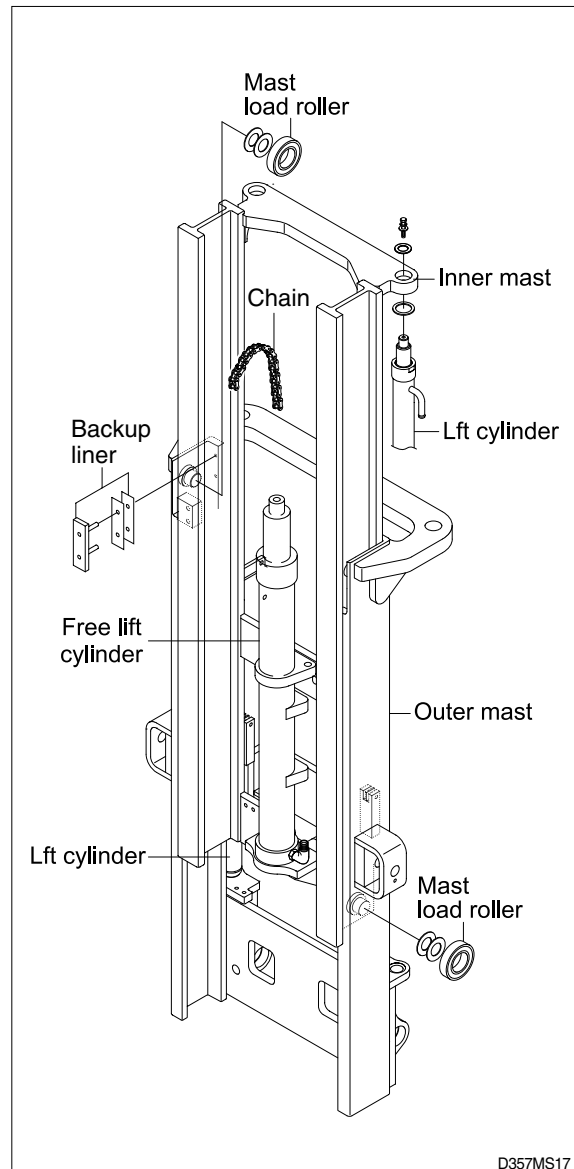
(1) 2 stage mast(V mast)

- ① Remove the carriage assembly and move them to one side.
- ② Loosen and remove hexagon bolts and clamps securing lift cylinders to outer mast.
- ③ Loosen and remove hexagon bolts and washers 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.



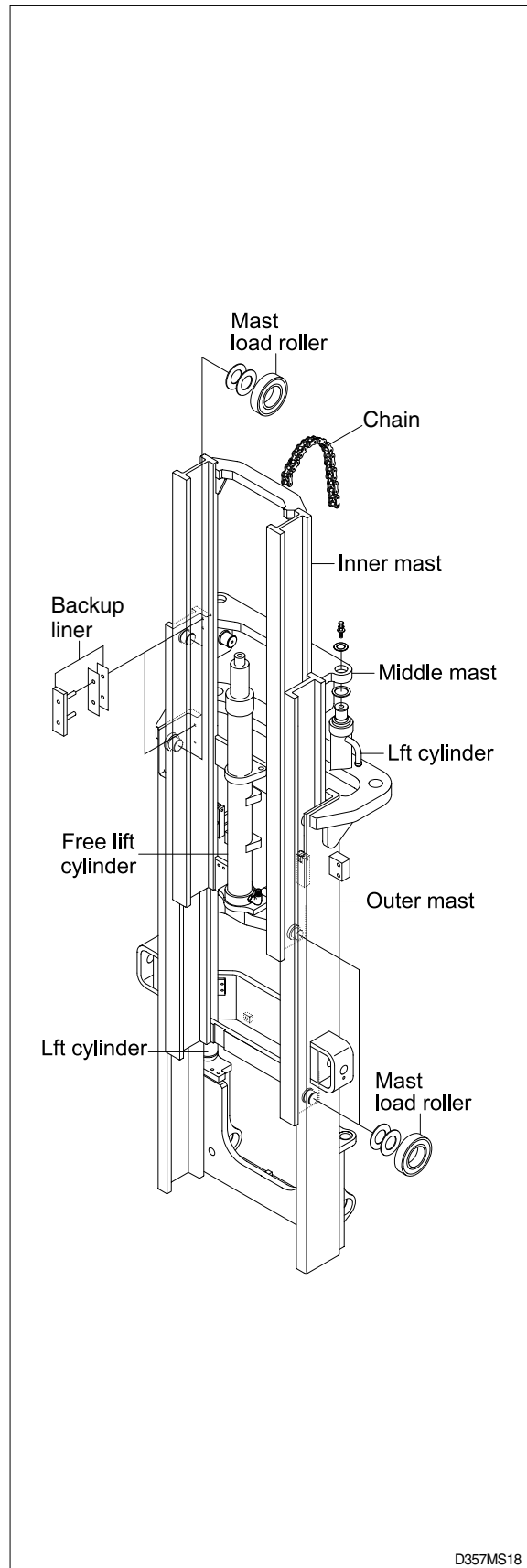
(2) 2 stage mast(VF mast)

- ① Remove free lift chain connected between carriage and free lift cylinder.
- ② Remove the carriage assembly and move them to one side.
- ③ Loosen and remove hexagon bolts and washers securing lift cylinders to inner mast.
- ④ Loosen and remove hexagon bolts and nuts securing lift cylinders to inner mast.
- ⑤ 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.
- ⑥ 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.
- ⑦ Using the overhead hoist, lower inner mast until top and bottom rollers and back up liners are exposed.
- ⑧ Using a pryer, remove load rollers from load roller bracket. Remove back up liners and shims.
- ⑨ Thoroughly clean, inspect and replace all worn or damaged parts.
- ⑩ Reverse the above procedure to assemble. Refer to MAST LOAD ROLLER ADJUSTMENT paragraph.



(3) 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). 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. Using a pryer, remove load rollers from
- ⑧ load bracket. Remove back up liners and shims. Attach chains or sling to the middle mast
- ⑨ section at top crossmember. Using an overhead hoist, slowly raise the middle mast until top and bottom rollers are exposed. Using a player, remove load rollers from
- ⑩ load roller bracket. Thoroughly clean, inspect and replace all
- ⑪ worn or damaged parts. Reverse the above procedure to
- ⑫ assemble. Refer to MAST LOAD ROLLER ADJUSTMENT paragraph.



5) ELEVATING MAST

(1) Inner mast (V, VF 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.

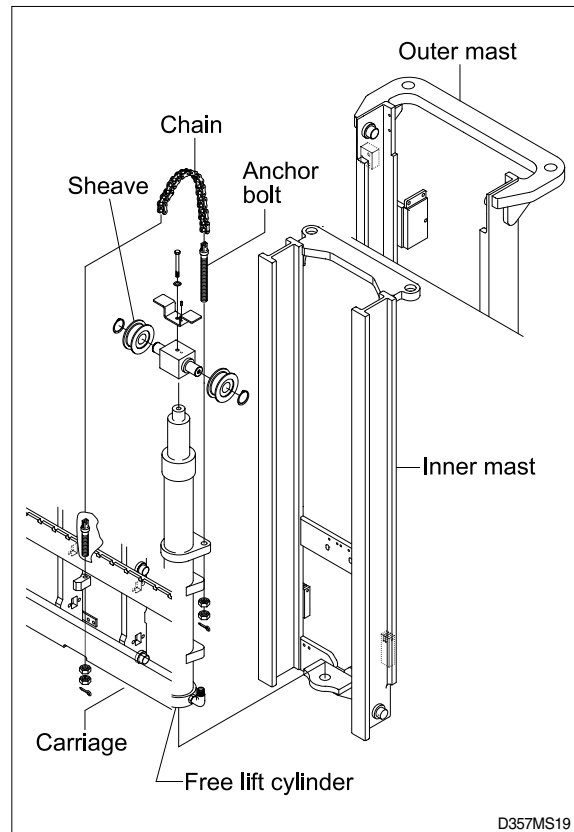
(2) Inner and middle mast(TF mast)

- 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, VF mast)

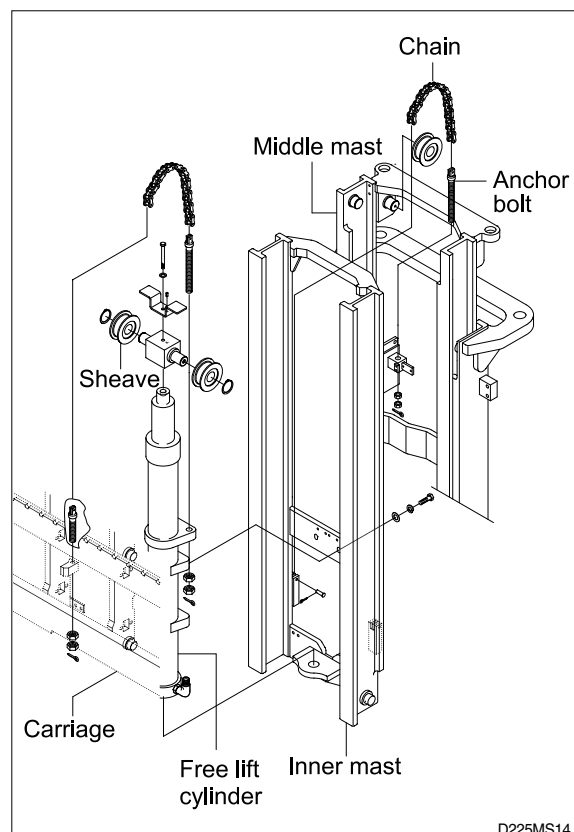
- ① Place a sling around carriage and attach to an overhead hoist. Lift carriage high enough so that the tension on the chain over sheaves is relieved after the carriage is blocked. Position wooden blocks under the carriage and lower it.
- ② Remove the split pin securing the chain anchor pins and discard. While supporting the chains, remove the chain anchor pins and drape the chains over the
- ③ carriage.
Remove retaining ring securing sheaves to sheave support. Remove sheaves
- ④ with bearings.
Remove bearing retaining ring from
- ⑤ sheave and press bearings from sheaves.
Thoroughly clean, inspect and replace all
- ⑥ worn or damaged parts.
Reverse the above to assemble and install.
Use new split pins in chain anchor pins.



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(2) Rear chain sheave(TF mast)

- ① Raise and securely block carriage and inner mast section.
- ② Remove the split pin securing the chain anchor pins and discard. While supporting the chains, remove the chain anchor pins from outer mast section.
- 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. Use new split pins in chain anchor pins.



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(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 phenomenon 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 joints 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.

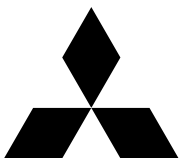
③ **Adjustment**

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**

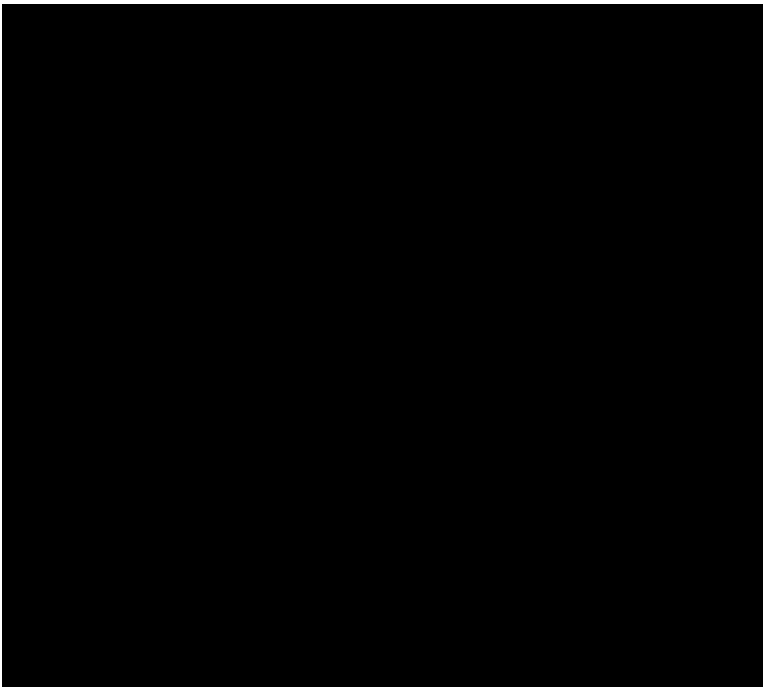
- With mast in its fully collapsed and vertical position, lower the fork to the floor.
- Adjust the chain length by loosening or tightening nut on the chain anchor.
After making adjustment on the mast, be sure to tighten the nut.



August 2008

 SERVICE MANUAL

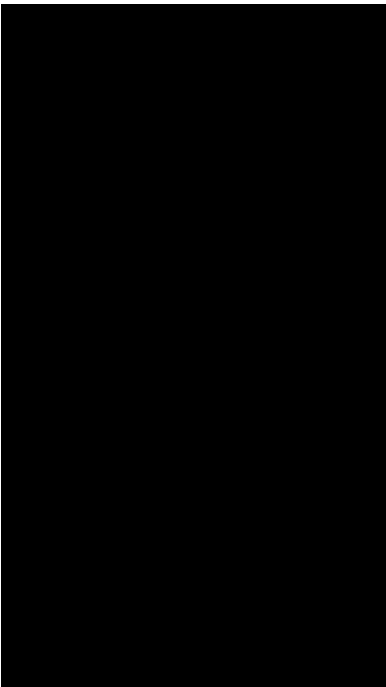
SERVICE MANUAL



S6S-Y3T61HF S6S-Y3T62HF

for HYUNDAI HEAVY INDUSTRIES CO.,LTD.

Pub. No. 99616-25000



**MITSUBISHI
DIESEL ENGINES**
S6S-Y3T61HF
S6S-Y3T62HF
for HYUNDAI HEAVY INDUSTRIES CO.,LTD.

August 2008



INTRODUCTION

This service manual describes the specifications, maintenance and service procedures for Mitsubishi diesel engines.

To maintain the performance of the engine for many years and to ensure safe operation, it is important to use the engine correctly and conduct regular inspection and maintenance, and also to take necessary measures which involves the disassembly, inspection, repair and reassembly of the engine and engine parts.

Read this manual carefully and understand the work procedures fully before disassembling, inspecting, repairing or reassembling the engine.

The contents of the manual are based on the engine models that are being produced at the time of publication. Due to improvements made thereafter, the actual engine that you work on may differ partially from the one described in this manual.

How to use this manual

This service manual consists of several Groups, which are arranged so as to allow you to make reference quickly to specifications, maintenance standards, adjustment procedures and service procedures including methods for disassembly, inspection, repair and reassembly of the Mitsubishi Diesel Engine (standard model for land use).

A short summary describing the content of each Group is given in the General Contents page, and there is also a detailed table of contents at the beginning of each Group.

Regarding the procedures for operation and periodical maintenance of the engine, refer to the Operation and Maintenance Manual. For information on the engine components and ordering of service parts, refer to the Parts Catalogue. Structure and function of the engine are described in the relevant training manuals.

Methods of presentation

- (1) Index numbers allotted to parts in exploded views are not only a call-out of part names listed in the text but also an indication of the sequence of disassembly.
- (2) Inspections to be conducted during disassembly process are indicated in boxes in the relevant exploded views.
- (3) Maintenance standards required for inspection and repair works are indicated in the appropriate positions in the text. They are also collectively indicated in Group 2, the General Contents group.
- (4) Fasteners to be tightened in “wet” condition, or with engine oil applied, are identified by [Wet] placed after tightening torque values. If no such indication is suffixed, the fastener should be tightened in “dry” condition, or without lubricating with engine oil.
- (5) In this manual, important safety or other cautionary instructions are emphasized with the following marks headed.



Indicates an immediately hazardous situation which, if not avoided, will result in death or serious injury.



Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.



Indicates an immediately hazardous situation which, if not avoided, may result in minor or moderate injury.



Indicates a potentially hazardous situation which, if not avoided, can result in property damage.

Note:

Emphasizes important matter, or indicates information useful for operation or maintenance of the engine.

INTRODUCTION

Terms used in this manual

Nominal

means the rated (design) size or magnitude of a part to be measured.

Standard

means the quantitative requirement for dimension of a part, clearance between parts and performance. This is given in a form of tolerance. Therefore, the values shown are not in agreement with the design values.

Limit

means that, if this value is reached, the part must be repaired or replaced with a new part.

Abbreviations

- BTDC: Before Top Dead Center
- ATDC: After Top Dead Center
- BBDC: Before Bottom Dead Center
- ABDC: After Bottom Dead Center
- TIR: Total Indicated Runout
- API: American Petroleum Institute
- ASTM: American Society for Testing and Materials
- JIS: Japanese Industrial Standards
- LLC: Long Life Coolant
- MIL: Military Specifications and Standards (U.S.A.)
- MSDS: Material Safety Data Sheet
- SAE: Society of Automotive Engineers (U.S.A.)

Units of measurement

Measurements are based on the International System of Units (SI), and their converted metric values are indicated in parentheses { }. For metric conversion, the following rates are used.

- Pressure: 1 MPa = 10.197 kgf/cm²
- Torque: 1 N·m = 0.10197 kgf·m
- Force: 1 N = 0.10197 kgf
- Horsepower: 1 kW = 1.341 HP = 1.3596 PS
- Meter of mercury: 1 kPa = 0.7 cmHg
- Meter of water: 1 kPa = 10.197 cmH₂O (cmAq)
- Rotational speed: 1min⁻¹ = 1 rpm

Safety Cautions

WARNING

Fire and explosion

Keep flames away

Store fuel and engine oil in a well ventilated designated area.

Make sure that the caps of fuel and engine oil containers are tightly closed.

Do not use flames, do not smoke, and do not work near a heater or other fire hazard where fuel or oil is handled or when cleaning solvent is being used for washing parts.

Wipe off spilled fuel, oil and LLC immediately and thoroughly. Spilled fuel, oil and LLC may ignite and cause a fire.



Keep surrounding area tidy and clean

Do not leave combustible or explosive materials, such as fuel, engine oil and LLC, near the engine. Such substances can cause fire or explosion.

Remove dust, dirt and other foreign materials accumulated on the engine and surrounding parts thoroughly. Such materials can cause fire or the engine to overheat. In particular, clean the top surface of the battery thoroughly. Dust can cause a short-circuit.

Always operate the engine at a position at least 1 m [3.28 ft.] away from buildings and other equipment to prevent possible fire caused by engine heat.

Avoid accessing crankcase until engine cools

Do not attempt to open the side cover of the crankcase before the engine cools down. Wait at least 10 minutes after stopping the engine.

Opening the cover when the engine is hot allows fresh air to flow into the crankcase, which can cause oil mist to ignite and explode.

Care about fuel, oil and exhaust gas leakage

If any fuel, oil or exhaust gas leakage is found, immediately take corrective measures to stop it.

Such leakages, if left uncorrected, can cause fuel or engine oil to reach hot engine surfaces or hot exhaust gas to contact flammable materials, possibly leading to personal injury and/or damage to equipment.

Use explosion-proof lighting apparatus

When inspecting fuel, engine oil, coolant, battery electrolyte, etc., use a flameproof light. An ordinary light, if accidentally broken, may ignite and cause an explosion.

Prevent electrical wires from short-circuiting

Avoid inspecting or servicing the electrical system with the ground cable connected to the battery. Otherwise, a fire could result from short-circuiting. Be sure to disconnect the battery cable from the negative (-) terminal before beginning with the work procedure.

Short-circuits, possibly resulting in fire, may be caused by a loose terminal or damaged cable/wire. Inspect the terminals, cables and wires, and repair or replace the faulty parts before beginning with the service procedure.

Keep fire extinguishers and first-aid kit handy

Keep fire extinguishers handy, and become familiar with their usage.

Keep a first-aid kit at the designated place where it is easily accessible by anyone at any time.

Establish response procedures to follow in the event of fire or accident. Provide an emergency evacuation route, contact points, and means of communication in case of emergency.



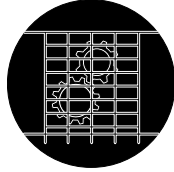
INTRODUCTION

WARNING

Stay clear of all rotating and moving parts

Install protective covers on rotating parts

Make sure the protective covers for engine rotating parts are properly installed as intended. Repair loose or damaged protective covers as necessary.



Never remove the covers guarding personnel from rotating parts, when the engine is operating.

When combining the engine with the engine-driven machine or radiator, always provide a cover on every exposed moving part such as driving belt and coupling. Never remove protective covers.

Ensure safety of neighboring people before starting engine

Before starting the engine, ensure that there is nobody in the neighborhood and that no tools are left on or near the engine. Verbally notify people around the engine or in the work area when starting the engine.

When the starter device is posted with a sign that prohibits startup operation, do not operate the engine.

Stay clear of moving parts during engine running

Do not approach rotating or sliding parts of the engine when the engine is in operation.

Keep objects likely to be caught by rotating parts away from such parts. If any part of the clothing or outfitting is caught by a rotating part, serious bodily injuries could result.



Lockout and tagout

Be sure to lockout and tagout before starting inspection and maintenance.

Lockout and tagout are effective methods of cutting off machines and equipment from energy sources.

To accomplish the lockout/tagout, remove the starter switch key, set the battery switch to OFF and attach a "Do Not Run" or similar caution tag to the starter switch. The starter switch key must be kept by the person who performs inspection and maintenance during the work. In the case of pneumatic starting type, close the main valve of the air tank and post a tag saying "Do Not Open the Valve" or the like.

Keep engine stopped during servicing

Be sure to stop the engine before proceeding to inspection and service procedure. Never attempt to make adjustments on the engine parts while the engine is running. Rotating parts such as belt can entangle your body and cause serious injuries.

Always restore engine turning tools after use

Do not forget to remove the tools which have been used for turning the engine during inspection or servicing, after the procedure is finished. Remember also that the turning gear must be returned to the operating condition before starting the engine.

Starting the engine with the turning tools inserted or with the turning gear in engagement can lead to not only engine damage but also personal injuries.

⚠ WARNING

Be careful of burns

Do not touch the engine during or immediately after operation

Do not touch the engine during or immediately after operation to avoid risk of burns.

To conduct maintenance and inspection work, wait until the engine has cooled sufficiently, checking the temperature gauge.



Slowly and carefully open radiator cap

Never attempt to open the radiator cap while the engine is running or immediately after the engine stops. Give a sufficient cooling time to the engine coolant before opening the cap.

When opening the radiator cap, slowly turn the cap to release internal pressure. To prevent scalds with steam gushing out, wear thick rubber gloves or cover the cap with a cloth.

Close the radiator cap tightly without fail.

The coolant is very hot and under pressure during engine running or just after the engine stops. If the radiator cap is not closed tightly, steam and hot coolant may gush out and can cause scalds.

Add coolant only after the coolant temperature dropped

Do not add coolant immediately after the engine stops. Wait until the coolant temperature lowers sufficiently to avoid a risk of burns.

Never remove heat shields

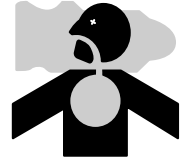
The exhaust system, which becomes extremely hot while the engine is operating, is provided with various heat shields. Do not remove these heat shields. If any of these heat shields have been removed owing to unavoidable circumstances during the work, be sure to restore them after the work is completed.

⚠ WARNING

Be careful of exhaust fume poisoning

Operate engine in well-ventilated area

If the engine is installed in an enclosed area and the exhaust gas is ducted outside, ensure that there is no exhaust gas leak from duct joints.



Take care that the exhaust gas is not discharged toward plants or animals.

Exhaust gas from the engine contains carbon monoxide and other harmful substances. Operating the engine in an ill-ventilated area can produce gas poisoning.

⚠ WARNING

Protect ears from noises

Wear ear plugs

Always wear ear plugs when entering the machine room (engine room). Combustion sound and mechanical noise generated by the engine can cause hearing problems.



INTRODUCTION

WARNING

Be careful of falling down

Lift engine correctly

To lift the engine, always use a correct wire rope capable of withstanding the engine weight.

Attach the wire rope to the lifting hangers provided on the engine using a correct sling.

During lifting process, keep the engine in a well-balanced position by taking the center of gravity of the engine into consideration.

If the wire rope contacts the engine directly, place a cloth or other soft padding to avoid damage to the engine and wire rope.



Do not climb onto the engine

Do not climb onto the engine, nor step on any engine parts located on the lateral sides.

To work on parts located on the upper section of engine, use a ladder, stool, etc., that is firmly secured.

Climbing on the engine may not only damage engine parts but also cause parts to fall off and result in personal injuries.

Establish firm scaffold during work

When working on the upper part of the engine and other hard-to-reach places, use a stable work platform.

Standing on a decrepit stool or parts box may result in personal injury. Do not place any unnecessary objects on a work platform.



CAUTION

Be careful of handling fuel, engine oil and LLC

Use only specified fuel, engine oil and long-life coolant (LLC)

Use only the fuel, oil and LLC specified in the applicable operation manual, and handle them carefully.

Use of any other fuel, oil or LLC, or improper handling may cause various engine problems and malfunctions. Obtain the Material Safety Data Sheets (MSDS) issued by the fuel, oil and LLC suppliers, and follow the directions in the MSDSs for proper handling.

Handle LLC (long life coolant) carefully

When handling LLC, always wear rubber gloves and protective face mask. If LLC or cooling water containing LLC comes into contact with your skin or eyes, or if it is swallowed, you would suffer from inflammation, irritation or poisoning.

Should LLC be accidentally swallowed, induce vomiting immediately and seek medical attention. Should LLC enter your eyes, flush them immediately with plenty of water and seek medical attention. If LLC splashes onto your skin or clothing, wash it away immediately with plenty of water.

Keep flames away from LLC. The LLC can catch flames, causing a fire.

Coolant containing LLC is a hazardous material. Do not dispose of it in unauthorized manner. Abide by the applicable law and regulations when discarding drained coolant.

Proper disposal of waste oil and coolant (LLC)

Do not discharge waste engine oil or coolant into sewerage, river, lake or other similar places. Such a way of disposal is strictly prohibited by laws and regulations. Dispose of waste oil, coolant and other environmentally hazardous waste in accordance with the applicable law and regulations, or consult a Mitsubishi dealer.

⚠ CAUTION

Service battery

Handle the battery correctly

- Never use flames or allow sparks to generate near the battery. The battery releases flammable hydrogen gas and oxygen gas. Any flames or sparks in the vicinity could cause an explosion.
- Do not use the battery the fluid level of which is lowered below the lower limit line. Sustained use of the battery could result in an explosion.
- Do not short the battery terminals with a tool or other metal object.
- When disconnecting battery cables, always remove the cable from the negative (-) terminal first. When reconnecting the cables, attach the cable to the positive (+) terminal first.
- Charge the battery in a well-ventilated area, with all filling hole plugs removed.
- Make sure the cable clamps are securely installed on the battery terminals. A loose cable clamp can cause sparks that may result in an explosion.
- Before servicing electrical components or conducting electric welding, set the battery switch to the [Open/OFF] position or disconnect the cable from the negative (-) battery terminal to cut off the electrical current.
- Electrolyte (battery fluid) contains dilute sulfuric acid. Careless handling of the battery can lead to the loss of sight and/or skin burns. Also, keep the battery fluid off the mouth.
- Wear protective goggles and rubber gloves when working with the battery (when adding water, charging, etc.).
- If electrolyte is spilled onto the skin or clothing, immediately wash it away with lots of water. Use soap to thoroughly clean.
- The battery fluid can cause blindness if splashing into eyes. If it gets into eyes, immediately flush it away with plenty of clean fresh water, and seek immediate medical attention.
- If the battery fluid is accidentally swallowed, gargle with plenty of water, then drink lots of water, and seek immediate medical attention.



⚠ CAUTION

When abnormality occurs

Stop overheated engine after cooling run

Even if the engine comes to overheat, do not stop the engine immediately. Abrupt stopping of an overheated engine can cause the coolant temperature to rise, resulting in seized engine parts. If the engine comes to overheat, run the engine at low idling speed (cooling operation), and stop the engine after the coolant temperature lowers sufficiently.

Do not add coolant immediately after stopping the engine. Adding coolant to a hot engine can cause the cylinder heads to crack due to sudden change in temperature. Add coolant little by little after the engine cools down to room temperature.

Avoid immediate restart after abnormal stop

If the engine stops abnormally, do not restart the engine immediately. If the engine stops with an alarm, check and remedy the cause of the problem before restarting. Sustained use of the engine without any remedy could result in serious engine problems.

Avoid continuous engine operation with too low oil pressure

If an abnormal engine oil pressure drop is indicated, stop the engine immediately, and inspect the lubrication system to locate the cause. Continuous engine operation with low oil pressure may cause bearings and other parts to seize.

Stop the engine immediately if the fan belt breaks

If the fan belt breaks, stop the engine immediately. Continuous engine operation with the broken fan belt could cause the engine to overheat and thereby the coolant to boil into steam, which may gush out from the reserve tank or radiator, and cause personal injuries.

INTRODUCTION

CAUTION

Other cautions

Modification of engine prohibited

Unauthorized modification of the engine will void the manufacturer's warranty.

Modification of the engine may not only cause engine damage but also produce personal injuries.

Never break the seals

To ensure proper engine operation, the fuel control link is provided with seals that protect the fuel injection volume and rotation speed settings against tampering. If these seals are broken and the settings are changed, proper operation of the engine will no longer be guaranteed, and the following problems will be expected to occur.

- Rapid wear of moving and rotating parts
- Engine troubles such as damage and seizure of engine parts
- Increased consumption of fuel and lubricating oil
- Deterioration of engine performance due to poorly balanced fuel injection volume and governor operation

Pre-operational check and periodic inspection/maintenance

Be sure to perform the pre-operational checks and periodic inspection/maintenance as described in this manual.

Neglecting the pre-operational check or periodic inspection/maintenance can arouse various engine troubles such as damage to parts, eventually leading to serious accidents.

Break-in operation

A new engine needs to be broken in for the first 50 hours of operation. During this period, do not subject the engine to heavy loads.

Operating a new engine under high loads or severe conditions during the break-in period can shorten the service life of the engine.

Warming-up operation

After starting the engine, run the engine at low idling speeds for 5 to 10 minutes for warming-up. Start the work after this operation is completed.

Warm-up operation circulates the lubricant through the engine. Therefore, individual engine parts are well lubricated before they are subjected to heavy loads. This is very important for longer service life, high-performance and economical operation.

Do not conduct warm-up operation for a longer time than necessary. Prolonged warm-up operation causes carbon build-up in the cylinders that leads to incomplete combustion.

Avoid engine operations in a overload condition

If the engine is considered to be in an overloaded condition which is identified by too much black smoke, etc., immediately reduce the load on the engine such that the correct output and load conditions may be achieved.

Overloading the engine causes not only high fuel consumption but also excessive carbon deposits inside the engine. Excessive carbon deposits can cause various engine problems and shorten the service life of the engine remarkably.

Cooling operation before stopping engine

Always conduct the cooling operation (low speed idling) for 5 to 6 minutes before stopping the engine.

Abruptly stopping the engine immediately after high-load operation can cause partial overheating and shorten the service life of the engine.

During cooling operation, check the engine for abnormalities.

Protection of engine against water entry

Do not allow rainwater, etc. to enter the engine through the air inlet or exhaust openings.

Do not wash the engine while it is operating. Cleaning fluid (water) can be sucked into the engine.

Starting the engine with water inside the combustion chambers can cause the water hammer action which may result in internal engine damage and serious accidents.

Maintenance of air cleaner or pre-cleaner

The major cause of abnormal wear on engine parts is dust entering with intake air. Worn parts produce many problems such as an increase of oil consumption, decrease of output, and starting difficulties. For effective removal of dust from intake air, conduct maintenance of the air cleaner according to the following instructions.

- Do not conduct maintenance of the air cleaner/pre-cleaner while the engine is operating. Engine operation without the air cleaner/precleaner in place allows foreign matters to enter the turbocharger, causing it to damage seriously.
- Remove the air cleaner/pre-cleaner slowly to prevent dust accumulated on the element from falling off. After removing the air cleaner or pre-cleaner, immediately cover the opening (inlet port in case of air cleaner; port in body in case of pre-cleaner) with plastic sheet or similar means to prevent dust from entering the engine.
- Air cleaners equipped with a dust indicator will issue an alarm if the element gets clogged. Service the cleaner as soon as possible if an alarm is issued.

Observe safety rules at work site

Observe the safety rules established at your workplace when operating and maintaining the engine.

Do not operate the engine if you are feeling ill.

Operation of the engine with reduced awareness may cause improper operation that could result in accidents. In such a case, inform your supervisor of your condition.

When working in a team of two or more people, use specified hand signals to communicate among workers.

Work clothing and protective gear

Wear a hardhat, face shield, safety shoes, dust mask, gloves and other protective gear as needed.

When handling compressed air, wear safety goggles, hardhat, gloves and other necessary protective gear. Works without wearing proper protective gear could result in serious injuries.

Use of tools optimum for each work

Always keep in mind to select most appropriate tools for the work to be performed and use them correctly. If tools are damaged, replace with new tools.

Avoidance of prolonged time of starter operation

Do not operate the starter for more than 10 seconds at a time even if the engine does not start. Wait for at least 30 seconds before next engine cranking.

Continuous operation of the starter will drain the battery power and cause the starter to seize.

Do not turn off battery switch during operation

If the battery switch is turned OFF when the engine is running, not only various meters will stop working but also the alternator may have its diode and transistor deteriorated.

Cautionary instructions for transporting engine

When transporting the engine on a truck, consider the engine weight, width and height to ensure safety. Abide by road traffic law, road vehicles act, vehicle restriction ordinance and other pertinent laws.

Avoid continuous engine operation in a low load condition

Do not operate the engine continuously for more than 10 minutes at a load of less than 30%. Engine operation in a low load condition increases the emission of unburned fuel. Therefore, a prolonged time of engine operation in a low load condition increases the quantity of unburned fuel adhering to engine parts, provoking the possibility of engine malfunctioning and shortening the service life of the engine.

Ventilation of engine room

Always keep the engine room well ventilated. Insufficient amount of intake air causes the operating temperature to rise, resulting in poor output and lowered performance.

It is highly recommended to calculate the required amount of air supply to the engine and install an adequate ventilation system before installing the engine.

Avoid contact with high-pressured fuel

Should fuel leak from a fuel injection pipe, do not touch the spouting fuel directly.

Fuel in the fuel injection pipes is under high pressure. If high-pressured fuel contacts you skin, it penetrates through the skin and may result in gangrene.

INTRODUCTION

⚠ CAUTION

About warning labels

Maintenance of warning labels

Make sure all warning/caution labels are legible.

Clean or replace the warning/caution labels when the description and/or illustration are not clear to read.

For cleaning the warning/caution labels, use a cloth, water and soap. Do not use cleaning solvents, gasoline or other chemicals to prevent the letters from getting blurred or the adhesion from being weakened.

Replace damaged or fractured labels with new ones.

If any engine part on which a warning label is attached is replaced with a new one, attach a new identical warning label to the new part.



Warning labels

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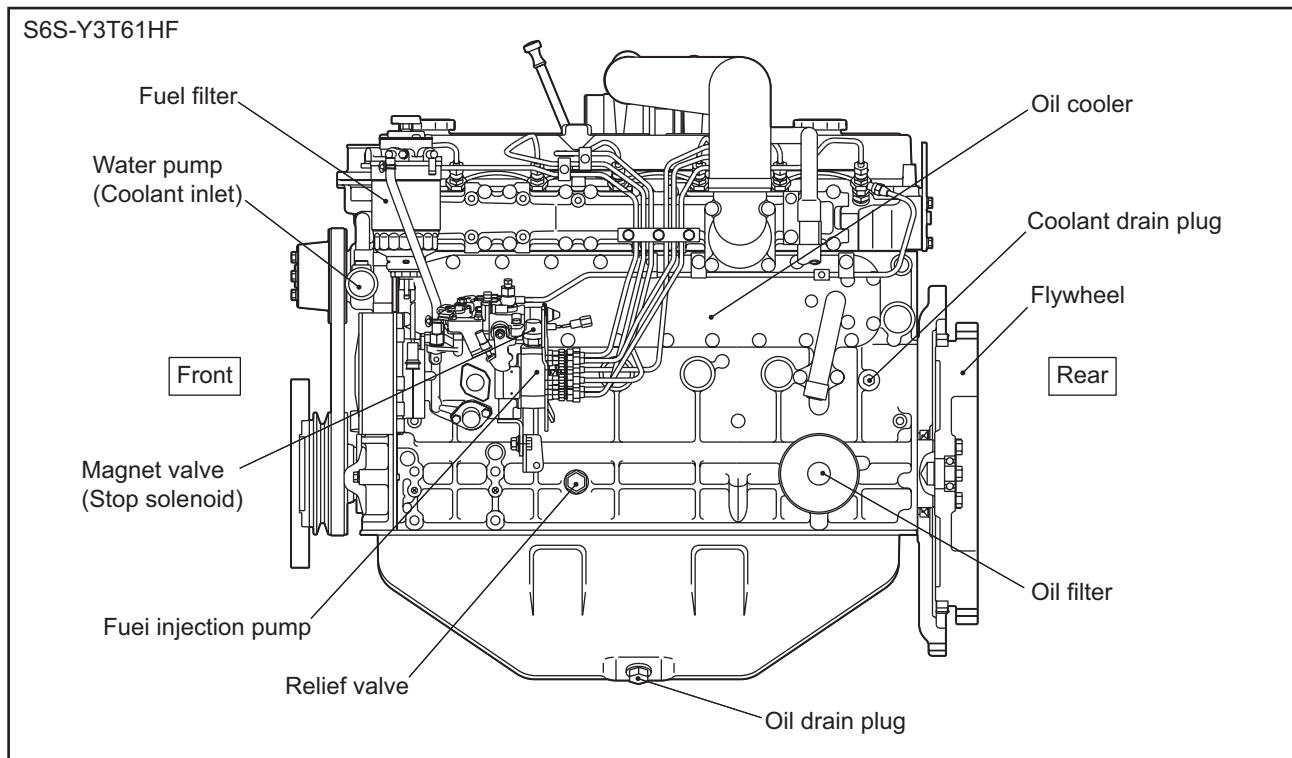
Group Name	Contents	Group No.
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Service tools	Special tool	3
Determination of overhaul	Determining overhaul timing Testing compression pressure	4
Disassembly of basic engine	Disassembling and inspecting cylinder head and valve mechanism Disassembling and inspecting flywheel Disassembling and inspecting damper, gear case, timing gear and camshaft Disassembling and inspecting piston, connecting rod, crankshaft and crankcase	5
Inspection and repair of basic engine	Inspecting and repairing cylinder head and valve mechanism Inspecting and repairing flywheel Inspecting and repairing timing gear and camshaft Inspecting and repairing piston, connecting rod, crankshaft and crankcase	6
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GENERAL

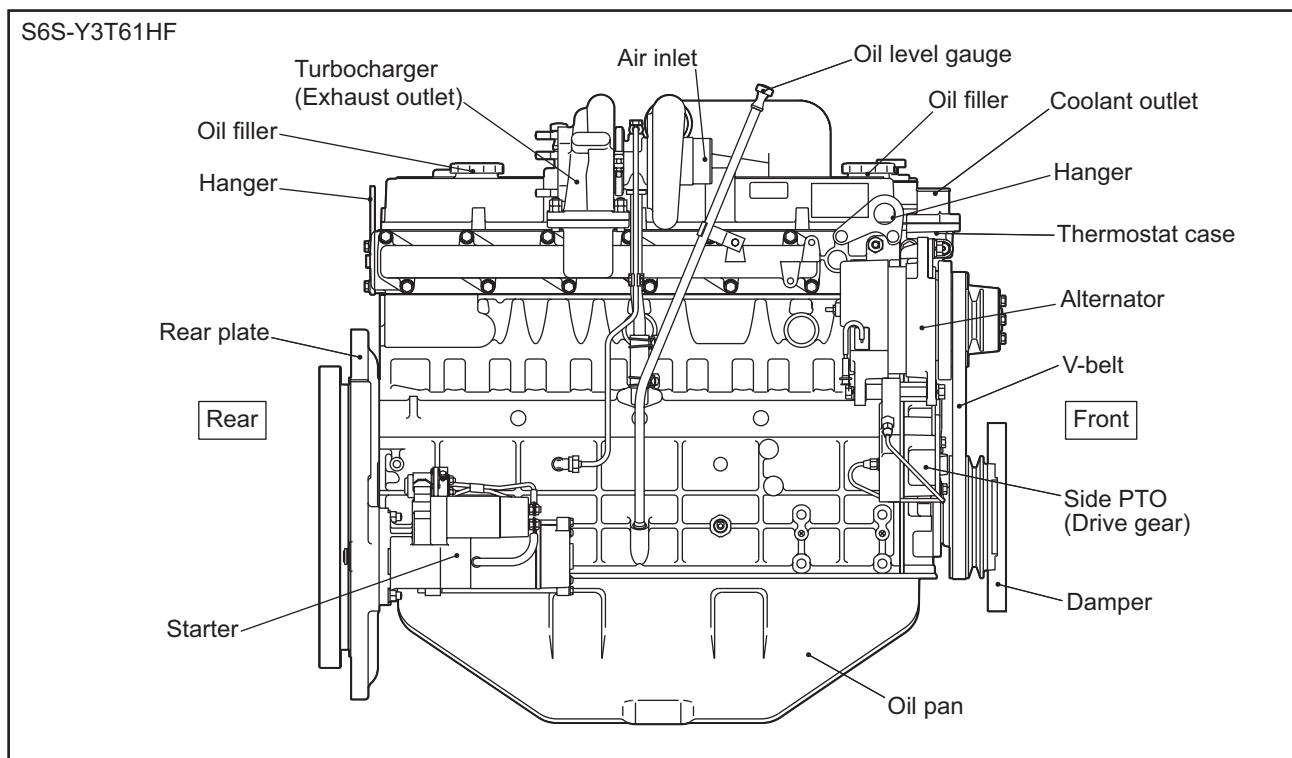
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GENERAL

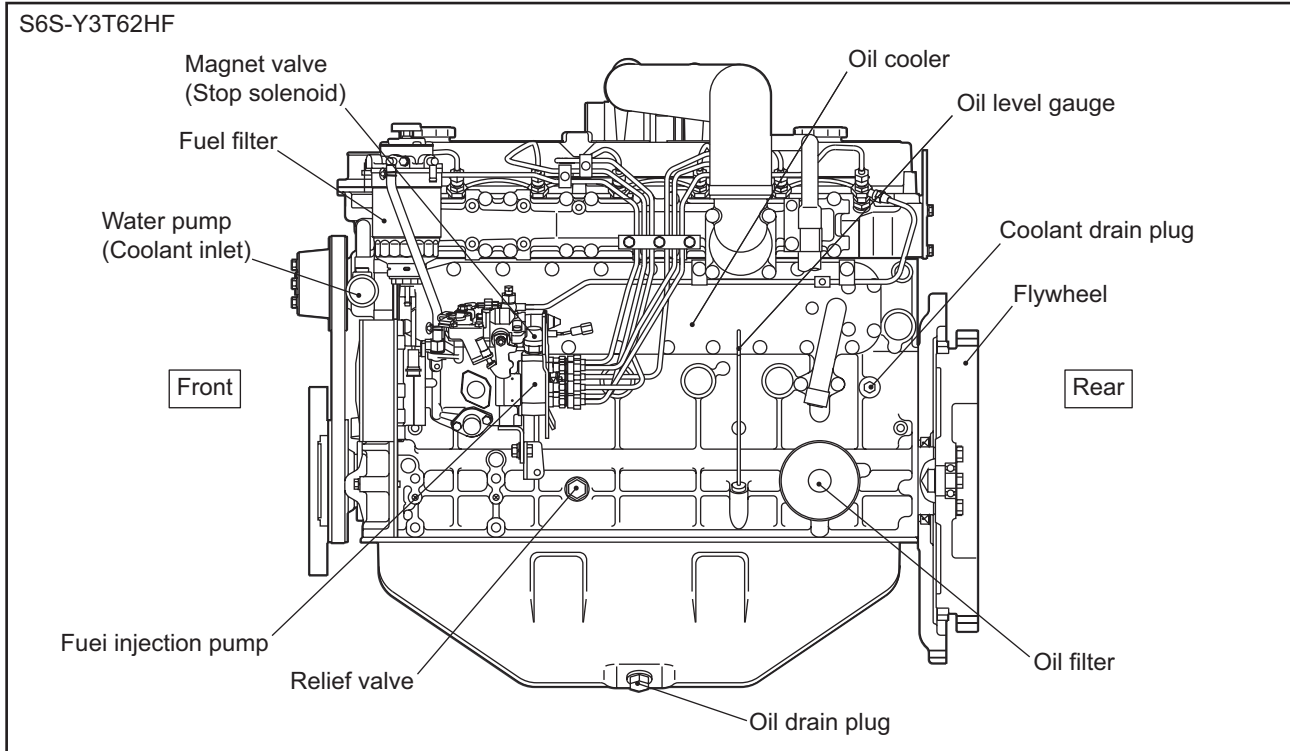
1. External view



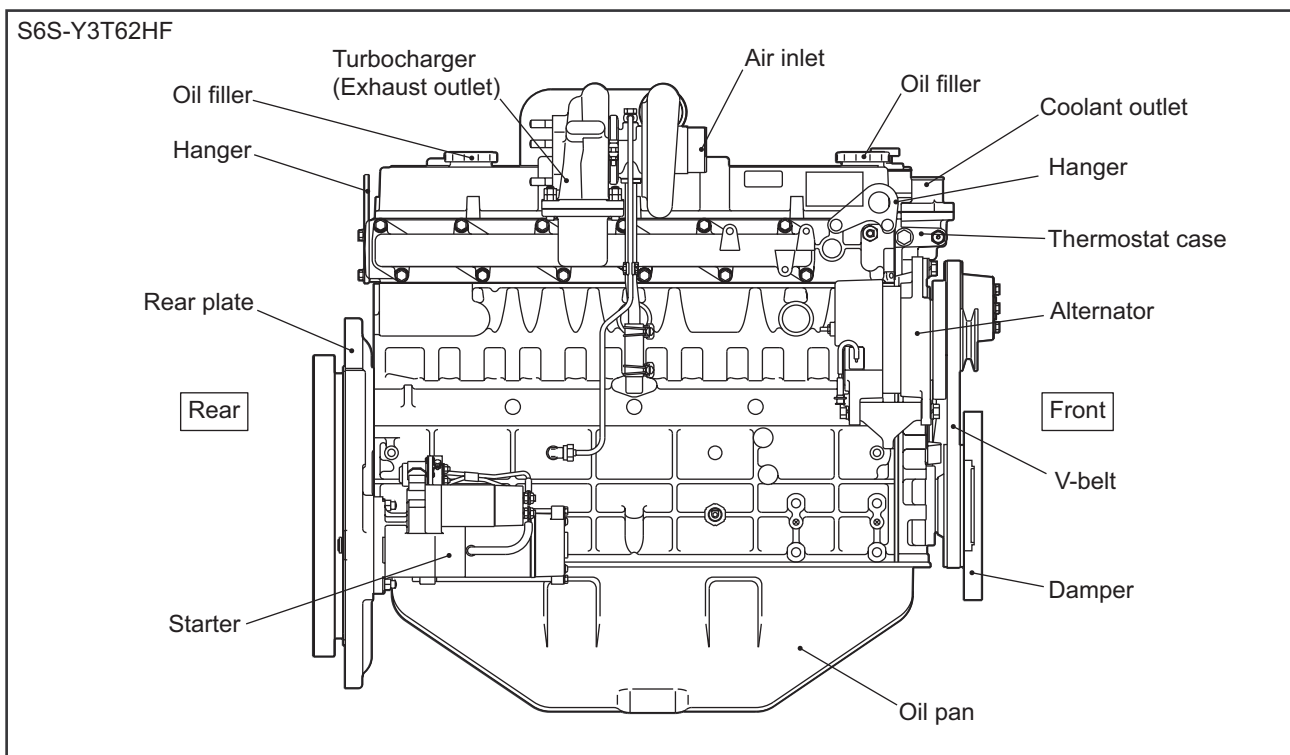
Engine left view



Engine right view



Engine left view

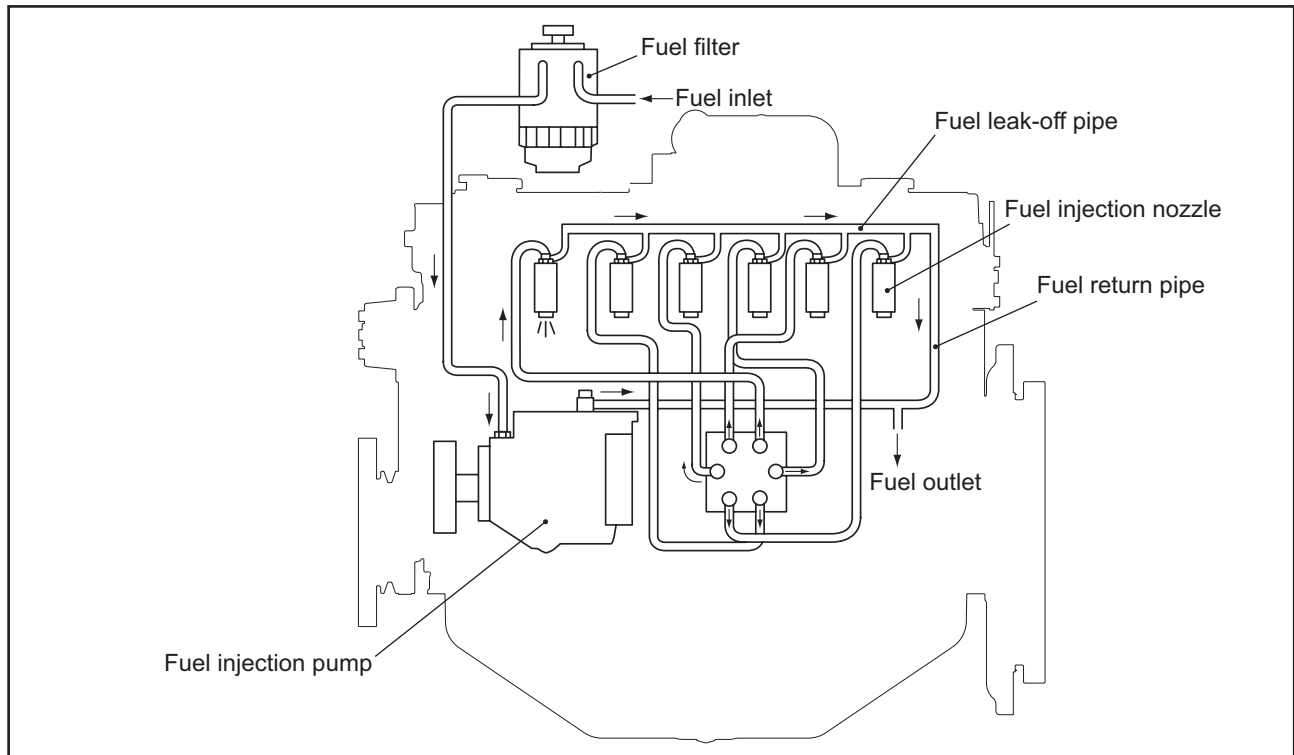


Engine right view

GENERAL

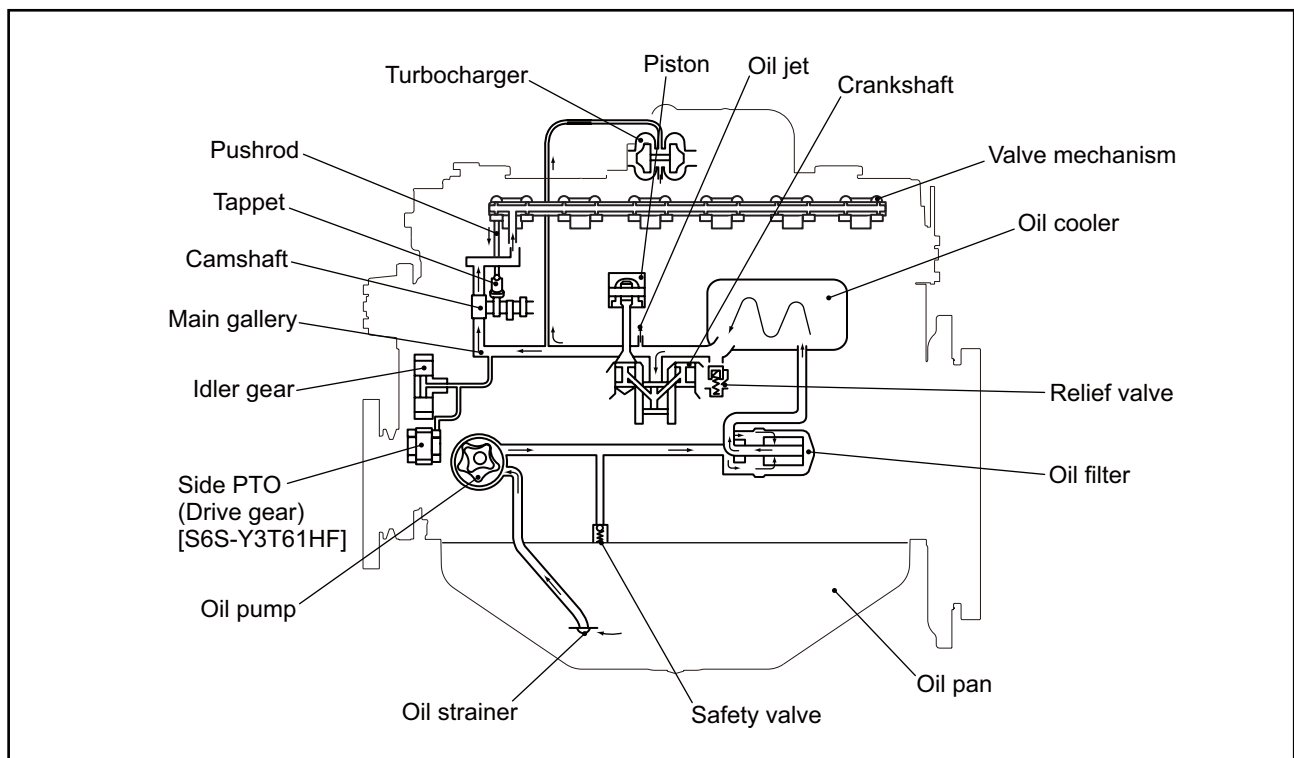
2. System flow diagrams

2.1 Fuel system - flow diagram



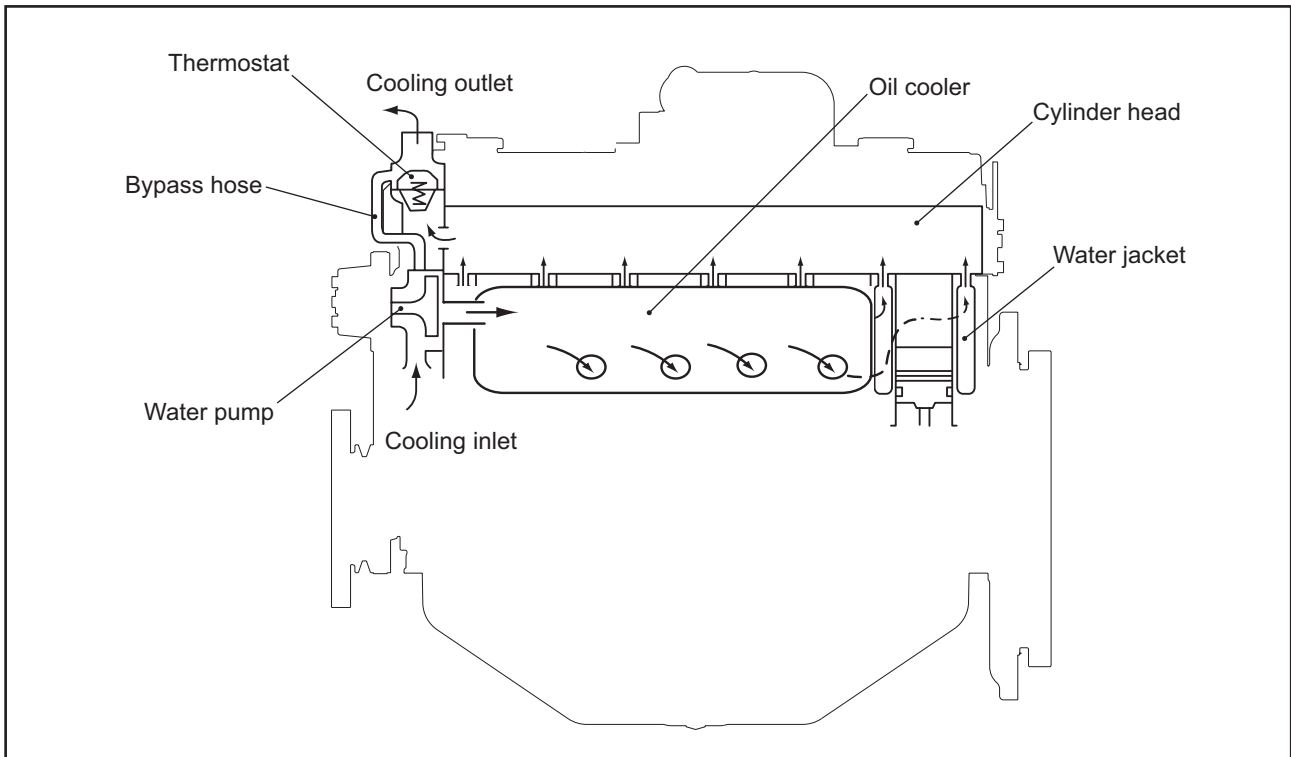
Fuel system - flow diagram

2.2 Lubrication system - flow diagram



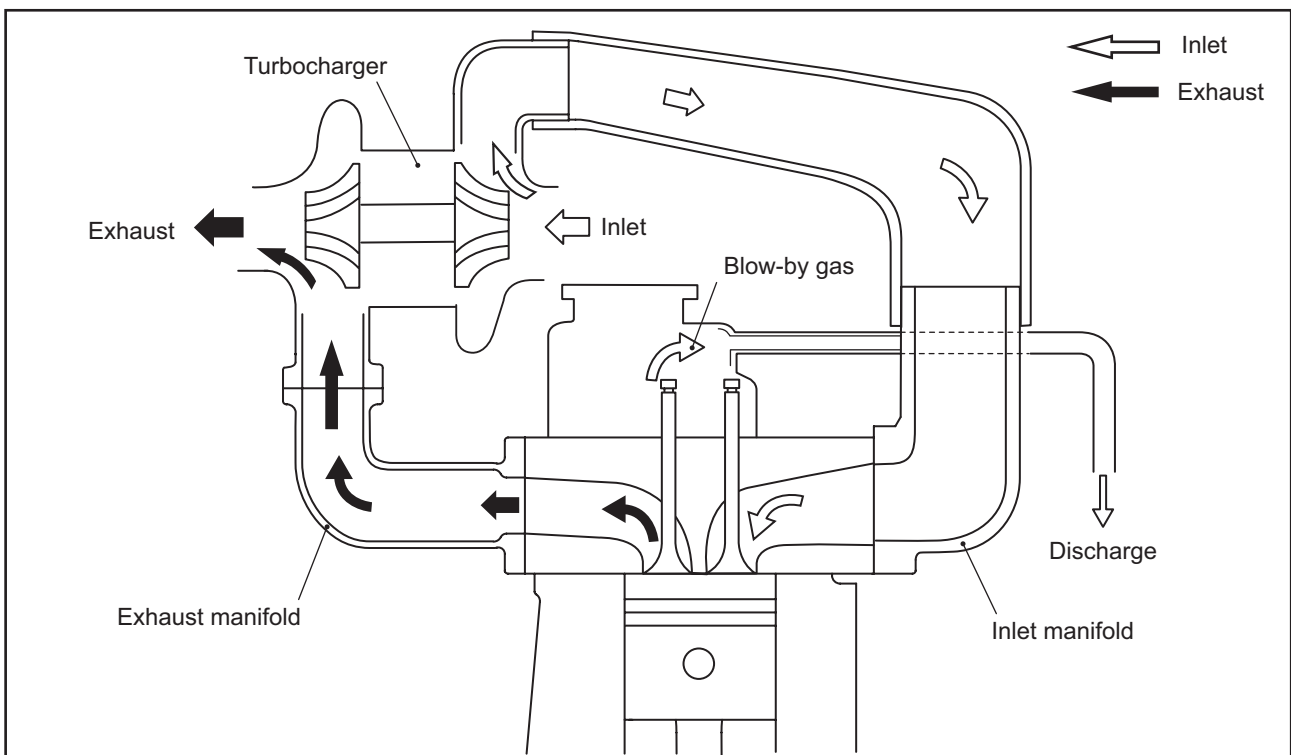
Lubrication system - flow diagram

2.3 Cooling system - flow diagram



Cooling system - flow diagram

2.4 Inlet and exhaust system - flow diagram

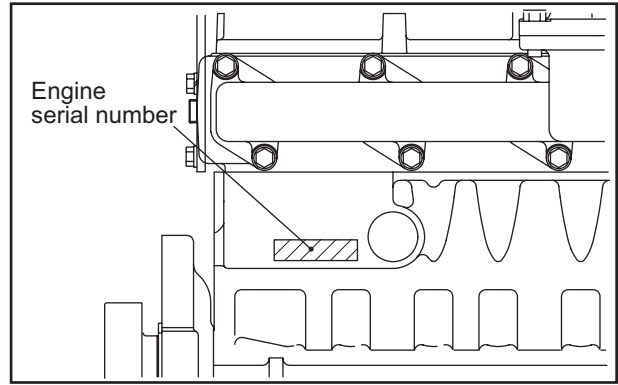


Inlet and exhaust system - flow diagram

GENERAL

3. Engine serial number location

The engine serial number is stamped on the right side of cylinder block.



Engine serial number location

4. Main specifications

Table 1-1 Main specifications (1 / 3)

Engine model				S6S-Y3T61HF		S6S-Y3T62HF	
Main specification	Type			Water cooled, 4 cycle diesel engine, turbocharged			
	No. of cylinders - arrangement			6 cylinder in-line			
	Combustion system			Swirl chamber type			
	Valve mechanism			Overhead			
	Cylinder bore × stroke			94 × 120 mm [3.70 × 4.72 in.]			
	Displacement			4.996 L [305 cu. in.]			
	Compression ratio			22.0 : 1			
	Fuel			ASTM diesel fuel oil No.2-D (JIS K2204 gas oil specification No.2 or 3)			
	Firing order			1 - 5 - 3 - 6 - 2 - 4			
	Direction of rotation			Counterclockwise when viewed from flywheel side			
	Dimensions (varies depending on the specifications)	Length		999 mm [39.33 in.]		908 mm [35.75 in.]	
		Width		617 mm [24.29 in.]		622 mm [24.49 in.]	
		Height		854 mm [33.62 in.]		839 mm [33.03 in.]	
Dry weight			350 kg [771.6 lb]				
Basic engine	Cylinder	Type		Dry (integral with cylinder block)			
	Piston ring	Number of rings		Compression rings: 2 Oil ring (w/expander): 1			
	Valve timing (when warm)	Inlet valve	Open	BTDC 18°			
			Close	ABDC 54°			
		Exhaust valve	Open	BBDC 66°			
			Close	ATDC 22°			
	Starting system			Electric			
	Starting aid system			Glow plug			
	Side PTO	Allowable torque		98 N·m {10 kgf·m} [72 lbf·ft]		-	
		Gear ratio		1 : 1		-	
Fuel system	Fuel injection pump	Type		Distribution (Bosch VE type)			
		Plunger diameter		ø 11 mm [0.43 in.]			
		Cam lift		1.741 mm [0.0685 in.]			
		Governor		Bosch, all speed type			
	Fuel injection nozzle	Nozzle type		Denso, throttle type			
		Number of spray holes		1			
		Spray hole diameter		ø 1.0 mm [0.039 in.]			
		Spray angle		0°			
		Valve opening pressure		11.77 MPa {120 kgf/cm²} [1706.80 psi]			
Fuel filter	Type		Cartridge type paper element				

GENERAL

Table 1-1 Main specifications (2 / 3)

Engine model			S6S-Y3T61HF	S6S-Y3T62HF
Lubrication system	Lubricating method		Forced circulation type (pressure feed by oil pump)	
	Engine oil	Standard	Class CF-4 oil SAE No.30 (API service classification)	
		Engine oil capacity	Engine total: approx. 16.5 L [4.36 U.S. gal.] (approx. 15.5 L [4.10 U.S. gal.] in oil pan)	
	Oil pump	Type	Trochoid	
		Speed ratio to crankshaft	0.74	
		Discharge capacity	38.7 L [10.22 U.S. gal.]/min (at pump rotation of 2230 min ⁻¹ , 0.3 MPa {3 kgf/cm ² } [42.67 psi])	
	Relief valve	Type	Piston valve type	
		Valve opening pressure	0.35 ± 0.05 MPa {3.5 ± 0.5 kgf/cm ² } [49.78 ± 7.11 psi]	
	Safety valve	Opening pressure	1.1 MPa {11 kgf/cm ² } [157 psi]	
	Oil cooler	Type	Plate type	
	Oil filter	Type	Cartridge type paper element	
Cooling system	Cooling method		Water-cooled, forced circulation	
	Coolant capacity (engine)		8 L [2.11 U.S. gal.]	
	Water pump	Type	Volute type centrifugal pump	
		Speed ratio to crankshaft	1.05	
		Discharge capacity	160 L [42.27 U.S. gal.]/min (at pump rotation of 3600 min ⁻¹ , 0.075 MPa {0.75 kgf/cm ² } [10.67 psi])	
	Cooling fan	Type	Pressure type	
		Diameter	ø 500 mm [19.69 in.]	
	Thermostat	Type	Wax type	
		Valve opening temperature	76.5 ± 2°C [169.7 ± 3.6°F] (90°C [194.0°F] when fully opened)	
Inlet and exhaust system	Turbocharger	Model number	TD06H	
		Qty	1	

Table 1-1 Main specifications (3 / 3)

Engine model			S6S-Y3T61HF	S6S-Y3T62HF
Electrical system	Voltage - polarity		24V - negative (-) ground	
	Starter	Model number	M008T60373	
		Pinion meshing type	Pinion shift	
		Output	24 V - 5 kW	
		Qty	1	
		Ring gear and pinion ratio	10/122	
	Alternator	Type	3-phase alternating current, with rectifier	
		Output	24 V - 35 A	
		Speed in use	to 8000 min ⁻¹	
		Rated generating speed	5000 min ⁻¹	
		Permissible speed	10000 min ⁻¹	
		Speed ratio to crankshaft	1.85	
	Glow plug	Type	Electric	
		Rated voltage - current	22 V - 4.4 A (15-second duration)	
	Magnetic valve (Stop solenoid)	Rated voltage	24 V	
		Power consumption	14 W	
		Starting voltage	13 V or below	
		Return voltage	5 V or more	
		Coil resistance	37 Ω	

GENERAL

5. Tips on disassembling and reassembling

This service manual specifies the recommended procedures to be followed when servicing Mitsubishi engines. The manual also specifies the special tools that are required for the work, and the basic safety precautions to follow when working.

Note that this manual does not exhaustively cover potential hazards that could occur during maintenance, inspection and service work of engine.

When working on an engine, follow the relevant directions given in this manual and observe the following instructions:

5.1 Disassembling

- (1) Use correct tools and instruments. Serious injury or damage to the engine will result from using the wrong tools and instruments.
- (2) Use an overhaul stand or work bench if necessary, and follow the disassembling procedures described in this manual.
- (3) Keep the engine parts in order of removal to prevent losing them.
- (4) Pay attention to assembling marks. Put your marks on the parts, if necessary, to ensure correct reassembling.
- (5) Carefully check each part for defects during disassembling or cleaning. Do not miss symptoms which can not be detected after disassembling or cleaning.
- (6) When lifting or carrying heavy parts, exercise utmost caution to ensure safety. Pay attention to balance of heavy parts when handling. (Get help, and use jacks, chain blocks and guide bolts as necessary.)

5.2 Reassembling

- (1) Wash all engine parts, except such parts as oil seals, O-rings and rubber sheets, in cleaning oil and dry them with compressed air.
- (2) Use correct tools and instruments.
- (3) Use only high-quality lubricating oils and greases of appropriate types. Be sure to apply oil, grease or adhesive to the part wherever specified.
- (4) Use a torque wrench to tighten parts correctly when their tightening torques are specified.
Refer to "Tightening torque table."
- (5) Replace all gaskets and packings with new ones unless specified otherwise. Apply adhesive if necessary. Use only the proper amount of adhesive.

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SERVICE DATA

1. Maintenance service data

1.1 General

Table 2-1 Maintenance service data table - General

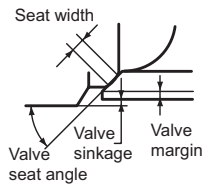
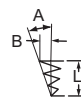
Unit: mm [in.]

Inspection point		Nominal	Standard	Limit	Remark
Maximum rotation speed (No-load)			2570 ± 50 min ⁻¹		
Minimum rotation speed (No-load)			820 ± 25 min ⁻¹		
Compression pressure (at 300 min ⁻¹)			3.2 MPa {33 kgf/cm ² } [469 psi] or more	2.8 MPa {29 kgf/cm ² } [412 psi] or less	When oil and water temperatures at 20 to 30°C [68 to 86°F]
Lubricating oil pressure	Rotated speed at 1500 min ⁻¹		0.3 to 0.5 MPa {3 to 5 kgf/cm ² } [43 to 71 psi]	0.15 MPa {1.5 kgf/cm ² } [21 psi] or less	Oil temperature at 60 to 70°C [140 to 158°F]
	Idling speed		0.10 MPa {1.0 kgf/cm ² } [14 psi] or more	0.05 MPa {0.5 kgf/cm ² } [7 psi] or less	
Valve timing	Inlet open		BTDC 18°		Values are only for checking valve timing and are different from the actual ones.
	Inlet closes		ABDC 54°		
	Exhaust open		BBDC 66°		
	Exhaust closes		ATDC 22°		
Valve clearance	Inlet		0.25 [0.0098]		When engine is cold
	Exhaust		0.25 [0.0098]		
Fuel injection timing (before TDC)			5°		

1.2 Basic engine

Table 2-2 Maintenance service data table - Basic engine (1 / 4)

Unit: mm [in.]

Inspection point			Nominal	Standard	Limit	Remark
Rocker	Rocker bushing inside diameter		ø 19 [0.75]	19.010 to 19.030 [0.7484 to 0.7492]		
	Rocker shaft outside diameter		ø 19 [0.75]	18.980 to 19.000 [0.7472 to 0.7480]		
	Clearance between rocker bushing and shaft			0.010 to 0.050 [0.0004 to 0.0020]	0.070 [0.0028]	
Valve and valve guide	Valve stem outside diameter	Inlet	ø 8 [0.31]	7.940 to 7.955 [0.3126 to 0.3132]	7.900 [0.3110]	
		Exhaust	ø 8 [0.31]	7.920 to 7.940 [0.3118 to 0.3126]	7.850 [0.3091]	
	Clearance between valve stem and guide	Inlet		0.065 to 0.095 [0.0026 to 0.0037]	0.150 [0.0059]	
		Exhaust		0.080 to 0.115 [0.0031 to 0.0045]	0.200 [0.0079]	
	Valve guide mounting dimension		14 [0.55]	13.9 to 14.1 [0.547 to 0.555]		
Valve seat	Valve seat angle		30°			
	Valve sinkage	Inlet	0.4 [0.016]	0.3 to 0.5 [0.012 to 0.020]	1.0 [0.039]	
		Exhaust	0.5 [0.020]	0.4 to 0.6 [0.016 to 0.024]	1.0 [0.039]	
	Seat width		1.4 [0.055]	1.26 to 1.54 [0.0496 to 0.0606]	1.8 [0.071]	
	Valve margin			2.13 [0.0839]	Refacing permissible up to 1.83 [0.0720]	
Valve spring	Free length			48.85 [1.9232]	47.60 [1.8740]	
	Perpendicularity			A = 1.5° or less B = 1.3 [0.051] or less Lf = 48.85 [1.9232]	B = 1.5 [0.059] at the end	
	Set length/set load			43 mm [1.69 in.]/ 176 to 196 N {18 to 20 kgf} [39 to 44 lbf]	43 mm [1.69 in.]/ 147 N {15 kgf} [33 lbf]	
Pushrod	Runout			0.6 [0.024] or less	0.6 [0.024]	Runout (dial gauge reading) when push rod is supported along center line of spherical surface at either end.
Cylinder head	Distortion of bottom face			0.05 [0.0020] or less	0.20 [0.0079]	Reface minimum thickness.
	Compressed thickness of gasket		1.2 [0.047]	1.20 ± 0.05 [0.0472 ± 0.0020]		
Cylinder	Inside diameter		ø 94 [3.70]	94.000 to 94.035 [3.7008 to 3.7022]	Repair limit: 94.200 [3.7087] Replace limit: 94.700 [3.7283]	Refinish cylinder to 0.25 [0.0098] or 0.50 [0.0197] oversize of nominal valve by honing. Use oversize piston and piston ring.
	Circularity			0.01 [0.0004] or less		
	Cylindricity			0.015 [0.0006] or less		

SERVICE DATA

Table 2-2 Maintenance service data table - Basic engine (2 / 4)

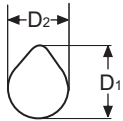
Unit: mm [in.]

Inspection point			Nominal	Standard	Limit	Remark
Piston	Outside diameter (at piston skirt)	STD	ø 94 [3.70]	93.955 to 93.985 [3.6990 to 3.7002]	93.770 [3.6917]	
		0.25 [0.0098]/OS		94.205 to 94.235 [3.7089 to 3.7100]	94.020 [3.7016]	
		0.50 [0.0197]/OS		94.455 to 94.485 [3.7187 to 3.7199]	94.270 [3.7114]	
	Protrusion from crankcase			-0.25 to 0.15 [-0.0098 to 0.0059]		Bearing clearance check.
	Weight difference in one engine			5 g [0.2 oz.] or less		
Piston ring	Clearance between piston ring groove	No.1 compression ring	2.5 [0.098]	0.07 to 0.11 [0.0028 to 0.0043]	0.200 [0.0079]	Use the piston with replacing the piston rings until reaching the limits. when reaching the limits, replace the piston.
		No.2 compression ring	2.0 [0.079]	0.045 to 0.085 [0.0018 to 0.0033]	0.150 [0.0059]	
		Oil ring	4.0 [0.157]	0.020 to 0.060 [0.0008 to 0.0024]	0.150 [0.0059]	
	Closed gap of ring	No.1 compression ring		0.30 to 0.50 [0.0118 to 0.0197]	1.50 [0.0591]	
		No.2 compression ring		0.50 to 0.70 [0.0197 to 0.0276]	1.50 [0.0591]	
		Oil ring		0.30 to 0.50 [0.0118 to 0.0197]	1.50 [0.0591]	
Piston pin	Outside diameter		ø 30 [1.18]	29.994 to 30.000 [1.1809 to 1.1811]		
	Clearance between piston pin			0.000 to 0.016 [0.0000 to 0.0006]	0.050 [0.0020]	
	Clearance between connecting rod bushing			0.020 to 0.091 [0.0008 to 0.0036]	0.120 [0.0047]	
Connecting rod	Bushing inside diameter		ø 30 [1.18]	30.020 to 30.045 [1.1819 to 1.1829]		
	Bend and twist			0.05/100 [0.0020/3.94] or less	0.15 [0.0059]	
	Clearance between crankpin and connecting rod bearing (oil clearance)			0.030 to 0.090 [0.0012 to 0.0035]	0.200 [0.0079]	Use connecting rod with replacing bearing until reaching the limit. when exceeding the limit, re-grinding the crankpin and replace the bearing with under size.
	End play		33 [1.30]	0.15 to 0.35 [0.0059 to 0.0138]	0.50 [0.0197]	Replace connecting rod.
	Weight difference of connecting rod assembly in one engine			10 g [0.35 oz.] or less		
Flywheel	Flatness			0.15 [0.0059] or less	0.50 [0.0197]	
	Runout			0.15 [0.0059] or less	0.50 [0.0197]	
Damper	Perpendicularity runout			0.5 [0.020] or less	1.5 [0.059]	Replace with a new one after operating 8000 hours.
	Periphery runout			0.5 [0.020] or less	1.5 [0.059]	

SERVICE DATA

Table 2-2 Maintenance service data table - Basic engine (3 / 4)

Unit: mm [in.]

Inspection point			Nominal	Standard	Limit	Remark
Camshaft	Runout			0.04 [0.0016] or less	0.10 [0.0039]	TIR
	Cam lift	Inlet	6.682 [0.2631]	6.382 to 6.782 [0.2513 to 0.2670]	6.182 [0.2434]	
		Exhaust	6.722 [0.2646]	6.422 to 6.822 [0.2528 to 0.2686]	6.222 [0.2450]	
	Journal outside diameter	No. 1, 2, 3	ø 54 [2.13]	53.94 to 53.96 [2.1236 to 2.1244]	53.90 [2.1220]	
		No.4	ø 53 [2.09]	52.94 to 52.96 [2.0842 to 2.0850]	52.90 [2.0827]	
	Clearance between camshaft journal and camshaft bushing			0.07 to 0.11 [0.0028 to 0.0043]	0.15 [0.0059]	Replace bushing if limit is exceeded. Reaming if necessary.
	End play		5 [0.20]	0.10 to 0.25 [0.0039 to 0.0098]	0.30 [0.0118]	Replace thrust plate.
Idler	Clearance between bushing and shaft			0.009 to 0.050 [0.0004 to 0.0020]	0.100 [0.0039]	
	Idler gear end play		30 [1.18]	0.05 to 0.20 [0.0020 to 0.0079]	0.35 [0.0138]	Replace thrust plate.
	Interference between shaft and crankcase hole		ø 35 [1.38]	0.035T to 0.076T [0.0014 to 0.0030]		
Timing gear backlash				0.05 to 0.15 [0.0020 to 0.0059]	0.25 [0.0098]	Replace gear.
Crankshaft	Crank journal outside diameter		ø 78 [3.07]	77.955 to 77.970 [3.0691 to 3.0697]	77.850 [3.0650] (Repair) 77.100 [3.0354] (Replace)	
	Crankpin outside diameter		ø 58 [2.28]	57.955 to 57.970 [2.2817 to 2.2823]	57.800 [2.2756]	
	Distance between centers of journal and crankpin		60 [2.36]	59.96 to 60.04 [2.3606 to 2.3638]		
	Parallelism between journal and crankpin			Pin maximum defection: 0.01 [0.0004] or less		
	Roundness of journals and crankpins			0.01 [0.0004] or less	0.03 [0.0012]	
	Cylindricity of journals and crankpins			0.01 [0.0004] or less	0.03 [0.0012]	
	Fillet radius of pin and journal		R3 [0.12]	2.8 to 3.2 [0.110 to 0.126]		
	Runout (TIR)			0.04 [0.0016] or less	0.10 [0.0039]	TIR
	End play		31 [1.22]	0.100 to 0.264 [0.0039 to 0.0104]	0.300 [0.0118]	Replace thrust plates before limit is reached. If limit is exceeded, use one of follow- ing oversize thrust plates; +0.25 [+0.0098], +0.50 [+0.0197], +0.75 [+0.0295]

SERVICE DATA

Table 2-2 Maintenance service data table - Basic engine (4 / 4)

Unit: mm [in.]

Inspection point		Nominal	Standard	Limit	Remark
Main bearing	Clearance between main bearing and crankshaft journal		0.050 to 0.110 [0.0020 to 0.0043]	0.200 [0.0079] crank journal outside diameter (ϕ 78 [3.0709]) -0.9 [-0.0354]	Replace bearings before limit is reached. Re grind crank journal and use next undersize bearings if limit is exceeded; -0.25 [-0.0098], -0.50 [-0.0197], -0.75 [-0.0295]
Crankcase	Flatness of top surface		0.05 [0.0020] or less	0.20 [0.0079]	Reface minimum thickness.
	Tappet guide hole inside diameter		14.000 to 14.018 [0.5512 to 0.5519]	14.100 [0.5551]	
	Clearance between tappet and tappet guide hole		0.016 to 0.052 [0.0006 to 0.0020]	0.08 [0.0031]	If the diameter is the limit or more, replace tappet.

1.3 Fuel system

Table 2-3 Maintenance service data table - Fuel system

Unit: mm [in.]

Inspection point		Nominal	Standard	Limit	Remark
Fuel injection nozzle	Valve opening pressure	11.77 MPa {120 kgf/cm ² } [1707 psi]	11.77 to 12.75 MPa {120 to 130 kgf/cm ² } [1707 to 1849 psi]		Make shim adjustment. Pressure varies by 1 MPa {10 kgf/cm ² } [142 psi] per 0.1 [0.004] thickness of shim.
	Spray cone angle	0°			Check nozzle with a hand tester (at fuel oil temperature 20°C [68°F]). Replace the nozzle tip if the spray pattern is still bad after washing in clean fuel oil.
	Nozzle valve seat oil sealing	Seat shall hold a test pressure lower than valve opening pressure by 2 MPa {20 kgf/cm ² } [285 psi] for 10 seconds.			Wash in clean fuel oil or replace nozzle tip.

1.4 Lubrication system

Table 2-4 Maintenance service data table - Lubrication system

Unit: mm [in.]

Inspection point		Nominal	Standard	Limit	Remark
Oil pump	Clearance between outer rotor and case		0.20 to 0.30 [0.0079 to 0.0118]	0.50 [0.0197]	Replace pump assembly.
	Main shaft outside diameter (between case)	ϕ 16 [0.63]	15.985 to 16.000 [0.6293 to 0.6299]		
	Main shaft outside diameter (between oil pump bushing)	ϕ 14 [0.55]	13.957 to 13.975 [0.5495 to 0.5502]		
	Clearance between main shaft and pump case		0.032 to 0.074 [0.0013 to 0.0029]	0.150 [0.0059]	Replace pump case or replace pump assembly.
	Clearance between main shaft and oil pump bushing		0.025 to 0.111 [0.0010 to 0.0044]	0.200 [0.0079]	Replace oil pump bushing or replace pump assembly.
	Clearance between inner rotor and outer rotor		0.13 to 0.15 [0.0051 to 0.0059]	0.20 [0.0079]	Replace outer rotor and shaft assembly.
	Rotor and case end play		0.04 to 0.09 [0.0016 to 0.0035]	0.15 [0.0059]	Replace pump assembly.
Relief valve	Valve opening pressure	0.35 MPa {3.6 kgf/cm ² } [51.20 psi]	0.35 $\pm$ 0.05 MPa {3.5 $\pm$ 0.5 kgf/cm ² } [49.78 $\pm$ 7.11 psi]		
Safety valve	Valve opening pressure		1.1 MPa {11 kgf/cm ² } [157 psi]		

1.5 Cooling system

Table 2-5 Maintenance service data table - Cooling system

Unit: mm [in.]

Inspection point		Nominal	Standard	Limit	Remark
Thermostat	Temperature at which valve starts opening		76.5 ± 1.5°C [170 ± 3.5°F]		
	Temperature at which valve lift is 9 [0.35], minimum		90 ± 1.5°C [194 ± 2.7°F]		

1.6 Inlet and exhaust system

Table 2-6 Maintenance service data table - Inlet and exhaust system

Unit: mm [in.]

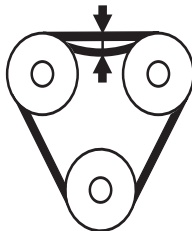
Inspection point		Nominal	Standard	Limit	Remark
Distortion of exhaust manifold			0.2 [0.008] or less		Repair by grinding or replace.
Axial clearance of cartridge assembly			0.057 to 0.103 [0.0022 to 0.0041]		

SERVICE DATA

1.7 Electrical system

Table 2-7 Maintenance service data table - Electrical system

Unit: mm [in.]

Inspection point			Nominal	Standard	Limit	Remark
Starter	Commutator	Outside diameter	ø 32 [1.26]		31.4 [1.236]	
		Runout		0.05 [0.0020] or less	0.10 [0.0039]	
		Undercut depth		0.4 to 0.6 [0.016 to 0.024]	0.2 [0.008]	
	Brush length			18 [0.71]	11 [0.43]	
	Tension of brush springs		34 N {3.5 kgf} [7.7 lbf]	29.4 to 39.4 N {3.0 to 4.0 kgf} [6.6 to 8.8 lbf]	13.7 N {1.4 kgf} [3.1 lbf]	
	No-load characteristics	Voltage		23 V		
		Armature current		85 A or less		
		Rotational speed		3300 min ⁻¹ or more		
	Load characteristics	Voltage		9 V		
		Armature current		1400 A or less		
		Torque		88.26 N·m {9.0 kgf·m} {65 lbf·ft} or more		
Alternator	Regulator adjusting voltage (alternator 5000 min ⁻¹ , load at 5 A or lower)			28.5 × 0.5 V		
	Resistance between slip rings			9.0 to 10.4 Ω		at 20°C [68°F]
	Brush spring tension			5.8 to 7.0 N {590 to 710 gf} [1.3 to 1.6 lbf]	3.2 N {330 gf} [0.7 lbf]	
	Brush length			21.5 [0.85]	8 [0.31]	
Glow plug	Rated voltage			DC22 V		(When applying the rated voltage for 15 seconds.)
	Armature current			4.4 ^{+0.3} _{-0.7} A		
Magnetic valve	Resistance value			37 to 41 Ω		Ambient temperature: 23 ± 5°C [73.4 ± 9°F])
V-belt	Deflection			8 [0.31]		When center of belt pressed at approx. 98 N {10 kgf} [22 lbf] 

2. Tightening torque table

2.1 Major bolt tightening torque

2.1.1 Basic engine

Table 2-8 Tightening torque table - Basic engine

Description	Threads Dia × Pitch (mm)	Torque			Remark
		N·m	kgf·m	lbf·ft	
Cylinder head	12 × 1.75	118 ± 5	12 ± 0.5	87 ± 3.6	
Cylinder head plug	16 × 1.5	44.1 ± 5	4.5 ± 0.5	32.5 ± 3.6	
Rocker cover	8 × 1.25	11.3 ± 1.5	1.15 ± 0.15	8.5 ± 1.1	
Rocker shaft bracket (long)	8 × 1.25	17.5 ± 2.5	1.75 ± 0.25	12.7 ± 1.8	
Main bearing cap	14 × 2.0	103 ± 5	10.5 ± 0.5	76 ± 3.6	[Wet]
Connecting rod cap	10 × 1.25	54 ± 5	5.5 ± 0.5	40 ± 3.6	
Flywheel	12 × 1.25	83.4 ± 4.9	8.5 ± 0.5	61.5 ± 3.6	
Camshaft thrust plate	8 × 1.25	11.5 ± 1.5	1.15 ± 0.15	8.3 ± 1.1	
Front plate	8 × 1.25	11.3 ± 1.5	1.15 ± 0.15	8.3 ± 1.1	
Timing gear case cover	8 × 1.25	18.5 ± 1.5	1.85 ± 0.15	13.4 ± 1.1	
Crankshaft pulley	30 × 1.5	490 ± 10	50 ± 1	362 ± 7.2	
Idler thrust plate	10 × 1.25	34 ± 5	3.5 ± 0.5	25 ± 3.6	
Rear plate	10 × 1.25	56 ± 5.9	5.7 ± 0.6	41.2 ± 4.3	
Rocker adjusting nut	8 × 1.25	20 ± 2	2 ± 0.2	14.5 ± 1.4	

Note: When [Wet] is indicated, apply engine oil to the threads and bearing surfaces of the bolts and nuts.

2.1.2 Fuel system

Table 2-9 Tightening torque table - Fuel system

Description	Threads Dia × Pitch (mm)	Torque			Remark
		N·m	kgf·m	lbf·ft	
Fuel injection nozzle (engine)	20 × 1.5	58.8 ± 5.9	6 ± 0.6	43.4 ± 4.3	
Fuel injection nozzle retaining nut	16 × 0.75	36.8 ± 2.5	3.75 ± 0.25	27.1 ± 1.8	
Fuel injection pump gear	12 × 1.75	63.7 ± 5	6.5 ± 0.5	47 ± 3.6	
Fuel injection pump over flow valve	-	17.5 ± 2.5	1.75 ± 0.25	12.7 ± 1.8	
Fuel injection pipe nut	12 × 1.5	29.4 ± 2.9	3 ± 0.3	21.7 ± 2.2	
Fuel return pipe nut	10 × 1.25	19.6 ± 1.9	2 ± 0.2	14.5 ± 1.4	
Fuel filter drain plug	14 × 1.0	2 ± 0.5	0.2 ± 0.05	1.4 ± 0.4	
Fuel filter cartridge	20 × 1.5	15 ± 3	1.5 ± 0.3	10.8 ± 2.2	
Fuel filter water level sensor	36 × 1.5	5 ± 1	0.5 ± 0.1	3.6 ± 0.7	
Fuel leak off pipe mounting nut	12 × 1.5	22.6 ± 1.9	2.3 ± 0.2	16.6 ± 1.4	

SERVICE DATA

2.1.3 Lubrication system

Table 2-10 Tightening torque table - Lubrication system

Description	Threads Dia × Pitch (mm)	Torque			Remark
		N·m	kgf·m	lbf·ft	
Oil pan	8 × 1.25	11.3 ± 1.5	1.15 ± 0.15	8.3 ± 1.1	
Oil pan drain plug	20 × 1.5	78 ± 5	8 ± 0.5	57.9 ± 3.6	
Oil pump gear	10 × 1.25	33 ± 5	3.4 ± 0.5	24.6 ± 3.6	
Oil pressure relief valve	22 × 1.5	49 ± 4.9	5 ± 0.5	36.2 ± 3.6	
Safety valve	18 × 2.0	69 ± 5	7 ± 0.5	50.6 ± 3.6	

2.1.4 Cooling system

Table 2-11 Tightening torque table - Cooling system

Description	Threads Dia × Pitch (mm)	Torque			Remark
		N·m	kgf·m	lbf·ft	
Thermostat case	8 × 1.25	18.1 ± 1.5	1.85 ± 0.15	13.4 ± 1.1	
Water drain plug	1/4-18NPTF	39.2 ± 3.9	4 ± 0.4	28.9 ± 2.9	
Water pump mounting bolt	8 × 1.25	9.8 ± 1	1 ± 0.1	7.2 ± 0.7	
	8 × 1.25	18.1 ± 3.4	1.85 ± 0.35	13.4 ± 2.5	
Water pump plug	R3/8	32.4 ± 2	3.3 ± 0.2	23.9 ± 1.4	

2.1.5 Inlet and exhaust systems

Table 2-12 Tightening torque table - Inlet and exhaust systems

Description	Threads Dia × Pitch (mm)	Torque			Remark
		N·m	kgf·m	lbf·ft	
Exhaust manifold	8 × 1.25	18.1 ± 3.4	1.85 ± 0.35	13.4 ± 2.5	
Turbo oil feed eye bolt	10 × 1.25	16.2 ± 2.5	1.65 ± 0.25	11.9 ± 1.8	
Clamp	-	4 ± 0.5	0.41 ± 0.05	3.0 ± 0.37	
Coupling assembly	6 × 1.0	8.3 ± 0.5	0.85 ± 0.05	6.1 ± 0.4	

2.1.6 Electrical system

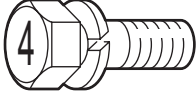
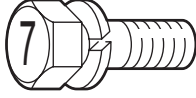
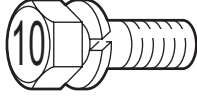
Table 2-13 Tightening torque table - Electrical system

Description	Threads Dia × Pitch (mm)	Torque			Remark
		N·m	kgf·m	lbf·ft	
Starter terminal B	8 × 1.25	10.8 ± 1	1.1 ± 0.1	8 ± 0.7	
Alternator pulley	20 × 1.5	147 ± 15	15 ± 1.5	108.4 ± 11.1	
Glow plug (Engine body)	10 × 1.25	17.5 ± 2.5	1.75 ± 0.25	12.7 ± 1.81	
Glow plug (terminal)	4 × 0.7	1.25 ± 0.25	0.13 ± 0.03	0.94 ± 0.2	
Magnetic valve assembly	24 × 1	20 ± 5	2 ± 0.5	15 ± 3.6	

2.2 Standard bolt and nut tightening torque

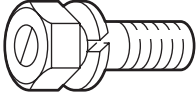
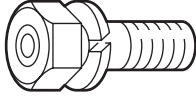
2.2.1 Metric automobile screw thread

Table 2-14 Metric automobile screw thread

Threads Dia × Pitch (mm)	Width across flats (mm) [in.]	Strength classification								
		4T			7T			10.9		
										
		N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft
M6 × 1.0	10 [0.39]	3.9	0.4	2.9	8.8	0.9	6.5	12.7	1.3	9.4
M8 × 1.25	12 [0.47]	11.8	1.2	8.7	18	1.9	13	30	3.1	22
M10 × 1.25	14 [0.55]	21.1	2.15	16	35	3.6	26	60	6.1	44
M12 × 1.25	17 [0.67]	35.3	3.6	26	64	6.5	47	108	11.0	80

2.2.2 Metric course screw thread

Table 2-15 Metric course screw thread

Threads Dia × Pitch (mm)	Width across flats (mm) [in.]	Strength classification					
		7T			10.9		
							
		N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft
M10 × 1.5	14 [0.55]	32	3.3	24	58	5.9	43
M12 × 1.75	17 [0.67]	57	5.8	42	102	10.4	75

Note: (a) This table lists the tightening torque for standard bolts and nuts.

(b) The numerical values in the table are for fasteners with spring washers.

(c) The table shows the standard values with a maximum tolerance value of $\pm 10\%$.

(d) Use the tightening torque in this table unless otherwise specified.

(e) Do not apply oil to threaded portions. (Dry)

2.3 Standard stud tightening torque

Table 2-16 Standard stud tightening torque

Threads Dia × Pitch (mm)	For driving in aluminum materials			For driving in ferrous materials		
	N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft
M8 × 1.25	5.4 ± 0.5	0.55 ± 0.05	4.0 ± 0.4	13.7 ± 1.0	1.4 ± 0.1	10.1 ± 0.7
M10 × 1.25	12.7 ± 1.0	1.3 ± 0.1	9.4 ± 0.7	23.5 ± 2.0	2.4 ± 0.2	17.4 ± 1.4

SERVICE DATA

3. Regarding submission of parts for EPA exhaust gas regulation

CAUTION

When replacing parts, be sure to use OEM designated parts.

If OEM parts are not used, the exhaust emission's warranty be voided.

New parts may be updated due to improvement.

Fuel and exhaust system repairs should only be conducted by an authorized Mitsubishi forklift truck dealer. Tampering or adjusting the fuel system components will void the warranty and could be in violation of the EPA regulations.

The fuel injection pump is an emission control device. Components inside the pump are specifically calibrated to meet the engine emissions requirements and should never be disassembled or rebuilt.

If the pump fails to operate, replace the assembly with an OEM replace part.

The following parts have been submitted in accordance with EPA emission regulation.

- (1) Fuel injection assembly
- (2) Fuel injection nozzle
- (3) Turbocharger assembly
- (4) Other related parts (including designated fuel and lubricant)

SERVICE TOOLS

1. Special tool.....3-2

SERVICE TOOLS

1. Special tool

Table 3-1 Special tool list (1 / 3)

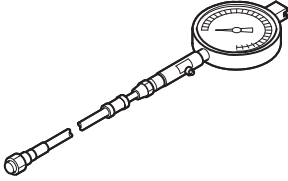
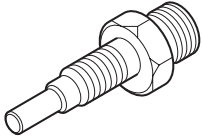
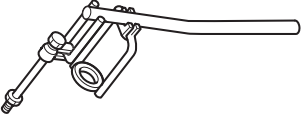
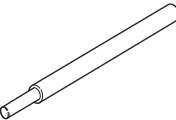
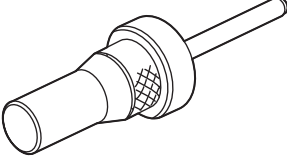
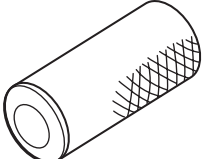
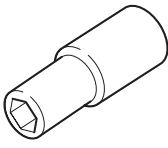
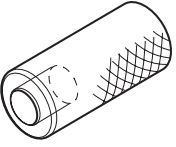
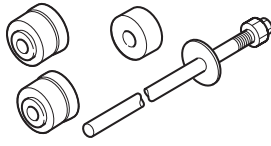
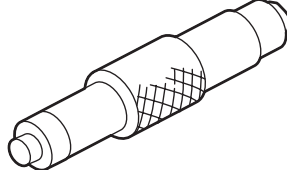
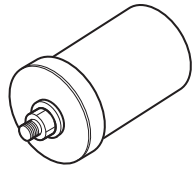
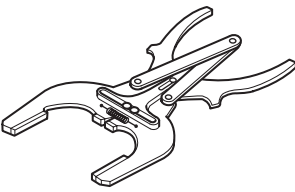
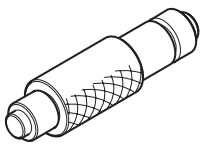
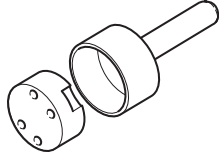
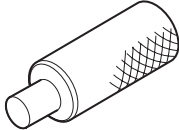
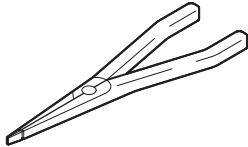
Tool name	Part No.	Shape	Use
Compression gauge	33391-02100		Engine compression pressure measuring 0 to 7 MPa {0 to 71.4 kgf/cm ² } [0 to 1015.54 psi]
Gauge adapter	30691-21100		Engine compression pressure measuring
Socket	58309-73100		Engine turning
Valve spring pusher	30691-04500		Valve spring removal/installation
Valve guide remover	32A91-00300		Valve guide removal
Valve sheet insert caulking tool	Inlet: 36791-00200 Exhaust: 34491-03020		Valve seat installation
Stem seal installer	32A91-10200		Stem seal installation

Table 3-1 Special tool list (2 / 3)

Tool name	Part No.	Shape	Use
Socket	34491-00300		Camshaft, thrust plate and rocker bracket installation
Valve guide installer	32A91-00100		Valve guide installation
Camshaft bushing installer set	30691-00010		Camshaft bushing removal/installation
Idler bushing installer	30091-07300		Idler bushing removal/installation
Idler shaft puller	MH061077		Idler shaft removal
Piston ring pliers	31391-12900		Piston ring removal/installation
Connecting rod bushing puller	32A91-00500		Connecting rod bushing removal/installation

SERVICE TOOLS

Table 3-1 Special tool list (3 / 3)

Tool name	Part No.	Shape	Use
Oil seal sleeve installer guide set	30691-13010		Oil seal sleeve installation of crankshaft rear side
Piston installer	34491-00200		Piston installation
Oil pump bushing installer	32A91-00400		Oil pump bushing installation
Ring pliers	49160-90101		Snap ring removal/installation

DETERMINATION OF OVERHAUL

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DETERMINATION OF OVERHAUL

1. Determining overhaul timing

In most cases, the engine should be overhauled when the compression pressure of the engine becomes low. An increase in engine oil consumption and blow-by gas are also considered to evaluate the engine condition. Besides, such symptoms as a decrease in output, increase in fuel consumption, decrease in oil pressure, difficulty of engine starting and increase in noise are also considered for judging the overhaul timing, although those symptoms are often affected by other causes, and are not always effective to judge the overhaul timing. Decreased compression pressure shows a variety of symptoms and engine conditions, thus making it difficult to accurately determine when the engine needs an overhaul. The following shows typical problems caused by reduced compression pressure.

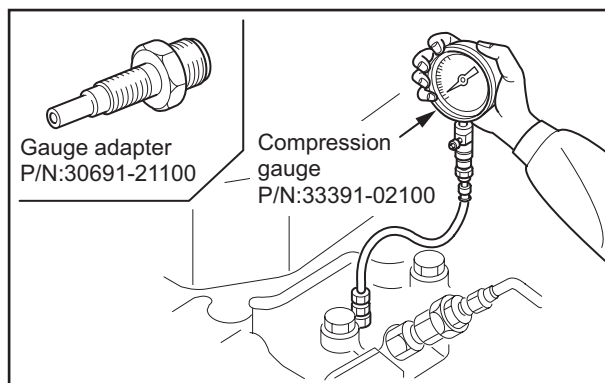
- (1) Decreased output power
- (2) Increased fuel consumption
- (3) Increased engine oil consumption
- (4) Increased blow-by gas through the breather due to worn cylinder liners and piston rings (Visually check the blow-by amount)
- (5) Increased gas leakage due to poor seating of inlet and exhaust valves
- (6) Difficulty in starting
- (7) Increased noise from engine parts
- (8) Abnormal exhaust color after warm-up operation

The engine can exhibit these conditions in various combinations. Some of these problems are directly caused by worn engine parts, while others are not. Phenomena described in items (2) and (6) will result from improper fuel injection volume, fuel injection timing, worn plunger, faulty nozzles and also faulty conditions of electrical devices such as battery and starter. The most valid reason to overhaul an engine is a decrease in compression pressure due to worn cylinder liners and pistons, as described in item (4). In addition to this item, it is reasonable to take other problems into consideration for making the total judgement.

2. Testing compression pressure

CAUTION

- (a) Be sure to measure the compression pressure for all the cylinders. It is not a good practice to measure the compression pressure for only one cylinder, and presume the compression for the remaining cylinders.
 - (b) Also be sure to check engine speed when measuring the compression pressure, as compression pressure varies with engine speed.
 - (c) Measuring the compression pressure at regular intervals is important to obtain correct data.
 - (d) The compression pressure will be slightly higher in a new or overhauled engine due to new piston rings, valve seats, etc. Pressure will drop gradually by the wear of these parts.
 - (e) Turn off the solenoid valve to stop fuel injection.
- (1) Remove the glow plug from the cylinder head where the compression pressure is to be measured.
 - (2) Attach the compression gauge adapter to the glow plug mount and connect compression gauge.
 - (3) Crank the engine with the starter, then read the compression gauge indication while the engine is running at the specified speed.
 - (4) If the compression pressure is lower than the limit, overhaul the engine.



Testing compression pressure

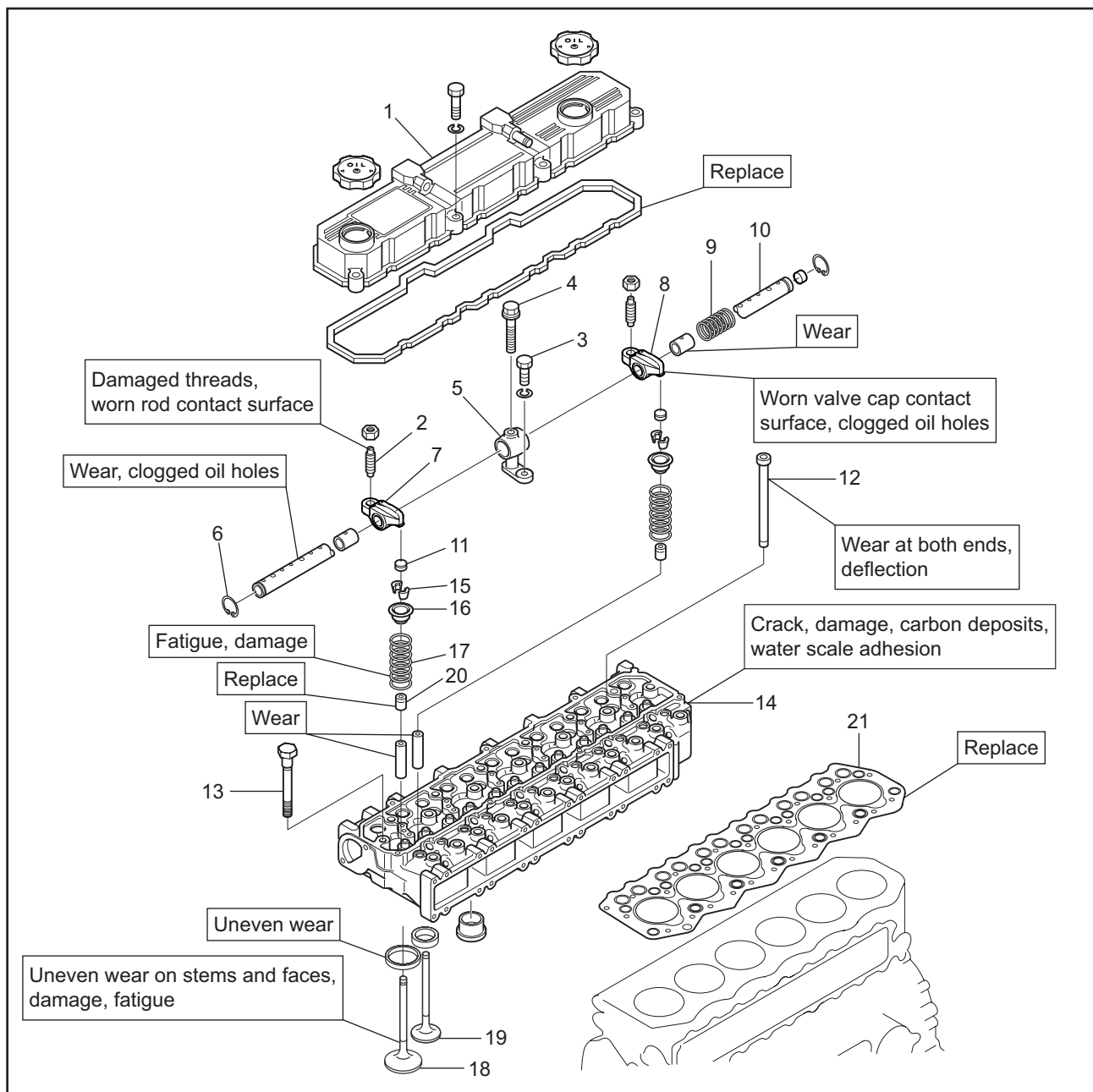
Item	Standard	Limit
Compression pressure	3.2 MPa { 33 kgf/cm ² } [469 psi] or more	2.8 MPa { 29 kgf/cm ² } [412 psi] or less
Engine speed	300 min ⁻¹	-
Oil and water temperatures	20 to 30°C [68 to 86°F]	-

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DISASSEMBLY OF BASIC ENGINE

1. Disassembling and inspecting cylinder head and valve mechanism



Disassembling and inspecting cylinder head and valve mechanism

Disassembling sequence

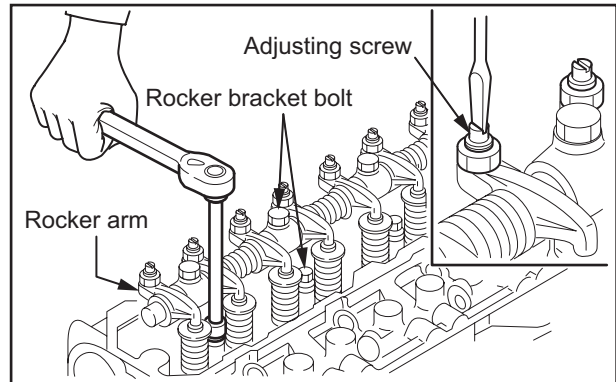
- | | | |
|------------------------|-----------------------|-------------------------|
| 1 Rocker cover | 8 Rocker arm (EX) | 15 Valve cotter |
| 2 Adjusting screw | 9 Rocker shaft spring | 16 Valve retainer |
| 3 Bolt (short) | 10 Rocker shaft | 17 Valve spring |
| 4 Bolt (long) | 11 Valve cap | 18 Valve (IN) |
| 5 Rocker shaft bracket | 12 Push rod | 19 Valve (EX) |
| 6 Snap ring | 13 Cylinder head bolt | 20 Valve stem seal |
| 7 Rocker arm (IN) | 14 Cylinder head | 21 Cylinder head gasket |

1.1 Removing rocker shaft assembly

⚠ CAUTION

Always loosen shorter bolts first. Failing to do so may cause the damage to the rocker shaft bracket.

- (1) Loosen the rocker arm adjusting screws by rotating about one turn.
- (2) Loosen the shorter rocker bracket bolts first.
- (3) Then, loosen the longer rocker bracket bolts.
- (4) Remove the rocker bracket bolts, and remove the rocker shaft assembly from the cylinder head.
- (5) Remove push rods.



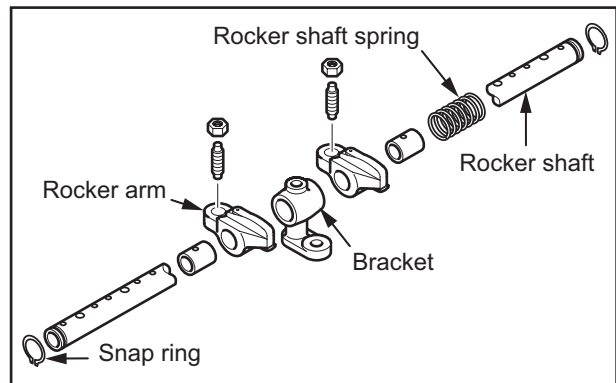
Removing rocker shaft assembly

1.2 Disassembling rocker shaft assembly

Remove the snap ring, disassemble the rocker shaft assembly into the rocker arms, brackets, rocker shaft springs and rocker shaft.

Note: (a) Be sure to arrange the parts of rocker shaft assembly in the order of disassembly. Reassemble the rocker shaft assembly in the reverse order of disassembly by making sure of the original combination of rocker arm and shaft assembly so that the same clearance between the rocker shaft and arms is restored when reassembling.

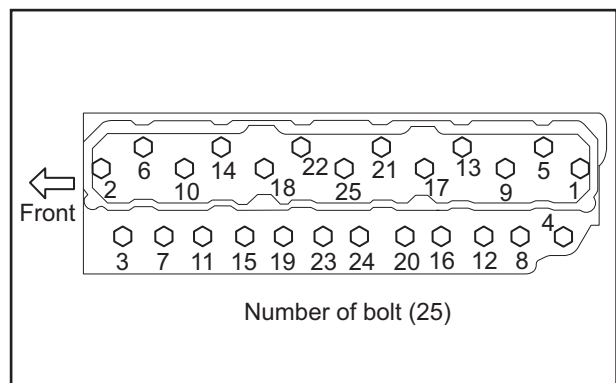
- (b) Do not remove the rocker bushing if it is not faulty, and its inside diameter does not exceed the limit.



Disassembling rocker shaft assembly

1.3 Removing cylinder head bolt

Loosen cylinder head bolts in the numerical order as shown in the illustration.



Removing cylinder head bolt

DISASSEMBLY OF BASIC ENGINE

1.4 Removing cylinder head assembly

CAUTION

When removing the cylinder head gasket, be careful not to damage the cylinder head or crankcase surface with tools such as a screwdriver.

- (1) Remove the cylinder head bolt.
- (2) Remove the cylinder head assembly by lifting it up.

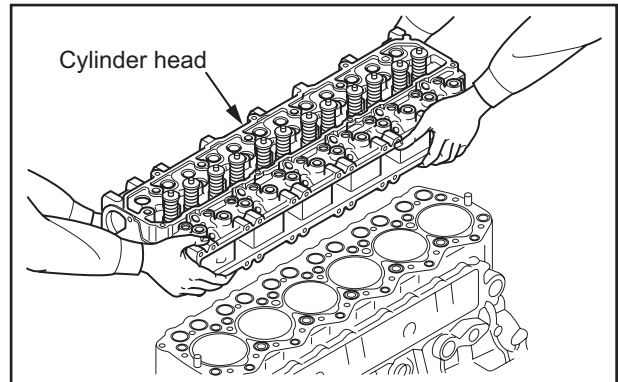
Note: If the cylinder head assembly cannot be removed due to crimping of the cylinder head gasket, tap the thick area on the side of the cylinder head using a plastic hammer to give a shock.

Do not lift up the cylinder head by one person.

Use crane or lift up by two persons.

- (3) Remove the gasket from the cylinder head.

Note: If there is a cylinder head problem, check the bolts for tightness with a torque wrench before removing the cylinder head bolts.

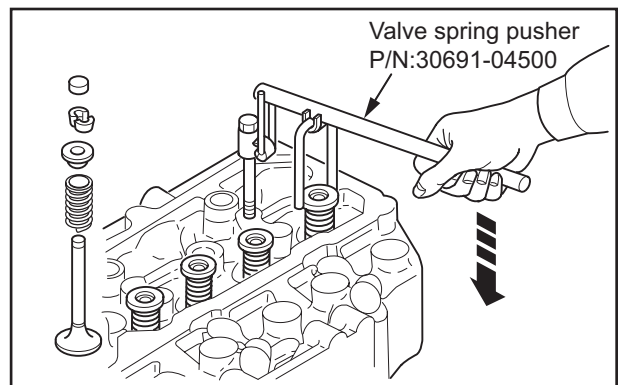


Removing cylinder head assembly

1.5 Removing valve and valve spring

Using a valve spring pusher, compress the valve spring evenly and remove the valve cotters.

Note: If valves are reusable, mark each valve seat and the mating valve for identifying their original positions.
Do not mix valve seats with other valve.

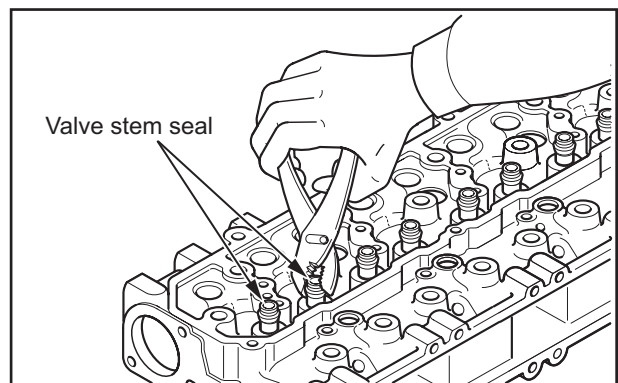


Removing valve and valve spring

1.6 Removing valve stem seal

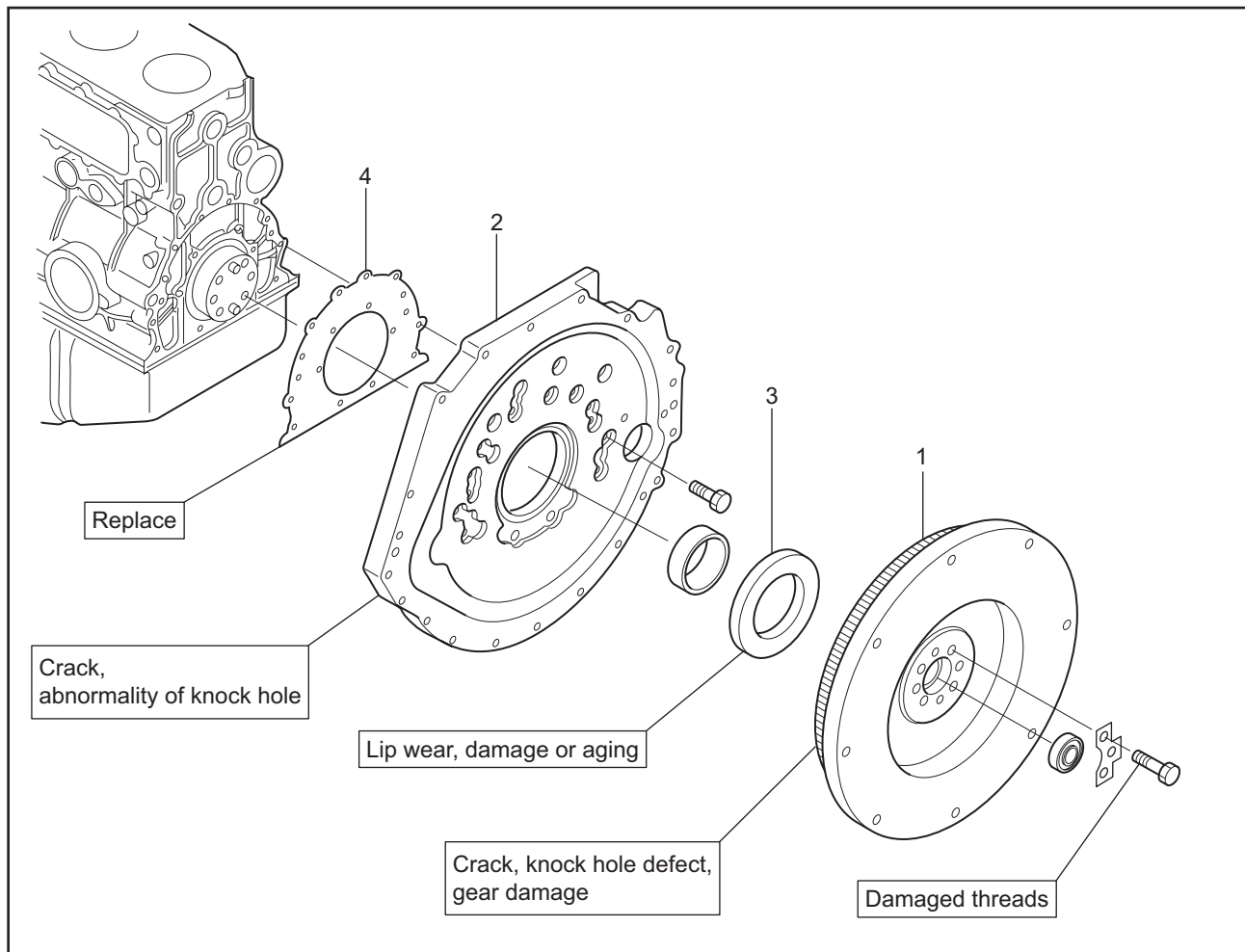
Grab the valve stem seal with pliers and remove.

Note: Be sure to replace the valve stem seal with a new one when reassembling the valve and valve spring.



Removing valve stem seal

2. Disassembling and inspecting flywheel



Disassembling and inspecting flywheel

Disassembling sequence

1 Flywheel

2 Rear plate

3 Oil seal

4 Gasket

DISASSEMBLY OF BASIC ENGINE

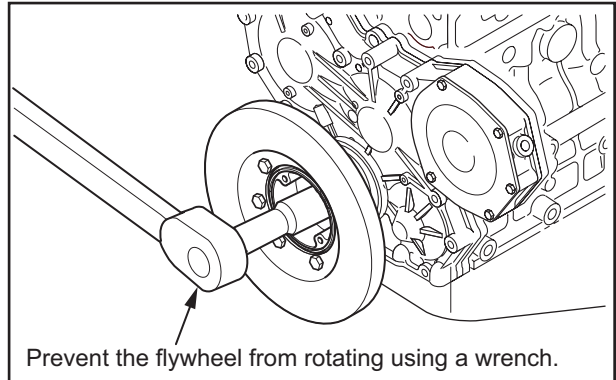
2.1 Removing flywheel

CAUTION

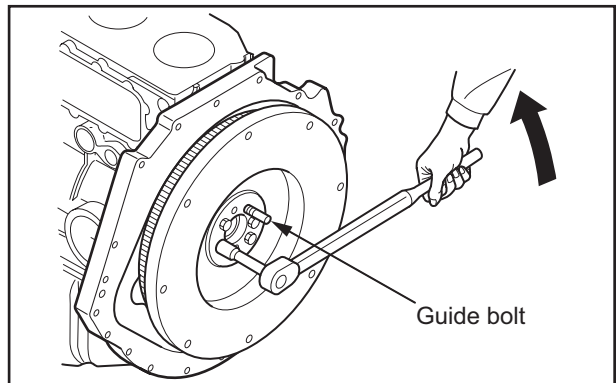
- (a) Be careful not to cut yourself with the ring gear when pulling out the flywheel.
Be careful not to drop or hit the flywheel when removing.
- (b) The person who holds the pulley must be very careful to assure safety by communicating with the person who is removing the flywheel.

- (1) One personnel must firmly hold the pulley with a wrench to prevent the flywheel from turning.
- (2) Remove one bolt from the flywheel.
- (3) Screw a guide bolt into the threaded hole of the bolt that has been removed.
- (4) Remove remaining bolts from the flywheel.
- (5) Hold the flywheel firmly with both hands, and while moving it back and forth, pull it out straight.

Note: The ring gear is shrink fitted to the flywheel. Do not remove the ring gear unless it is defective.



Locking the flywheel



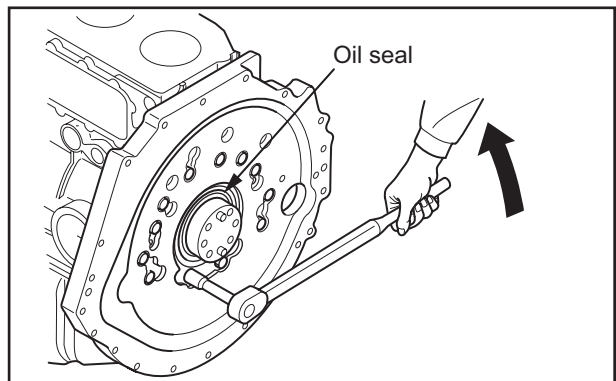
Removing flywheel

2.2 Removing rear plate

CAUTION

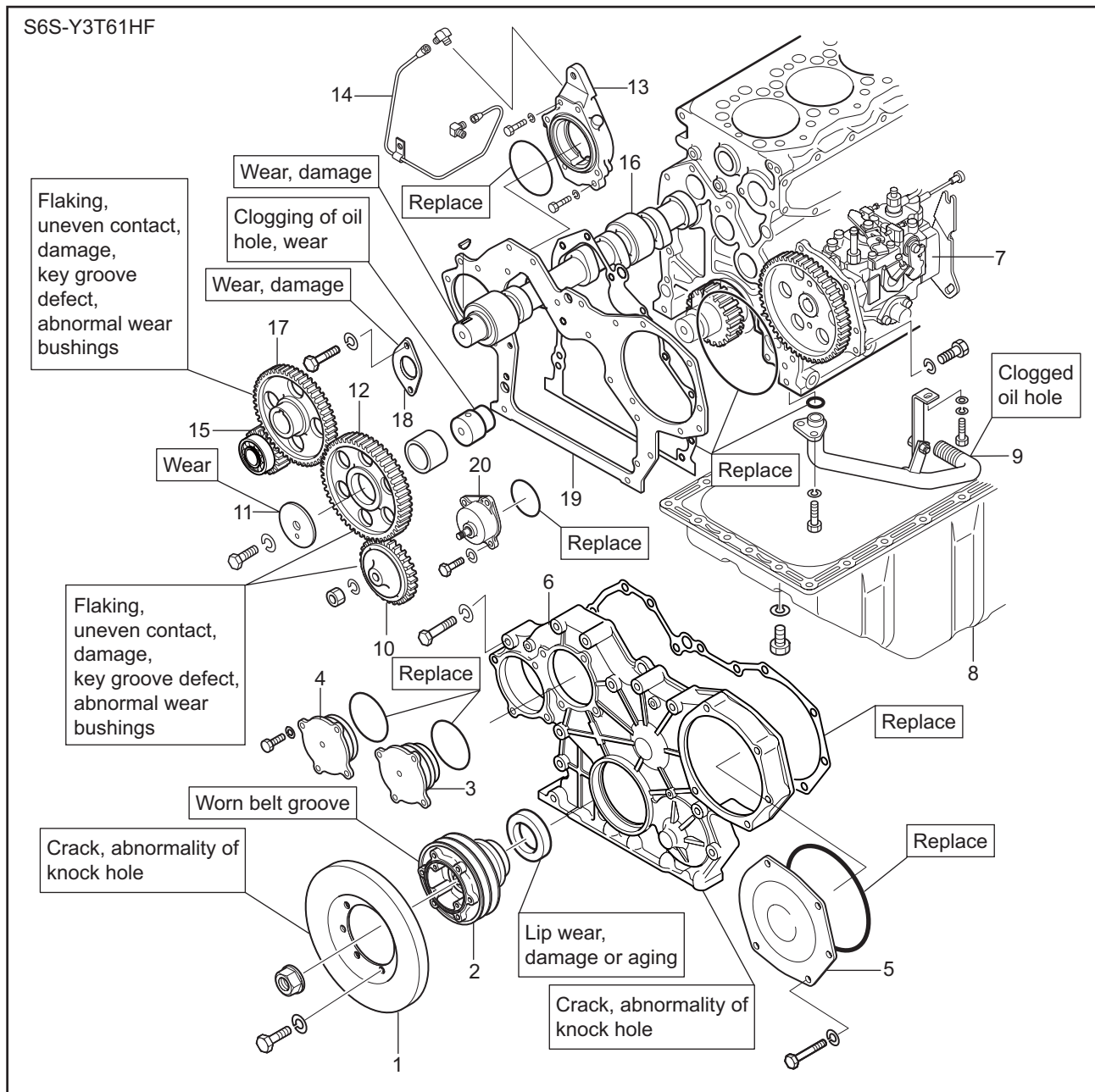
Be very careful not to damage the oil seal.

Remove the rear plate mounting bolts, and remove the rear plate using a guide bolt.



Removing rear plate

3. Disassembling and inspecting damper, gear case, timing gear and camshaft



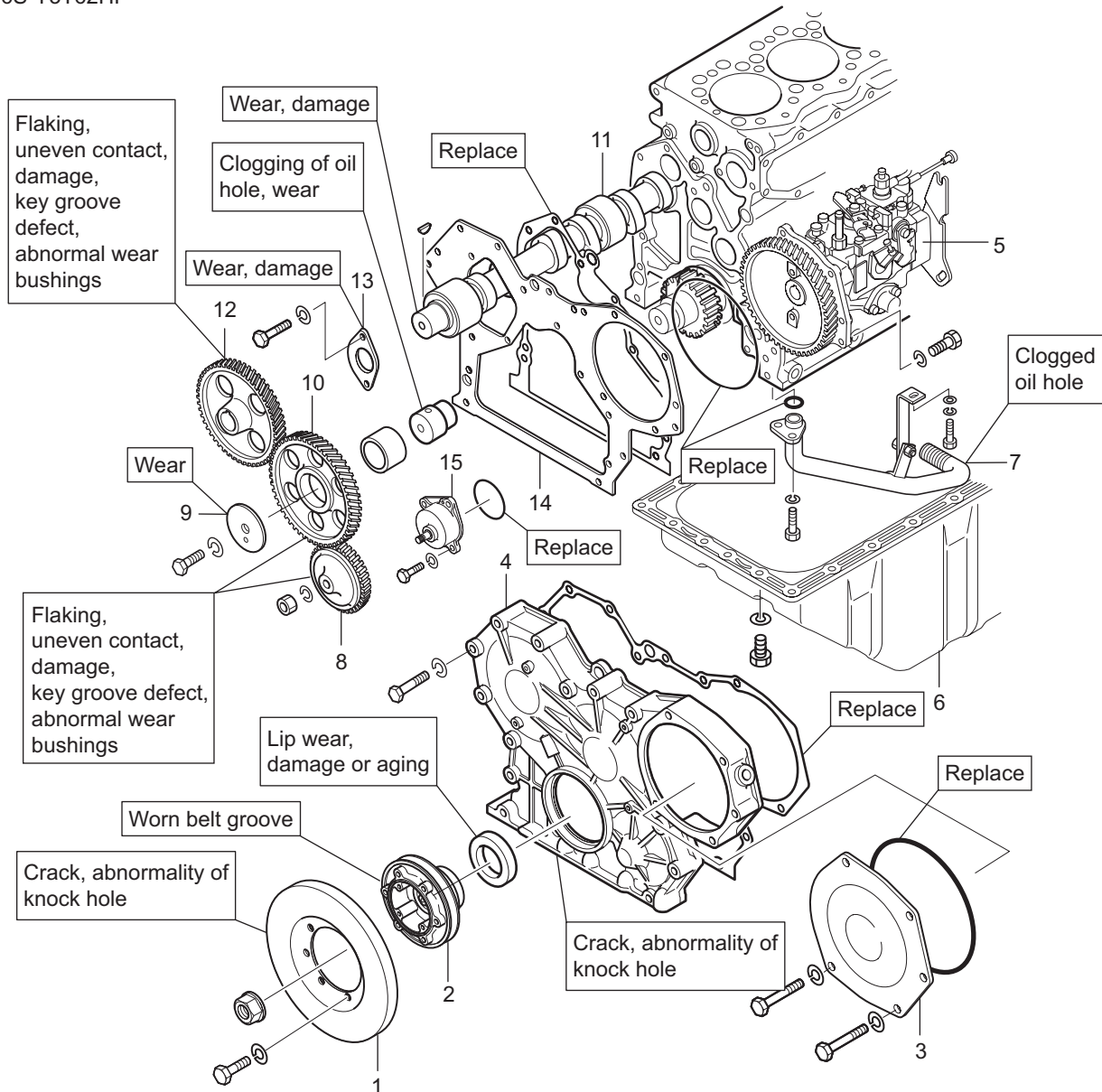
Disassembling and inspecting damper, gear case, timing gear and camshaft

Disassembling sequence

- | | | |
|-----------------------|---------------------|----------------------------|
| 1 Damper | 8 Oil pan | 15 PTO drive gear, bearing |
| 2 Crankshaft pulley | 9 Oil strainer | 16 Camshaft |
| 3 Bearing case | 10 Oil pump gear | 17 Camshaft gear |
| 4 Bearing case | 11 Thrust plate | 18 Thrust plate |
| 5 Cover | 12 Idler gear | 19 Front plate |
| 6 Timing gear case | 13 PTO bearing case | 20 Oil pump |
| 7 Fuel injection pump | 14 Oil pipe | |

DISASSEMBLY OF BASIC ENGINE

S6S-Y3T62HF



Disassembling and inspecting damper, gear case, timing gear and camshaft

Disassembling sequence

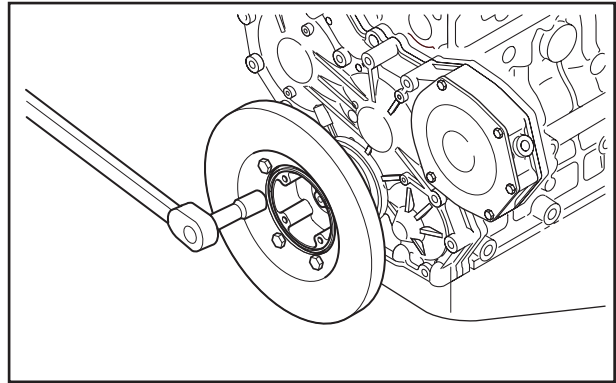
- | | | |
|-----------------------|-----------------|------------------|
| 1 Damper | 6 Oil pan | 11 Camshaft |
| 2 Crankshaft pulley | 7 Oil strainer | 12 Camshaft gear |
| 3 Cover | 8 Oil pump gear | 13 Thrust plate |
| 4 Timing gear case | 9 Thrust plate | 14 Front plate |
| 5 Fuel injection pump | 10 Idler gear | 15 Oil pump |

3.1 Removing crankshaft pulley and damper

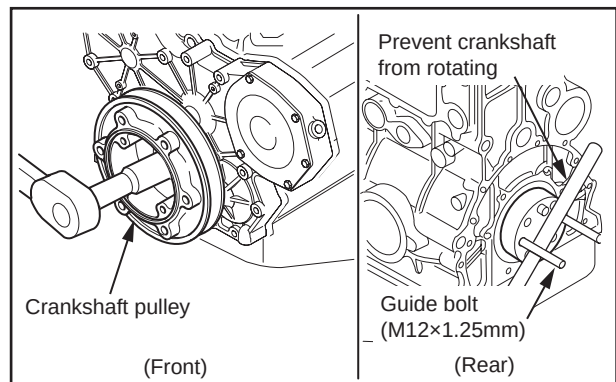
CAUTION

The bar that stops the crankshaft from turning may come off. Pay special attention to safety.

- (1) Screw two guide bolts into the threaded holes at the rear end of the crankshaft. Stick a bar across the guide bolts to prevent the crankshaft from turning.
- (2) Remove the crankshaft pulley and damper.



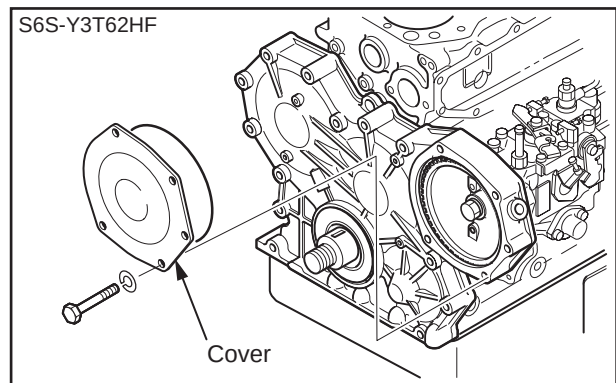
Removing damper



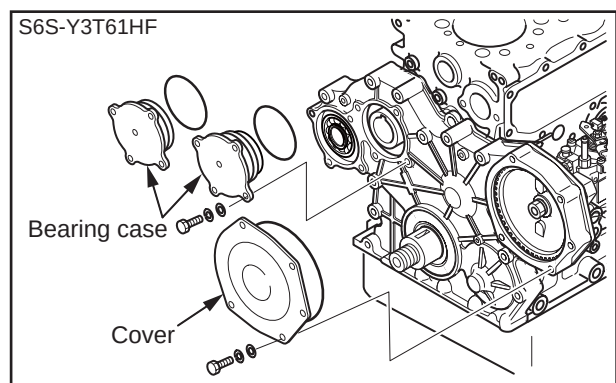
Removing crankshaft pulley

3.2 Removing cover

Unscrew the cover mounting bolts, and remove the cover.



Removing cover



Removing cover

DISASSEMBLY OF BASIC ENGINE

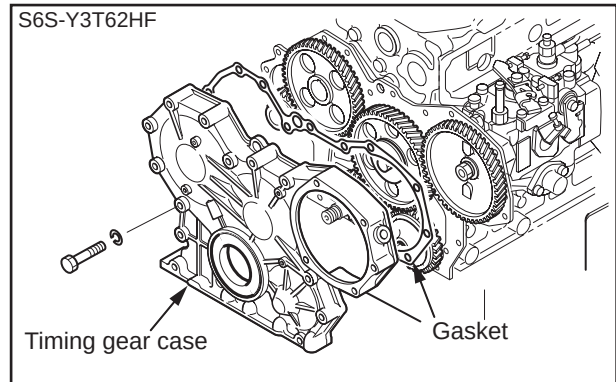
3.3 Removing timing gear case

CAUTION

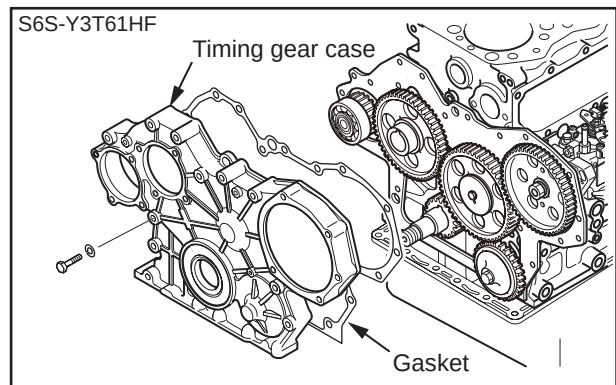
The front plate is bolted to the crankcase from inside the gear case. Do not attempt to remove the front plate together with the gear case by tapping.

- (1) Remove bolts from the timing gear case.
- (2) Remove the timing gear case.

Note: Bolts have different lengths. Pay attention to the positions of bolts to ensure correct reassembling.



Removing timing gear case



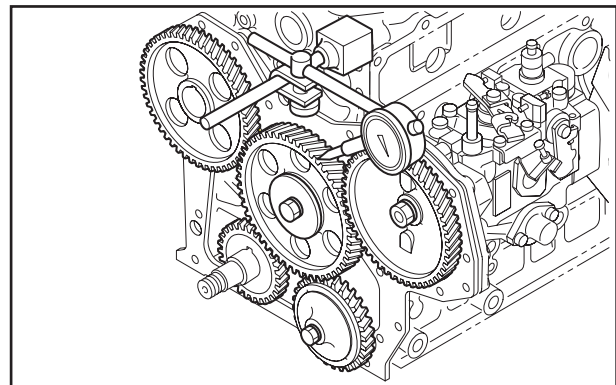
Removing timing gear case

3.4 Measuring timing gear backlash

Measure the backlash of the timing gears by using one of the following two methods; measure the gear play with the dial gauge plunger applied to a tooth flank on the pitch circle at a right angle to the tooth axis, or measure the clearance between gears by inserting a feeler gauge between the gears at the tooth-to-tooth contacting area. Replace the faulty gear pair if the limit is exceeded.

Item	Standard	Limit
Timing gear backlash	0.05 to 0.15 mm [0.0020 to 0.0059 in.]	0.25 mm [0.0098 in.]

Note: With the injection pump gear attached to the pump, install the injection pump gear to the front plate.



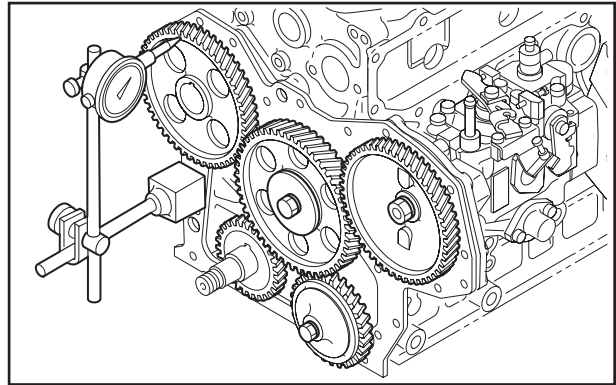
Measuring backlash timing gear

3.5 Measuring idler gear and camshaft gear end play

Using a feeler gauge or dial gauge, measure the end play of idler gear and camshaft gear.

If the measured value exceeds the limit, replace the thrust plate with a new one.

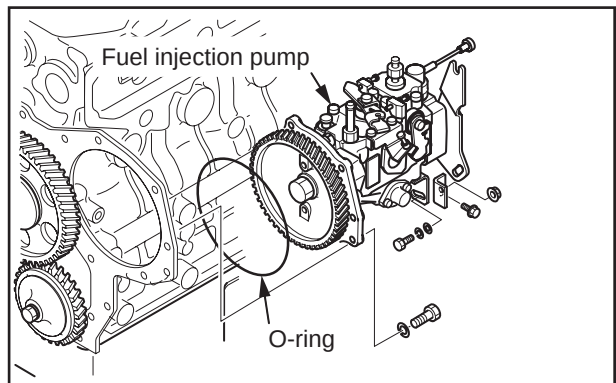
Item		Standard	Limit
End play	Idler gear	0.05 to 0.20 mm [0.0020 to 0.0079 in.]	0.35 mm [0.0138 in.]
	Camshaft	0.10 to 0.25 mm [0.0039 to 0.0098 in.]	0.30 mm [0.0118 in.]



Measuring idler gear and camshaft gear end play

3.6 Removing fuel injection pump

- (1) Remove the pump bracket mounting bolts.
- (2) Unscrew the mounting bolts of fuel injection pump, and remove the fuel injection pump.



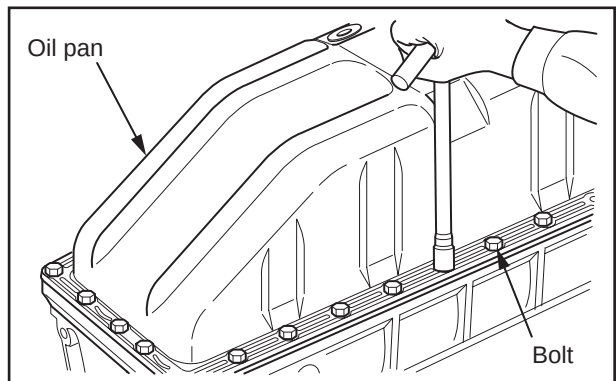
Removing fuel injection pump

3.7 Removing oil pan

CAUTION

Do not insert a chisel or screwdriver between the oil pan and crankcase to remove the oil pan, as it could deform the oil pan flange.

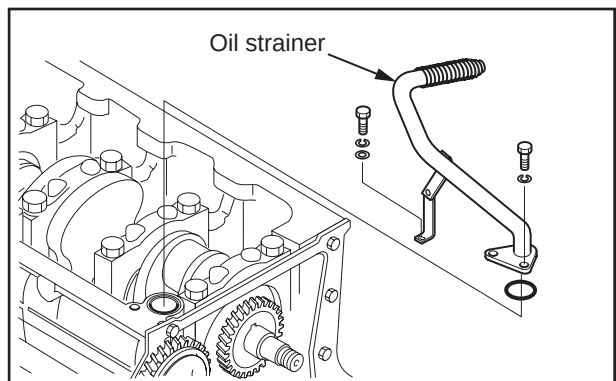
- (1) Turn the engine upside down.
- (2) Remove bolts from the oil pan.
- (3) To remove oil pan, tap flange corners of the oil pan with a plastic hammer.



Removing oil pan

3.8 Removing oil strainer

- (1) Remove the oil strainer mounting bolts.
- (2) Remove the oil strainer from the crankcase.

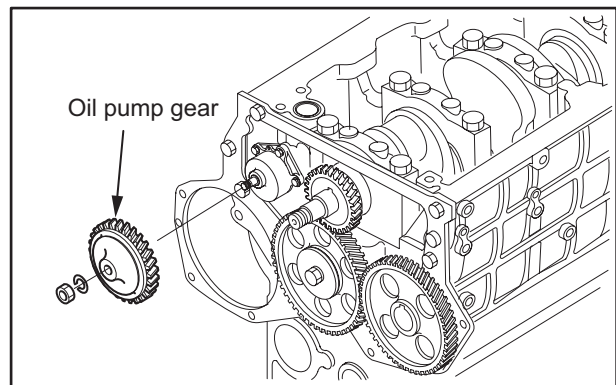


Removing oil strainer

DISASSEMBLY OF BASIC ENGINE

3.9 Removing oil pump gear

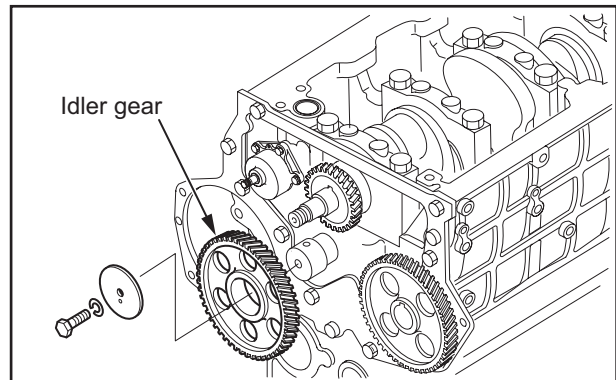
- (1) Remove the oil pump gear tightening nut.
- (2) Remove the oil pump gear.



Removing oil pump gear

3.10 Removing idler gear

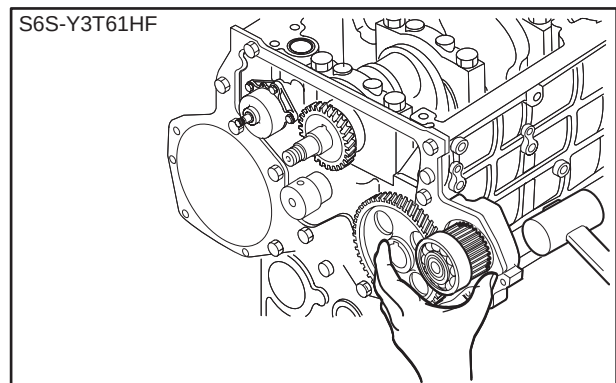
- (1) Remove the thrust plate bolt.
- (2) Remove the idler gear while turning the gear.



Removing idler gear

3.11 Removing PTO drive gear

Remove the PTO drive gear tapping lightly with plastic hammer.



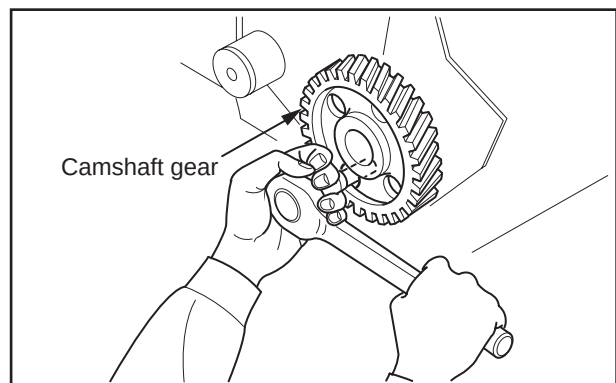
Removing PTO drive gear

3.12 Removing camshaft

CAUTION

Be careful not to damage the cams of camshaft and the bushings.

- (1) Reverse the crankcase.
- (2) Remove the thrust plate bolt.
- (3) Remove the camshaft from the crankcase.
- (4) Remove the tappet.

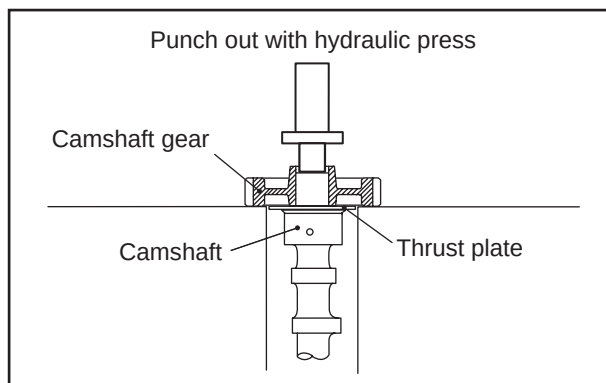


Removing camshaft

3.13 Separating camshaft gear

Using hydraulic press, remove the camshaft gear and thrust plate from the camshaft.

Note: Do not remove the camshaft gear from the camshaft unless the camshaft gear or the thrust plate is defective.



Separating gear from camshaft

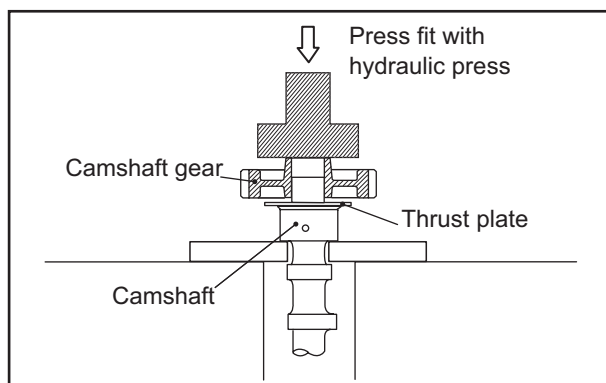
3.14 Installing camshaft gear and thrust plate

(1) Install the woodruff key and the thrust plate on the camshaft.

Note: Be sure to install the thrust plate before installing the camshaft gear.

(2) Heat the camshaft gear with a gear heater to a temperature of about 150°C [302°F].

(3) Press fit the camshaft gear with press.



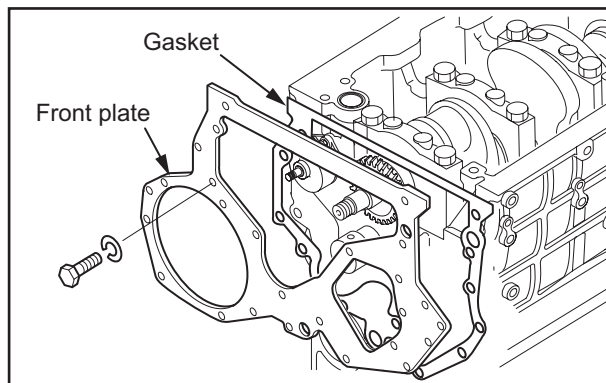
Installing camshaft gear and thrust plate

3.15 Removing front plate

(1) Remove the front plate bolts.

(2) Remove the front plate from the crankcase.

Note: If it is difficult to remove the front plate, lightly tap it with a plastic hammer.

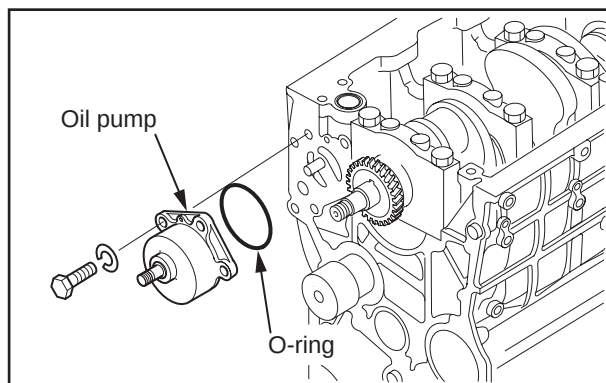


Removing front plate

3.16 Removing oil pump

(1) Remove the oil pump mounting bolts.

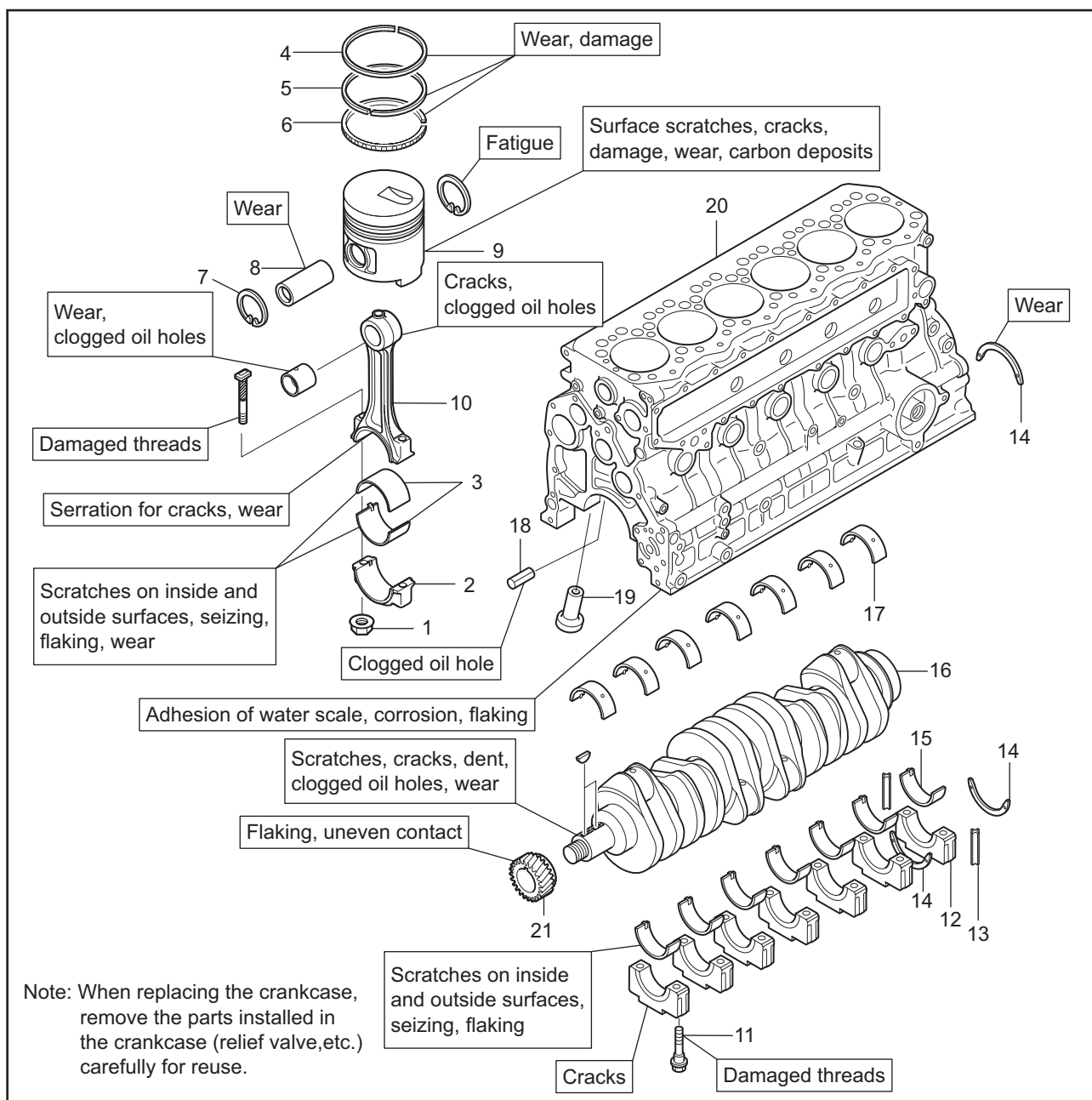
(2) Remove the oil pump.



Removing oil pump

DISASSEMBLY OF BASIC ENGINE

4. Disassembling and inspecting piston, connecting rod, crankshaft and crankcase



Disassembling and inspecting piston, connecting rod, crankshaft and crankcase

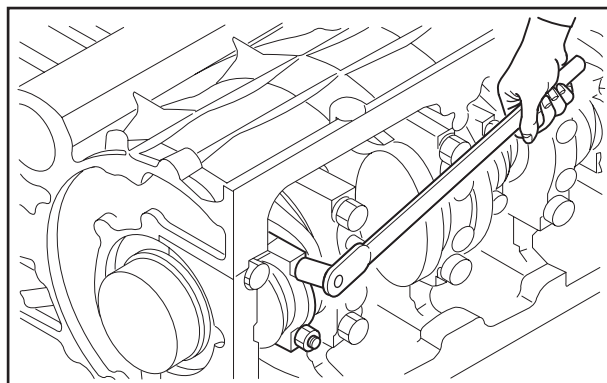
Disassembling sequence

- | | | |
|--------------------------|---------------------|--------------------------|
| 1 Nut | 8 Piston pin | 15 Main bearing (lower) |
| 2 Connecting rod cap | 9 Piston | 16 Crankshaft |
| 3 Connecting rod bearing | 10 Connecting rod | 17 Main bearing (upper) |
| 4 No. 1 compression ring | 11 Bearing cap bolt | 18 Piston cooling nozzle |
| 5 No. 2 compression ring | 12 Main bearing cap | 19 Tappet |
| 6 Oil ring | 13 Side seal | 20 Crankcase |
| 7 Snap ring | 14 Thrust plate | 21 Crank gear |

4.1 Removing connecting rod cap

- (1) Lay the engine on its side.
- (2) Mark the cylinder number on the connecting rod and connecting rod cap so that their combination is not changed when reassembling.
- (3) Remove the connecting rod caps.

Note: Mark the cylinder No. and upper/lower on connecting rod bearings to ensure correct reassembling.



Removing connecting rod cap

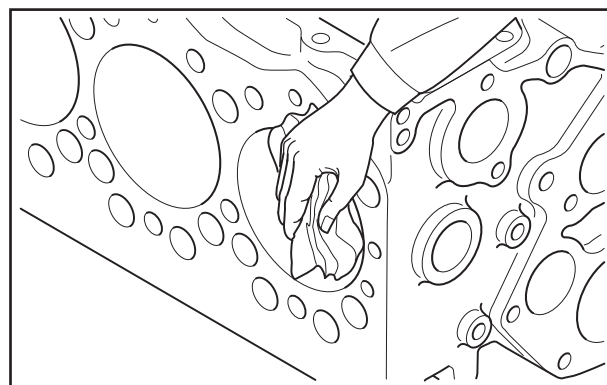
4.2 Removing carbon deposits from the upper part of cylinder liner

CAUTION

Be sure to remove carbon deposits from the upper part of the cylinder liner before removing the piston, as it could cause damage to the piston and piston ring.

Remove carbon deposits from the upper part of cylinder liner using a carbon remover.

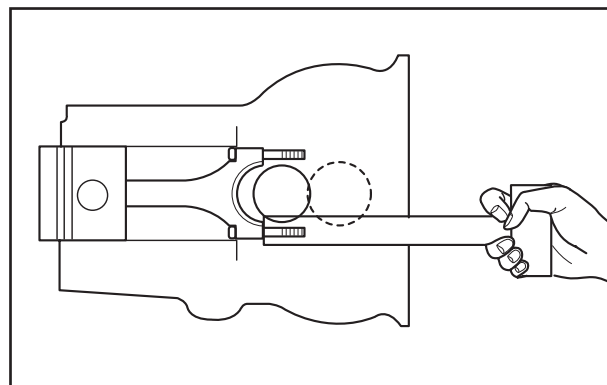
Note: Be careful not to damage the inner surface of the cylinder liner.



Removing carbon deposits from the upper part of cylinder liner

4.3 Pulling out piston

- (1) Turn the crankshaft to bring the piston to top dead center.
- (2) Using a piece of wood such a hammer handle, push the mating surface of the connecting rod cap, and pull the piston and connecting rod upward from the cylinder.

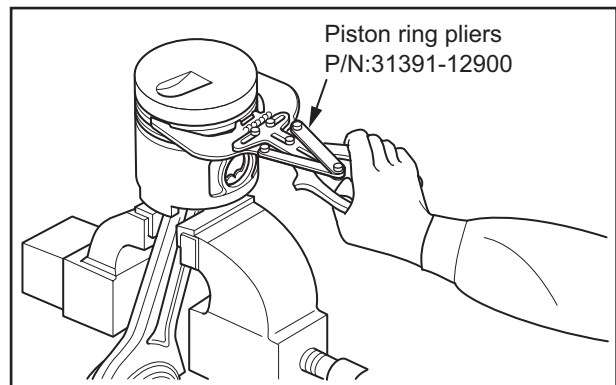


Removing piston

DISASSEMBLY OF BASIC ENGINE

4.4 Removing piston ring

Remove the piston rings using piston ring pliers.

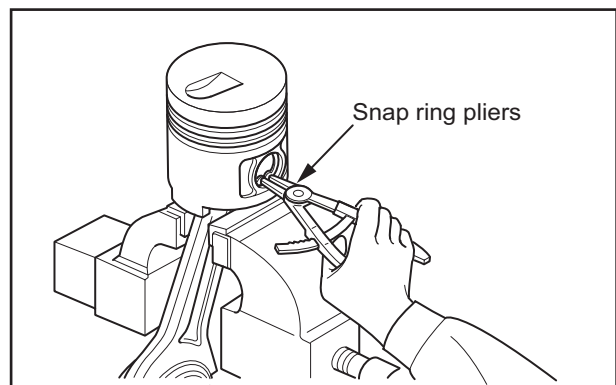


Removing piston ring

4.5 Removing piston pin and piston

- (1) Using ring pliers, remove the snap ring.
- (2) Using a wooden block and mallet, remove the piston pin, and separate the piston from the connecting rod.

Note: (a) Do not tap the piston pin directly with a mallet.
(b) If the piston is stubborn, heat the piston with a piston heater or in hot water.

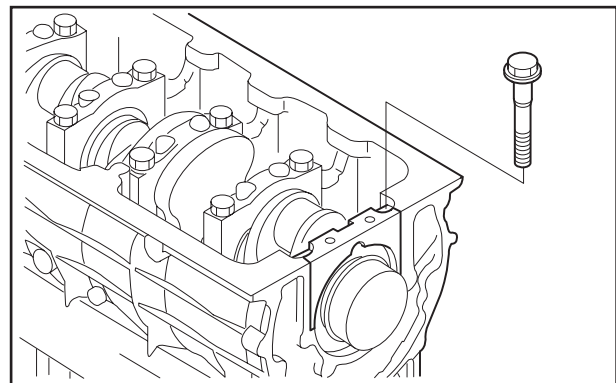


Removing piston pin

4.6 Removing main bearing cap

- (1) Unscrew the main bearing cap bolts.
- (2) Remove the main bearing cap.

Note: (a) Be careful not to damage the main bearings.
(b) Mark the bearings with their cylinder numbers.



Removing main bearing cap

4.7 Removing crankshaft

CAUTION

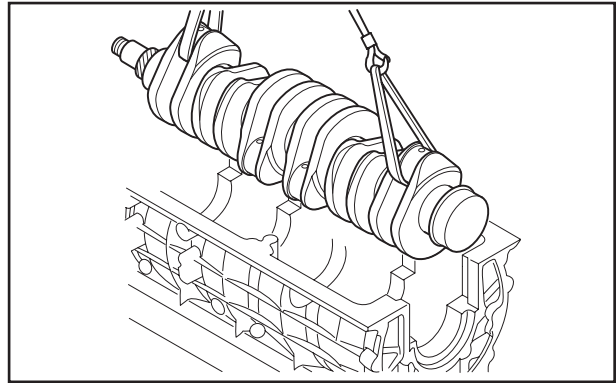
Be careful not to damage bearings when removing the crankshaft.

- (1) Slowly lift the crankshaft straight up.
- (2) Arrange the bearings in the order of disassembly so that their original positions are restored when reassembling.

Note: (a) When raising the crankshaft, do not allow wire or chain to come into contact with the crankshaft.

To avoid damage to the crankshaft when raising, use a cloth belt or pad.

- (b) Mark the bearings with their cylinder numbers.



Removing crankshaft

4.8 Removing tappet

Remove the tappets using a magnet.

Note: Be sure to arrange the removed tappets for reassembling to the same tappet hole.

INSPECTION AND REPAIR OF BASIC ENGINE

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INSPECTION AND REPAIR OF BASIC ENGINE

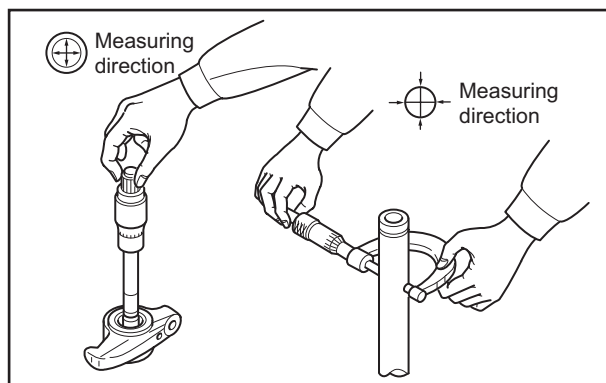
1. Inspecting and repairing cylinder head and valve mechanism

1.1 Measuring clearance between rocker

bushing and rocker shaft

Measure the rocker assembly inside diameter and the rocker shaft diameter. If the clearance exceeds the limit, replace either rocker assembly or rocker shaft with a new one.

Item	Nominal	Standard	Limit
Rocker bushing inside diameter	ø 19 mm [0.75 in.]	19.010 to 19.030 mm [0.7484 to 0.7492 in.]	-
Rocker shaft outside diameter	ø 19 mm [0.75 in.]	18.980 to 19.000 mm [0.7472 to 0.7480 in.]	-
Clearance between rocker bushing and shaft	-	0.010 to 0.050 mm [0.0004 to 0.0020 in.]	0.070 mm [0.0028 in.]

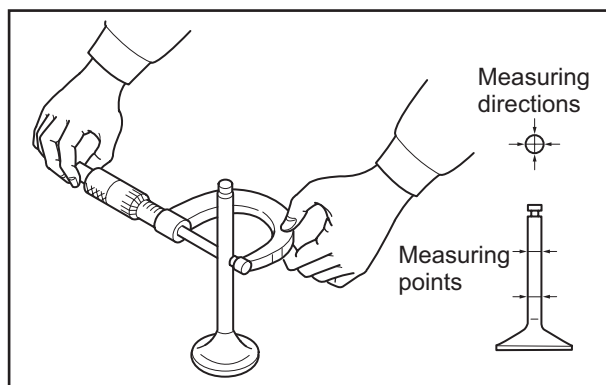


Measuring clearance between rocker bushing and rocker shaft

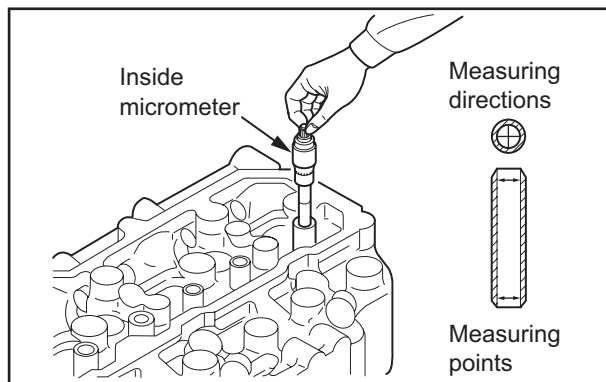
1.2 Measuring valve stem outside diameter and valve guide inside diameter

Measure the diameter at the top and bottom ends at right angles to the outer and inner surfaces, since valve stems and valve guides are more likely to wear at both ends. If the outside diameter is less than the limit, or the clearance exceeds the limit, replace either the valve or the valve guide with a new one.

Item		Nominal	Standard	Limit
Valve stem outside diameter	Inlet	ø 8 mm [0.31 in.]	7.940 to 7.955 mm [0.3126 to 0.3132 in.]	7.900 mm [0.3110 in.]
	Exhaust	ø 8 mm [0.31 in.]	7.920 to 7.940 mm [0.3118 to 0.3126 in.]	7.850 mm [0.3091 in.]
Clearance between valve stem and valve guide	Inlet	-	0.065 to 0.095 mm [0.0026 to 0.0037 in.]	0.150 mm [0.0059 in.]
	Exhaust	-	0.080 to 0.115 mm [0.0031 to 0.0045 in.]	0.200 mm [0.0079 in.]
Valve guide mounting dimension		14 mm [0.55 in.]	13.9 to 14.1 mm [0.547 to 0.555 in.]	-



Measuring valve stem outside diameter



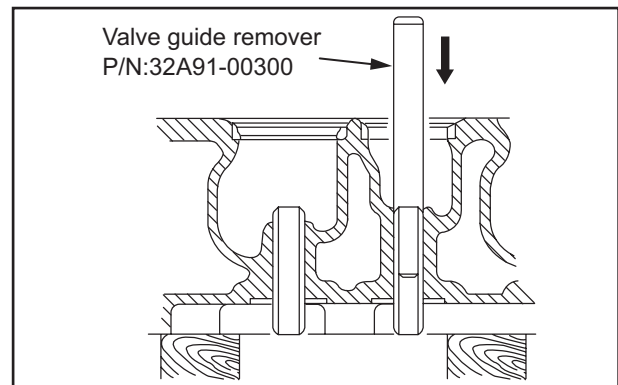
Measuring valve guide inside diameter

1.3 Replacing valve guide

CAUTION

Because valve guides must be inserted to the specified amount, be sure to use a valve guide installer.

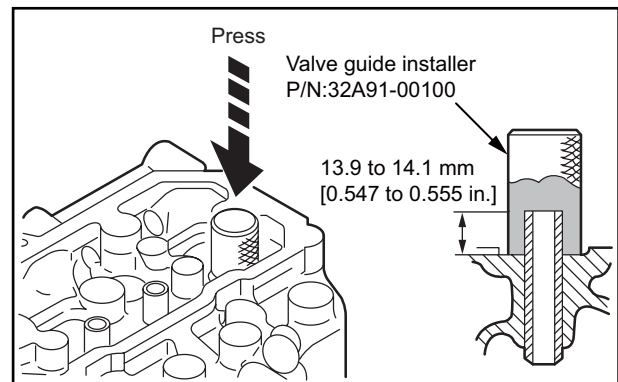
(1) To remove valve guides, use a valve guide remover.



Pulling out valve guide

(2) To press-fit valve guides, use a valve guide installer.

(3) Check contacts between valves and valve seats after replacing valve guides.



Press fitting valve guide

INSPECTION AND REPAIR OF BASIC ENGINE

1.4 Inspecting valve face

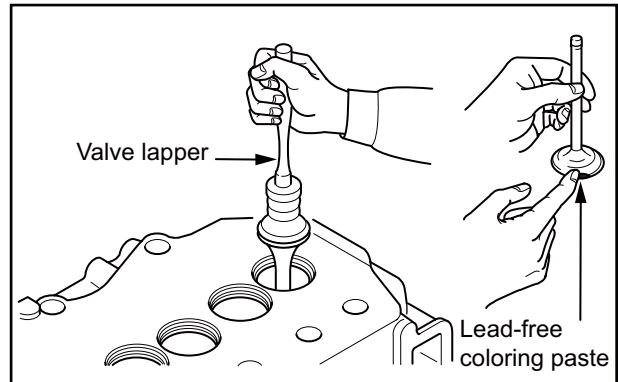
Apply a thin coat of lead-free coloring paste on the valve face, and strike the valve face against the valve seat using a valve lapper to check for contact condition.

If the contact is not even, or any defects are found, or if the limit is exceeded, reface or replace the valve.

Note: (a) Inspect the valve face after the valve guide is repaired or replaced.

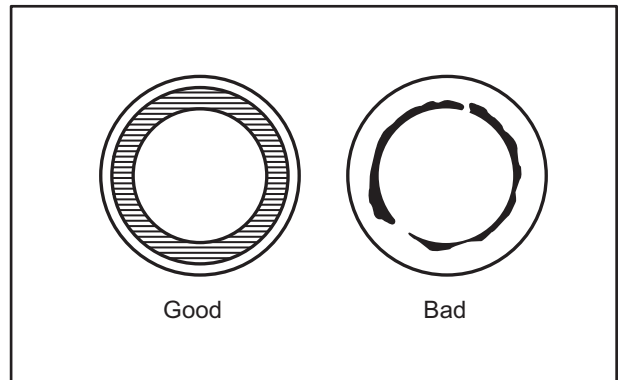
(b) Do not rotate the valve when pressing the valve face coated with lead-free coloring paste against the valve seat.

(c) Always lap the valve and valve seat after the valve has been refaced or replaced.

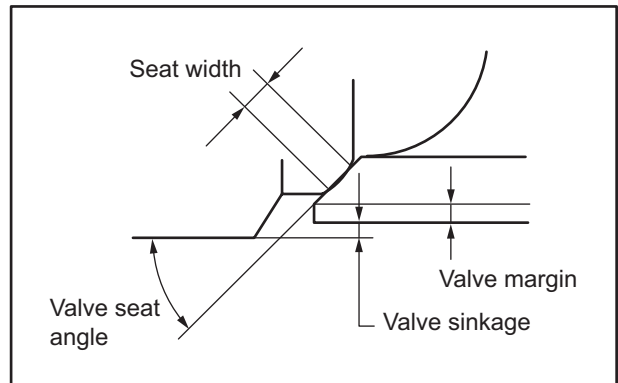


Checking valve face

Item			Nominal	Standard	Limit
Valve seat	Valve seat angle		30°	-	-
	Valve sinkage	Inlet	0.4 mm [0.016 in.]	0.3 to 0.5 mm [0.012 to 0.020 in.]	1.0 mm [0.039 in.]
		Exhaust	0.5 mm [0.020 in.]	0.4 to 0.6 mm [0.016 to 0.024 in.]	1.0 mm [0.039 in.]
	Seat width		1.4 mm [0.055 in.]	1.26 to 1.54 mm [0.0496 to 0.0606 in.]	1.8 mm [0.071 in.]
Valve margin			-	2.13 mm [0.0839 in.]	Refacing permissible up to 1.83 mm [0.0720 in.]



Valve-to-valve seat contact



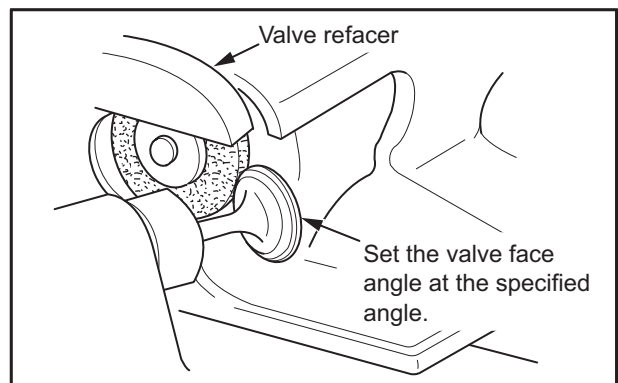
Measuring positions of valve seat and valve

1.5 Refacing valve face

If the valve face is significantly worn out, reface the valve face using a valve refacer.

Note: (a) Grind the valve face using the valve refacer at the specified angle.

(b) Secure the valve margin width equal to or greater than the limit. If the dimensions after refacing does not meet the specified values, replace the valve with a new one.



Refacing valve face

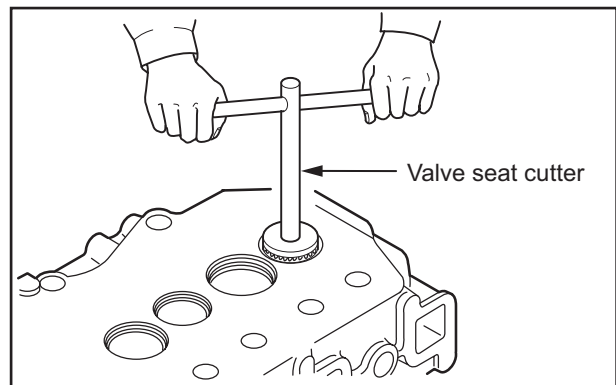
1.6 Refacing valve seat

- (1) Use the valve seat cutter or valve seat grinder to reface the valve seat. After refacing, sand the valve seat lightly using 400 grit sandpaper, inserting it between the cutter and valve seat.
- (2) Lap the valve in the valve seat.

Note: (a) Valve seat refacing should be kept to an absolute minimum.

- (b) If the valve seat width exceeds the limit due to wear or refacing, replace the valve seat with a new one.

- (c) If the valve sinkage exceeds the limit after refacing, replace the valve seat with a new one.



Refacing valve seat

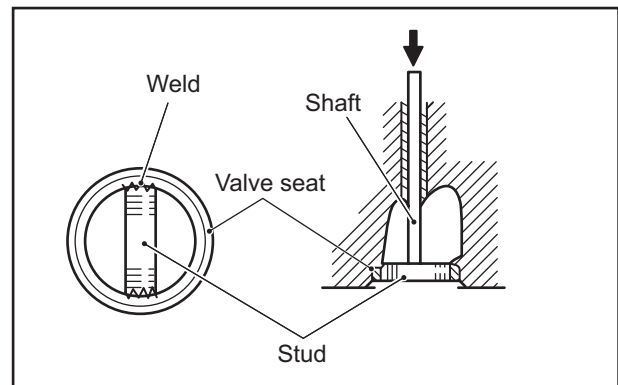
INSPECTION AND REPAIR OF BASIC ENGINE

1.7 Replacing valve seat

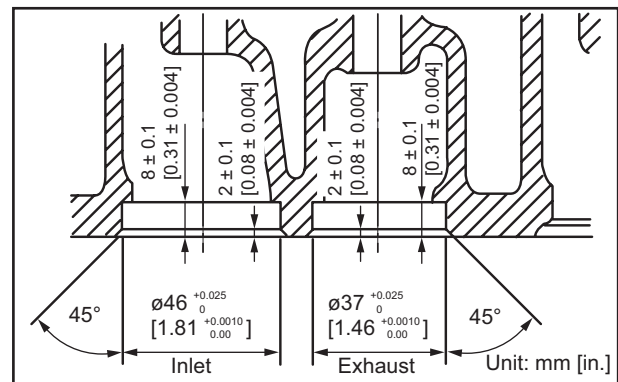
- (1) To remove the valve seat, weld a stud to the valve seat as illustrated. Then, insert a rod into the valve guide hole from the top of the cylinder head, and press out the valve seat with the rod.

Note: Be careful not to allow spatters to adhere to the machined surface of the cylinder head during welding.

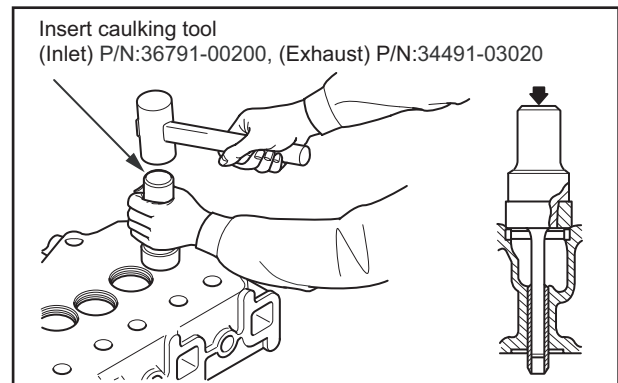
- (2) Before inserting a new valve seat, measure valve seat fitting bore diameter and valve seat outside diameter to make sure the interference meets the specified value.
- (3) Cool the valve seat at least for four minutes in liquid nitrogen before fitting it into the cylinder head that is kept at room temperature.
- (4) Fit the cold valve seat into the cylinder head using a insert caulking tool.



Replacing valve seat



Valve seat fitting bore



Driving in valve seat

1.8 Lapping valve and valve seat

Always lap the valve against the valve seat after refacing the valve seat or after replacing the valve.

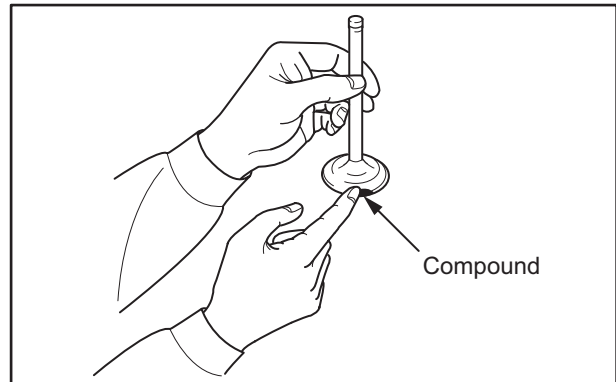
- (1) Apply a thin coat of lapping compound evenly to the valve face.

Note: (a) Do not allow the compound to adhere on the valve stem.

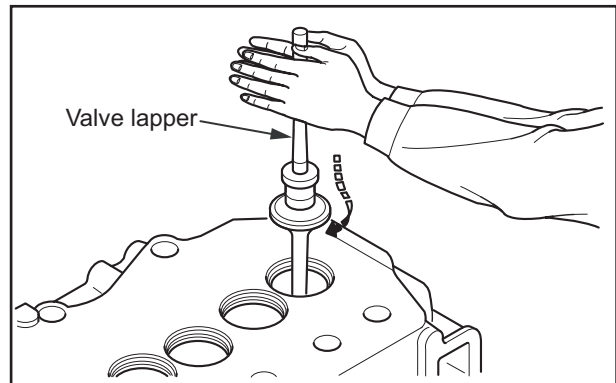
(b) Compound spreads more evenly if it is mixed with a small amount of engine oil.

(c) Use medium-grain compound (120 to 150 mesh) for initial lapping, then use fine-grain compound (200 mesh or finer) for finishing.

- (2) Use a valve lapper for lapping. Strike the valve against the valve seat while rotating the valve little by little.
- (3) Wash off the compound using diesel fuel.
- (4) Coat the contact surface of the valve with engine oil, then lap the valve again.
- (5) Check valve-to-seat contact.



Coating valve with lapping

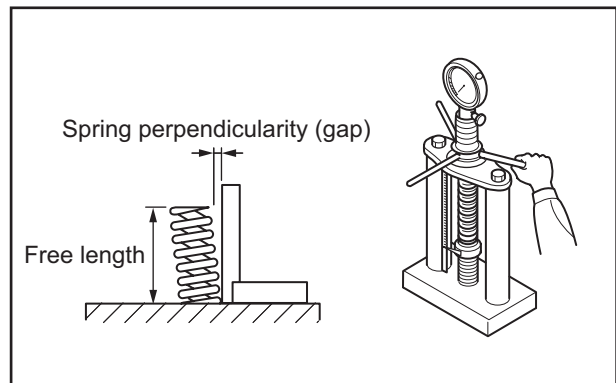


Lapping valve and valve seat

1.9 Measuring perpendicularity and free length of valve spring

Measure the perpendicularity and free length of the valve spring. If the measured free length and/or perpendicularity exceed the limit, replace the valve spring with a new one. If the measured set length and/or set load deviate from the standard, replace the valve spring with a new one.

Item	Standard	Limit
Free length	48.85 mm [1.9232 in.]	47.60 mm [1.8740 in.]
Perpendicularity	 A = 1.5° or less B = 1.3 mm [0.051 in.] or less Lf = 48.85 mm [1.9232 in.]	B = 1.5 mm [0.059 in.] at the end
Set length/set load	43 mm [1.69 in.] 176 to 196 N {18 to 20 kgf} [39 to 44 lbf]	43 mm [1.69 in.] 147 N {15 kgf} [33 lbf]



Squareness and free length of spring

INSPECTION AND REPAIR OF BASIC ENGINE

1.10 Measuring distortion of the bottom surface of the cylinder head

CAUTION

Refacing of cylinder head should be kept to an absolute minimum.

Excessive grinding of the cylinder head may result in defects such as defective combustion and stamping (contact between piston and valve).

With a straight edge placed on the bottom face of the cylinder head, measure the bottom face distortion using a feeler gauge. If the measurement exceeds the limit, grind the bottom face using a surface grinder.

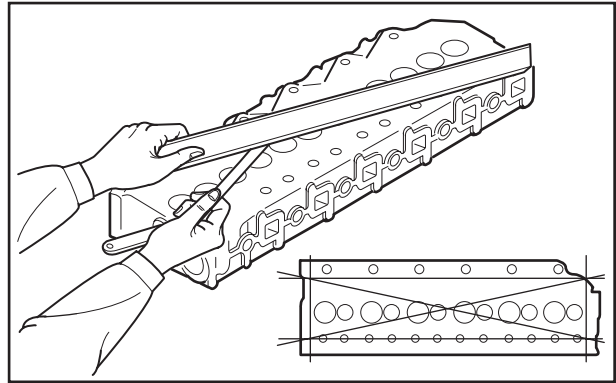
Item	Standard	Limit
Distortion of bottom face	0.05 mm [0.0020 in.] or less	0.20 mm [0.0079 in.]

Note: Do not grind the surfaces more than 0.2 mm [0.008 in.] in total (cylinder head bottom surface plus crankcase top surface).

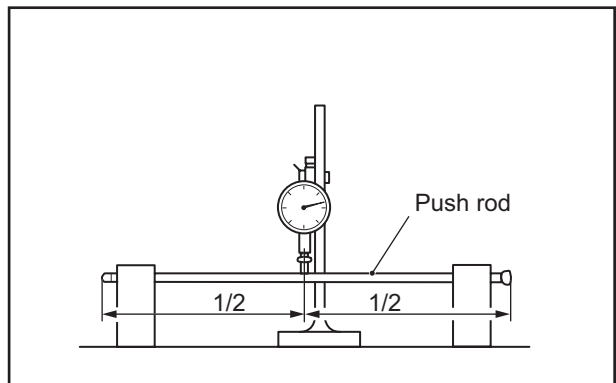
1.11 Measuring push rod runout

Measure the runout of each push rod. Replace if the limit is exceeded.

Item	Standard	Limit	Remark
Push rod runout	0.6 mm [0.024 in.] or less	0.6 mm [0.024 in.]	Total indicated reading (TIR)



Measuring distortion of the bottom surface of the cylinder head

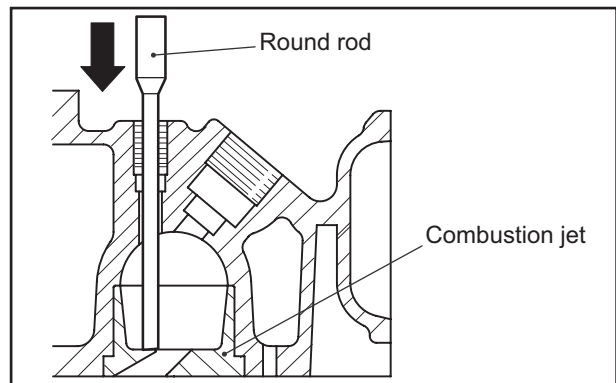


Measuring push rod runout

1.12 Removing combustion jet

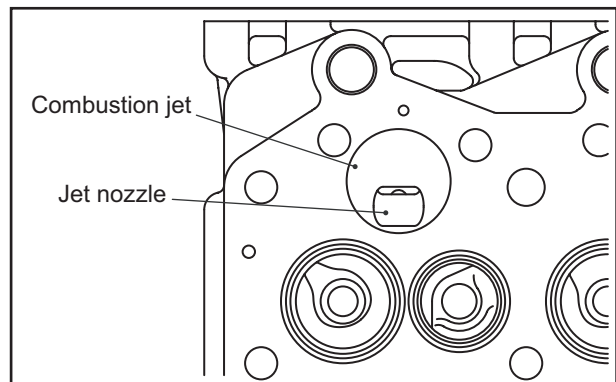
Replace the combustion jet only when it has a defect or crack.

- (1) Insert a round bar (approx; $\varnothing 6$ mm [0.24 in.]) into glow plug hole, and tap the combustion jet inner face perimeter lightly to pull out the combustion jet.



Removing combustion jet

- (2) When installing the combustion jet, align the positioning hole and jet nozzle with the center of cylinder, press fit by tapping with plastic hammer.



Press-fitting combustion jet

INSPECTION AND REPAIR OF BASIC ENGINE

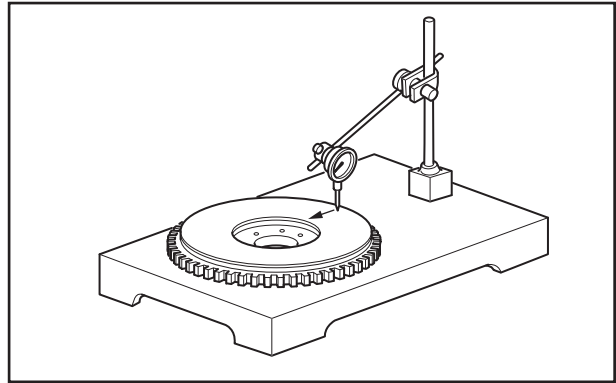
2. Inspecting and repairing flywheel

2.1 Measuring flatness of flywheel

Place the flywheel on a surface plate and move a dial gauge on the friction surface of the flywheel to measure the flatness.

Grind the friction surface of the flywheel if the limit is exceeded.

Item	Standard	Limit
Flywheel flatness	0.15 mm [0.0059 in.] or less	0.50 mm [0.0197 in.]

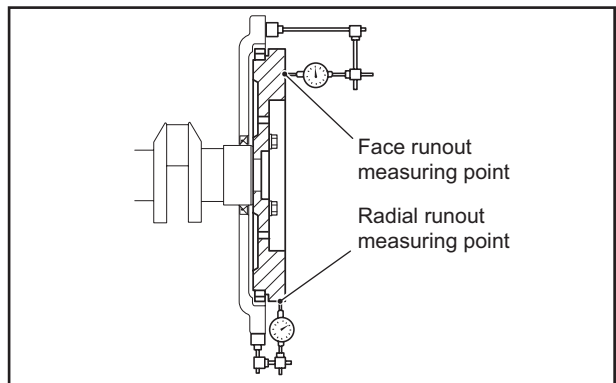


Measuring flatness of flywheel

2.2 Measuring flywheel face and radial runouts

Measure the runouts of the flywheel in the installed condition. If the measured value exceeds the standard, check the bolt for looseness as well as the accumulation of foreign matter on the mounting face.

Item	Standard	Limit
Flywheel face runout and radial runout	0.15 mm [0.0059 in.] or less	0.50 mm [0.0197 in.]



Measuring flywheel face and radial runout

2.3 Inspecting ring gear

Inspect the ring gear for a missing tooth or worn teeth, and if defects are found, replace the ring gear.

2.4 Replacing ring gear

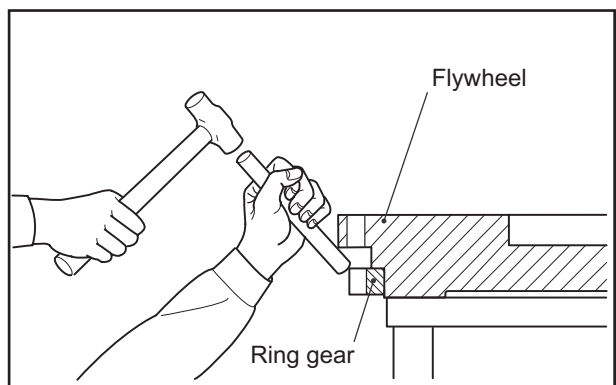
2.4.1 Removing ring gear

- (1) Heat the ring gear evenly using an acetylene torch or other appropriate heat source.
- (2) With a rod placed on the periphery of ring gear, tap the rod with a hammer evenly around the ring gear, and remove the ring gear.

2.4.2 Installing ring gear

- (1) Heat the ring gear evenly up to approx. 150°C [176°F] with an appropriate heater.
- (2) Install the ring gear onto the flywheel with the no-gear-chamfering side faced to the flywheel.

Note: Do not heat the ring gear excessively.



Removing ring gear

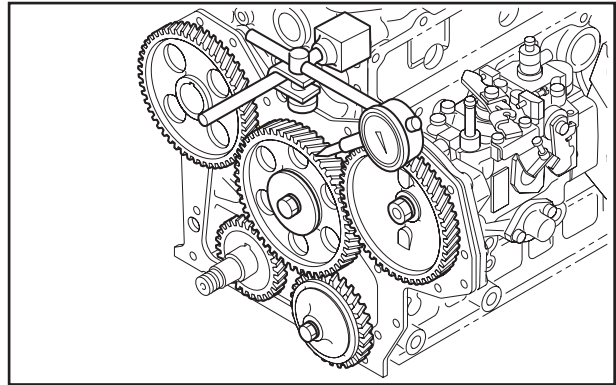
3. Inspecting and repairing timing gear and camshaft

3.1 Measuring timing gear backlash

Measure the backlash of the timing gears by using one of the following two methods; measure the gear play with the dial gauge plunger applied to a tooth flank on the pitch circle at a right angle to the tooth axis, or measure the clearance between gears by inserting a feeler gauge between the gears at the tooth-to-tooth contacting area. Replace the faulty gear pair if the limit is exceeded.

Item	Standard	Limit
Timing gear backlash	0.05 to 0.15 mm [0.0020 to 0.0059 in.]	0.25 mm [0.0098 in.]

Note: With the injection pump gear attached to the pump, install the injection pump gear to the front plate.



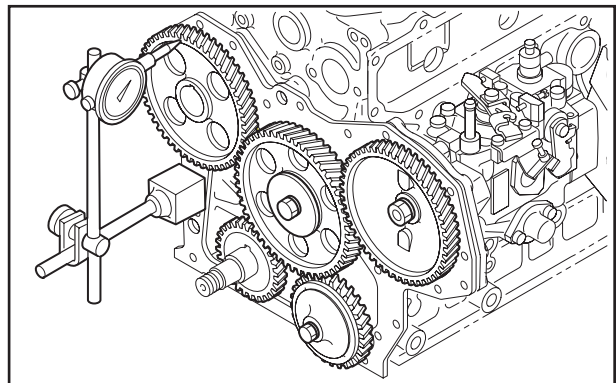
Measuring timing gear backlash

3.2 Measuring idler gear and camshaft gear end play

Using a feeler gauge or dial gauge, measure the end play of idler gear and camshaft gear.

If the measured value exceeds the limit, replace the thrust plate with a new one.

Item	Standard	Limit
Idler gear	0.05 to 0.20 mm [0.0020 to 0.0079 in.]	0.35 mm [0.0138 in.]
Camshaft	0.10 to 0.25 mm [0.0039 to 0.0098 in.]	0.30 mm [0.0118 in.]

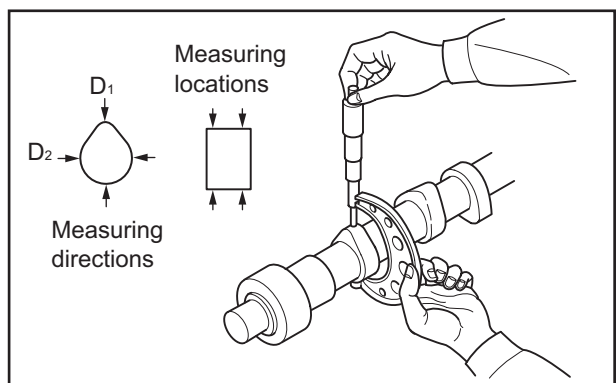


Measuring idler gear and camshaft gear end play

3.3 Measuring cam lift

Measure the minor and major axes of cam to determine cam lobe lift. If the lift is less than the limit, replace the camshaft with a new one.

Item	Nominal	Standard	Limit
Inlet	6.682 mm [0.2631 in.]	6.382 to 6.782 mm [0.2513 to 0.2670 in.]	6.182 mm [0.2434 in.]
Exhaust	6.722 mm [0.2646 in.]	6.422 to 6.822 mm [0.2528 to 0.2686 in.]	6.222 mm [0.2450 in.]



Measuring cam lift

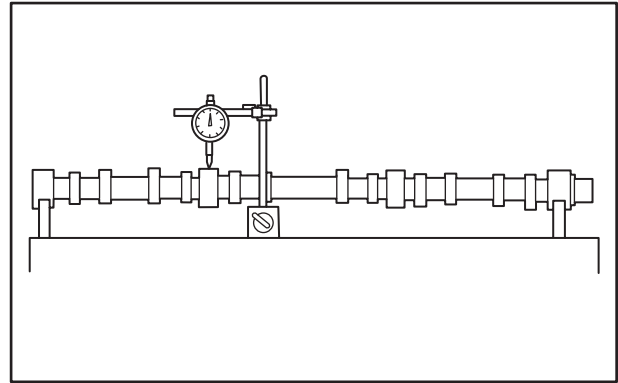
INSPECTION AND REPAIR OF BASIC ENGINE

3.4 Measuring camshaft runout

Measure the camshaft runout using a dial gauge. If the limit is exceeded, correct the camshaft using a press, or replace the camshaft with a new one.

Note: With a dial gauge set on the camshaft, rotate the camshaft one turn and read the gauge indication.

Item	Standard	Limit	Remark
Camshaft runout	0.04 mm [0.0016 in.] or less	0.10 mm [0.0039 in.]	TIR

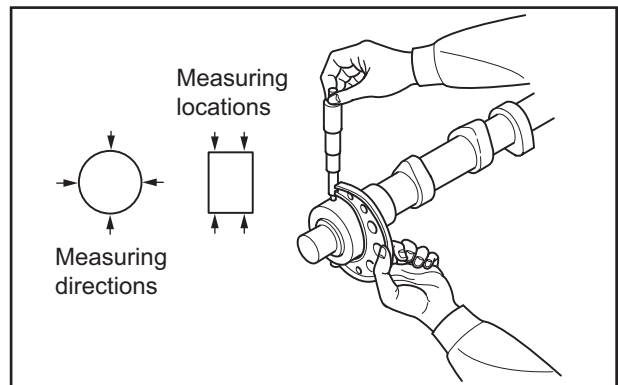


Measuring camshaft runout

3.5 Measuring camshaft journal outside diameter

Measure the diameter of each camshaft journal in two direction at right angles to each other. If the limit is exceeded, replace the camshaft with a new one.

Item	Standard	Limit
Camshaft journal outside diameter	No. 1, 2, 3 53.94 to 53.96 mm [2.1236 to 2.1244 in.]	53.90 mm [2.1220 in.]
	No. 4 52.94 to 52.96 mm [2.0842 to 2.0850 in.]	52.90 mm [2.0827 in.]

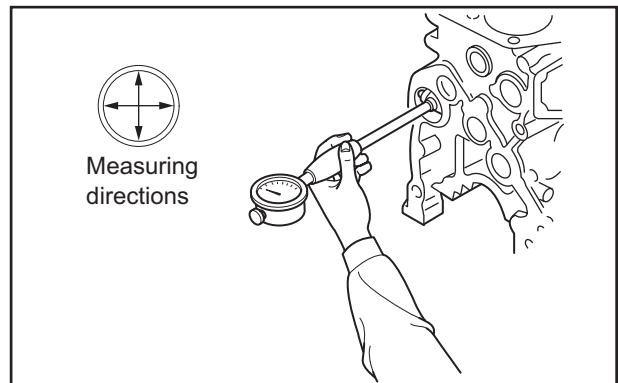


Measuring camshaft journal outside diameter

3.6 Measuring camshaft bushing inside diameter

With the camshaft bushings installed in the crankcase, measure the inside diameters using a cylinder gauge. If the limit is exceeded, replace the bushing with a new one.

Item	Standard	Limit
Clearance between camshaft journal and camshaft bushing	0.07 to 0.11 mm [0.0028 to 0.0043 in.]	0.15 mm [0.0059 in.]

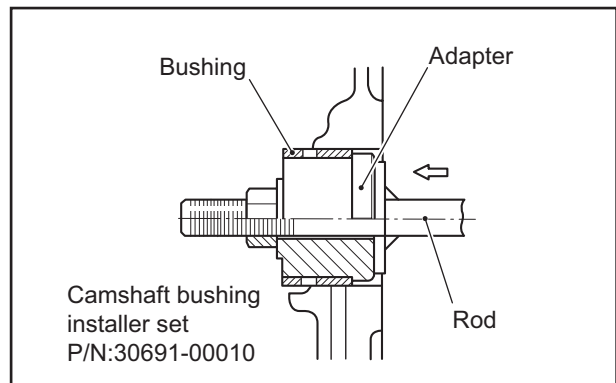


Measuring camshaft bushing inside diameter

3.7 Replacing camshaft bushing

3.7.1 Removing camshaft bushing

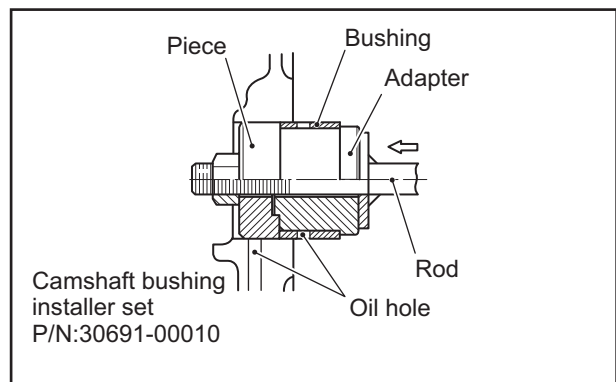
- (1) Install a camshaft bushing installer set to the camshaft bushing.
- (2) Remove the camshaft bushing by tapping the end of the rod of camshaft bushing installer set.



Removing camshaft bushing

3.7.2 Installing camshaft bushing

- (1) Install the camshaft bushing to a camshaft bushing installer set.
- (2) When driving in a bushing, tap the end of camshaft bushing installer rod so that the oil hole in the bushing aligns with the oil hole of the oil gallery.

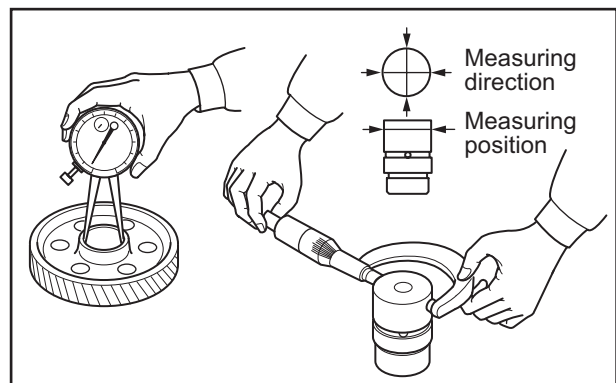


Installing camshaft bushing

3.8 Measuring idler bushing inside diameter and idler shaft outside diameter

Measure the idler bushing inside diameter and idler shaft outside diameter, and calculate the clearance between them. If the measured value exceeds the limit, locate the defective part and replace it.

Item	Standard	Limit
Clearance between idler bushing and idler shaft	0.009 to 0.050 mm [0.0004 to 0.0020 in.]	0.100 mm [0.0039 in.]



Measuring idler bushing inside diameter and idler shaft outside diameter

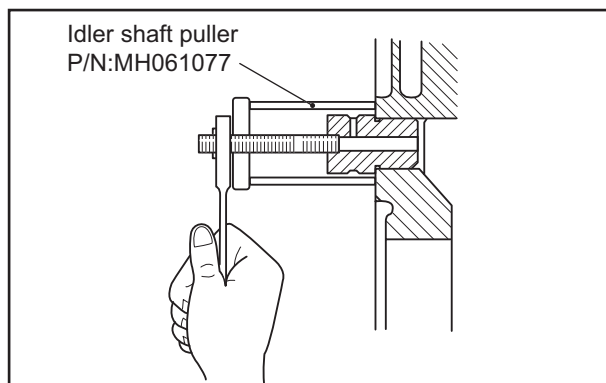
INSPECTION AND REPAIR OF BASIC ENGINE

3.9 Replacing idler shaft

To remove the idler shaft, use the idler shaft puller.

Note: When installing the idler shaft into the crankcase, orient the idler shaft so that its oil hole faces the upper crankcase.

Item	Nominal	Standard
Interference between shaft and crankcase hole	ø 35 mm [1.38 in.]	0.035T to 0.076T mm [0.0014 to 0.0030 in.]



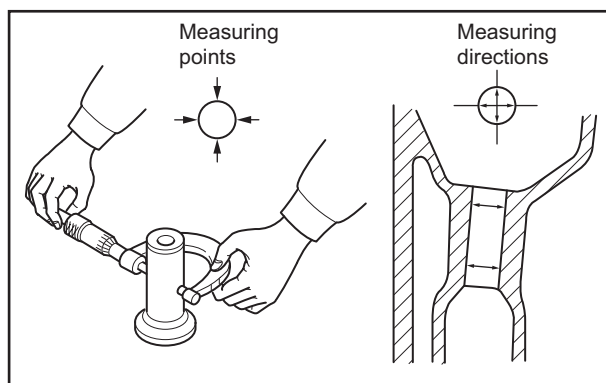
Replacing idler shaft

3.10 Measuring clearance between tappet and tappet guide hole

Measure clearance between the tappet and tappet hole.

Replace the tappet with a new one if the limit is exceeded.

Item	Standard	Limit
Tappet guide hole inside diameter	14.000 to 14.018 mm [0.5512 to 0.5519 in.]	14.100 mm [0.5551 in.]
Clearance between tappet and tappet guide hole	0.016 to 0.052 mm [0.0006 to 0.0020 in.]	0.08 mm [0.0031 in.]

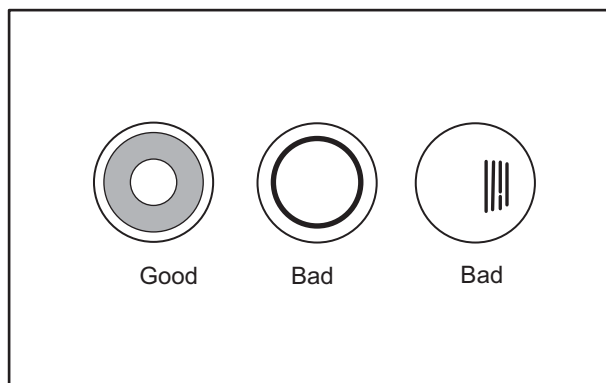


Measuring clearance between tappet and tappet guide hole

3.11 Inspecting tappet

3.11.1 Contact surface of camshaft

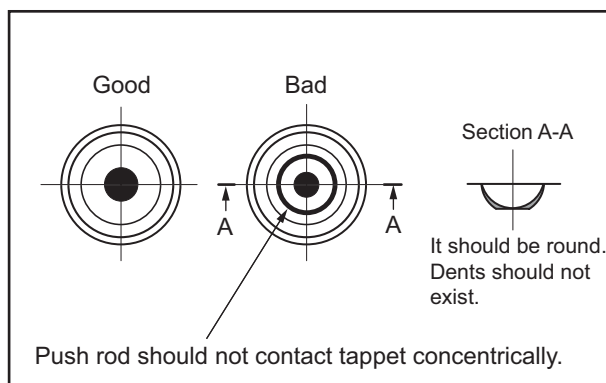
Inspect the cam contact surface of the tappets. Fit new tappets if the surface is excessively worn or damaged.



Contact surface of camshaft

3.11.2 Contact surface of push rod

- (1) Apply a lead-free coloring paste on the push rods, and check the contact surface.
- (2) Check that the push rod contacts the tappet concentrically. If it does, replace the tappet and push rod with new one.



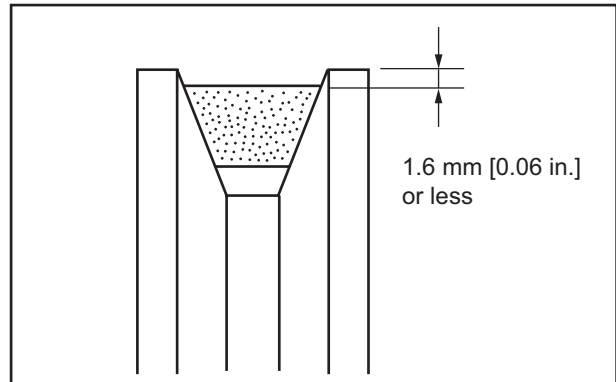
Contact surface of push rod

3.12 Inspecting V-belt groove wear

Check the V-belt groove of the pulley for wear. Attach a new V-belt around the pulley, apply high tension and measure the sinkage of V-belt.

If the wear appears excessively, and the belt top surface sinks 1.6 mm [0.06 in.] or more down from the top edge of groove, replace the pulley with a new one.

If the pulley has two or more grooves for belt, and the difference of the wear amount between grooves is significant, replace the pulley with a new one.



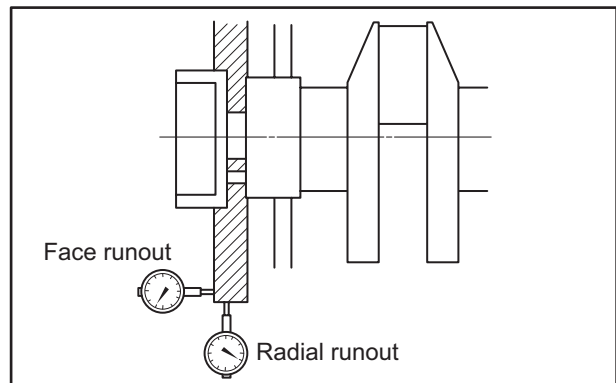
Inspecting V-belt groove wear

3.13 Inspecting damper

(1) Check the damper for cracks around the outer periphery, swelling and/or cracks in the end plate, silicone oil leakage and discoloration and separation of coating due to thermal effect.

If any defect is found, replace the damper with a new one.

(2) With the damper installed on the engine, measure the face and radial runouts of the damper in the following manner: Attach the dial gauge plunger on the outer circumference of the damper to measure the radial runout, or on the end face near the perimeter to measure the face runout, and slowly turn the crankshaft. If the limit is exceeded, replace the damper with a new one.



Measuring face and radial runout of damper

Item	Nominal	Standard	Limit
Perpendicularity runout	0.5 mm [0.020 in.] or less	1.5 mm [0.059 in.]	Replace with a new one after operating 8000 hours.
Periphery runout	0.5 mm [0.020 in.] or less	1.5 mm [0.059 in.]	

INSPECTION AND REPAIR OF BASIC ENGINE

4. Inspecting and repairing piston, connecting rod, crankshaft and crankcase

4.1 Measuring crankcase top surface distortion

CAUTION

Refacing of cylinder head should be kept to an absolute minimum.

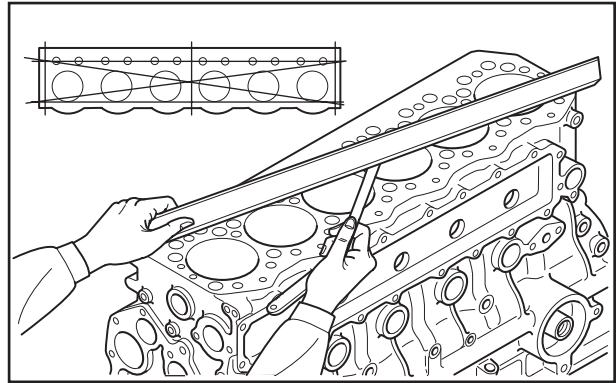
Excessive grinding of the cylinder head may result in defects such as defective combustion and stamping (contact between piston and valve).

Apply a straight edge to the top surface of the crankcase and measure its distortion using a feeler gauge. If the distortion exceeds the limit, grind the crankcase using a surface grinder.

Note: Do not overgrind the cylinder head, as the piston protrusion deviates from the standard value.

Item	Standard	Limit
Flatness of top surface	0.05 mm [0.0020 in.] or less	0.20 mm [0.0079 in.]

Note: Do not grind the surfaces more than 0.2 mm [0.0079 in.] in total (cylinder head bottom surface plus crankcase top surface).

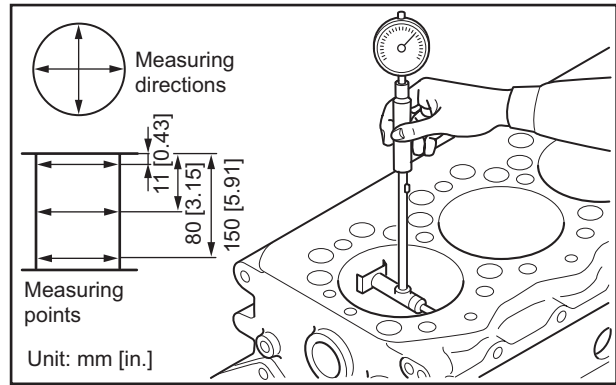


Measuring crankcase top surface distortion

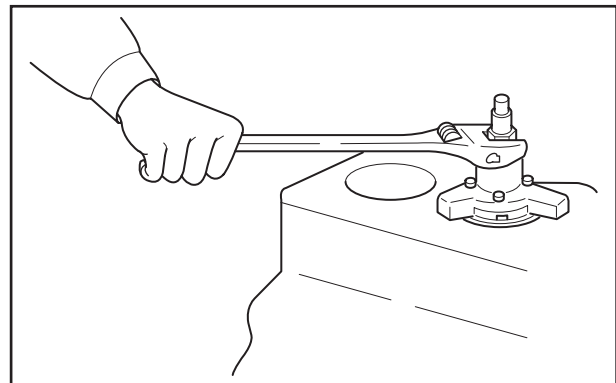
4.2 Measuring cylinder inside diameter

- (1) Measure the inside diameter of the cylinder at three levels, i.e., upper (with much stepped wear), middle, and lower levels, in both directions parallel to and perpendicular to the crankshaft direction.
- (2) If the measurement is between the repair limit and replacement limit, re-bore the cylinder to +0.25 mm [0.0098 in.] or +0.5 mm [0.0197 in.] oversize. Hone the re-bored cylinder to the accuracy of the standard.
- (3) Use an oversize piston and piston rings to fit the re-bored cylinder.
- (4) If the cylinder is worn unevenly, select an oversize diameter that ensures complete roundness when the cylinder is re-bored to the maximum. All cylinders must be re-bored to the same oversize diameter if one cylinder is re-bored.
- (5) If the cylinder has a slight wear and is reused after replacing only the piston rings, remove the steps in worn portion in the upper part of the cylinder using a ridge reamer. Hone it as necessary.

Item	Standard	Limit
Cylinder inside diameter	94.000 to 94.035 mm [3.7008 to 3.7022 in.]	Repair limit: 94.200 mm [3.7087 in.] Replace limit: 94.700 mm [3.7283 in.]
Circularity	0.01 mm [0.0004 in.] or less	-
Cylindricity	0.015 mm [0.0006 in.] or less	-



Measuring cylinder sleeve inside diameter

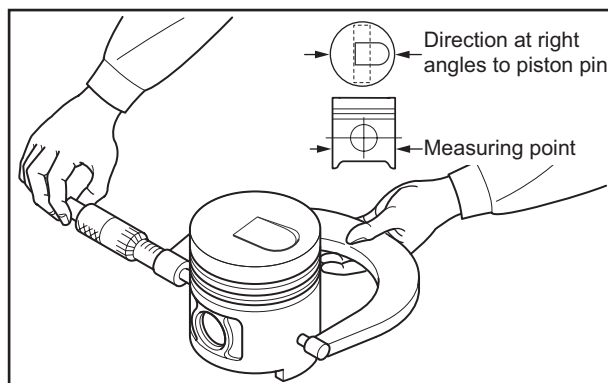


Refacing using a ridge reamer

INSPECTION AND REPAIR OF BASIC ENGINE

4.3 Measuring piston outside diameter

- Measure the piston outside diameter of the piston skirt at right angles to the piston pin. If it exceeds the limit, replace the piston with a new piston. When replacing piston, be sure to select a piston so that the piston weight difference in one engine is kept within the permissible range.

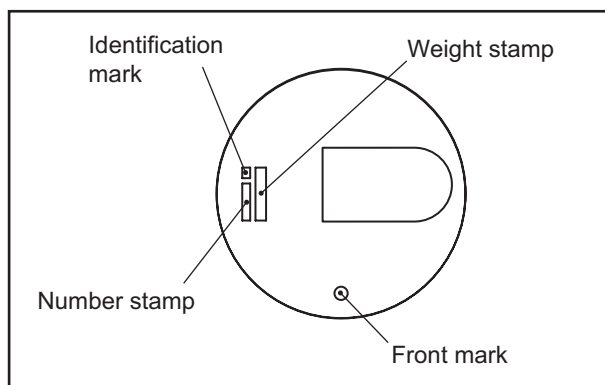


Measuring piston outside diameter

- The piston weight is stamped on the top of piston head.

Item		Nominal	Standard	Limit
Piston outside diameter (at piston skirt)	STD	ø 94 mm [3.70 in.]	93.955 to 93.985 mm [3.6990 to 3.7002 in.]	93.770 mm [3.6917 in.]
	0.25 mm [0.0098 in.] /OS		94.205 to 94.235 mm [3.7089 to 3.7100 in.]	94.020 mm [3.7016 in.]
	0.50 mm [0.0197 in.] /OS		94.455 to 94.485 mm [3.7187 to 3.7199 in.]	94.270 mm [3.7114 in.]
Weight difference in one engine			5 g [0.2 oz.] or less	-

The piston weight is stamped on the top of piston head.



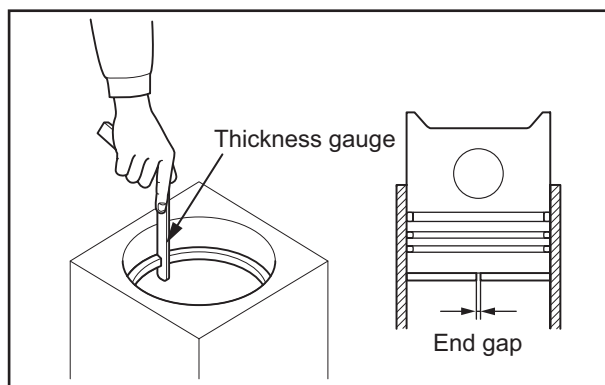
Piston weight stamp location

4.4 Measuring piston ring end gap

Place the piston ring in a gauge or a new sleeve to measure the ring end gap. If the limit is exceeded, replace all the rings as a set.

Note: Use a piston to push the piston ring squarely into the gauge or the sleeve.

Item		Standard	Limit
Closed gap of ring	No. 1 compression ring	0.30 to 0.50 mm [0.0118 to 0.0197 in.]	1.50 mm [0.0591 in.]
	No. 2 compression ring	0.50 to 0.70 mm [0.0197 to 0.0276 in.]	
	Oil ring	0.30 to 0.50 mm [0.0118 to 0.0197 in.]	



Measuring piston ring end gap

4.5 Measuring clearance between piston ring groove and piston ring

CAUTION

Remove carbon deposits from pistons and check the entire circumference of the piston.

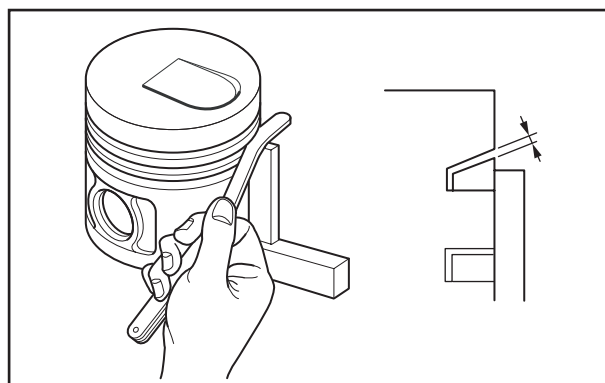
- (1) Remove deposits such as carbon from each ring groove.
- (2) Check each ring groove for wear or damage. If it is worn or damaged, replace the piston with a new one.
- (3) Insert the piston ring into the piston ring groove. Apply a straight edge and insert thickness gauges to measure the clearance between ring and ring groove.
If the limit is exceeded, replace the piston ring with a new one.
- (4) When the piston ring has been replaced, measure the clearance again, and if the limit is exceeded, then replace the piston with a new one.

Item		Standard	Limit
Clearance between piston ring groove	No. 1 compression ring	0.07 to 0.11 mm [0.0028 to 0.0043 in.]	0.200 mm [0.0079 in.]
	No. 2 compression ring	0.045 to 0.085 mm [0.0018 to 0.0033 in.]	0.150 mm [0.0059 in.]
	Oil ring	0.020 to 0.060 mm [0.0008 to 0.0024 in.]	0.150 mm [0.0059 in.]

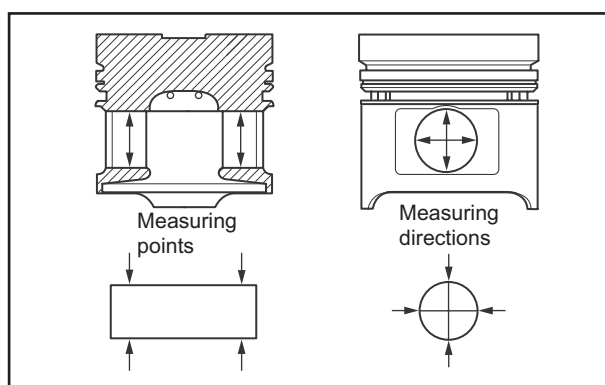
4.6 Measuring piston pin bore diameter and piston pin outside diameter

Measure the piston pin bore diameter and piston pin outside diameter. Replace if the limit is exceeded.

Item	Nominal	Standard	Limit
Piston pin outside diameter	ø 30 mm [1.18 in.]	29.994 to 30.000 mm [1.1809 to 1.1811 in.]	-
Clearance between piston pin	-	0.000 to 0.016 mm [0.0000 to 0.0006 in.]	0.050 mm [0.0020 in.]



Measuring clearance between piston ring groove and piston ring



Measuring piston pin bore diameter and piston pin outside diameter

INSPECTION AND REPAIR OF BASIC ENGINE

4.7 Measuring piston protrusion

CAUTION

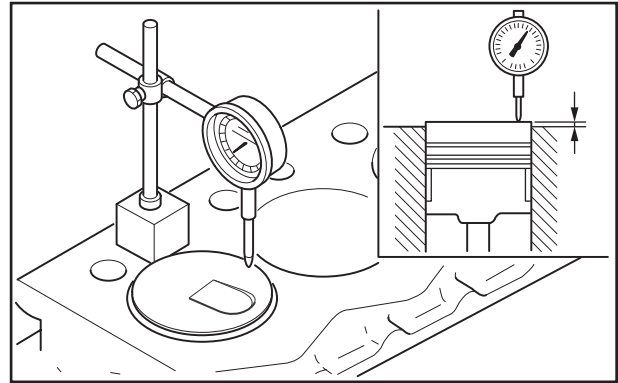
Piston protrusion must always meet the standard, as the amount of protrusion not only influences on the engine performance, but also it is important to prevent valve interference.

Measure the protrusion of each piston following the instructions below. If the measured value does not meet the standard, inspect the clearances between various parts involved.

- (1) Bring the piston to top dead center.
- (2) Apply the dial gauge plunger to the top surface of the crankcase, and zero the dial gauge.
- (3) Measure the protrusion at four points on the piston head, and calculate the mean value.

Note: Subtract the mean value from the thickness of the gasket compressed by tightening the cylinder head, and the clearance between the piston top and cylinder head will be determined.

Item	Standard
Piston protrusion	-0.25 to 0.15 mm [-0.0098 to 0.0059 in.]
Compressed thickness of cylinder head gasket	1.15 to 1.25 mm [0.0453 to 0.0492 in.]



Measuring piston protrusion

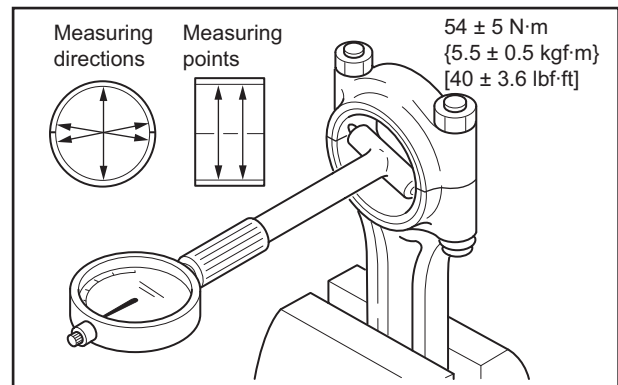
4.8 Measuring clearance between connecting rod bearing and crankpin

CAUTION

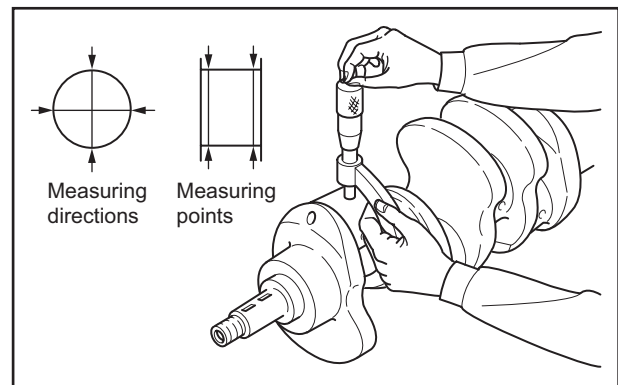
When grinding crankpins, be sure to grind all the pins to the same size.

Finish the fillet radius to the specified dimension.

- (1) Reassemble the bearing into the big end of the connecting rod.
- (2) Tighten the connecting rod cap bolts to the specified torque.
- (3) Measure the inside diameter of the connecting rod bearing.
- (4) Measure the outside diameter of the crankpin.
- (5) Calculate the clearance from the difference between the inside diameter of the connecting rod bearing and outside diameter of the crankpin.
- (6) Replace the connecting rod bearing if the clearance exceeds the limit.
- (7) Measure the clearance between the connecting rod bearing and the crankpin again. Use the undersize bearing if the limit is exceeded.
- (8) If an undersize bearing is used, grind the crankpin to the specified undersize.



Measuring connecting rod bearing inside diameter



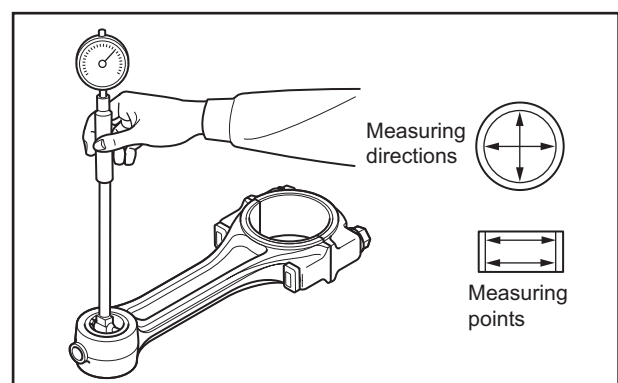
Measuring crankpin diameter

Item	Nominal	Standard	Limit
Crankpin outside diameter	ø 58 mm [2.28 in.]	57.955 to 57.970 mm [2.2817 to 2.2823 in.]	57.800 mm [2.2756 in.]
Clearance between crankpin and connecting rod bearing (oil clearance)	-	0.030 to 0.090 mm [0.0012 to 0.0035 in.]	0.200 mm [0.0079 in.]

4.9 Measuring clearance between connecting rod bushing and piston pin

Measure the inside diameter of the connecting rod bushing and the outside diameter of the piston pin. Replace if the limit is exceeded.

Item	Nominal	Standard	Limit
Bushing inside diameter	ø 30 mm [1.18 in.]	30.020 to 30.045 mm [1.1819 to 1.1829 in.]	-
Clearance between connecting rod bushing	-	0.020 to 0.091 mm [0.0008 to 0.0036 in.]	0.120 mm [0.0047 in.]



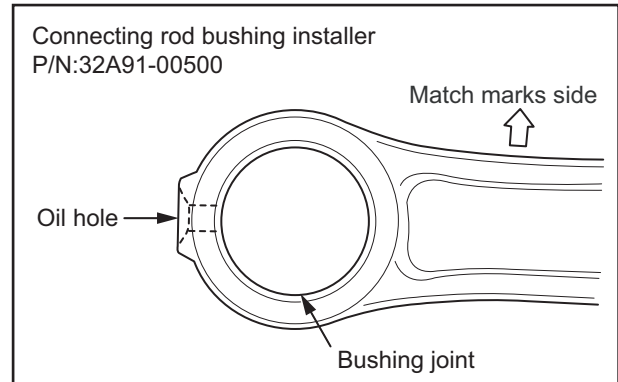
Measuring connecting rod bushing inside diameter

INSPECTION AND REPAIR OF BASIC ENGINE

4.10 Replacing connecting rod bushing

Use a connecting rod bushing installer to replace the connecting rod bushing.

- (1) With the bushing joints oriented as shown in the illustration, align the oil hole of bushing with the oil hole of connecting rod, and press-fit the connecting rod bushing into the connecting rod.
- (2) After press-fitting, insert the piston pin, and check for smooth movement of the connecting rod and piston without looseness.



Replacing connecting rod bushing

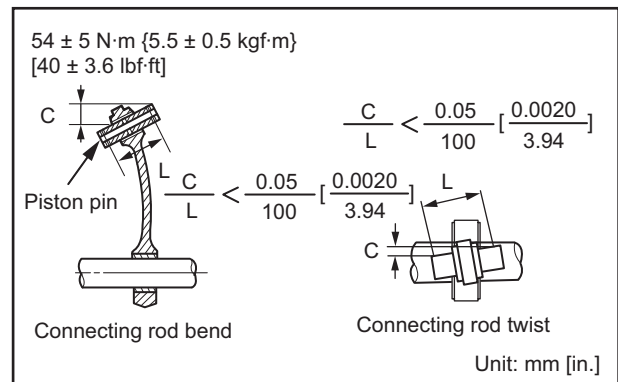
4.11 Inspecting connecting rod bend and twist

- (1) Measure the dimensions of C and L in the illustration to check bend and twist of the connecting rod. Straighten the connecting rod with a press to meet the standard. If the standard is exceeded after correction, replace the connecting rod with a new one.
- (2) In general, a connecting rod aligner is used to check bend and twist.

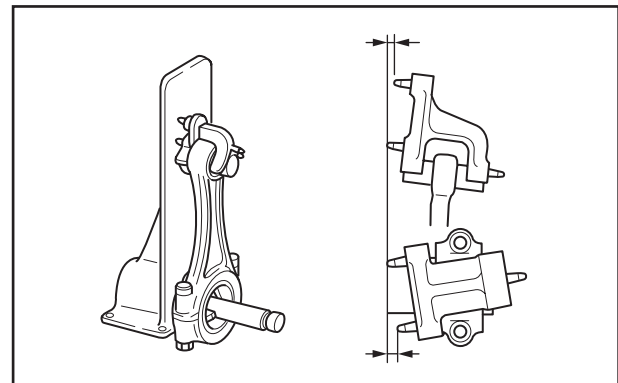
Note: Before checking bend, tighten the connecting rod cap to the specified torque.

- (3) To inspect the connecting rod with the piston installed, turn the piston upside down and place it on a surface plate. Insert a round bar having the same diameter as the crankpin into the big-end bore, and measure the height of the bar using a dial gauge.

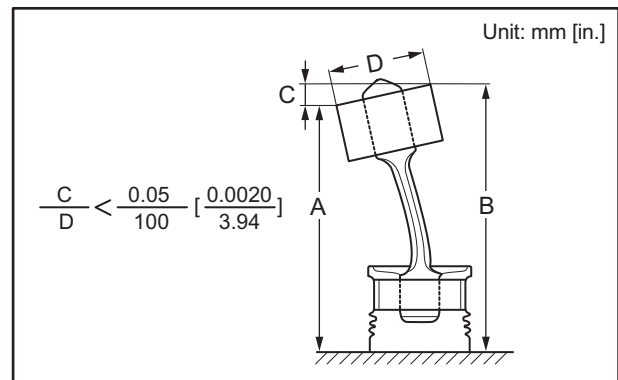
Item	Standard	Limit
Connecting rod bend and twist	0.05/100 mm [0.0020/3.94 in.] or less	0.15 mm [0.0059 in.]



Inspecting connecting rod bend and twist



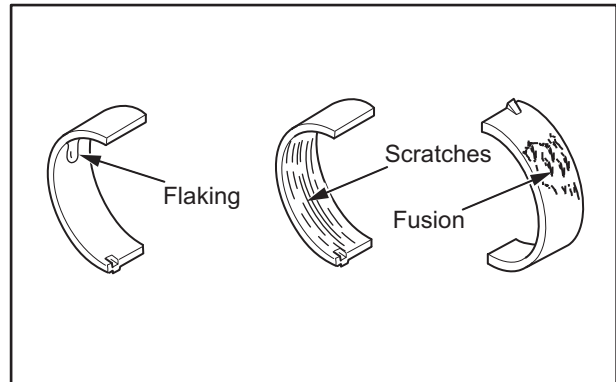
Using a connecting rod aligner to measure rod bend and twist



Measuring with a dial gauge

4.12 Inspecting connecting rod bearing

Inspect the connecting rod bearings. If any defect is found, replace it with a new one.

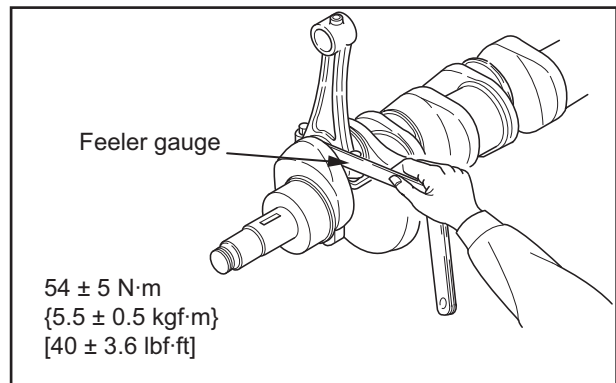


Inspecting connecting rod bearing

4.13 Measuring connecting rod end play

- (1) Install the connecting rods onto the respective crankpins and tighten the connecting rod cap bolts to the specified torque.
- (2) Measure the clearance of the crank arm (end play) at two positions (above and below the crankpin).
- (3) If the limit is exceeded, replace the connecting rod with a new one.

Item	Standard	Limit
Connecting rod end play	0.15 to 0.35 mm [0.0059 to 0.0138 in.]	0.50 mm [0.0197 in.]

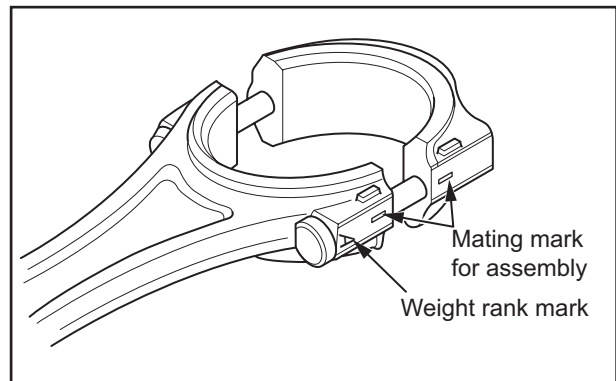


Measuring connecting rod end play

4.14 Weight difference of connecting rod assembly in one engine

When replacing a connecting rod, be sure to check the weight rank of the connecting rod. All the connecting rods must be of the same weight rank in an engine.

Item	Tolerance on weight
Weight difference of connecting rod assembly	10 g [0.35 oz.] or less



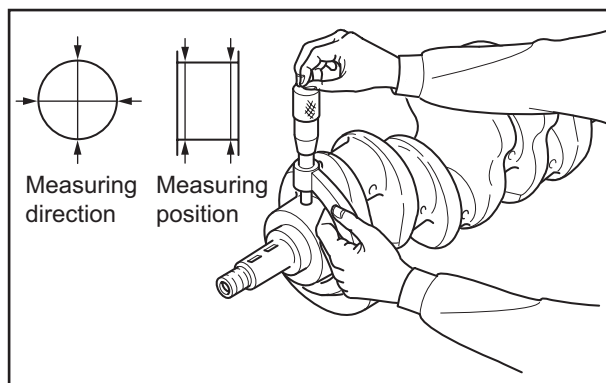
Weight difference in connecting rod assembly

INSPECTION AND REPAIR OF BASIC ENGINE

4.15 Measuring crankshaft journal outside diameter

Measure the crankshaft journal diameter using a micrometer. Check the crankshaft journal for circularity, cylindricity and clearance between the bearing and journal. If the measurement value is below the repair limit, grind the journal to fit the undersize bearing. If the measurement value is below the service limit, replace the crankshaft with a new one.

Item	Nominal	Standard	Limit
Outside diameter	ø 78 mm [3.07 in.]	77.955 to 77.970 mm [3.0691 to 3.0697 in.]	77.850 mm [3.0650 in.] (Repair) 77.100 mm [3.0354 in.] (Replace)
Roundness	-	0.01 mm [0.0004 in.] or less	0.03 mm [0.0012 in.]
Cylindricity	-	0.01 mm [0.0004 in.] or less	0.03 mm [0.0012 in.]
Parallelism	-	Pin maximum defection: 0.01 mm [0.0004 in.] or less	-

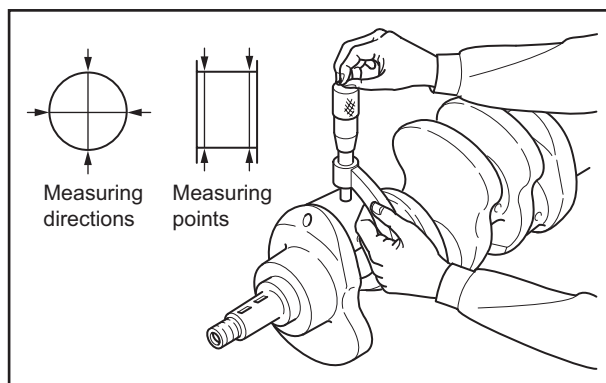


Measuring crankshaft journal outside diameter

4.16 Measuring crankshaft crankpin outside diameter

Measure the crankpin outside diameter using a micrometer. Check the crankpin for roundness, cylindricity, and the clearance with the bearing. If the measurement value is below the limit, grind the journal to fit the undersize bearing. If the measurement value is below the service limit, replace the crankshaft with a new one.

Item	Nominal	Standard	Limit
Outside diameter	ø 58 mm [2.28 in.]	57.955 to 57.970 mm [2.2817 to 2.2823 in.]	57.800 mm [2.2756 in.]
Roundness	-	0.01 mm [0.0004 in.] or less	0.03 mm [0.0012 in.]
Cylindricity	-	0.01 mm [0.0004 in.] or less	0.03 mm [0.0012 in.]
Parallelism	-	Pin maximum defection: 0.01 mm [0.0004 in.] or less	-



Measuring crankpin diameter

4.17 Grinding crankshaft

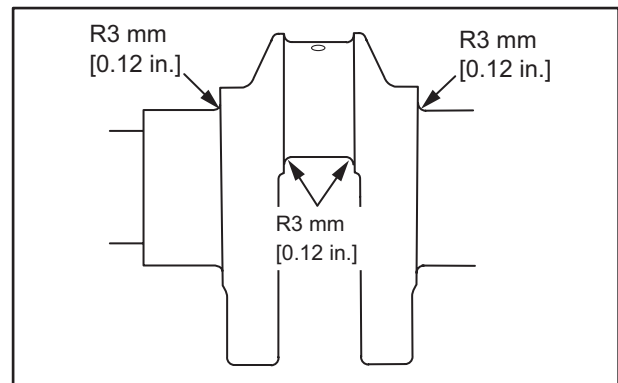
CAUTION

- (a) When grinding crank journals, be sure to grind all the journals to the same size.
- (b) Finish the fillet radius to the specified dimension.

Grind the crankshaft journal (or pin) to the diameter that fits the inside diameter of the next undersize main (or connecting) bearing. By doing so, the fitness check with an actual bearing can be omitted.

When grinding, be careful not to change the fillet radius and width. If the surface hardness is considered to have been reduced considerably, re-harden the crankshaft and check for flaws by means of magnetic particle inspection.

Ensure that the surface finish accuracy of the crankpins and journals is kept within the standard even after the correction by grinding.



Finished dimension of fillet R

Item	Undersize	Finished size
Crank journal	0.25 mm [0.0098 in.]	77.705 to 77.720 mm [3.0592 to 3.0598 in.]
	0.50 mm [0.0197 in.]	77.455 to 77.470 mm [3.0494 to 3.0500 in.]
	0.75 mm [0.0295 in.]	77.205 to 77.220 mm [3.0396 to 3.0402 in.]
Crankpin	0.25 mm [0.0098 in.]	57.705 to 57.720 mm [2.2718 to 2.2724 in.]
	0.50 mm [0.0197 in.]	57.455 to 57.470 mm [2.2620 to 2.2626 in.]
	0.75 mm [0.0295 in.]	57.205 to 57.220 mm [2.2522 to 2.2528 in.]

INSPECTION AND REPAIR OF BASIC ENGINE

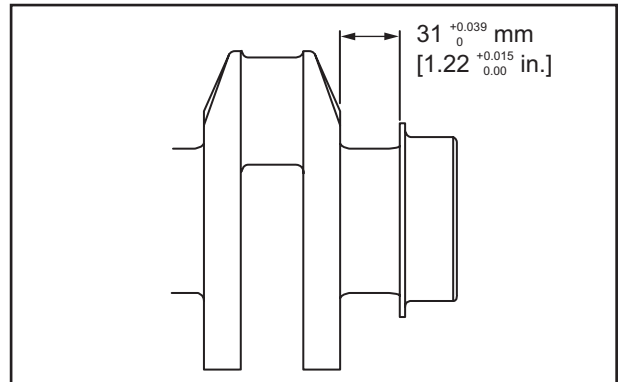
4.18 Measuring crankshaft end play

- (1) Measure the crankshaft end play (clearance between the crank arm at the thrust force receiving journal and the bearing cap with thrust plate attached). If the limit is exceeded, replace the thrust plate with a new one.
- (2) If the limit is still exceeded after a new thrust plate has been installed, use an oversize thrust plate.

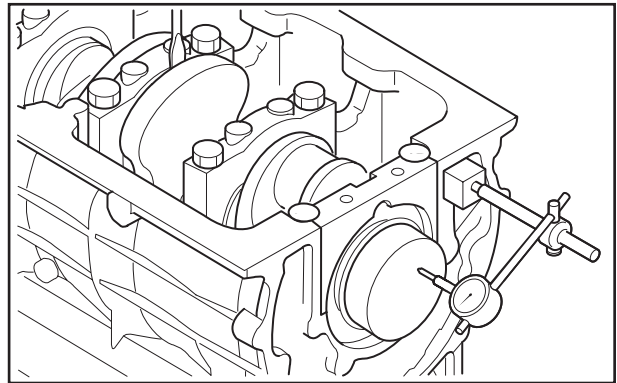
Note: In general, the rear thrust bearing wears faster than the front thrust bearing. Therefore, in most cases, the correction is achieved by replacing the rear thrust plate with the next oversize one.

Item	Standard	Limit
Crankshaft end play	0.100 to 0.264 mm [0.0039 to 0.0104 in.]	0.300 mm [0.0118 in.]

Crankshaft thrust size after grinding			
Item	OS, used on one side	OS, used on both sides	Tolerance
+0.15 mm [+0.0059 in.] OS	31.15 mm [1.2264 in.]	31.30 mm [1.2323 in.]	+0.039 0 mm [+0.0015 0.00 in.]
+0.30 mm [+0.0118 in.] OS	31.30 mm [1.2323 in.]	31.45 mm [1.2382 in.]	



Width of crankshaft thrust journal



Measuring crankshaft end play

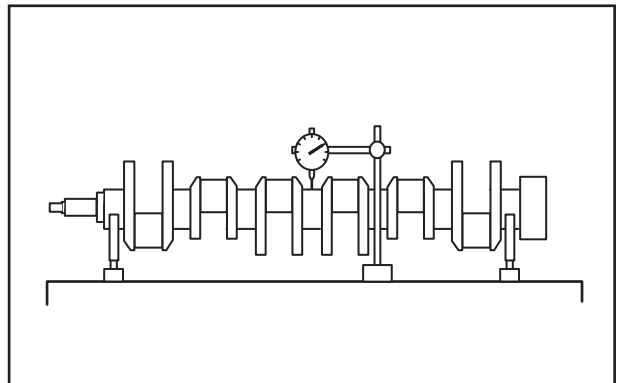
4.19 Measuring crankshaft runout

Support the crankshaft at the front and rear journals with V-blocks, and measure the crankshaft runout at the center journal using a dial gauge. If the runout deviates from the standard only slightly, grind the crankshaft to repair. If the runout exceeds the standard considerably, straighten the crankshaft using a press.

If the limit is exceeded, replace the crankshaft.

If the crankshaft has been repaired by grinding or pressing, inspect the crankshaft for cracks and other harmful damage using a magnetic particle method.

Item	Standard	Limit	Remark
Crankshaft runout	0.04 mm [0.0016 in.] or less	0.10 mm [0.0039 in.]	TIR



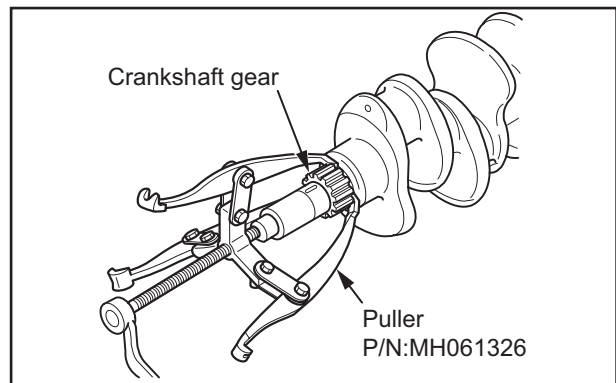
Measuring crankshaft runout

4.20 Replacing crankshaft gear

4.20.1 Removing crankshaft gear

Using a gear puller, remove the gear from the crankshaft.

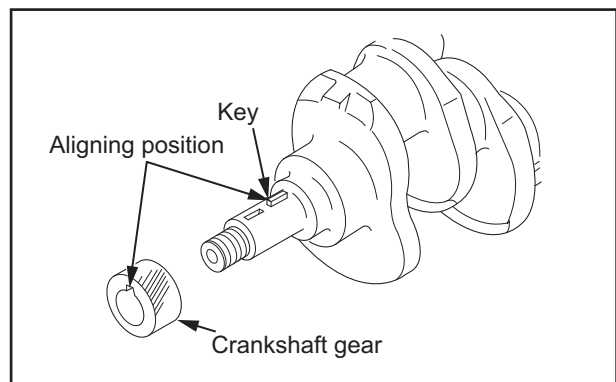
Note: Do not strike the gear with a hammer.



Removing crankshaft gear

4.20.2 Installing crankshaft gear

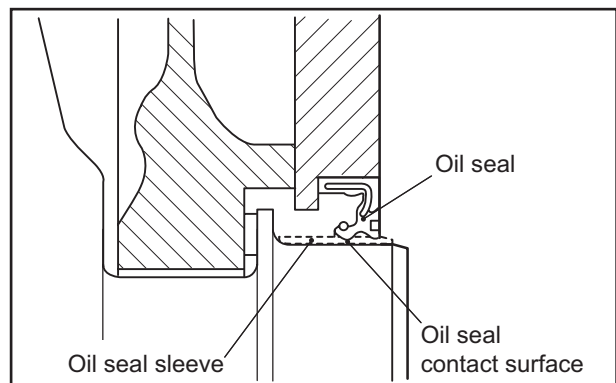
- (1) Install the key on the crankshaft.
- (2) Press-fit the gear fully in alignment with the key.



Installing crankshaft gear

4.21 Inspecting oil seal contact surface

Inspect the oil seal contact surface located on the crankshaft rear part. If the crankshaft wears due to the oil seal, replace the oil seal and the oil seal sleeve with new spare parts.



Inspecting oil seal contact surface (1)

INSPECTION AND REPAIR OF BASIC ENGINE

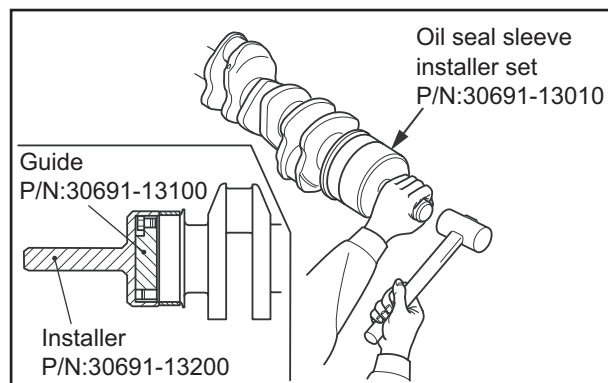
4.22 Installing oil seal sleeve

CAUTION

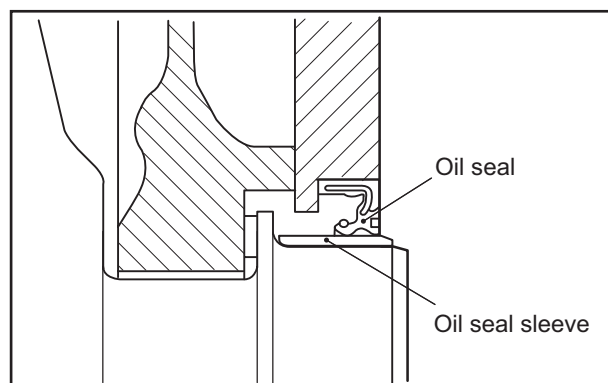
Be careful not to dent or damage the oil seal sleeve circumference.

When installing the oil seal sleeve, apply the oil to the inside of the oil seal sleeve, and drive it into the crankshaft by using oil seal sleeve installer set.

When the engine is operated again and the oil seal sleeve wears, remove the oil seal sleeve by using following method and replace the oil seal assembly (oil seal and oil seal sleeve) with the new spare parts.



Installing oil seal sleeve



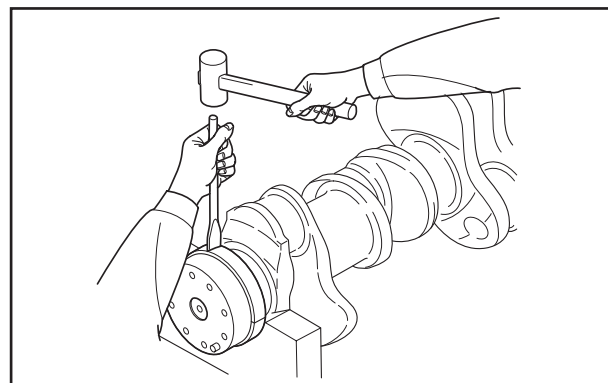
Inspecting oil seal contact surface (2)

4.23 Removing oil seal sleeve

CAUTION

When making a cut in the sleeve, be very careful not to damage the crankshaft with the chisel.

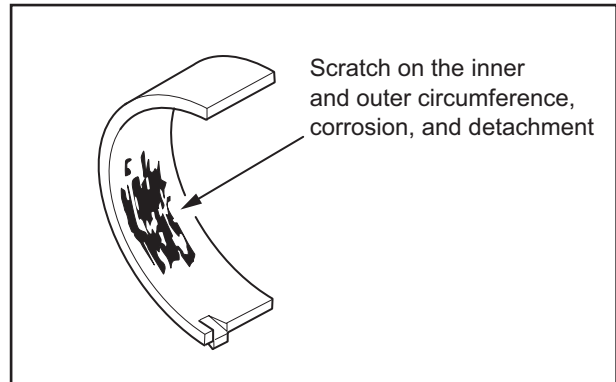
Make a cut at three locations on the periphery of the oil seal sleeve to reduce its tension. To do so, hold a chisel against the sleeve periphery in the radial direction and strike it with a hammer. When the sleeve is loosened, remove the sleeve. If the sleeve can not be removed by the above procedure, hold the chisel against the sleeve in the axial direction and tap on it lightly to make the sleeve expand. Once the interference between the crankshaft and sleeve is eliminated, the sleeve can be removed easily.



Removing oil seal sleeve

4.24 Inspecting main bearing surface

Check the inside surface of each main bearing shell for abnormal contact, scratches, corrosion and peeling from foreign material. Also check the outside surface of each bearing shell which comes into contact with the crankcase or main bearing cap for abnormal seating.

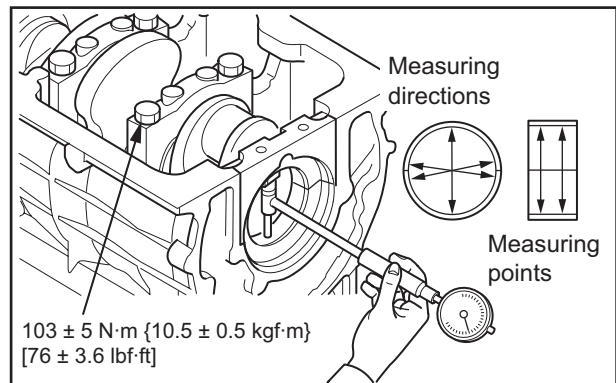


Inspecting main bearing surface

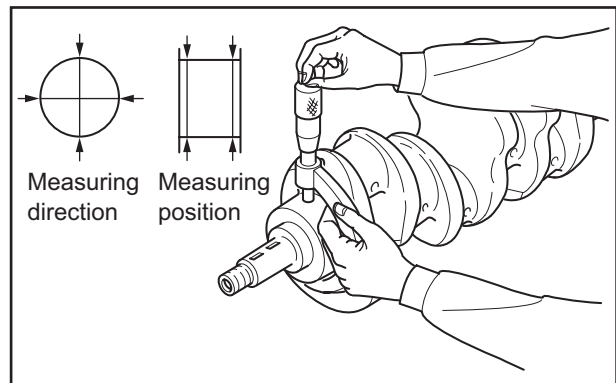
4.25 Measuring clearance between main bearing and crankshaft journal

- (1) Reassemble main bearings.
- (2) Tighten the main bearing caps to the specified torque.
- (3) Measure the inside diameter of the main bearings.
- (4) Measure the outside diameter of the crank journal.
- (5) Calculate the clearance between the inside diameter of the main bearing and outside diameter of the crank journal.
- (6) Replace the main bearing if the clearance exceeds the limit.
- (7) Measure the clearance between the main bearing cap and the crank journal again. Use the undersize bearing if the limit is exceeded.
- (8) If an undersize bearing is used, grind the crank journal to the specified undersize.

Item	Standard	Limit
Clearance between main bearing and crankshaft journal	0.050 to 0.110 mm [0.0020 to 0.0043 in.]	0.200 mm [0.0079 in.]



Measuring inside diameter of lower hole of main bearing



Measuring crank journal outside diameter

REASSEMBLY OF BASIC ENGINE

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REASSEMBLY OF BASIC ENGINE

1. Reassembling piston, connecting rod, crankshaft and crankcase

1.1 Installing main bearing

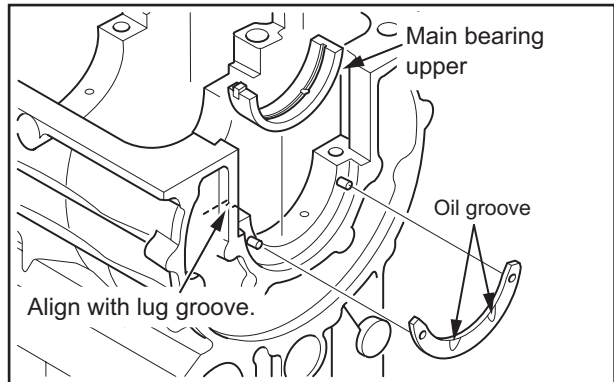
CAUTION

Do not apply oil to the bearing outer surface, as the oil may cause bearing seizure.

- (1) Press the upper main bearing into position by aligning its lug to the lug groove on the crankcase.

Note: The oil hole of the main bearing is aligned with the oil hole of the crankcase by installing the upper main bearing in alignment with the lug groove.

- (2) Apply a small amount of engine oil to each bearing.



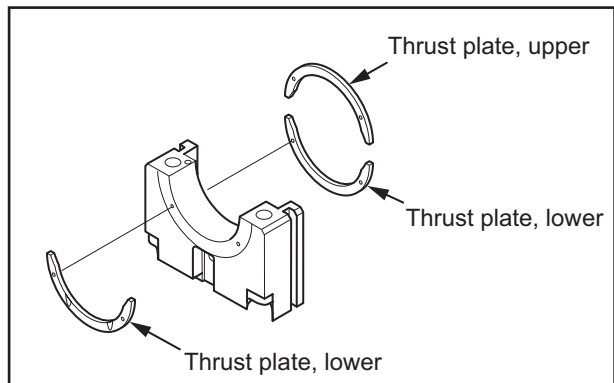
Installing main bearing upper

1.2 Installing thrust plate

Install the thrust plates to the crankcase outside face of rearmost bearing and to the main bearing cap with their grooves facing outward.

1.3 Installing tappet

Apply engine oil onto the periphery of tappets, insert them into the tappet holes.



Installing thrust plate

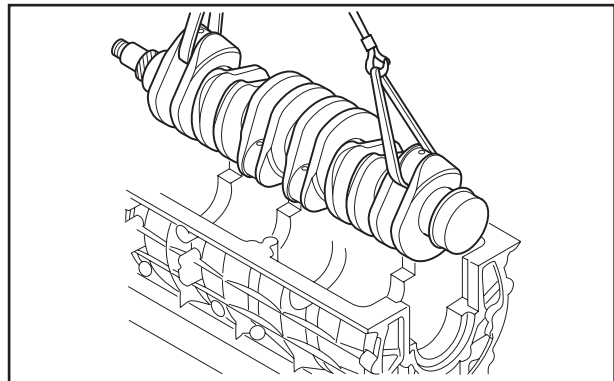
1.4 Installing crankshaft

- (1) Install the wood ruff key on the crankshaft.
- (2) Make sure that the main bearing upper shells that are installed in the crankcase bores have their inner periphery (the surface comes into contact with the journal) lubricated with an even coat of fresh engine oil.
- (3) Wash the crankshaft thoroughly with cleaning oil and dry it completely by blowing compressed air. Then, apply an even coat of fresh engine oil to the crankshaft journals.

Note: When cleaning the crankshaft, pay special attention to the oil holes in the crank journals and crankpins, and make sure that they are free from any foreign matter.

- (4) Sling up the crankshaft horizontally, then move it above the crankcase and lower it slowly into position.

Note: When lifting the crankshaft with a chain block, do not attach a metal hook or similar fitting directly onto the crankshaft. Such metal fittings can damage the crankshaft easily. Always lift the crankshaft using cloth belts or pads on the supporting points.



Installing crankshaft

1.5 Installing main bearing caps

CAUTION

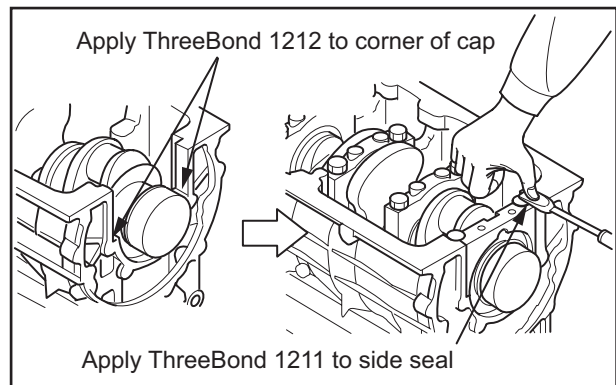
The foremost and rearmost caps should be installed so that they are flush with the crankcase surface.

Install the main bearing caps from the front side in the order of the numbers marked on them.

- (1) Apply engine oil to lower main bearings and install them to the main bearing caps.
- (2) Apply ThreeBond 1212 to the mating surface of the foremost and rearmost caps and the crankcase mating faces before installing the main bearing caps.

Note: Do not apply ThreeBond 1212 to any other surface other than the mating surfaces of the foremost and rearmost caps and the crankcase mating faces.

- (3) Install the main bearing caps and temporarily tighten bolts.



Installing main bearing cap

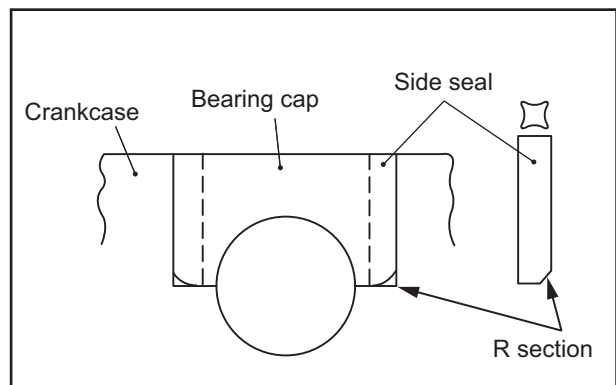
1.6 Inserting side seal

- (1) Apply a sealant to the outer periphery of new side seals.

Sealant	ThreeBond 1211
---------	----------------

- (2) With the round section of the side seals facing outward, press them partway into the front and rear caps using hands.
- (3) When the side seals are installed partway into caps, use a tool with a flat surface to install completely, taking care not to bend the seal.

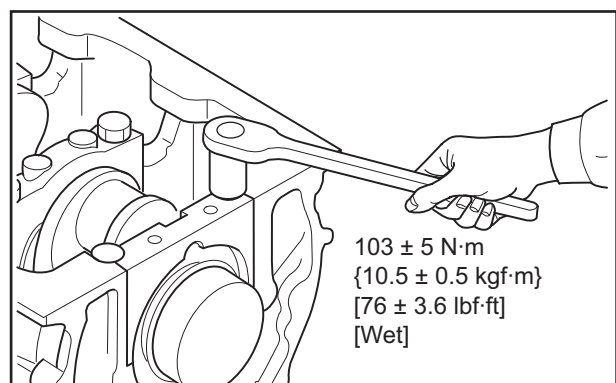
Note: Make sure that the rear bearing cap rear face is flush with the engine rear face.



Inserting side seal

1.7 Installing main bearing cap bolt

- (1) Tighten the main bearing cap bolts alternately and progressively to the specified torque.
- (2) Make sure that the crankshaft rotates smoothly.



Installing main bearing cap bolt

REASSEMBLY OF BASIC ENGINE

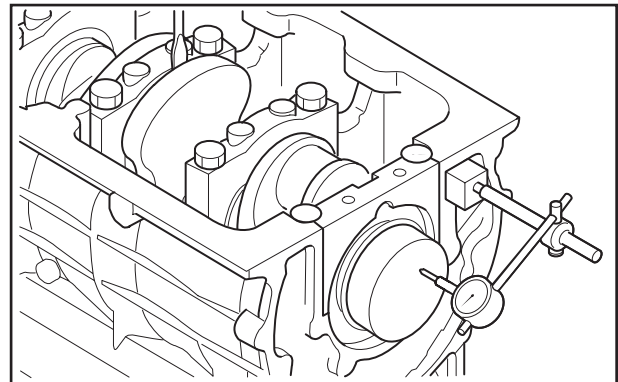
1.8 Measuring crankshaft end play

Attach a dial gauge to the end of the crankshaft to measure the end play.

If the end play deviates from the standard value, loosen the main bearing cap bolts and retighten.

Make sure that the crankshaft turns freely.

Item	Standard	Limit
Crankshaft end play	0.100 to 0.264 mm [0.0039 to 0.0104 in.]	0.300 mm [0.0118 in.]



Measuring crankshaft end play

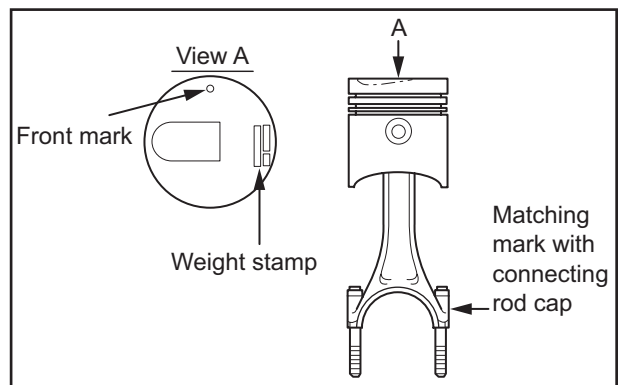
1.9 Reassembling piston and connecting rod

- (1) Apply engine oil to the piston pin, and reassemble the piston and the connecting rod by inserting the piston pin, observing the orientation of piston and connecting rod shown in the illustration.

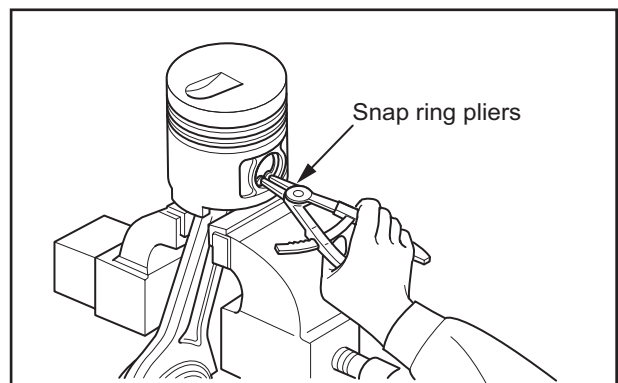
Note: The pistons and piston pins are assembled to each other in clearance fit. However, the piston pins are more easily inserted into the pistons if the pistons are warmed up with a heater or in hot water.

- (2) Using ring pliers, install the snap ring. Check the snap ring for its tension, and make sure the ring fits snugly in the groove.

Note: Install all the snap rings so that their end gap faces toward the bottom of the piston.



Reassembling piston and connecting rod



Installing snap ring

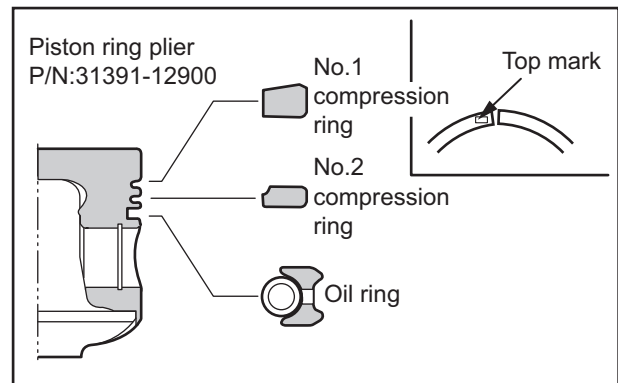
1.10 Installing piston ring

CAUTION

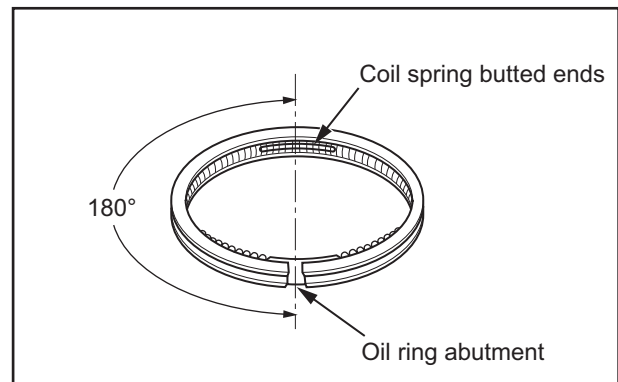
A marking is stamped near the end gap to indicate the top face of piston ring. Install all piston rings with this mark facing upward.

If the rings are installed upside down, it could cause malfunctions such as excessive oil consumption or an engine seizing.

- (1) Install the piston rings to the piston with a ring expander.
- (2) Install the oil ring with its end gap 180° away from the joint of the coil spring, as shown in the illustration.



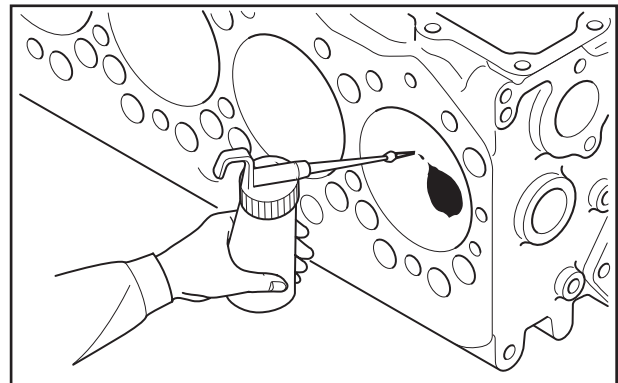
Piston/piston ring orientation



Reassembling oil ring

1.11 Preparation for installing pistons

- (1) Lay the engine on its side.
- (2) Clean the cylinder inner surface and the crank pin with a cloth, and apply engine oil.



Cleaning cylinder inner surface and applying engine oil

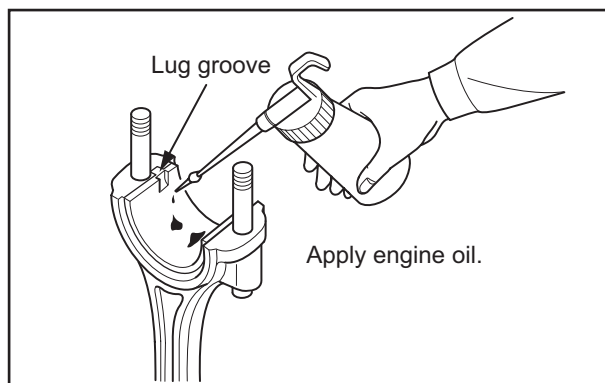
REASSEMBLY OF BASIC ENGINE

1.12 Installing connecting rod bolt and connecting rod bearing

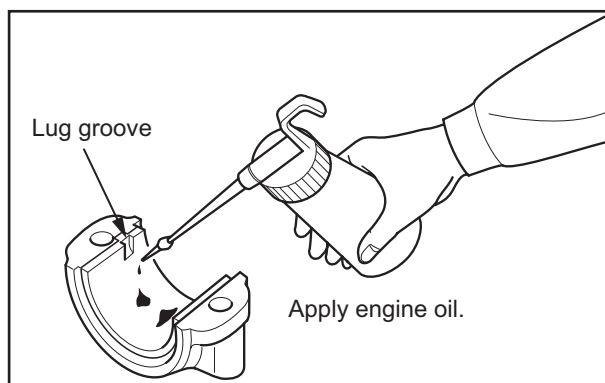
- (1) Press fit the connecting rod bolts into the connecting rod.

Note: When press fitting the bolt, make sure that the bolt fully contacts its seating position without any interference with the shoulder of mounting surface.

- (2) Install the upper connecting rod bearing with its lug fitted in the lug groove of connecting rod.
- (3) Install the connecting rod bearing with its lug fitted in the lug groove of connecting rod cap.
- (4) Apply engine oil to the inner surface of bearing.



Installing connecting rod bolt and bearing upper



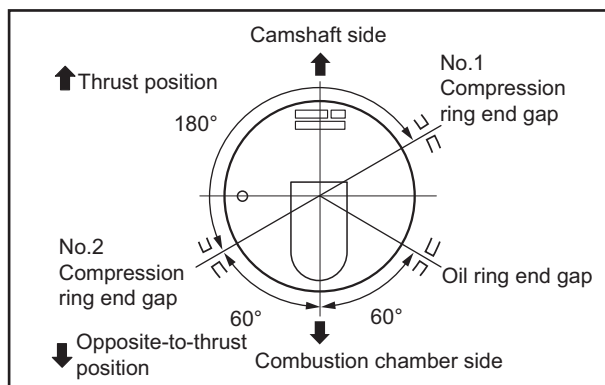
Installing connecting rod bearing

1.13 Installing pistons

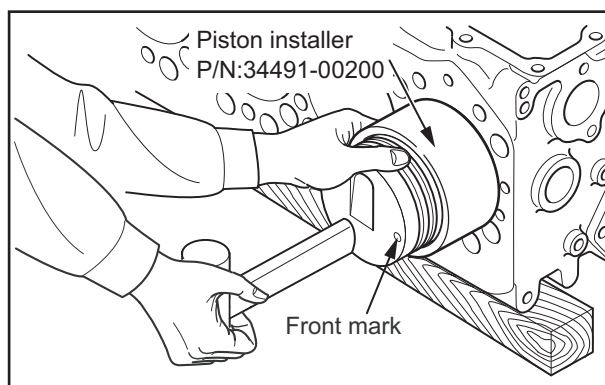
CAUTION

Do not forcefully insert the piston, as it may cause damage to the piston rings and crank pin.

- (1) Apply engine oil to the circumference of the piston and piston rings.
- (2) Orient the ring end gaps diagonally opposite each other avoiding the piston pin direction and its right angle direction.
- (3) Turn the crankshaft to bring the crank pin of the cylinder to bottom dead center.
- (4) Orient the front mark on the top of piston toward engine front.
- (5) Using a piston installer, insert the piston from the top face of crankcase into the cylinder.



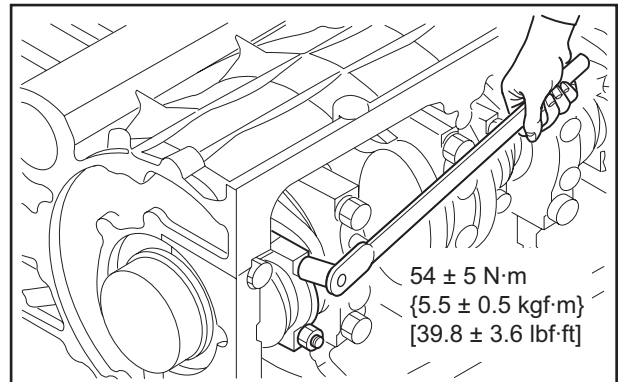
Orientation of piston ring end gaps



Installing piston

1.14 Installing connecting rod cap

- (1) Install the connecting rod cap with its match mark facing on the same side as the match mark on the connecting rod.
- (2) Tighten the connecting rod cap nuts evenly and progressively to the specified torque.
- (3) Inspect end play of the connecting rod. If end play is small, loosen and retighten the cap nuts.



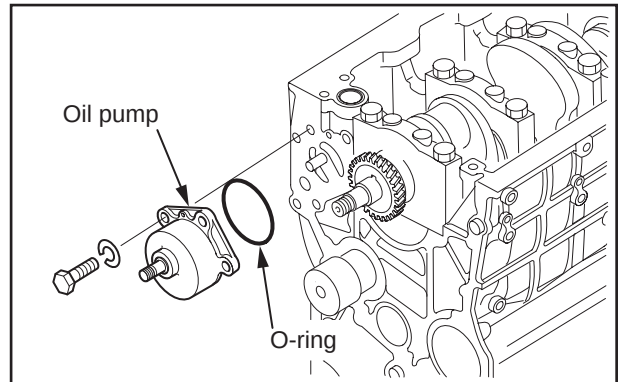
Installing connecting rod cap

REASSEMBLY OF BASIC ENGINE

2. Reassembling timing gear and camshaft

2.1 Installing oil pump

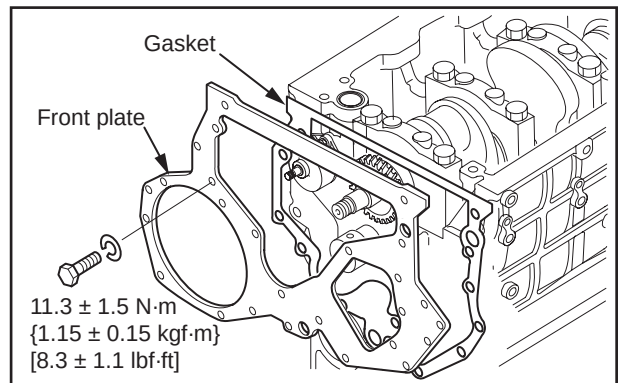
Install a new O-ring to the oil pump case, and install the oil pump to the crankcase.



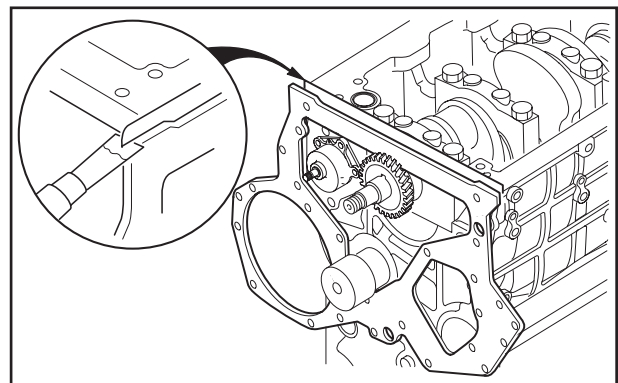
Installing oil pump

2.2 Installing front plate

- (1) Clean the gasket mounting surface.
- (2) Apply sealant to the gasket to prevent it from falling.
- (3) With aligning to the dowel pin, install the gasket and the front plate.
- (4) Secure the front plate with mounting bolts.
- (5) Cut the gasket protruding from crankcase bottom side with cutter.



Installing front plate (1)



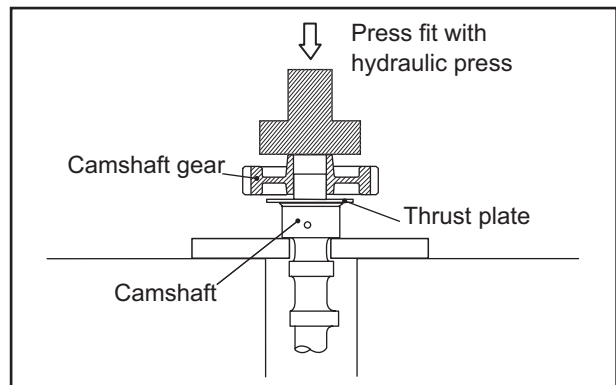
Installing front plate (2)

2.3 Installing camshaft gear and thrust plate

CAUTION

Be careful not to damage the cam of the camshaft or bushing.

Warm the camshaft gear and insert the thrust plate without fail when installing the gear.



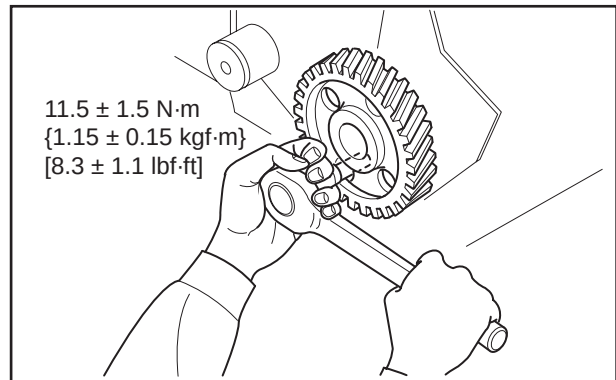
Installing camshaft gear and thrust plate

2.4 Installing camshaft

CAUTION

Be careful not to damage camshaft journals, cams and camshaft holes during insertion.

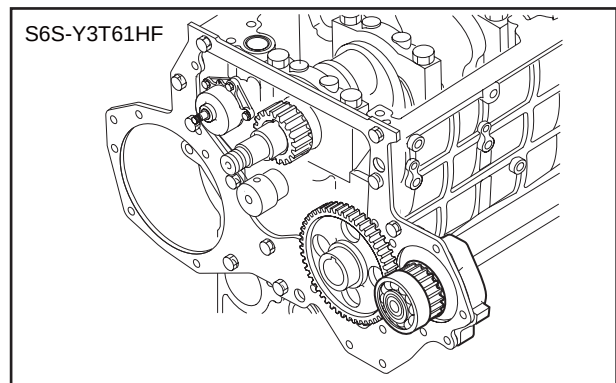
- (1) Apply engine oil to the camshaft journals and cams.
- (2) Slowly insert the camshaft assembly.
- (3) Tighten the thrust plate bolt to the specified torque.
- (4) Make sure that the camshaft rotates lightly. Move the camshaft gear back and forth, and make sure there is end play.



Installing camshaft

2.5 Installing PTO drive gear

- (1) Press fit the bearing into the PTO drive gear.
- (2) Install the PTO drive gear with bearing to the bearing case.
- (3) Install the PTO gear as assembly with the bearing case to the front plate.

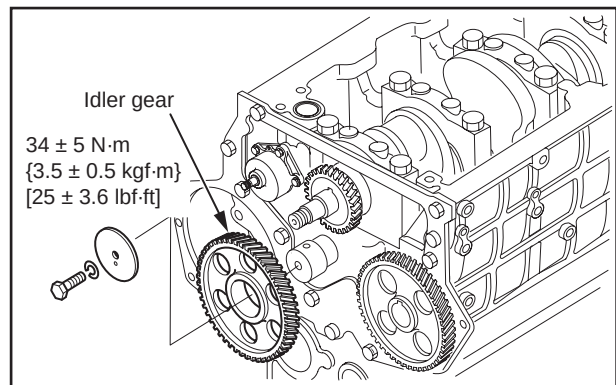


Installing PTO drive gear

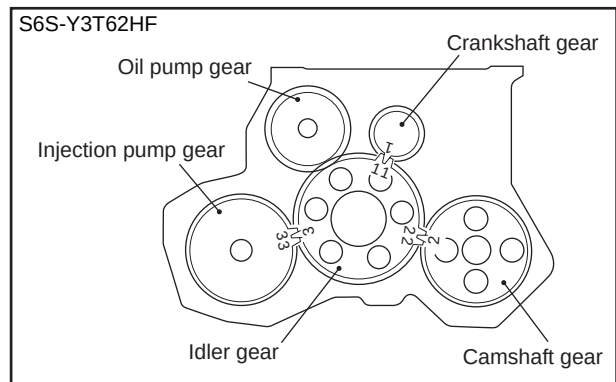
REASSEMBLY OF BASIC ENGINE

2.6 Installing idler gear

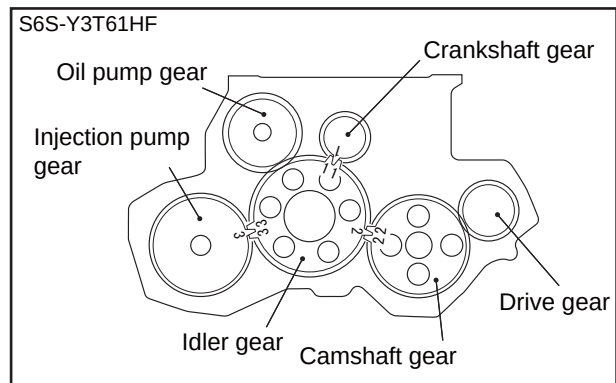
- (1) Apply engine oil to the idler gear shaft.
- (2) Install the idler gear with its match marks aligned with the marks on the crankshaft gear and camshaft gear.
- (3) Attach the thrust plate to the idler gear and tighten the mounting bolt to the specified torque.



Installing idler gear



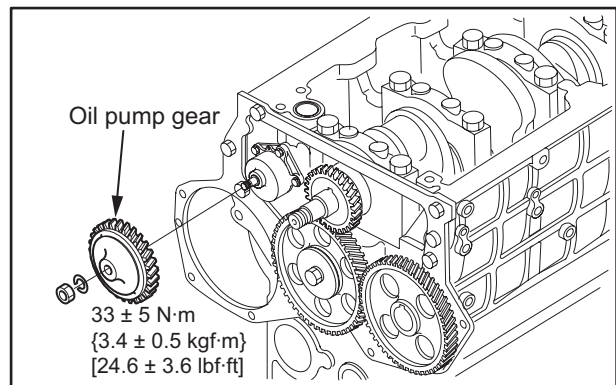
Timing gear train



Timing gear train

2.7 Installing oil pump gear

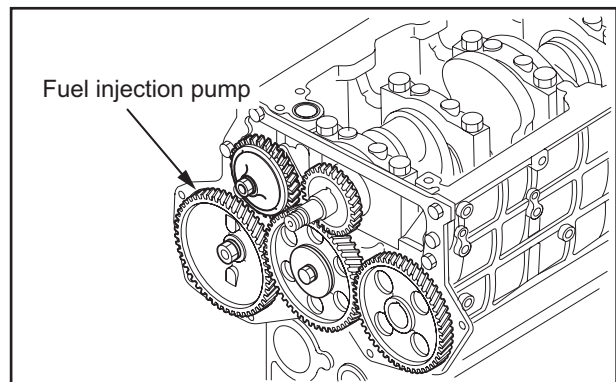
- (1) Install the oil pump gear to the oil pump shaft.
- (2) Tighten the jam nut to the specified torque.



Installing oil pump gear

2.8 Installing fuel injection pump

- (1) Install the fuel pump gear with its match marks aligned with the marks on the fuel injection pump and idler gear.
- (2) Tighten the fuel injection pump mounting bolts evenly.



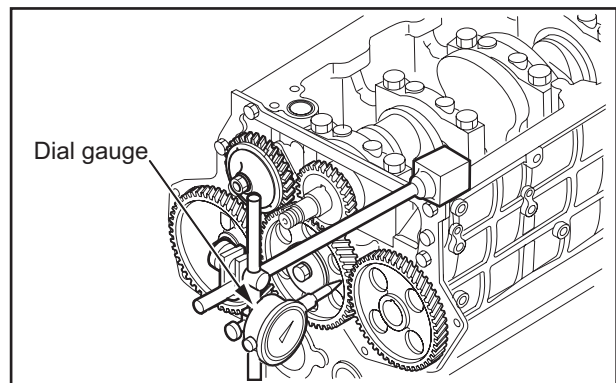
Installing fuel injection pump

2.9 Inspecting and adjusting timing gear after installation

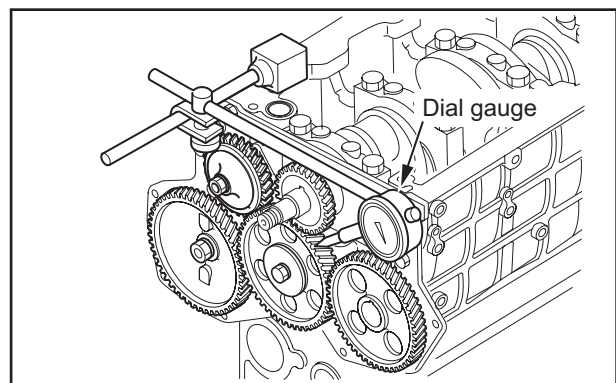
Be sure to inspect and adjust the timing gear when the timing gear has been reassembled.

2.9.1 Inspecting backlash and end play

After installing the timing gears, be sure to inspect and adjust the backlash and end play between gears.



Measuring idler gear end play

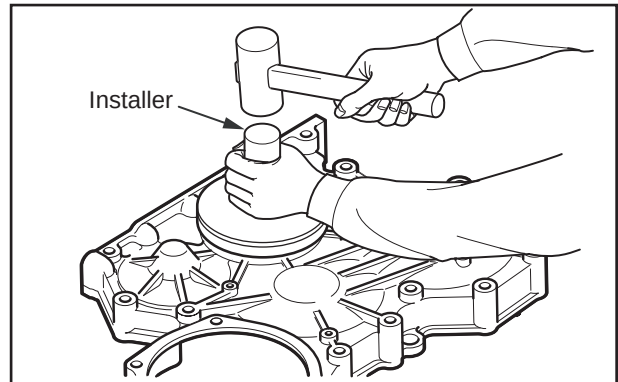


Measuring timing gear backlash

REASSEMBLY OF BASIC ENGINE

2.10 Installing front oil seal

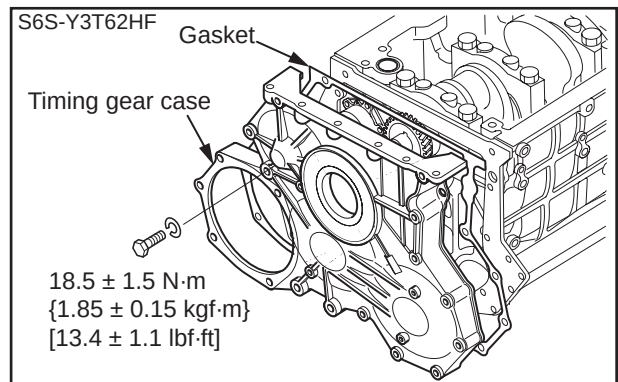
Using an installer, install new oil seal in the timing gear case. Make sure the oil seal is flush with the gear case.



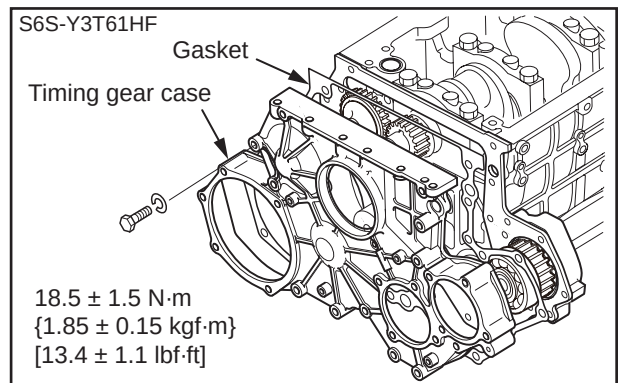
Installing front oil seal

2.11 Installing timing gear case

- (1) Aligning with the dowel pins, install the gasket to the crankcase.
- (2) Apply engine oil to the oil seal lip.
- (3) Install the timing gear case and tighten the bolts.
- (4) Cut the gasket protruding from crankcase bottom side with cutter.



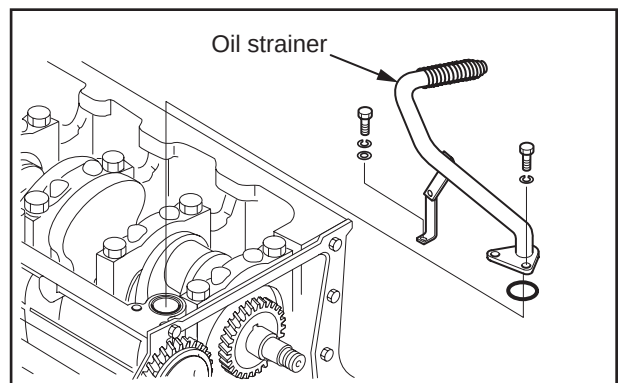
Installing timing gear case



Installing front plate

2.12 Installing oil strainer

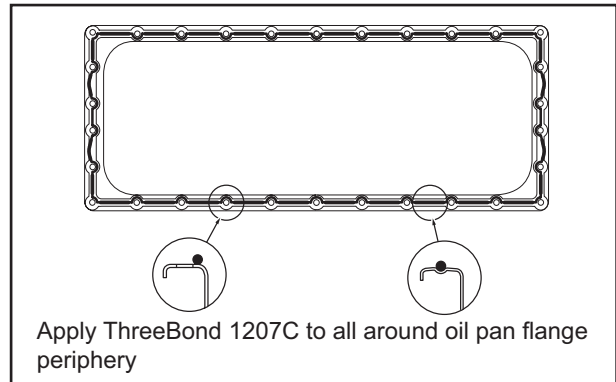
Install a new O-ring to the oil strainer, and install the oil strainer to the crankcase.



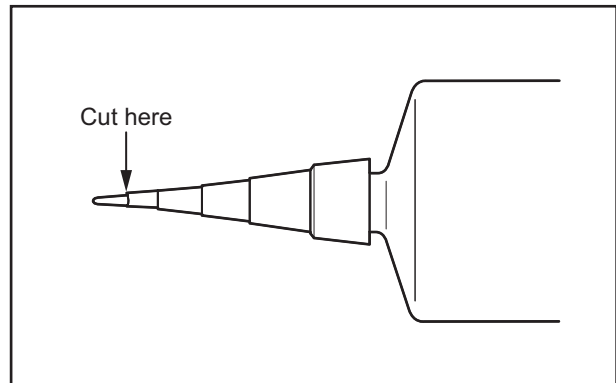
Installing oil strainer

2.13 Installing oil pan

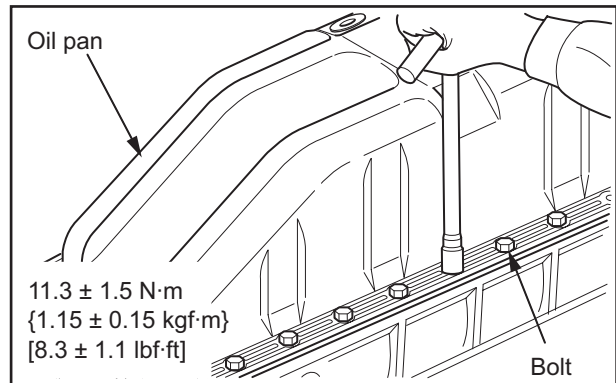
- (1) Clean the mount surfaces of the crankcase, timing gear case, and oil pan.
- (2) Squeeze ThreeBond 1207C (32A91-05100: liquid gasket) in a 4 mm [0.16 in.] diameter bead all around the oil pan flange periphery, and spread it.
- (3) Install the oil pan to the crankcase within five minutes of applying the liquid gasket.
- (4) Tighten the mounting bolts to the specified torque.



Liquid gasket application position



Cutting end of sealant tube

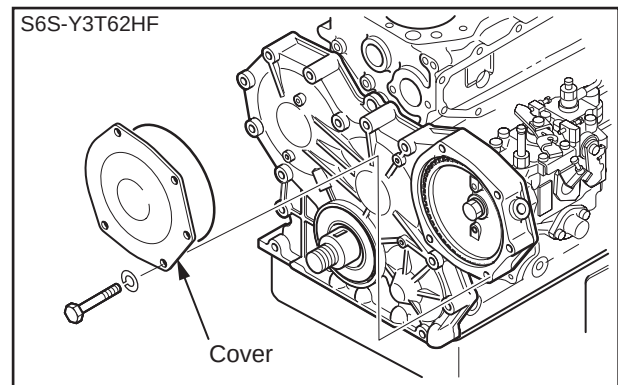


Installing oil pan

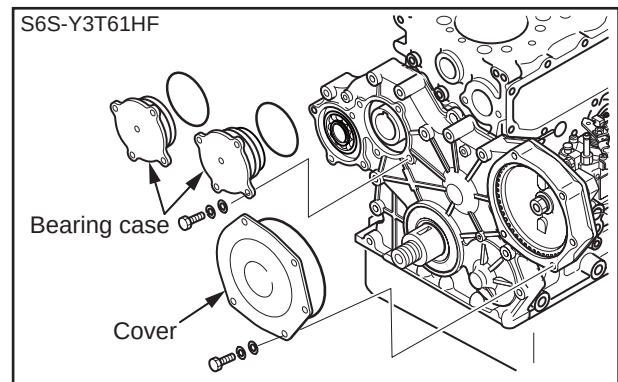
REASSEMBLY OF BASIC ENGINE

2.14 Installing cover

Tighten the cover mounting bolts evenly.



Installing cover



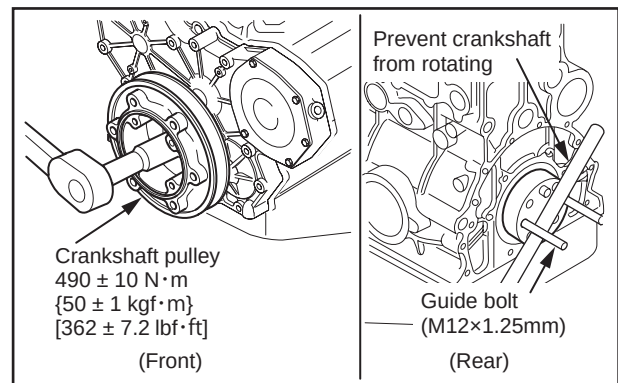
Installing cover

2.15 Installing crankshaft pulley and damper

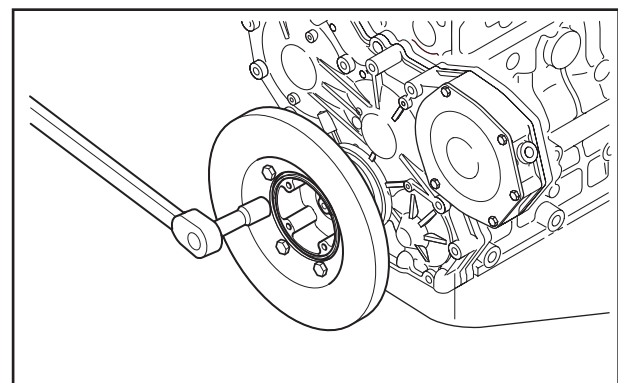
CAUTION

The bar could come off. Be very careful.

- (1) Screw two guide bolts into the threaded holes at the rear end of the crankshaft. Place a bar across the two guide bolts so that the crankshaft does not turn.
- (2) Install the crankshaft pulley and tighten the nuts to the specified torque.
- (3) Install the damper to the crankshaft pulley.



Installing crankshaft pulley



Installing damper

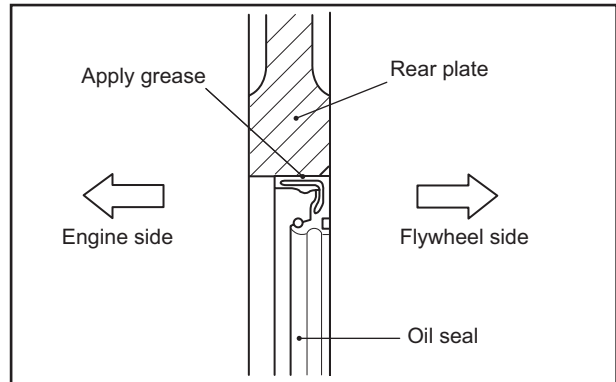
3. Reassembling flywheel

3.1 Installing oil seal

Apply a small quantity of grease to the new oil seal, and install the oil seal to the rear plate.

Be careful of the oil seal installation direction.

Note: Use an oil seal with a sleeve if the oil seal contacting surface of the crankshaft is worn.

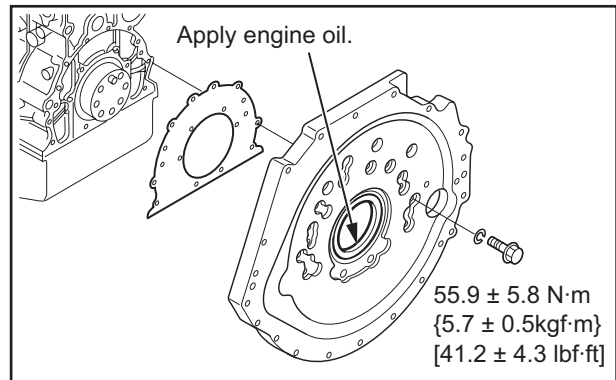


Installing oil seal

3.2 Installing rear plate

- (1) Clean the mounting surface of the gasket.
- (2) Apply sealant to the gasket to prevent it from falling off.
- (3) Install the gasket.
- (4) Install the rear plate, use a guide bar aligning its dowel pin holes and dowel pins, and tighten the bolts.

Note: When the dowel pins are worn or when the rear plate is replaced, replace the dowel pins with new ones.



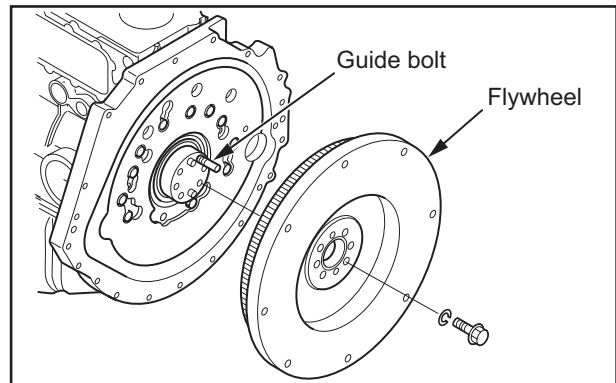
Installing rear plate

3.3 Installing flywheel

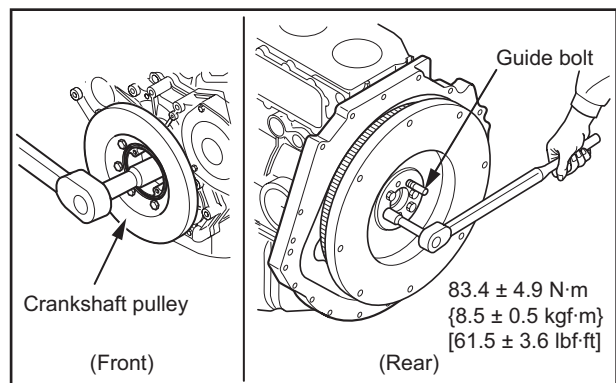
CAUTION

The person who holds the pulley must be very careful to assure safety by communicating with the person who is installing the flywheel.

- (1) One person must firmly hold the pulley with a wrench to prevent the crankshaft from turning.
- (2) Screw the guide bolt into the rear end of the crankshaft.
- (3) Align the bolt hole of flywheel with the guide bolt and install the flywheel to the crankshaft.
- (4) Temporarily tighten bolts.
- (5) Remove the guide bolt and temporarily tighten the last bolt.
- (6) Tighten the flywheel bolts to the specified torque.



Installing flywheel (1)



Installing flywheel (2)

REASSEMBLY OF BASIC ENGINE

4. Reassembling cylinder head and valve mechanism

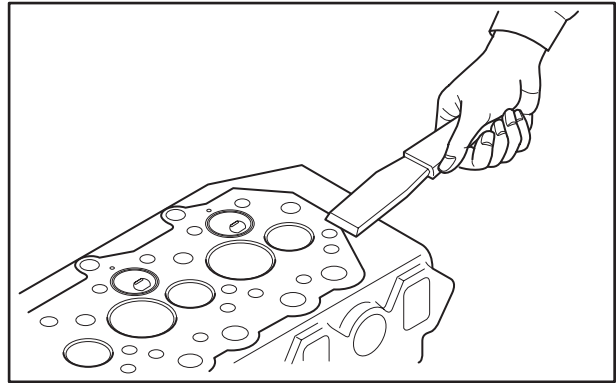
4.1 Cleaning cylinder head bottom surface

CAUTION

Do not use liquid gasket on the cylinder head.

Taking care not to damage the cylinder head bottom surface, remove residue of old gasket.

Note: First, roughly scrape off residue of old gasket using a scraper. Then, grind off the remaining residue using an engine-oil immersed oil stone.



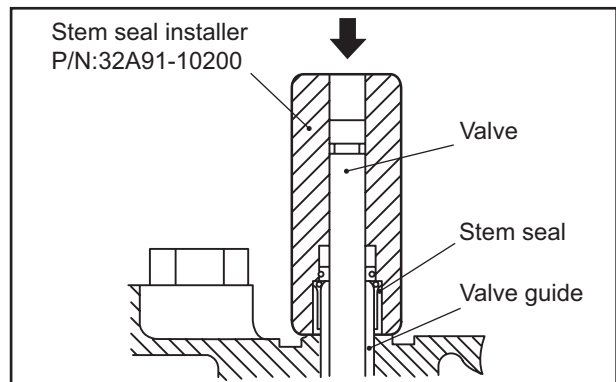
Cleaning cylinder head bottom surface

4.2 Installing valve stem seal

CAUTION

Do not apply oil or liquid gasket to the inner side of stem seal that comes in contact with the valve guide.

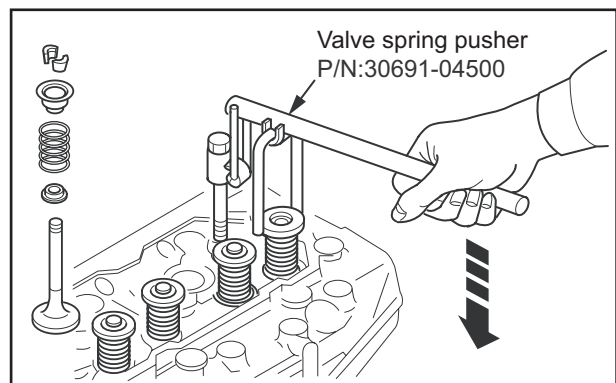
- (1) Apply engine oil to the lip of new valve stem seal.
- (2) Push the shoulder of the valve stem seal and fit the valve stem seal into the valve guide.
- (3) Insert the valve stem seal into the valve guide using the valve stem seal installer.



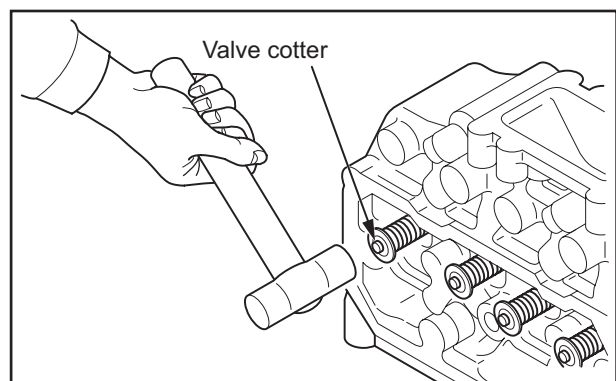
Installing valve stem seal

4.3 Installing valve and valve spring

- (1) Install the valve spring and retainer on the valve guide. Install the valve cotter using a valve spring pusher.
- (2) Tap the top of valve stem lightly several times with a soft hammer to make sure that the valve spring and valve cotter are properly installed and seated firmly.



Installing valve and valve spring



Inspecting valve cotter

4.4 Installing cylinder head gasket

CAUTION

Do not use liquid gasket on the cylinder head.

- (1) Make sure that there is no dirt or dents on the top surfaces of the crankcase and pistons.
- (2) Place new gasket on the crankcase by aligning it with dowel pins on the crankcase.

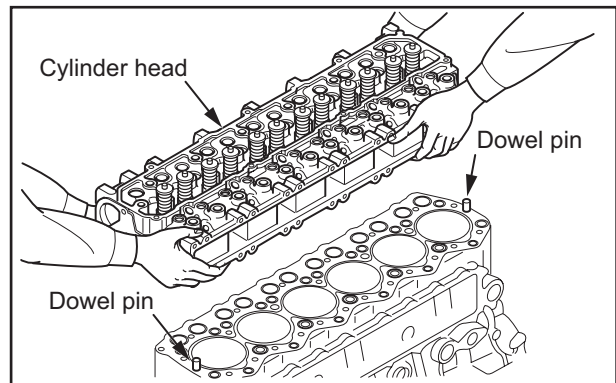
4.5 Installing cylinder head assembly

Install the cylinder head to fit the dowel pins on the crankcase top surface with guide.

Note: (a) Be careful not to displace the cylinder head gasket when installing.

(b) Do not lift up cylinder head by one person.

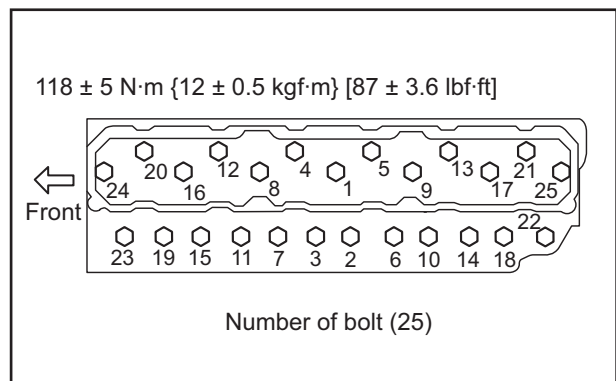
Use crane or lift up by two persons.



Installing cylinder head assembly

4.6 Tightening cylinder head bolts

In the numerical order as shown in the illustration, tighten cylinder head bolts progressively to the specified torque.

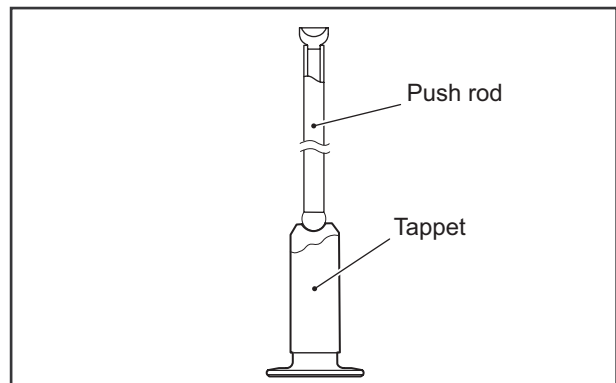


Tightening order of cylinder head bolt

REASSEMBLY OF BASIC ENGINE

4.7 Inserting push rod

- (1) Insert each push rod into its hole in the cylinder head.
- (2) Make sure that the ball end of each push rod is placed correctly on the tappet cup.



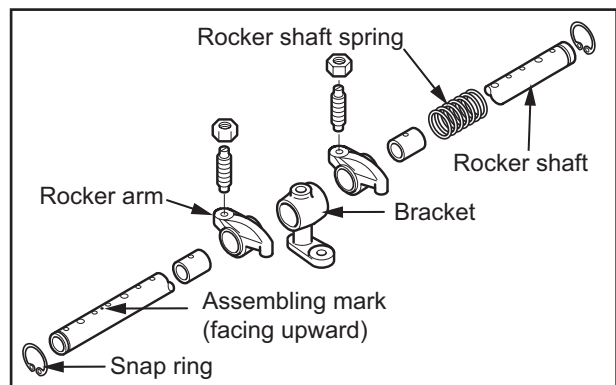
Inserting push rod

4.8 Reassembling rocker shaft assembly

- (1) Apply engine oil to the rocker shaft.
- (2) When reassembling, install the rocker shaft assembly in the same position as it was.

Note: If the rocker shaft assembly is not installed as it was, the clearance becomes different, and it may result in a defect such as increased wear.

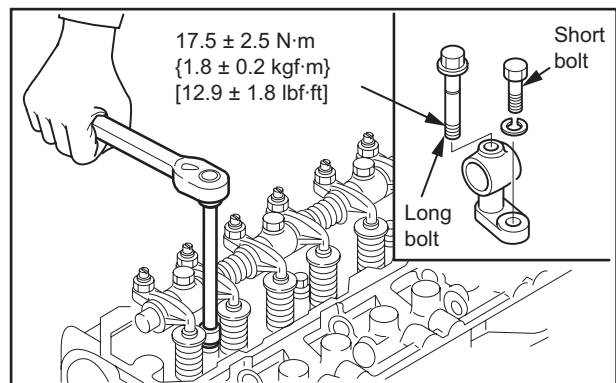
- (3) After reassembling, make sure the rocker arm move freely.



Reassembling rocker shaft assembly

4.9 Installing rocker shaft assembly

- (1) Install the valve caps to the valve heads.
- (2) Tighten the long bolts of the rocker bracket to the specified torque.
- (3) Tighten the short bolts of the rocker bracket.



Installing rocker shaft assembly

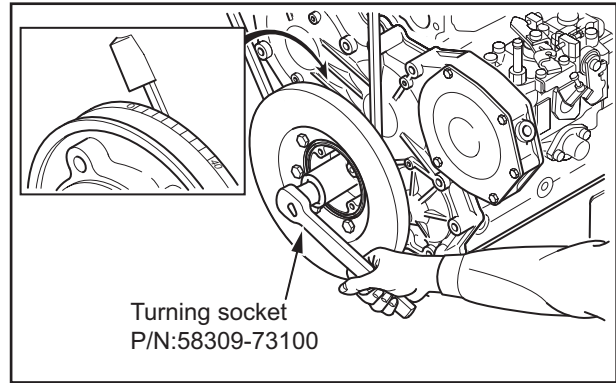
4.10 Determining top dead center of No. 1 cylinder compression stroke

4.10.1 When reusing the damper

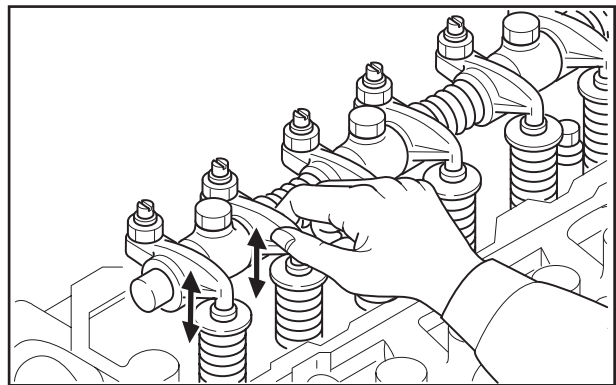
- (1) Attach a socket and ratchet handle to the nut of crankshaft pulley, and rotate the crankshaft in the normal direction (clockwise when viewed from the front of the engine.)
- (2) Stop turning the crankshaft when the notch mark stamped on the damper is aligned with a "0" mark on the pointer.

4.10.2 When replacing the damper with a new one

- (1) Remove the rocker arm, valve cap, valve cotter, valve retainer and valve spring from the No. 1 cylinder inlet side, and make the inlet valve free.
- (2) Attach the dial gauge to the inlet valve and rotate the crankshaft to determine the compression top dead center, when determined, stop rotating the crankshaft.
- (3) With aligning the "0" mark on the timing plate, draw the line to the damper outside periphery.
- (4) Install the valve spring, valve retainer, valve cotter, valve cap and rocker arm to the No. 1 cylinder inlet side.



Determining top dead center of No. 1 cylinder compression stroke (1)

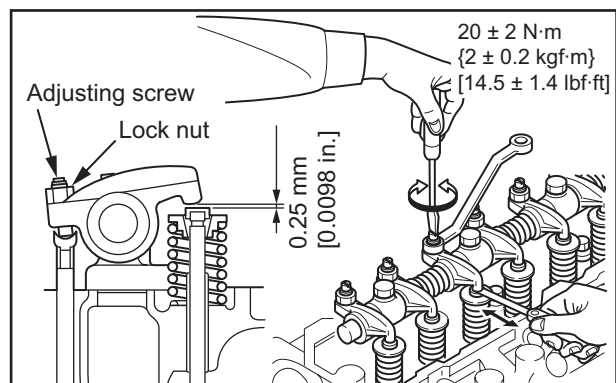


Determining top dead center of No. 1 cylinder compression stroke (2)

4.11 Adjusting valve clearance

Adjust the valve clearance.

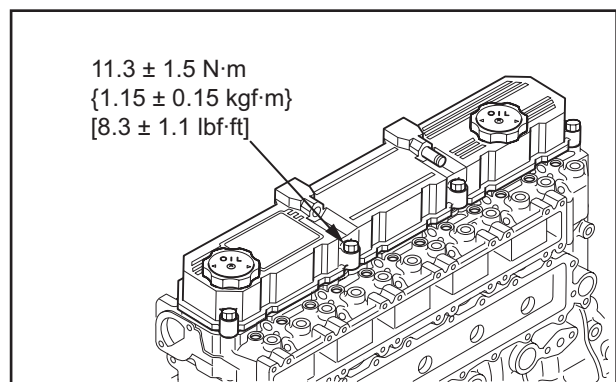
For adjusting procedures, refer to "Adjustment and Operation."



Adjusting valve clearance

4.12 Installing rocker cover

- (1) Make sure that the gasket is firmly installed into the rocker cover.
- (2) Tighten the rocker cover mounting nuts to the specified torque.



Installing rocker cover

FUEL SYSTEM

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 - 1.1 Removing fuel filter 8-2
 - 1.2 Removing fuel injection pipe 8-3
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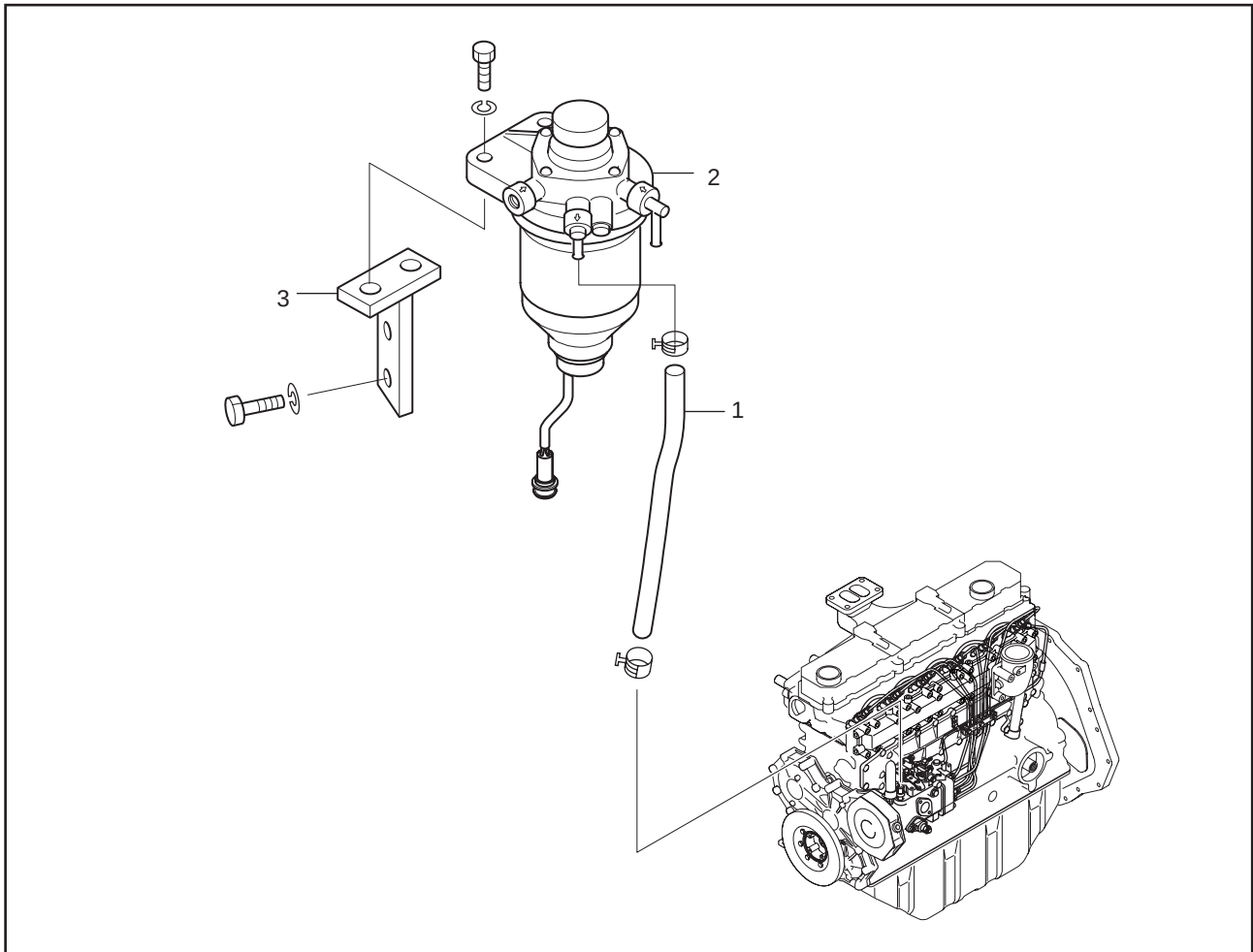
FUEL SYSTEM

1. Removing fuel system

CAUTION

Cover the openings on the injection pump, nozzle inlet connector and injection pipe to prevent dust from entering the fuel system.

1.1 Removing fuel filter



Removing fuel filter

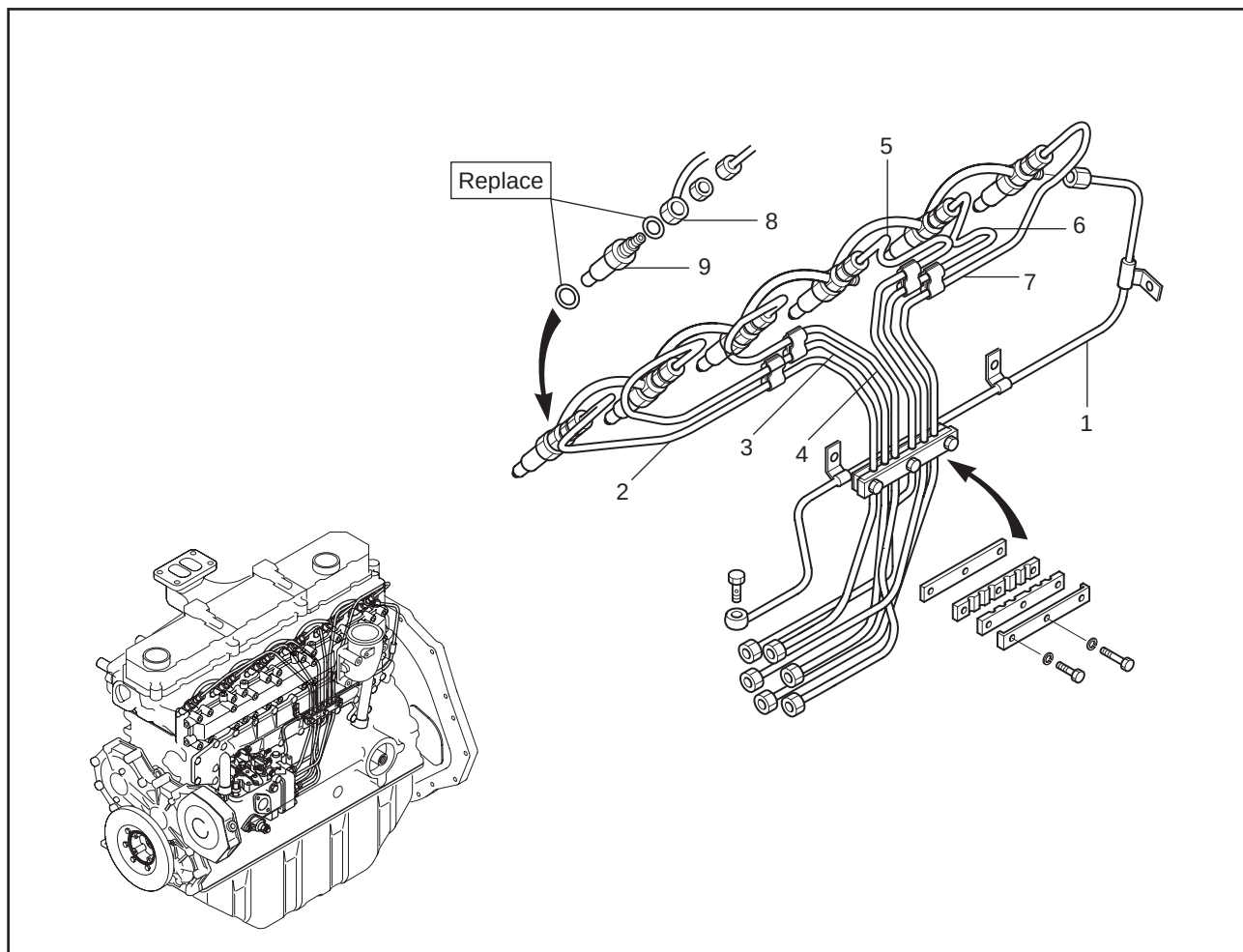
Removing sequence

1 Fuel hose

2 Fuel filter

3 Fuel filter bracket

1.2 Removing fuel injection pipe



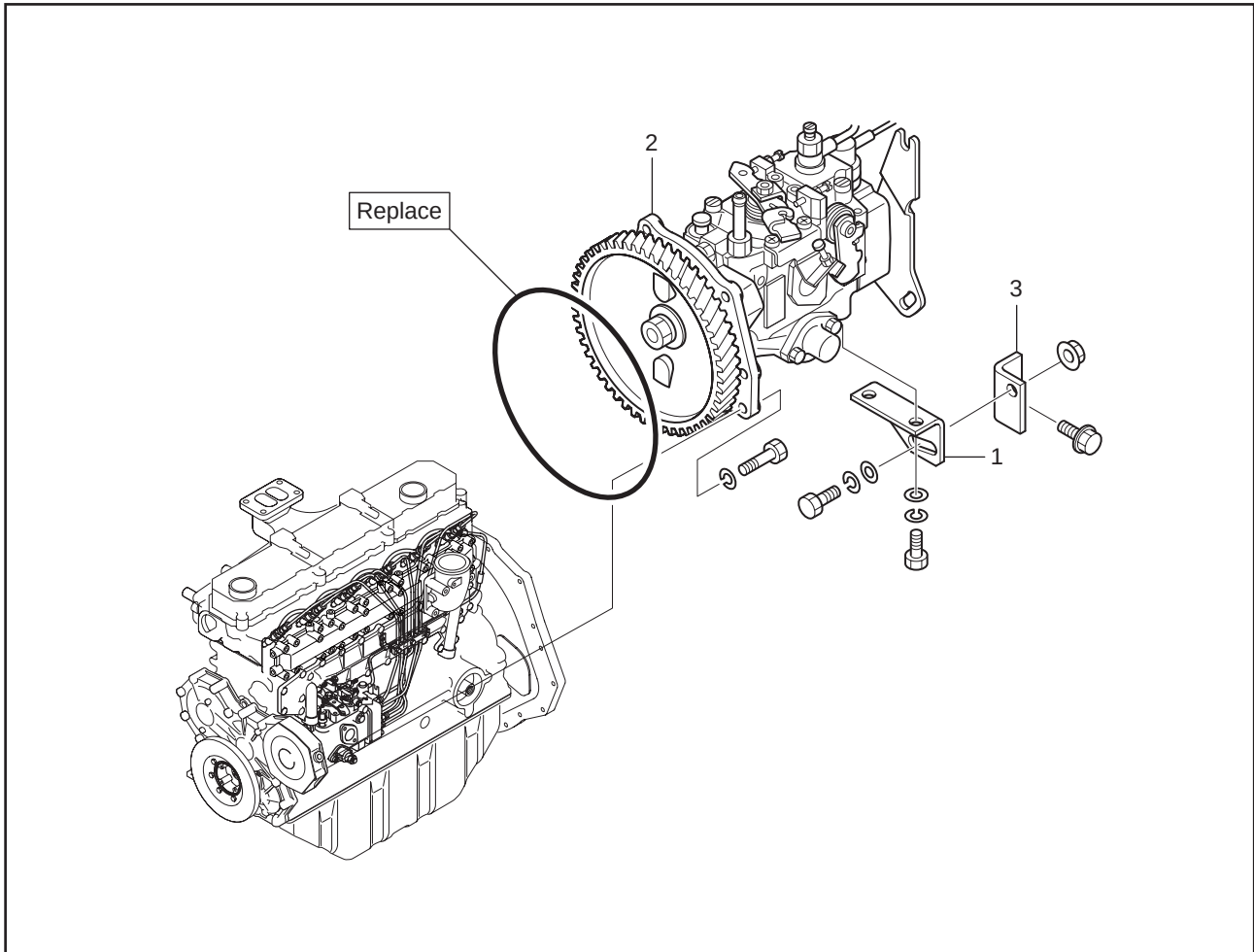
Removing fuel injection pipe

Removing sequence

- | | |
|-----------------------------|-----------------------------|
| 1 Fuel return pipe | 6 No. 5 fuel injection pipe |
| 2 No. 1 fuel injection pipe | 7 No. 6 fuel injection pipe |
| 3 No. 2 fuel injection pipe | 8 Fuel leak-off pipe |
| 4 No. 3 fuel injection pipe | 9 Fuel injection nozzle |
| 5 No. 4 fuel injection pipe | |

FUEL SYSTEM

1.3 Removing fuel injection pump



Removing fuel injection pump

Removing sequence

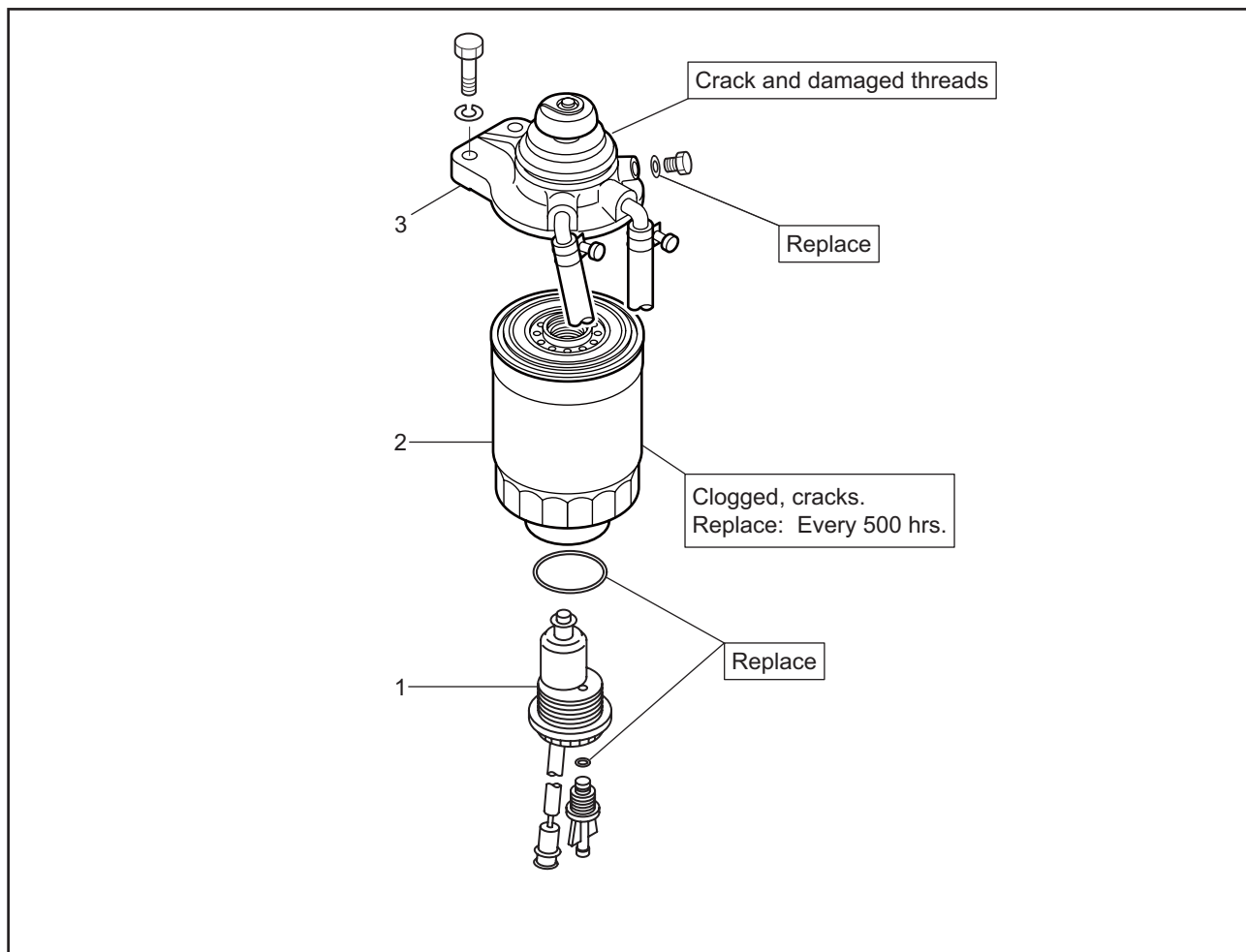
1 Bracket

2 Fuel injection pump

3 Bracket

2. Disassembling, inspecting and reassembling fuel system

2.1 Disassembling and inspecting fuel filter



Disassembling and inspecting fuel filter

Disassembling sequence

1 Level sensor

2 Filter element

3 Body

FUEL SYSTEM

2.2 Changing fuel filter

WARNING

- (a) When handling fuel, make sure no open flames are nearby.
- (b) Wipe off any spilled fuel. Spilled fuel becomes a fire hazard.

- (1) Clean the outside of the fuel filter and the area around it.
- (2) Disconnect the fuel filter level sensor from its connector.
- (3) Place a drip pan under the fuel filter.
- (4) Loosen the drain plug and drain fuel from the fuel filter.
- (5) Remove the level sensor from the fuel filter.
- (6) Remove the fuel filter element.
- (7) Wipe off any fuel on the fuel filter element mounting surface of fuel filter body with a cloth.
- (8) Have the new fuel filter element ready for installation and make sure that the gasket is properly seated on the groove.

WARNING

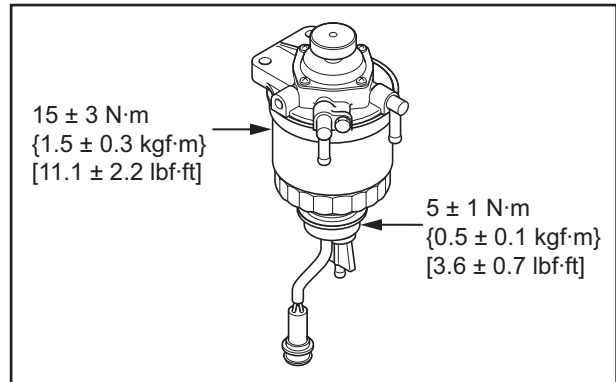
Do not use the filter of which case has dents, as it may be damaged during operation, and cause fuel leakage that becomes fire hazard.

- (9) Install the fuel filter element to the filter body.

CAUTION

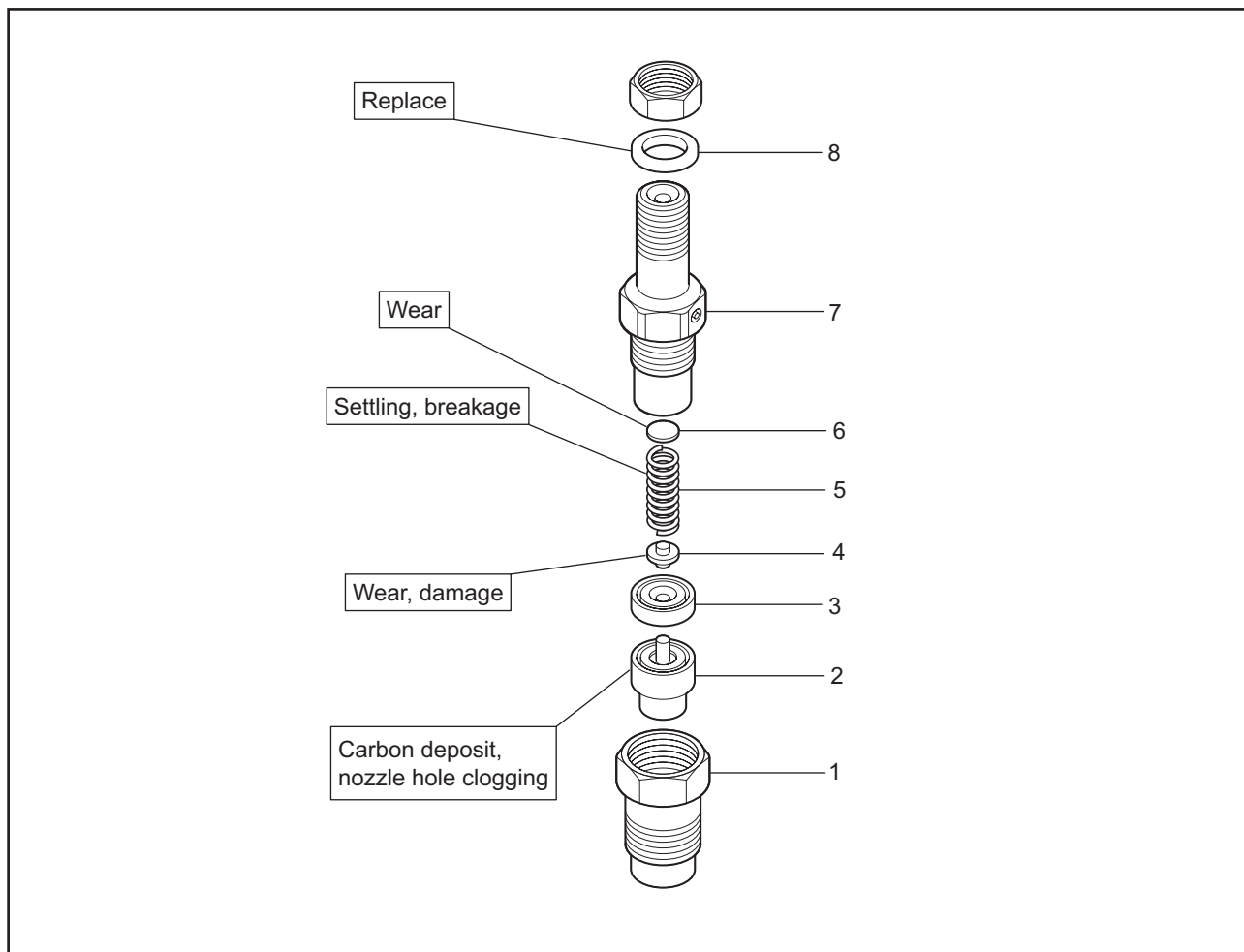
Be careful not to dent or damage the fuel filter case.

- (10) Using new O-ring, install the level sensor to the fuel filter element.
- (11) After completion of the fuel filter change, bleed the fuel system.
- (12) Start the engine and run at idling speed for a few minutes.
- (13) Check the fuel filter element mounting surface for fuel leakages. If leakages are found, loosen the fuel filter and check the gasket for seating or damage. Then retighten the fuel filter.



Changing fuel filter

2.3 Disassembling and inspecting fuel injection nozzle



Disassembling and inspecting fuel injection nozzle

Disassembling sequence

- | | | |
|------------------------|-------------------|-----------------|
| 1 Nozzle retaining nut | 4 Pressure pin | 7 Nozzle holder |
| 2 Nozzle tip assembly | 5 Pressure spring | 8 Gasket |
| 3 Distance piece | 6 Washer | |

FUEL SYSTEM

2.4 Inspecting and adjusting fuel injection valve opening pressure

CAUTION

Never touch the spray hole during injection

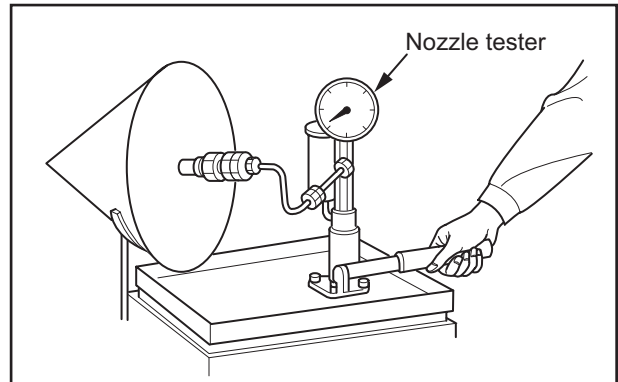
- (1) Mount the nozzle on the nozzle tester.
- (2) Pump the tester handle at a rate of approximately one cycle per second while observing the pressure at which injection starts. If the pressure is not in the standard range, make an adjustment by changing shim.
- (3) To adjust the valve opening pressure, remove the retaining nut, and change the shim. The thicker the shim, the more it increases the pressure
- (4) After adjusting the pressure, tighten the retaining nut to the specified torque.
- (5) Check the injection valve opening pressure once again to make sure the pressure is within the standard range.

Item	Nominal	Standard
Valve opening pressure	11.77 MPa { 120 kgf/cm ² } [1707 psi]	11.77 to 12.75 MPa { 120 to 130 kgf/cm ² } [1707 to 1849 psi]

Note: (a) Standard is a value of new parts.

- (b) A change in thickness of the shim by 0.1 mm [0.004 in] results in a change in the fuel injection pressure by 1.0 MPa { 10kgf/cm² } [142 psi].

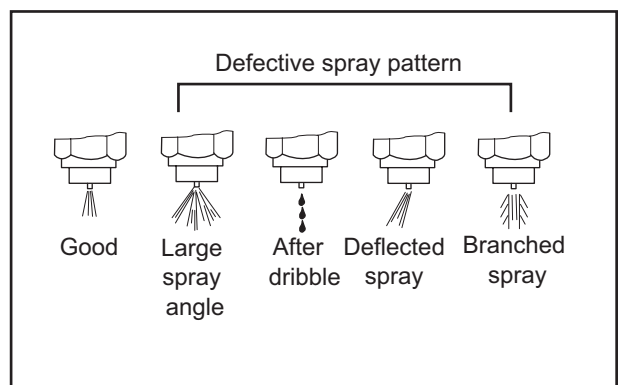
There are ten different sizes of shims available 1.25 to 1.70 mm [0.0492 to 0.0669 in.] to obtain proper pressure.



Inspecting fuel injection nozzle with nozzle tester

2.5 Inspecting fuel spray pattern of fuel injection nozzle

- (1) When adjusting the nozzle opening pressure using the nozzle tester, check for nozzle hole condition, and fuel spray pattern.
- (2) Checking points of fuel spray are as follows:
 - Fuel is injected conically at the specified spray angle.
 - Fuel is injected in a spray of fine droplets.
 - Fuel is injected without after-dribbling.
- (3) If spray condition is faulty, clean or replace the nozzle tip.



Inspecting fuel injection nozzle spray condition

2.6 Cleaning and inspecting nozzle tip

(1) Clean the needle valve and body of the nozzle tip in a clean wash oil.

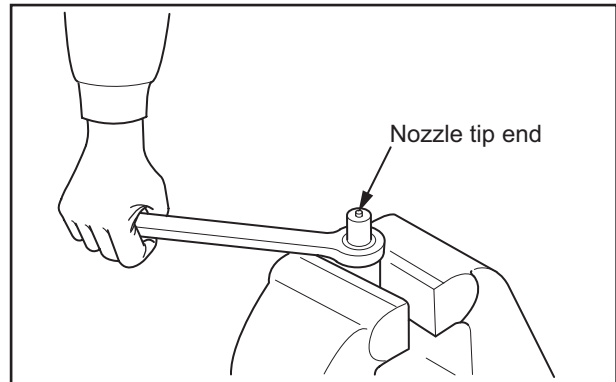
(2) After cleaning, assemble the needle valve and the body in a clean diesel oil.

Note: The needle valve and body are precision parts. Handle them carefully, and do not change the combination of the valve and body.

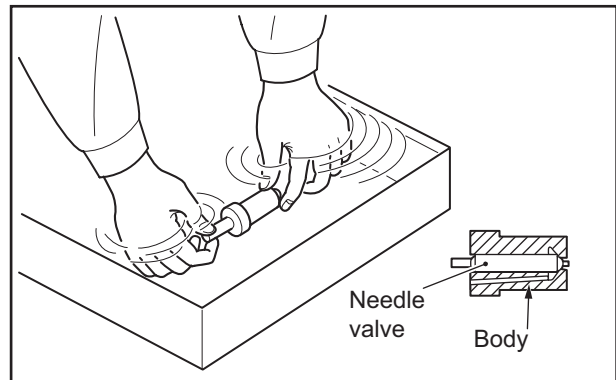
(3) Tighten the nozzle tip tightening retainer nut to the specified torque.

(4) If the spray pattern is still faulty after cleaning and adjusting, change the nozzle tip with a new one.

Note: New nozzle tips are coated with vaseline to prevent from rusting. Wash it off in a clean diesel oil before installation.



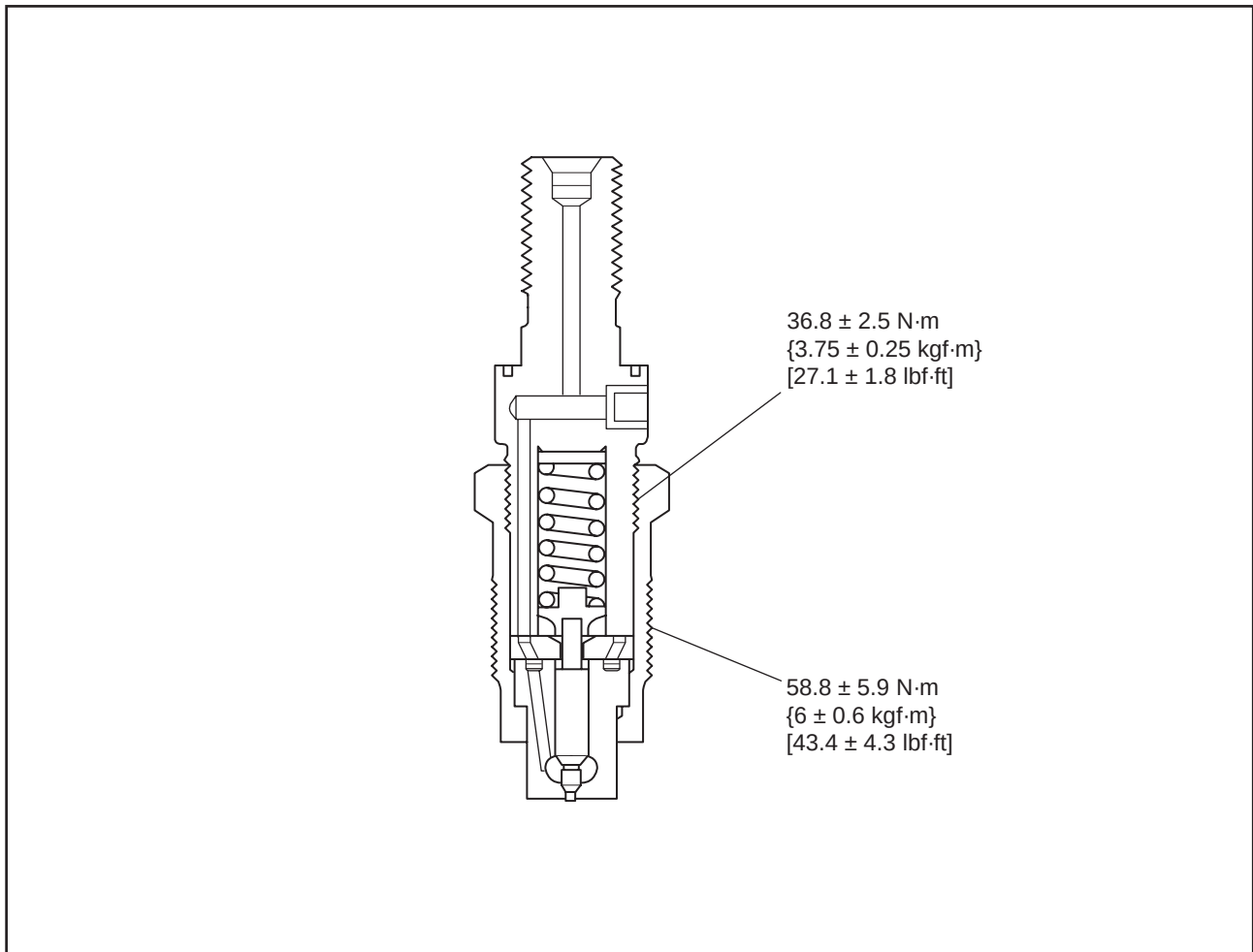
Replacing fuel injection nozzle tip



Cleaning nozzle tip assembly

FUEL SYSTEM

2.7 Reassembling fuel injection nozzle



Reassembling fuel injection nozzle

2.8 Inspecting and cleaning gauze filter of distribute type fuel injection pump

WARNING

Keep flames away when handling a diesel fuel. Wipe off any spilled fuel thoroughly.
Spilled fuel could cause a fire.

CAUTION

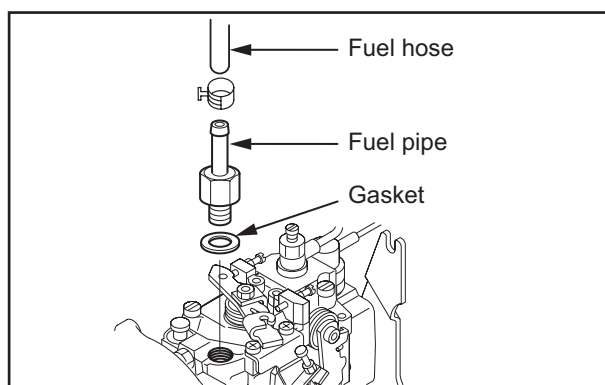
Cover the openings on the fuel injection pump to prevent dust from entering the fuel system.

When output shortage and/or hunting of the engine occurred, the gauze filter may be dirty. Clean the gauze filter accordingly.

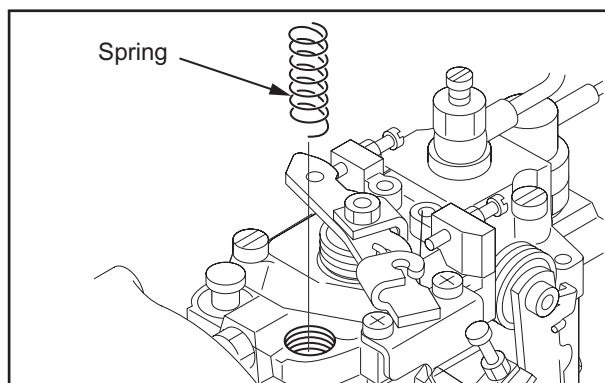
- (1) Clean around the injection pump.
- (2) Drain the fuel in the injection pump, and remove the fuel hose and fuel pipe.
- (3) Remove the spring with a tweezer.
- (4) Remove the gauze filter with a tweezer.

Note: When removing the gauze filter, be careful not to damage the metal mesh of the gauze filter.

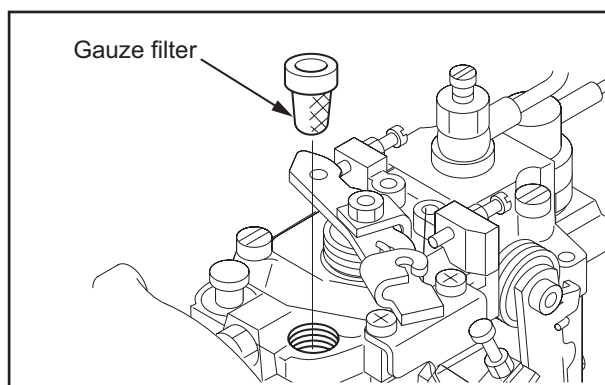
- (5) Remove the dirt and dust from the gauze filter cleaning with compressed air or diesel fuel. When damage is found, or when the gauze filter is still dirty after cleaning, replace the gauze filter with a new one.
- (6) Install the cleaned gauze filter and new gasket, and in reverse order of disassembly, install the fuel pipe and fuel hose.



Removing fuel hose and fuel pipe



Removing spring

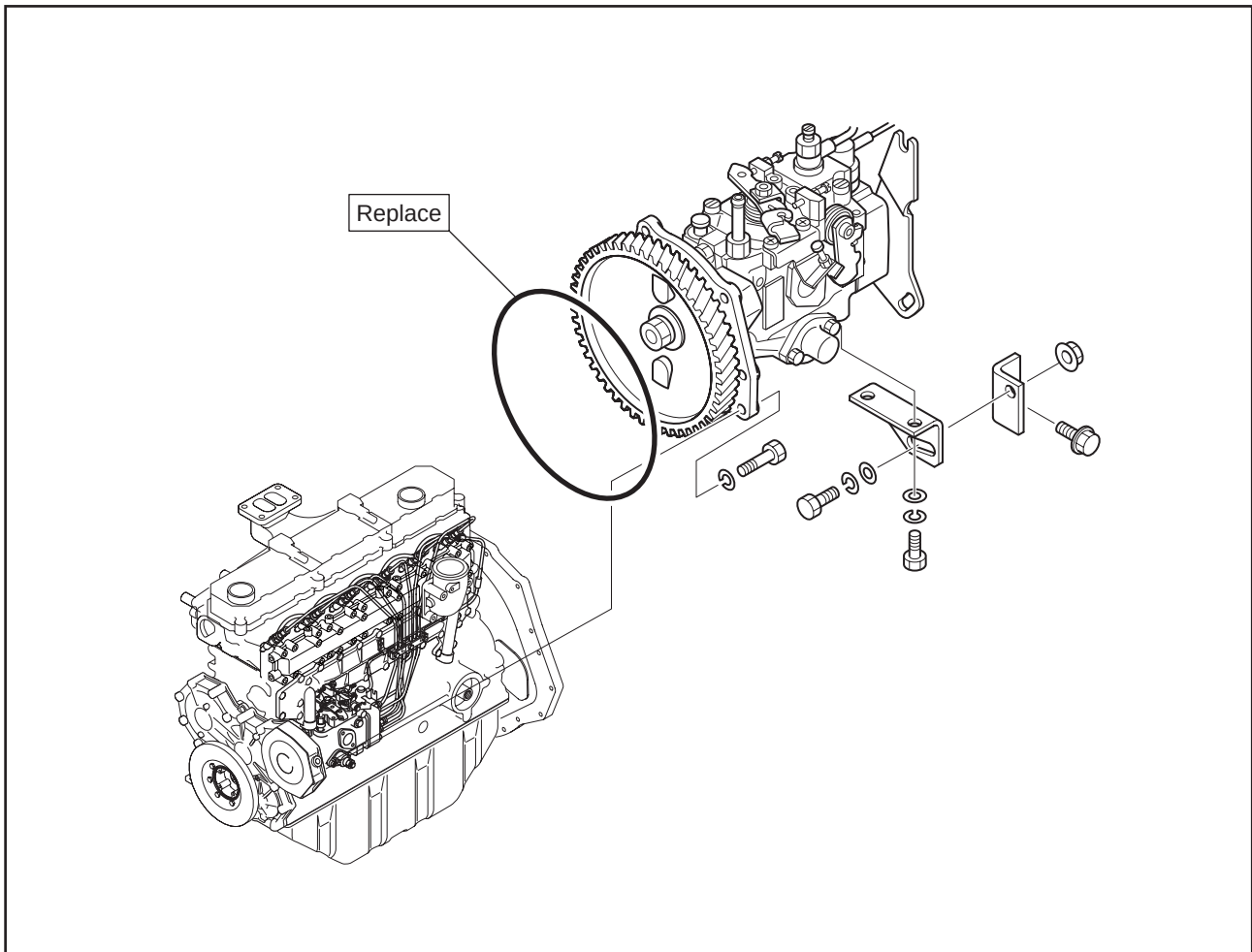


Removing gauze filter

FUEL SYSTEM

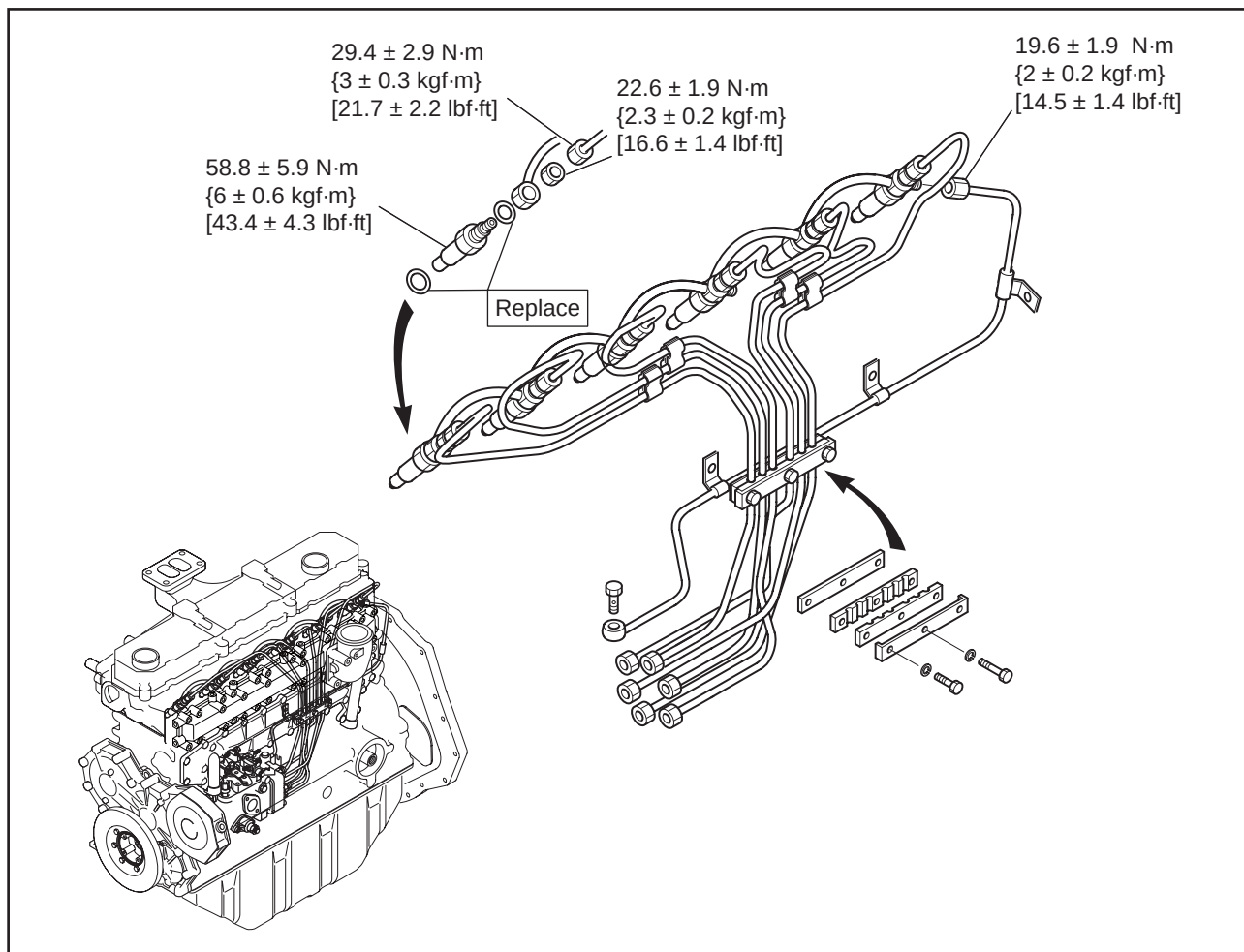
3. Installing fuel system

3.1 Installing fuel injection pump



Installing fuel injection pump

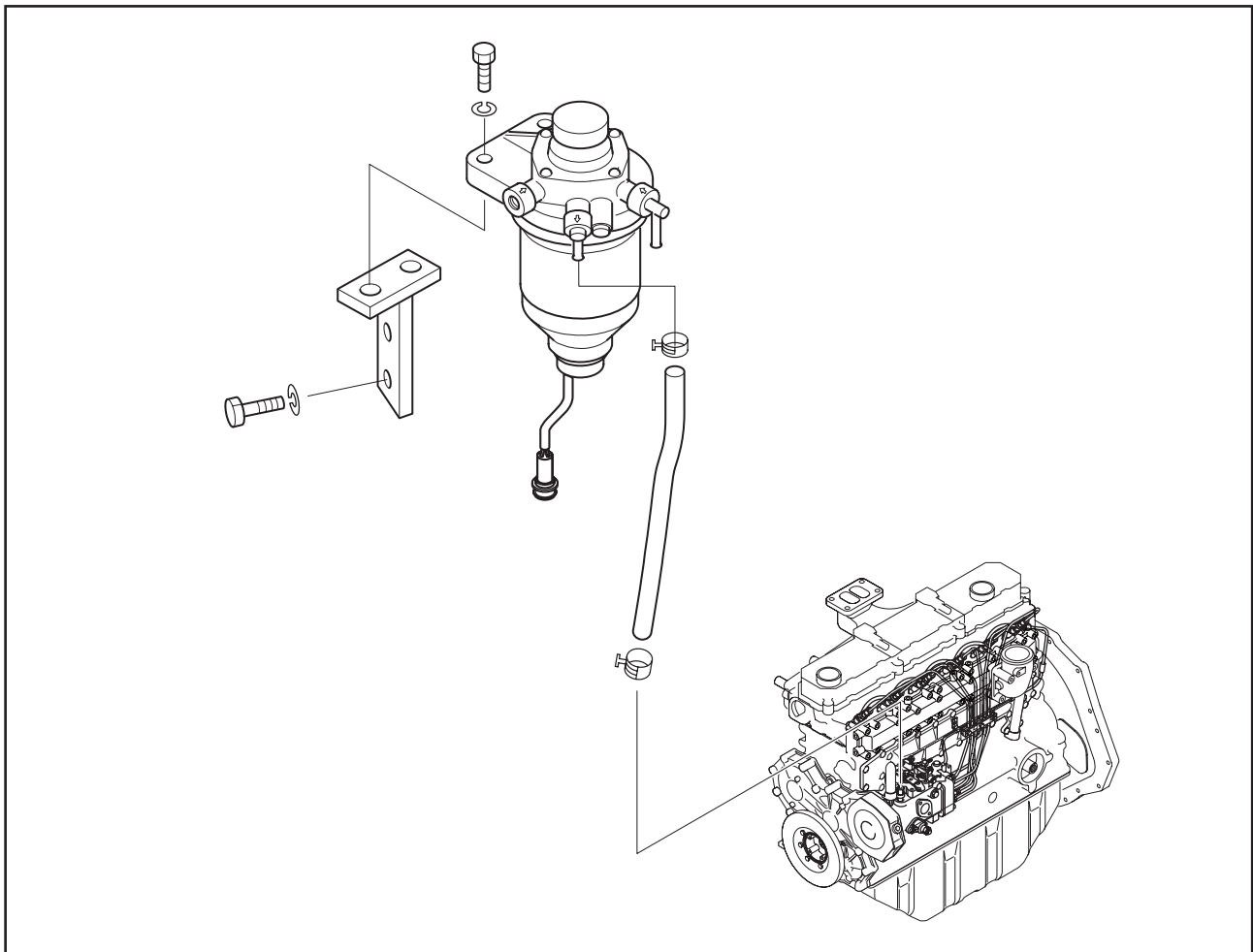
3.2 Installing fuel injection pipe



Installing fuel injection pipe

FUEL SYSTEM

3.3 Installing fuel filter



Installing fuel filter

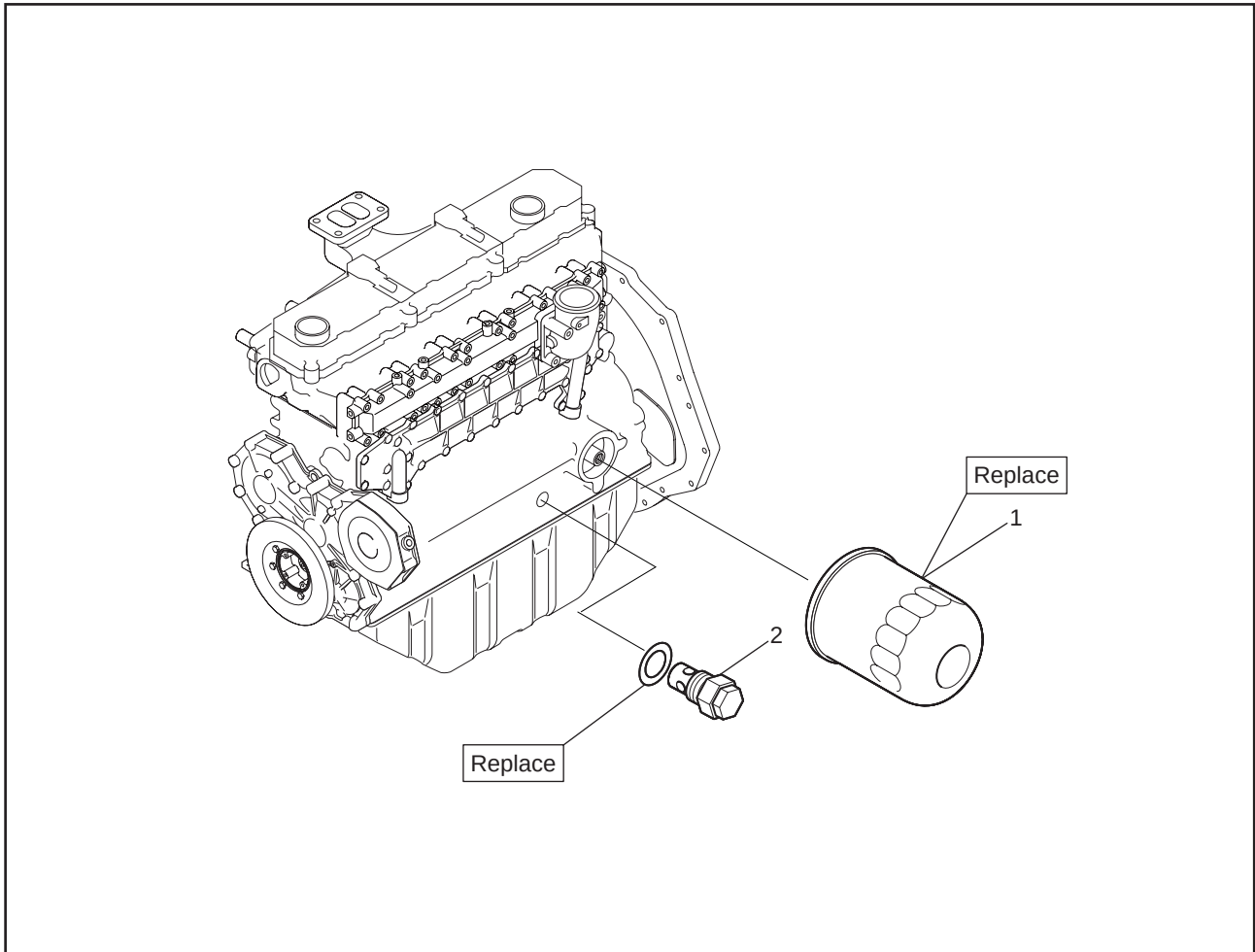
LUBRICATION SYSTEM

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LUBRICATION SYSTEM

1. Removing lubrication system

1.1 Removing oil filter and relief valve



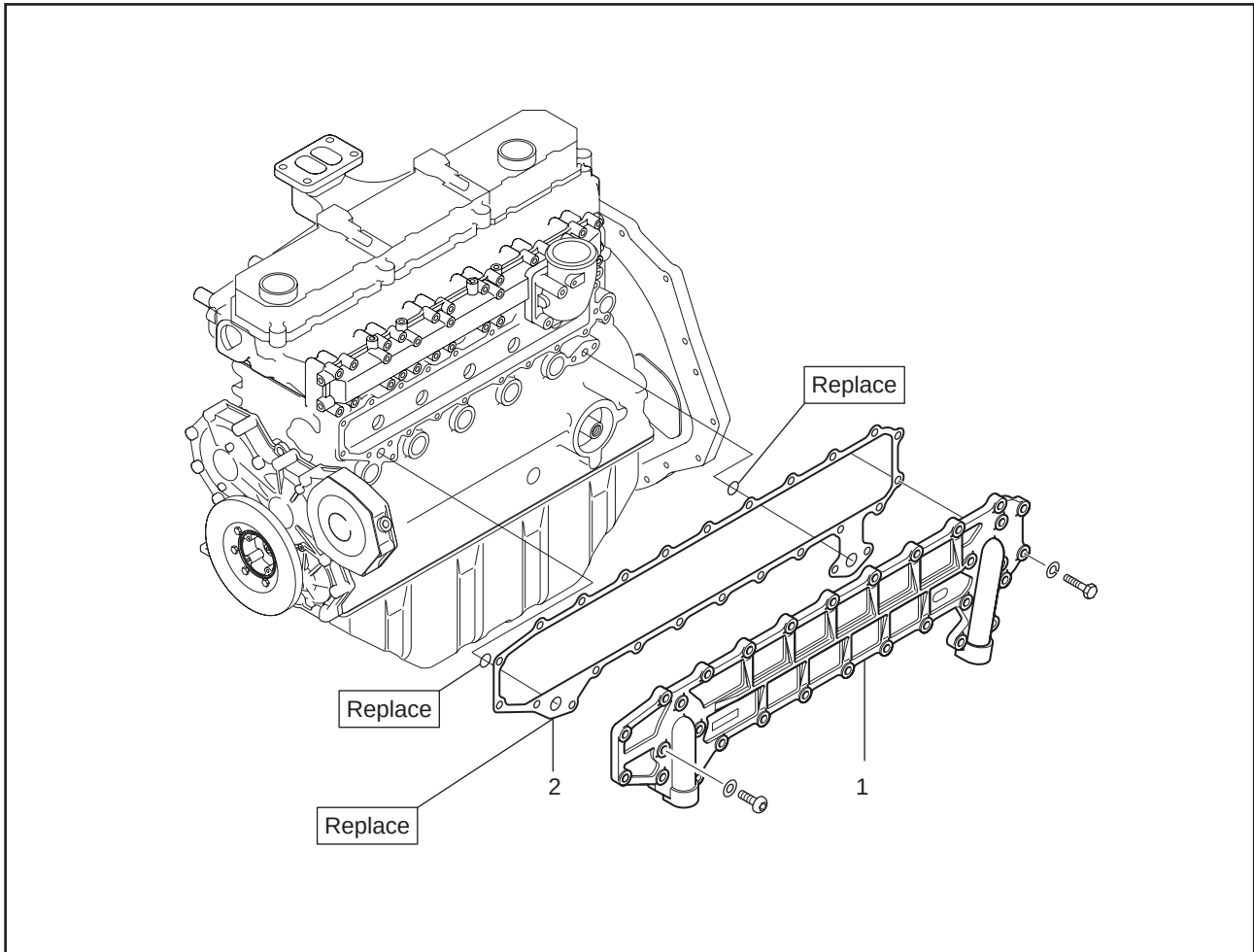
Removing oil filter and relief valve

Removing sequence

1 Oil filter

2 Relief valve

1.2 Removing oil cooler



Removing oil cooler

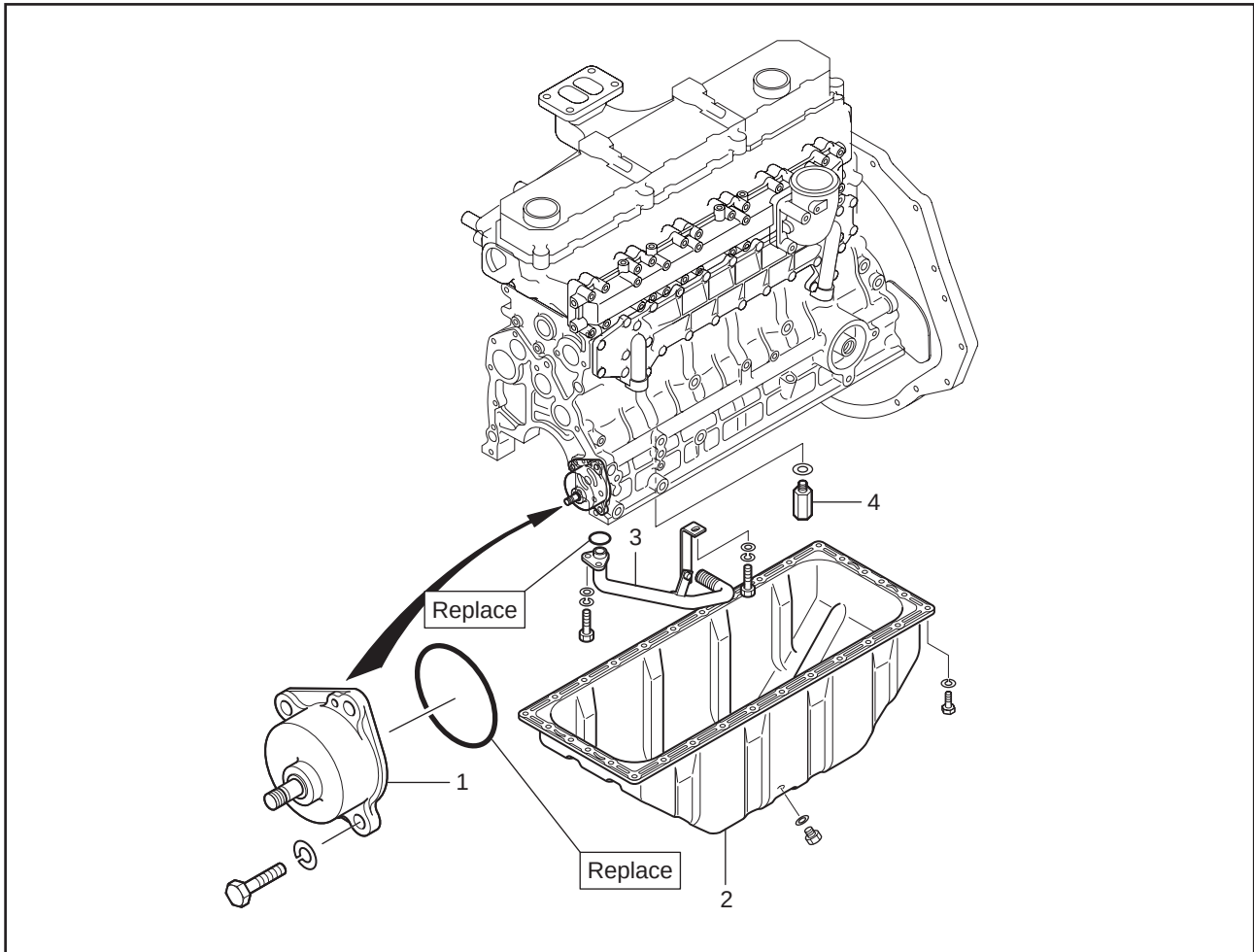
Removing sequence

1 Oil cooler assembly

2 Oil cooler gasket

LUBRICATION SYSTEM

1.3 Removing oil pump, oil pan and oil strainer



Removing oil pump, oil pan and oil strainer

Removing sequence

1 Oil pump

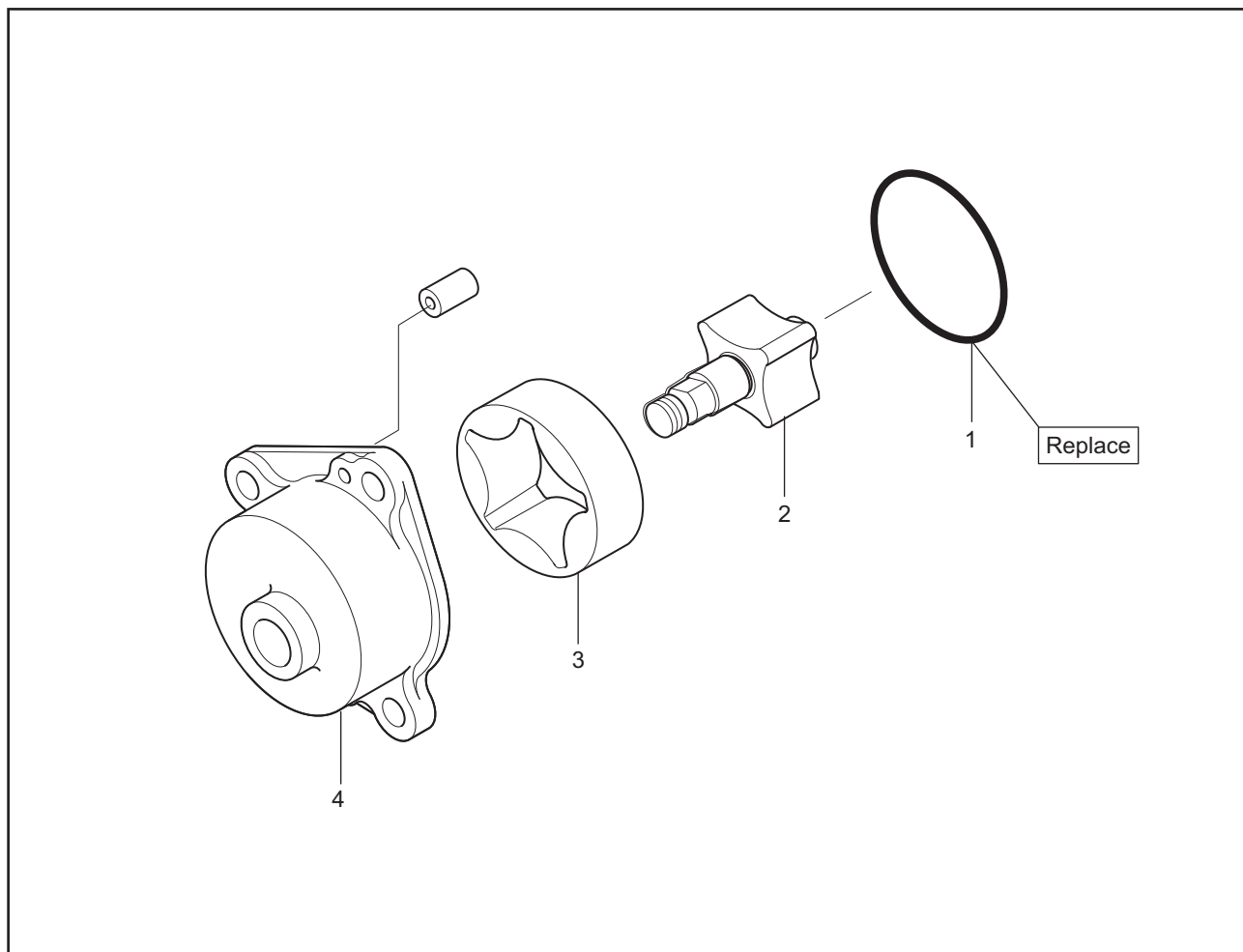
2 Oil pan

3 Oil strainer

4 Safety valve

2. Disassembling, inspecting and reassembling lubrication system

2.1 Disassembling and inspecting oil pump



Disassembling oil pump

Disassembling sequence

1 O-ring

2 Shaft assembly

3 Outer rotor

4 Pump case

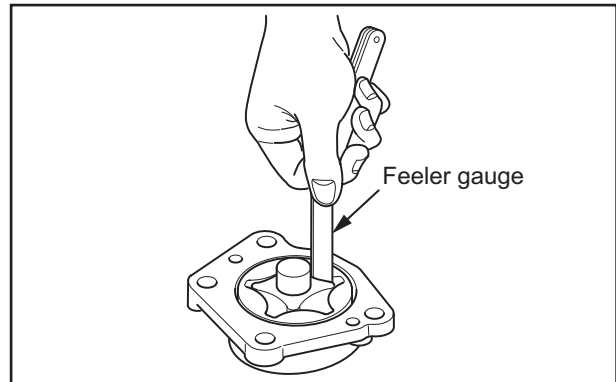
LUBRICATION SYSTEM

2.2 Inspecting oil pump

2.2.1 Measuring clearance between outer rotor and inner rotor

Measure the clearance between the outer rotor and the inner rotor. If measured value exceeds the limit, replace the oil pump with new one.

Item	Standard	Limit
Clearance between outer rotor and inner rotor	0.13 to 0.15 mm [0.0051 to 0.0059 in.]	0.20 mm [0.0079 in.]

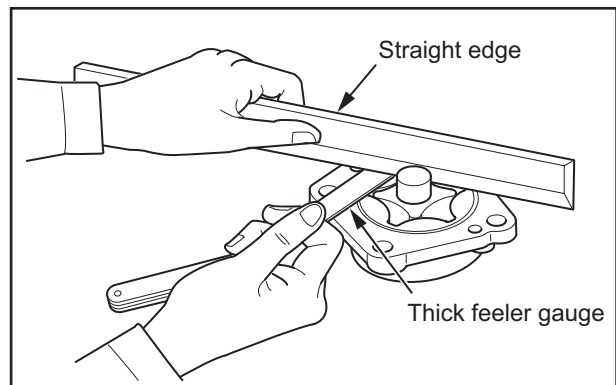


Measuring clearance between outer rotor and inner rotor

2.2.2 Measuring end play of rotor and pump case

Measure the end play of the rotor and the pump case. If measured value exceeds the limit, replace the oil pump with new one.

Item	Standard	Limit
End play of rotor and pump case	0.04 to 0.09 mm [0.0016 to 0.0035 in.]	0.15 mm [0.0059 in.]

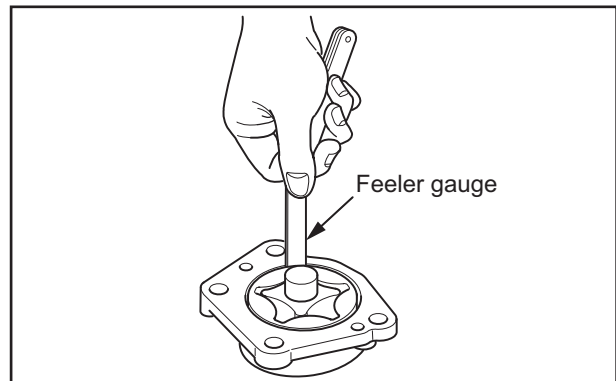


Measuring end play of rotor and pump case

2.2.3 Measuring clearance between outer rotor and pump case

Measure the clearance between the outer rotor and the pump case. If measured value exceeds the limit, replace the oil pump with new one.

Item	Standard	Limit
Clearance between outer rotor and case	0.20 to 0.30 mm [0.0079 to 0.0118 in.]	0.50 mm [0.0197 in.]

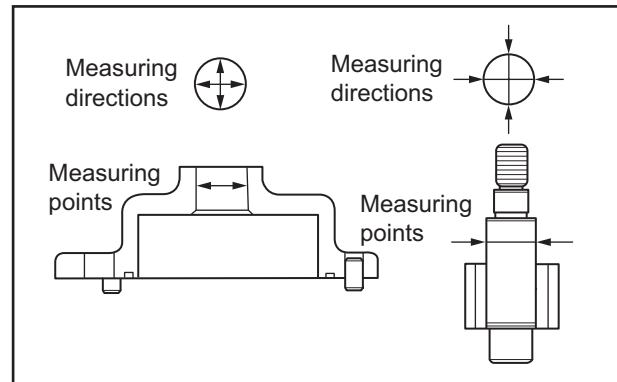


Measuring clearance between outer rotor and pump case

2.2.4 Measuring clearance between main shaft and pump case

Measure the diameter of the shaft and the inside diameter of the bore in the case for the shaft to find the clearance between the two. If the clearance exceeds the limit, replace the oil pump assembly.

Item	Standard	Limit
Main shaft outside diameter (between case)	15.985 to 16.000 mm [0.6293 to 0.6299 in.]	-
Clearance between main shaft and pump case	0.032 to 0.074 mm [0.0013 to 0.0029 in.]	0.150 mm [0.0059 in.]

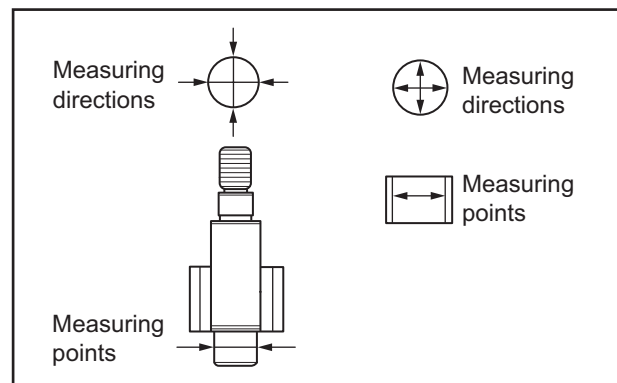


Measuring clearance between main shaft and pump case

2.2.5 Measuring clearance between main shaft and bushing

Measure the diameter of the main shaft and the inside diameter of the oil pump bushing in the crankcase to find the clearance between the two. If the clearance exceeds the limit, replace the bushing or the oil pump assembly.

Item	Standard	Limit
Main shaft outside diameter (between oil pump bushing)	13.957 to 13.975 mm [0.5495 to 0.5502 in.]	-
Clearance between main shaft and oil pump bushing	0.025 to 0.111 mm [0.0010 to 0.0044 in.]	0.200 mm [0.0079 in.]



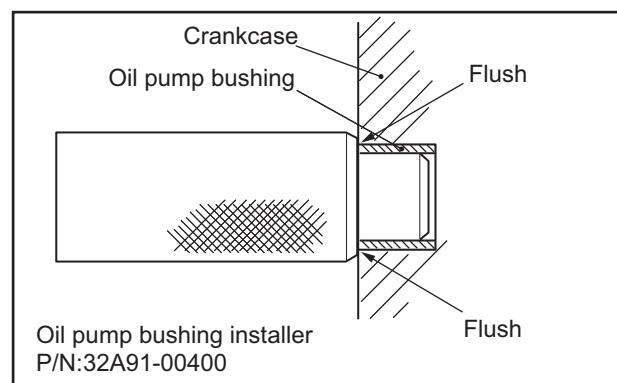
Measuring clearance between main shaft and bushing

2.2.6 Installing oil pump bushing

CAUTION

Install the oil pump bushing in the crankcase so that it is even with the front face of the crankcase.

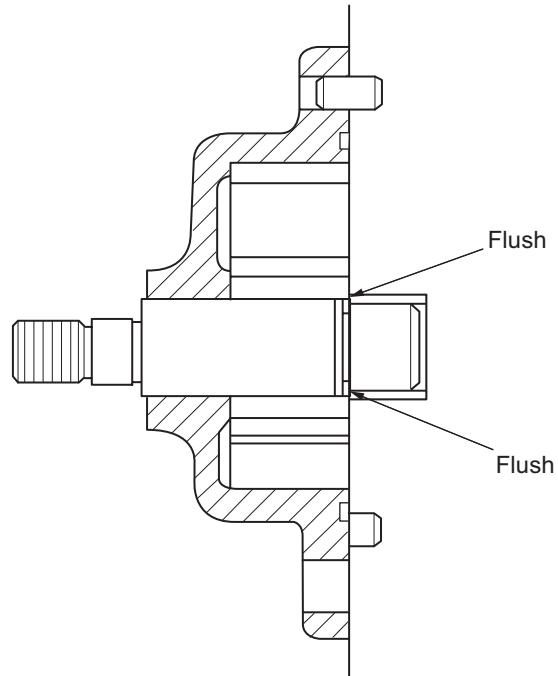
Install the oil pump bushing by using the oil pump bushing installer.



Installing oil pump bushing

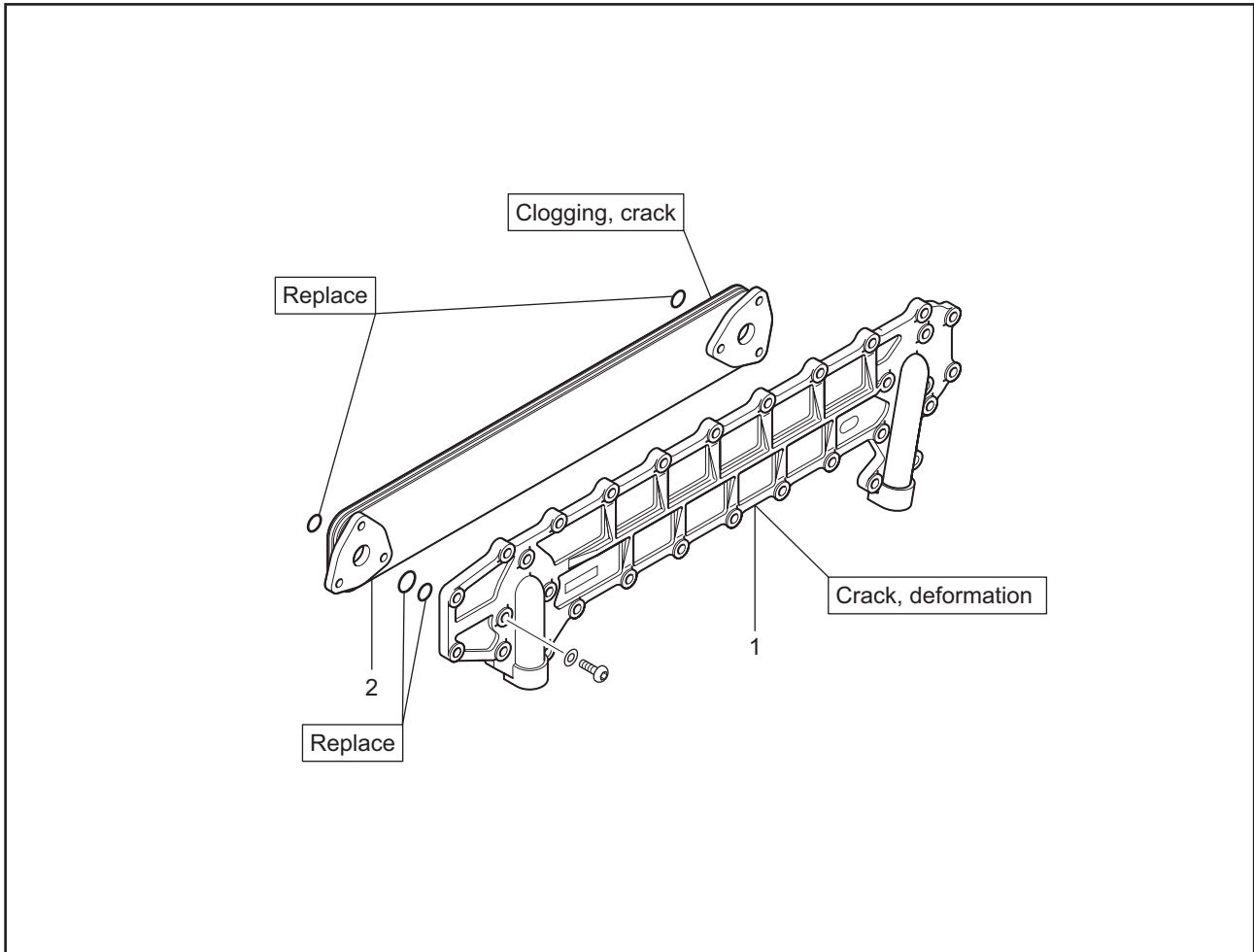
LUBRICATION SYSTEM

2.3 Reassembling oil pump



Reassembling oil pump

2.4 Disassembling and inspecting oil cooler



Disassembling and inspecting oil cooler

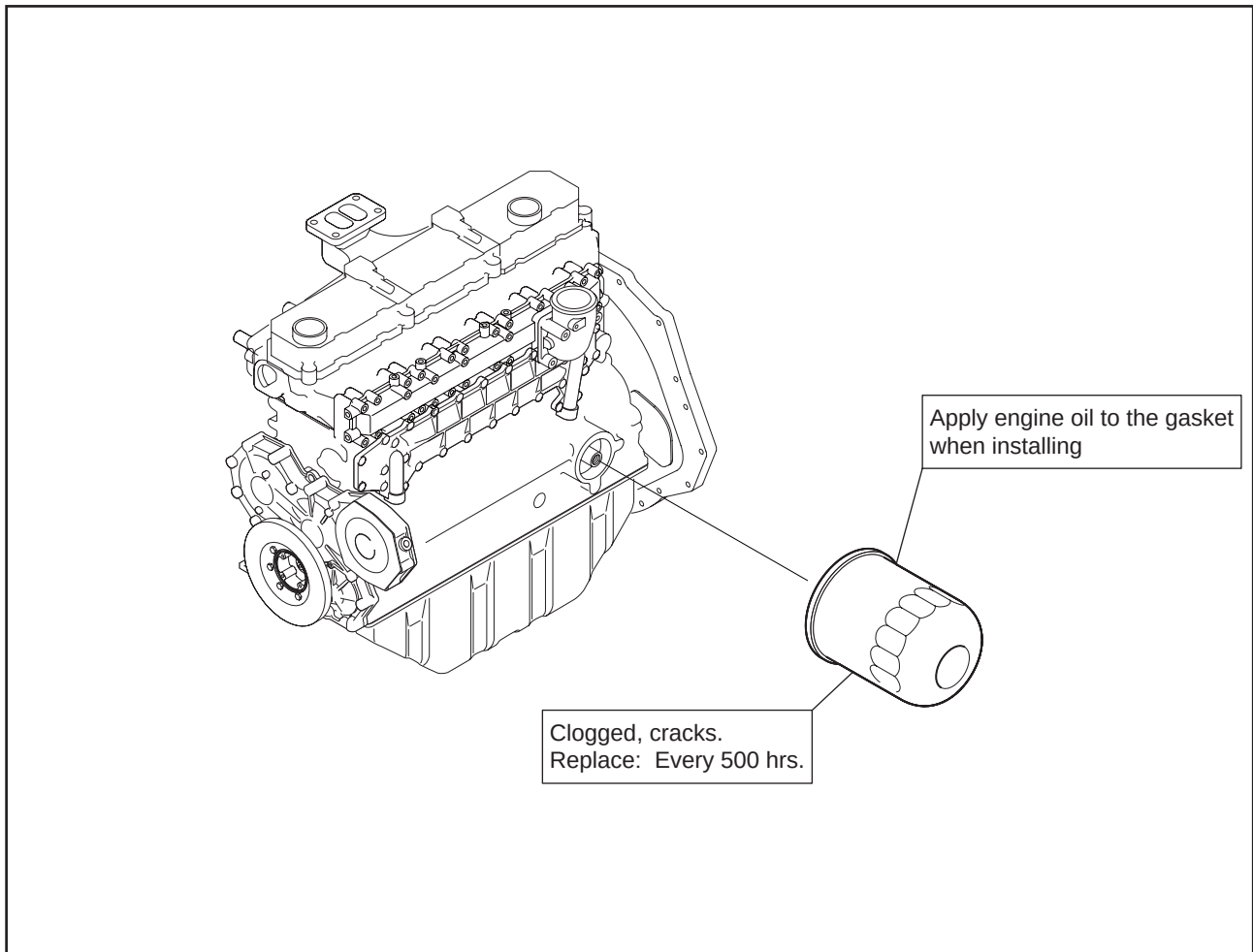
Disassembling sequence

1 Oil cooler case

2 Oil cooler element

LUBRICATION SYSTEM

2.5 Inspecting oil filter

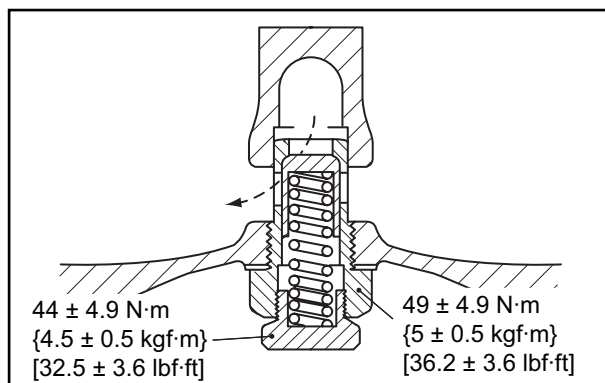


Inspecting oil filter

2.6 Inspecting relief valve

- (1) Check the relief valve and its seat for contact. Check the spring for fatigue and damage. If faulty, replace the relief valve with a new one.
- (2) Measure the relief valve opening pressure. If the pressure does not fall within the standard range, replace the relief valve with a new one.

Item	Standard
Relief valve opening pressure	$0.35 \pm 0.05 \text{ MPa}$ $\{3.5 \pm 0.5 \text{ kgf/cm}^2\}$ $[49.8 \pm 7.1 \text{ psi}]$

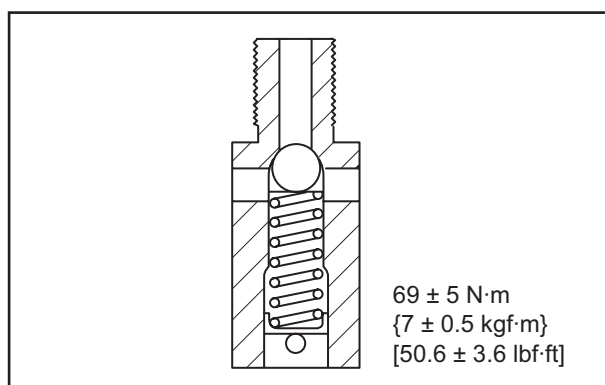


Inspecting relief valve

2.7 Inspecting safety valve

- (1) Check the safety valve and its seat for contact. Check the spring for fatigue and damage. If faulty or damaged, replace the part.
- (2) Measure the safety valve opening pressure. If the pressure does not fall within the standard range, replace the spring with a new one.

Item	Standard
Safety valve opening pressure	1.1 MPa ($\{11 \text{ kgf/cm}^2\}$ [157 psi])

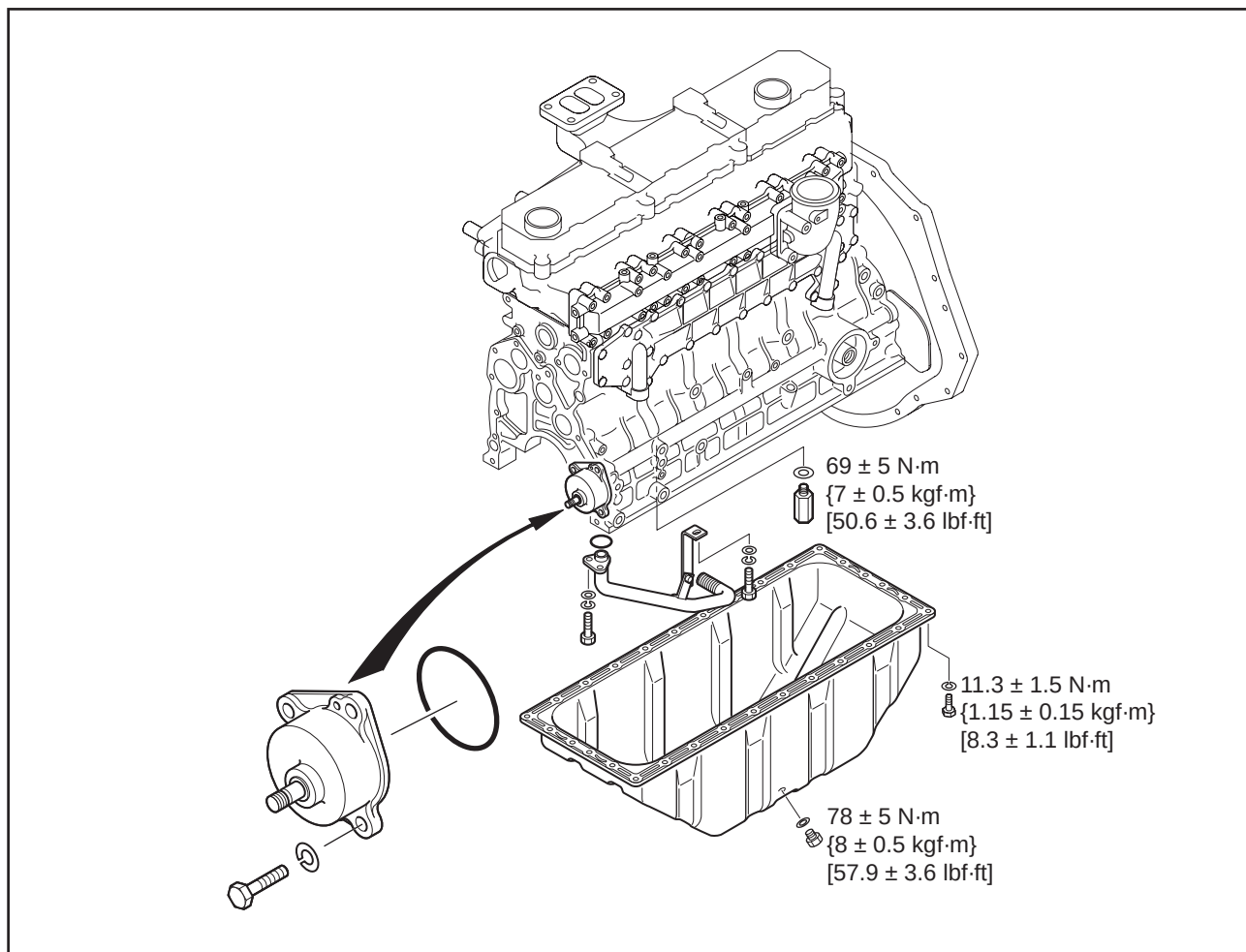


Inspecting safety valve

LUBRICATION SYSTEM

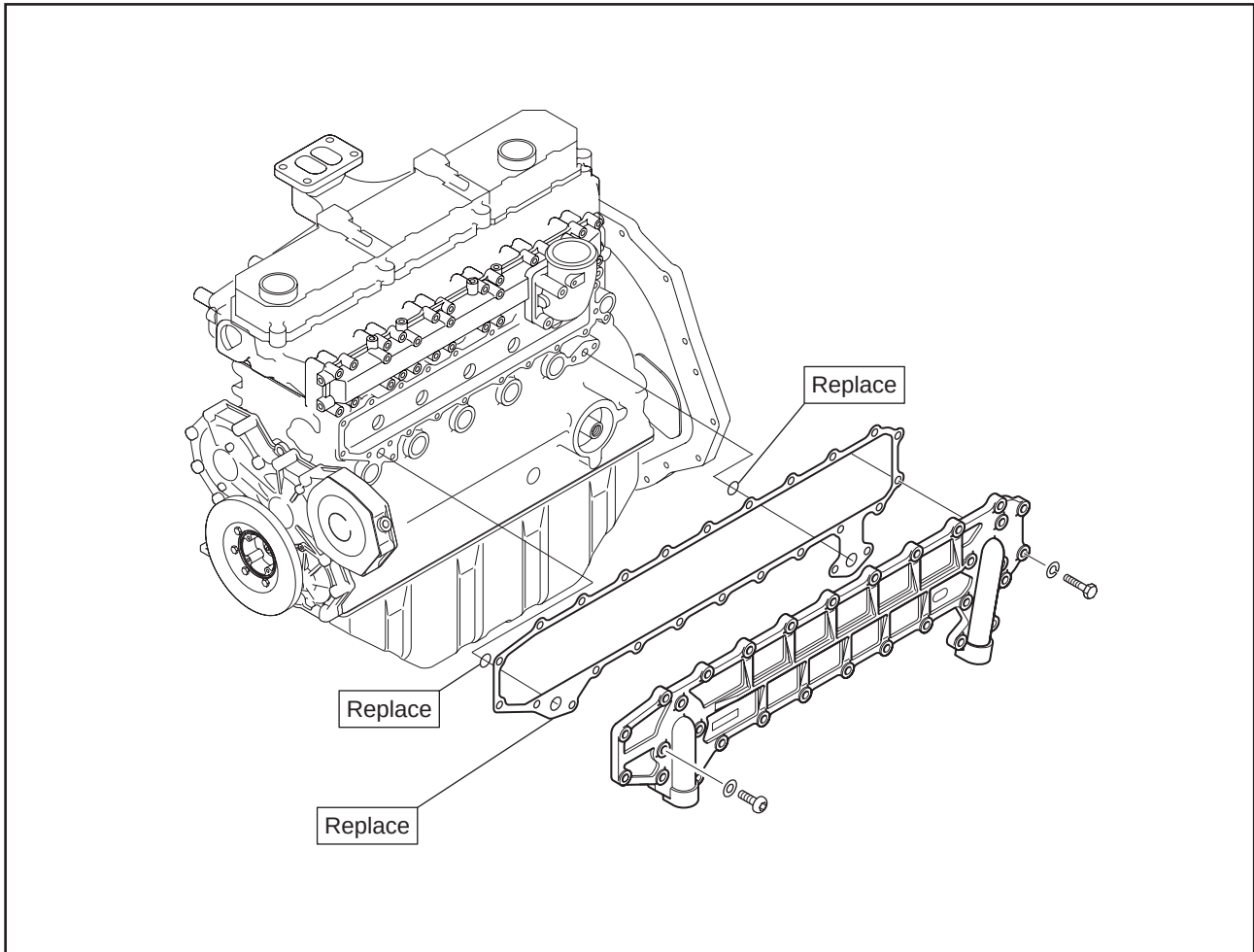
3. Installing lubrication system

3.1 Installing oil pump, oil pan and oil strainer



Installing oil pump, oil pan and oil strainer

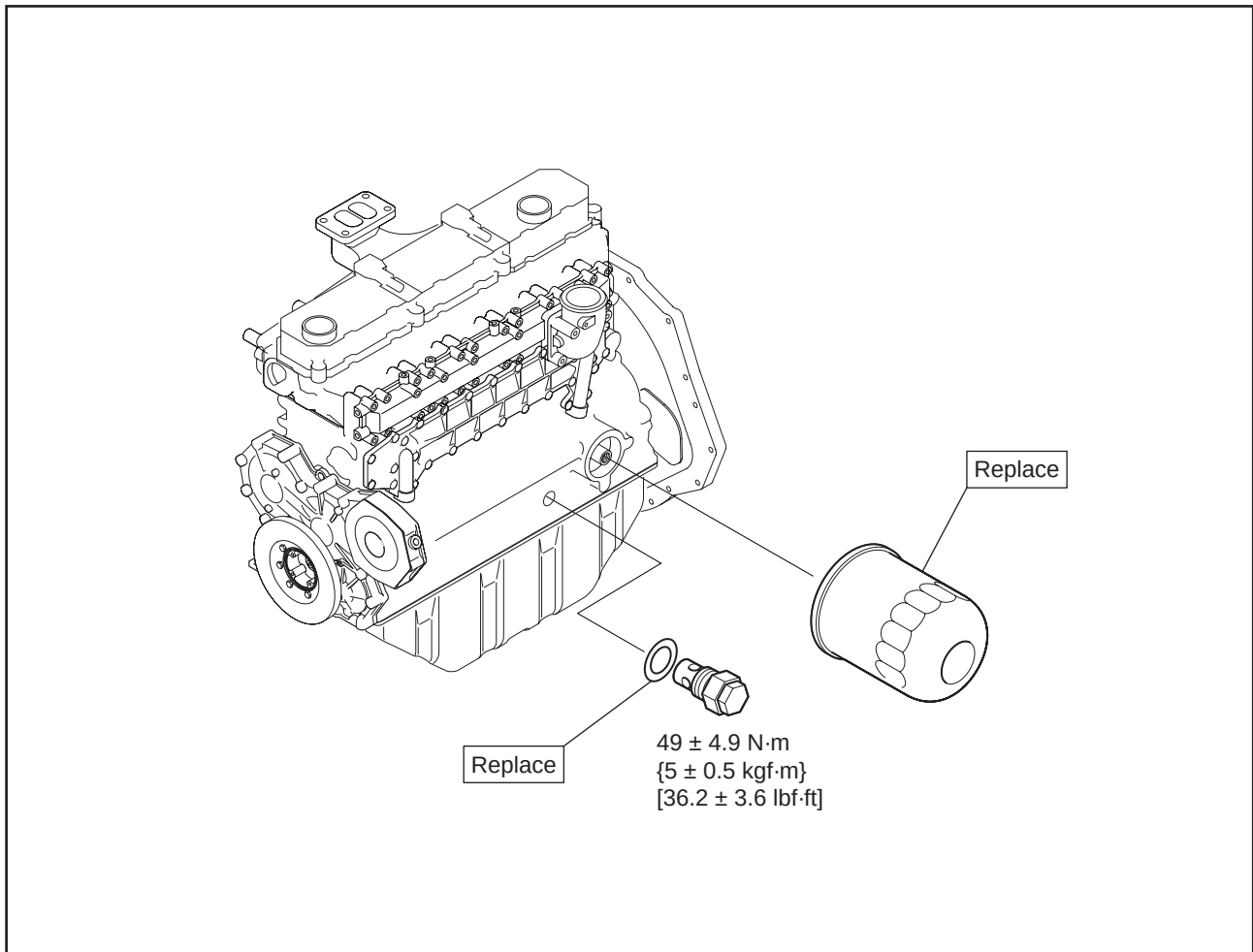
3.2 Installing oil cooler



Installing oil cooler

LUBRICATION SYSTEM

3.3 Installing oil filter and relief valve



Installing oil filter and relief valve

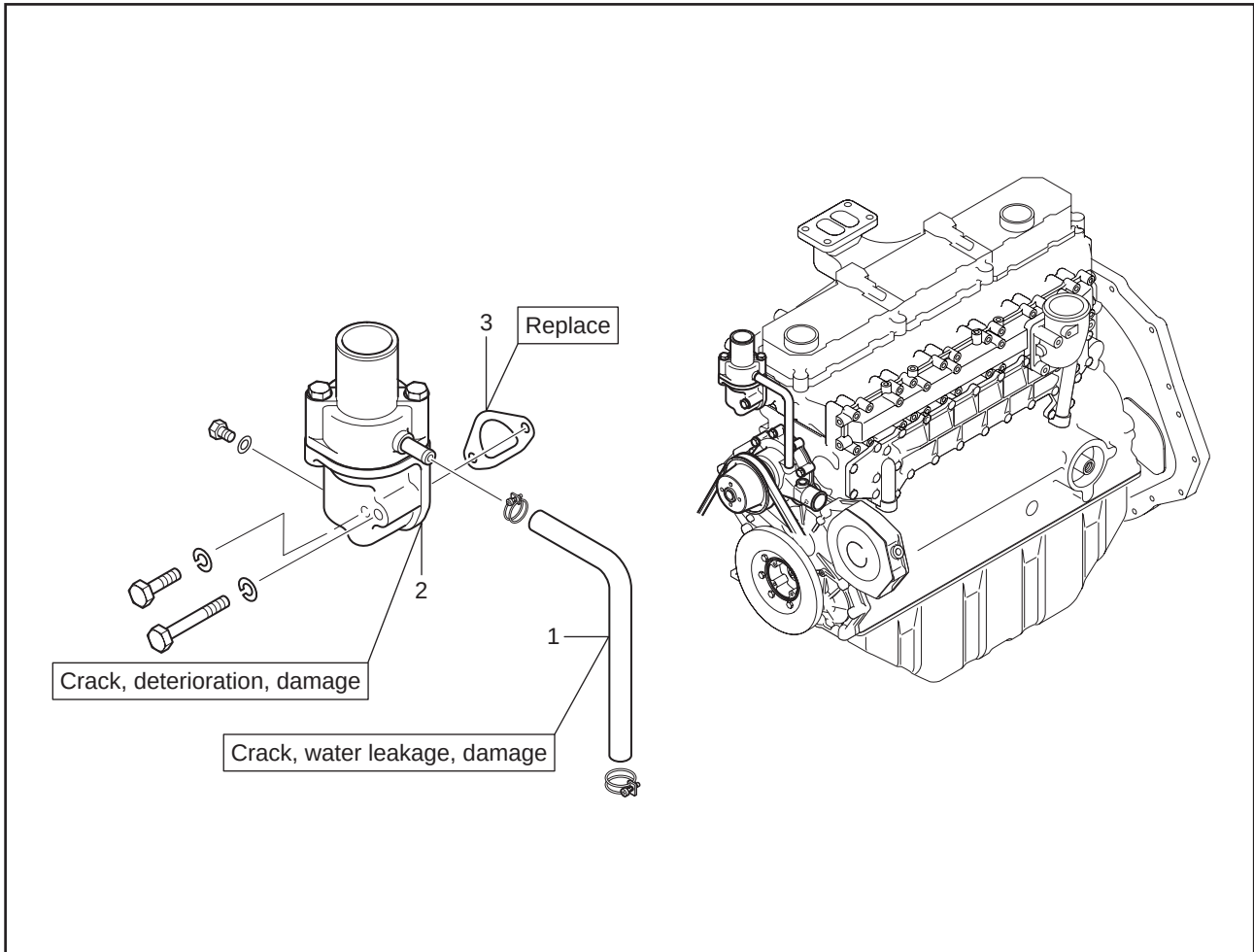
COOLING SYSTEM

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3. Installing cooling system10-7
 - 3.1 Installing water pump, water pump pulley and V-belt..... 10-7
 - 3.2 Installing thermostat..... 10-8

COOLING SYSTEM

1. Removing cooling system

1.1 Removing thermostat



Removing thermostat

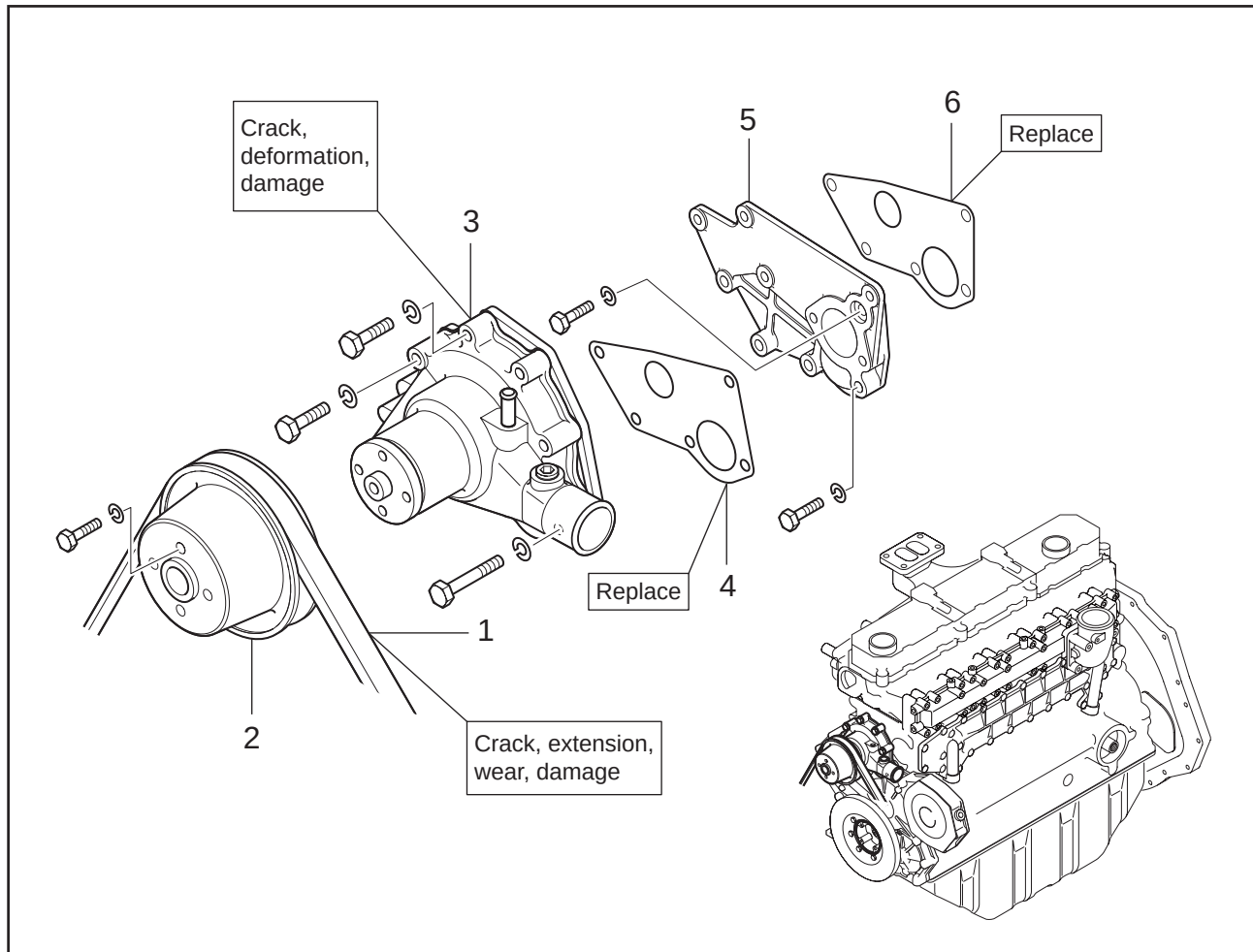
Removing sequence

1 Hose

2 Thermostat assembly

3 Gasket

1.2 Removing water pump, water pump pulley and V-belt



Removing water pump, water pump pulley and V-belt

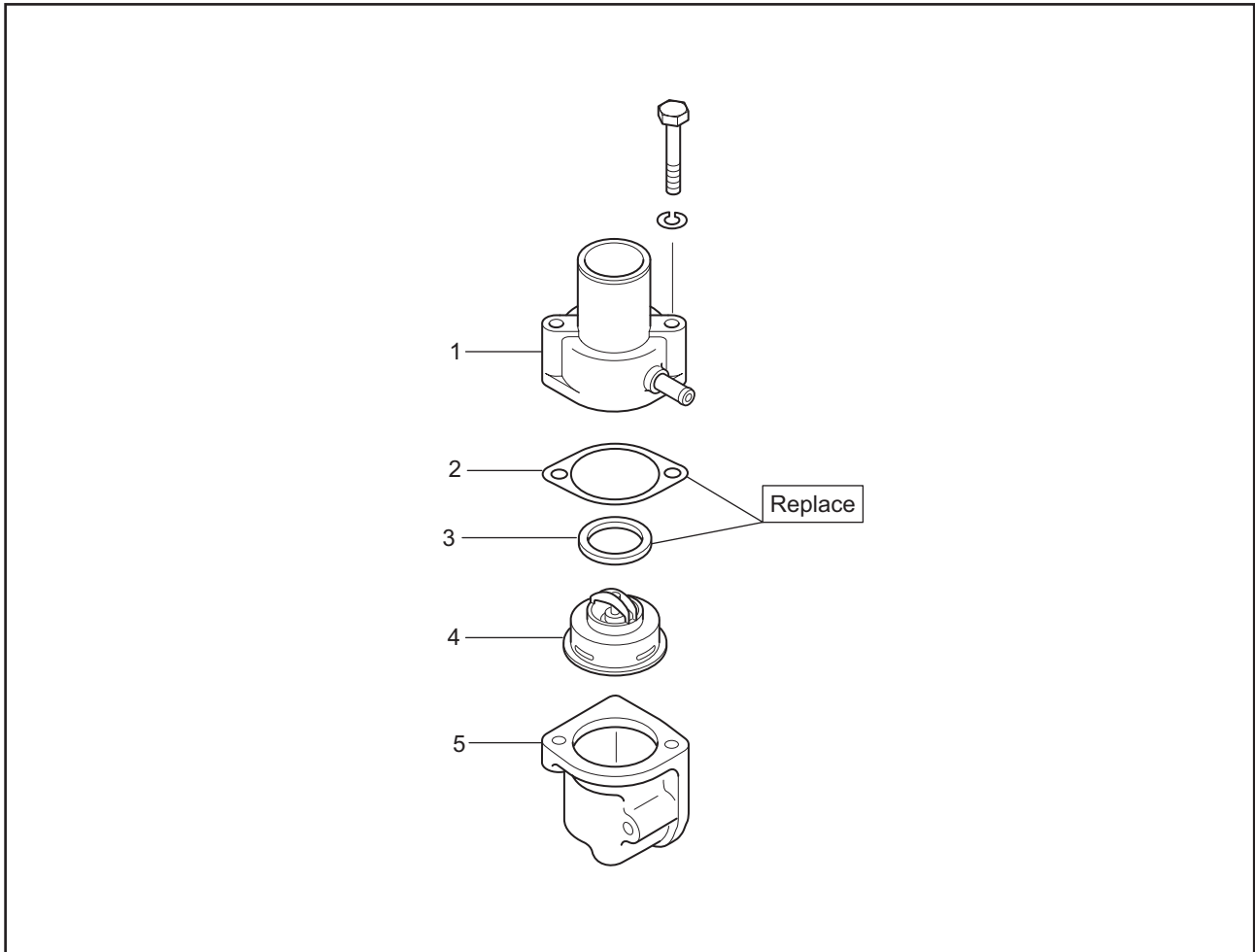
Removing sequence

- | | | |
|---------------------|-----------------------|---------------------|
| 1 V-belt | 3 Water pump assembly | 5 Water pump spacer |
| 2 Water pump pulley | 4 Gasket | 6 Gasket |

COOLING SYSTEM

2. Disassembling, inspecting and reassembling cooling system

2.1 Disassembling and inspecting thermostat



Disassembling thermostat

Disassembling sequence

- 1 Cover assembly
- 2 Gasket

- 3 Gasket
- 4 Thermostat

- 5 Thermostat case

2.2 Inspecting thermostat

⚠ CAUTION

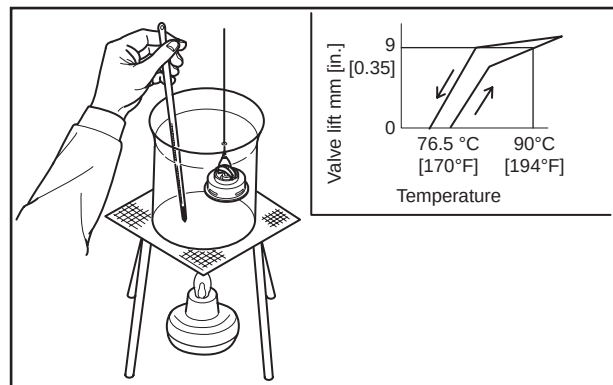
Be careful of burns or a fire when measuring temperature, as it involves a high-temperature and open flame.

To test the thermostat operation, immerse the thermostat in a container filled with water. Heat the water, while measuring the water temperature. Record the temperature at the conditions shown in the table below. If the temperatures are not within the standard range, replace the thermostat.

Note: (a) Stir the water in the container with a stick to ensure uniform temperature distribution.

(b) Before installing the thermostat, be sure to check the valve opening temperature stamped on the thermostat valve side face.

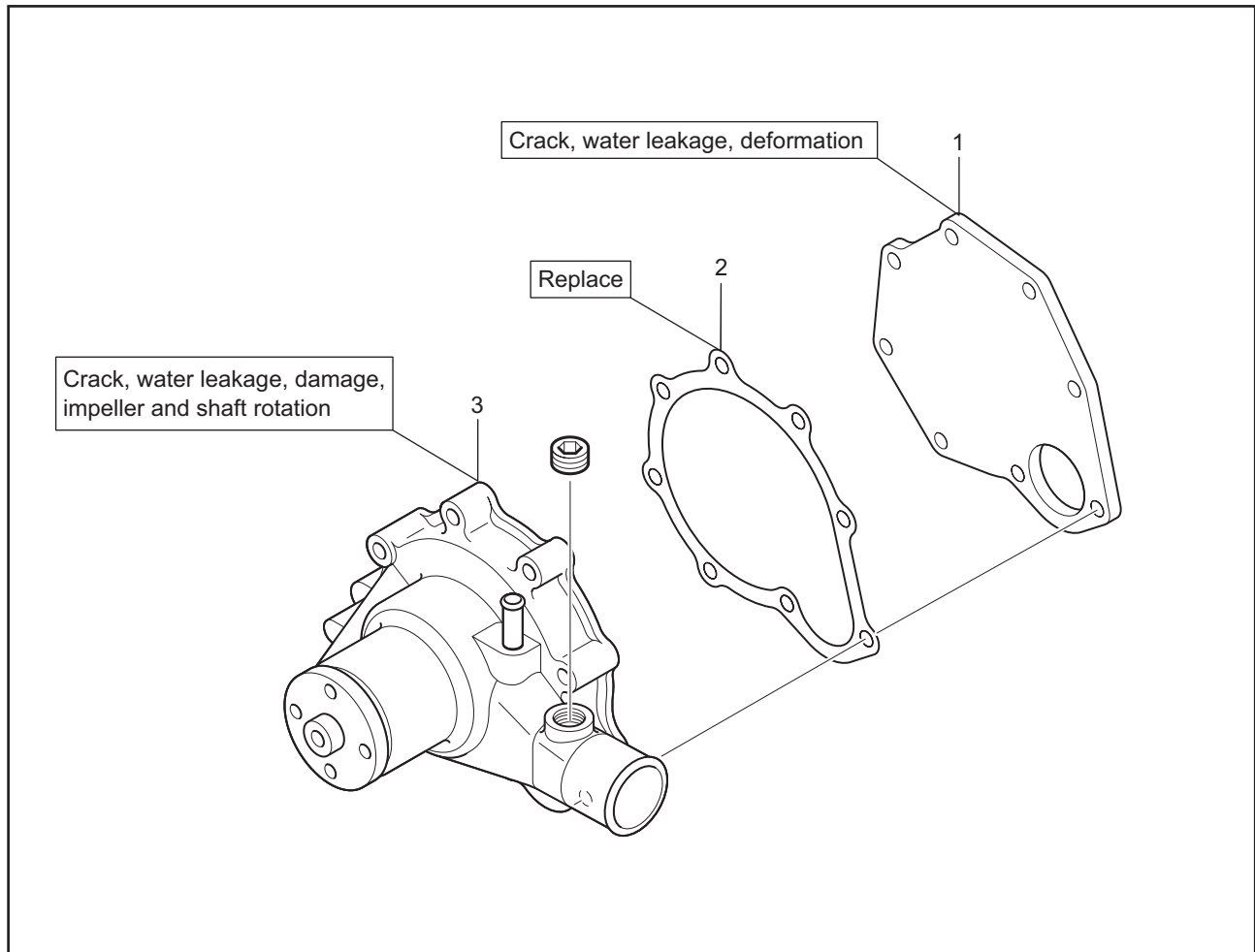
Item	Standard
Temperature at which valve starts opening	$76.5 \pm 1.5^{\circ}\text{C}$ [$170 \pm 3.5^{\circ}\text{F}$]
Temperature at which valve lift becomes 9 mm [0.35 in.] or more.	$90 \pm 1.5^{\circ}\text{C}$ [$194 \pm 2.7^{\circ}\text{F}$]



Inspecting thermostat

COOLING SYSTEM

2.3 Disassembling water pump



Disassembling water pump

Disassembling sequence

1 Water pump cover

2 Gasket

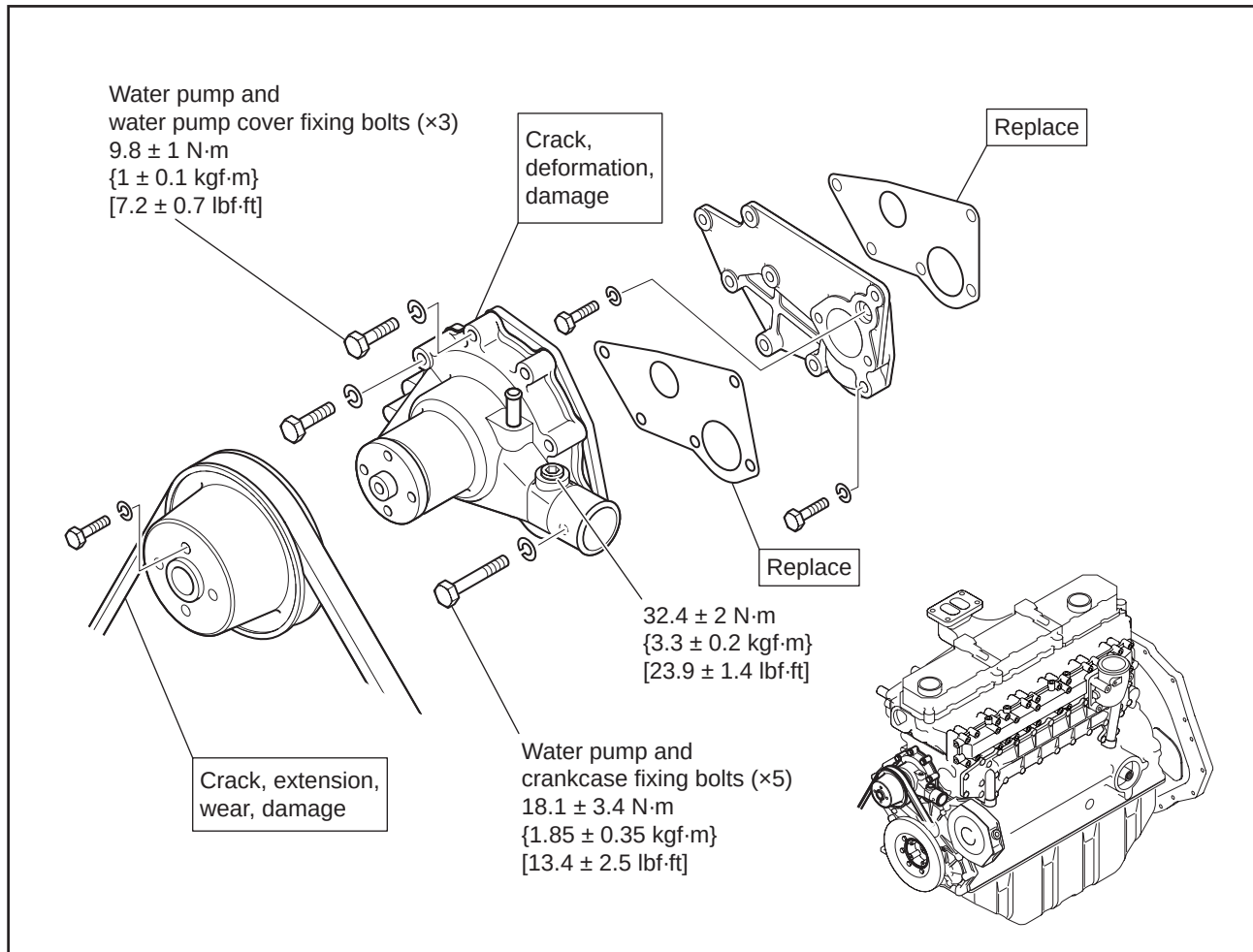
3 Water pump

2.4 Inspecting water pump

Check to make sure that the impeller and shaft of water pump rotate smoothly without noise and irregularities. If faulty, replace the assembly.

3. Installing cooling system

3.1 Installing water pump, water pump pulley and V-belt



Installing water pump, water pump pulley and V-belt

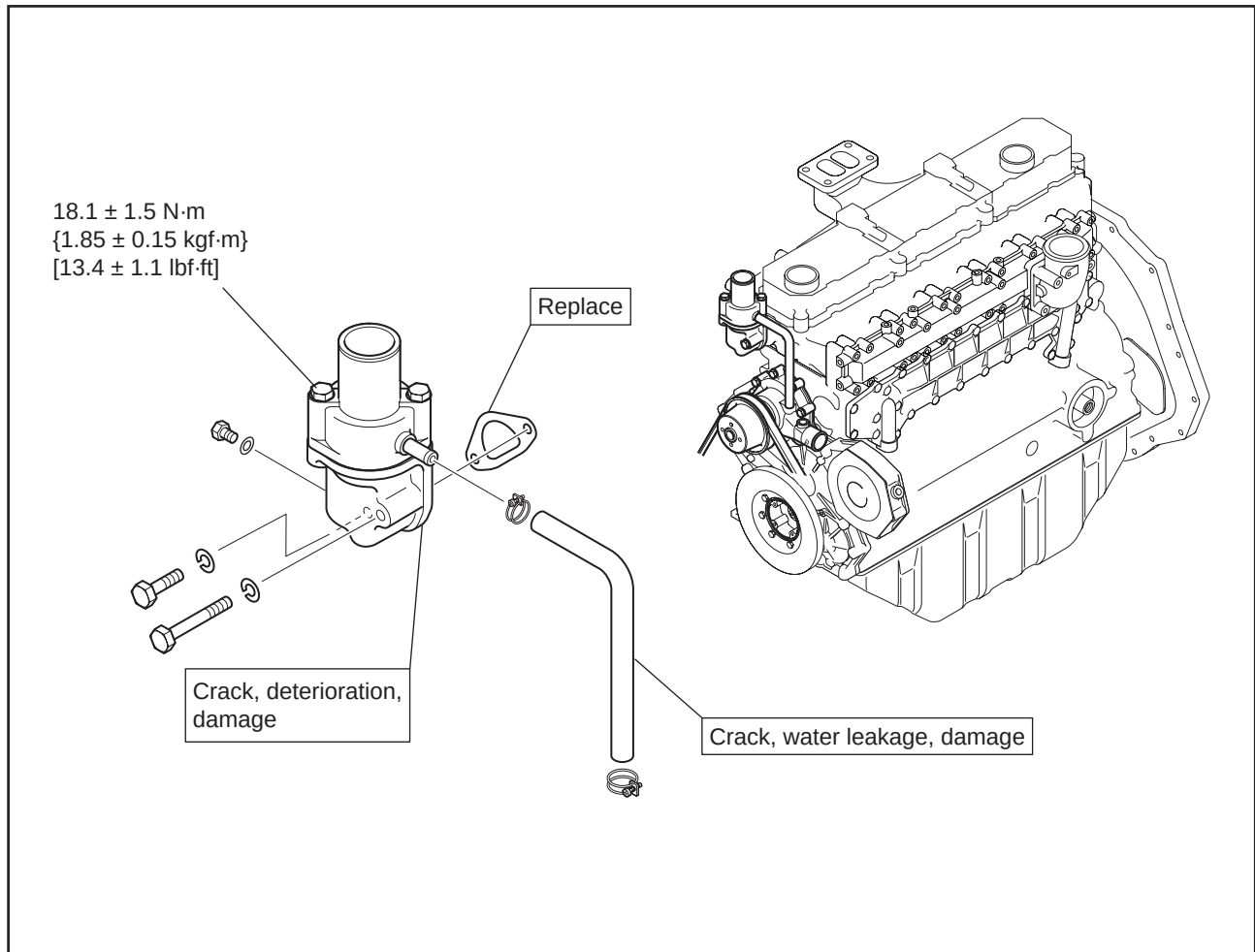
CAUTION

Inspect and adjust the V-belt every 200 hours of operation.

Depending on the operating condition, inspecting and adjusting interval may shorten.

COOLING SYSTEM

3.2 Installing thermostat



Installing thermostat

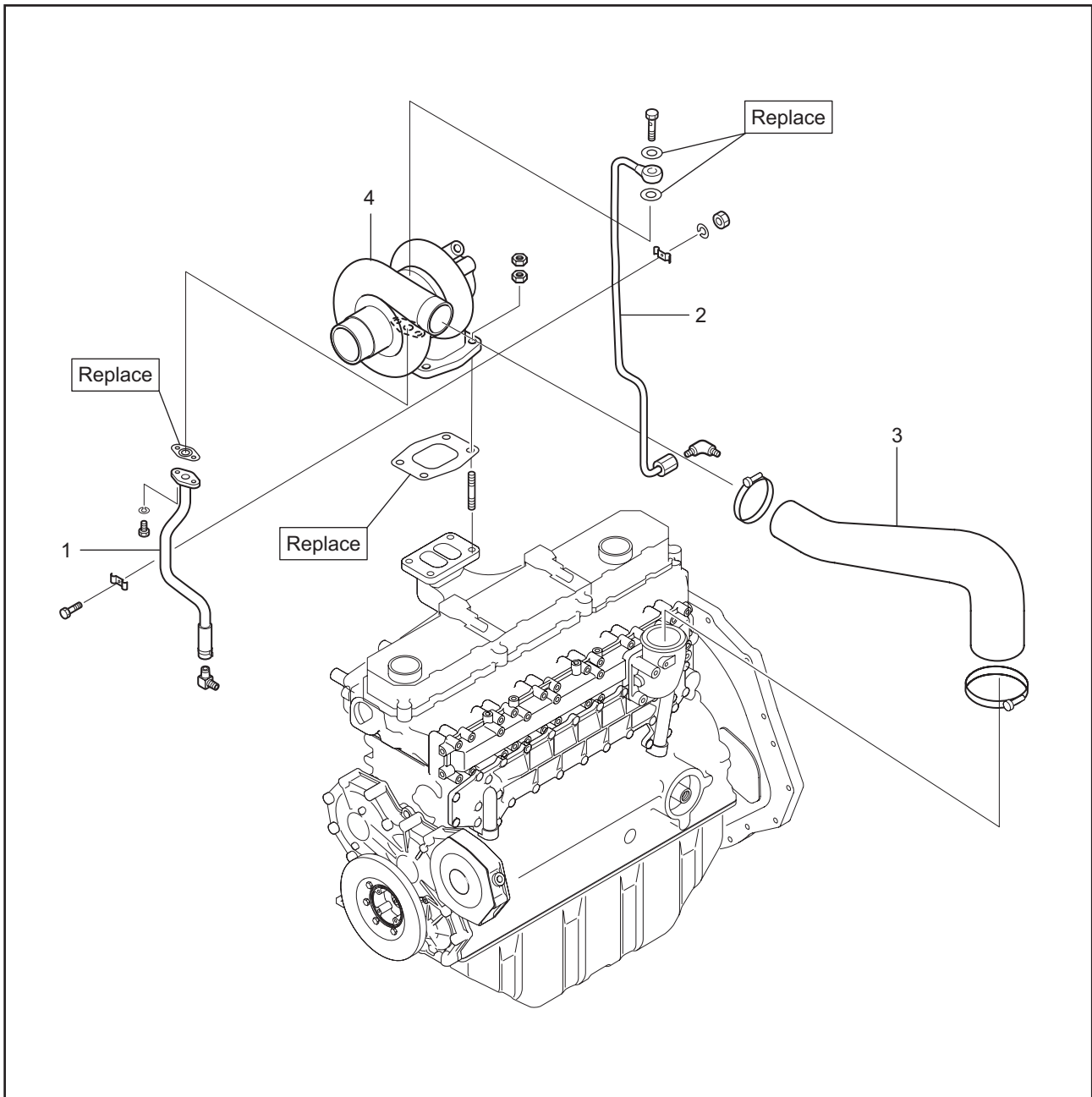
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INLET AND EXHAUST SYSTEMS

1. Removing turbocharger, inlet and exhaust systems

1.1 Removing turbocharger



Removing turbocharger

Removing sequence

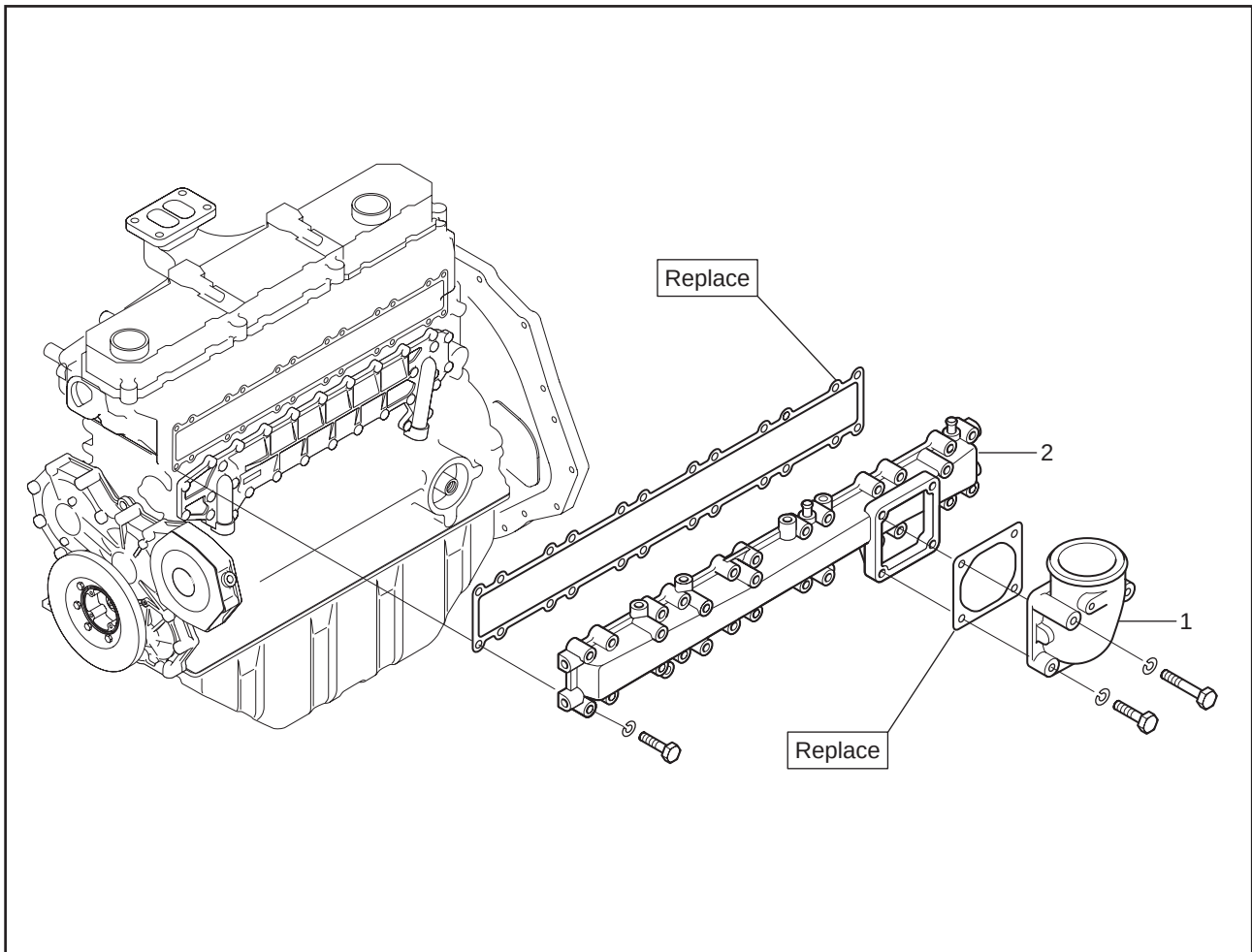
1 Oil pipe

2 Oil pipe

3 Air hose

4 Turbocharger

1.2 Removing inlet manifold



Removing inlet manifold

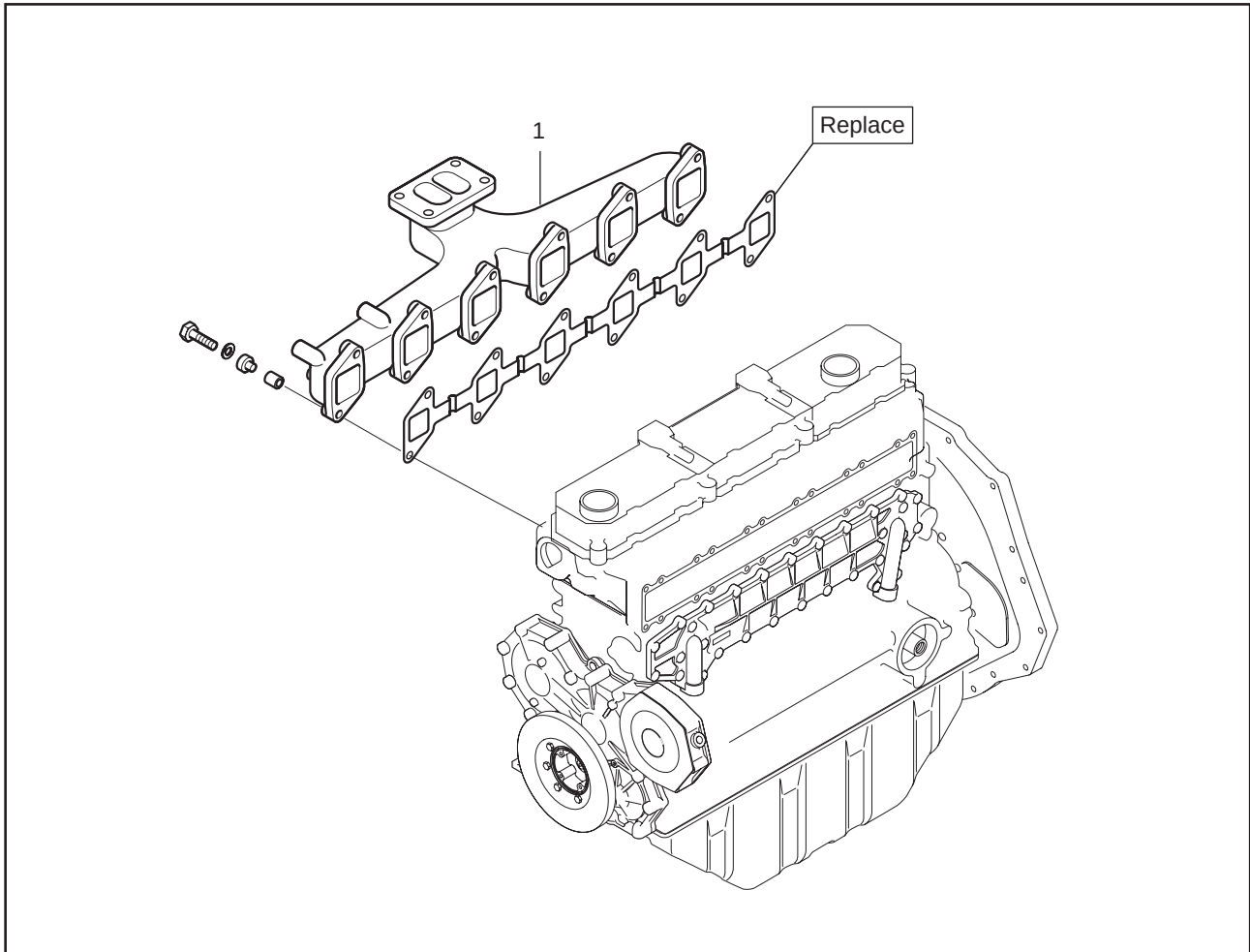
Removing sequence

1 Air inlet elbow

2 Inlet manifold

INLET AND EXHAUST SYSTEMS

1.3 Removing exhaust manifold



Removing exhaust manifold

Removing sequence

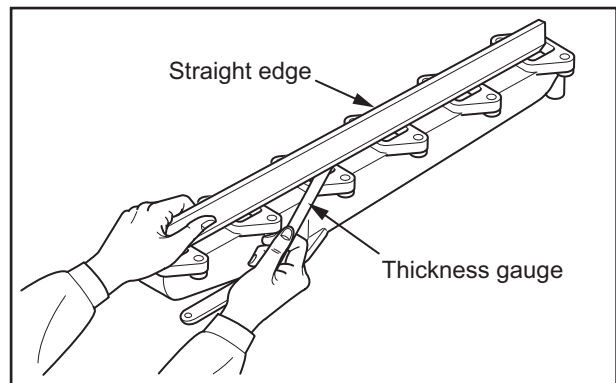
- 1 Exhaust manifold

2. Disassembling, inspecting and reassembling inlet and exhaust systems

2.1 Measuring exhaust manifold distortion

- (1) Check the flange for crack.
- (2) Check the flange surface for distortion. If the distortion exceeds the standard, retouch the surface or replace it.

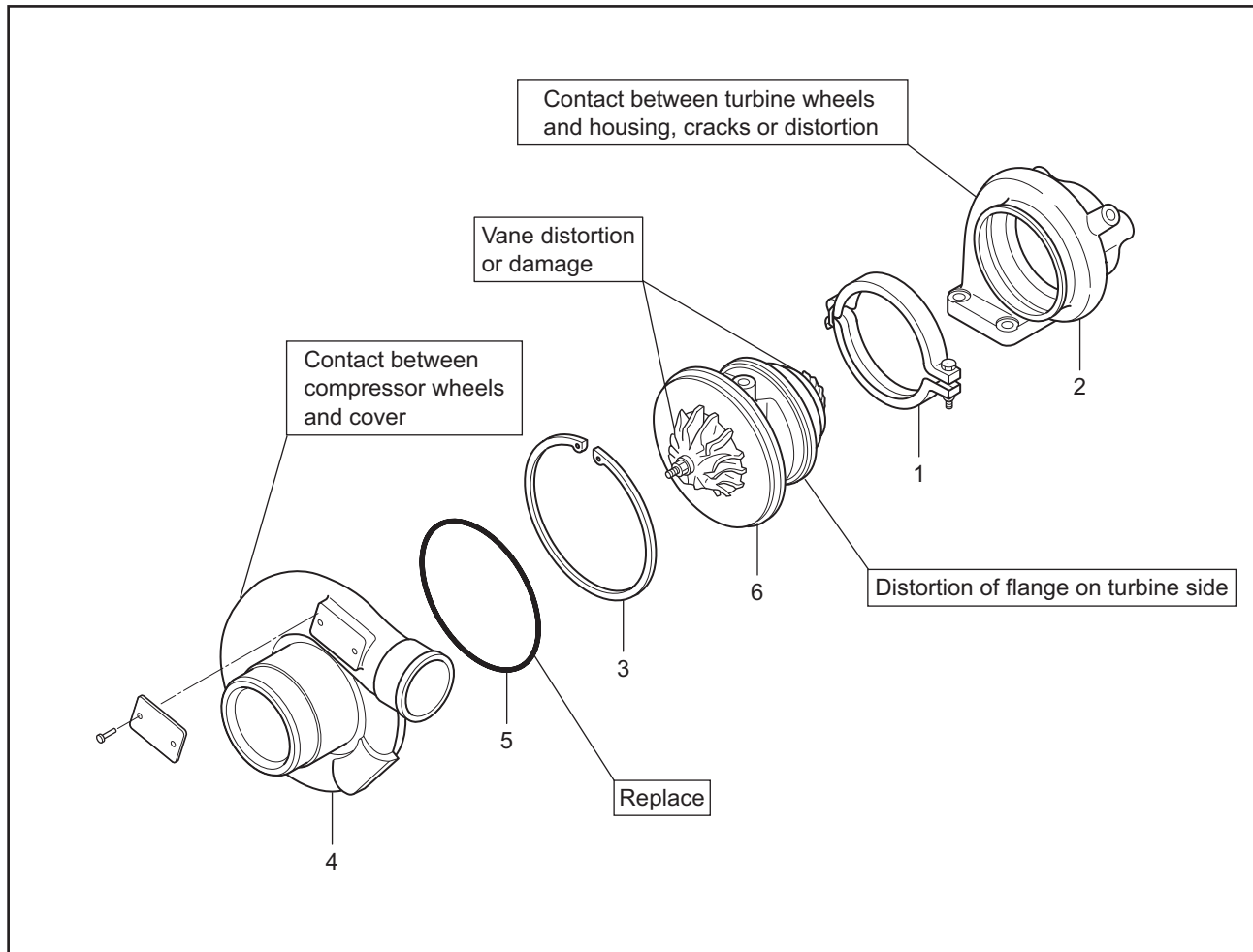
Item	Standard
Exhaust manifold distortion	0.2 mm [0.008 in.] or less



Measuring distortion on exhaust manifold

INLET AND EXHAUST SYSTEMS

2.2 Disassembling and inspecting turbocharger



Disassembling and inspecting turbocharger

Disassembling sequence

- | | |
|---------------------|----------------------|
| 1 Coupling assembly | 4 Compressor cover |
| 2 Turbine housing | 5 O-ring |
| 3 Snap ring | 6 Cartridge assembly |

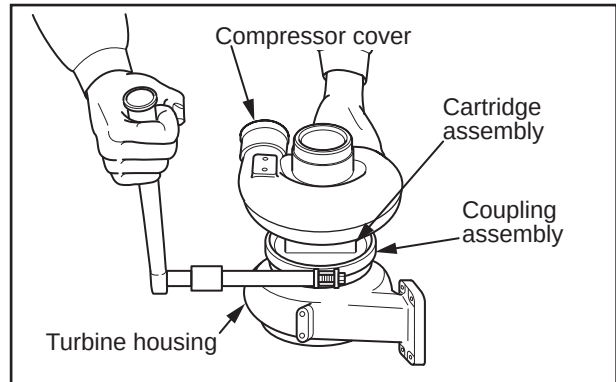
CAUTION

Carefully handle the compressor wheel and turbine wheel during disassembly and assembly, since vanes can easily bend when dropped or hit.

2.2.1 Removing turbine housing

Loosen the coupling assembly as shown, and separate the turbine housing.

Note: The positional relationship between the turbine housing and the cartridge assembly is very important. Therefore before disassembling, mark the components with a punch or felt-tip pen to ensure correct reassembly.



Removing turbine housing

2.2.2 Removing compressor cover

⚠ CAUTION

Hold the snap ring by hand while pinching the ring ends with the snap ring pliers so that the ring will not fly off if the ring ends slip off the pliers.

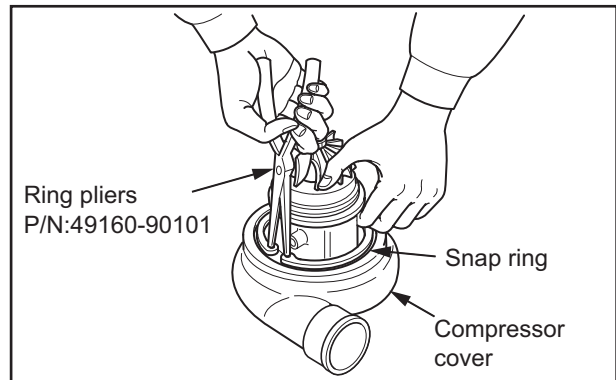
CAUTION

Be careful not to hit the vane of compressor wheel against the cover.

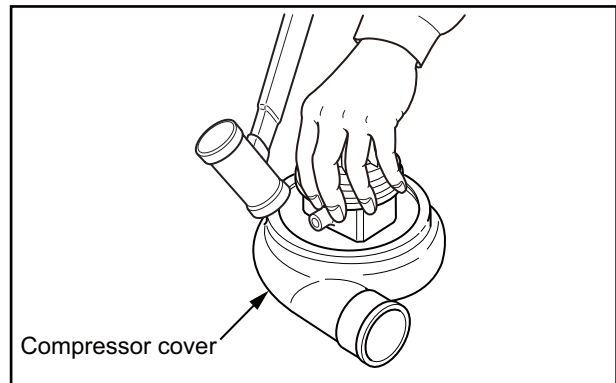
- (1) Lay the compressor cover flat on the table as shown. Using the ring pliers, remove the snap ring.
- (2) Using a plastic hammer, lightly tap around on the compressor cover and remove the cover.

Remove the O-ring from the housing.

Note: The positional relationship between the compressor cover and the cartridge assembly is very important. Therefore before disassembling, mark the components with a punch or felt-tip pen to ensure the correct reassembly.



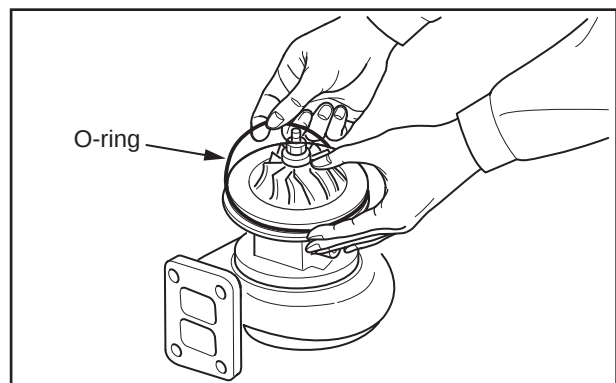
Removing compressor cover (1)



Removing compressor cover(2)

2.2.3 Installing O-ring

Apply grease to the O-ring, and install the O-ring to the cartridge.

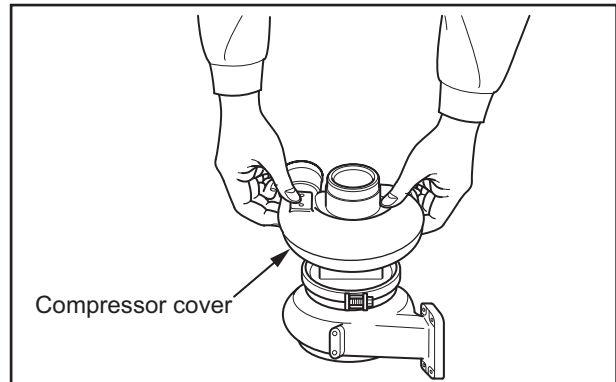


Installing O-ring

INLET AND EXHAUST SYSTEMS

2.2.4 Installing compressor cover

Install the compressor cover, paying attention to its orientation.



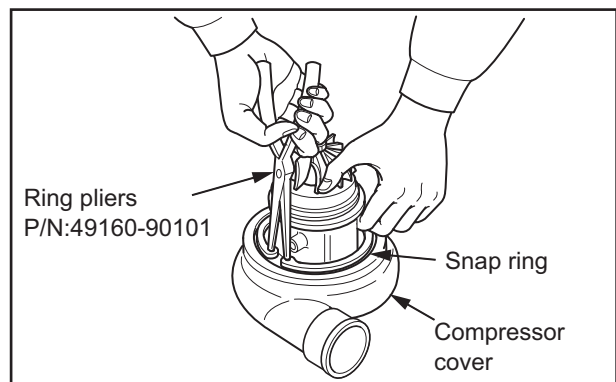
Installing compressor cover

2.2.5 Installing snap ring

CAUTION

- (a) Be sure to install the snap ring in the correct direction.
- (b) Lightly drive both ends of the snap ring using a screwdriver and a hammer to insert the ring securely into the groove on the bearing housing.
- (c) Make sure the screwdriver does not hit the bearing housing when driving the snap ring with the screwdriver and the hammer.

With the tapered face facing up, install the snap ring in the compressor cover using the pliers.



Installing snap ring

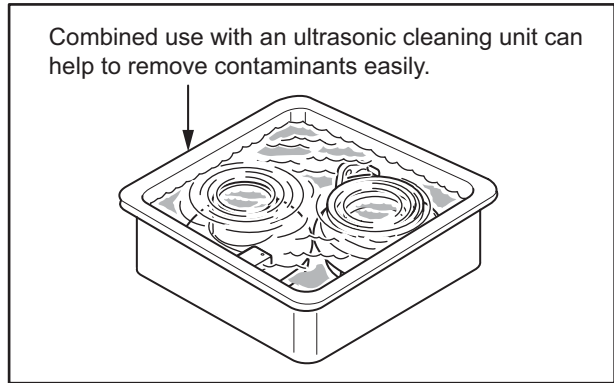
2.3 Cleaning

CAUTION

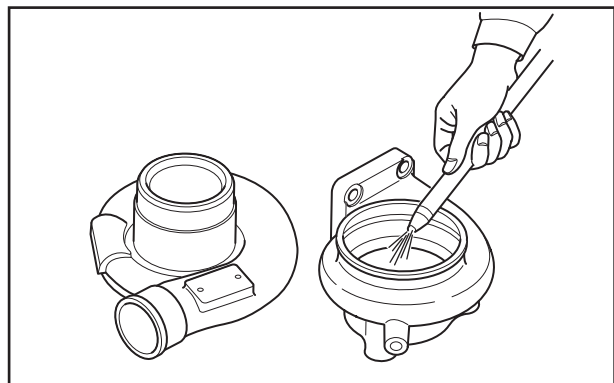
- (a) When using a commercial neutral detergent, be sure to use non-corrosive type.
- (b) Be careful not to damage components.

When cleaning the compressor cover and the turbine housing, observe the followings:

- (1) Visually check the parts condition before cleaning to note any burns or abrasions, which may not be observable after cleaning.
- (2) Soak the disassembled parts in the inflammable solvent (e.g. Die Cleaner T-30 manufactured by Daido Chemical Industry Corp.) to remove oil contaminants and carbon attachments. However, do not soak the O-ring, thrust bearing, and other bearings.
- (3) Blow compressed air over the inside and outside surfaces.

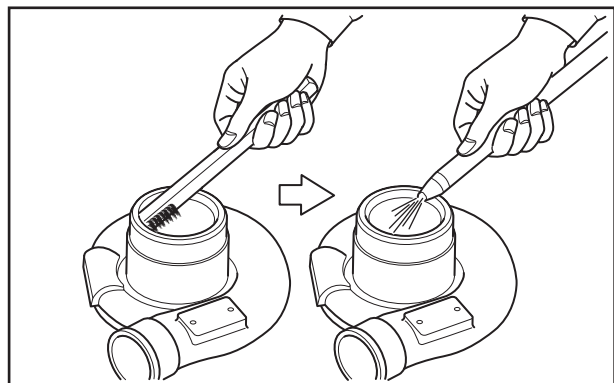


Cleaning turbocharger



Blow compressed air onto

- (4) Remove deposits using a plastic scraper or a bristle brush. After removing deposits, soak the components in a nonflammable solvent and apply compressed air again.



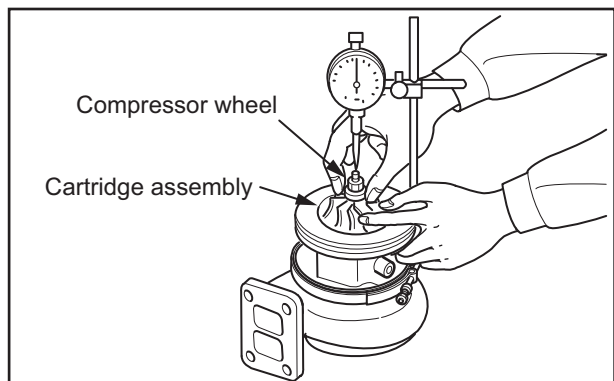
Removing carbon deposits thoroughly

2.3.1 Measuring axial clearance of cartridge assembly

Set a dial indicator on the end of compressor wheel shaft as shown.

Move the compressor wheel in the axial direction and measure the clearance.

If the clearance is out of standard, replace the cartridge assembly, with a new one.

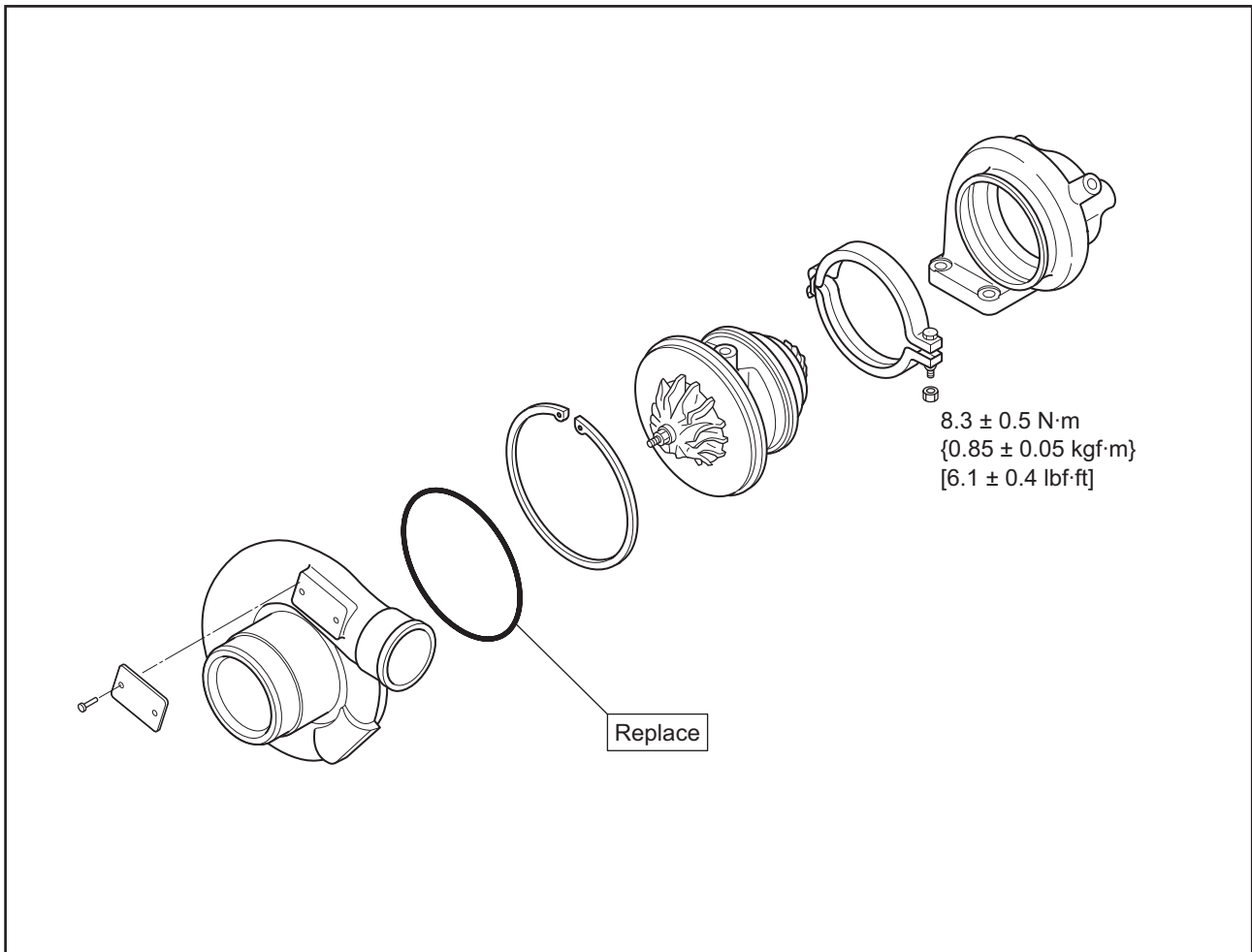


Measuring axial clearance of cartridge assembly

Item	Standard
Axial clearance of cartridge assembly	0.057 to 0.103 mm [0.0022 to 0.0041 in.]

INLET AND EXHAUST SYSTEMS

2.3.2 Reassembling turbocharger



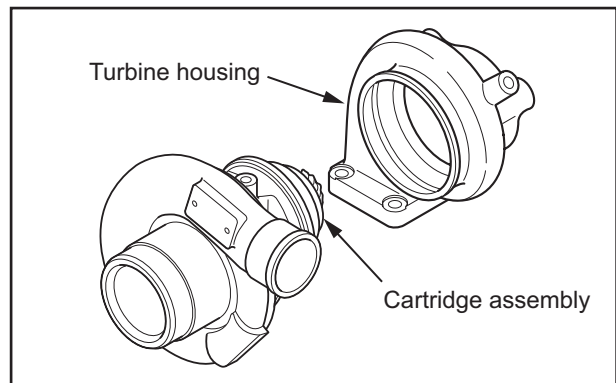
Reassembling turbocharger

CAUTION

- (a) Change the following parts at reassembling
 - O-ring
- (b) Replace the compressor cartridge assembly if its vanes are distorted or cracked.
Minor distortion or minor scratches on one piece of the vane may not require replacement of cartridge assembly, however, do not attempt to re-shape a distorted vane.

2.3.3 Installing turbine housing

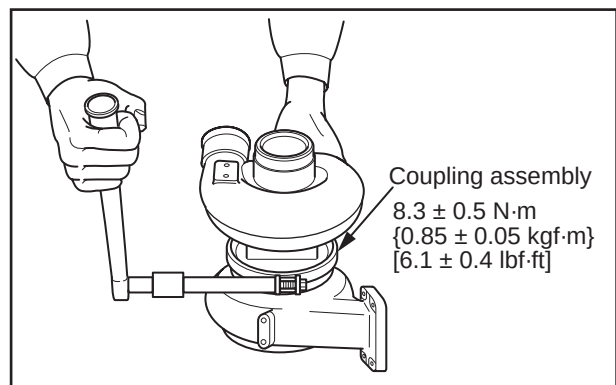
Install the turbine housing to the cartridge assembly by aligning the marks put during disassembly.



Installing turbine housing

2.3.4 Installing coupling assembly

Apply Molykote grease or equivalent to threads of the coupling assembly nut, and tighten the nut to the specified torque.

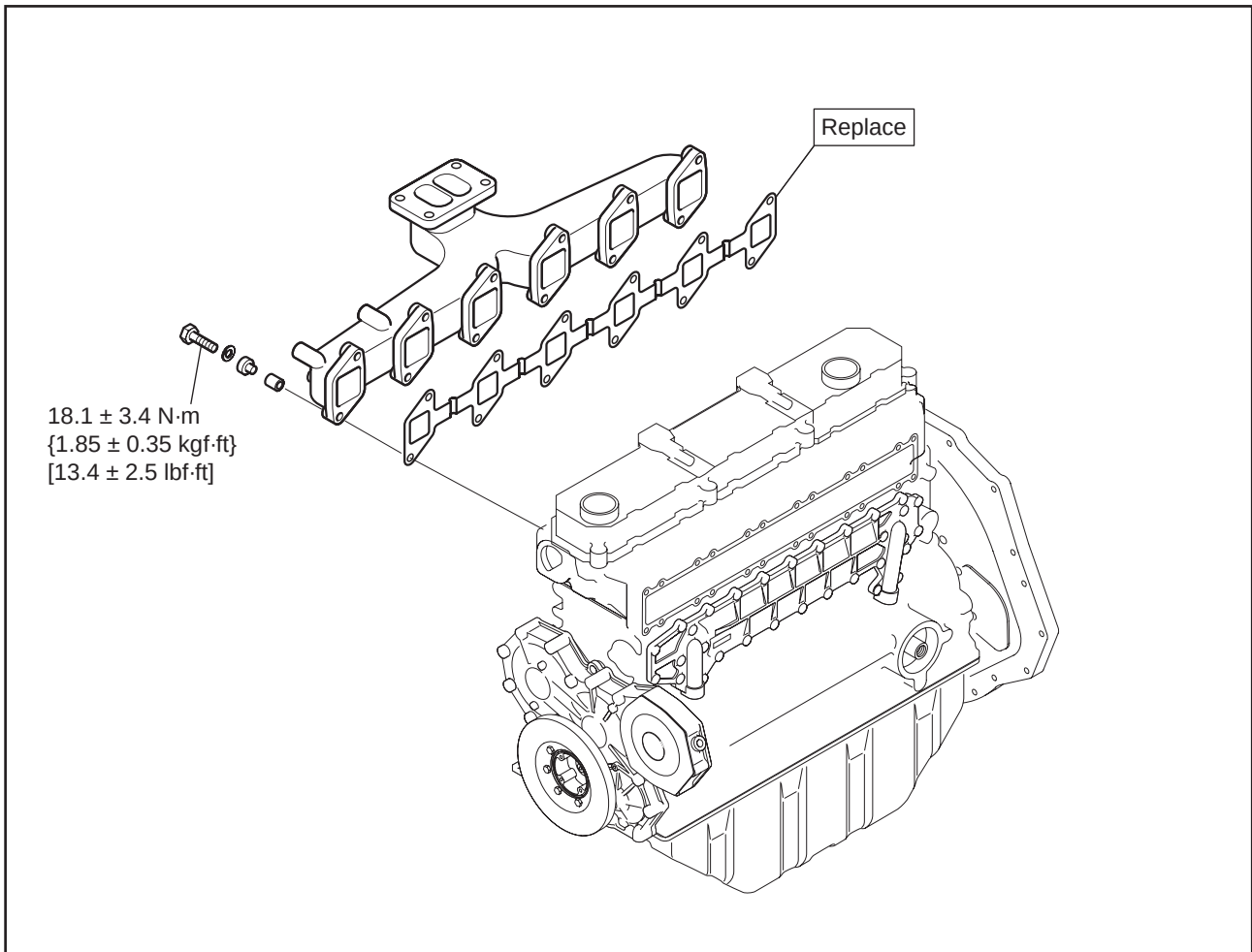


Installing coupling assembly

INLET AND EXHAUST SYSTEMS

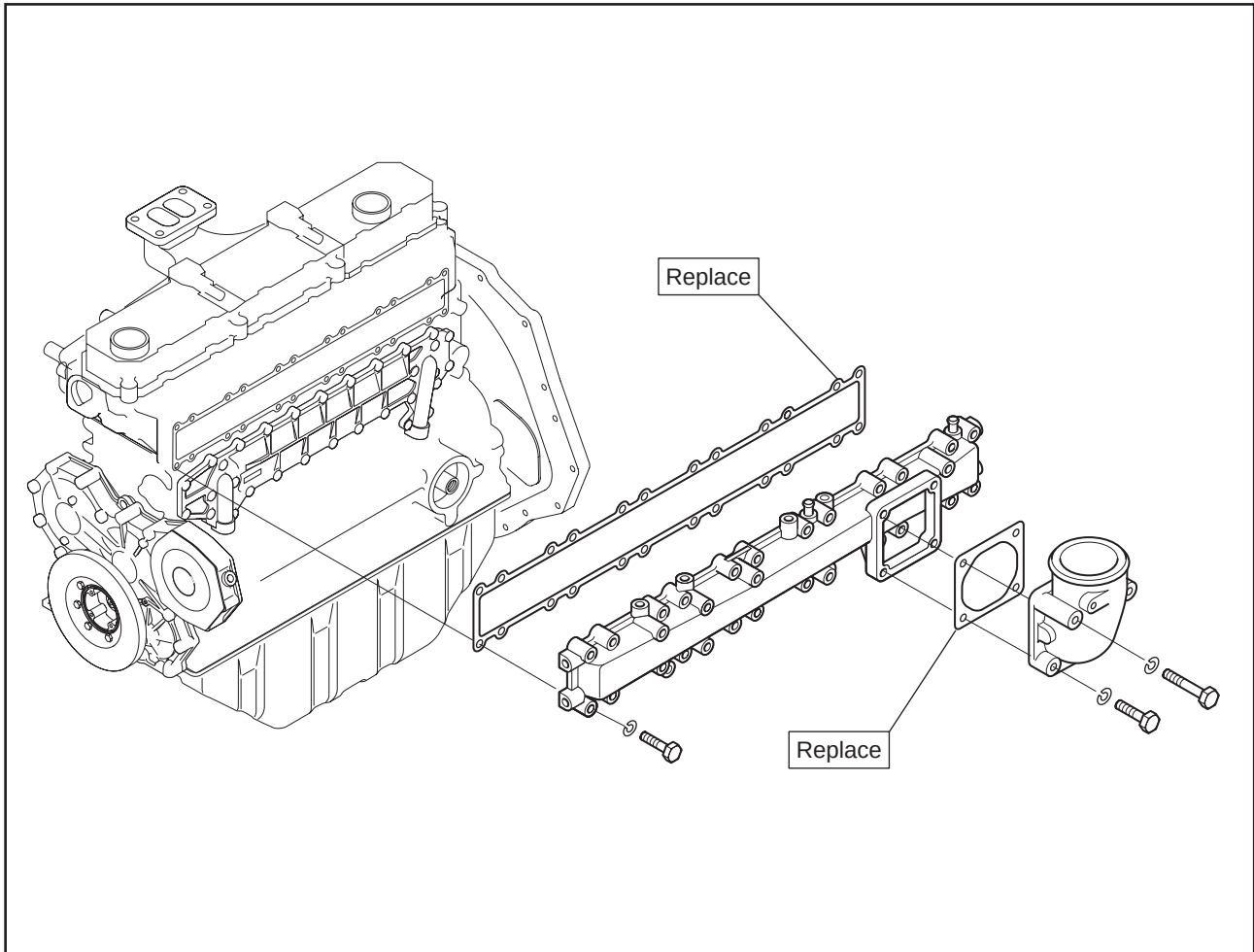
3. Installing turbocharger, inlet and exhaust systems

3.1 Installing exhaust manifold



Installing exhaust manifold

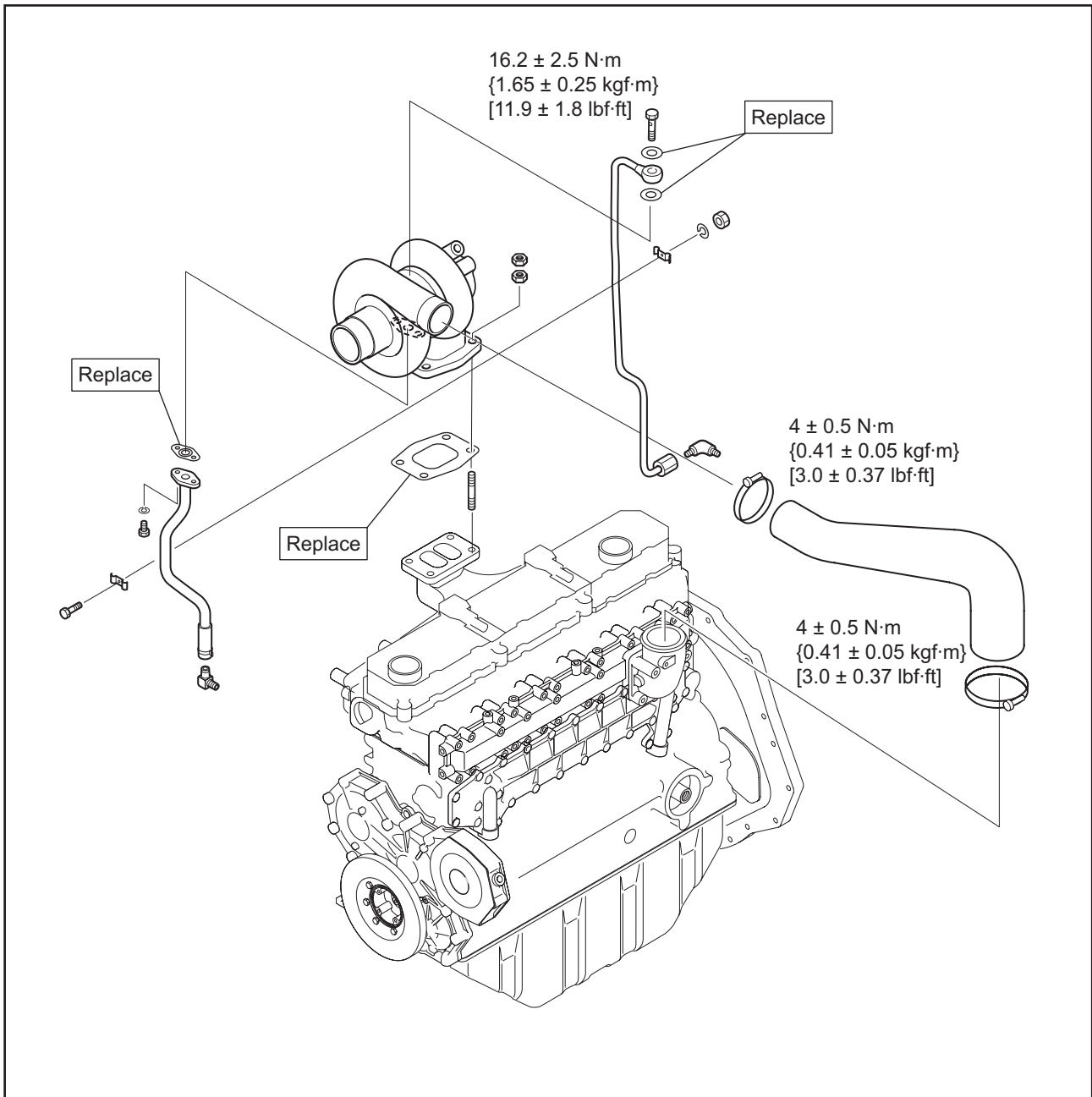
3.2 Installing inlet manifold



Installing inlet manifold

INLET AND EXHAUST SYSTEMS

3.3 Installing turbocharger



Installing turbocharger

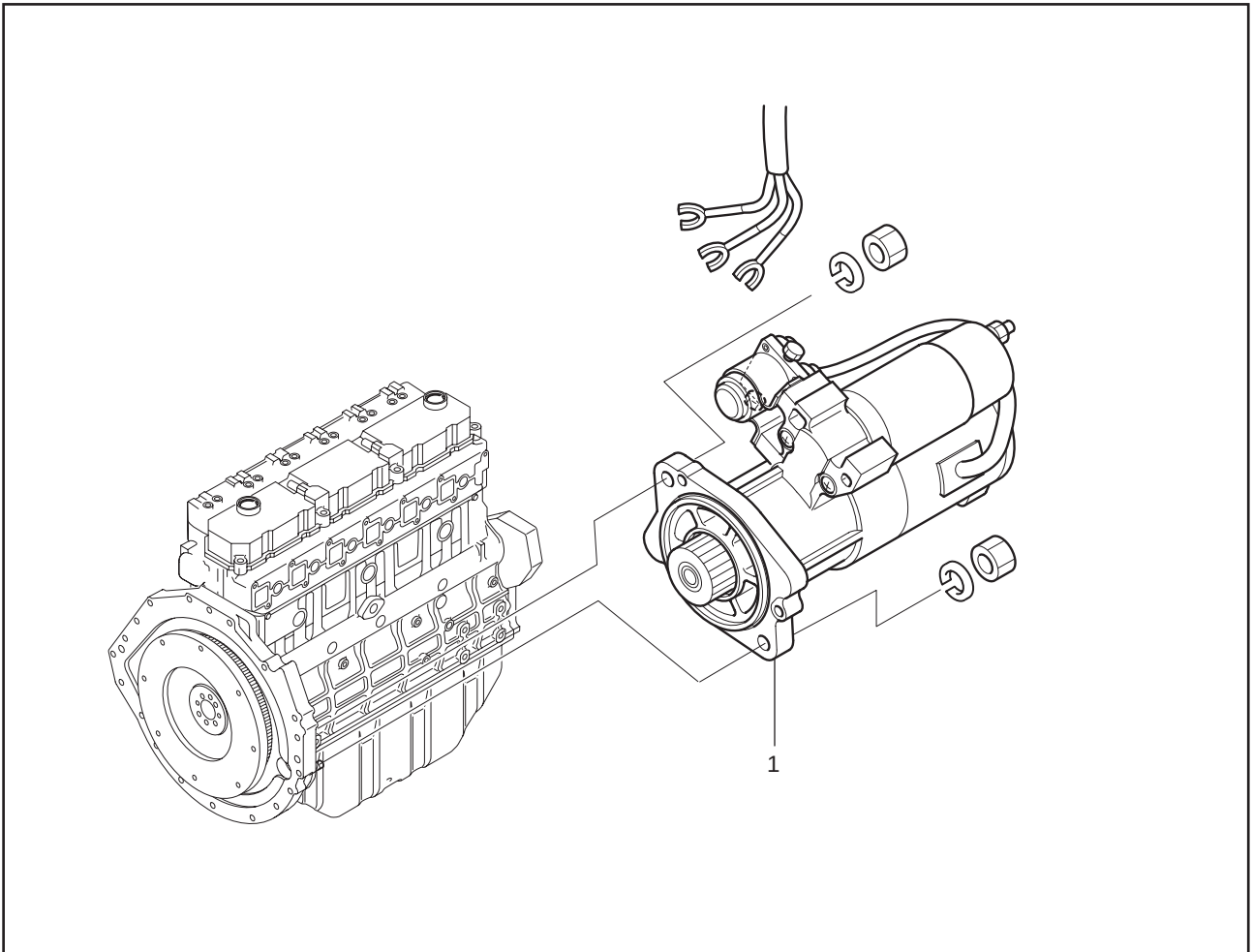
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ELECTRICAL SYSTEM

1. Removing electrical system

1.1 Removing starter



Removing starter

Removing sequence

- 1 Starter

1.2 Inspection before removing alternator

1.2.1 Inspecting alternator operation

Locate the cause of faulty charging from malfunctions described below. Do not remove the alternator for inspection and repair unless inspection cannot be performed with the alternator installed on the engine.

Overcharge	Adjusted value of voltage regulator is high.
	Faulty battery.
Over discharge	Low adjusted value of voltage relay.
	Faulty alternator output.
	Electric power consumption is extremely high.
	Special load is used.
	Faulty wiring.

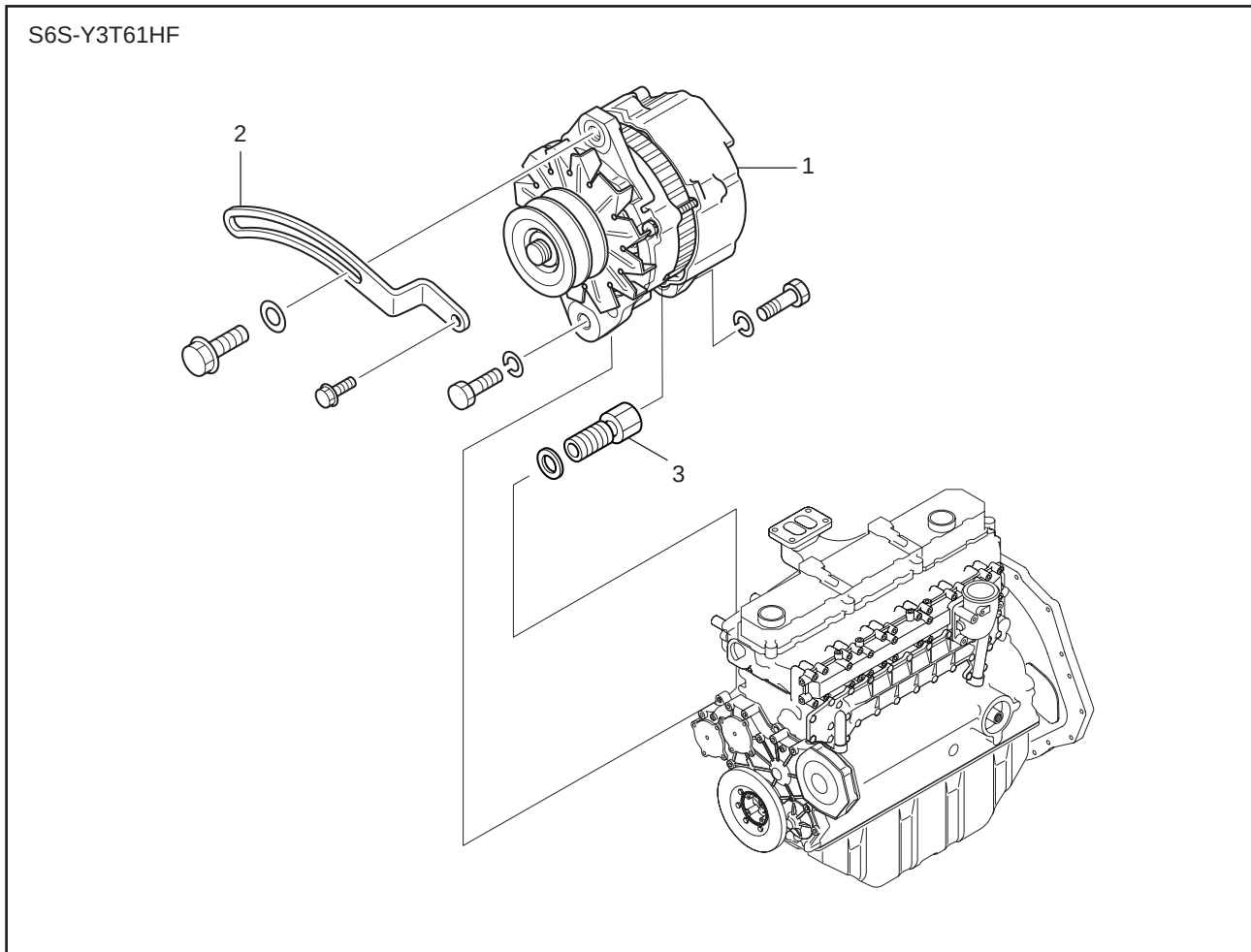
1.2.2 Handling precaution

Improper handling could cause damage or failure to the alternator.

- (1) Connect battery cables correctly. B terminal is positive (+), and E terminal is negative (-).
- (2) Do not use any high voltage tester such as megger.
- (3) Do not disconnect lead wire from B terminal of the alternator while the engine is running.
- (4) Battery voltage is constantly applied to B terminal of the alternator. Do not ground at this terminal.
- (5) Do not short circuit or ground at L terminal. (For a built-in IC regulator type)
- (6) When a steam cleaner is used, do not allow the steam directly contact the alternator.

ELECTRICAL SYSTEM

1.3 Removing alternator



Removing alternator

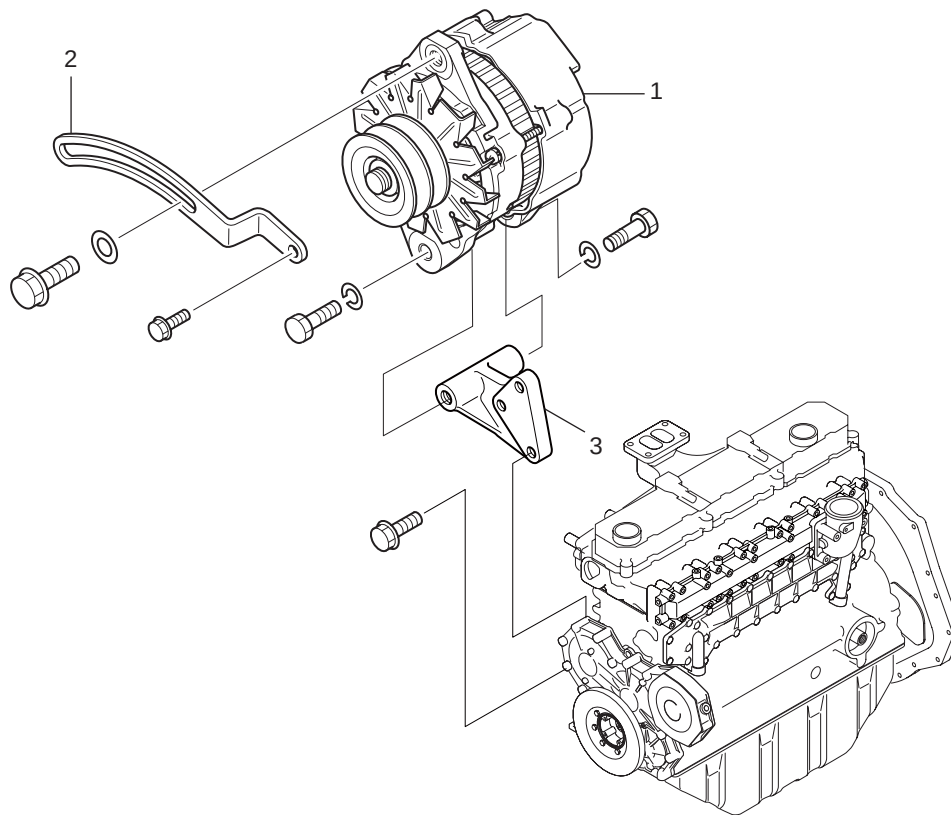
Removing sequence

1 Alternator

2 Adjusting plate

3 Bracket

S6S-Y3T62HF



Removing alternator

Removing sequence

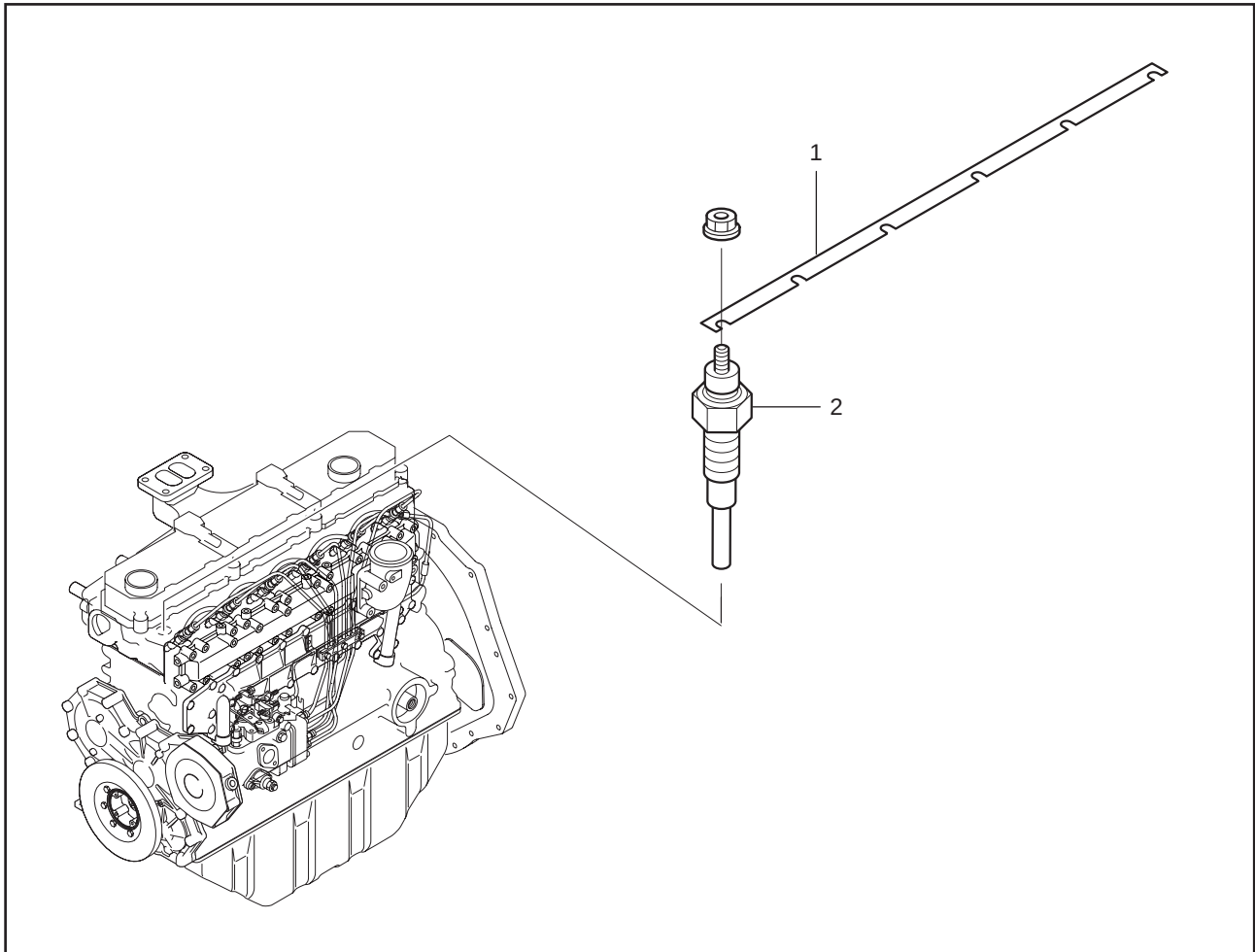
1 Alternator

2 Adjusting plate

3 Bracket

ELECTRICAL SYSTEM

1.4 Removing glow plug



Removing glow plug

Removing sequence

1 Connection plate

2 Glow plug

2. Disassembling, inspecting and reassembling electrical system

2.1 Inspection before disassembling starter

2.1.1 Inspecting magnetic switch

Perform the inspection as described below. If faulty, replace the magnetic switch with a new one.

CAUTION

Do not apply current continuously for longer than 10 seconds.

(1) Disconnect the connector of M terminal.

(2) Pull-in test

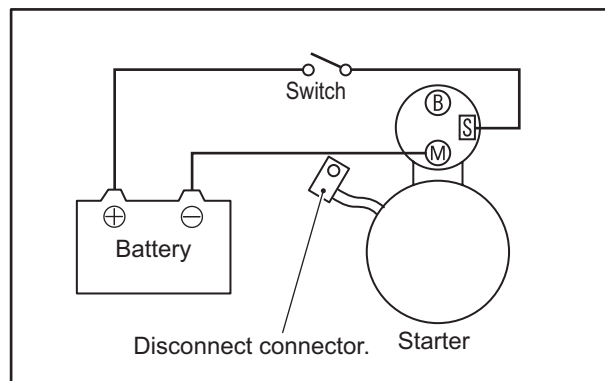
Connect the starter to the circuit as shown in the illustration. The magnetic switch is normal if the pinion springs out when the switch is turned ON.

(3) Holding test

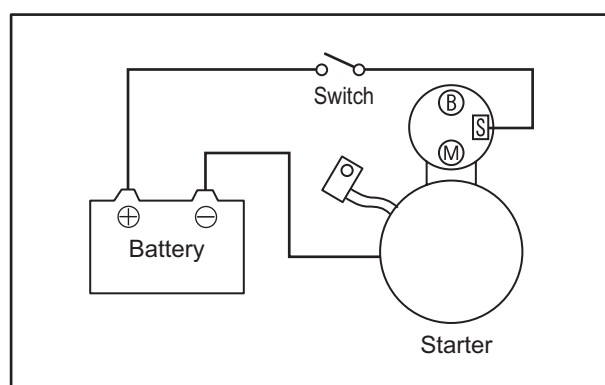
Connect the starter to the circuit as shown in the illustration. Pull out the pinion fully by hand. The magnetic switch is normal if the pinion does not return when it is released.

(4) Return test

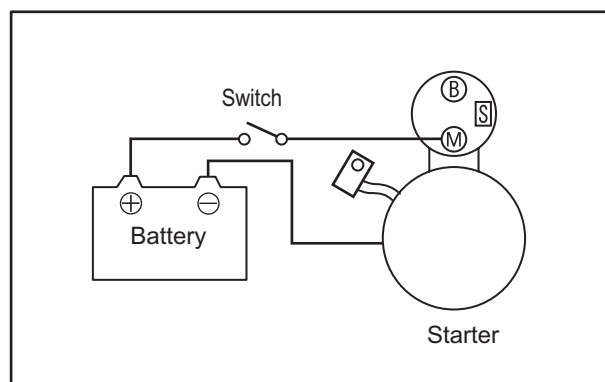
Connect the starter to the circuit as shown in the illustration. Pull out the pinion fully by hand. The magnetic switch is normal if the pinion returns immediately when it is released.



Pull-in test



Holding test



Return test

ELECTRICAL SYSTEM

2.1.2 No load test

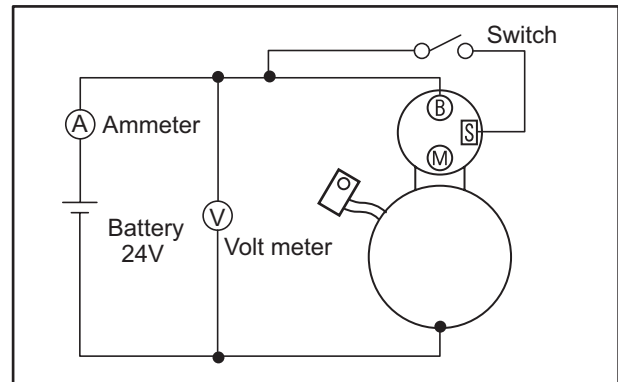
CAUTION

Use as thick a wire as possible and firmly tighten each terminal.

When detecting the rotation at the tip of the pinion, be careful, as the pinion pops out during operation.

- (1) Connect the starter to the circuit as shown in the illustration.
- (2) In normal condition, the pinion pops out when the switch is turned ON, and the starter rotates at more than the specified rotation speed.

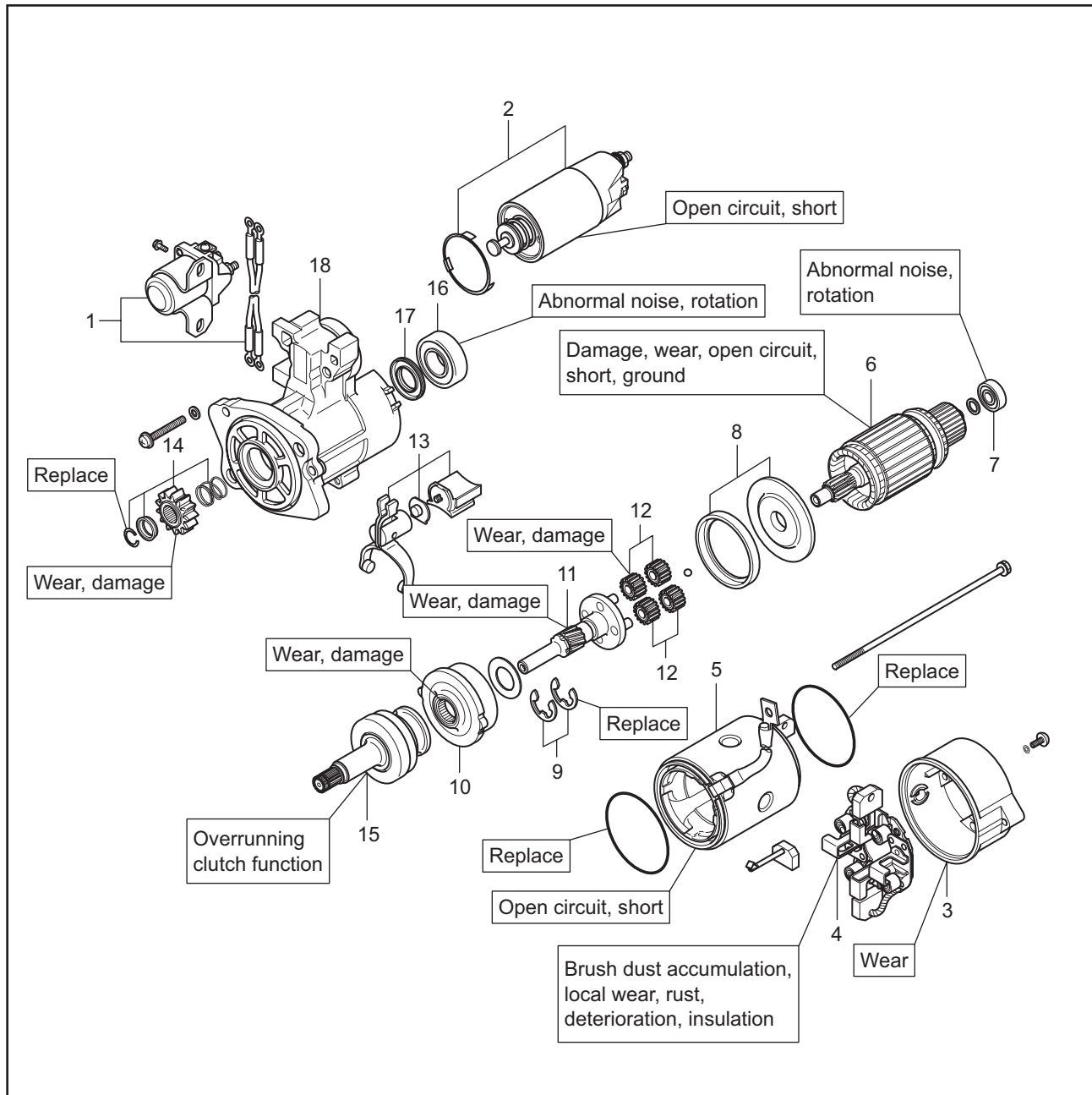
If the terminal voltage, current or rotation speed does not meet the standard, disassemble, inspect and repair the starter.



Test at no load

Item		Standard
Starter model name		M008T60373
Nominal output		24 V - 5 kW
No-load characteristics	Terminal voltage	23 V
	Current	85 A or less
	Rotation speed	3300 min ⁻¹ or more

2.2 Disassembling and inspecting starter



Disassembling and inspecting starter

Disassembling sequence

- | | | |
|----------------------------|------------------|-----------------------|
| 1 Auxiliary switch | 7 Ball bearing | 13 Lever assembly |
| 2 Magnetic switch assembly | 8 Packing set | 14 Pinion set |
| 3 Rear bracket | 9 Washer set | 15 Overrunning clutch |
| 4 Brush holder | 10 Internal gear | 16 Ball bearing |
| 5 Yoke assembly | 11 Gear shaft | 17 Oil seal |
| 6 Armature | 12 Gear | 18 Front bracket |

ELECTRICAL SYSTEM

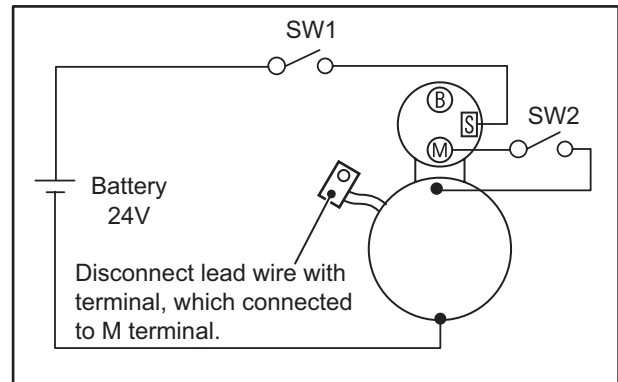
2.2.1 Removing pinion set

CAUTION

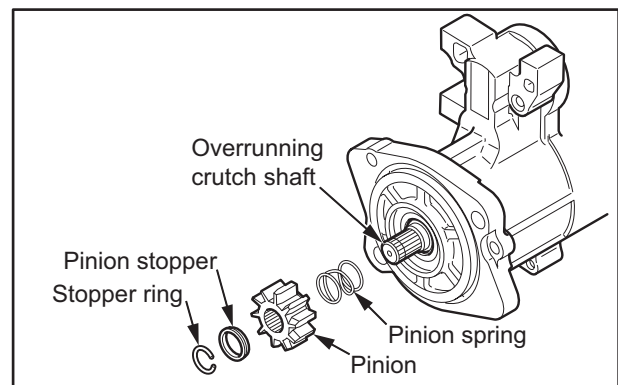
The starter generates heat when current is being applied. Remove the pinion within 10 seconds.

- (1) Connect the starter to the circuit as shown in the illustration.
- (2) Turn the switches SW1 and SW2 ON to move the pinion out and then turn the SW2 OFF to stop the rotation of the armature and the pinion.
- (3) Place an appropriate tube on the pinion stopper.
Tap the tube with a hammer to drop the pinion stopper to the clutch side. This will expose the stopper ring.
- (4) Remove the stopper ring with pliers and remove the pinion.

Note: Do not reuse the stopper ring for reassembly.



Connection to move the pinion forward



Removing pinion

2.2.2 Removing magnetic switch

Disconnect the leads, and remove the magnetic switch.

2.2.3 Removing rear bracket

Remove the through bolts and screws of the brush holder, and then remove the rear bracket.

2.2.4 Removing brush holder and brush assembly

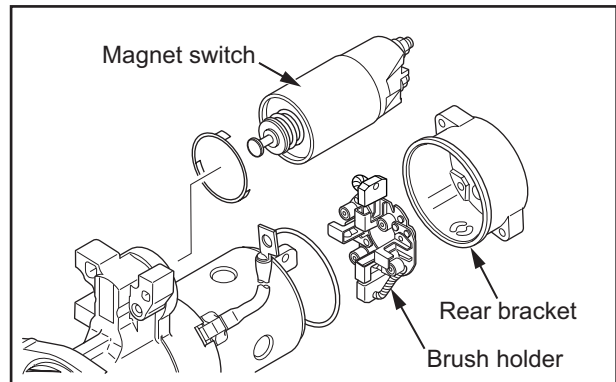
Apply a socket (of the same diameter as the commutator) to the commutator of the armature. Remove the brush holder and brush assembly by sliding on the socket.

2.2.5 Removing armature and yoke

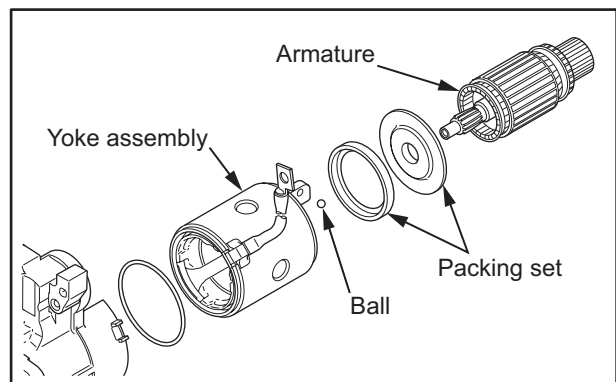
- (1) Remove the armature and the yoke.
- (2) Remove the packing from the internal gear.
- (3) Remove the packing and plate on the lever support.
- (4) Remove the ball from the internal gear.
- (5) Remove the planetary gears.

2.2.6 Removing overrunning clutch

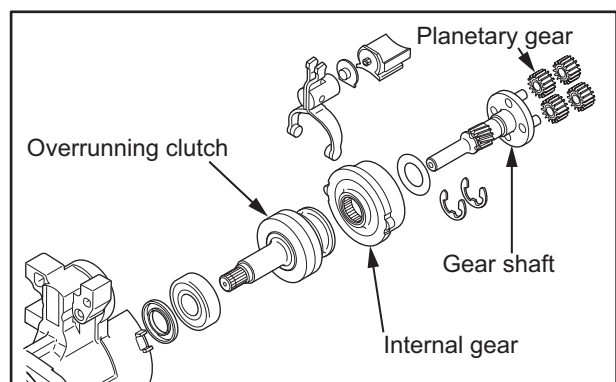
Pull out the internal gear, gear shaft, overrunning clutch and lever as an assembly from the front bracket, and remove the lever.



Disassembling starter (1)



Disassembling starter (2)



Disassembling starter (3)

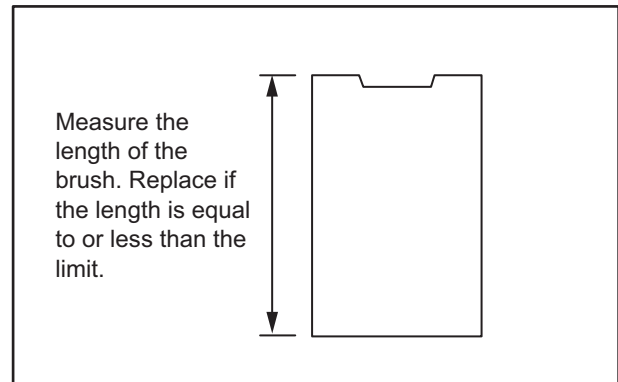
ELECTRICAL SYSTEM

2.3 Inspecting and repairing starter

2.3.1 Inspecting brushes for wear

Measure the length of the brushes. If the measured value is less than the limit, replace both the brush holder assembly and the brush assembly with new ones.

Item	Standard	Limit
Brush length	18 mm [0.71 in.]	11 mm [0.43 in.]

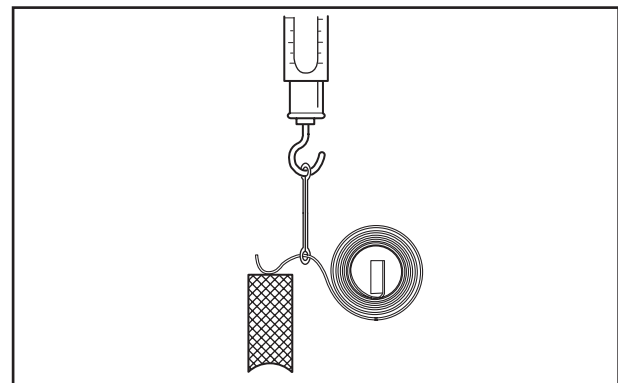


Inspecting brushes for wear

2.3.2 Measuring brush spring load

Using a new brush, measure the spring load at which the spring lifts from the brush. If the measured value is less than the limit, replace the spring with a new one.

Item	Standard	Limit
Brush spring load	29.4 to 39.4 N {3.0 to 4.0 kgf} [6.6 to 8.8 lbf]	13.7 N {1.4 kgf} [3.1 lbf]

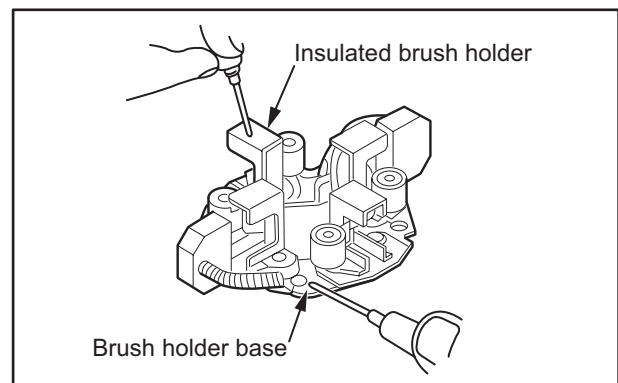


Measuring brush spring load

2.3.3 Inspecting brush holder for insulation

Check for no continuity between each brush holder and the brush holder base. If continuity is found, replace the brush holder assembly.

Check the brush holders for looseness.

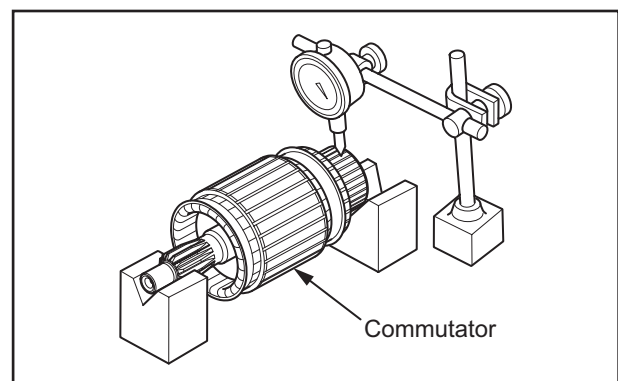


Checking brush holder for grounding

2.3.4 Measuring commutator radial runout

- (1) Inspect the commutator surface. If the surface is rough, polish it using a 400 to 600 grit sandpaper.
- (2) Measure the commutator radial runout with a dial gauge. If the measured value exceeds the limit, replace the armature with a new one.

Item	Standard	Limit
Commutator runout	0.05 mm [0.0020 in.] or less	0.10 mm [0.0039 in.]



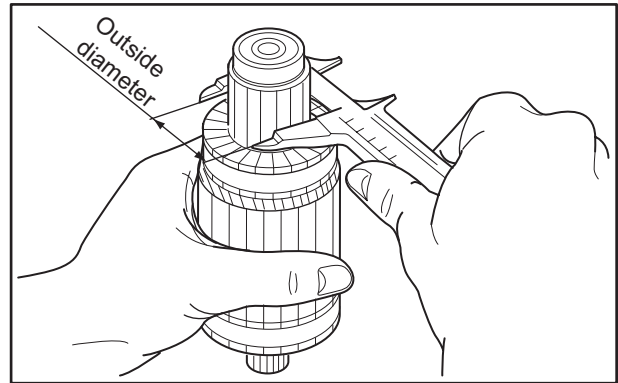
Measuring commutator radial runout

2.3.5 Measuring commutator outside diameter

Measure the commutator outside diameter.

If the measured value is less than the limit, replace the armature with a new one.

Item	Nominal	Limit
Commutator outside diameter	ø32 mm [1.26 in.]	31.4 mm [1.236 in.]



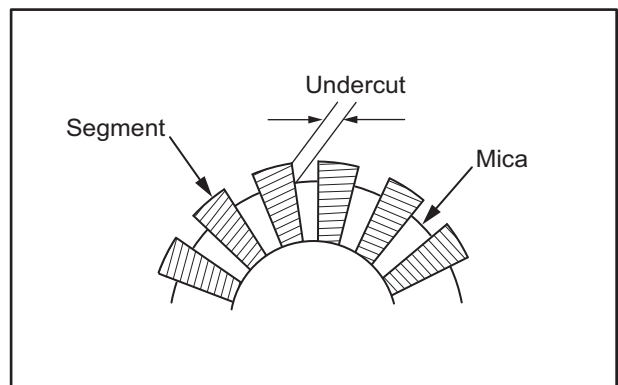
Measuring commutator outside diameter

2.3.6 Measuring undercut depth

Measure the depth of undercutting between the commutator segments.

If the measured value is less than the limit, repair or replace with a new part.

Item	Standard	Limit
Undercut depth	0.4 to 0.6 mm [0.016 to 0.024 in.]	0.2 mm [0.008 in.]

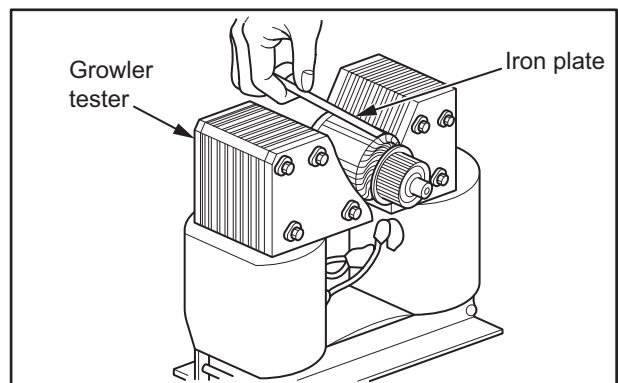


Measuring commutator undercut depth

2.3.7 Checking armature coil

- (1) Inspect the armature coil using a growler.

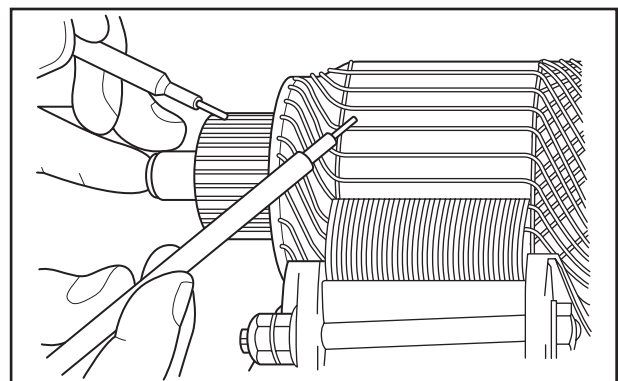
Place the armature on the growler. Hold a piece of iron plate and make it contact with the armature coil as shown in the illustration. In this condition, rotate the armature slowly by hand. If the short circuit exists on the coil, the iron plate is attracted to the coil. If coil is not defective, the iron plate is not attracted.



Inspecting armature coil for short circuit

- (2) Check that there is no continuity between the commutator and the shaft (core).

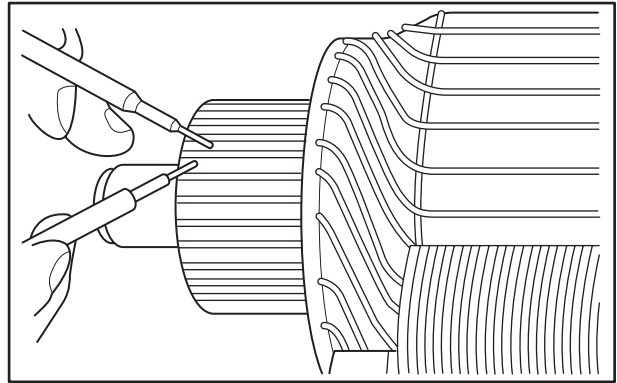
If any continuity is observed, replace the armature with a new one.



Inspecting insulation between commutator and shaft

ELECTRICAL SYSTEM

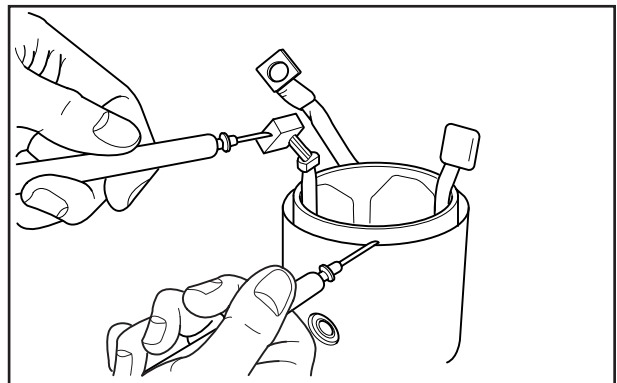
- (3) Check continuity between segments in various combinations.
If poor or no continuity is found, replace the armature with a new one.



Inspecting continuity between segment

2.3.8 Inspecting field coil

- (1) Check for no continuity between the end of the coil (brush) and the yoke.
(2) Check continuity between both ends of the coil.
(3) Check that the pole piece and the coil is not loosen.
(4) If it is defective, replace the yoke with a new one.



Inspecting field coil

2.3.9 Inspecting rear bracket

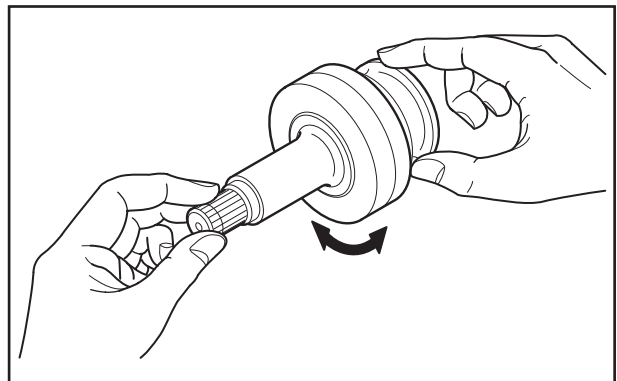
Replace the rear bracket if the bearing is worn.

2.3.10 Inspecting overrunning clutch operation

CAUTION

Do not clean the overrunning clutch in wash oil since grease is applied inside.

Make sure that, when attempting to turn the overrunning clutch, it locks in one direction and rotates smoothly in the opposite direction.



Inspecting overrunning clutch

2.3.11 Inspecting front bracket

The ball bearing should rotate smoothly without abnormal noise. If defective, replace the whole front bracket.

2.3.12 Inspecting gears of starter

Check gears of the starter for wear or damage. If faulty, replace the gears.

2.3.13 Inspecting magnetic switch

Inspect the magnetic switch for following items. Replace the magnetic switch if it is defective.

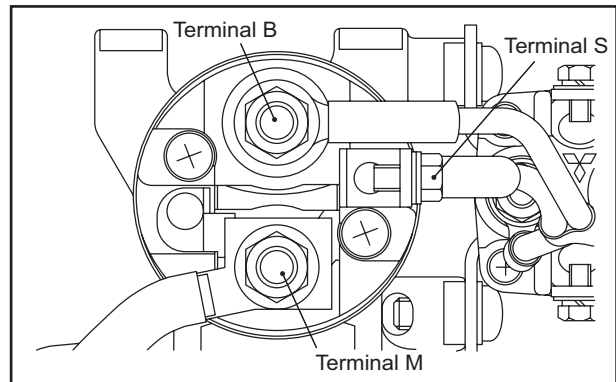
(1) Open circuit of coil

Check continuity between terminal S and terminal M, also check continuity between terminal S and ground. if continuity does not exist, the coil has an open circuit.

(2) Adhesion of contactor

Check for no continuity between terminal B and terminal M.

If continuity is found, the contactor is welded closed.



Inspecting magnetic switch

2.3.14 Inspecting starter relay

(1) Open circuit of coil

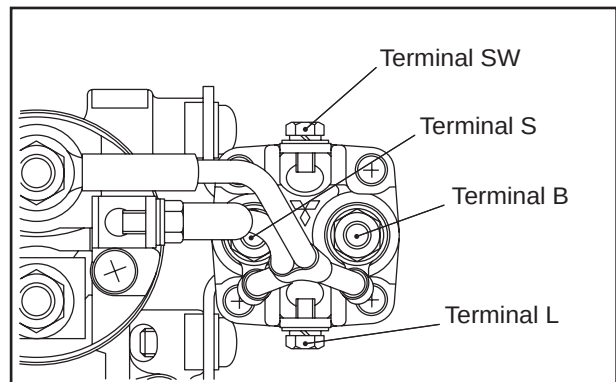
Check continuity between terminal SW and terminal L. If continuity is not found, replace the starter relay.

(2) Adhesion of contactor

Check for no continuity between terminal S and terminal B.

If continuity is found, the contactor is welded closed.

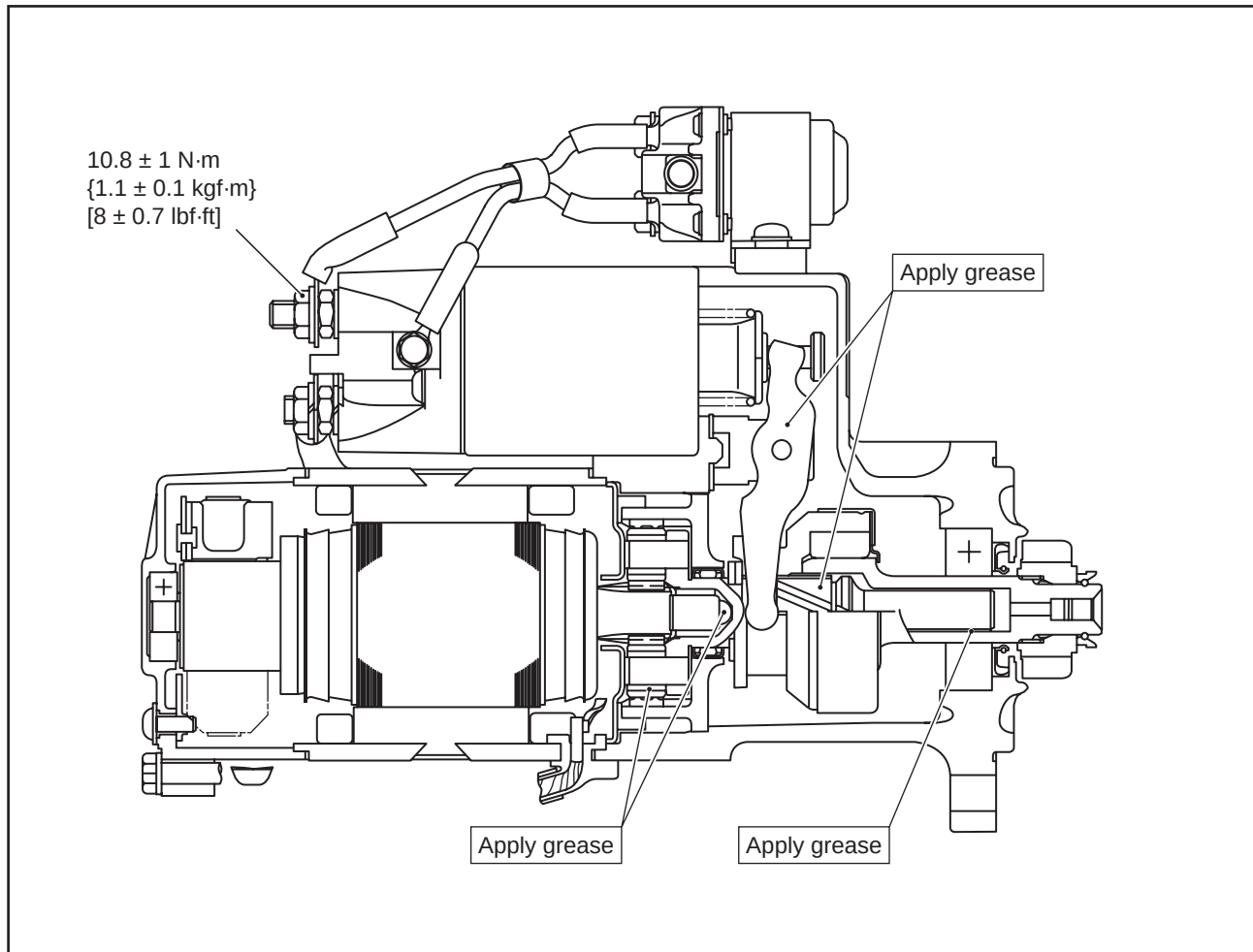
Replace the starter relay.



Inspecting starter relay

ELECTRICAL SYSTEM

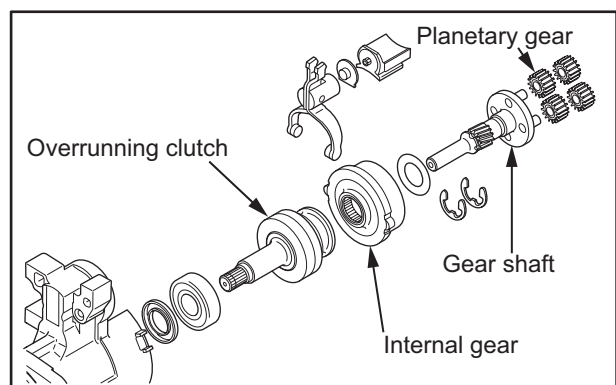
2.4 Reassembling starter



Reassembling starter

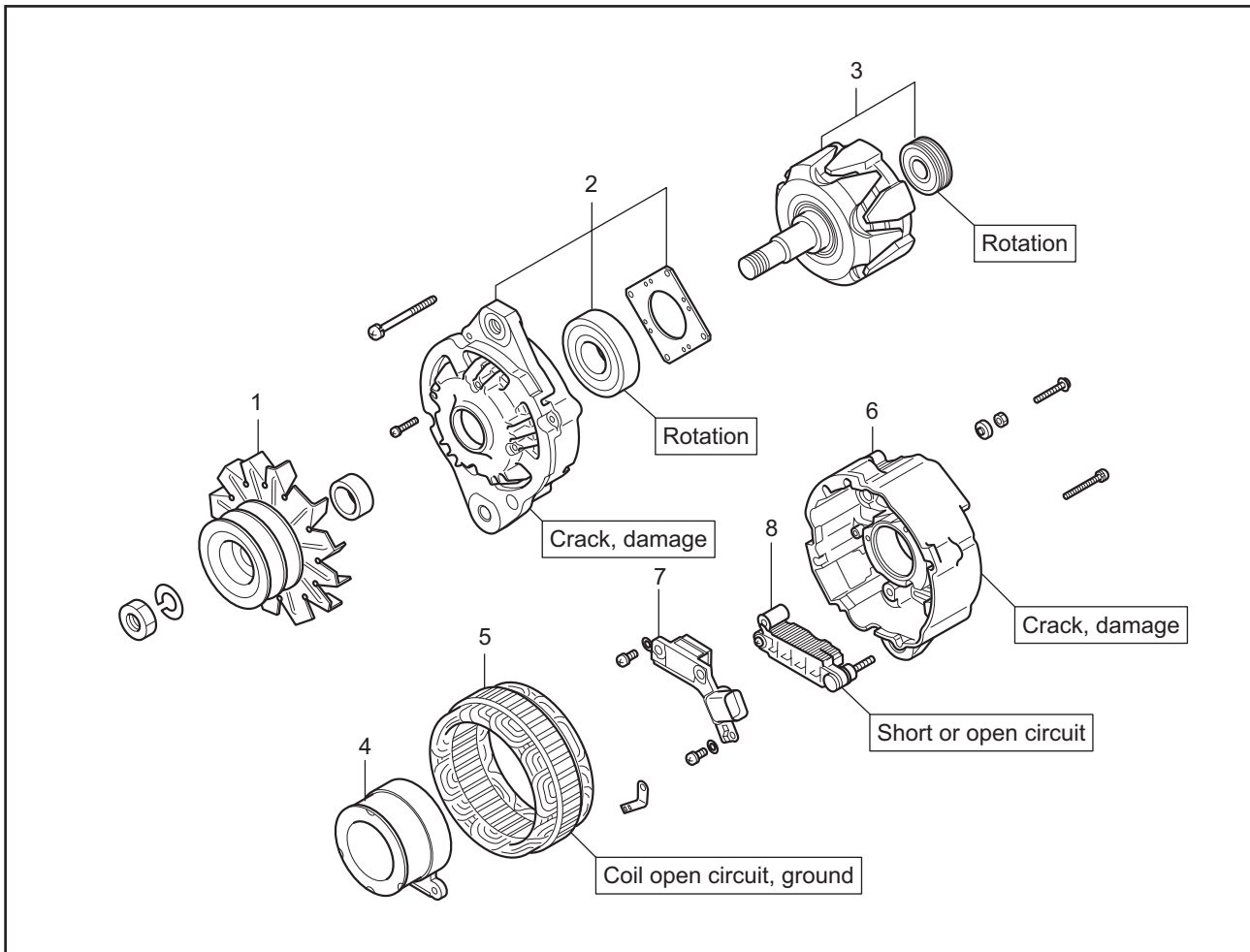
2.4.1 Installing gear shaft

- (1) Install the lever to the overrunning clutch.
- (2) Fit the internal gear into the gear shaft.
- (3) Put the gear shaft into the overrunning clutch.



Installing gear shaft

2.5 Disassembling and inspecting alternator



Disassembling and inspecting alternator

Disassembling sequence

- | | | |
|--------------------------|----------------|----------------------|
| 1 Pulley (with fan) | 4 Coil | 7 Regulator assembly |
| 2 Front bracket assembly | 5 Stator coil | 8 Rectifier assembly |
| 3 Rotor assembly | 6 Rear bracket | |

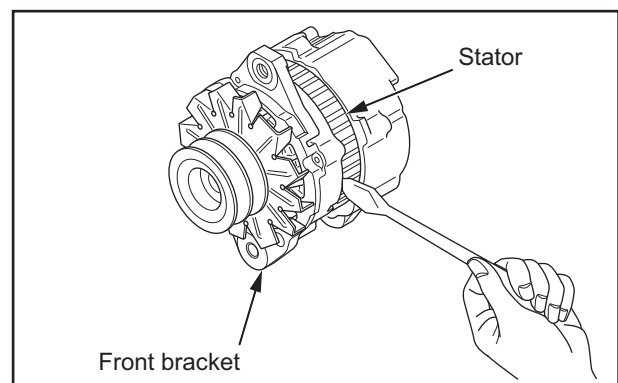
2.5.1 Separating front bracket from stator

CAUTION

Do not disassemble the alternator unless the repair is necessary.

Do not insert the screwdrivers too deep, as it can damage the stator.

- (1) Remove the through bolts.
- (2) With two flat-head screwdrivers inserted between the front bracket and stator, pry them apart.



Separating front bracket from stator

ELECTRICAL SYSTEM

2.5.2 Removing field coil

CAUTION

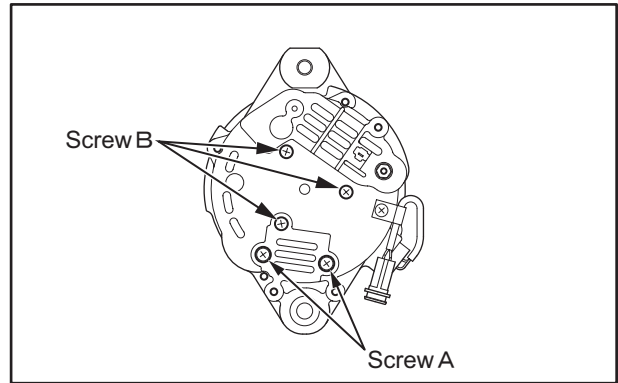
When removing the field coil, be sure to observe the removal order of screws.

Otherwise, the outlet lines of the field coil will be damaged.

If all the screws are removed, the coil will fall with its own weight. Be careful not to drop the coil.

When removing the field coil, the outlet side of the coil may be caught with the stator. Do not pull the coil forcibly.

- (1) Unscrew the screw A.
- (2) Unscrew the screw B.
- (3) Remove the field coil.



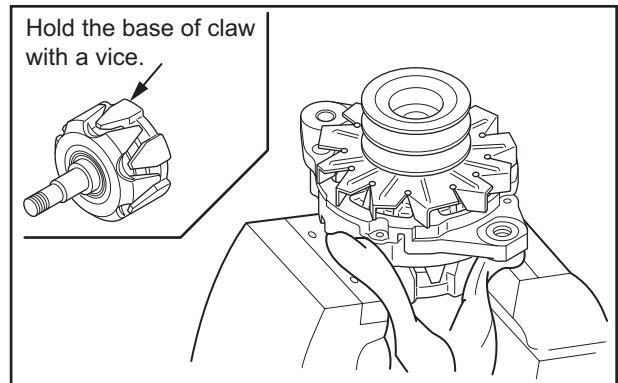
Removing field coil

2.5.3 Removing pulley

CAUTION

When setting the rotor in a vise, be sure to hold the base of the rotor claw. Do not hold the rotor claw, as it causes damage to the claw.

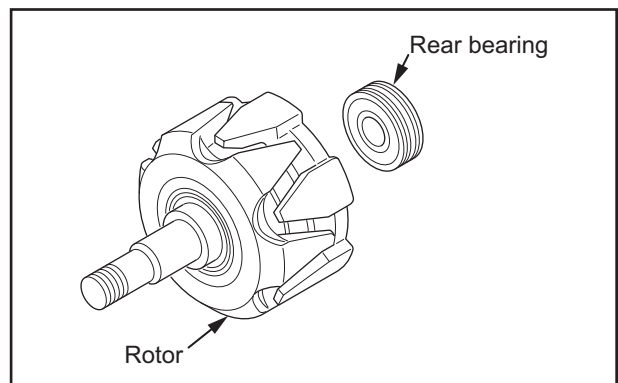
- (1) Apply a cloth to the rotor and set it in a vise.
- (2) Remove the pulley nut and then pull out the pulley.



Removing pulley

2.5.4 Removing rear bearing

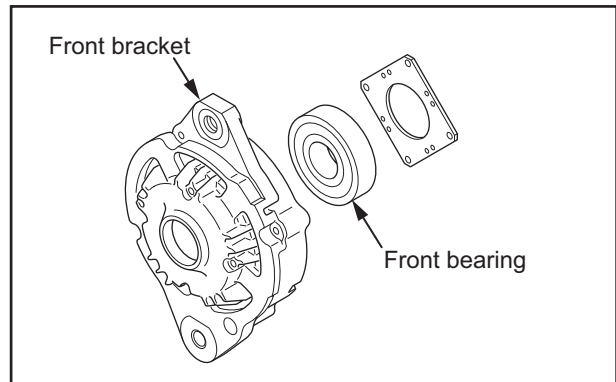
Remove the rear bearing from the rotor using a bearing puller.



Removing rear bearing

2.5.5 Removing front bearing

Remove the screw, and then remove the bearing retainer and front bearing from the front bracket.



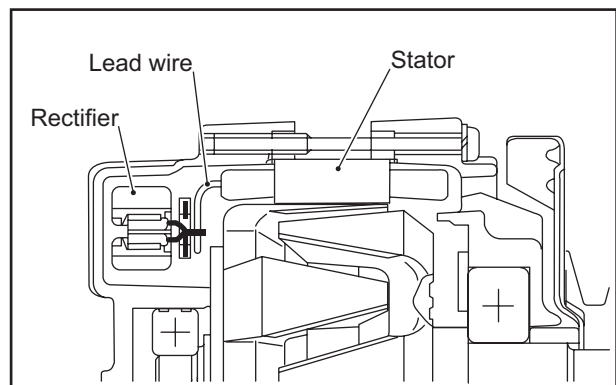
Removing front bearing

2.5.6 Removing stator

CAUTION

Unsoldering must be finished as quickly as possible.
Extended heating will damage the diodes.

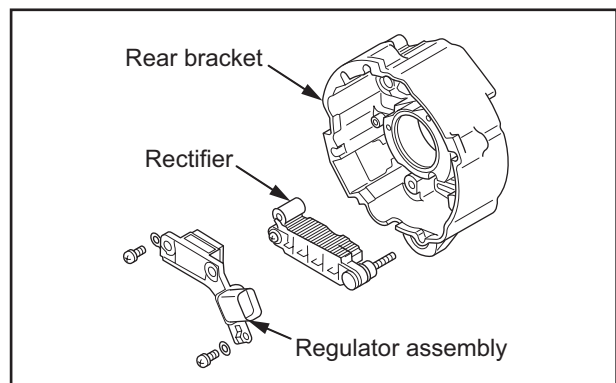
Unsolder the joint of the stator and remove the stator from the rectifier.



Removing stator

2.5.7 Removing regulator assembly

Remove the screws of the regulator assembly and then remove the regulator assembly.



Removing regulator assembly and rectifier assembly

2.5.8 Removing rectifier assembly

- (1) Remove the screw and nut from the rectifier.
- (2) Remove the rectifier assembly.

ELECTRICAL SYSTEM

2.6 Inspecting and repairing alternator

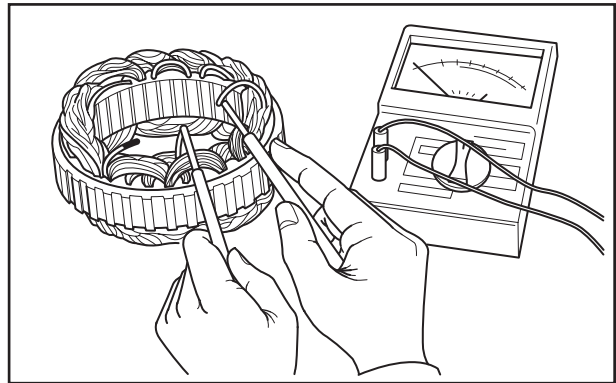
2.6.1 Inspecting stator

(1) Checking continuity between lead wires.

Check continuity between a pair of lead wires.

Also check for no continuity between a pair of lead wires and other pairs of lead wires.

If defective, replace the stator.

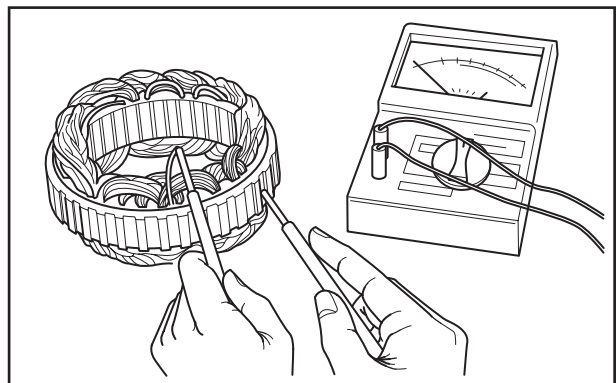


Inspecting continuity between lead wires

(2) Checking insulation between lead wire and core.

Check for no continuity between each lead wire and the stator core. If continuity is found, replace the stator.

Note: The core cannot be replaced as a single item.

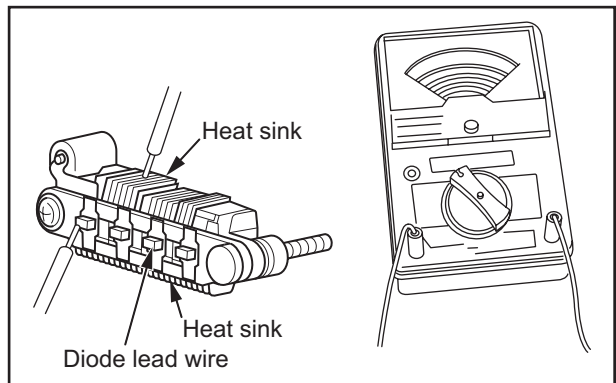


Inspecting continuity between lead wires and core

2.6.2 Inspecting rectifier

Check that diodes in a rectifier function properly. To check, measure both negative (-) and positive (+) resistance alternately twice. If both infinite negative and infinite positive resistances are observed, the diode is open-circuited. If measured value is close to $0\ \Omega$, the diode is short-circuited. In either case, replace the rectifier with a new one.

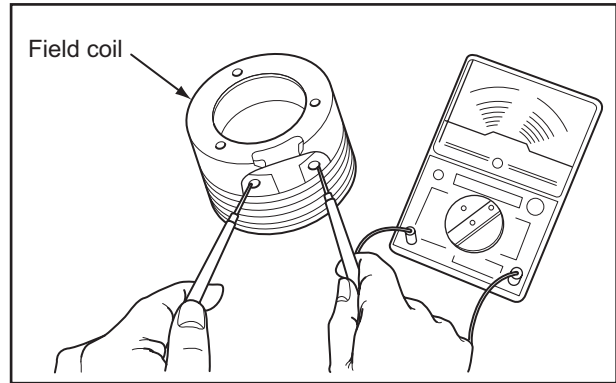
Note: Use a wide measuring range as much as possible. The current flow during test is significantly lower than the current that normally flows in the rectifier, by which the accurate resistance may not be measured using a tester, and this tendency is noticeable if the measuring range is small.



Inspecting rectifier

2.6.3 Measuring field coil

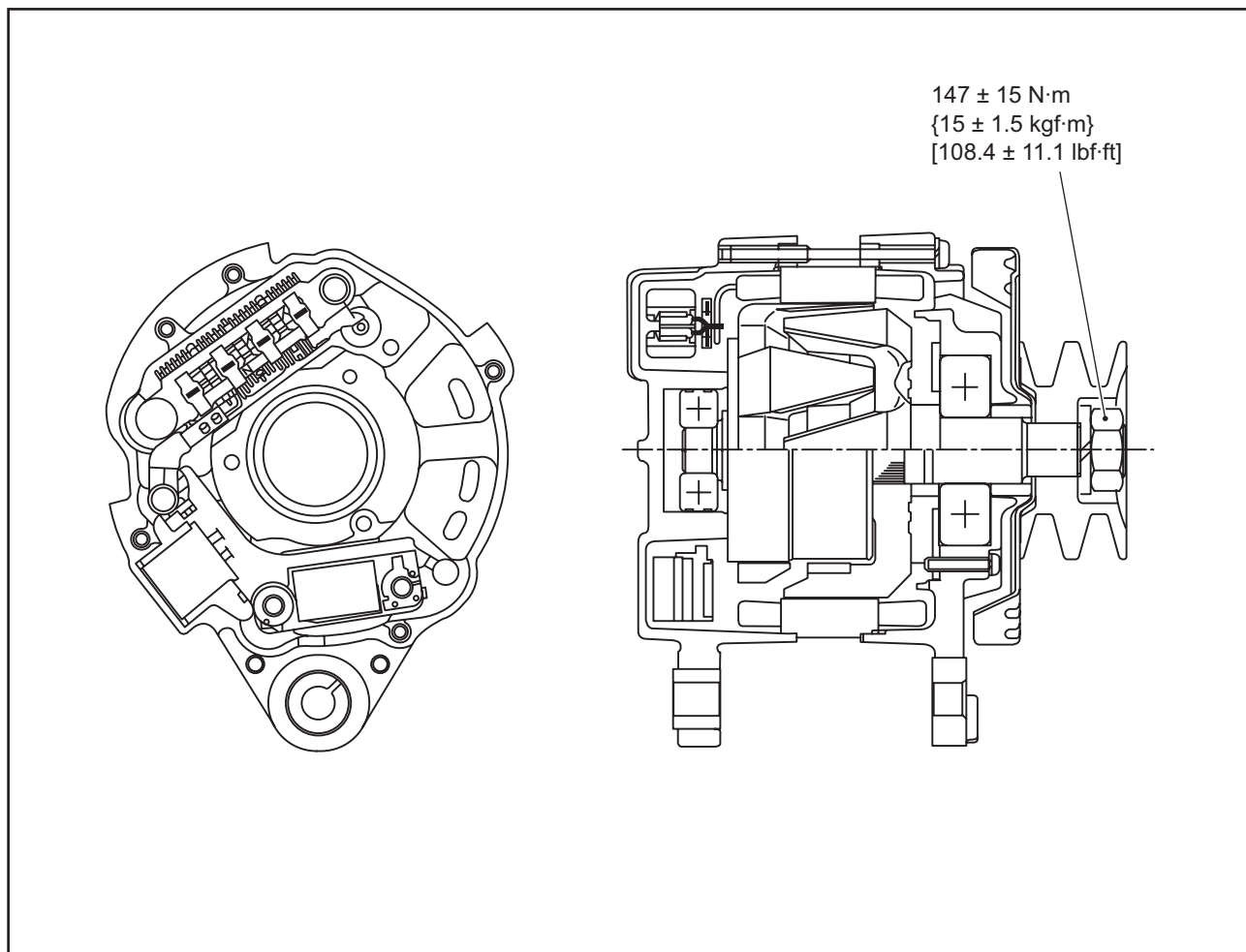
Measure resistance between the terminals of the field coil.
If the measured value deviates from the standard value,
replace the field coil with a new one.



Measuring field coil

ELECTRICAL SYSTEM

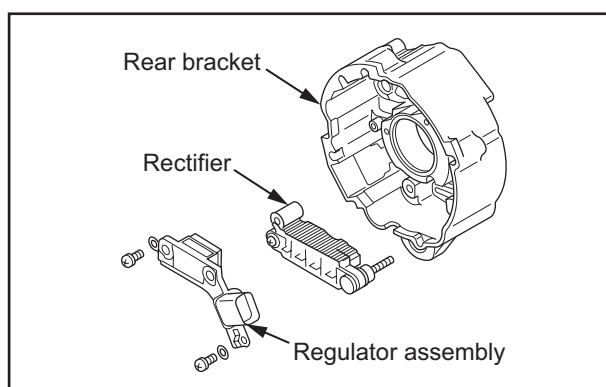
2.7 Reassembling alternator



Reassembling alternator

2.7.1 Installing rectifier assembly and regulator assembly

Install the rectifier assembly and regulator assembly on the rear bracket.



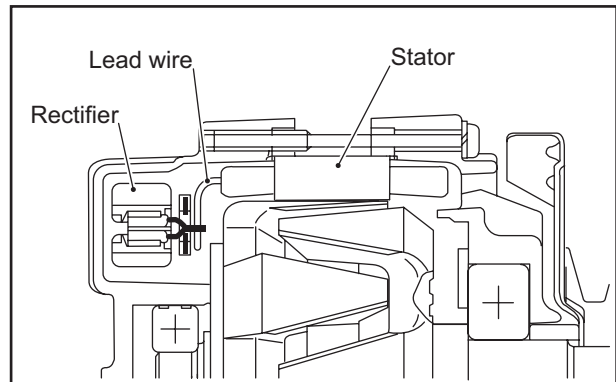
Installing rectifier assembly and regulator assembly

2.7.2 Installing stator

CAUTION

Soldering must be finished as quickly as possible.
Extended heating will damage the diodes.

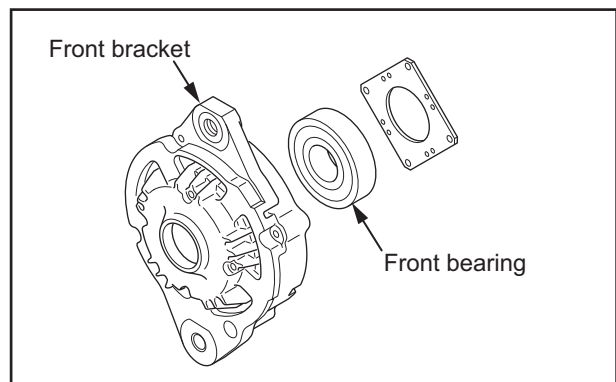
Install the stator and solder the leads of the stator to the rectifier.



Installing stator

2.7.3 Installing front bearing

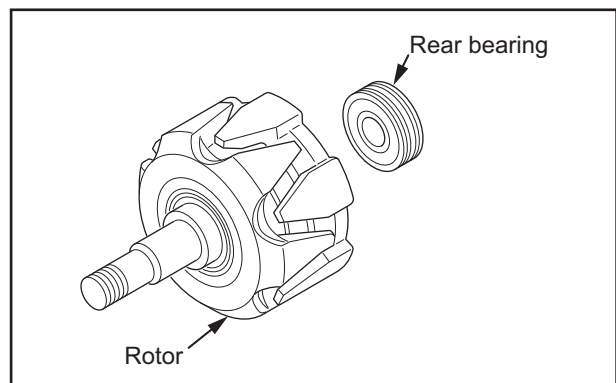
Drive the front bearing into the front bracket and secure the bearing retainer with a screw.



Installing front bearing

2.7.4 Installing rear bearing

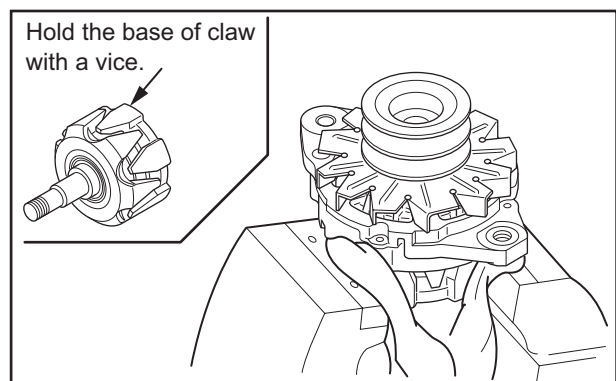
Press-fit the rear bearing to the rotor.



Installing rear bearing

2.7.5 Installing pulley

- (1) Insert the rotor into the front bracket.
Apply a cloth to the rotor and set it in a vise.
- (2) Install the spacer and pulley, and secure the pulley with a nut.

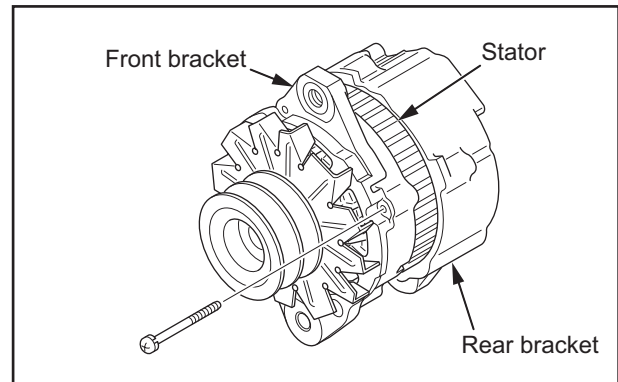


Installing pulley

ELECTRICAL SYSTEM

2.7.6 Assembling stator and front bracket

Assemble the front bracket, stator and rear bracket, and secure them with through bolts.



Installing stator and front bracket

2.8 Inspecting glow plug

2.8.1 Continuity test of glow plug

As shown in the illustration, check the continuity between the terminal and body.

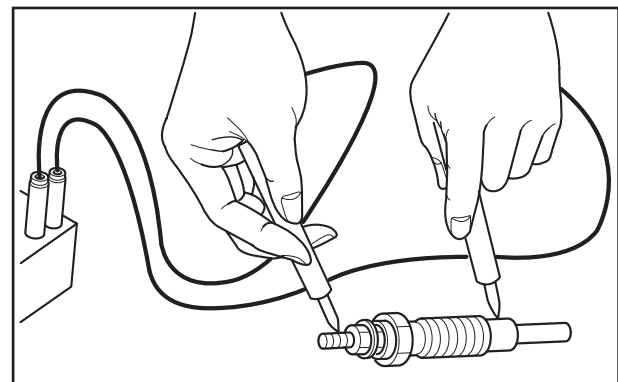
If there is no continuity or if the resistance is high, replace the glow plug.

Item	Standard
Resistance value	1.0 Ω

2.8.2 Heating test of glow plug

Connect the wiring to the terminal, and ground the body. If the glow plug heats red, it is normal.

Item	Standard	
Rated voltage - Armature current	22 V - 4.4 $\pm_{-0.7}^{+0.3}$ A	When applying the rated voltage for 15 seconds.



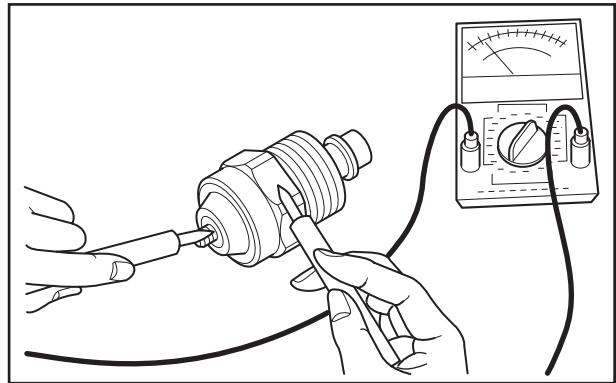
Continuity test of glow plug

2.9 Inspecting magnetic valve (stop solenoid)

2.9.1 Continuity test of magnetic valve (stop solenoid)

Inspect the continuity between the terminal and body as shown in the illustration. If there is no continuity or if the resistance is lower than the standard value, replace the magnetic valve assembly with new one.

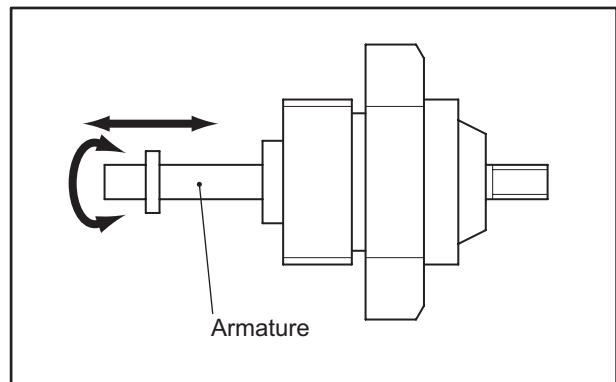
Item	Standard
Resistance value	37 to 41 Ω (Ambient temperature: $23 \pm 5^{\circ}\text{C}$ [$73.4 \pm 9^{\circ}\text{F}$])



Continuity test of magnetic valve

2.9.2 Inspecting magnetic valve (stop solenoid) operation

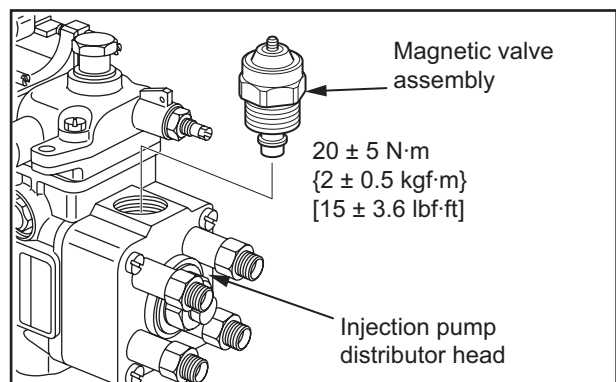
Check visually for rubber strips of the tip of the armature and damages. Also check the armature moves smoothly by rotating with a hand.



Inspecting magnetic valve operation

2.10 Installing magnetic valve (stop solenoid)

Install the magnetic valve assembly to the distributor with the specified torque.

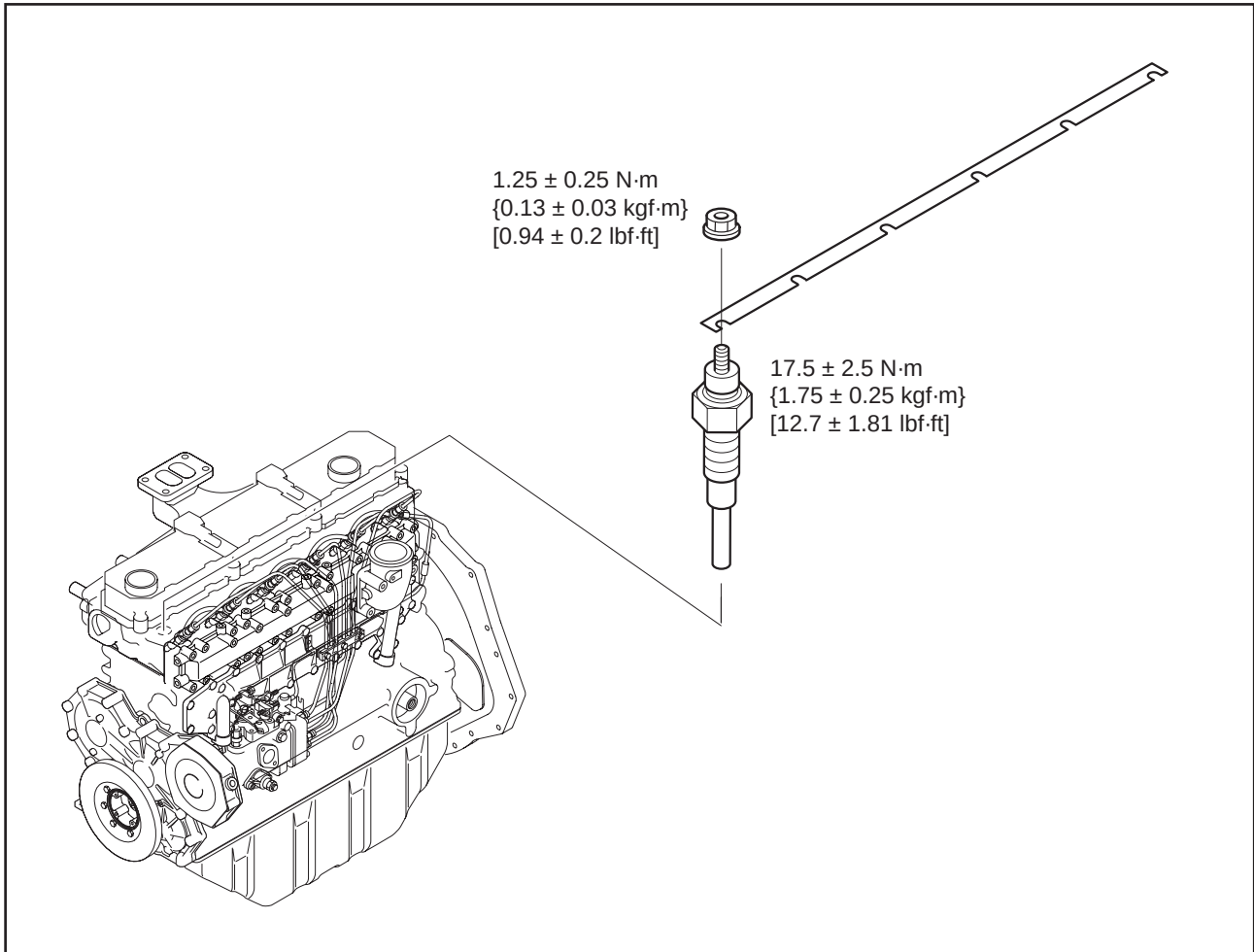


Installing magnetic valve

ELECTRICAL SYSTEM

3. Installing electrical system

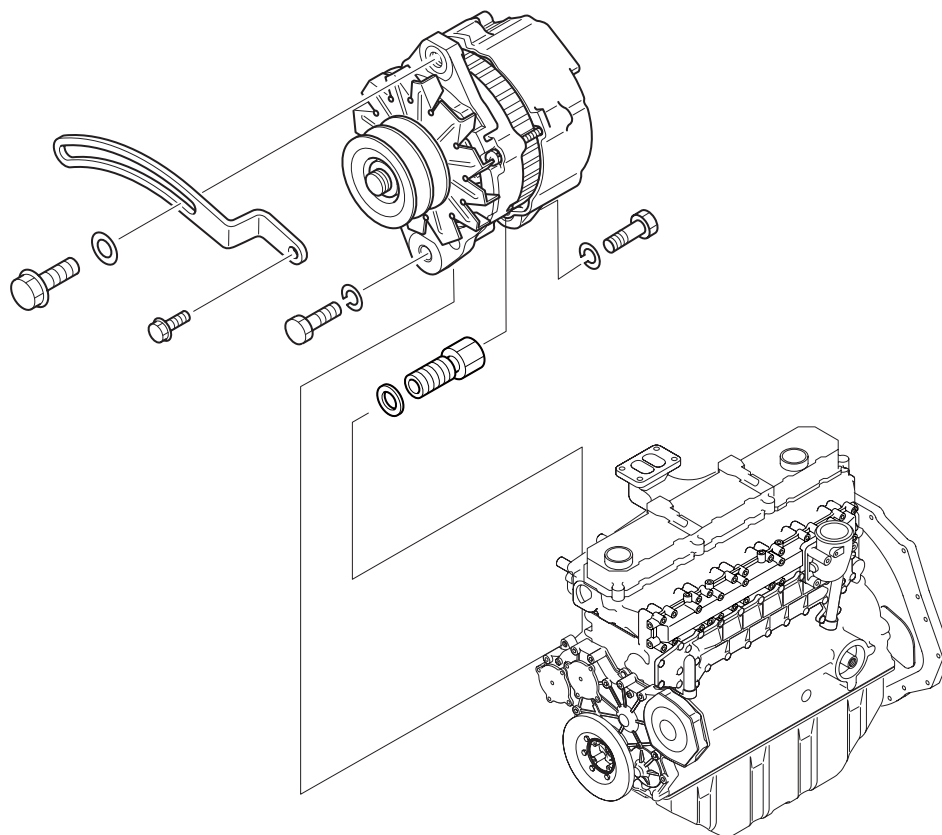
3.1 Installing glow plug



Installing glow plug

3.2 Installing alternator

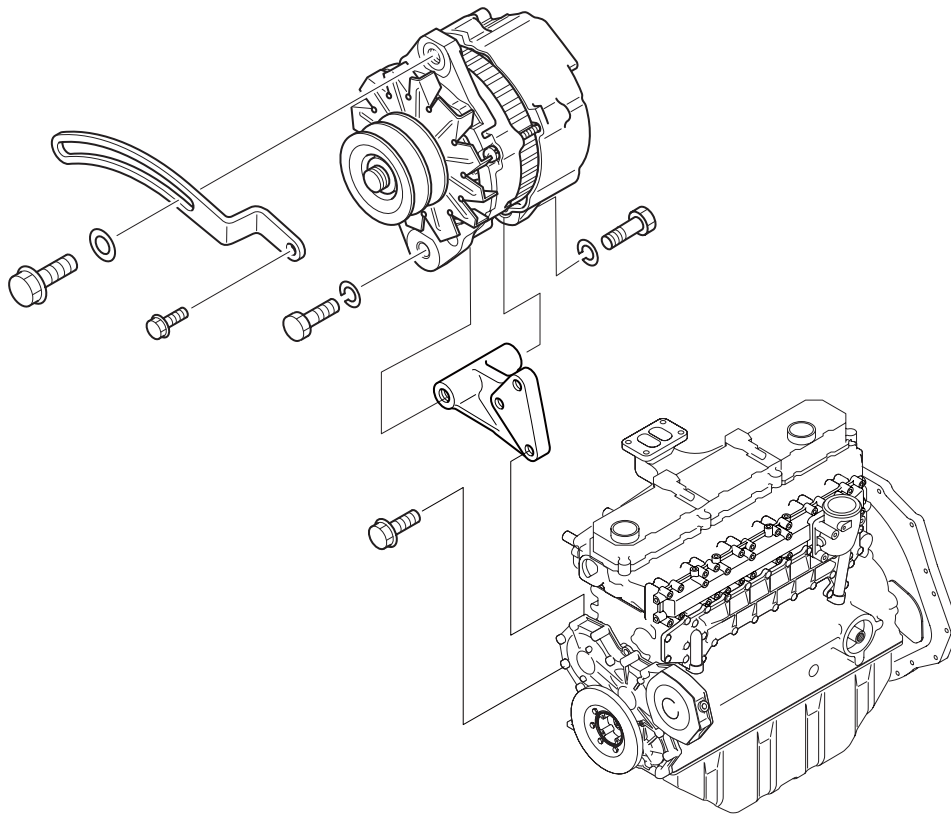
S6S-Y3T61HF



Installing alternator

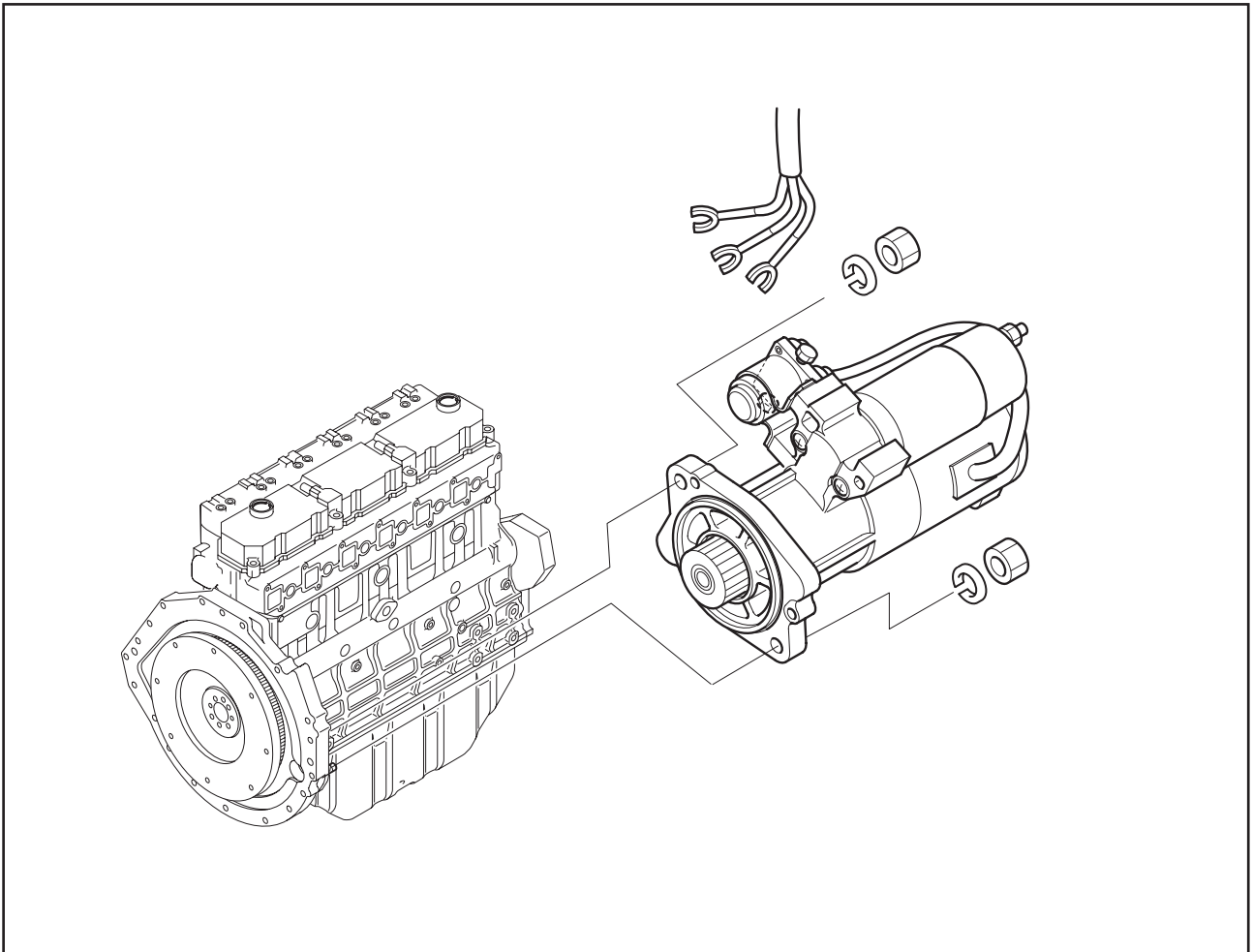
ELECTRICAL SYSTEM

S6S-Y3T62HF



Installing alternator

3.3 Installing starter



Installing starter

ADJUSTMENT AND OPERATION

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ADJUSTMENT AND OPERATION

1. Adjusting engine

1.1 Inspecting and adjusting valve clearance

Inspect and adjust the valve clearance when the engine is cold.

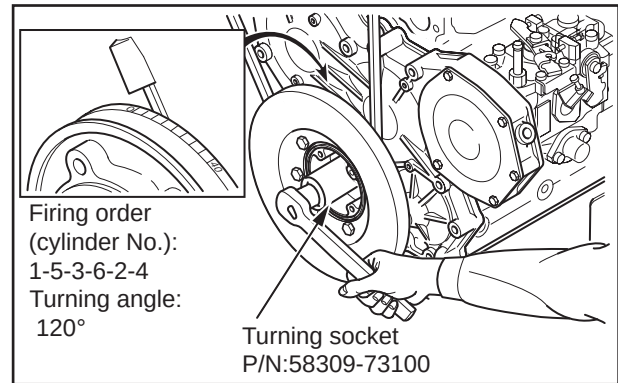
Item		Standard
Valve clearance (when engine is cold)	Inlet	0.25 mm [0.0098 in.]
	Exhaust	

1.1.1 Inspecting valve clearance

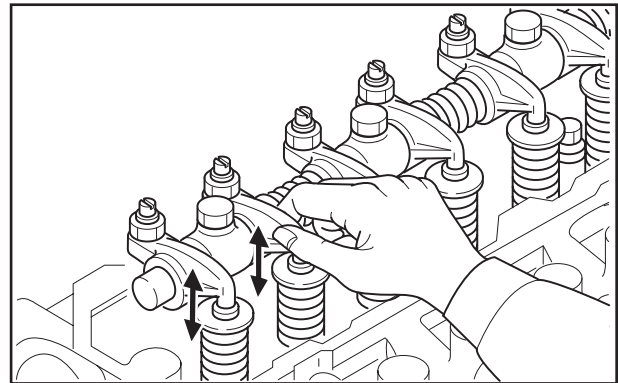
- (1) Inspect the valve clearance for all cylinders in the firing order by turning the crankshaft to the specified degrees in the normal direction (clockwise when viewed from engine front side) to bring each piston to top dead center on the compression stroke.

Note: To turn the crankshaft, fit a socket and ratchet handle on the crankshaft pulley nut.

- (2) When the No. 1 piston is at top dead center on the compression stroke, the notch mark on the periphery of the damper is aligned with the pointer on the timing gear case, and neither the inlet valve nor the exhaust valve is not lifted off its seat by the push rod.
- (3) Insert a thickness gauge between the rocker arm and valve cap to inspect the clearance.



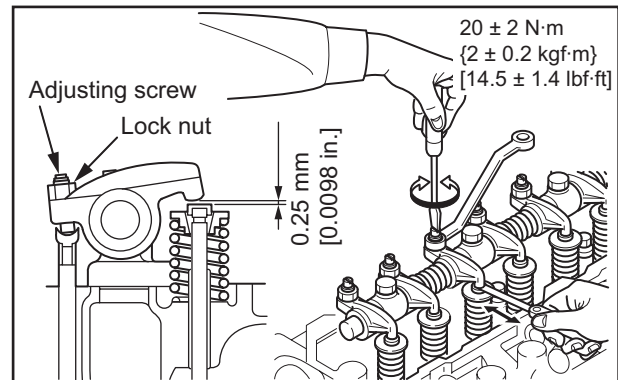
Turning engine



Determining top dead center of No. 1 cylinder compression stroke

1.1.2 Adjusting valve clearance

- (1) Insert the feeler gauge of the specified thickness between the rocker arm and valve cap, then adjust the clearance by turning the screw in either direction so that the gauge is gripped softly between the rocker arm and bridge cap.
- (2) After adjusting the clearance, tighten the lock nut firmly, and inspect the clearance again.



Adjusting valve clearance

1.2 Draining fuel system

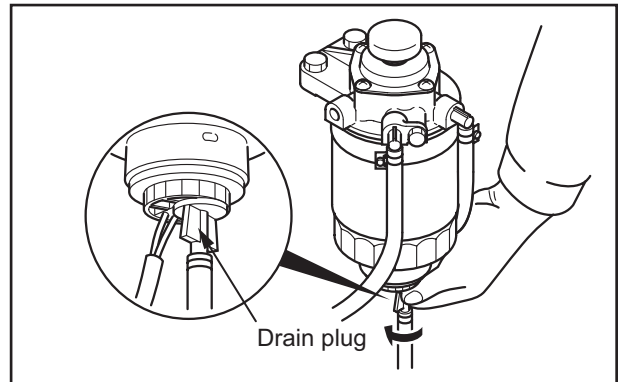
⚠ WARNING

- (a) When draining the fuel filter, fuel flows out with the water. Wipe up any spilled fuel thoroughly. Spilled fuel could cause a fire.
- (b) Tighten the drain plug securely after draining water otherwise fuel may leak out, and it could lead to a fire.

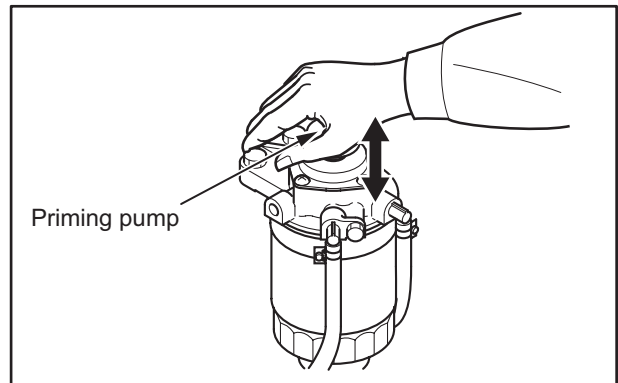
When water stayed in the bottom of the fuel filter exceeds the specified level, the water may enter into the fuel system. Bleed the fuel filter of water in the following procedures.

1.2.1 Draining fuel filter

- (1) Loosen the drain plug on the bottom of the fuel filter.
- (2) Water is easily drained by pressing the manual feed pump repeatedly (approx. 7 times) to feed the fuel.
- (3) Tighten the drain plug securely after draining the water.
- (4) Bleed the fuel system of air after bleeding the fuel system of water.



Draining fuel filter (1)



Draining fuel filter (2)

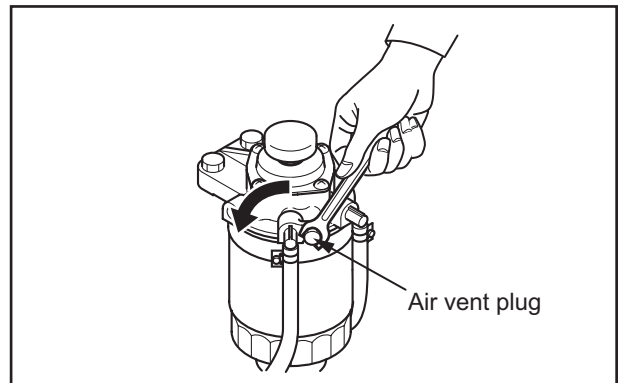
1.3 Bleeding fuel system

⚠ WARNING

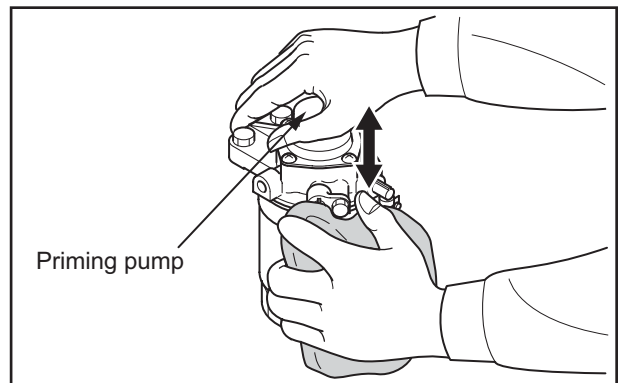
Completely wipe off any spilled fuel from the air vent plug with a cloth, and be sure to tighten the air vent plug after air bleeding. Failure to do so could cause a fire.

1.3.1 Bleeding fuel filter

- (1) Loosen the air vent plug of the fuel filter with a wrench.
- (2) Repeatedly press the priming pump with a cloth applied to the air vent plug.
- (3) When fuel with air bubbles no longer comes out, tighten the air vent plug securely.



Bleeding fuel filter (1)



Bleeding fuel filter (2)

ADJUSTMENT AND OPERATION

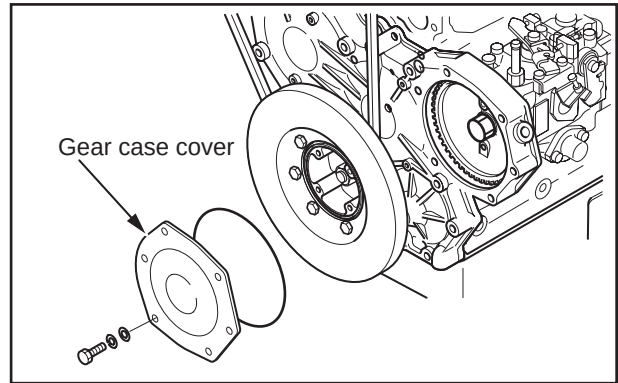
1.4 Inspecting and adjusting fuel injection timing

1.4.1 Adjusting fuel injection timing

When the fuel injection pump is replaced, adjust the fuel injection timing after the replacement.

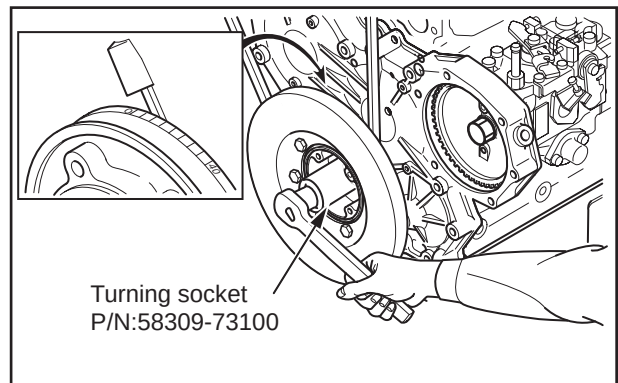
To adjust it, bring No. 1 cylinder piston to top dead center on compression stroke. Make sure that the marks on the flange plate and the fuel injection pump body are aligned.

(1) Remove the gear case cover.



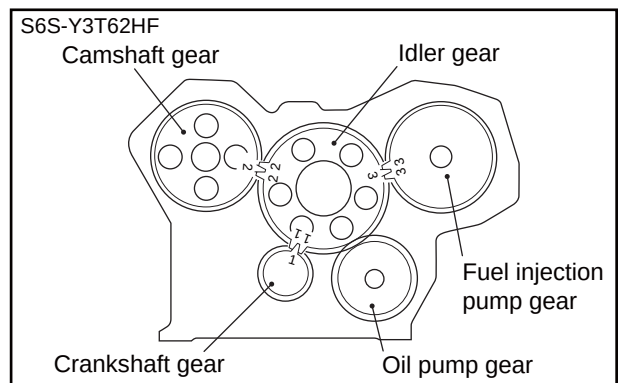
Removing gear case cover

(2) Attach the turning socket to the pulley nut and turn the crankshaft in the normal direction (clockwise as viewed from the front end).

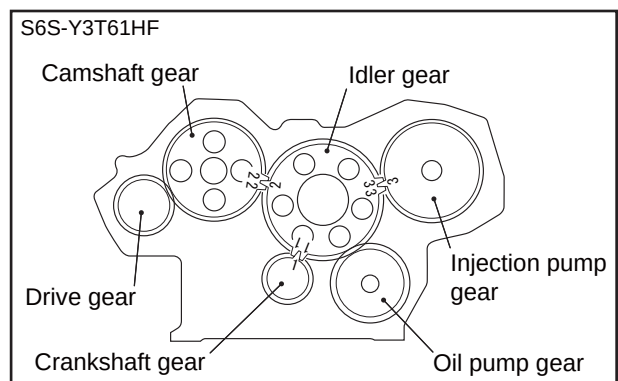


Turning engine

(3) Stop turning the crankshaft when the marks of the fuel injection pump gear and idler gear are aligned.

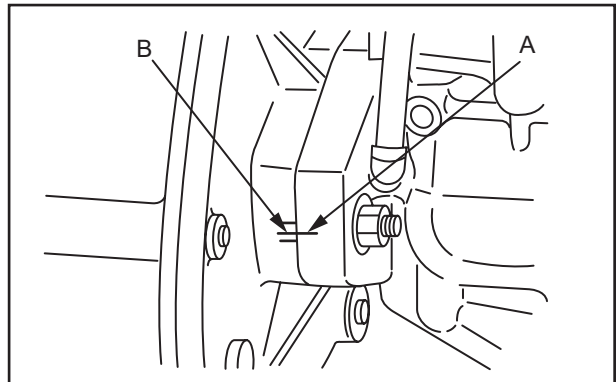


Match mark of gears



Match mark of gears

- (4) Put a mark B on the flange plate where aligned with the mark A of the fuel injection pump.



Alignment mark of fuel injection pump

CAUTION

When removing the flange plate from the fuel injection pump assembly, be sure to put a mark on the flange plate before removal to ensure proper reassembly.

- (5) Unscrew the flange plate retaining bolt and remove the fuel injection pump from the front plate.
- (6) Remove retaining bolt, remove the flange plate from the fuel injection pump.

CAUTION

When replacing parts, be sure to use OEM designated parts.

If OEM parts are not used, the exhaust emission's warranty be voided.

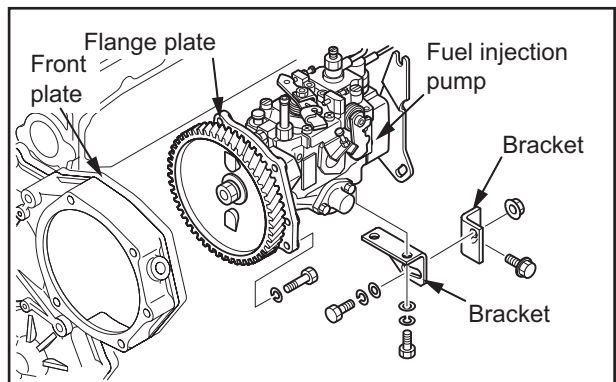
New parts may be updated due to improvement.

Fuel and exhaust system repairs should only be conducted by an authorized Mitsubishi forklift truck dealer. Tampering or adjusting the fuel system components will void the warranty and could be in violation of the EPA regulations.

The fuel injection pump is an emission control device. Components inside the pump are specifically calibrated to meet the engine emissions requirements and should never be disassembled or rebuilt.

If the pump fails to operate, replace the assembly with an OEM replace part.

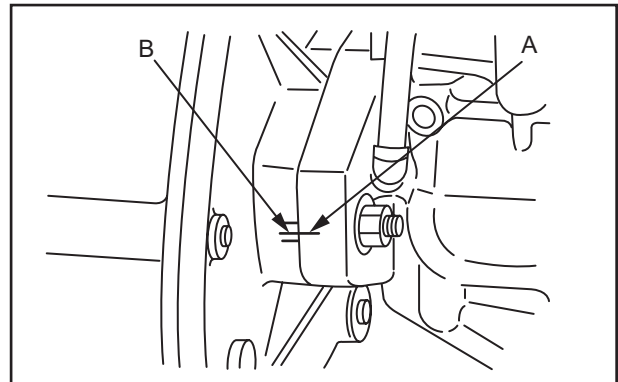
- (7) Replace the fuel injection pump with a new one.



Removing fuel injection pump

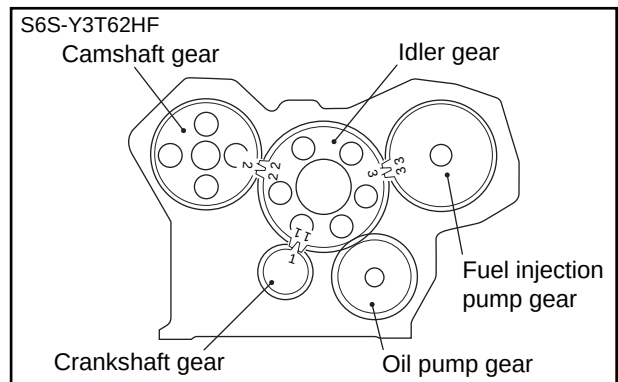
ADJUSTMENT AND OPERATION

- (8) Install the flange plate and the fuel injection pump gear to the fuel injection pump.
- (9) Align the mark A of the fuel injection pump with the mark B which was marked above procedure (4) and tighten the nut. Then install the retaining bolt to the nut.

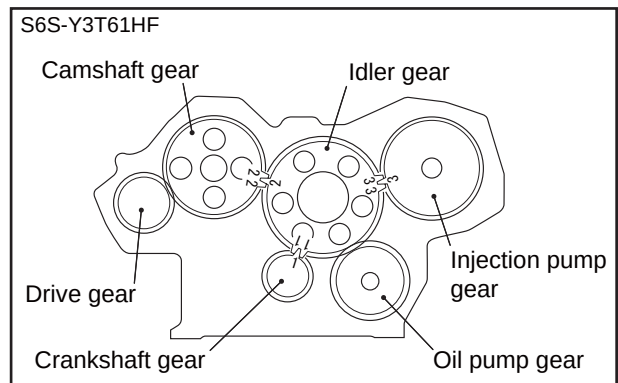


Alignment mark of fuel injection pump

- (10) After aligning the timing marks of the fuel injection pump gear and the idler gear, install the fuel injection pump to the front plate.

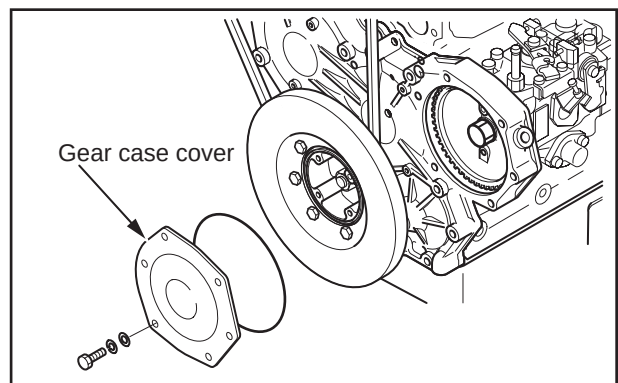


Match mark of gears



Match mark of gears

- (11) Install the gear case cover.



Installing gear case cover

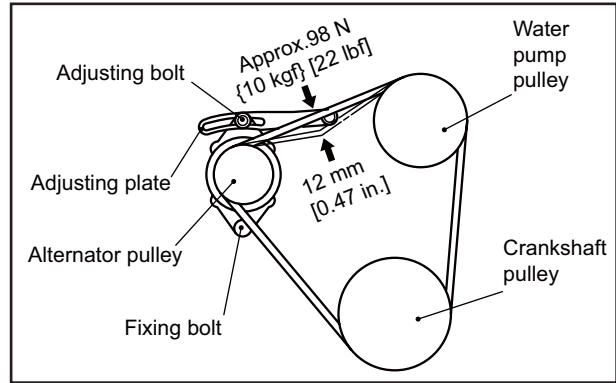
1.5 Inspecting V-belt and adjusting V-belt tension

CAUTION

- (a) If defects such as cuts or surface separations are found during inspection, replace the V-belt.
- (b) Keep oil and grease away from the V-belt, since they may cause the V-belt to slip and shorten the service life.
- (c) Excessive V-belt tension can cause rapid wear of the alternator bearing and shorten the service life of the V-belt. Adjust the belt tension accurately by following the procedures below.

1.6 Inspecting V-belt

- (1) Inspect the V-belt visually for separation or damage. If any abnormality is found, replace the V-belt with a new one.
- (2) Inspect V-belt tension (deflection).
When pressing the V-belt strongly at the center of its span, the deflection should be 12 mm [0.47 in.].
Force on the V-belt: Approx. 98 N {10 kgf} [22 lbf]
If the deflection of V-belt is not within the standard, adjust the V-belt tension.



Inspecting V-belt

1.7 Adjusting V-belt tension

- (1) Loosen all retaining bolts of the alternator and adjusting plate.
- (2) Adjust V-belt tension properly with the adjusting bolt.
- (3) Tighten all retaining bolts of the alternator and adjusting plate.

ADJUSTMENT AND OPERATION

2. Break-in operation

After the engine is overhauled, install the engine to the dynamometer, and run the engine for break-in operation and inspection.

2.1 Starting up

- (1) Before starting the engine, check the levels of coolant, engine oil and fuel. Also check the inlet and exhaust systems.
Bleed air from the fuel and cooling systems.
- (2) Stop the fuel supply, and crank the engine with the starter for about 10 seconds to lubricate the engine.
- (3) Move the control lever slightly in the fuel increase direction (but not to the "full injection" position), and then turn the starter switch key to the [START] position to start the engine.
- (4) After the engine is started, adjust the control lever to let the engine operate at a minimum no-load speed (low idle speed).
- (5) Turn the starter switch key to the [OFF] position and make sure that the engine is stopped.

2.2 Inspecting engine condition after starting up

During the break-in operation, check the followings.

If any abnormality is found, stop the engine, investigate the cause, and take appropriate measures.

- (1) The oil pressure must be within the specified value.
- (2) The coolant temperature must be within the specified value.
- (3) The engine must be free from any leakages such as oil, coolant, fuel and gas (air). Pay special attention to oil leakage from the fitting face of turbocharger lube oil pipe.
- (4) Check for an abnormal noise.
- (5) Check for the color of smoke and odors.

2.3 Break-in operation time

The relationship between the load in break-in operation and the operation time is as shown below.

Break-in operation time				
	Engine speed (min ⁻¹)		Load	Duration (min)
1	Low rotation speed	800 to 900	No-load	5
2	Medium rotation speed	1000 to 1200	No-load	5
3	High rotation speed	1400 to rated speed	No-load	10
4	Rated speed		25 %	10
5			50 %	10
6			75 %	30
7			100 %	20

Note: The table above is provided solely for reference purpose. Run the engine at appropriate speed and load for the break-in operation of your engine. Be sure to perform break-in operation after overhaul or installation.

2.4 Inspection and adjustment after break-in operation

- (1) Valve clearance adjustment
- (2) Ignition timing inspection
- (3) Exterior bolt and nut tightness check

3. Performance test (JIS standard)

The following describes the procedures specified in "Earth moving machinery - Engines - Part 1: Test code of net power (JIS D0006-1)" and "Earth moving machinery - Engines - Part 2: Standard format of specifications and testing methods of diesel engines (JIS D0006-2)."

Other test items may be required in some applications. All test results should be evaluated comprehensively in order to determine the engine performance.

3.1 Engine equipment condition

The engine must be equipped with standard auxiliary devices such as cooling fan, air cleaner and alternator.

3.2 Test items and purposes

3.2.1 Operation load test

Conduct this test to evaluate the engine output, torque, fuel consumption rate and governor performance under various load conditions.

3.2.2 Continuous load test

Operate the engine continuously for 10 hours at 90% load (continuous load application) of nominal net brake power while the engine speed is maintained at revolutions corresponding to the nominal brake power. In this test, evaluate the fuel consumption rate and operating condition, and confirm that the engine is capable of continuous operation.

3.2.3 Low idle test

Conduct this test to confirm that the engine can operate stably at the specified low idle speed.

3.3 Other inspections

Check for gas, coolant and oil leaks; abnormal odors; and hunting. Make adjustment as needed.

3.4 Engine output adjustment

Diesel engine output is affected by atmospheric pressure, temperature and humidity. Therefore, correction calculations must be performed to obtain the value of engine output under the standard atmospheric conditions.

3.4.1 Standard atmospheric conditions:

Base temperature: 298 K (25°C) [77°F]

Total pressure: 100 kPa (750 mmHg)

Dry pressure: 99 kPa (743 mmHg)

ADJUSTMENT AND OPERATION

3.4.2 Calculation of corrected power

Multiply the measured brake power or torque by the calculated diesel engine correction factor to obtain a corrected value.

If the applicable range of the correction formula is exceeded, indicate the corrected values and record the test conditions on the test record.

Calculation output = Correction factor(α_c) $\times$ Measured brake power

- Atmospheric conditions during test

Temperature(T):283K(10°C)[50°F] $\leq T \leq$ 313K(40°C)[104°F]

Dry atmospheric pressure(P_d):80kPa(600mmHg) $\leq P_d \leq$ 110kPa(825mmHg)

$\alpha_c = (f_a)^{f_m}$ f_a :Atmospheric factor f_m :Engine factor

- Range of correction equation use

The range of correction factor(α_c)is as follows:

$0.9 \leq \alpha_c \leq 1.1$.

Calculation of correction factor(f_a)

Natural aspiration engine and engine with mechanically driven air charger

$$f_a = \left(\frac{99}{P_d}\right) \cdot \left(\frac{T}{298}\right)^{0.7}$$

- Turbocharged engine without air cooler or with air-to-air cooler

$$f_a = \left(\frac{99}{P_d}\right)^{0.7} \cdot \left(\frac{T}{298}\right)^{1.2}$$

- Turbocharged engine with air-to-liquid cooler

$$f_a = \left(\frac{99}{P_d}\right)^{0.7} \cdot \left(\frac{T}{298}\right)^{0.7}$$

Calculation of engine factor(f_m)

$$f_m = 0.036q_c - 1.14$$

q_c :Corrected fuel supply volume

$$q_c = \frac{q}{r}$$

$$q = \frac{(z) \times (\text{Fuel flow rate g/s})}{(\text{Stroke volume } l) \times (\text{Engine speed min}^{-1})}$$

$z = 120000$ (4-cycle engine)

r :Ratio between pressure at turbocharger or air cooler outlet and atmospheric pressure ($r=1$ for natural aspiration engine)

- Applicable range of engine factor(f_m)

$37.2 \leq q_c \leq 65\text{mg/(l-cycle)}$

• $q_c \leq 37.2\text{mg/(l-cycle)}$: $f_m = 0.2$ (constant)

• $65\text{mg/(l-cycle)} \leq q_c$: $f_m = 1.2$ (constant)