HYUNDAI
CONSTRUCTION EQUIPMENT U.S.A., INC.

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

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Forklift Service Manual

HYUNDAI
HEAVY INDUSTRIES CO.,LTD.

1. STRUCTURE

This service manual has been prepared as an aid to improve the quality of repairs by giving the serviceman an accurate understanding of the product and by showing him the correct way to perform repairs and make judgements. Make sure you understand the contents of this manual and use it to full effect at every opportunity.

This service manual mainly contains the necessary technical information for operations performed in a service workshop.

For ease of understanding, the manual is divided into the following sections.

SECTION 1 GENERAL

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

SECTION 2 REMOVAL & INSTALLATION OF UNIT

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

SECTION 3 POWER TRAIN SYSTEM

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

SECTION 4 BRAKE SYSTEM

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

SECTION 5 STEERING SYSTEM

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

SECTION 6 HYDRAULIC SYSTEM

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

SECTION 7 ELECTRICAL SYSTEM

This section explains the electrical circuit and each component.

It serves not only to give an understanding electrical system, but also serves as reference material for troubleshooting.

SECTION 8 MAST

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

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

2. HOW TO READ THE SERVICE MANUAL

Distribution and updating

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

Filing method

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

   10 - 4
   10 - 4 - 1
   10 - 4 - 2 Added pages
   10 - 5

Revised edition mark(①②③…)

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

Revisions

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

Symbols

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

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

3. CONVERSION TABLE

Method of using the Conversion Table

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

Example

1. Method of using the Conversion Table to convert from millimeters to inches
   Convert 55mm into inches.

   (1) Locate the number 50in the vertical column at the left side, take this as ⓐ, then draw a horizontal line from ⓐ.

   (2) Locate the number 5in the row across the top, take this as ⓑ, then draw a perpendicular line down from ⓑ.

   (3) Take the point where the two lines cross as ⓒ. This point ⓒ gives the value when converting from millimeters to inches. Therefore, 55mm = 2.165 inches.

2. Convert 550mm into inches.

   (1) The number 550 does not appear in the table, so divide by 10(Move the decimal point one place to the left) to convert it to 55mm.

   (2) Carry out the same procedure as above to convert 55mm to 2.165 inches.

   (3) The original value(550mm) was divided by 10, so multiply 2.165 inches by 10(Move the decimal point one place to the right) to return to the original value.
   This gives 550mm = 21.65 inches.

Millimeters to inches ⓑ 1mm = 0.03937 in

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

Millimeters to inches

1mm = 0.03937in

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

Kilogram to Pound

1kg = 2.2046lb

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

Liter to U.S. Gallon

1 l = 0.2642 U.S.Gal

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

Liter to U.K. Gallon

1 l = 0.21997 U.K.Gal

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

kgf · m to lbf · ft

1kgf · m = 7.233lbf · ft

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

kgf/cm^2 to lbf/in^2

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

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

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 8 MAST

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SECTION 1 GENERAL

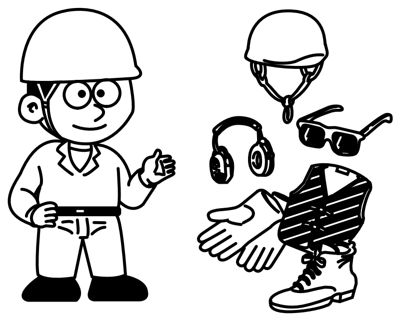
GROUP 1 SAFETY HINTS

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

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

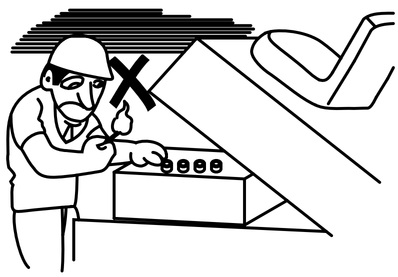
D50ASF01

· 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.



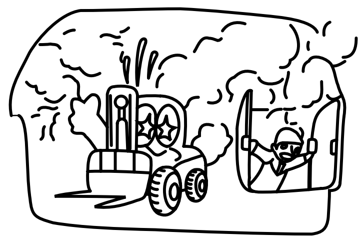
D50ASF02

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



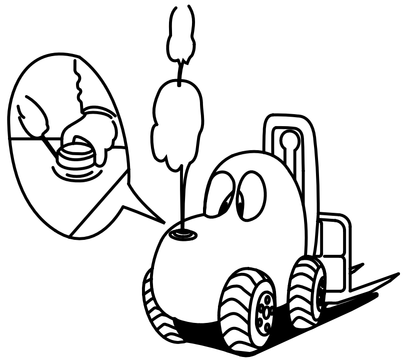
D50ASF03

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



D50ASF04

- ⚠ 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.

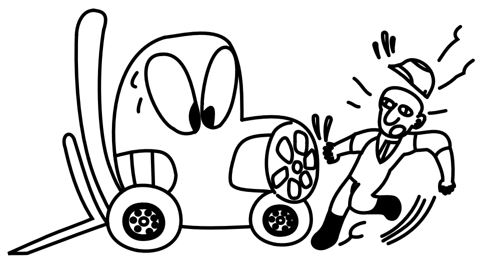


D50ASF05

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

D50ASF06

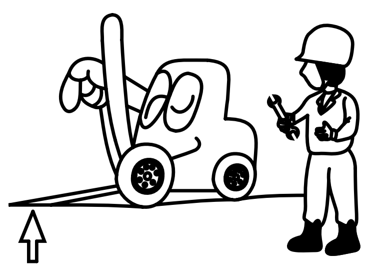
- Hand a caution sign in the operator's compartment (For example **Do not start** or **Maintenance in progress**).
  This will prevent anyone from starting or moving the machine by mistake.
- ⚠ It is extremely dangerous to try to check the fan belt tension while he engine is running.



D50ASF07

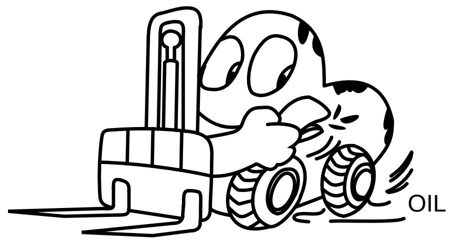
When inspecting the engine is running parts, or near such parts, always stop the engine first.
Before checking or servicing accumulator or piping, depress brake pedal repeatedLy to release pressure.

- 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.



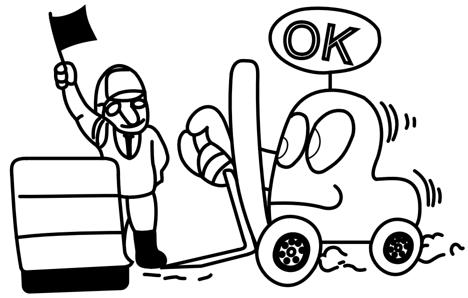
D50ASF08

- 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.



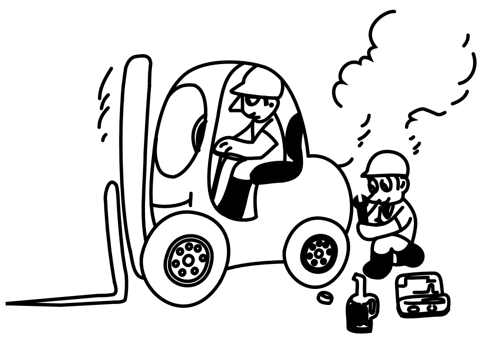
D50ASF09

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



D50ASF10

- 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.


D50ASF11

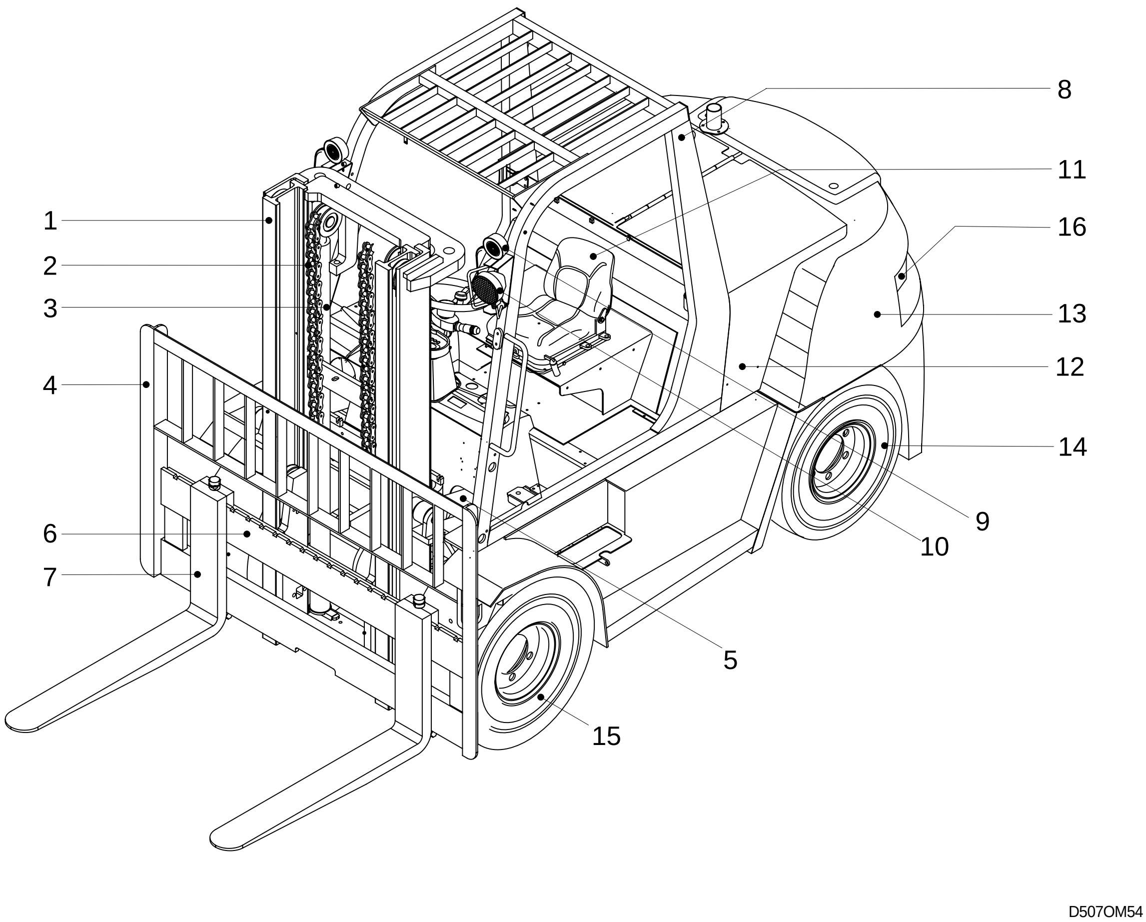
- Always remember that the hydraulic oil circuit is under pressure. When feeding or draining the oil or carrying out inspection and maintenance, release the pressure first.

- 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.

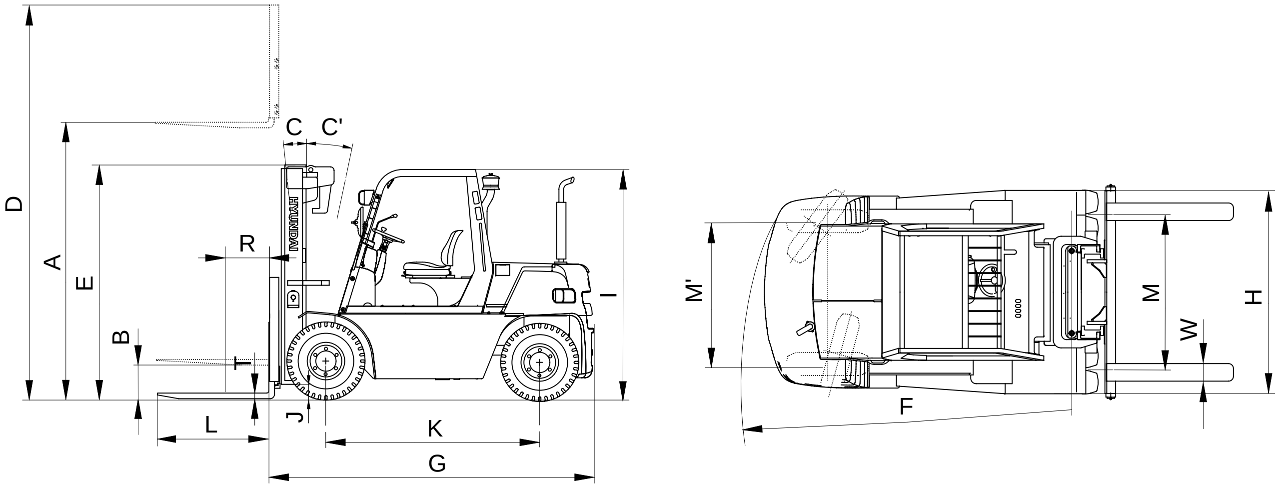
GROUP 2 SPECIFICATIONS

1. MAJOR COMPONENTS



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	Carrige	12	Bonnet		

2. SPECIFICATIONS



D507SP01

Model			Unit	HDF 50-7S	HDF 70-7S
Capacity			kg	5000	7000
Load center			mm	600	←
Weight(Unloaded)			kg	8347	9680
Fork	Lifting height	A	mm	3000	←
	Free lift	B	mm	140	←
	Lifting speed(Unload/Load)		mm/sec	500/470	500/450
	Lowering speed(Unload/Load)		mm/sec	450/500	←
	L×W×T	L,W,T	mm	1200×150×60	1200×180×60
Mast	Tilt angle (forward/backward)	C/C’	degree	15/10	←
	Max height	D	mm	4275	←
	Min height	E	mm	2515	←
Body	Travel speed		km/h	33.1	32.6
	Gradeability		degree(%)	27.9(53)	22.2(40.9)
	Min turning radius(Outside)	F	mm	3290	3370
ETC	Max hydraulic pressure		kgf/cm^2	185	←
	Hydraulic oil tank		l	105	←
	Fuel tank		l	150	←
Overall length		G	mm	3540	3620
Overall width		H	mm	2087	←
Overhead guard height		I	mm	2523	←
Ground clearance		J	mm	195	←
Wheel base		K	mm	23000	←
Wheel tread front/rear		M, M'	mm	1580/1604	←

3. SPECIFICATION FOR MAJOR COMPONENTS

1) ENGINE

ITEM	UNIT	SPECIFICATION
Model	-	MITSUBISHI S6S-DT
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	-	In direct injection
Cylinder bore X stroke	mm(in)	94×120(3.7×4.7)
Piston displacement	cc(cu in)	4996(305)
Compression ratio	-	19.5
Rated gross horse power	ps/rpm	88/2200
Maximum gross torque at rpm	kgf · m/rpm	34.8/1400
Engine oil quantity	ℓ (U.S.gal)	17.5(4.6)
Dry weight	kg(lb)	350(772)
High idling speed	rpm	2400±50
Low idling speed	rpm	875±50
Rated fuel consumption	g/ps.hr	180
Starting motor	V-kW	24-5.0
Alternator	V-A	24-50
Battery	V-AH	12-80×2
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	72±9
Maximum operating pressure	bar	250
Rated speed (Max/Min)	rpm	3000/600

3) MAIN CONTROL VALVE

ITEM	UNIT	SPECIFICATION
Type	-	Sectional
Operating method	-	Mechanical
Main relief valve pressure	bar	185/150
Flow capacity	lpm	163

4) POWER TRAIN DEVICES

Item			Specification
Torque converter	Model		F&S 300*16/4/-1(ZF SACH)
	Type		3 Element, 1 stage, 2 phase
	Stall ratio		2.5 : 1
Transmission	Type		Full auto, Power shift
	Gear shift(FR/RR)		3/3
	Adjustment		Electrical single lever type
	Overhaul ratio	FR	1 : 4.578 2 : 2.396 3 : 0.994
		RR	1 : 4.593 2 : 2.404 3 : 0.996
Axle	Type		Front-wheel drive type, fixed location
	Gear		Hypoid gear type
Wheels	Q'ty(FR/RR)		Double : 4/2
	Front(drive)		8.25-15-14 PR
	Rear(steer)		8.25-15-14 PR
Brakes	Travel		Front wheel, Duo-servo
	Parking		Ratchet, internal expanding mechanical type
Steering	Type		Full hydraulic, power steering
	Steering algle		75.87° 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	Torque converter mounting bolt	M10×1.5	6.9±1.4	50±10
4		MCV mounting bolt, nut	M12×1.75	12.8±3.0	93±22
5		Steering unit mounting bolt	M10×1.5	6.9±1.4	50±10
6	Power train system	Transmission mounting bolt, nut	M16×2.0	7.5	54
7		Drive axle mounting bolt, nut	M24×3.0	100±15	723±108
8		Steering axle mounting bolt, nut	M18×2.5	41.3±6.2	300±45
9		Front wheel mounting nut	M22×1.5	61.2±9.2	448±67
10		Rear wheel mounting nut	M22×1.5	61.2±9.2	448±67
11	Others	Counterweight mounting bolt	M30×3.5	120±15	1555±239
12		Operator's seat mounting nut	M 8×1.25	2.5±0.5	18.1±3.6
13		Head guard mounting bolt	M12×1.75	12.8±3.0	93±22

5. TORQUE CHART

Use following table for unspecified torque.

1) BOLT AND NUT - Coarse thread

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

(1) Fine thread

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

2) PIPE AND HOSE(FLARE TYPE)

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

3) PIPE AND HOSE(ORFS TYPE)

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

4) FITTING

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

6. RECOMMENDED LUBRICANTS

Use only oils listed below or equivalent.

Do not mix different brand oil.

Service point	Kind of fluid	Capacity ℓ (U.S.gal) 5.0 ~ 7.0 ton	Ambient temperature °C (°F) -20 (-4) -10 (14) 0 (32) 10 (50) 20 (68) 30 (86) 40 (104)
Engine oil pan	Engine oil	17.5 (4.6)	SAE 30 (0 to 40); SAE 10W (-30 to 10); SAE 10W-30 (-30 to 40); SAE 15W-40 (-20 to 40)
Torque converter transmission	T/M oil*1 Engine oil*2	22(5.7)*1 25(6.4)*2	ATF DEXRON III*1, SAE 10W-30*2 (-30 to 40)
Axle	Gear oil	12.5 (3.3)	SAE 80W-90/API GL-5 (-30 to 40)
Hydraulic tank	Hydraulic oil	105 (27.7)	ISO VG32 (-30 to 27); ISO VG46 (-20 to 34); ISO VG68 (-10 to 40)
Fuel tank	Diesel fuel	150 (39.6)	ASTM D975 No.1 (-30 to 4); ASTM D975 No.2 (-10 to 40)
Fitting (Grease nipple)	Grease	-	NLGI No.1 (-30 to 20); NLGI No.2 (-10 to 40)
Brake reservoir tank	Hyd oil	-	DOT 3 (-30 to 40)
Radiator	Antifreeze:Water 50:50	17 (4.5)	Ethylene glycol base permanent type (-20 to 40)

*1 : HDF50-7 : #1196-, HDF70-7 : #1668-, HDF50-7S : #0117-, HDF70-7S : #0647-

*2 : HDF50-7 : -#1195, HDF70-7 : -#1667, HDF50-7S : -#0116, HDF70-7S : -#0646

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.

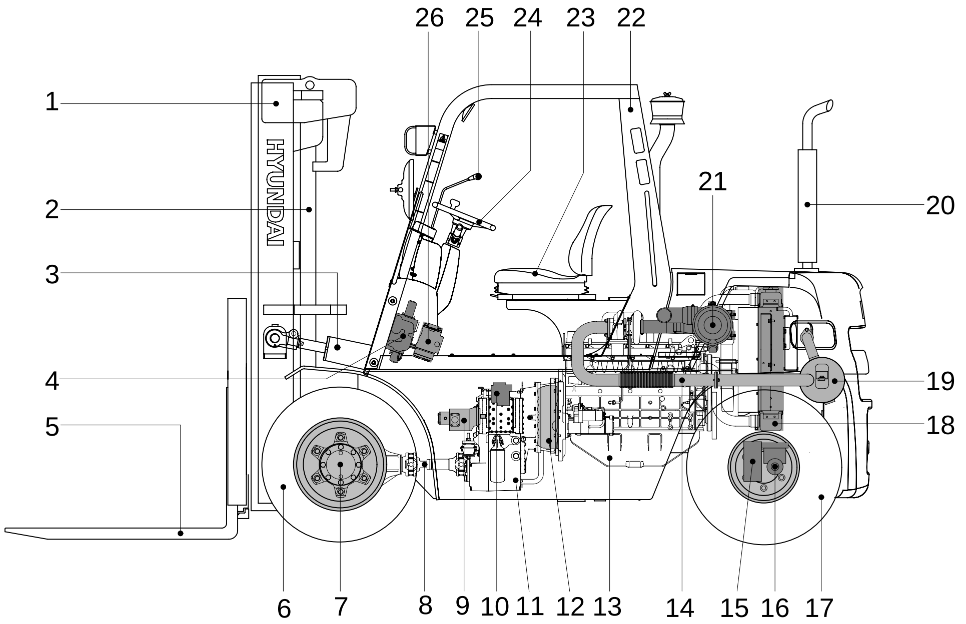
GROUP 3 PERIODIC REPLACEMENT

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



1	Mast	10	Priority valve	19	Muffler
2	Lift cylinder	11	Transmission	20	Silencer
3	Tilt cylinder	12	Torque converter	21	Air cleaner
4	Control valve	13	Engine	22	Overhead guard
5	Fork	14	Exhaust pipe	23	Seat
6	Front wheel	15	Steering axle	24	Steering wheel
7	Drive axle	16	Steering cylinder	25	Control lever
8	Propeller shaft	17	Rear wheel	26	Steering unit
9	Hydraulic pump	18	Radiator		

GROUP 2 REMOVAL AND INSTALLATION OF UNIT

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

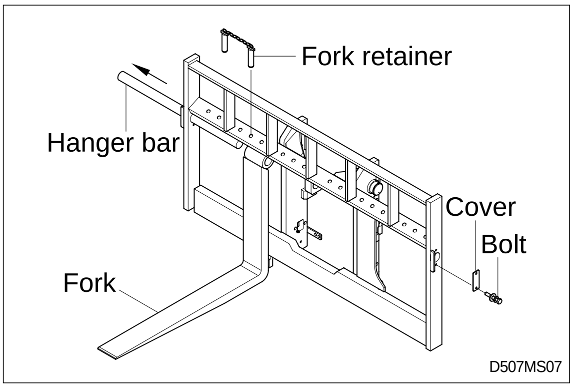
1. MAST

1) REMOVAL

Fork — Carriage — Piping — Mast

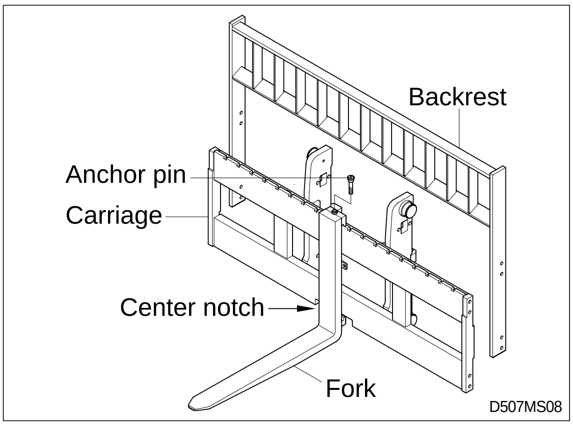
(1) SHAFT TYPE FORKS

① Lower the fork carriage until the forks are approximately 25mm(1in) from the floor.
② Release fork retainer and remove cover.
③ Slide one hanger bar at a time out of carriage assembly.
④ Remove only one fork at a time.
※ On larger forks it may be necessry to use a block of wood.



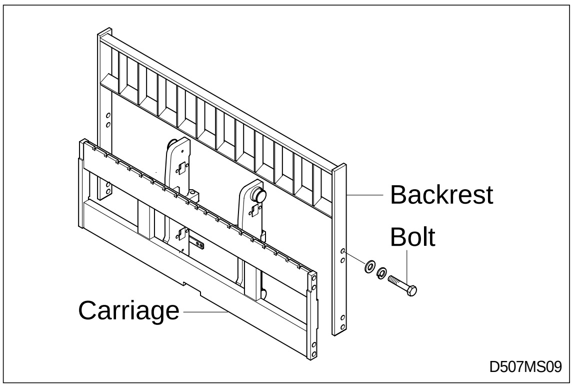
(2) HOOK ON TYPE FORKS(OPTION)

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 necessry to use a block of wood.



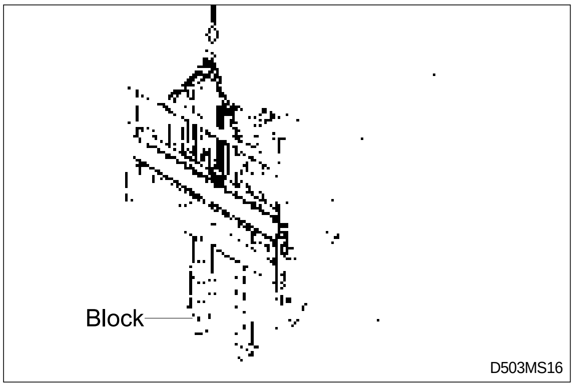
(3) BACKREST(HOOK ON TYPE)

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

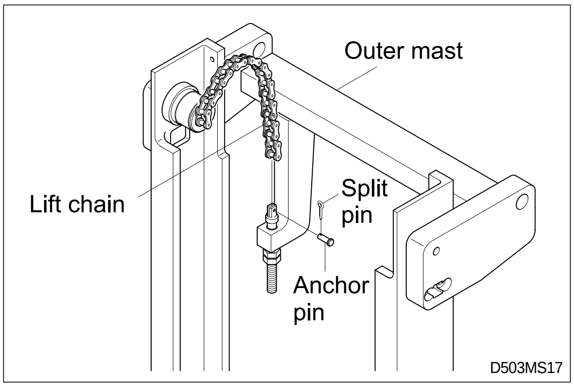


(4) CARRIAGE

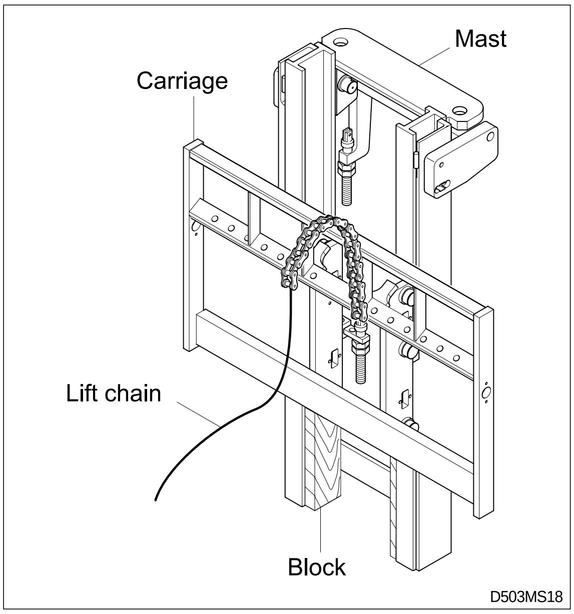
① With the mast vertical, raise the carriage high enough to place blocks under the load forks. This is done to create slack in the load chains when the carriage is lowered. Lower the carriage all the way down to the floor. Make sure the carriage is level, this will prevent any binding when the mast is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



② While supporting lift chains, remove the split pin and slide out chain anchor pins from the chain anchors of stationary upright.



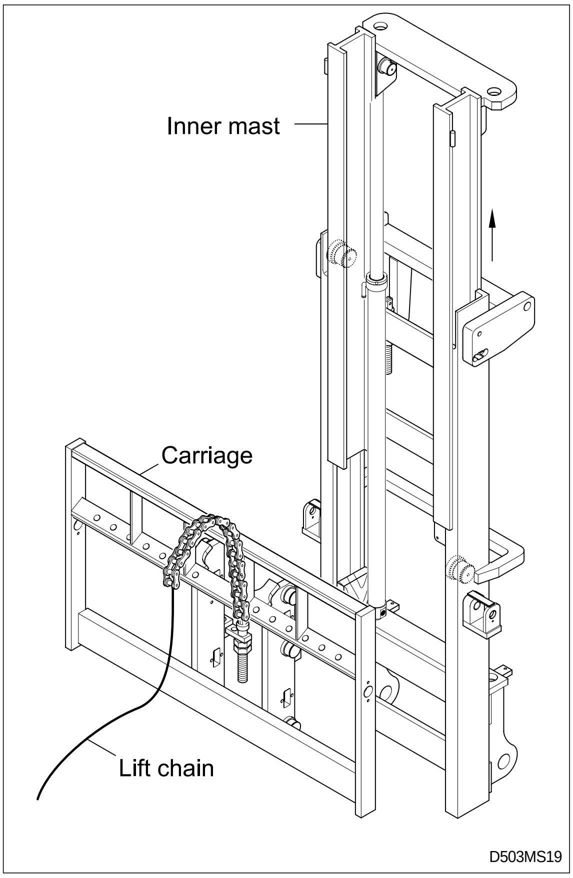
③ Pull the chains out of the sheaves and drape them over the front of the carriage.



④ Slowly raise 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.**

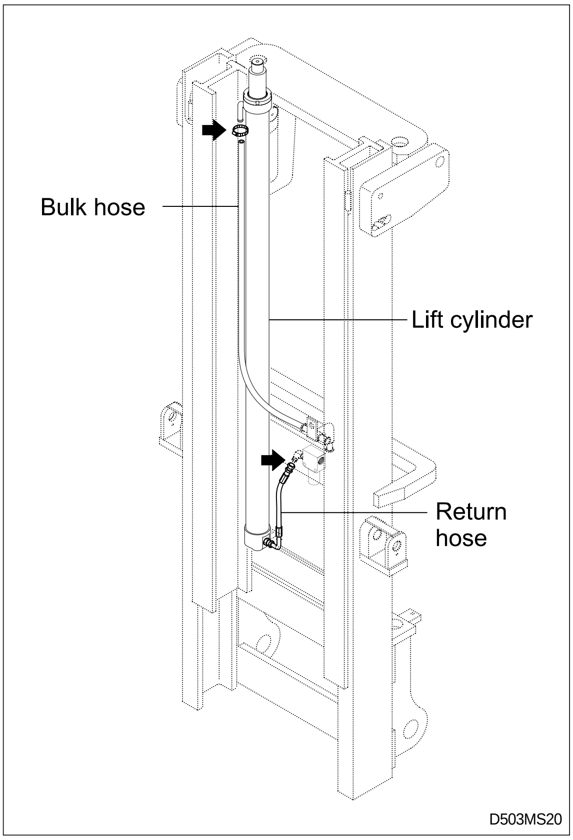
※ Inspect all parts for wear or damage. Replace all worn or damaged parts.



(5) PIPING

① Remove the bulk hoses and clamps attached to the cylinder.
② Remove the return hose from the down control valve.

※ 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.



(6) LIFT CYLINDER

① Loosen and remove hexagon bolts and washers securing lift cylinders to inner mast.

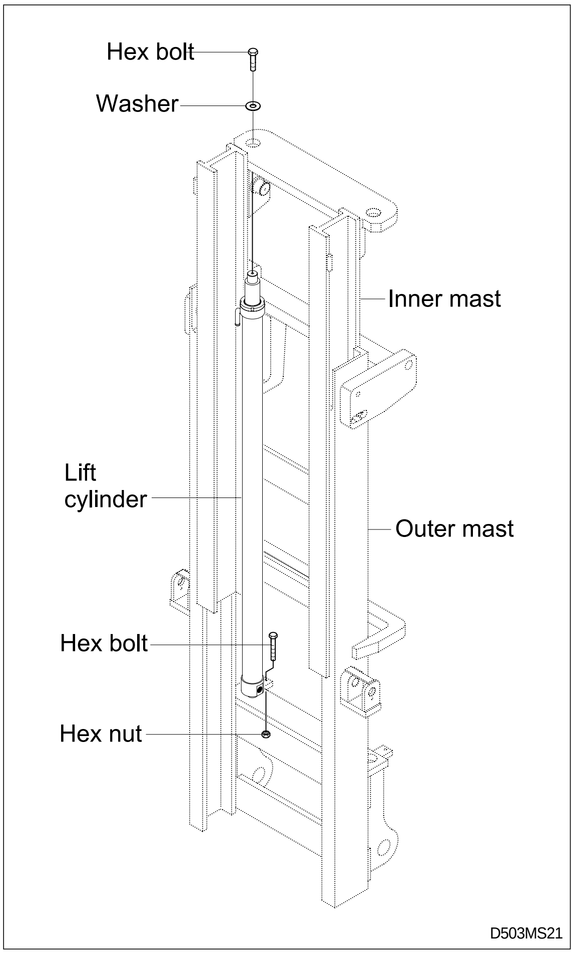
② Bind the lift cylinder with overhead hoist rope and pull up so that the rope has no slack or binding.

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

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

④ Using an overhead hoist, slowly raise the inner mast high enough to clear lift cylinder.

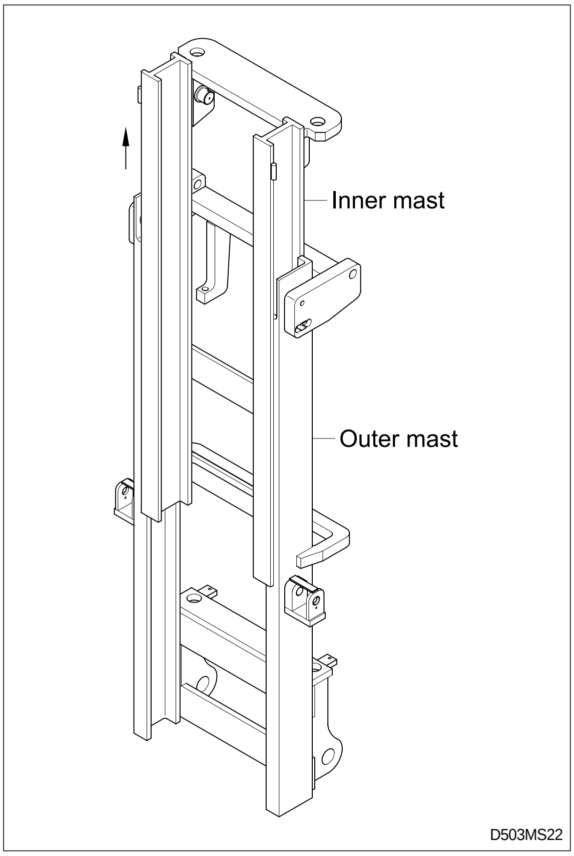
⑤ Using an overhead hoist, draw out lift cylinder carefully and put down on the work floor.



(7) 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.**

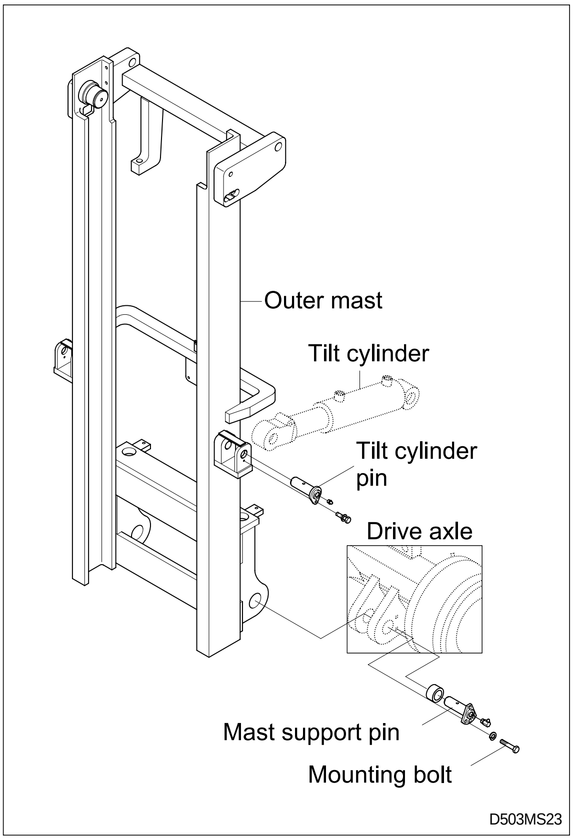


(8) TILT CYLINDER PIN

(9) MAST SUPPORT PIN

Attach a crane to the stay at the top of the outer mast, and raise it.
Remove the mounting bolts and pins from drive axle, then slowly raise outer mast.

※ 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) INSTALLATION

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

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

(1) MAST SUPPORT PIN

Check the mast support pins for wear, then install pins into the mast support bracket and drive axle.

(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

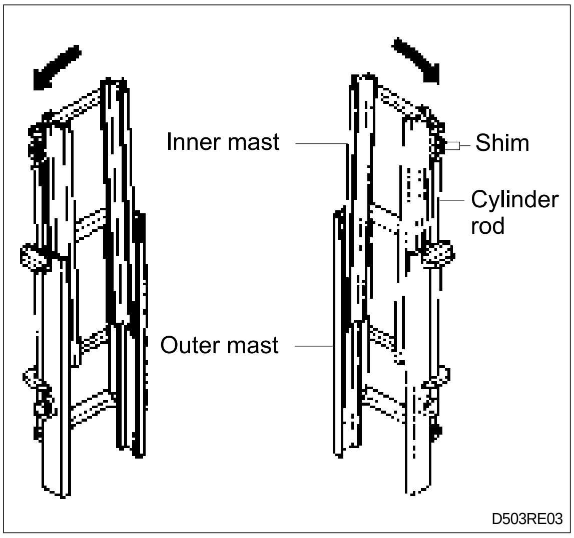
① Assemble the lift cylinder inside the outer mast, then tighten the stopper bolt. If the cylinder assembly has been replaced, adjust as follows so that the left and right cylinders are synchronized at the maximum lifting height.

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.

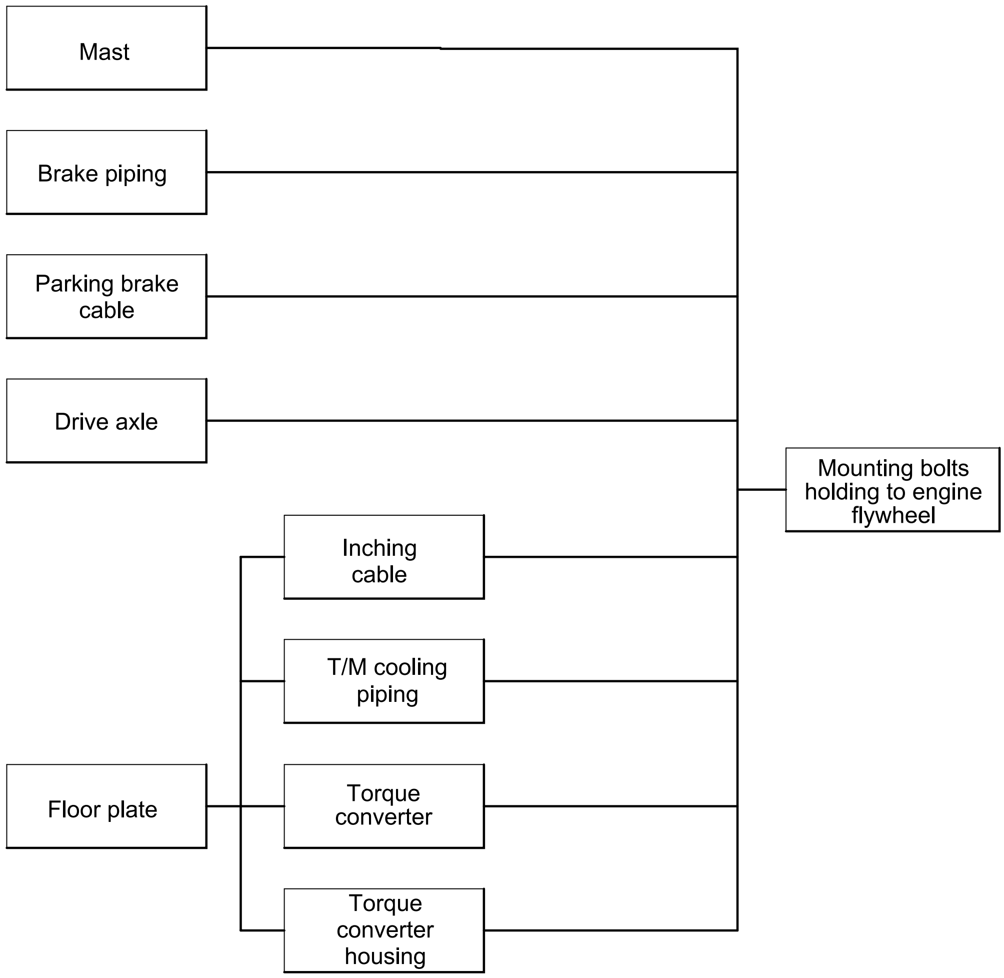
※ If play is to RIGHT, install adjustment shim to RIGHT cylinder.

· Shim thickness : 1.0mm(0.04in)



2. POWER TRAIN ASSEMBLY

1) REMOVAL



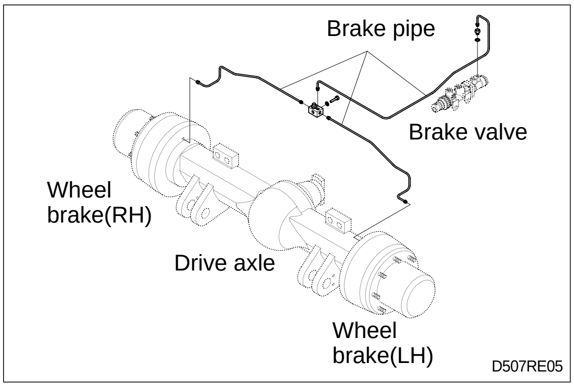
D503RE04

(1) Mast

Refer to section on mast(Page 2-3)

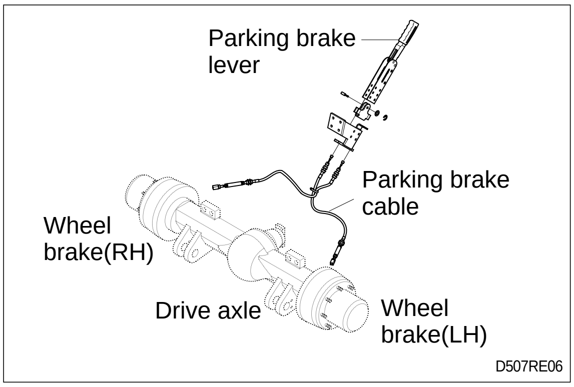
(2) Brake piping

Disconnect the brake piping from the wheel cylinder end.



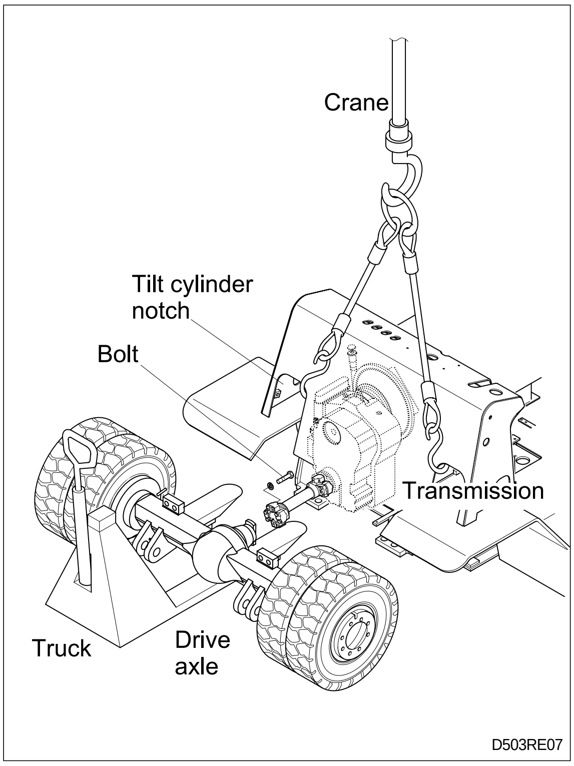
(3) Parking brake cable

Disconnect parking brake cable from the wheel brake assembly.

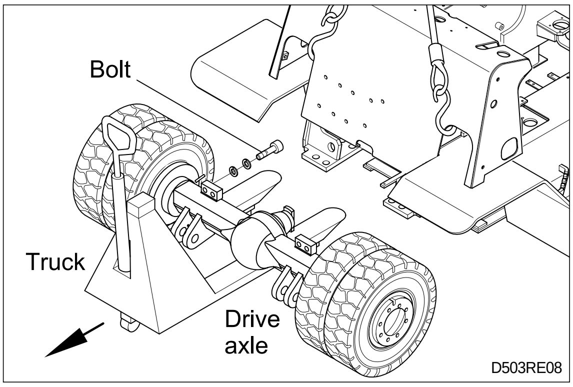


(4) Drive axle

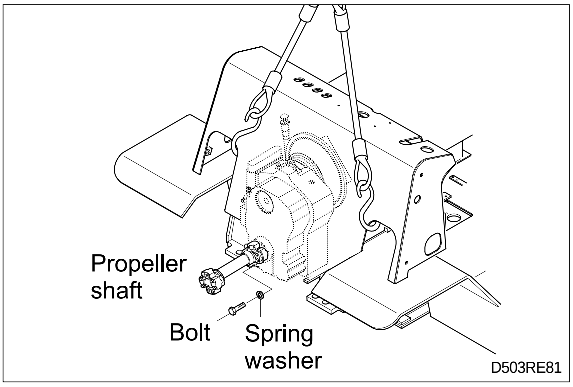
① Attach a crane to the tilt cylinder notches on the dashboard and raise the machine.
② Loosen hexagonal bolts connection drive axle to the transmission.
③ Put the block under the front axle and support under the drive axle with a truck.



④ Remove drive axle mount bolts from the frame and then slowly pull out the truck with drive axle to the front.

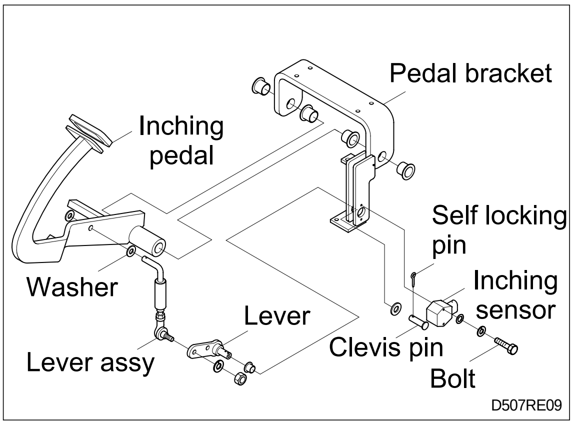


⑤ Remove propeller shaft from the transmission by loosening the mounting bolts.



(5) Inching linkage

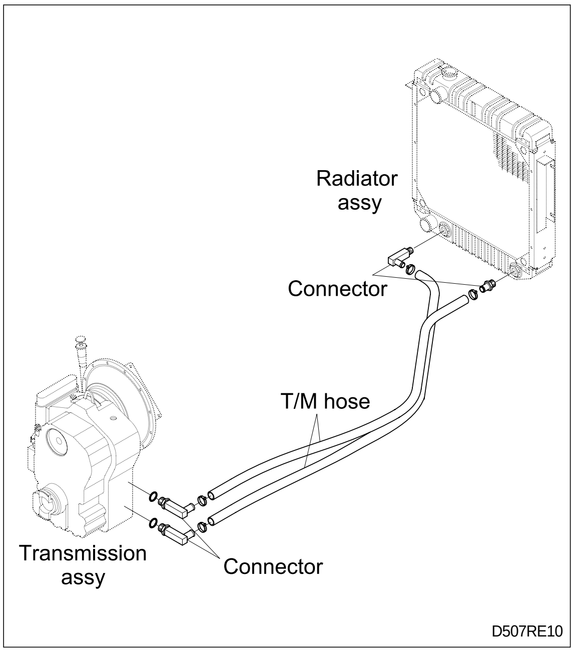
Remove the nut, clevis pins and self locking pin.



(6) Transmission cooling piping

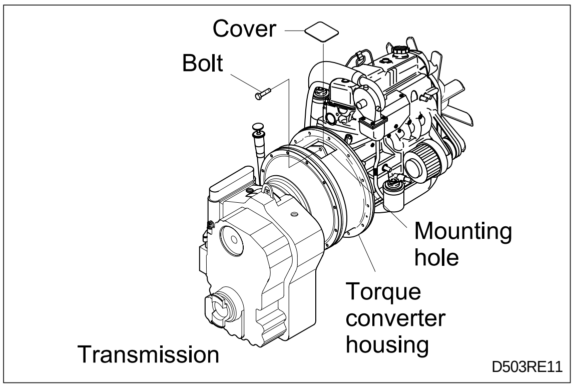
① Disconnect cooling hose and connector from the transmission.

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



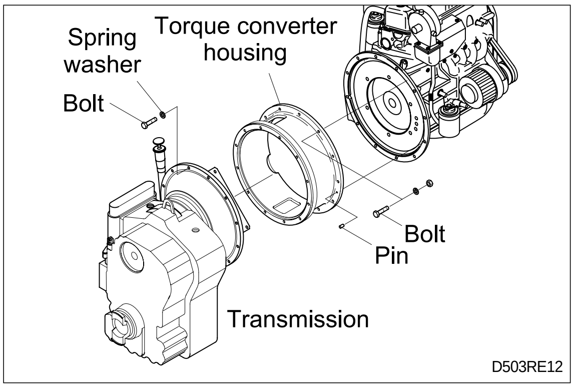
(7) Torque converter

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.

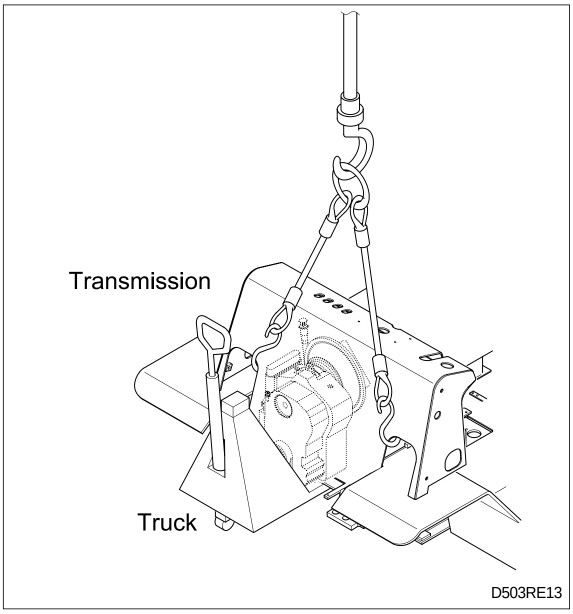


(8) Mounting bolts holding to flywheel housing

① Remove the transmission assembly from the torque converter housing by loosening the mounting bolts.
Remove torque converter housing from the engine flywheel by loosening the mounting bolts and pins.



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

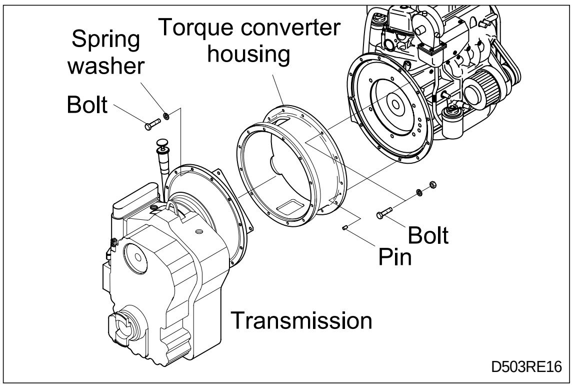


2) INSTALLATION

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

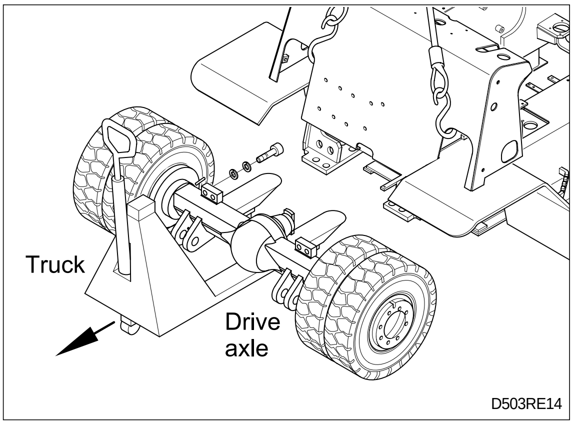
(1) Tightening torque of mounting bolt for torque converter housing.

· 4.2~5.0kgf · m(30~36lbf · ft)



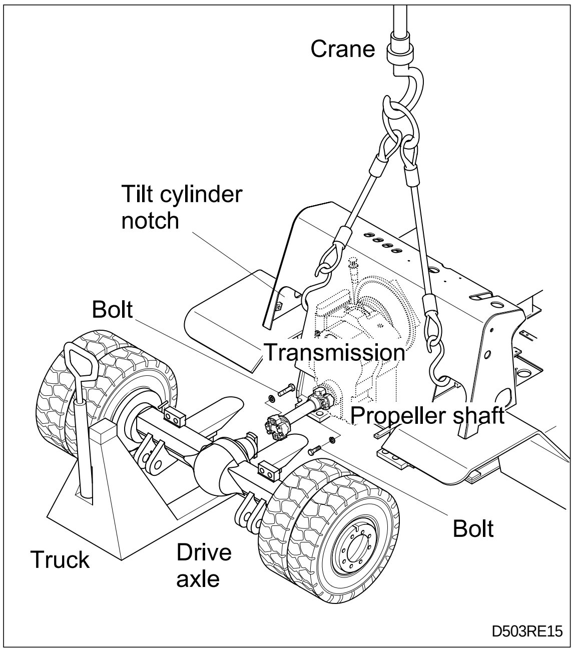
(2) Tightening torque of mounting bolt for drive axle.

· 120kgf · m(868lbf · ft)



(3) Tightening torque of mounting bolt for transmission and propeller shaft.

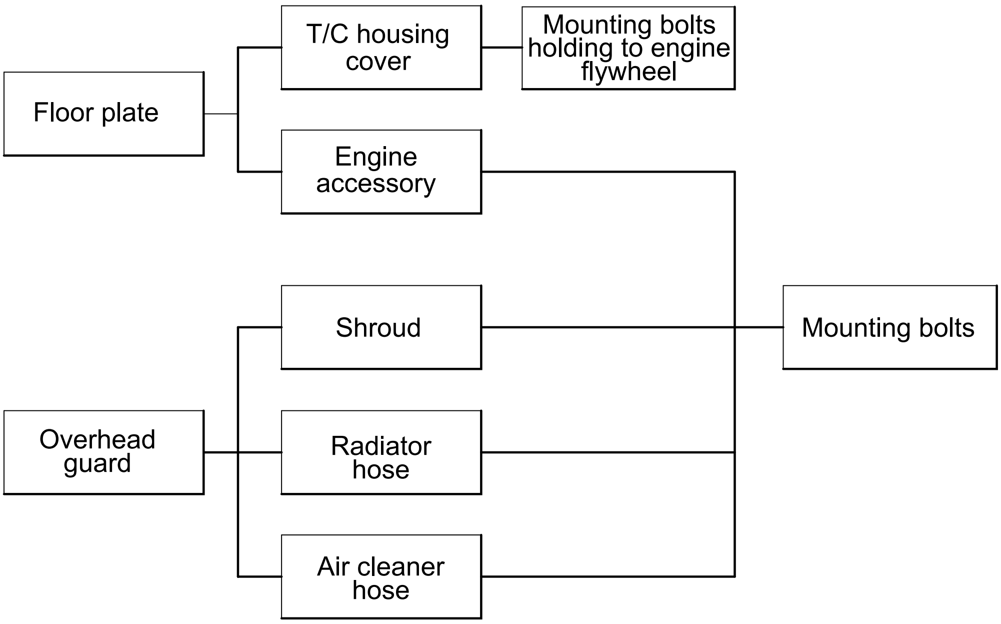
· 7.2~9.5kgf · m(52~69lbf · ft)



3. ENGINE

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

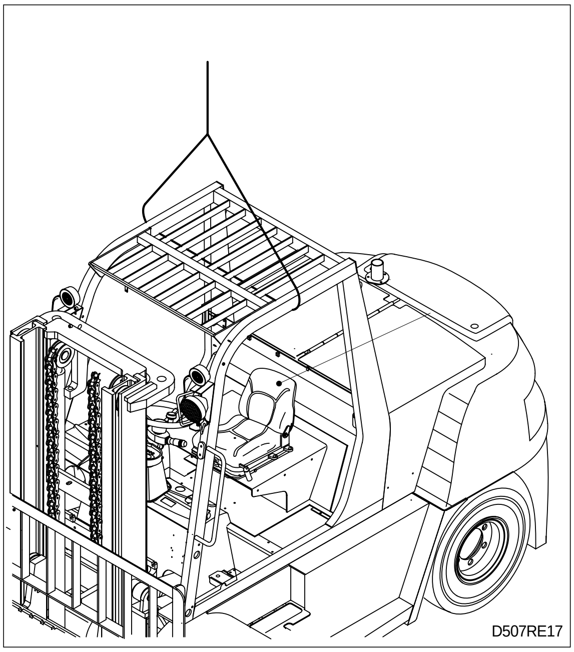
1) REMOVAL



D503RE25

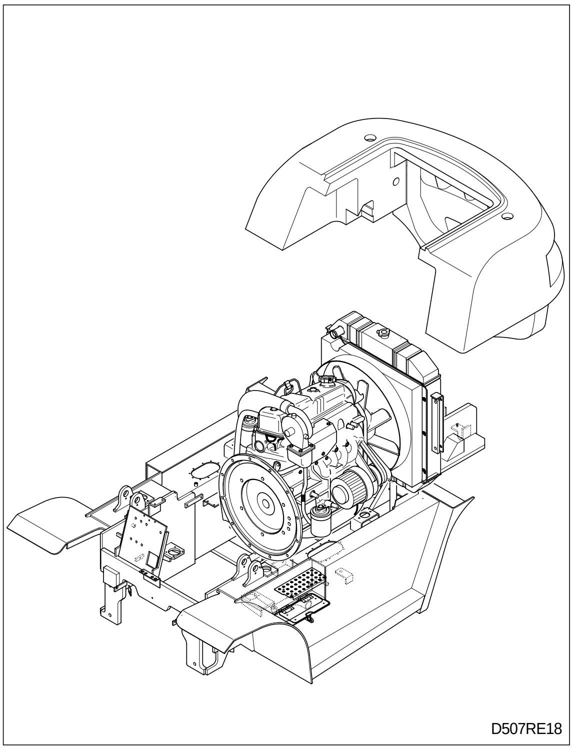
(1) Overhead guard

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.



D507RE17

(2) Torque converter housing cover, mounting bolts installed to flywheel housing.
For details, see page 2-12.



(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.

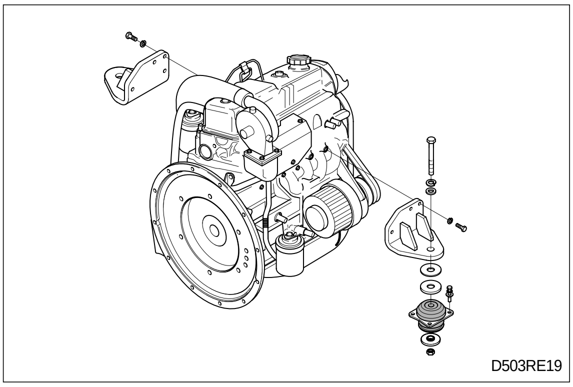
(4) Radiator hose

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

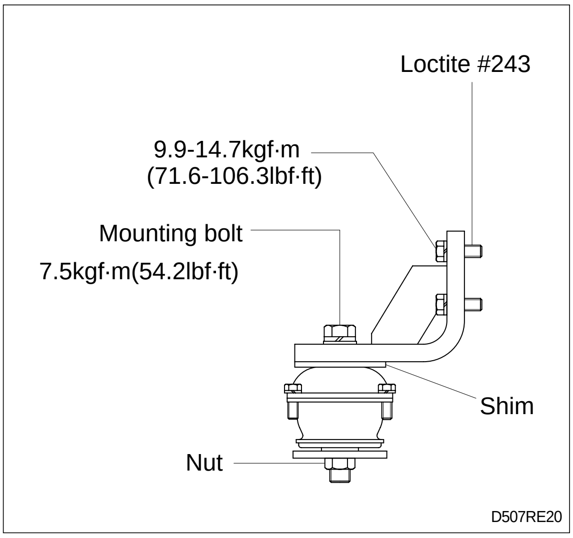
Installation is the reverse order of removal, but be careful of the following points.

(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

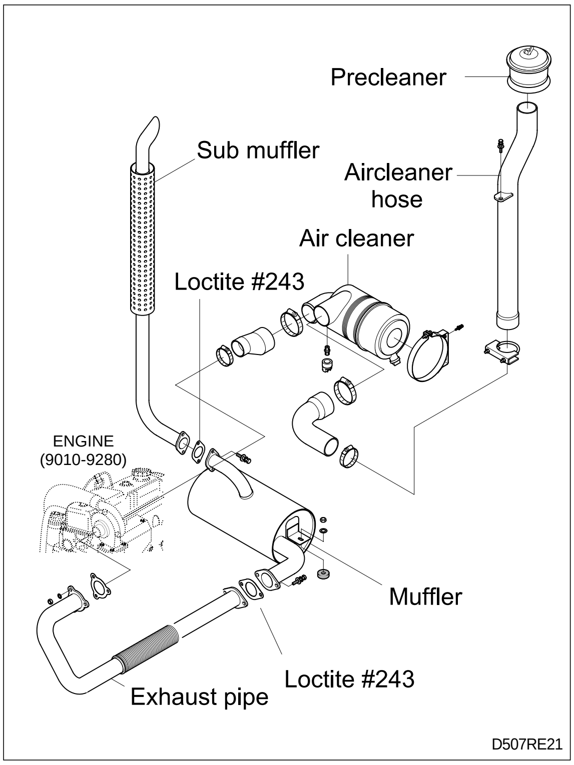
- Distance to insert hose : 42mm(1.65in)

(5) Air cleaner hose

Insert the air cleaner hose securely and fit a clamp.

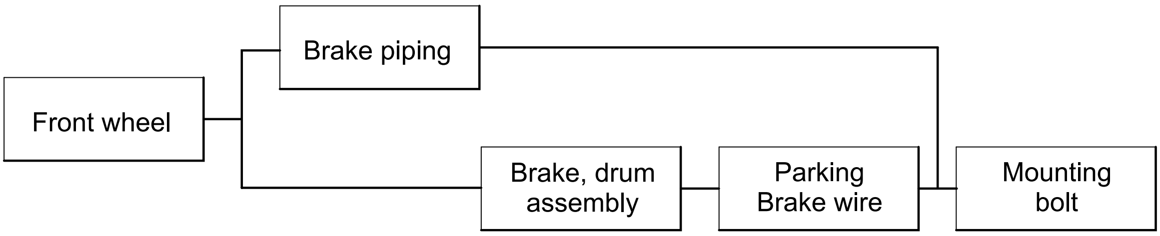
Distance to insert hose

- Air cleaner hose : 89mm(3.5in)
- Engine end(MHI) : 60mm(2.36in)
- Engine end(HMC) : 64mm(2.5in)



5. WHEEL BRAKE

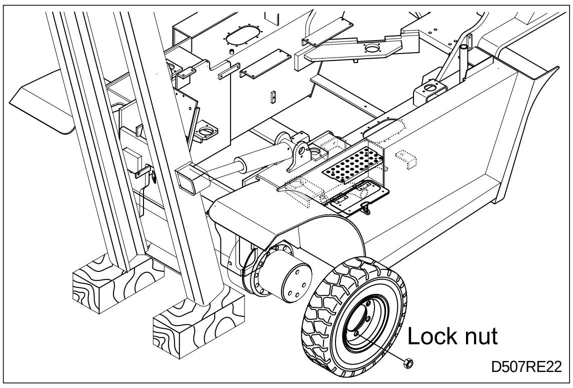
1) REMOVAL



D503RE34

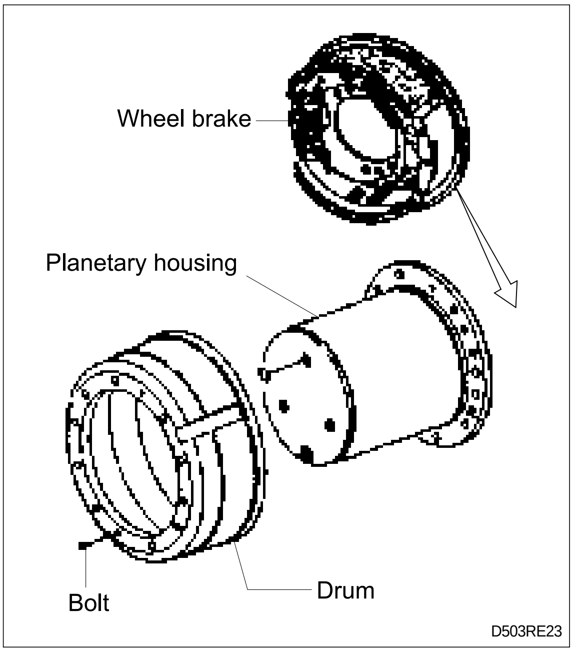
(1) Front wheel

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



D507RE22

(2) Brake, drum assembly.



D503RE23

2) INSTALLATION

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

(1) Tightening torque of hub nut for front wheel.

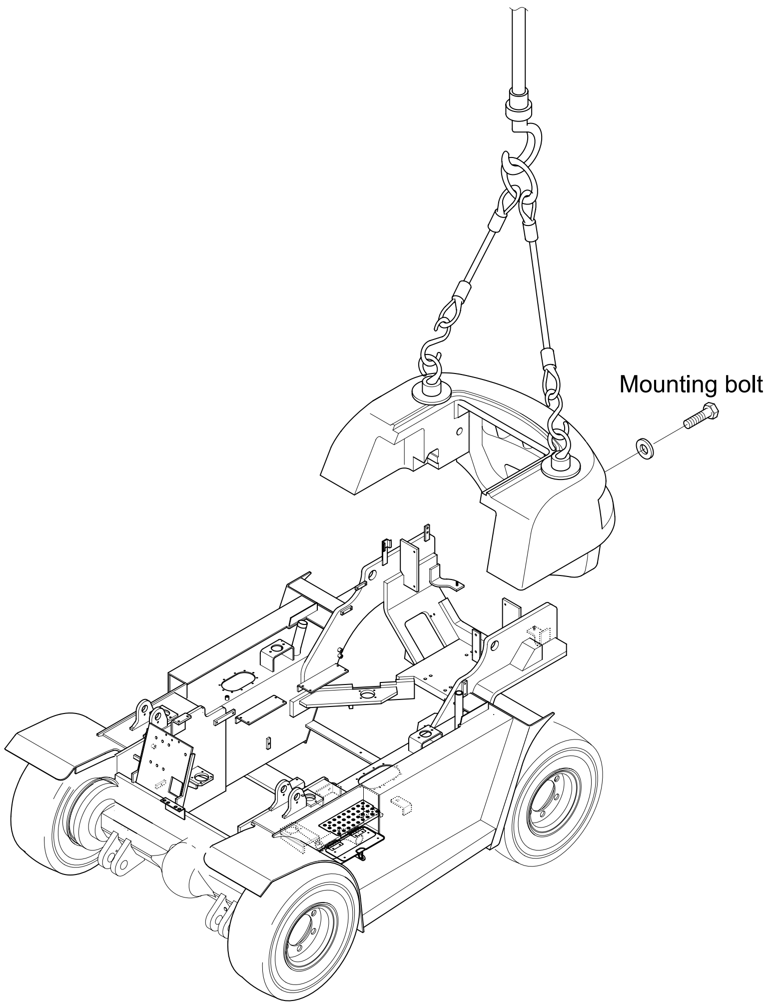
· 61.2kgf · m(443lbf · ft)

6. REAR AXLE

1) REMOVAL

Counter weight — Rear wheel — Hose — Mounting bolt

D503RE35



D507RE30

(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.

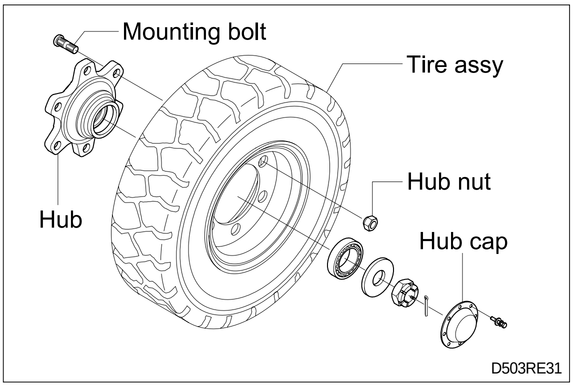
· Weight of counterweight(standard)

HDF50-7S : 1,900㎏(4,189lb)

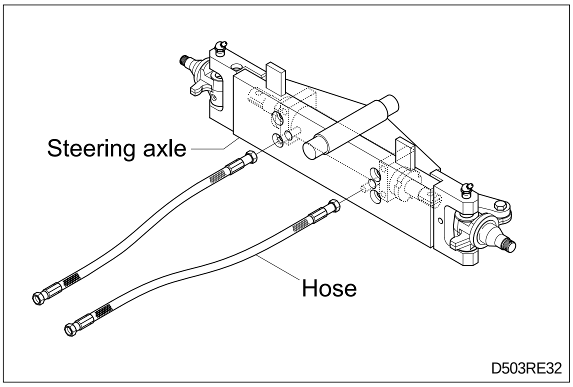
HDF70-7S : 3,150㎏(6,945lb)

(2) Rear wheel

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



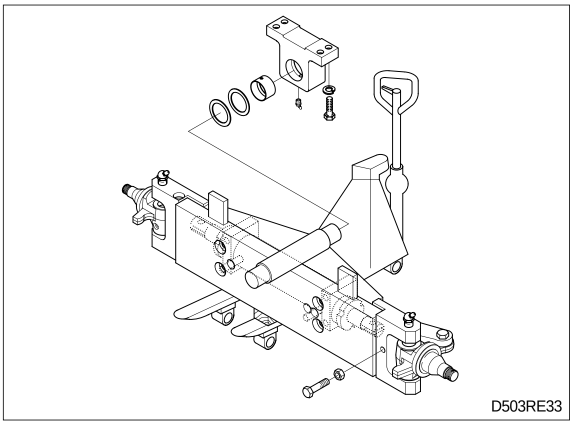
(3) Hose



(4) Mounting bolt

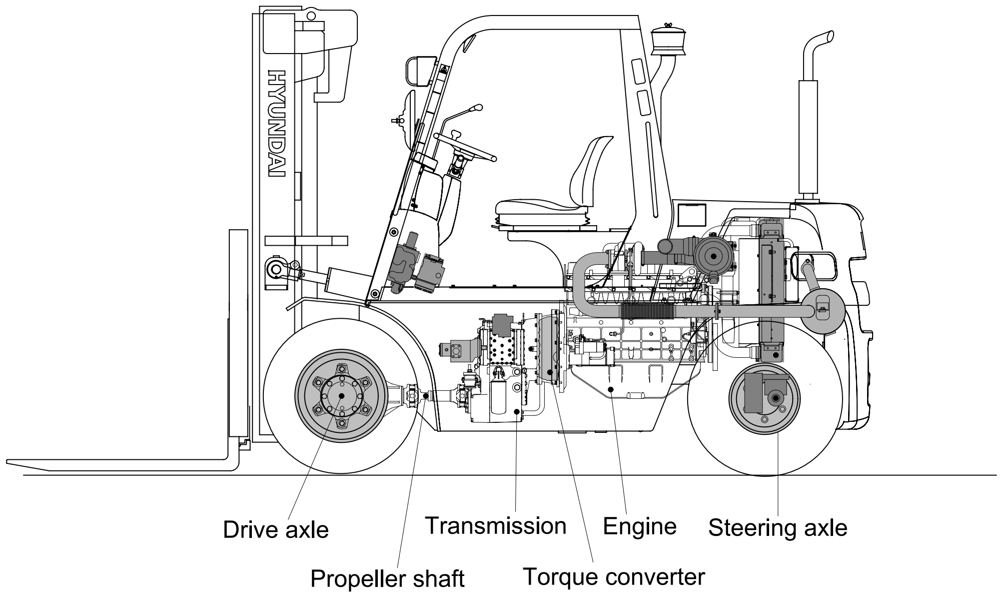
Put a block under the steering axle, support on a truck, an raise the frame with a crane. Remove the mounting bolts installing to the frame, and pull out to the rear.

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



GROUP 1 STRUCTURE AND OPERATION

1. POWER TRAIN COMPONENT OVERVIEW



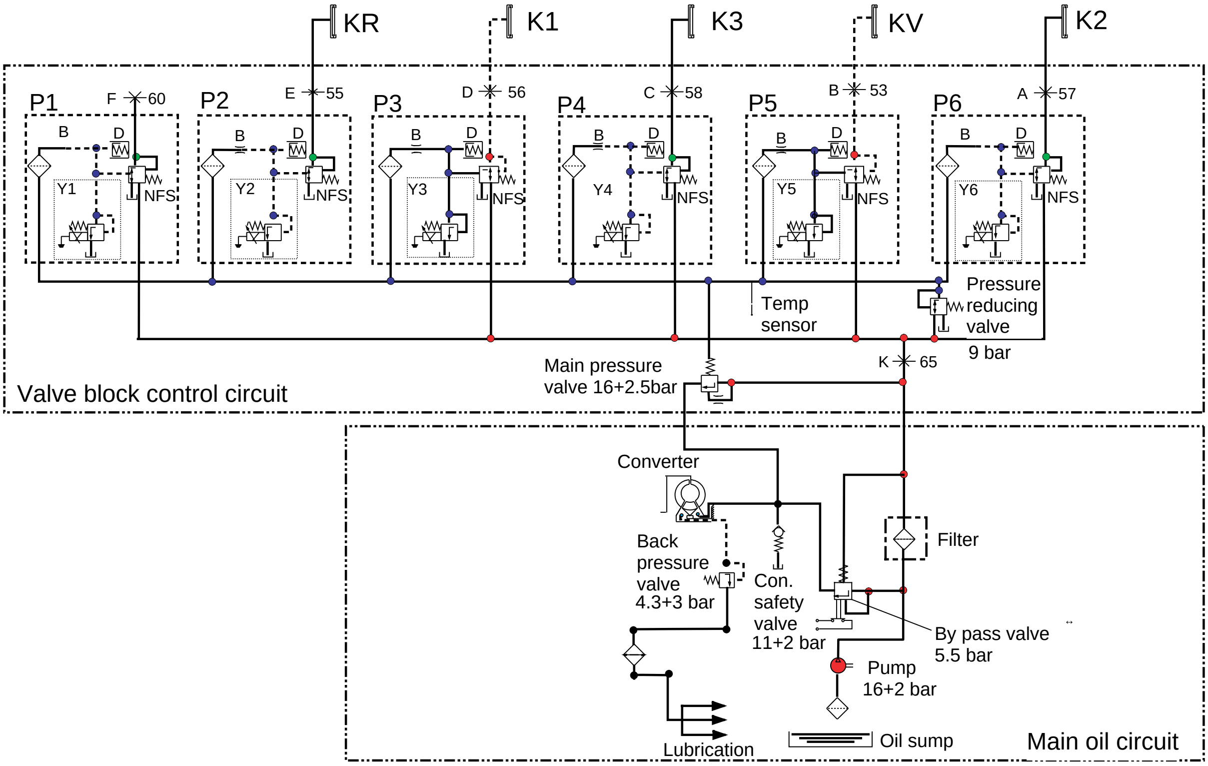
D507PT01

The power train consists of the following components :

- Torque converter
- Transmission
- Propeller shaft
- Drive axle

Engine power is transmitted to the transmission through the torque converter.
The transmission is a hydraulically engaged three speed forward, three speed reverse power shift type transmission.
The transmission outputs through universal joints to drive axle assembly.
The power transmitted to front axle drives front wheels.

· Hydraulic circuit

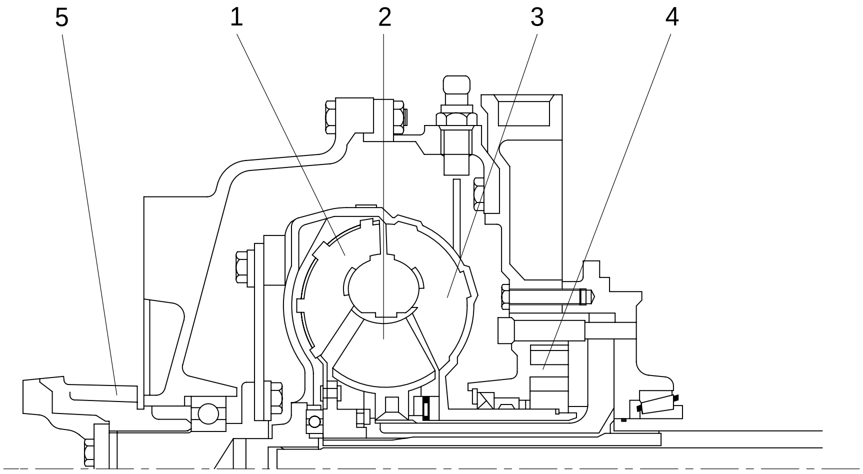


D507PT31

Speed	Forward			Reverse			Neutral	Positions on the valve block	No. of measuring points
	F1	F2	F3	R1	R2	R3			
Y1							-	F	60
Y2				●	●	●	-	E	55
Y3	●			●			-	D	56
Y4			●			●	-	C	58
Y5	●	●	●				-	B	53
Y6		●			●		-	A	57
Clutch engaged	KV, K1	KV, K2	KV, K3	KR, K1	KR, K2	KR, K3	-	-	-

NFS Follow-on slide
D Vibration damper
B Orifice
P1 Not used
P2 Proportional valve KR
P3 Proportional valve K1
P4 Proportional valve K3
P5 Proportional valve KV
P6 Proportional valve K2
Y1~Y6 Pressure regulators

2. TORQUE CONVERTER



1	Turbine	3	Pump	5	Input shaft
2	Stator	4	Transmission pump		

The converter is working according to the Trilok-system, i.e. it assumes at high turbine speed the characteristics, and with it the favorable efficiency of a fluid 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-shape system that the fluid is streaming through the circuit components in the indicated order.

Pressure oil is constantly streaming 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 dissipated through the escaping oil.
The oil, escaping out of the pump wheel, enters the turbine wheel and is there inversed in the direction of flow.

According to the rate of inversion, the turbine wheel and with it also the output shaft, receive 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.
Due to the inversion, the stator receives a reaction moment.
The relation turbine moment/pump moment is called torque conversion. This is the higher the greater the speed difference of pump wheel and turbine wheel will be.

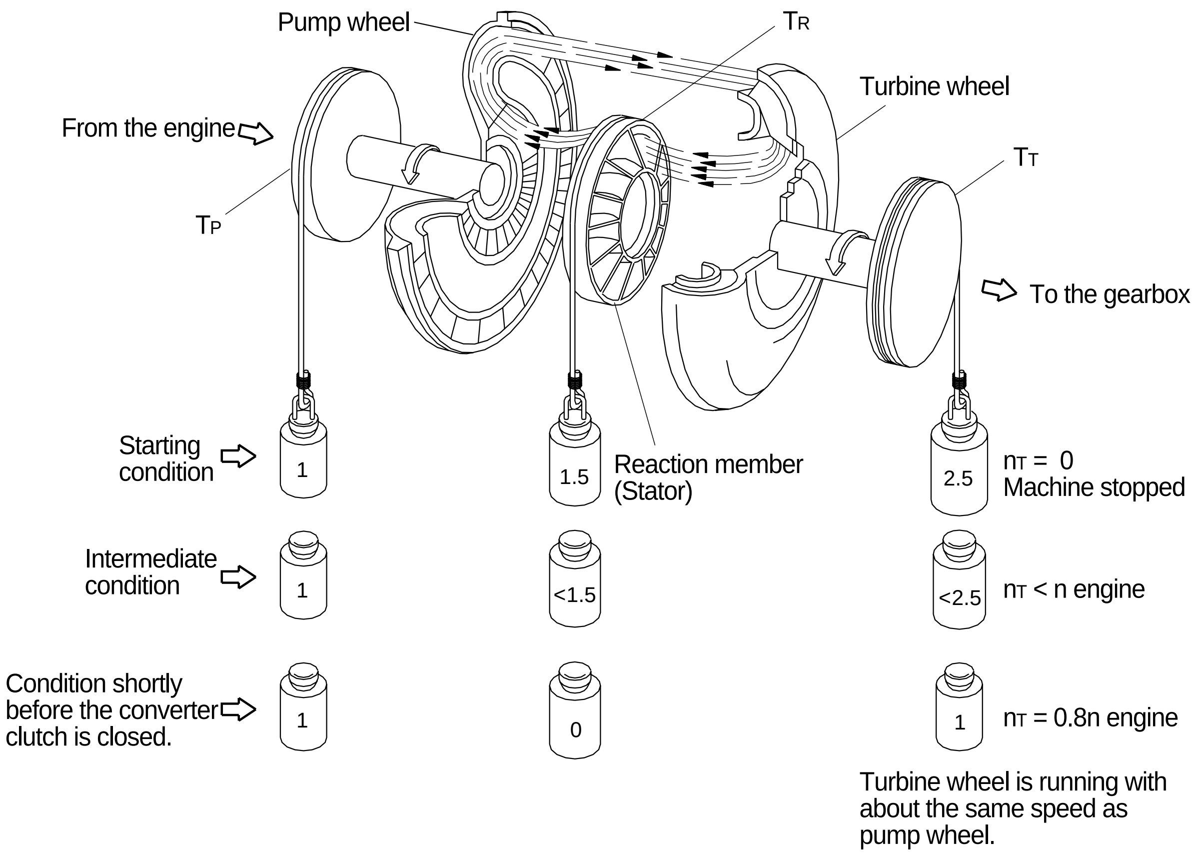
Therefore, the maximum conversion is created at standing turbine wheel.
With increasing output speed, the torque conversion is decreasing. The adoption of the output speed to a certain required output moment is infinitely variable and automatically achieved by the torque converter.

If the turbine speed is reaching about 80% of the pump speed, the conversion becomes 1.0 i.e. the turbine moment becomes equal to that of the pump moment.
From this point on, the converter is working similar to a fluid clutch.

A stator freewheel serves to improve the efficiency in the upper driving range, it is backing up in the conversion range the moment upon the housing, and is released in the coupling range.
In this way, the stator can rotate freely.

Function of a hydrodynamic torque converter(Schematic view)

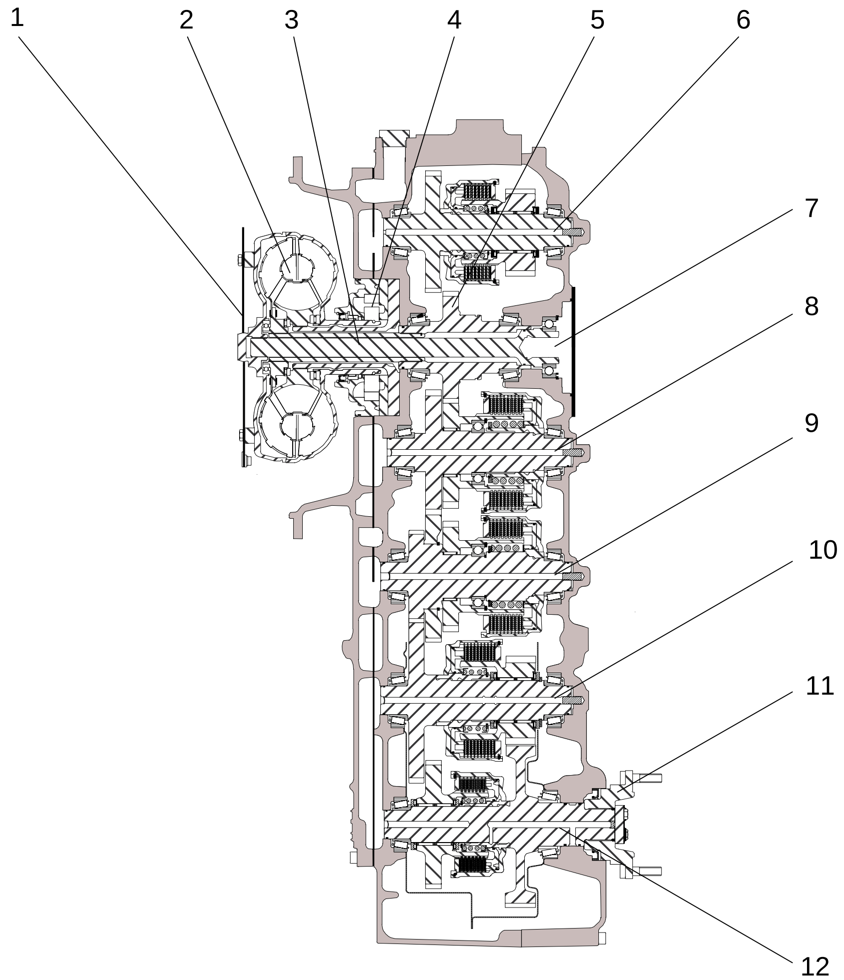
T_P = Torque of the pump wheel
T_T = Torque of the turbine wheel
T_R = Torque of the reaction member(Stator)



D503TM02

3. TRANSMISSION

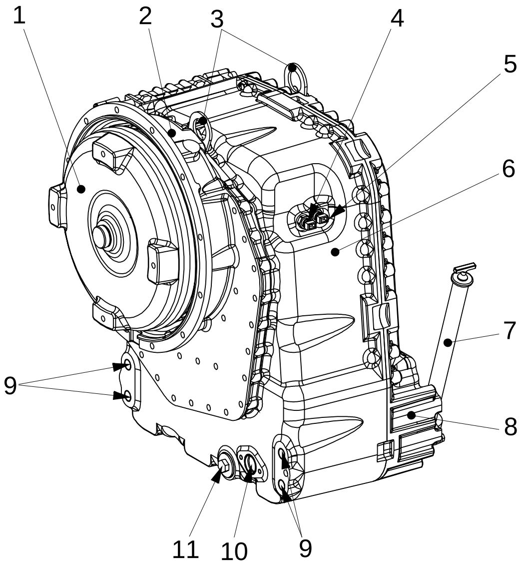
1) LAYOUT



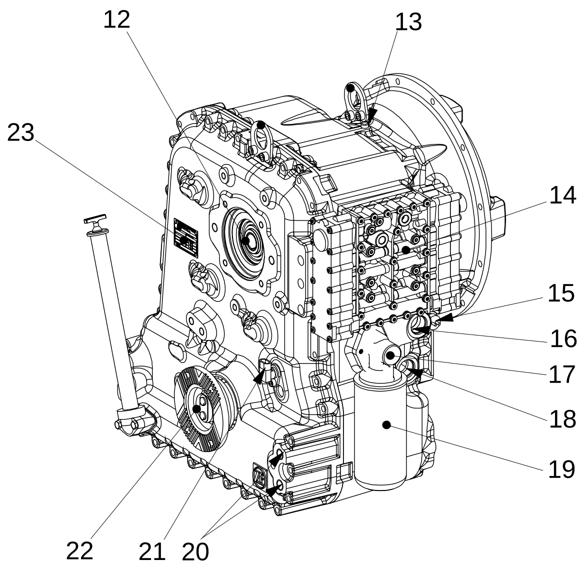
D507TM03

1	Engine connection	5	Input gear	9	Clutch shaft(KR)
2	Converter	6	Clutch shaft	10	Clutch shaft(K1)
3	Input shaft	7	Power take-off	11	Output flange
4	Transmission pump	8	Clutch shaft(KV)	12	Clutch shaft(K3/output)

2) INSTALLATION VIEW



FRONT VIEW



REAR VIEW

D507PT26

1	Converter	13	Breather
2	Converter bell	14	Electro - hydraulic control
3	Lifting lugs	15	Temperature sensor behind the converter
4	Inductive transmitter n central gear train	16	Connection to the oil cooler
5	Inductive transmitter n turbine	17	Filter head
6	Gearbox housing - Front section	18	Connection from the oil cooler
7	Oil level tube with oil dipstick	19	Exchange filter
8	Gearbox housing - Rear section	20	Transmission suspension holes M20
9	Transmission suspension holes M20	21	Speed sensor n output
10	Attachment possibility oil level tube with oil dipstick	22	Output flange
11	Oil drain plug M38×1.5	23	Type plate
12	Power take - off		

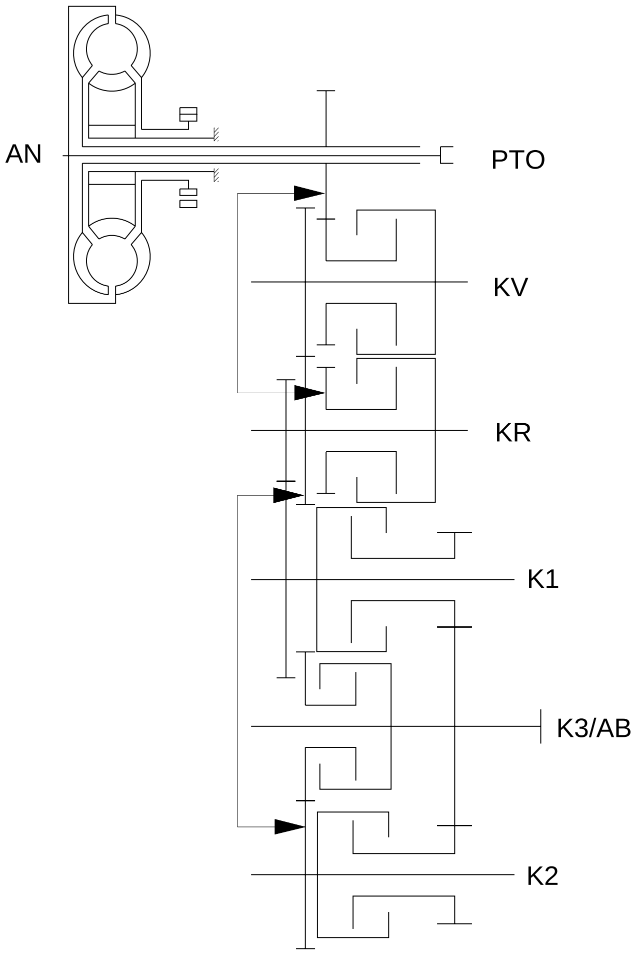
3) OPERATION OF TRANSMISSION

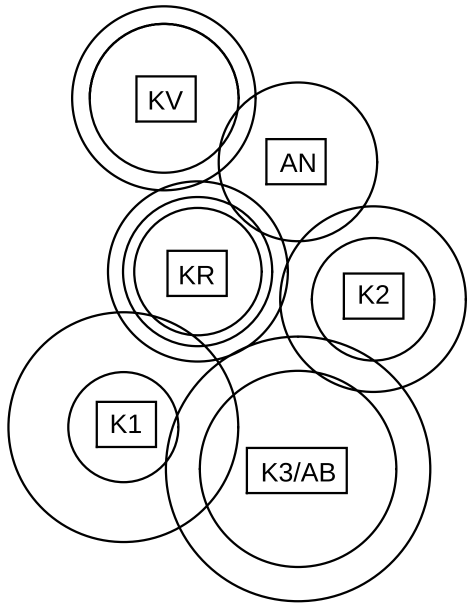
(1) Gearbox diagram

The multi-speed reversing transmission in countershaft design is power shiftable by hydraulically actuated multi-disk clutches.

All gears are constantly meshing and carried on antifriction bearings.
The gear wheels, bearings and clutches are cooled and lubricated with oil.
The 3-speed reversing transmission is equipped with 5 multi-disk clutches.
At the shifting, the actual plate pack is compressed by a piston, movable in axial direction, which is pressurized by pressure oil.

A compression spring takes over the pushing bask of the piston, thus the release of the plate pack. As to the layout of the transmission as well as the specifications of the closed clutches in the single speeds.





Legend:

AN = Input
KV = Clutch forward
KR = Clutch reverse
K1 = Clutch 1st speed
K2 = Clutch 2nd speed
K3 = Clutch 3rd speed/output
PTO = Power take-off

Diagram Clutches

Driving direction	Speed	Clutch
Forward	1	KV/K1
	2	KV/K2
	3	KV/K3
Reverse	1	KR/K1
	2	KR/K2
	3	KR/K3

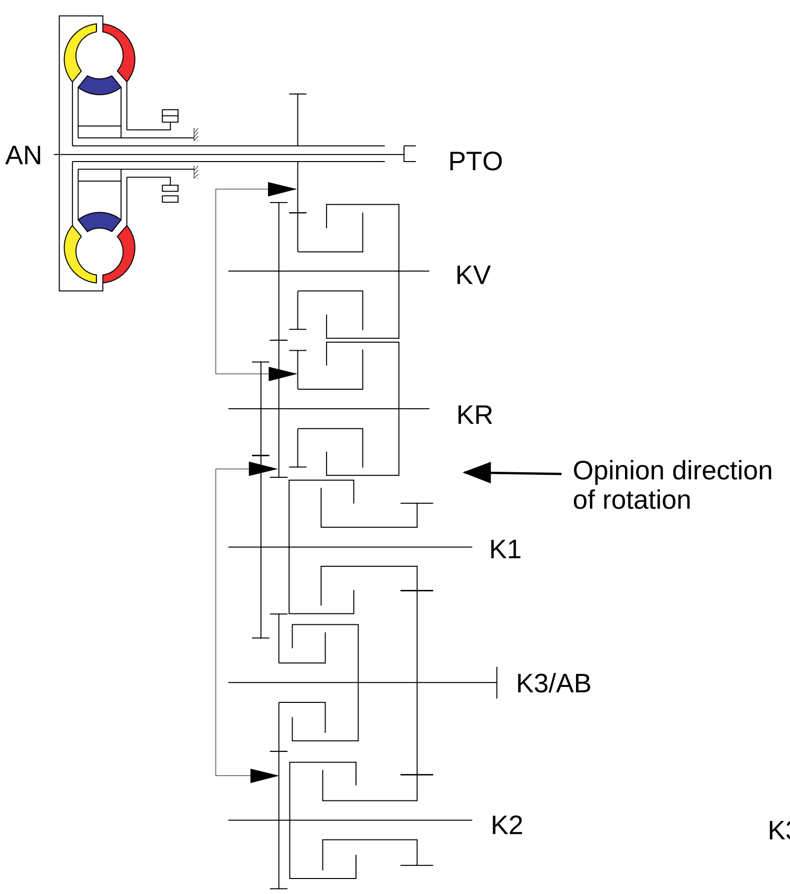
D507PT32

(2) Forward

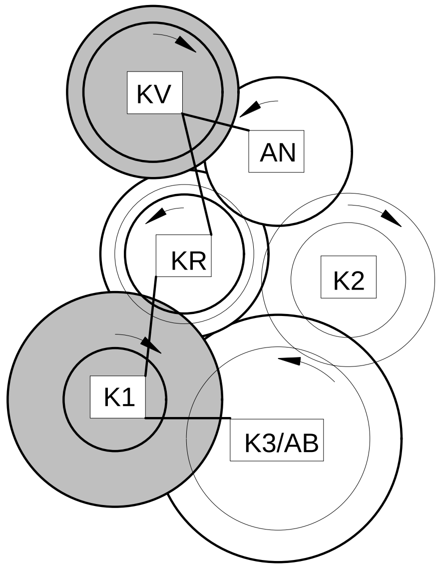
In forward, forward clutch and 1st, 2nd, 3rd clutch are engaged.

Forward clutch and 1st, 2nd, 3rd clutch are actuated by the hydraulic pressure applied to the clutch piston.

Transmission diagram



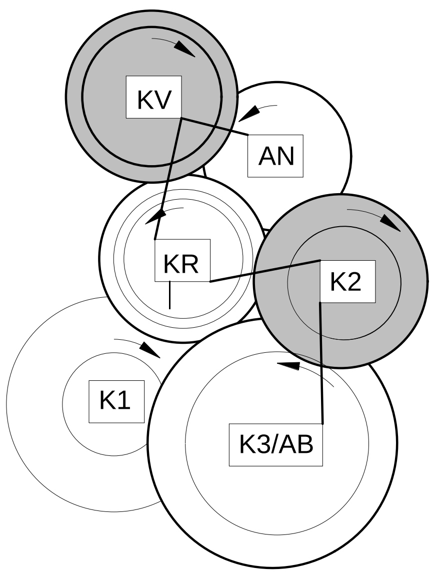
1st speed-forward



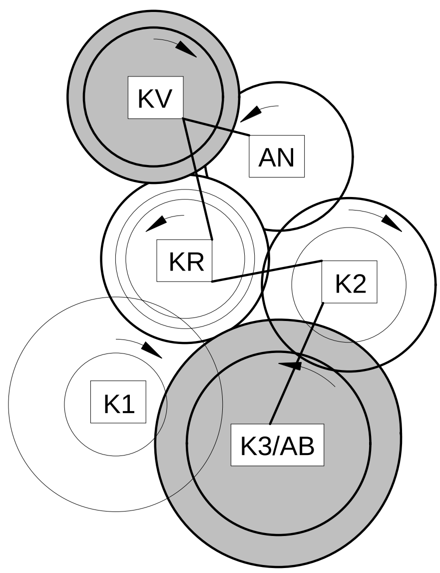
Legend:

AN = Input
KV = Clutch forward
KR = Clutch reverse
K1 = Clutch 1st speed
K2 = Clutch 2nd speed
K3/AB = Clutch 3rd speed/output
PTO = Power take-off

2nd speed-forward



3rd speed-forward



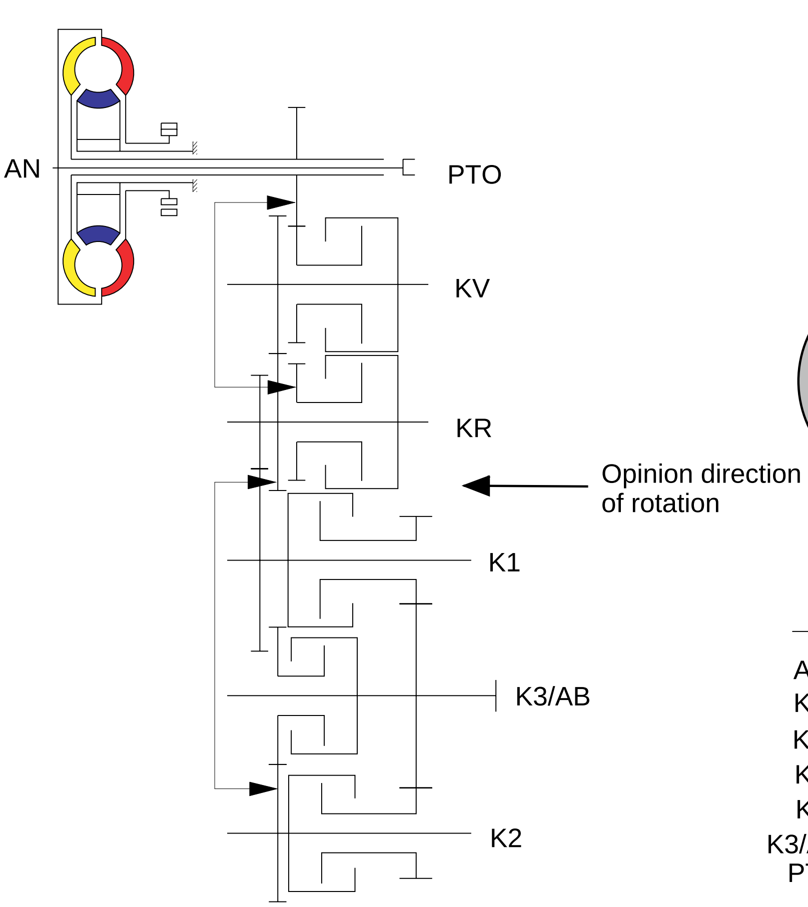
D503PT33

(3) Reverse

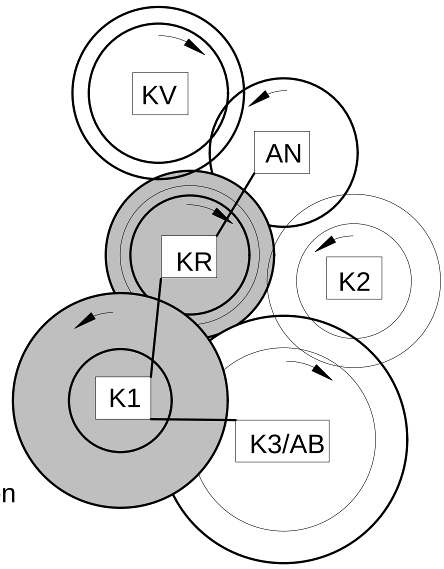
In reserve, reserve clutch and 1st, 2nd, 3rd clutch are engaged.

Reverse clutch and 1st, 2nd, 3rd are actuated by the hydraulic pressure applied to the clutch piston.

Transmission diagram



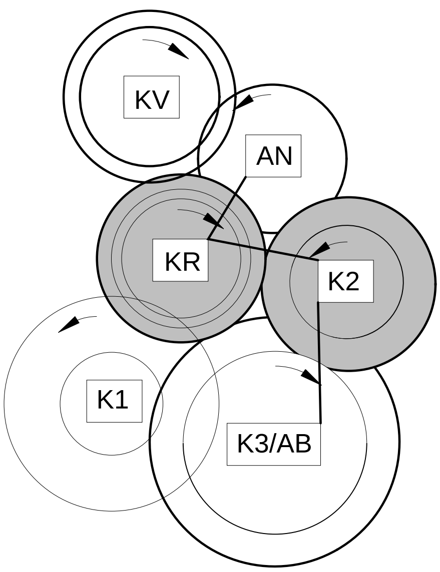
1st speed-reverse



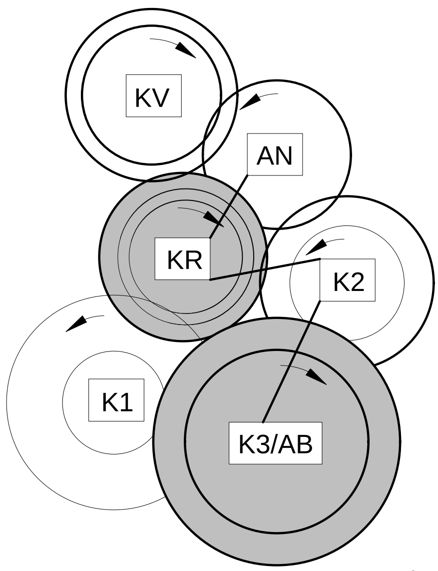
Legend:

AN = Input
KV = Clutch forward
KR = Clutch reverse
K1 = Clutch 1st speed
K2 = Clutch 2nd speed
K3/AB = Clutch 3rd speed/output
PTO = Power take-off

2nd speed-reverse



3rd speed-reverse



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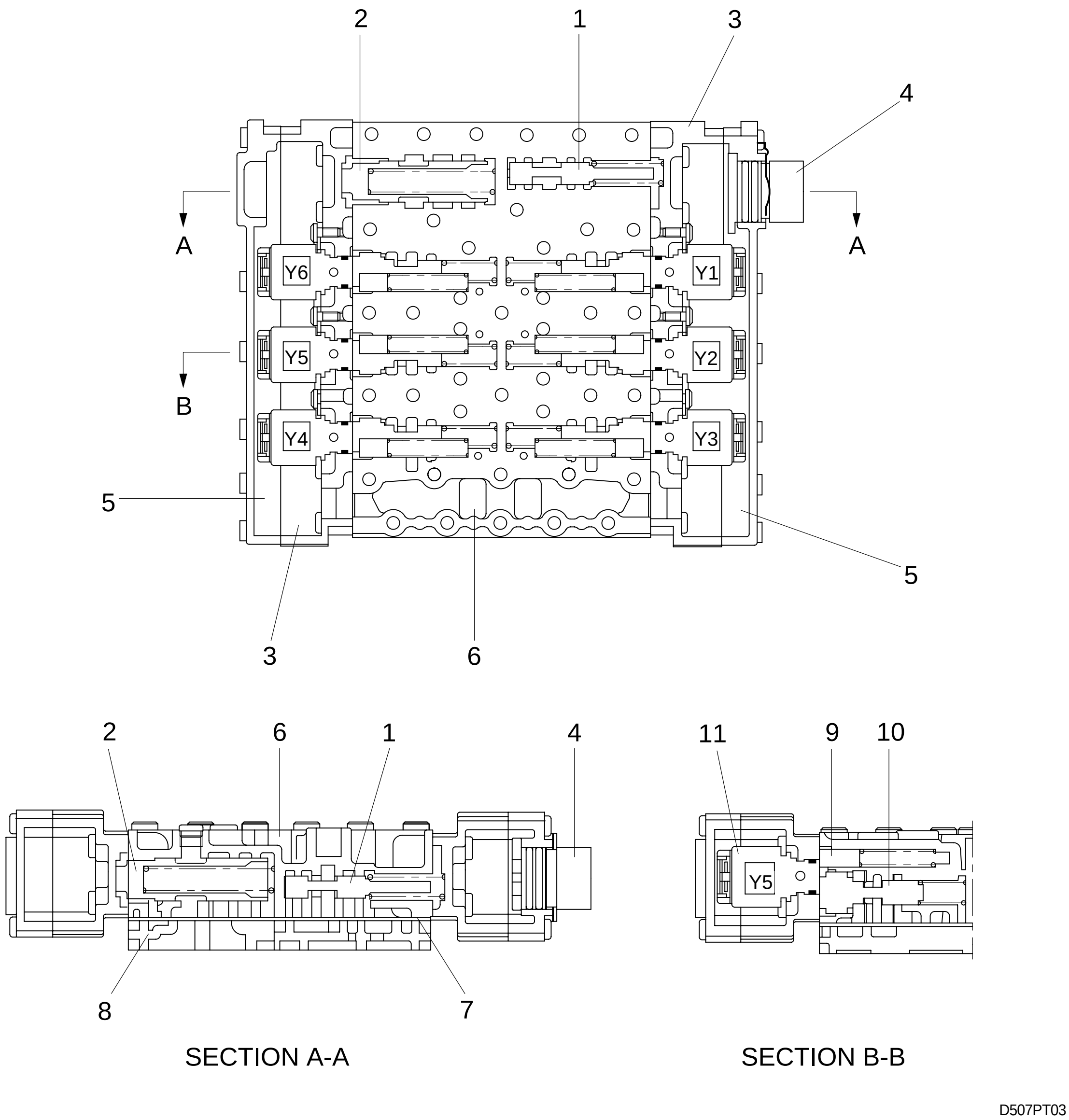
4) ELECTRO-HYDRAULIC SHIFT CONTROL WITH PROPORTIONAL VALVE



1	Pressure reducing valve(9bar)	7	Intermediate plate
2	Main pressure valve (16 + 2bar)	8	Duct plate
3	Housing	9	Vibration damper
4	Plug(cable harness)	10	Follow - on slide
5	Cover	11	Pressure regulator
6	Valve block		

Transmission control, see schedule of measuring points, Oil circuit diagram and Electro-hydraulic control unit see page 3-2, 3-10.

The transmission pump, necessary for the oil supply of the converter, and for the transmission control, is sitting in the transmission on the engine-dependent input shaft.

The feed rate of the pump is
$Q = 85\ \ell/\mathrm{min}$, at $n_{Motor} = 2000\ \mathrm{min}^{-1}$
This pump is sucking the oil via the coarse filter out of the oil sump and delivers it via the fine filter - the filter can also be fitted externally from the transmission - to the main pressure valve.

If because of contamination, resp. damage, the through-flow through the fine filter is not ensured, the oil will be directly conducted via a filter differential pressure valve(bypass valve ¡ p = 5.5+3bar) to the lubrication.
In this case, an error indication is shown on the display.

The five clutches of the transmission are selected via the 6 proportional valves P1 to P6(P1 will not be under current at the 3-speed version, i.e. without function).
The proportional valve(pressure regulator unit) is composed of pressure regulator(e.g. Y6), follow-on slide and vibration damper.

The control pressure of 9 bar for the actuation of the follow-on slides is created by pressure reducing valve. The pressure oil(16+2bar) is directed via the follow-on slide to the respective clutch.

Due to the direct proportional selection with separated pressure modulation for each clutch, the pressure to the clutches, which are engaged in the gear change, will be controlled. In this way, a hydraulic intersection of the clutches to be engaged and disengaged becomes possible.
This is creating spontaneous shftings without traction force interruption.

At the shifting, the following criteria will be considered :
- Speed of engine, turbine, central gear train and output.
- Transmission temperature.
- Shifting mode(up-,down-, reverse shifting and speed engagement out of Neutral).
- Load condition(full and part load, traction, overrun inclusive consideration of load cycles during the shifting).

The main pressure valve is limiting the max. control pressure to 16+2.5bar and releases the main stream to the converter and lubrication circuit.
In the inlet to the converter, a converter safety valve is installed which protects the converter from high internal pressures(opening pressure 11+2bar).
Within the converter, the oil serves to transmit the power according to the well-known hydrodynamic principle(see Chapter torque converter page 3-3).
To avoid cavitation, the converter must be always completely filled with oil.

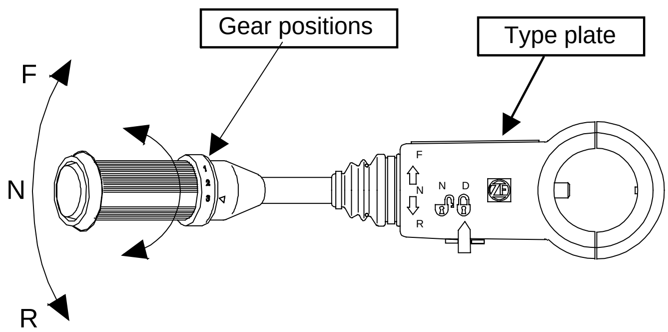
This is achieved by converter pressure back-up valve, rear-mounted to the converter, with an opening pressure of at least 4.3+3bar.
The oil, escaping out of the converter, is directed to the oil cooler.

From the oil cooler, the oil is directed to the transmission and there to the lubricating oil circuit, so that all lubricating points are supplied with cooled oil.
In the electrohydraulic control unit are 6 pressure regulators installed.

5) GEAR SELECTOR(DW-3)

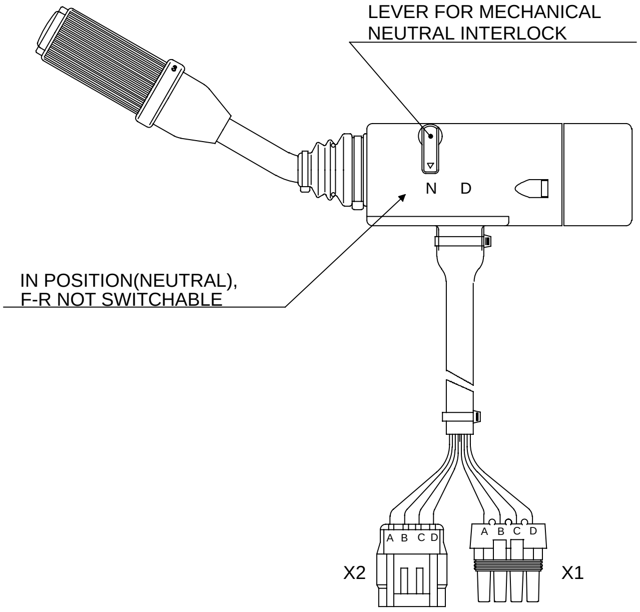
The gear selector is designed for the mounting on the steering column left side. By a rotative motion, the positions(speeds) 1 to 3 are selected by tilting the lever, the driving direction(Forward (F) - Neutral(N) - Reverse(R)).

For the protection from unintended start off, a neutral interlock is installed :
Position "N" - Controller lever blocked in this position
Position "D" - Driving



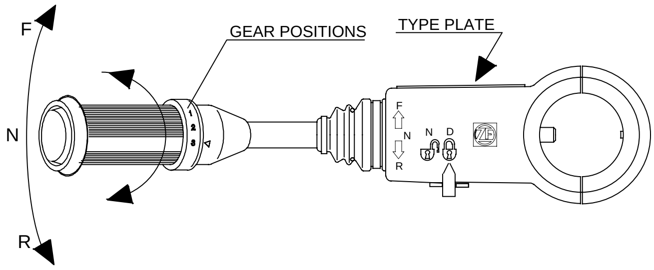
D507PT12

Gear selector(DW-3)



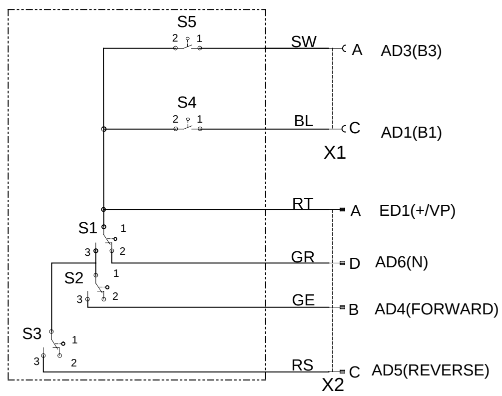
CODING GEAR SELECTOR

SPEED		OUTPUT								
		FORWARD			REVERSE			NEUTRAL		
		1	2	3	1	2	3	1	2	3
AD1	B1	●			●			●		
AD2	B2									
AD3	B3	●	●		●	●		●	●	
AD4	V	●	●	●						
AD5	R				●	●	●			
AD6	N							●	●	●

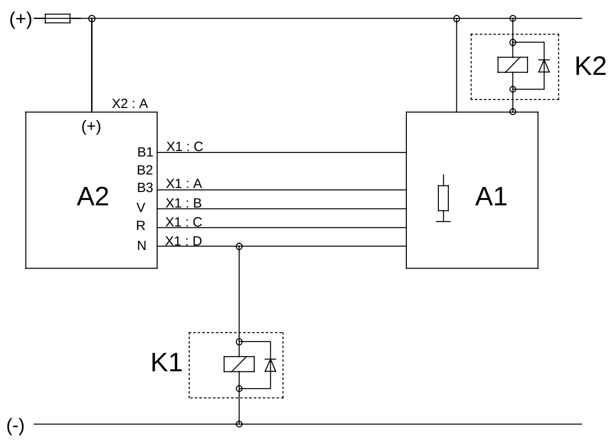


F = FORWARD
N = NEUTRAL
R = REVERSE
D = MECANICAL NEUTRAL INTERLOCK
1 = 1st SPEED
2 = 2nd SPEED
3 = 3rd SPEED

CIRCUIT DIAGRAM SELECTOR



CONNECTION DIAGRAM SELECTOR



K1 = RELAY STARTER INTERLOCK
K2 = RELAY REVERSE LIGHTS
A1 = TCU(Transmission Control Unit)
A2 = CONTROLLER

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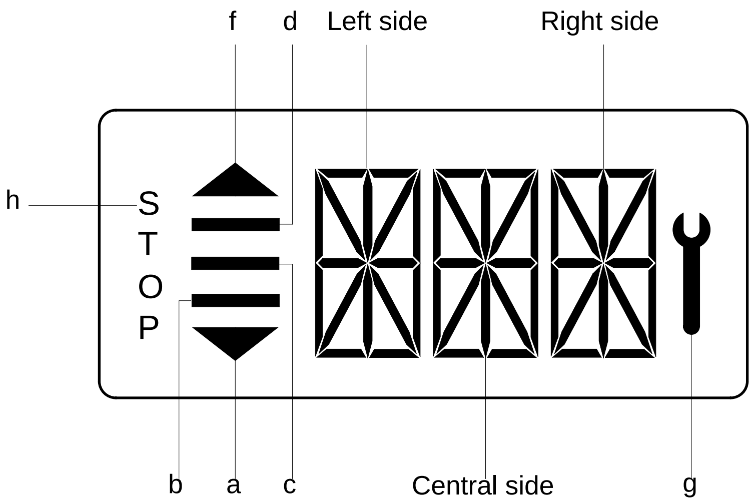
6) TRANSMISSION ERROR DISPLAY

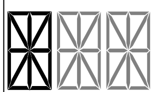
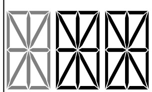
(1) Function

The display can be used with the gear selector. It indicates speed and driving direction as well as the activated inching.

When driving in the automatic mode, a bar indicator gives additionally also information about the selected driving range; The automatic range is symbolized by arrows above and below the bar indicator. In case of possible errors in the system, a wrench appears on the display, combined with indication of the error number. Also sporadically occurring errors can be indicated.



D507CD33

1	Bars	a, f	Automatic range(up and down shifting)
		b, c, d,	Preselected gear
2	Left side		For the moment still without function
3	Central and Right side		On the two alphanumeric 16-segment display, the electric control unit issues the actual state of gear and driving direction. Besides, a two digit error code will be indicated via these two segment
4	Spanner	g	Electronic control unit recognized an error, is flashing
5	Letters **STOP**	h	Immediate stop is required(At the moment not activated)

(2) Abbreviations

OC : Open circuit
SC : Short circuit
OP mode : Operating mode
TCU : Transmission control unit
EEC : Electronic engine controller
PTO : Power take off

(3) Display during operation

Symbol	Meaning	Remarks
F, N, R 1, 2, 3	Actual gear and direction Central side shows actual gear Right side shows actual direction	
NN (Central and right side)	Not neutral, waiting for neutral after power up or a severse fault	To engage a gear, first move shift selector to neutral position and again to F to R position
1 bar	Manual mode lst gear	
2 bar	Manual mode 2nd gear	
3 bar	Manual mode 3nd gear	
3bars and 2 arrows	Automatic mode	a, f
	Transmission neutral	Cold start phase
Spanner flashing	At least on fault active	Select neutral to get fault code displayed
WT	Warning torgue converter temperature	Changes between actual gear/direction while driving, in neutral only displayed if no fault is detected(spanner)
WS	Warning sump temperature	Changes between actual gear/direction while driving, in neutral only displayed if no fault is detected(spanner)
WE	Warning high engine speed	Changes between actual gear/direction while driving, in neutral only displayed if no fault is detected(spanner)
PN	Direction F or R selected while parking brake engaged	Transmission in neutral until parking brake is released. ※ Machine starts to move after release of parking brake.
F or R flashing	Direction F or R selected while turbine speed is to high	※ Gear will engage when turbine speed drops
EE flashing (central and right side)	No communication with display	

(4) Definition of the error codes

① Introduction

The error codes consists of two hexadecimal numbers.

The first number shows the type of signal, the second number shows signal and the type of the error.

② Description of error codes

First No.	Meaning of number
1 hex	Digital input signals
2 hex	Analog input signals
3 hex	Speed signals
4 hex	Speed signals
7 hex	Analog current output signals
8 hex	Analog current output signals
9 hex	Digital output signals
A hex	Digital output signals
B hex	Clutch errors
D hex	Power supply
E hex	High speed signals
F hex	General errors

③ List of error codes

Number	Meaning of error code	
11 hex	Logical error at gear range signal	
12 hex	Logical error at direction select signal	
21 hex	Short circuit to battery voltage at clutch cutoff input	
22 hex	Short circuit to ground or open circuit at clutch cutoff input	
23 hex	Short circuit to battery voltage at load sensor input	not used
24 hex	Short circuit to ground or open circuit at load sensor input	not used
25 hex	Short circuit to battery voltage or open circuit at temperature sensor input	
26 hex	Short circuit to ground at temperature sensor input	
31 hex	Short circuit to battery voltage at engine speed input	
32 hex	Short circuit to ground or open circuit at engine speed input	
33 hex	Logical error at engine speed input	
34 hex	Short circuit to battery voltage at turbine speed input	
35 hex	Short circuit to ground or open circuit at turbine speed input	
36 hex	Logical error at turbine speed input	
37 hex	Short circuit to battery voltage at internal speed input	
38 hex	Short circuit to ground or open circuit at internal speed input	
39 hex	Logical error at internal speed input	

Number	Meaning of error code	
3A hex	Short circuit to battery voltage or open circuit at output speed input	
3B hex	Short circuit to ground or open circuit at output speed input	
3C hex	Logical error at output speed input	
71 hex	Short circuit to battery voltage at clutch K1	
72 hex	Short circuit to ground at clutch K1	
73 hex	Open circuit at clutch K1	
74 hex	Short circuit to battery voltage at clutch K2	
75 hex	Short circuit to ground at clutch K2	
76 hex	Open circuit at clutch K2	
77 hex	Short circuit to battery voltage at clutch K3	
78 hex	Short circuit to ground at clutch K3	
79 hex	Open circuit at clutch K3	
7A hex	Short circuit to battery voltage at converter clutch	not used
7B hex	Short circuit to ground at converter clutch	not used
7C hex	Open circuit at converter clutch	not used
81 hex	Short circuit to battery voltage at clutch K4	
82 hex	Short circuit to ground at clutch K4	
83 hex	Open circuit at clutch K4	
84 hex	Short circuit to battery voltage at clutch KV	
85 hex	Short circuit to ground at clutch KV	
86 hex	Open circuit at clutch KV	
87 hex	Short circuit to battery voltage at clutch KR	
88 hex	Short circuit to ground at clutch KR	
89 hex	Open circuit at clutch KR	
91 hex	Short circuit to ground at relay reverse warning alarm	
92 hex	Short circuit to battery voltage at relay reverse warning alarm	
93 hex	Open circuit at relay reverse warning alarm	
94 hex	Short circuit to ground at relay starter interlock	
95 hex	Short circuit to battery voltage at relay starter interlock	
96 hex	Open circuit at relay starter interlock	
97 hex	Short circuit to ground at park brake solenoid	
98 hex	Short circuit to battery voltage at park brake solenoid	
99 hex	Open circuit at park brake solenoid	

Number	Meaning of error code	
B1 hex	Slippage at clutch K1	
B2 hex	Slippage at clutch K2	
B3 hex	Slippage at clutch K3	
B4 hex	Slippage at clutch K4	
B5 hex	Slippage at clutch KV	
B6 hex	Slippage at clutch KR	
D1 hex	Short circuit to battery voltage at power supply for sensors	
D2 hex	Short circuit to ground at power supply for sensors	
D3 hex	Low voltage at battery	
D4 hex	High voltage at battery	
D5 hex	Error at valve power supply 1	
D6 hex	Error at valve power supply 2	
E1 hex	Short circuit to battery voltage at speedometer output	not used
E2 hex	Short circuit to ground or open circuit at speedometer output	not used
E3 hex	Short circuit to battery voltage at display output	not used
E4 hex	Short circuit to ground at display output	not used
E5 hex	Communication failure on devicenet	
F1 hex	General EEPROM fault	
F2 hex	Configuration lost	
F3 hex	Application error	

7) ELECTRONIC CONTROL FOR POWER TRANSMISSION

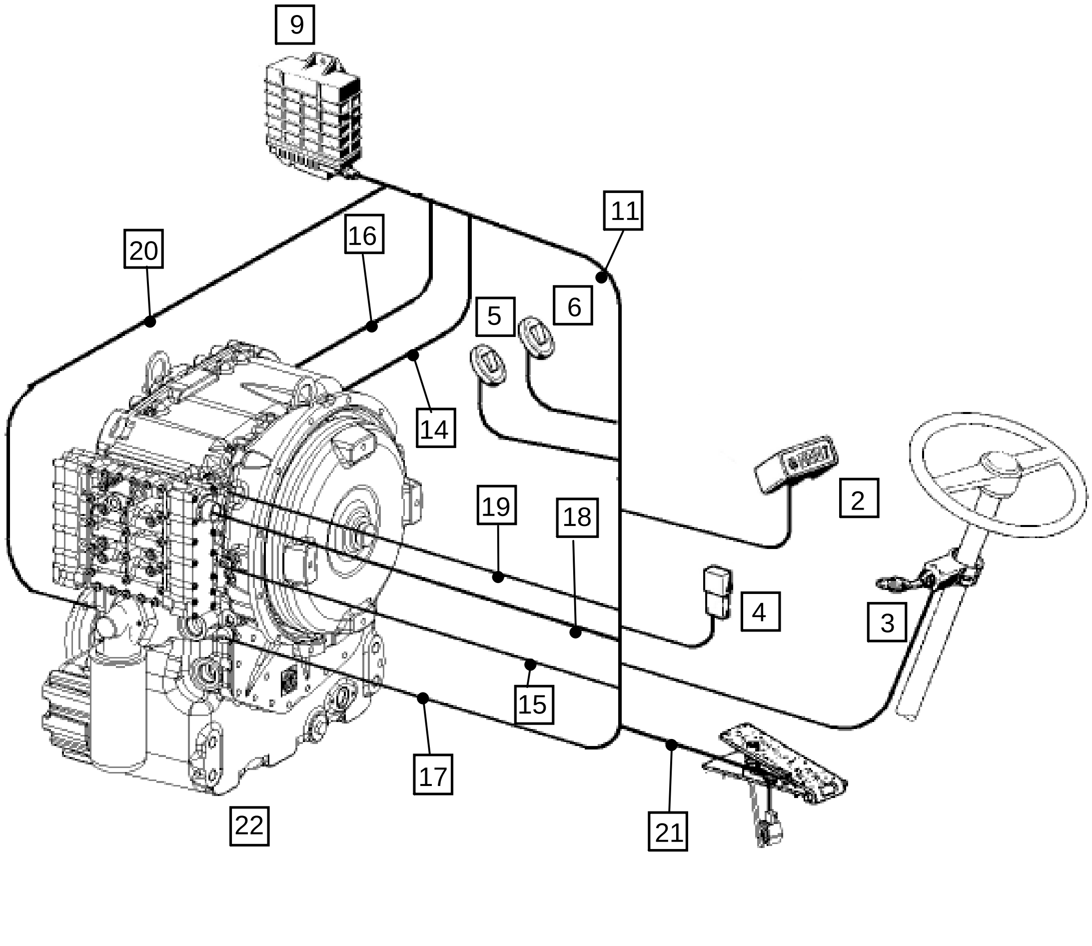
(1) Description of the basic functions

The powershift transmission is equipped with TCU.

· The system is processing the desire of the driver according to the following criteria :
· Gear determination depending on gear selector position, driving speed and load condition.
· Protection from operating error as far as necessary, is possible via electronic protecttion(programming).
· Protection from over-speeds(on the base of engine and turbine speed).
· Electronic inching.

Legend

2 = Display
3 = Gear selector DW - 3
4 = Power supply connection
5 = Switch for enable inched(Option)
6 = Switch for driving program manual/Auto 1/Auto 2
9 = TCU(EST-37A)
11 = Wiring
14 = Cable to inductive transmitter speed central gear train
15 = Cable to inductive speed engine
16 = Cable to inductive transmitter speed turbine
17 = Cable to temperature measuring point behind the converter
18 = Cable to plug connection on the electrohydraulic control unit
19 = Cable to filter contamination switch
20 = Cable to speed sensor output
21 = Cable from angle sensor/inch-sensor
22 = Transmission



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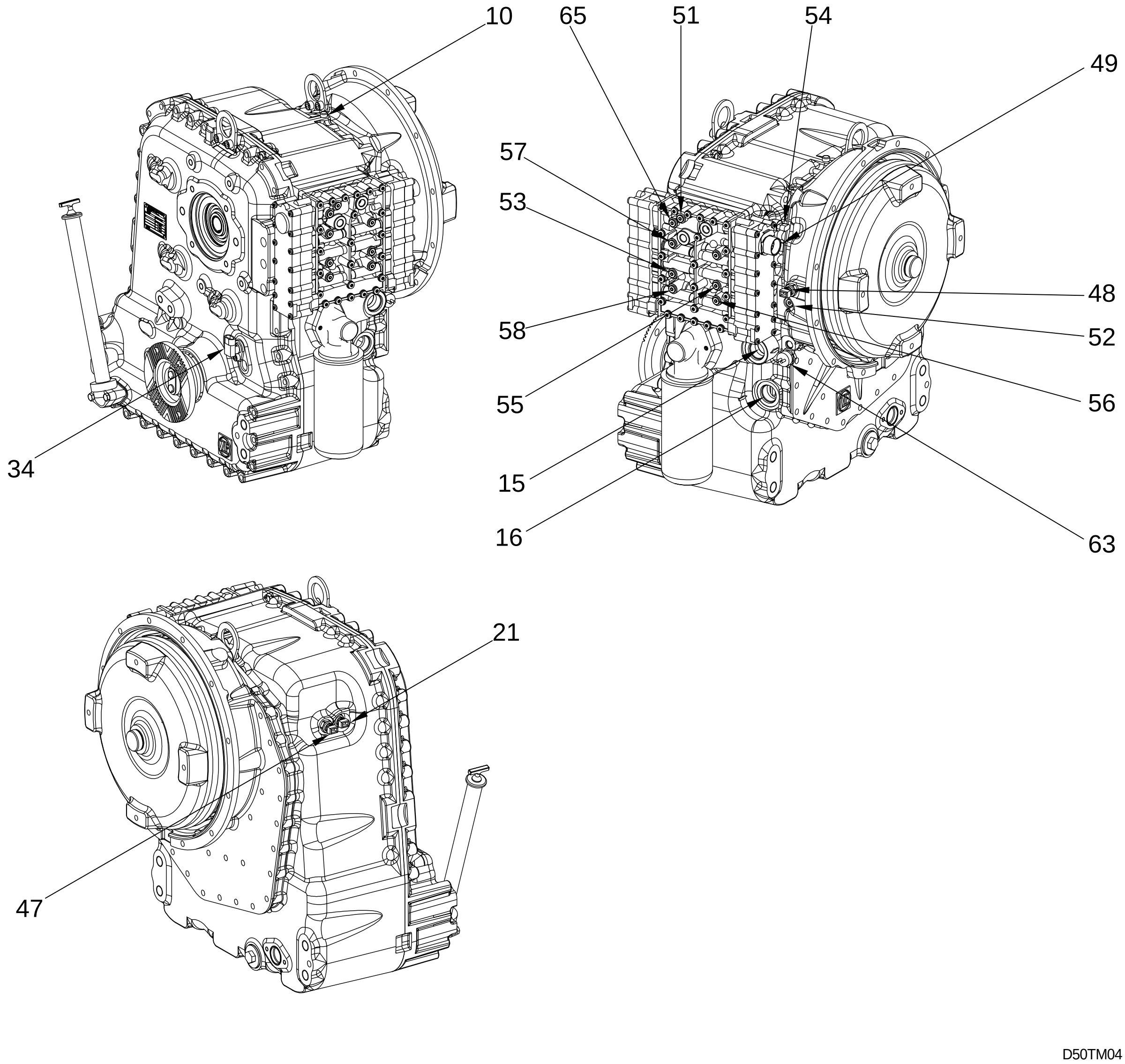
(2) Inching device

This function is especially suitable for lift trucks. It allows to reduce the driving speed infinitely variable without modification of the engine speed in such a way that driving with a very low speed will be possible. In his way, the driver can move the vehicle very exactly to a determined position. At the same time and important part of the engine power for the output of the hydraulic system is at disposal by the high engine speed.

Operation is carried out by a separate inching pedal, where an angle of rotation sensor is mounted.
By means of the proportional valve technology the TCU regulates the pressure in the driving direction clutch in such a way that the driving speed is adjusted in accordance with the inch rotating angle sensor position. Clutch overloading is avoided thanks to the electronic protection.

4. TRANSMISSION MEASURING POINTS AND CONNECTIONS

The measurement have to be carried out with hot transmission(about 80~95˚C)



1) OIL PRESSURE AND TEMPERATURE

Port	Description	Size
51	In front of converter - Opening pressure 11+2 bar	M10x1
52	Behind converter - Opening pressure 4.3 + 3 bar	M14x1.5
53	Clutch Forward 16 + 2 bar KV	M10x1
55	Clutch reverse 16 + 2 bar KR	M10x1
56	Clutch 16 + 2 bar K1	M10x1
57	Clutch 16 + 2 bar K2	M10x1
58	Clutch 16 + 2 bar K3	M10x1
63	Temperature sensor behind the converter	M14x1.5
65	System pressure 16 + 2.5 bar	M10x1

2) FLOW RATES

Port	Description	Size
15	Connection from oil cooler	1 $^5/_{16}$" - 12UN-2B
16	Connection to oil cooler	1 $^5/_{16}$" - 12UN-2B

3) TRANSMITTERS AND SWITCHES

Port	Description	Size
21	Inductive transmitter n Turbine	M18x1.5
34	Speed transmitter n Output	-
47	Inductive transmitter n Internal speed input	M18x1.5
48	Inductive transmitter n Engine	M18x1.5
54	Differential pressure switch for pressure filter	M14x1.5

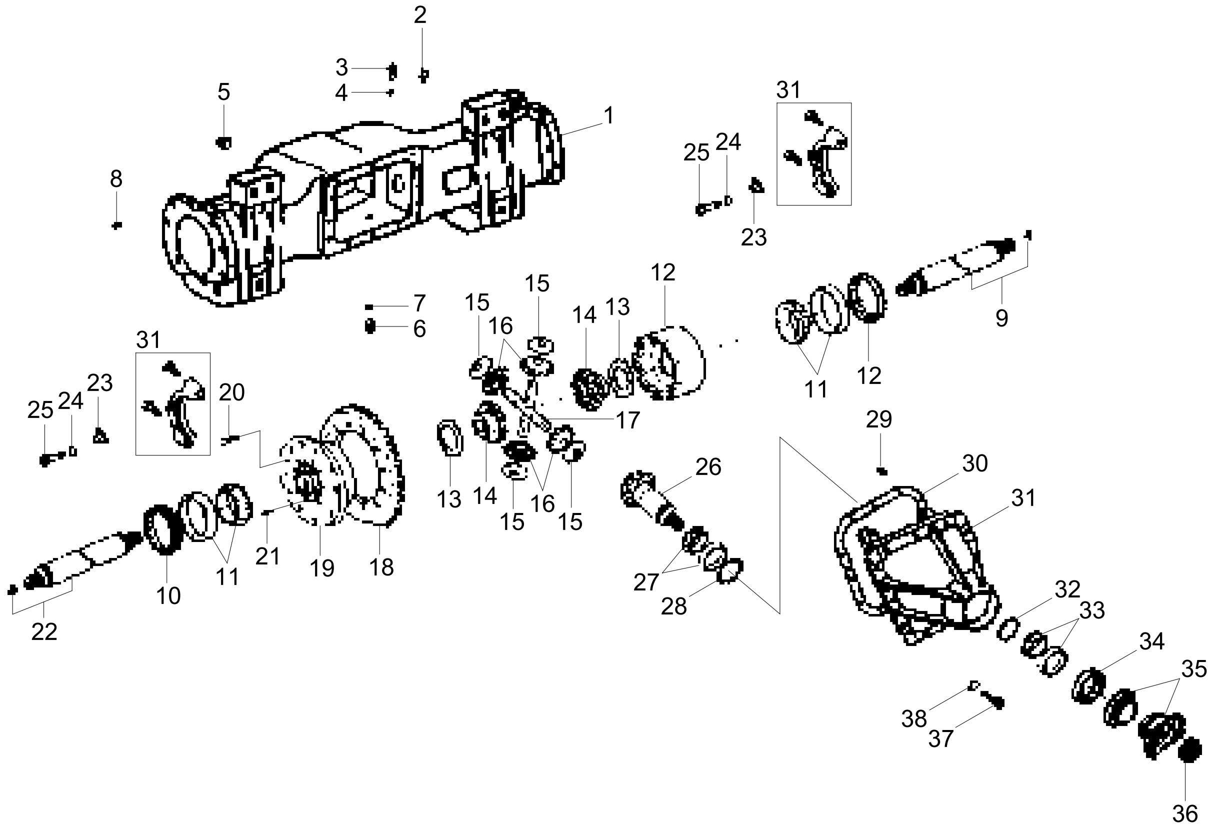
4) CONNECTIONS

Port	Description	Size
10	Breather	M10x1
49	Plug connection on electro-hydraulic control unit	

5. DRIVE AXLE

A. DRIVE AXLE

1) STRUCTURE



1	Axle housing		14	Side gear		27	Taper roller bearing	
2	Air breather		15	thrust washer		28	Shin set(0.15, 0.20, 0.25t)	
3	plug		16	Pinion gear		29	Dowel pin	
4	Gasket		17	Spider		30	Gasket	
5	Plug		18	Ring gear		31	Carrier housing assembly	
6	Plug		19	Differential case-LH		32	Spacer set(5.37, 5.40, 5.43t)	
7	O-ring		20	Wheel bolt		33	Taper roller bearing	
8	Pin		21	Bolt		34	Oil seal	
9	Drive shaft assembly-RH		22	Drive shaft assembly-LH		35	Input flange assembly	
10	Adjust nut		23	Plate		36	Nut	
11	Taper roller bearing		24	Spring washer		37	Bolt	
12	differential case-RH		25	Bolt		38	Spring washer	
13	Thrust washer		26	Pinion shaft				

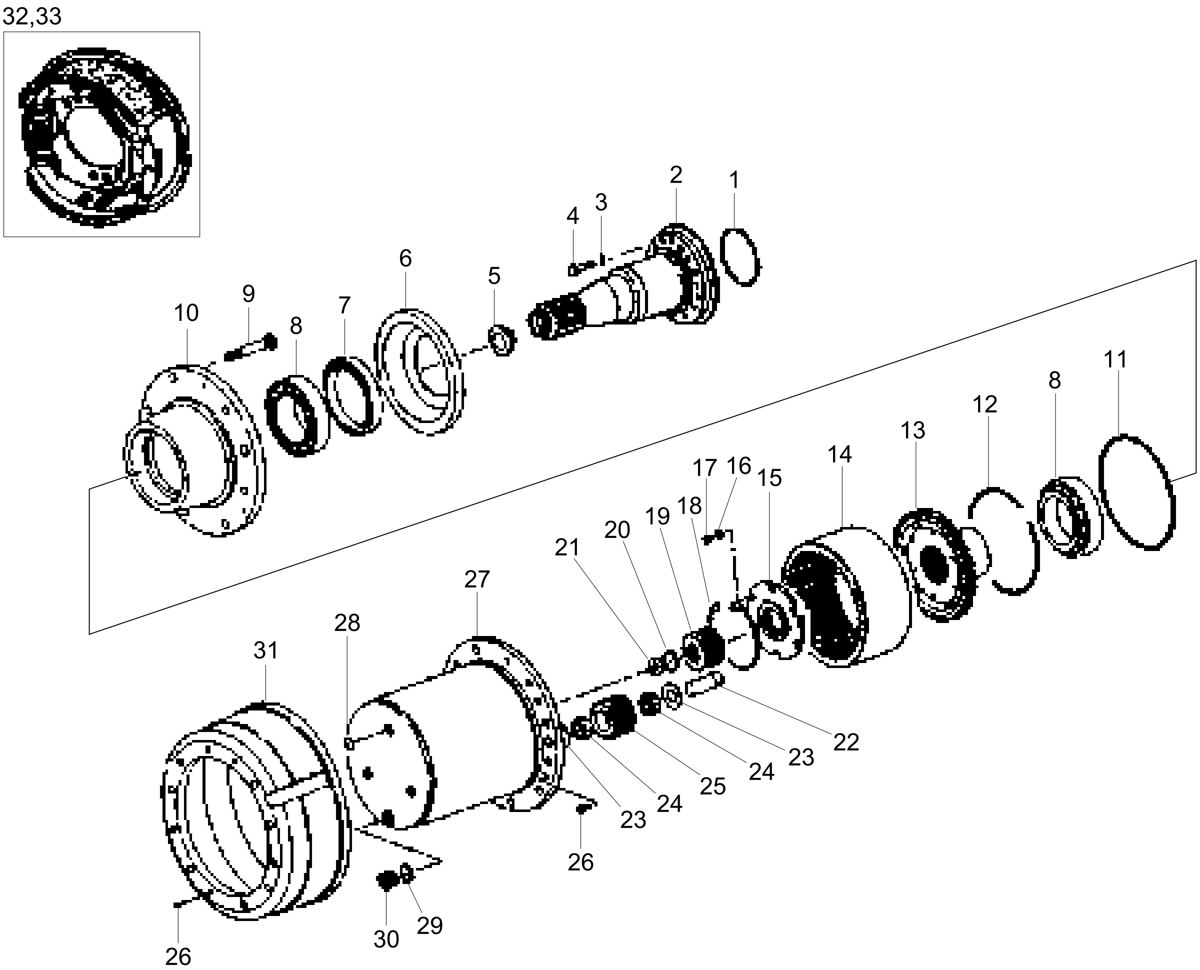
2) OPERATION

Both sides of the housing are supported by the frame and the center is mounted on the transmission case through propeller shaft.

the mast is installed on the front of the drive axle housing. The final deceleration and differential device built in the housing guarantee accurate rotation and smooth operation.

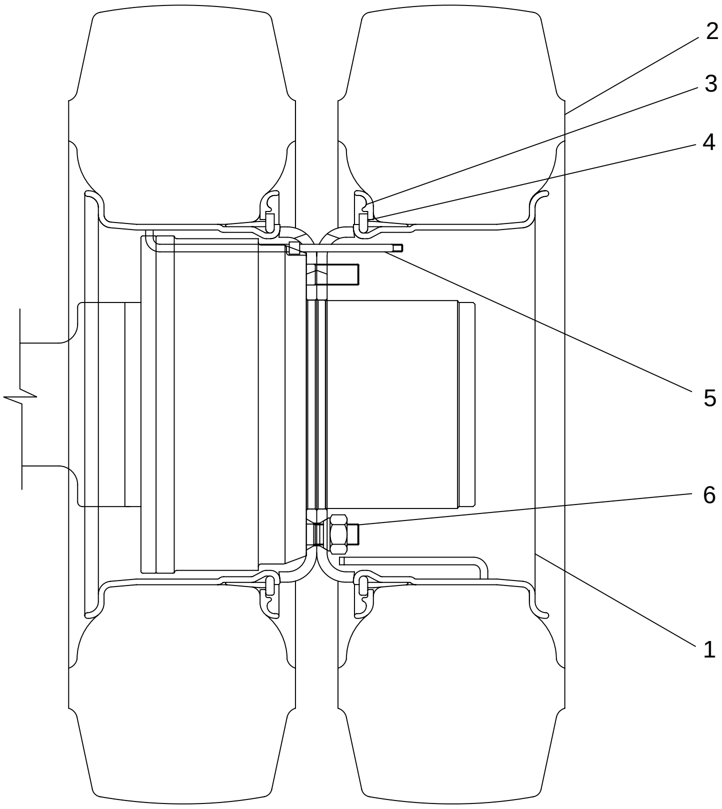
The power from the transmission in transferred through the hypoid pinion, hypoid gear, differential case, the pinion of the differential device and the side gear to the drive axle shaft by the side gear spline and to the hub and wheel mounted on the shaft by high tension bolts.

3) WHEEL HUB



1	O-ring	12	C-ring	S	23	Thrust washer
2	Brake tube	13	Carrier		24	Needle bearing
3	Washer	14	Ring gear		25	Planetary gear
4	Bolt	15	Nut		26	Bolt
5	Bushing	16	Washer		27	Planetary housing
6	Hub cover	17	bolt		28	O-ring
7	Oil seal	18	Snap ring		29	O-ring
8	Taper roller bearing	19	Sun gear		30	Plug
9	Wheel bolt	20	Snap ring		31	Brake drum
10	Wheel hub	21	Stopper		32	Wheel brake assembly-LH
11	O-ring	22	Shaft		33	Wheel brake assembly-RH

6. TIRE AND WHEEL



1	Wheel rim	3	Lock ring	5	Valve assembly
2	Tire	4	Side ring	6	Wheel nut

1) The tire acts to absorb the shock from the ground surface to the machine, and at the same time they must rotate in contact with the ground to gain the power which drives the machine.

2) Various types of tires are available to suit the purpose. Therefore it is very important to select the correct tires for the type of work.

GROUP 2 OPERATION AND MAINTENANCE

1. OPERATION

1) DRIVING PREPARATION AND MAINTENANCE

Prior to the commissioning of the transmission, take care that the prescribed oil grade will be filled in with the correct quantity. At the initial filling of the transmission has to be considered that the oil cooler, the pressure filters as well as the pipes must get filled with oil.

According to these cavities, the quantity of oil to be filled in, is greater than at the later oil fillings in the course of the usual maintenance service.

※ Because the converter and the oil cooler, installed in the vehicle, as well as the pipes can empty at standstill into the transmission, the **oil level check must be carried out at engine idling speed and operation temperature of the transmission.**

⚠ **At the oil level check, the vehicle has to be secured against rolling by blocks, articulated vehicles additionally against unintended turning-in.**

2) DRIVING AND SHIFTING

(1) Neutral position

Neutral position will be selected via the gear selector.

After the ignition is switched on, the electronics remains in the waiting state. By the position NEUTRAL of the gear selector, the TCU becomes ready for operation.

A gear can be engaged.

(2) Starting

The starting of the engine has always to be carried out in the NEUTRAL POSITION of the gear selector.

For safety reasons it is to recommend to brake the vehicle securely in position with the parking brake prior to start the engine.

After the starting of the engine and the preselection of the driving direction and the gear, the vehicle can be set in motion by acceleration.

At the start off, the converter takes over the funtion of a master clutch.

On a level road it is possible to start off also in higher gears.

- **Upshifiting under load.**
  Upshifting under load will be then realized if the vehicle can continue to accelerate by it.
- **Downshifting under load.**
  Downshfting under load will be then realized if more traction force is needed.

- **Upshifting in overrunning condition.**

  In the overrunning mode, the upshifting will be suppressed by accelerator pedal idling position, if the speed of the vehicle on a downgrade should not be further increased.
- **Downshifting in overrunning condition.**

  Downshifting in overrunning mode will be then carried out if the vehicle should be related.

If the vehicle will be stopped and is standing with running engine and engaged transmission, the engine cannot be stalled. On a level and horizontal roadway it is possible that the vehicle begins to crawl, because the engine is creating at idling speed a slight drag torque via the converter.
It is convenient to brake the vehicle at very stop securely in position with the parking brake. At longer stops, the controller has to be shifted to the NEUTRAL POSITION.

At the start off, the parking brake has to be released. We know from experience that at a converter transmission it might not immediately be noted to have forgotten this quite normal operating step because a converter, due to its high ratio, can easily overcome the braking torque of the parking brake.
Temperature increases in the converter oil as well as overheated brakes will be the consequences to be find out later.
Neutral position of the selector switch at higher vehicle speed(above stepping speed) is not admissible.
Either a suitable gear is to be shifted immediately, or vehicle must be stopped at once.

3) COLD START

At an oil temperature in the shifting circuit <-12°C, the transmission must be warmed-up for some minutes.
This must be carried out in neutral with an increased engine speed(about 1500min^{-1}).
Until this oil temperature is reached, the electronics remains in neutral, and the symbol of the cold start phase will be indicated on the display.

Indication on the display:

After the indication on the display is extinguished, the full driving programm can be utilized out of "NEUTRAL".

4) OIL TEMPERATURE

The oil temperature in the transmission sump is in the electrohydraulic control unit.

The service temperature in the sump of 60°-90°C must not be exceeded.
By overstepping results by 105°C notice "WS" on the display.

At a trouble-free unit and an adequate driving mode, a higher temperature will not occur.
The notice "WS" results at the display, the vehicle has to be stopped and controlled for external oil loss and the engine must run with a speed of 1200-1500min^{-1} at NEUTRAL POSITION of the transmission.

Now, the temperature must drop quickly(in about 2-3minutes) to normal values. If this is not the case, there is a trouble pending, which must be eliminated prior to continue working.

The monitoring of the oil temperature(behind the converter) is additionally on the temperature gauge which is located on the dashboard.

Operating temperature behind the converter at least 65°C and 100°C in continuous operation, a short-time increase up to max. 120°C is permitted.

The temperature is measured on the measuring point "63" (see schedule of measuring points-3-25)

2. MAINTENANCE

1) TRANSMISSION

(1) Oil level check

⚠ At the oil level check, the vehicle has to be secured against rolling with blocks.

The oil level check must be carried out as follows :

- Oil level check(weekly)
- At horizontally standing vehicle
- Transmission in neutral position "N"
- In the cold start phase, the engine must be running about 2-3minutes at idling speed, and the marking on the oil dipstick must then be lying above the cold start mark "COLD"
- At operating temperature of the transmission(about 80°-90°C)
- At engine idling speed
- Loosen oil dipstick by counterclock rotation, remove and clean it
- Insert oil dipstick slowly into the oil level tube until contact is obtained, and pull it out again.
- On the oil dipstick, the oil level must be lying in the zone "HOT"
- Insert the oil dipstick again, and tighten it by clockwise rotation

If the oil level has dropped in operating temperature condition below the "HOT" zone, it is absolutely necessary to replenish oil.
An oil level above the "HOT" marking, is leading to a too high oil temperature.

(2) Oil change and filter replacement intervals

※ **First oil change after 100operating hours in service.**
Every further oil change after 1000operating hours in service, however at least once a year.
At every oil change, the fine filter has to be replaced.

① **Oil change and oil filling capacity**

The oil change has to be carried out as follows. At operating temperature of the transmission, horizontally standing vehicle open the oil drain plug and drain the used oil.

- Clean oil drain plug with magnetic insert and surface on the housing and install again along with O-ring.
- Fill in oil(about 20 liters).
  (Sump capacity, external oil capacities e. g. in the heat exchanger, in the lines etc. are depended on the vehicle).
  The indicated value is a guide value.

※ **It is imperative to pay attention to absolute cleanliness of oil and filter.**
Binding is in any case the making on the oil dipstick.

- Start the engine-idling speed
- Transmission in neutral position "N"
- Top up oil up to the marking "COLD"
- Brake the vehicle securely in position and warm up the transmission
- Shift all controller positions through
- Check the oil level once more and top up oil once more if necessary
- On the oil dipstick, the oil level must be lying in the zone "HOT"
- Insert the oil dipstick again and tighten it by clockwise rotation

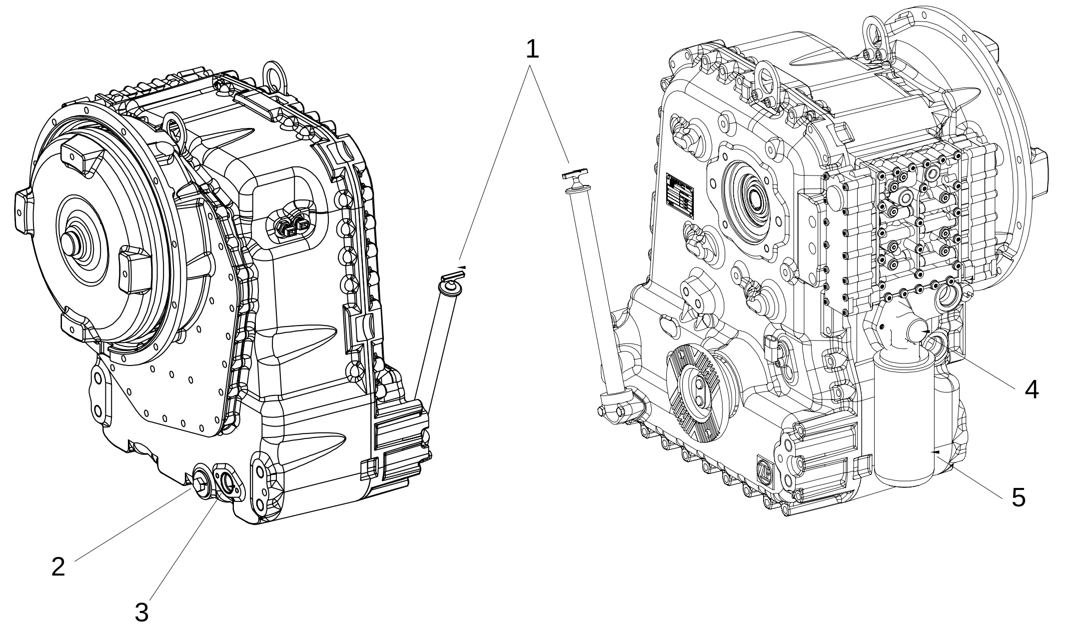
※ At the initial filling of the transmission has to be considered that the heat exchanger, the pressure filter as well as the pipes must get filled with oil.
According to these cavities, the oil capacity to be filled in is greater than at the later oil fillings in the course of the usual maintenance service.

② **Filter replacement**

At the replacement of the filter in the main oil steam, pay attention that no dirt or oil sludge can penetrate into the circuit.
At the mounting of the filter, any exertion of force has to be avoided.

※ Treat the filter carefully at the installation, the transport and the storage.
Damaged filters must no more be installed.
The mounting of the filter must be carried out as follows:

- Cover the gasket with a small amount of oil.
- Screw the filter in until contact with the sealing surface is obtained and tighten it now by hand about 1/3 to 1/2 turn.



D507PT19

Legend:

1 = Oil filter tube with oil dipstick

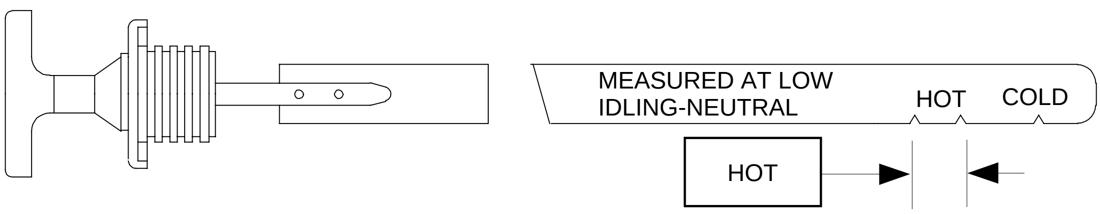
2 = Oil drain plug M38 × 1.5

3 = Attachment possibility oil level tube with oil dipstick(converter side)

4 = Filter head

5 = Fine filter

Oil dipstick



D507PT20

2) DRIVE AXLE

(1) General information

Drive axles generate small metal wear particles at a fairly steady rate, especially during the break-in period. If these fine, but hard particles are allowed to circulate in the lubricant, along with external moisture and dirt, internal components will wear at a much faster rate than normal.

(2) Magnets and magnetic drain plugs

Planetary axles are equipped with magnetic drain plus that have a minimum pick-up capacity of 0.57 kilograms(20 ounces) of low carbon steel. The drain plug must be checked for metal particles at every oil change interval.

※ Hyundai recommends replacing the magnetic drain plug each time the oil is changed.
Use the correct part. Pipe plugs will leak if used as a drain plug.
The magnetic drain plug can be reused if, after cleaning, the plug has a minimum pick-up capacity of 0.57kilograms(20 ounces) of low carbon steel.

(3) Breather

▲ **Cover the breather when steam cleaning the housing. If the breather is not covered, water can enter the housing and contaminate the oil.**

Breathers release pressure and vacuum condensation to minimize premature oil and component failure.

(4) Oil level

▲ **Check and adjust oil**

For complete fill procedures for wet side brakes, refer to 3-40, wet disc brakes.

▲ **To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.**

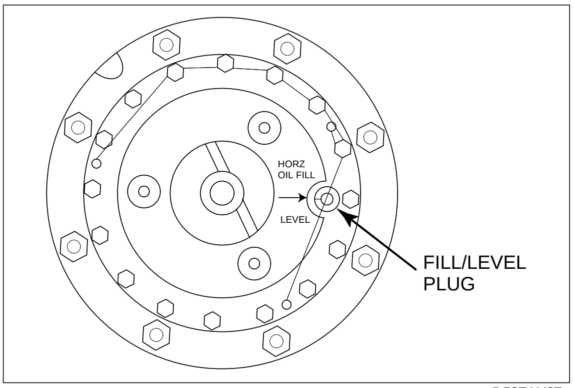
※ Fill and drain plugs are located in both brake housing and the main housing.

① Make sure the vehicle is on a level surface.

※ For axles with a common oil level that have drain and fill plugs only in the axle assembly, proceed to step ③.

② Rotate the wheels so that the "Oil level lines" on the wheel ends are parallel to the ground.

③ Clean the area around the fill/level plug.
Remove the fill/level plug from the wheel ends and the axle housing bowl. The oil level must be even with the bottom of the hole of the fill/level plug.



D507AX67

④ **If oil flows from the hole when you loosen the plug** : The oil level is high. Let the oil drain to the correct level.

※ Do not fill only through the axle housing bowl.

⑤ **If the oil level is below the bottom of the hole of the fill/level plug** : Fill the axle at each wheel end and the axle housing bowl to the bottom of the fill plug hole with the specified oil. Wait and allow the oil to flow through the axle.
Check the oil level again and fill to the specified level if necessary.

⑥ Install the fill/level plugs. Apply thread compound and tighten. Refer to the "Torque table".

(5) Oil change

▲ **Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury can result.**

① Make sure the vehicle is on a level surface.
Put large containers under the axle and wheel ends.

② Raise the vehicle so that the wheels are off the ground. Support the vehicle with safety stands.

③ Rotate the wheels so that the "fill/level" plugs in the wheel ends are toward the ground.

④ Remove the drain plugs from both brake housing and the main housing. Drain and discard the oil properly. Clean the plug.

⑤ Install the drain plugs in both brake housings and the main housing. Apply thread compound and tighten. Refer to the "torque table".

⑥ Rotate the wheels so that the " oil level lines" on the wheel ends are parallel to the ground.
Lower the vehicle.

⑦ Clean the area around the fill/level plug.
Remove the fill/level plug from the wheel ends and the axle housing bowl.

※ Do not fill only through the axle housing bowl.

⑧ Fill the axle at each each wheel end and the axle housing bowl to the bottom of the fill plugs hole with the specified oil. Wait and allow the oil to flow through the axle. Check the oil level again and fill to the specified level of necessary.

⑨ Install the fill/level plugs. Apply thread compound and tighten. Refer to the "torque table".

(6) Oil change intervals and specifications

Off-highway operation intervals*				**Oil specification**	**Remarks**
Recommended initial oil change	Check oil level	Petroleum oil change	Synthetic oil change	Mobile fluid424	Initial use or refill
100 operating hours	250 operating hours*	1,500 operating hours or twice a year(whichever comes first)	-	Transmission MP	OK to use only for refill

* The checking interval depends on individual operating conditions, speeds and loads, severe operating conditions may require more frequent checks.

3. TROUBLESHOOTING

1) BRAKE LEAKS ACTUATION FLUID

Condition	Possible cause	Correction
Internal leak : Fluid bypasses seals into axle and fills axle with fluid and blows out breather or empties brake fluid reservoir.	1. Worn or damaged piston seal. 2. Melted or extruded piston seals. 3. Corrosion, pitting, wear or other damage, marks, scratches to piston and/or brake housing bore in area of seal/sealing lips.	1. Replace piston seals. 2. Correct cause of overheating and replace seals. 3. Clean, smooth, rework or replace affected parts.
External leak	1. Loose bleeder screw. 2. Loose inlet fitting or plugs. 3. Damaged inlet fitting or plugs or damaged seats.	1. Tighten bleeder screw to 2.0~2.7kgf・m(15-20lb-ft) 2. Tighten inlet fitting to 3.4~4.8kgf・m(25-35 lb-ft) 3. Replace inlet fitting or plug and O-ring if used.

2) BRAKE NOISE AND VIBRATION

Condition	Possible cause	Correction
Brakes product noise, chatter, vibration.	Incorrect axle fluid and/or friction material used.	1. Use only meritor specified or approved materials. 2. Drain and flush fluid from axle. Replace with approved fluid. 3. Replace all friction discs. Thoroughly clean or replace stationary discs.

3) BRAKE OVERHEATS

Condition	Possible cause	Correction
Overheating due to excessive duty cycle.	Inadequate coolant flow or heat exchange.	1. Install brake cooling system if not already installed on vehicle. 2. Re-analyze and re-size brake cooling system if necessary.
Inadequate coolant flow	Low pump output, blocked filter or coolant lines.	Check pump output at different operating modes. Replace filter and check lines.
Low or no coolant.	1. Improper fill or leaks. 2. Leaking face seal. 3. Loose or damaged plugs. 4. Deteriorated or inadequate sealant used at joint.	1. Check for proper fill level. 2. Replace or reinstall face seal assembly. 3. Tighten drain, fill or forced cooling plug. Replace if damaged. 4. Dissemble, clean, re-seal and re-assemble brake housing joint.
Brake drags.	1. More than 1.4bar(20psi) pressure applies when brakes released. 2. Damaged piston return spring assembly. 3. Piston not returning. 4. Wrong cooling and/or actuation fluid used. 5. Tight or damaged splines(eg. friction disc-to-hub driver).	1. Repair hydraulic system so pressure is less than 1.4bar(20psi) when brakes released and while machine is operating in any mode. 2. Repair or replace piston return spring assembly. 3. Check piston seals and seal separator. 4. Check piston seals and seal separator for swelling or damaged. Replace as necessary. Purge system and use correct fluid. 5. Repair or replace parts.

4) BRAKE DOES NOT APPLY

Condition	Possible cause	Correction
Low or no pressure to brake	1. Empty fluid reservoir. 2. Damaged hydraulic system. 3. Leaked of brake actuation fluid. 4. Parking brake not adjusted properly.	1. Fill reservoir to correct level with specified fluid. 2. Repair hydraulic system. 3. Refer to "Brake leaks actuation fluid" in this section. 4. Adjust parking brake lever as described in assembly of this manual.

5) BRAKE DOES NOT RELEASE

Condition	Possible cause	Correction
Vehicle does not move	Damaged hydraulic system.	Repair hydraulic system.
Brakes dragging	1. More than 1.4bar(20psi) pressure applied when brakes released.	1. Repair hydraulic system so pressure is less than 1.4bar(20psi) when brakes released and while machine is operating in any mode.
	2. Damaged piston return spring assembly.	2. Repair or replace piston return spring assembly.
	3. Piston not returning.	3. Check piston seals for swelling or damage. Replace as necessary.
	4. Wrong cooling and/or actuation fluid used.	4. Check piston seals for swelling or damage. Purge system and use specified fluid.
	5. Parking brake not adjusted prope-rly.	5. Adjust parking brake lever as described in assembly of this manual.

6) BRAKING PERFORMANCE

Condition	Possible cause	Correction
Noticeable change or decrease in stopping performance.	1. Inadequate actuation fluid supply to brakes.	1. Replenish fluid in brake system. Check for leakage and correct cause.
	2. Inadequate pressure to apply brakes.	2. Check brakes apply system. Check for leakage in brake system or brakes, and correct cause.
	3. Worn or damaged discs.	3. Inspect and replace discs if necessary. ※As disc wear occurs, make sure brake system can supply adequate fluid to fully apply brakes.
	4. Overheated seals and/or discs.	4. Inspect and replace discs and seals if necessary.
	5. Dirty or contaminated cooling fluid.	5. Drain and flush cooling fluid from brakes and entire brake system. Replace with approved fluid. In some cases, it may necessary to replace discs. Clean or replace filter.
Brake does not fully apply.	1. Empty fluid reservoir.	1. Fill reservoir to correct level with specified fluid.
	2. Damaged hydraulic system.	2. Repair hydraulic system.
	3. Leakage of brake actuation fluid.	3. Refer to "Brake leaks actuation fluid" in this section.
Brakes fell spongy/soft.	Brakes or brake system not properly bled.	Bleed brakes and brake system.

7) TABLE OF TRANSMISSION OF FAULT CODES

Fault code (Hex)	Int. code (Dec)	Meaning of the fault code possible reason for fault detection	Reaction of the TCU	Possible steps to repair	Remarks
11	48	**Logical error at gear range signal** TCU detected a wrong signal combination for the gear range Cable from shift lever to TCU is broken Cable is defective and is contacted to battery voltage or vehicle ground Shift lever is defective	TCU shifts transmission to neutral OP-mode : Transmission shutdown	Check the cables from TCU to shift lever Check signal combinations of shift lever positions for gear range	Failure cannot be detected in systems with DW2/DW3 shift lever Fault is taken back if TCU detects a valid signal for the position
12	46	**Logical error at direction select signal** TCU detected a wrong signal combination for the direction Cable from shift lever to TCU is broken Cable is defective and is contacted to battery voltage or vehicle ground Shift lever is defective	TCU shifts transmission to neutral OP-Mode : Transmission shutdown	Check the cables from TCU to shift lever Check signal combinations of shift lever positions F-N-R	Fault is taken back if TCU detects a valid signal for the direction at the shift lever
25	33	**S.C. to battery voltage or O.C. at transmission sump temperature sensor input** The measured voltage is too high: Cable is defective and is contacted to battery voltage Cable has no connection to TCU Temperature sensor has an internal defect Connector pin is contacted to battery voltage or is broken	No reaction, TCU use default temperature OP mode : Normal	Check the cable from TCU to the sensor Check the connectors Check the temperature sensor	
26	30	**S.C. to battery voltage or O.C. at transmission sump temperature sensor input** The measured voltage is too low: Cable is defective and is contacted to vehicle ground Temperature sensor has an internal defect Connector pin is contacted to vehicle ground	No reaction, TCU uses default temperature OP mode : Normal	Check the cable from TCU to the sensor Check the connectors Check the temperature sensor	

Fault code (Hex)	Int. code (Dec)	Meaning of the fault code possible reason for fault detection	Reaction of the TCU	Possible steps to repair	Remarks
31	38	**S.C. to battery voltage or O.C. at engine speed input** TCU measures a voltage higher than 7.00V at speed input pin Cable is defective and is contacted to battery voltage Cable has no connection to TCU Speed sensor has an internal defect Connector pin is contacted to battery voltage or has no contact	OP mode : Substitute clutch control	Check the cable from TCU to the sensor Check the connectors Check the speed sensor	
32	34	**S.C. to ground at engine speed input** TCU measures a voltage less than 0.45V at speed input pin Cable/connector is defective and is contacted to vehicle ground Speed sensor has an internal defect	OP mode : Substitute clutch control	Check the cable from TCU to the sensor Check the connectors Check the speed sensor	
33	42	**Logical error at engine speed input** TCU measures a engine speed over a threshold and the next moment the measured speed is zero Cable/connector is defective and has bad contact Speed sensor has an internal defect Sensor gap has the wrong size	OP mode : Substitute clutch control	Check the cable from TCU to the sensor Check the connectors Check the speed sensor Check the sensor gap	This fault is reset after power up of TCU
34	39	**S.C. to battery voltage or O.C. at turbine speed input** TCU measures a voltage higher than 7.00V at speed input pin Cable is defective and is contacted to vehicle battery voltage Cable has no connection to TCU Speed sensor has an internal defect Connector pin is contacted to battery voltage or has no contact	OP mode : Substitute clutch control If a failure is existing at output speed, TCU shifts to neutral OP mode : Limp home	Check the cable from TCU to the sensor Check the connectors Check the speed sensor	

Fault code (Hex)	Int. code (Dec)	Meaning of the fault code possible reason for fault detection	Reaction of the TCU	Possible steps to repair	Remarks
35	35	**S.C. to ground at turbine speed input** TCU measures a voltage less than 0.45V at speed input pin Cable/connector is defective and is contacted to vehicle ground Speed sensor has an internal defect	OP mode : Substitute clutch control If a failure is existing at output speed, TCU shifts to neutral OP mode : Limp home	Check the cable from TCU to the sensor Check the connectors Check the speed sensor	This fault is reset after power up of TCU
36	43	**Logical error at turbine speed input** TCU measures a turbine speed over a threshold and at the next moment the measured speed is zero Cable/connector is defective and has bad contact Speed sensor has an internal defect Sensor gap has the wrong size	OP mode : Substitute clutch control If a failure is existing at output speed, TCU shifts to neutral OP mode : Limp home	Check the cable from TCU to the sensor Check the connectors Check the speed sensor Check the sensor gap	
37	40	**S.C. to battery voltage or O.C. at internal speed input** TCU measures a voltage higher than 7.00V at speed input pin Cable is defective and is contacted to vehicle battery voltage Cable has no connection to TCU Speed sensor has an internal defect Connector pin is contacted to battery voltage or has no contact	OP mode : Substitute clutch control	Check the cable from TCU to the sensor Check the connectors Check the speed sensor	
38	36	**S.C. to ground at turbine speed input** TCU measures a voltage less than 0.45V at speed input pin Cable/connector is defective and is contacted to vehicle ground Speed sensor has an internal defect	OP mode : Substitute clutch control	Check the cable from TCU to the sensor Check the connectors Check the speed sensor	

Fault code (Hex)	Int. code (Dec)	Meaning of the fault code possible reason for fault detection	Reaction of the TCU	Possible steps to repair	Remarks
39	44	**Logical error at internal speed input** TCU measures a internal speed over a threshold and at the next moment the measured speed is zero Cable/connector is defective and has bad contact Speed sensor has an internal defect Sensor gap has the wrong size	OP mode : Substitute clutch control	Check the cable from TCU to the sensor Check the connectors Check the speed sensor Check the sensor gap	This fault is reset after power up of TCU
3A	41	**S.C. to battery voltage or O.C. at output speed input** TCU measures a voltage higher than 12.5V at speed input pin Cable is defective and is contacted to battery voltage Cable has no connection to TCU Speed sensor has an internal defect Connector pin is contacted to battery voltage or has no contact	Special mode for gear selection OP mode : Substitute clutch control If a failure is existing at turbine speed, TCU shifts to neutral OP mode : lamp home	Check the cable from TCU to the sensor Check the connectors Check the speed sensor	
3B	37	**S.C. to ground at output speed input** TCU measures a voltage less than 1.00V at speed input pin Cable/connector is defective and is contacted to vehicle ground Speed sensor has an internal defect	Special mode for gear selection OP mode : Substitute clutch control If a failure is existing at turbine speed, TCU shifts to neutral OP mode : lamp home	Check the cable from TCU to the sensor Check the connectors Check the speed sensor	
3C	45	**Logical error at output speed input** TCU measures a turbine speed over a threshold and at the next moment the measured speed is zero Cable/connector is defective and has bad contact Speed sensor has an internal defect Sensor gap has the wrong size	Special mode for gear selection OP mode : Substitute clutch control If a failure is existing at turbine speed, TCU shifts to neutral OP mode : lamp home	Check the cable from TCU to the sensor Check the connectors Check the speed sensor Check the sensor gap	This fault is reset after power up of TCU

Fault code (Hex)	Int. code (Dec)	Meaning of the fault code possible reason for fault detection	Reaction of the TCU	Possible steps to repair	Remarks
3D	71	**Turbine speed zero doesn't fit to other speed signals**	-	-	Not used
3E	72	**Output speed zero doesn't fit to other speed signals** If transmission is not neutral and the shifting has finished, TCU measures output speed zero and turbine speed or internal speed not equal to zero. Speed sensor has an internal defect Sensor gap has the wrong size	Special mode for gear selection OP mode : Substitute clutch control If a failure is existing at turbine speed, TCU shifts to neutral OP mode : lamp home	Check the sensor signal of output speed sensor Check the sensor gap of output speed sensor Check the cable from TCU to the sensor	This fault is reset after power up of TCU
71	22	**S.C. to battery voltage at clutch K1** The measured resistance value of the valve is out of limit, the voltage at K1 valve is too high Cable/connector is defective and has contact to battery voltage Cable/connector is defective and has contact to another regulator output of the TCU Regulator has an internal defect	TCU shifts to neutral OP mode : Limp home If failure at another clutch is pending TCU shifts to neutral OP mode : TCU shutdown	Check the cable from TCU to the gearbox Check the connectors from TCU to the gearbox Check the regulator resistance* Check internal wire harness of the gearbox	
72	10	**S.C. to ground at clutch K1** The measured resistance value of the valve is out of limit, the voltage at K1 valve is too low Cable/connector is defective and has contact to vehicle ground Regulator has an internal defect	TCU shifts to neutral OP mode : Limp home If failure at another clutch is pending TCU shifts to neutral OP mode : TCU shutdown	Check the cable from TCU to the gearbox Check the connectors from gearbox to TCU Check the regulator resistance* Check internal wire harness of the gearbox	
73	16	**O.C. at clutch K1** The measured resistance value of the valve is out of limit Cable/connector is defective and has no contact to TCU Regulator has an internal defect	TCU shifts to neutral OP mode : Limp home If failure at another clutch is pending TCU shifts to neutral OP mode : TCU shutdown	Check the cable from TCU to the gearbox Check the connectors from gearbox to TCU Check the regulator resistance* Check internal wire harness of the gearbox	

Fault code (Hex)	Int. code (Dec)	Meaning of the fault code possible reason for fault detection	Reaction of the TCU	Possible steps to repair	Remarks
74	23	**S.C. to battery voltage at clutch K2** The measured resistance value of the valve is out of limit, the voltage at K2 valve is too high Cable/connector is defective and has contact to battery voltage Cable/connector is defective and has contact to another regulator output of the TCU Regulator has an internal defect	TCU shifts to neutral OP mode : Limp home If failure at another clutch is pending TCU shifts to neutral OP mode : TCU shutdown	Check the cable from TCU to the gearbox Check the connectors from gearbox to TCU Check the regulator resistance* Check internal wire harness of the gearbox	
75	11	**S.C. to ground at clutch K2** The measured resistance value of the valve is out of limit, the voltage at K2 valve is too low Cable/connector is defective and has contact to vehicle ground Regulator has an internal defect	TCU shifts to neutral OP mode : Limp home If failure at another clutch is pending TCU shifts to neutral OP mode : TCU shutdown	Check the cable from TCU to the gearbox Check the connectors from gearbox to TCU Check the regulator resistance* Check internal wire harness of the gearbox	
76	17	**O.C. at clutch K2** The measured resistance value of the valve is out of limit Cable/connector is defective and has no contact to TCU Regulator has an internal defect	TCU shifts to neutral OP mode : Limp home If failure at another clutch is pending TCU shifts to neutral OP mode : TCU shutdown	Check the cable from TCU to the gearbox Check the connectors from gearbox to TCU Check the regulator resistance* Check internal wire harness of the gearbox	
77	24	**S.C. to battery voltage at clutch K3** The measured resistance value of the valve is out of limit, the voltage at K3 valve is too high Cable/connector is defective and has contact to battery voltage Cable/connector is defective and has contact to another regulator output of the TCU Regulator has an internal defect	TCU shifts to neutral OP mode : Limp home If failure at another clutch is pending TCU shifts to neutral OP mode : TCU shutdown	Check the cable from TCU to the gearbox Check the connectors from gearbox to TCU Check the regulator resistance* Check internal wire harness of the gearbox	

Fault code (Hex)	Int. code (Dec)	Meaning of the fault code possible reason for fault detection	Reaction of the TCU	Possible steps to repair	Remarks
78	12	**S.C. to ground at clutch K3** The measured resistance value of the valve is out of limit, the voltage at K3 valve is too low Cable/connector is defective and has contact to vehicle ground Regulator has an internal defect	TCU shifts to neutral OP mode : Limp home If failure at another clutch is pending TCU shifts to neutral OP mode : TCU shutdown	Check the cable from TCU to the gearbox Check the connectors from gearbox to TCU Check the regulator resistance* Check internal wire harness of the gearbox	
79	18	**O.C. at clutch K2** The measured resistance value of the valve is out of limit Cable/connector is defective and has no contact to TCU Regulator has an internal defect	TCU shifts to neutral OP mode : Limp home If failure at another clutch is pending TCU shifts to neutral OP mode : TCU shutdown	Check the cable from TCU to the gearbox Check the connectors from gearbox to TCU Check the regulator resistance* Check internal wire harness of the gearbox	
85	14	**S.C. to ground at clutch KV** The measured resistance value of the valve is out of limit, the voltage at K4 valve is too low Cable/connector is defective and has contact to vehicle ground Regulator has an internal defect	TCU shifts to neutral OP mode : Limp home If failure at another clutch is pending TCU shifts to neutral OP mode : TCU shutdown	Check the cable from TCU to the gearbox Check the connectors from gearbox to TCU Check the regulator resistance* Check internal wire harness of the gearbox	
86	20	**O.C. at clutch KV** The measured resistance value of the valve is out of limit Cable/connector is defective and has contact to TCU Regulator has an internal defect	TCU shifts to neutral OP mode : Limp home If failure at another clutch is pending TCU shifts to neutral OP mode : TCU shutdown	Check the cable from TCU to the gearbox Check the connectors from gearbox to TCU Check the regulator resistance* Check internal wire harness of the gearbox	

Fault code (Hex)	Int. code (Dec)	Meaning of the fault code possible reason for fault detection	Reaction of the TCU	Possible steps to repair	Remarks
87	27	**S.C. to battery voltage at clutch KR** The measured resistance value of the valve is out of limit, the voltage at KR valve is too high Cable/connector is defective and has contact to battery voltage Cable/connector is defective and has contact to another regulator output of the TCU Regulator has an internal defect	TCU shifts to neutral OP mode : Limp home If failure at another clutch is pending TCU shifts to neutral OP mode : TCU shutdown	Check the cable from TCU to the gearbox Check the connectors from gearbox to TCU Check the regulator resistance* Check internal wire harness of the gearbox	
88	15	**S.C. to ground at clutch KR** The measured resistance value of the valve is out of limit, the voltage at KR valve is too low Cable/connector is defective and has contact to vehicle ground Regulator has an internal defect	TCU shifts to neutral OP mode : Limp home If failure at another clutch is pending TCU shifts to neutral OP mode : TCU shutdown	Check the cable from TCU to the gearbox Check the connectors from gearbox to TCU Check the regulator resistance* Check internal wire harness of the gearbox	
89	21	**O.C. at clutch KR** The measured resistance value of the valve is out of limit Cable/connector is defective and has no contact to TCU Regulator has an internal defect	TCU shifts to neutral OP mode : Limp home If failure at another clutch is pending TCU shifts to neutral OP mode : TCU shutdown	Check the cable from TCU to the gearbox Check the connectors from gearbox to TCU Check the regulator resistance* Check internal wire harness of the gearbox	
91	1	**S.C. to ground at relay reverse warning alarm** TCU detected a wrong voltage at the output pin, that looks like a S.C. to vehicle ground Cable is defective and is contact to vehicle ground Backup alarm device has an internal defect Connector pin is contacted to vehicle ground	Backup alarm will be on until TCU power down even if fault vanishes(Loose connection) OP mode : Normal	Check the cable from TCU to the backup alarm device Check the connectors from backup alarm device to TCU Check the resistance* of backup alarm device	

Fault code (Hex)	Int. code (Dec)	Meaning of the fault code possible reason for fault detection	Reaction of the TCU	Possible steps to repair	Remarks
92	3	**S.C. to battery voltage at relay reverse warning alarm** TCU detected a wrong voltage at the output pin, that looks like a S.C. to battery voltage Cable is defective and is contacted to battery voltage Backup alarm device has an internal defect Connector pin is contacted to battery voltage	No reaction OP mode : Normal	Check the cable from TCU to the backup alarm device Check the connectors from backup alarm device to TCU Check the resistance* of backup alarm device	
93	2	O.C. at relay reverse warning alarm TCU detected a wrong voltage at the output pin, that looks like a O.C. for this output pin Cable is defective and has no connection to TCU Backup alarm device has an internal defect Connector has no connection to TCU	No reaction OP mode : Normal	Check the cable from TCU to the backup alarm device Check the connectors from backup alarm device to TCU Check the resistance* of backup alarm device	
94	4	S.C. to ground at relay starter interlock TCU detected a wrong voltage at the output pin, that looks like a S.C. to vehicle ground Cable is defective and is connection to vehicle ground Starter interlock relay has an internal defect Connector pin is contacted to vehicle ground	No reaction OP mode : Normal	Check the cable from TCU to the stater interlock relay Check the connectors from starter interlock relay to TCU Check the resistance* of starter interlock relay	
95	6	**S.C. to battery voltage at relay starter interlock** TCU detected a wrong voltage at the output pin, that looks like a S.C. to battery voltage Cable is defective and has no connection to battery voltage Starter interlock relay has an internal defect Connector pin is contacted to battery voltage	No reaction OP mode : Normal	Check the cable from TCU to the starter interlock relay Check the connectors from starter interlock relay to TCU Check the resistance* of starter interlock relay	

Fault code (Hex)	Int. code (Dec)	Meaning of the fault code possible reason for fault detection	Reaction of the TCU	Possible steps to repair	Remarks
96	5	**O.C. at relay starter interlock** TCU detected a wrong voltage at the output pin, that looks like a O.C. for this output pin Cable is defective and has no connection to TCU Starter interlock relay has an internal defect Connector has no connection to TCU	No reaction OP mode : Normal	Check the cable from TCU to the starter interlock relay Check the connectors from starter interlock relay to TCU Check the resistance* of starter interlock relay	
97	7	**S.C. to ground at park brake solenoid** TCU detected a wrong voltage at the output pin, that looks like a S.C. to vehicle ground Cable is defective and is connection to vehicle ground Park brake solenoid has an internal defect Connector pin is contacted to vehicle ground	No reaction OP mode : Normal	Check the cable from TCU to the park brake solenoid Check the connectors from park brake solenoid to TCU Check the resistance* of park brake solenoid	
98	9	**S.C. to battery voltage at park brake solenoid** TCU detected a wrong voltage at the output pin, that looks like a S.C. to battery voltage Cable is defective and is connection to battery voltage Park brake solenoid has an internal defect Connector pin is contacted to battery voltage	No reaction Optional : (Some customers) TCU shifts to neutral caused by park brake feed back OP mode : Normal	Check the cable from TCU to the park brake solenoid Check the connectors from park brake solenoid to TCU Check the resistance* of park brake solenoid	
99	8	**O.C. at park brake solenoid** TCU detected a wrong voltage at the output pin, that looks like a O.C. for this output pin Cable is defective and has no connection to TCU Park brake solenoid has an internal defect Connector has no connection to TCU	No reaction Optional : Some customers TCU shifts to neutral caused by park brake feed back OP mode : Normal	Check the cable from TCU to the park brake solenoid Check the connectors from park brake solenoid to TCU Check the resistance* of park brake solenoid	

Fault code (Hex)	Int. code (Dec)	Meaning of the fault code possible reason for fault detection	Reaction of the TCU	Possible steps to repair	Remarks
B1	60	**Slippage at clutch K1** TCU calculates a differential speed at closed clutch K1. If this calculated value is out of range, TCU interprets this as slipping clutch Low pressure at clutch K1 Low main pressure Wrong signal at internal speed sensor Wrong signal at output speed sensor Wrong size of the sensor gap Clutch is defective	TCU shifts to neutral OP mode : Limp home If failure at another clutch is pending TCU shifts to neutral OP mode : TCU shutdown	Check pressure at clutch K1 Check main pressure in the system Check sensor gap at internal speed sensor Check sensor gap at output speed sensor Check signal at internal speed sensor Check signal at output speed sensor Replace clutch	
B2	61	**Slippage at clutch K2** TCU calculates a differential speed at closed clutch K2. If this calculated value is out of range, TCU interprets this as slipping clutch Low pressure at clutch K2 Low main pressure Wrong signal at internal speed sensor Wrong signal at output speed sensor Wrong size of the sensor gap Clutch is defective	TCU shifts to neutral OP mode : Limp home If failure at another clutch is pending TCU shifts to neutral OP mode : TCU shutdown	Check pressure at clutch K2 Check main pressure in the system Check sensor gap at internal speed sensor Check sensor gap at output speed sensor Check signal at internal speed sensor Check signal at output speed sensor Replace clutch	
B3	62	**Slippage at clutch K3** TCU calculates a differential speed at closed clutch K3. If this calculated value is out of range, TCU interprets this as slipping clutch Low pressure at clutch K3 Low main pressure Wrong signal at internal speed sensor Wrong signal at output speed sensor Wrong size of the sensor gap Clutch is defective	TCU shifts to neutral OP mode : Limp home If failure at another clutch is pending TCU shifts to neutral OP mode : TCU shutdown	Check pressure at clutch K3 Check main pressure in the system Check sensor gap at internal speed sensor Check sensor gap at output speed sensor Check signal at internal speed sensor Check signal at output speed sensor Replace clutch	

Fault code (Hex)	Int. code (Dec)	Meaning of the fault code possible reason for fault detection	Reaction of the TCU	Possible steps to repair	Remarks
B5	64	**Slippage at clutch KV** TCU calculates a differential speed at closed clutch KV. If this calculated value is out of range, TCU interprets this as slipping clutch Low pressure at clutch KV Low main pressure Wrong signal at internal speed sensor Wrong signal at turbine speed sensor Wrong size of the sensor gap Clutch is defective	TCU shifts to neutral OP mode : Limp home If failure at another clutch is pending TCU shifts to neutral OP mode : TCU shutdown	Check pressure at clutch KV Check main pressure in the system Check sensor gap at internal speed sensor Check sensor gap at turbine speed sensor Check signal at internal speed sensor Check signal at turbine speed sensor Replace clutch	
B6	65	**Slippage at clutch KR** TCU calculates a differential speed at closed clutch KR. If this calculated value is out of range, TCU interprets this as slipping clutch Low pressure at clutch KR Low main pressure Wrong signal at internal speed sensor Wrong signal at turbine speed sensor Wrong size of the sensor gap Clutch is defective	TCU shifts to neutral OP mode : Limp home If failure at another clutch is pending TCU shifts to neutral OP mode : TCU shutdown	Check pressure at clutch KR Check main pressure in the system Check sensor gap at internal speed sensor Check sensor gap at turbine speed sensor Check signal at internal speed sensor Check signal at turbine speed sensor Replace clutch	
B7	87	**Overtemp sump** TCU measured a temperature in the oil sump that is over the allowed threshold.	No reaction OP mode : Normal	Cool down machine Check oil level Check temperature sensor	

Fault code (Hex)	Int. code (Dec)	Meaning of the fault code possible reason for fault detection	Reaction of the TCU	Possible steps to repair	Remarks
D1	54	**S.C. to battery voltage at power supply for sensors** TCU measures more than 6V at the pin AU1 (5V sensor supply)	See fault codes No.21 to 2C	Check cables and connectors to sensors, which are supplied from AU1 Check the power supply at the pin AU1(Should be appx. 5V)	
D2	55	**S.C. to ground at power supply for sensors** TCU measures less than 4V at the pin AU1 (5V sensor supply)	See fault codes No.21 to 2C	Check cables and connectors to sensors, which are supplied from AU1 Check the power supply at the pin AU1(Should be appx. 5V)	
D3	53	**Low voltage at battery** Measured voltage at power supply is lower than 18V(24V device)	Shift to neutral OP mode : TCU shutdown	Check power supply battery Check cables from batteries to TCU Check connectors from batteries to TCU	
D4	52	**High voltage at battery** Measured voltage at power supply is higher than 32.5V(24V device)	Shift to neutral OP mode : TCU shutdown	Check power supply battery Check cables from batteries to TCU Check connectors from batteries to TCU	
D5	57	**Error at valve power supply VPS1** TCU switched on VPS1 and measured VPS1 is off or TCU switched off VPS1 and measured VPS1 is still on Cable or connectors are defect and are contacted to battery voltage Cable or connectors are defect and are contacted to vehicle ground Permanent power supply KL30 missing TCU has an internal defect	Shift to neutral OP mode : TCU shutdown	Check fuse Check cables from gearbox to TCU Check connectors from gearbox to TCU Replace TCU	

Fault code (Hex)	Int. code (Dec)	Meaning of the fault code possible reason for fault detection	Reaction of the TCU	Possible steps to repair	Remarks
D6	58	**Error at valve power supply VPS2** TCU switched on VPS2 and measured VPS2 is off or TCU switched off VPS2 and measured VPS2 is still on Cable or connectors are defect and are contacted to battery voltage Cable or connectors are defect and are contacted to vehicle ground Permanent power supply KL30 missing TCU has an internal defect	Shift to neutral OP mode : TCU shutdown	Check fuse Check cables from gearbox to TCU Check connectors from gearbox to TCU Replace TCU	

Fault code (Hex)	Int. code (Dec)	Meaning of the fault code possible reason for fault detection	Reaction of the TCU	Possible steps to repair	Remarks
E3		**S.C. to battery voltage at display output** TCU sends data to the display and measures always a high voltage level on the connector · Cable or connectors are defective and are contacted to battery voltage · Display has an internal defect	No reaction OP mode : Normal	Check the cable from TCU to the display Check the connectors at the display Change display	
E4		**S.C. to ground at display output** TCU sends data to the display and measures always a high voltage level on the connector · Cable or connectors are defective and are contacted to battery voltage · Display has an internal defect	No reaction OP mode : Normal	Check the cable from TCU to the display Check the connectors at the display Change display	

Fault code (Hex)	Int. code (Dec)	Meaning of the fault code possible reason for fault detection	Reaction of the TCU	Possible steps to repair	Remarks
F1	51	**General EEPROM fault** TCU can't read non volatile memory TCU is defective	No reaction OP mode : Normal	Replace TCU	Often shown together with fault code F2
F2	56	**Configuration lost** TCU has lost the correct configuration and can't control the transmission Interference during saving data on non volatile memory TCU is brand new or from another vehicle	Transmission stay neutral OP mode : TCU shutdown	Reprogram the correct configuration for the vehicle (e.g. with cluster controller,...)	
F3	59	**Application error** Something of this application is wrong	Transmission stay neutral OP mode : TCU shutdown	Replace TCU	This fault occurs only if an test engineer did something wrong in the application of the vehicle
F5	173	**Clutch failure** AEB was not able to adjust clutch filling parameters One of the AEB-Values is out of limit	Transmission stay neutral OP mode : TCU shutdown	Check clutch	TCU shows also the affected clutch on the display
F6	174	**Clutch adjustment data lost** TCU was not able to read correct clutch adjustment parameters Interference during saving data on non volatile memory TCU is brand new	No reaction, Default values : 0 for AEB Offsets used OP mode : Normal	Execute AEB	

GROUP 3 DISASSEMBLY AND ASSEMBLY

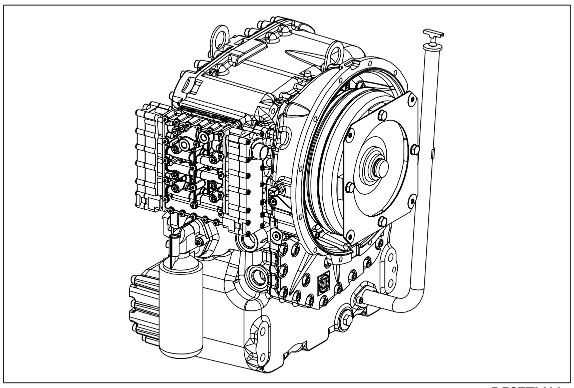
1. TRANSMISSION DISASSEMBLY

1) Electro-hydraulic control and filter (exchange filter)

① Mount the transmission to the assembly truck.

(S)Assembly truck	5870 350 000
(S)Holding fixture	5870 350 124

※ **Prior to start the disassembly, drain the oil**

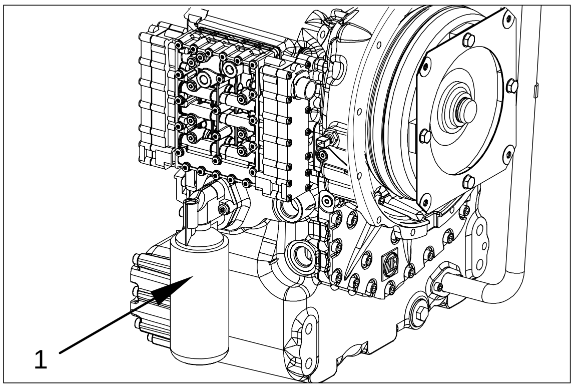


D507TM11

(1) Removal of the filter

① By means of the strap wrench separate the filter(1) from the filter head.

(S)Strap wrench 5870 105 005

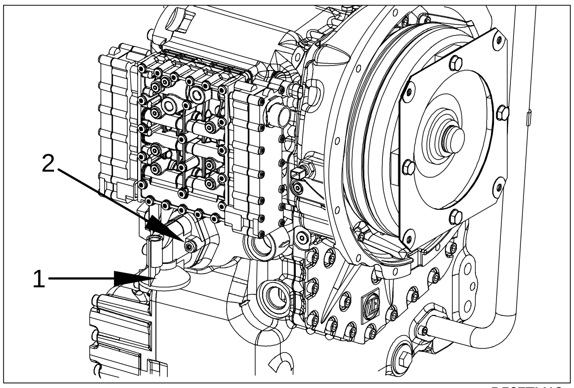


D507TM12

② Loosen the cap screws(2) and separate the filter head(1) from the transmission housing.

※ Remove the O-ring

(S) Socket spanner 5873 042 004

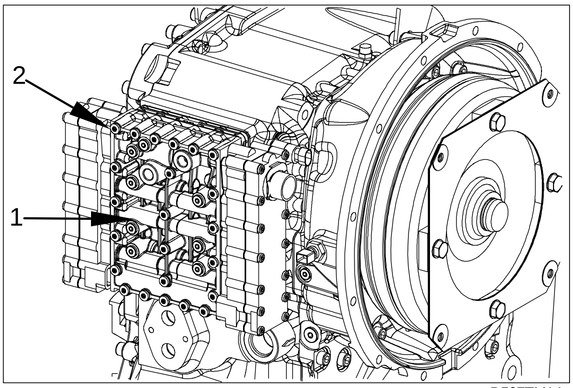


D507TM13

(2) Removal of the electric shift system

① Remove the shift system(1).
Loosen the Torx screws(2) and separate the gearshift housing from the intermediate sheet.

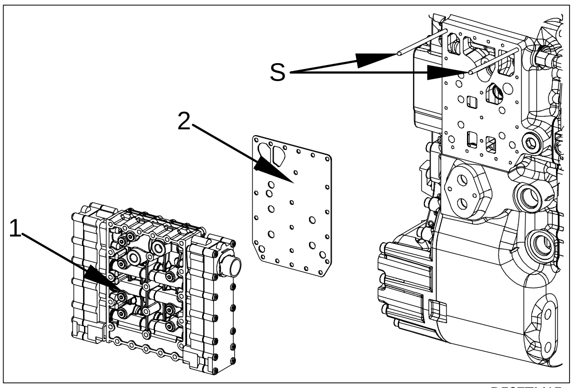
(S)Socket spanner TX-27 5873 042 002
(S)Adjusting screw M6 5870 204 063



D507TM14

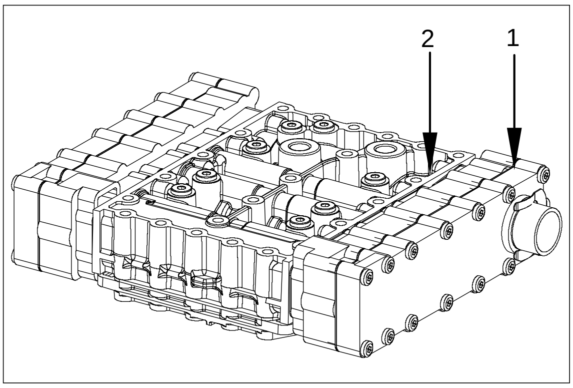
② Remove the complete shift system(1) and the intermrdiate shaft(2).

(S)Adjusting screw M6 5870 204 063



D507TM15

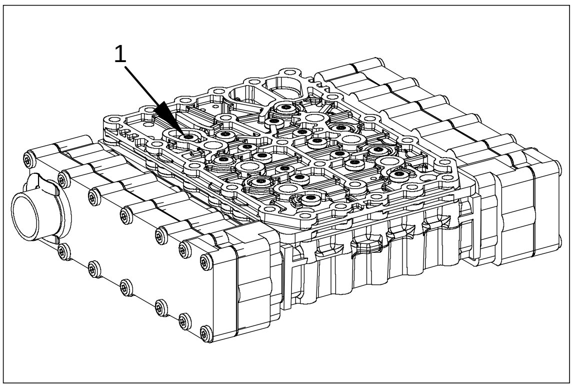
③ Mark the installation position of the cover(1) to the valve block(2).



D507TM16

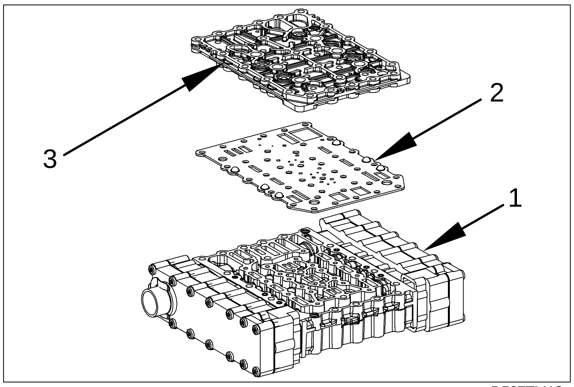
④ Loosen the Torx screws(1).

(S)Socket spanner TX-27 5873 042 002



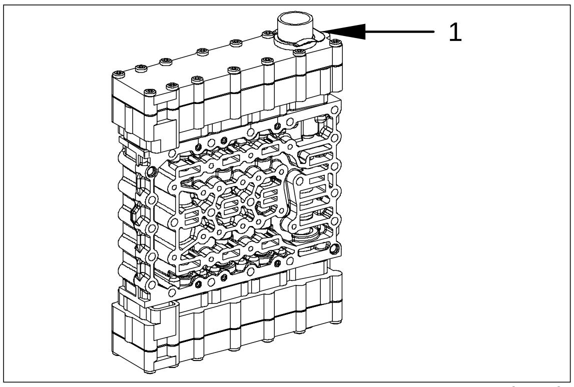
D507TM17

⑤ Separate the duct plate(3), and intermediate sheet(2) from the valve block(1).



D507TM18

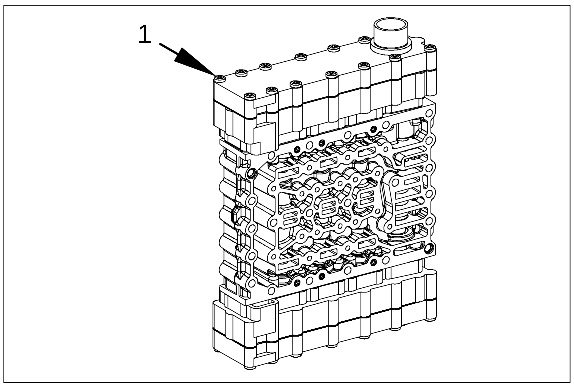
⑥ Remove the retaining clamp(1).



D507TM19

⑦ Loosen the cap screws(1) and remove the cover.
Remove the opposite cover.

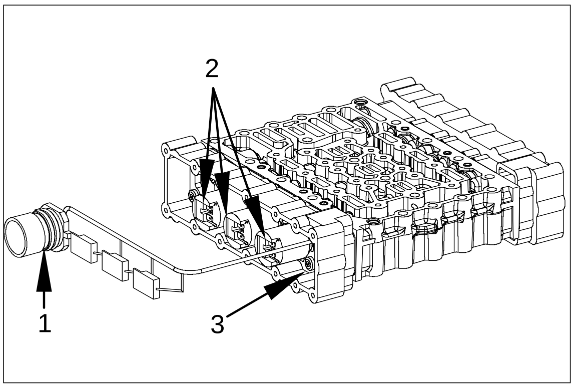
(S)Socket spanner TX-27 5873 042 002



D507TM20

⑧ Remove the wiring harness(1).
Loosen the cap screws(3), remove the fixing plates and the pressure regulators(2).

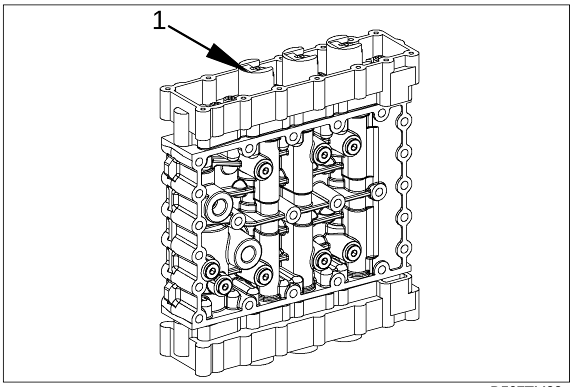
(S)Socket spanner TX-27 5873 042 002



D507TM21

⑨ Loosen the cap screws, remove the fixing plates and the pressure regulators(1).

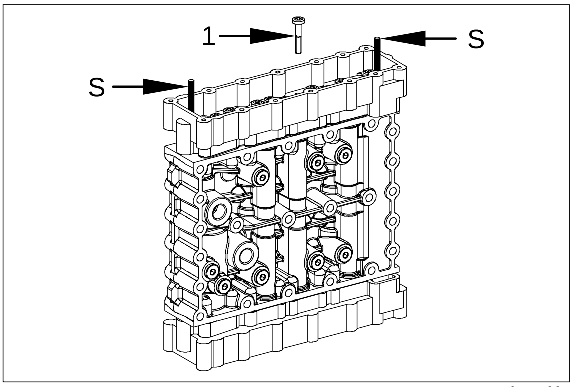
(S)Socket spanner TX-27   5873 042 002



D507TM22

⑩ Loosen two cap screws(1) and fasten the adjusting screws(S) preliminarily (housing is spring-loaded). Following to this loosen the remaining cap screws.

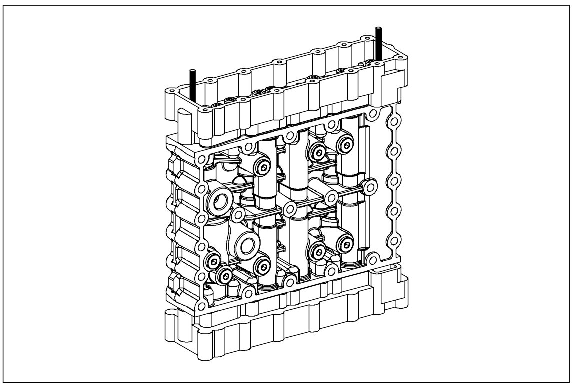
(S)Adjusting screws   5870 204 036
(S)Socket spanner   5873 042 002



D507TM23

⑪ Separate the housing from the valve housing by loosening the adjusting screws equally.

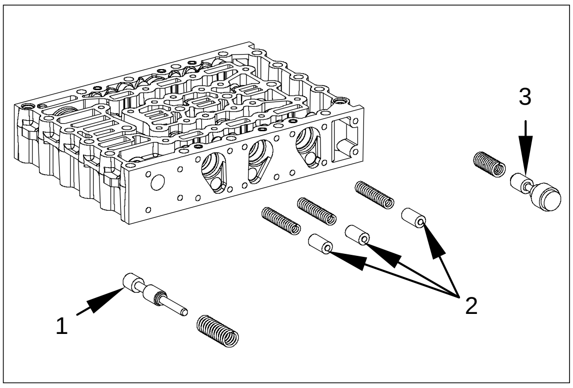
(S)Adjusting screws   5870 204 036



D507TM24

⑫ Remove the single parts:

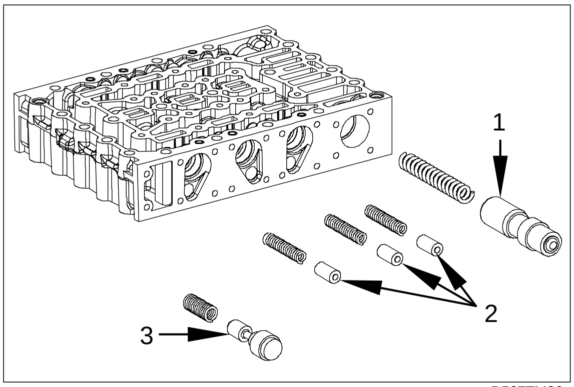
1 = Pressure reducing valve
2 = Vibration damper
3 = Follow-on slide



D507TM25

⑬ Remove the single parts on the opposite side analogously:

1 = Main pressure valve
2 = Vibration damper
3 = Follow-on slide

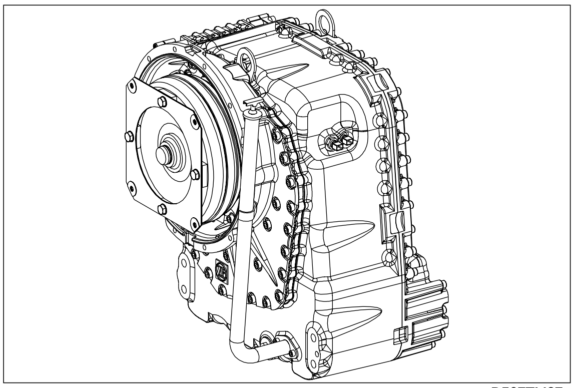


D507TM26

2) Inductive transmitters, valves, oil filter and oil drain plug, screw plugs

① Mount the transmission to the assembly truck.

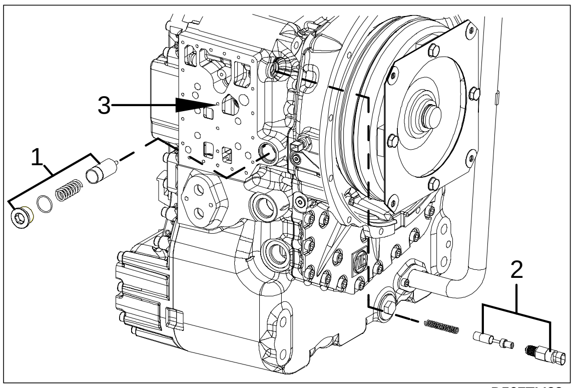
(S)Assembly truck	5870 350 000
(S)Holding fixture	5870 350 124



D507TM27

② Remove the converter pressure back-up valve(1) and differential pressure switch(3) for the filter(2).

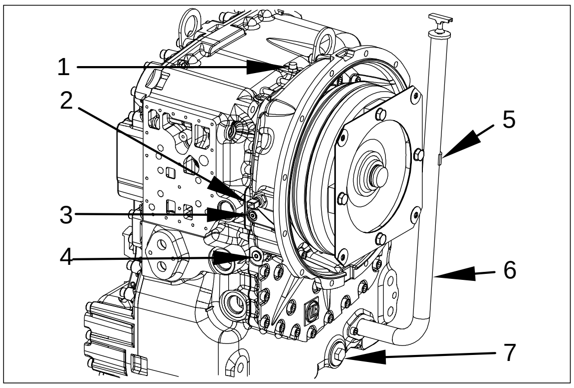
※ **Do not remove the pressure relief valve.**



D507TM28

③ Remove the positioned parts.

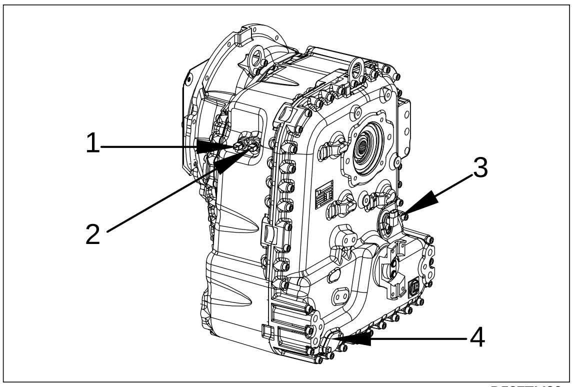
1 = Breather
2 = Inductive transmitter-n engine
3 =Screw plug(measuring point after converter)
4 =Screw plug(option for temperature sensor)
5 = Fixing strap oil filter tube
6 = Oil filter tube with oil dipstick
7 = Screw plug(Oil drain bore)



D507TM29

④ Remove the positioned parts.

1 = Inductive transmitter n - Internal speed input
2 = Inductive transmitter n - Turbine
3 = Speed transmitter n - Output
4 = Cover(mounting possibility for oil filler tube)



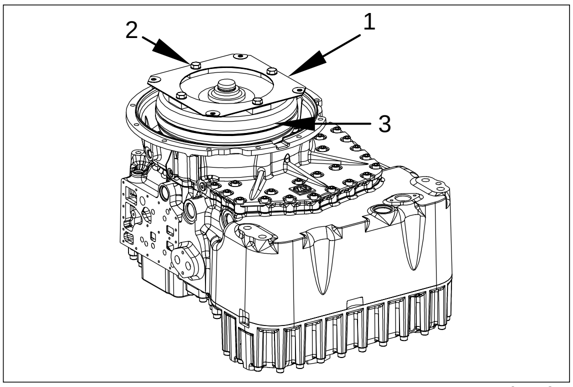
D507TM30

3) Engine connection, pressure oil pump and removal of the clutches

① Mount the transmission to the assembly truck.

(S)Assembly truck 5870 350 000
(S)Holding fixture 5870 350 124

Loosen the hexagon screw(2) and separate the flexplate(1) from the converter(3).

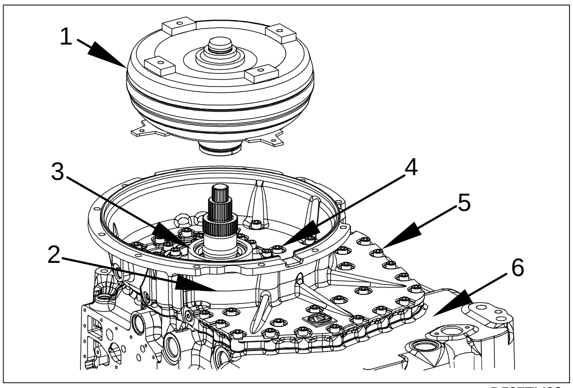


D507TM31

② By means of the lifting equipment separate the converter(1) from the transmission. Loosen the bolted connection(4) and (5).

1 = Converter
2 = Converter bell
3 = Pressure oil pump
4 = Bolted connection converter bell/transmission housing rear section
5 = Bolted connect. pressure oil pump/transmission housing rear section
6 = Transmission housing rear section

(S)Eyebolts assortment 5870 204 002
(S)Lifting chain 5870 281 047

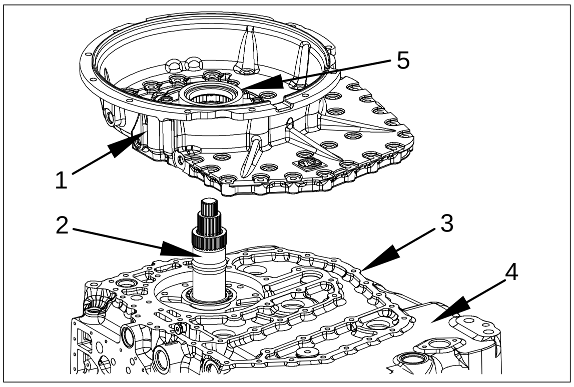


D507TM32

③ By means of the lifting equipment the converter bell(1) with pressure oil pump(5) are commonly to be separated from the transmission housing rear section(4).

Remove the intermediate sheet(3) and the stator hollow shaft(2).

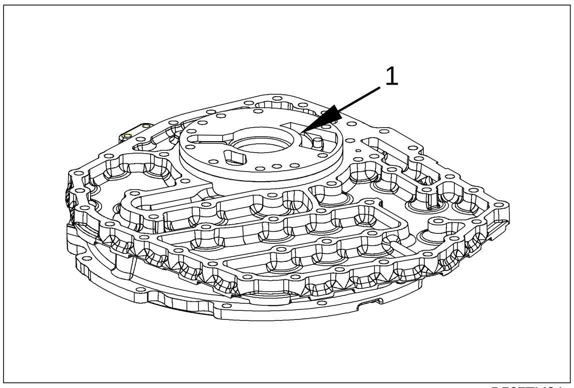
(S)Eyebolts assortment 5870 204 002
(S)Lifting chain 5870 281 047



D507TM33

④ Separate the pressure oil pump(1) from the converter bell.

(S)Hammer 5870 280 004



D507TM34

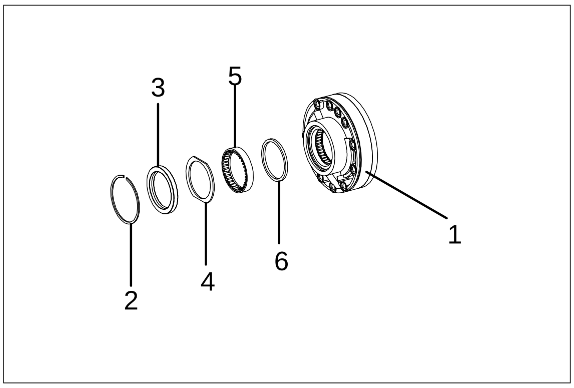
⑤ Loosen both cap screws and remove the cam disc.

※ **If running-in marks should be found in the pump housing or on the cam disc, the complete pump has to be replaced.**

D507TM35

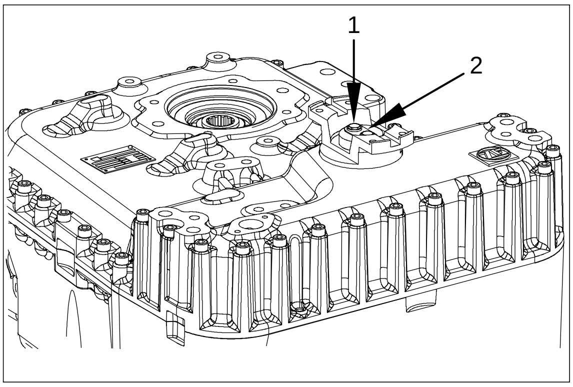
⑥ Squeeze out the snap ring(1) and remove the single parts.

1 = Pump housing with rotor
2 = Snap ring
3 = Saft seal
4 = Support shim
5 = Needle bearing
6 = Ring



D507TM36

⑦ Remove the tab washer(2) and loosen the hexagon screws(1).

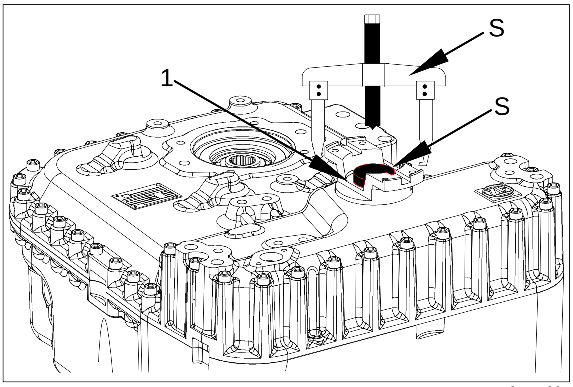


D507TM37

⑧ Pull off the input shaft(1).

Remove the shaft seal.

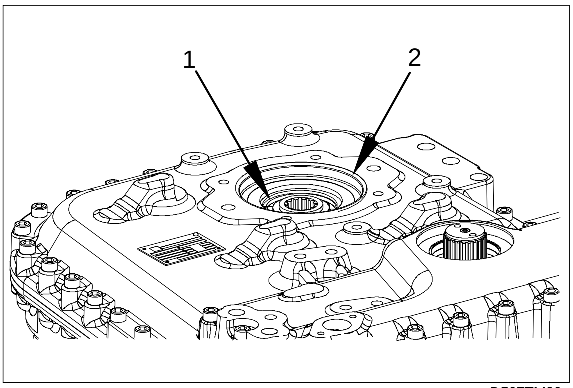
(S)Two-armed puller 5870 970 003



D507TM38

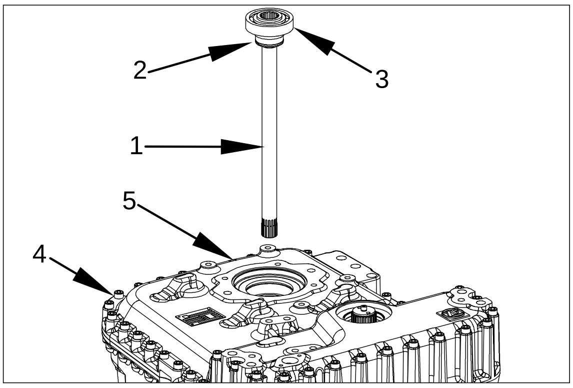
⑨ Unsnap the retaining ring(1) from the power take-off and remove the O-ring(2).

(S)Set of internal pliers 5870 900 013



D507TM39

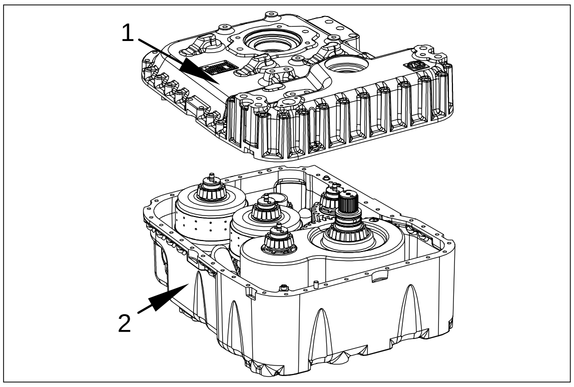
⑩ Pull the pump shaft (1) out of the housing bore.
Unsnap the rectangular ring(2).
Press off the ball bearing(3) from the shaft.
Loosen the bolted connection(4) transmission housing rear section/transmission housing front section.



D507TM40

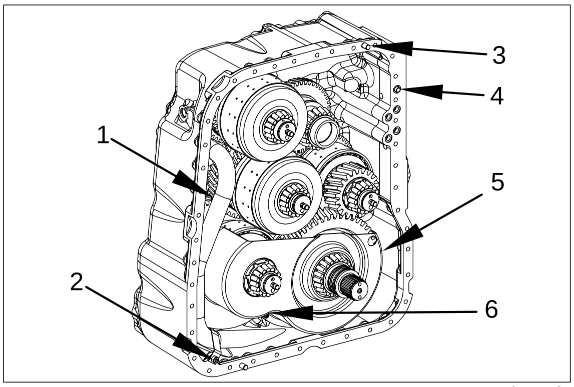
⑪ By means of the lifting equipment separate the transmission housing rear section(1) from the transmission housing front section(2).

(S)Eyebolts 2x(M20)	0636 804 003
(S)Ring nut(M12)	0664 462 774
(S)Lifting chain	5870 281 047



D507TM41

⑫ Loosen the cap screws(2) and remove the suction tube(1).
Remove the O-ring from the suction tube.
Loosen the cap screws(6) and remove the screen sheet(5).
Remove the pipes(4) with O-rings.

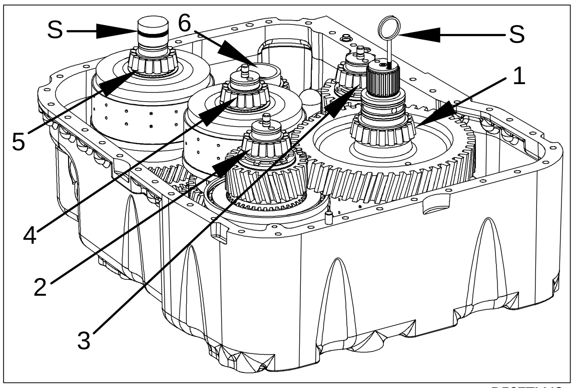


D507TM42

⑬ The clutch is to be removed from the transmission housing according to the sequence of numbers as described in the lengend.

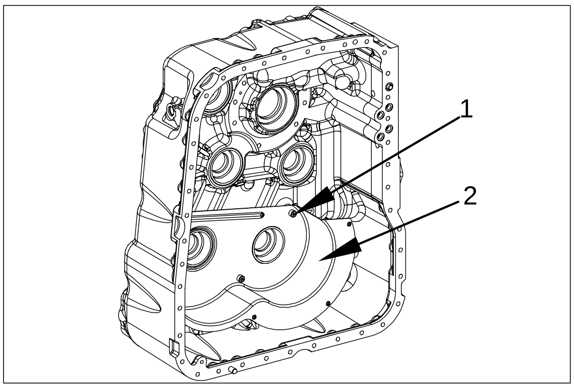
1 = Clutch K3
2 = Clutch K1
3 = Clutch K2
4 = Clutch KR
5 = Clutch KV
6 = Input shaft

(S)Handle 5870 260 014 (K1/K2/KV/KR)
(S)Eyebolt 5870 204 002 (K3)



D507TM43

⑭ Loosen the cap screws(1) and remove the screen sheet(2).



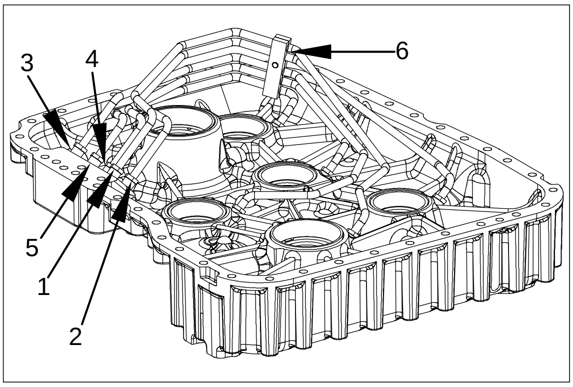
D507TM44

⑮ Remove the pipes(system pressure from the electro-hydraulic control to the respective clutch).

Remove the holding segment(6).

The pipes are to disassembled in the following sequence:

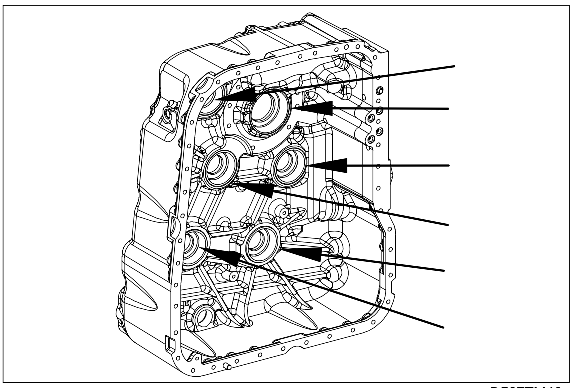
1 = Pipe	k3
2 = Pipe	k1
3 = Pipe	k2
4 = Pipe	kR
5= Pipe	kV



D507TM45

□ Remove all bearing outer rings(see arrows).

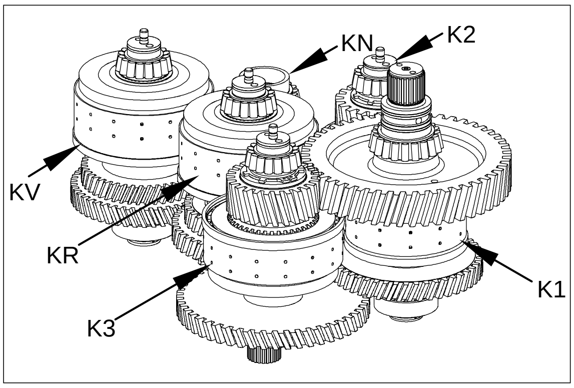
※ **Should contrary to the recommendations the taper roller bearings of the clutches as well as of the input not be replaced the assignment(bearing inner and outer ring) has to be kept at least. Mark the bearing inner and bearing outer rings to each other accordingly.**



D507TM46

4) Clutches KV/KR/K1/K2/K3 and Input

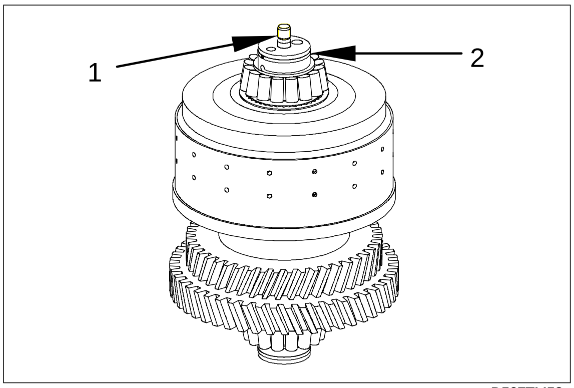
See figure on the right.



D507TM51

(1) Clutch KV

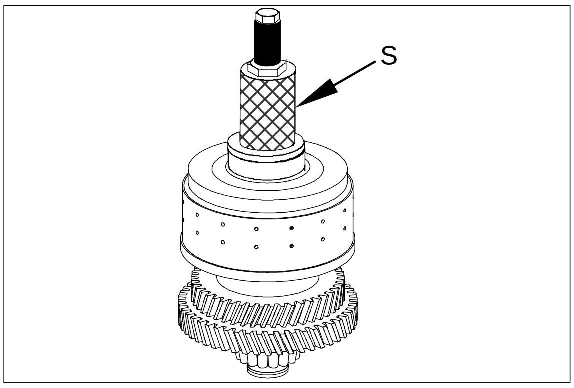
① Remove the stud(1) and unsnap the piston ring(2).



D507TM52

② Pull the taper roller bearing(inner ring) from the shaft.

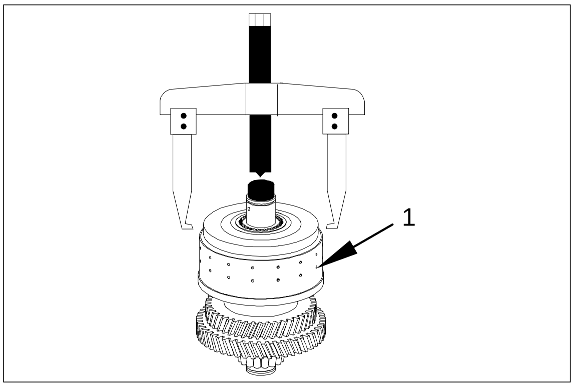
(S)Gripping insert	5873 001 057
(S)Back-off insert	5870 026 100
or	
(S)Rapid grip	5873 001 011



D507TM53

③ Pull the clutch(1) from the shaft.

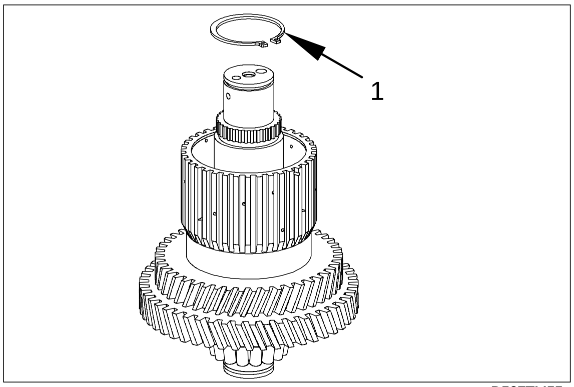
(S)Two-armed puller 5870 970 003



D507TM54

④ Unsnap the retaining ring(1).

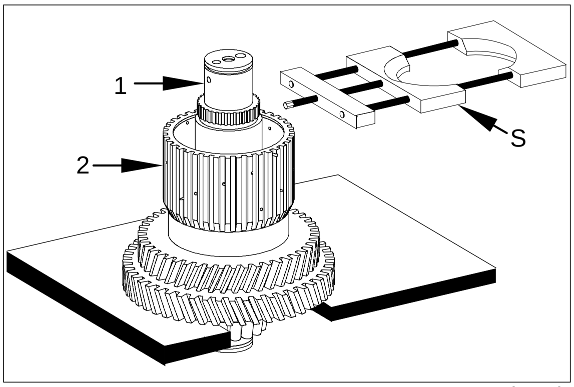
(S)Set of external pliers 5870 900 015



D507TM55

⑤ Press the clutch shaft(1) out of the idler(2).

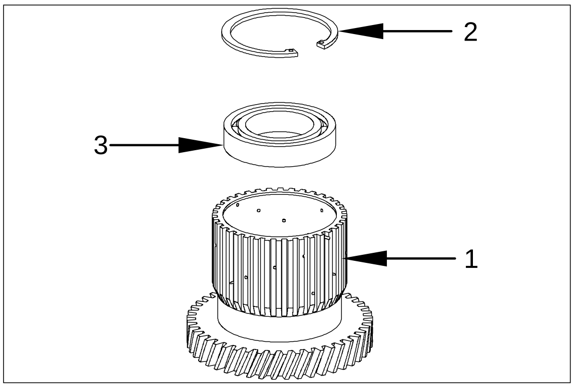
(S)Parting tool 5870 300 028



D507TM56

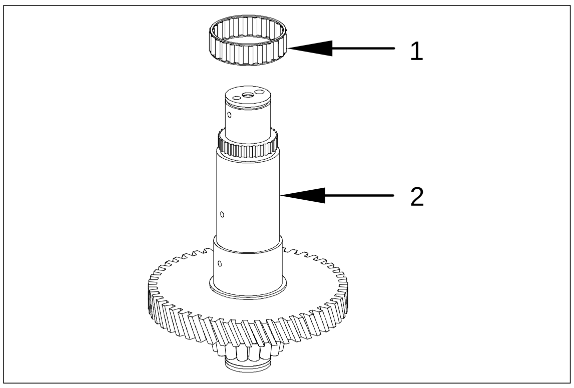
⑥ Unsnap the retaining ring(2) from the idler(1) and remove the ball bearing(3).

(S)Set of internal pliers 5870 900 013



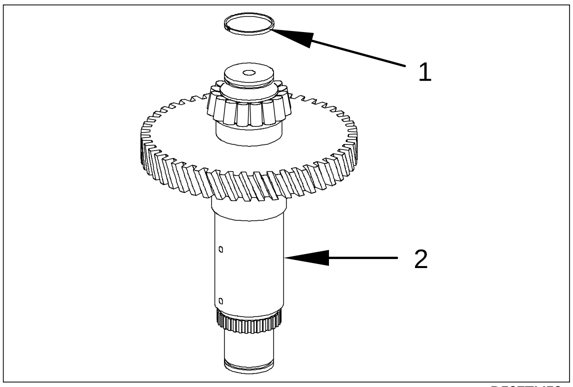
D507TM57

⑦ Remove the needle cage(1) from the shaft(2).



D507TM58

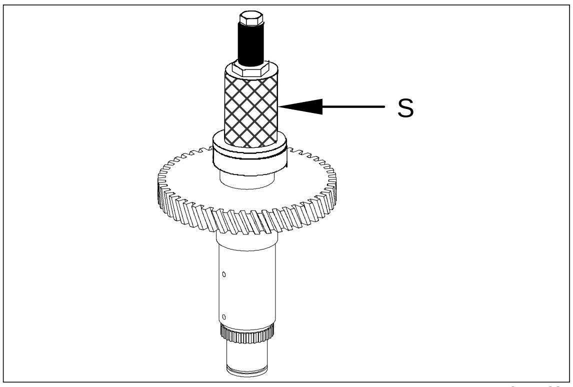
⑧ Rotate the shaft(2) by 180° and unsnap the piston ring(1).



D507TM59

⑨ Pull the taper roller bearing(inner ring) from the shaft.

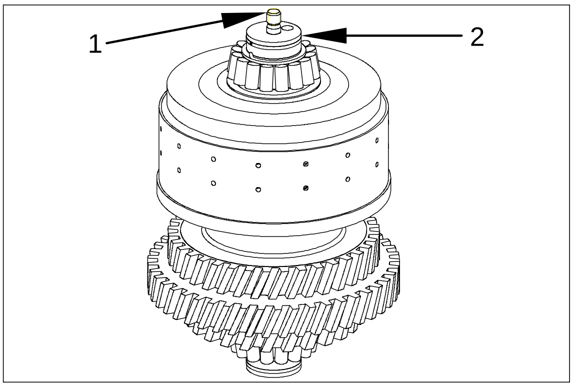
(S)Gripping insert	5873 001 057
(S)Back-off insert	5870 026 100
or	
(S)Rapid grip	5873 011 011



D507TM60

(2) Clutch KR

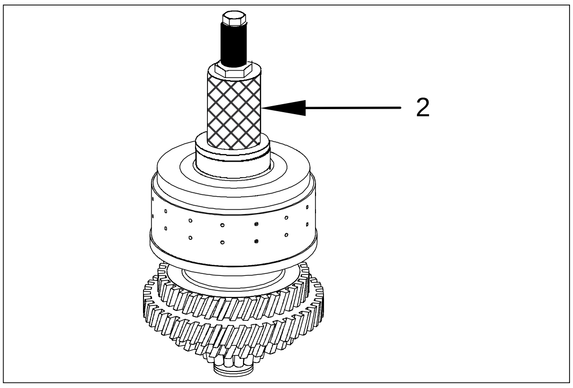
① Remove the stud(1) and unsnap the piston ring(2).



D507TM61

② Pull the taper roller bearing(inner ring)(2) from the shaft.

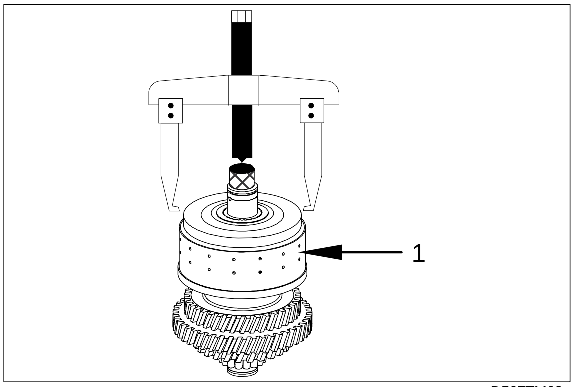
(S)Gripping insert	5873 001 057
(S)Bush	5870 026 016



D507TM62

③ Pull the clutch(1) from the shaft.

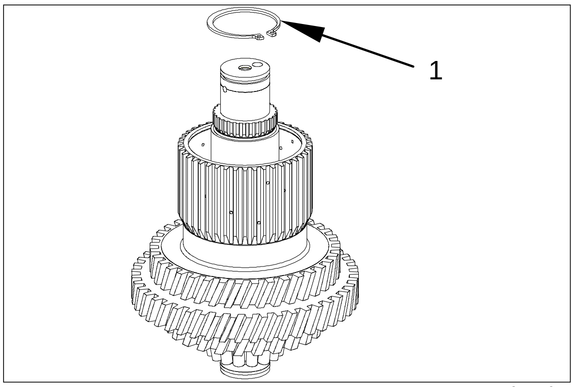
(S)Two-armed puller 5870 970 003



D507TM63

④ Unsnap the retaining ring(1).

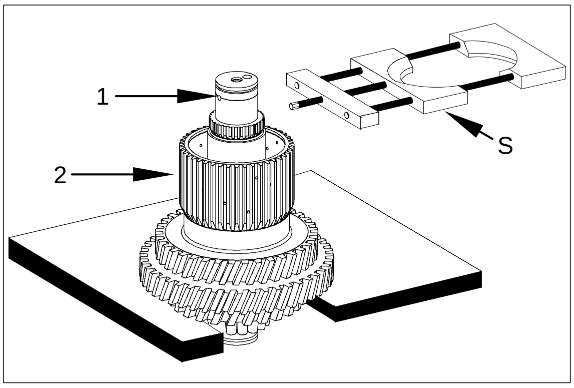
(S)Set of external pliers 5870 900 015



D507TM64

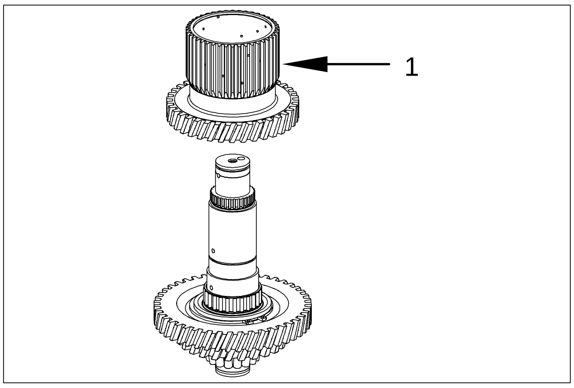
⑤ Press the clutch shaft(1) out of the idler(2).

(S)Parting tool 5870 300 028



D507TM65

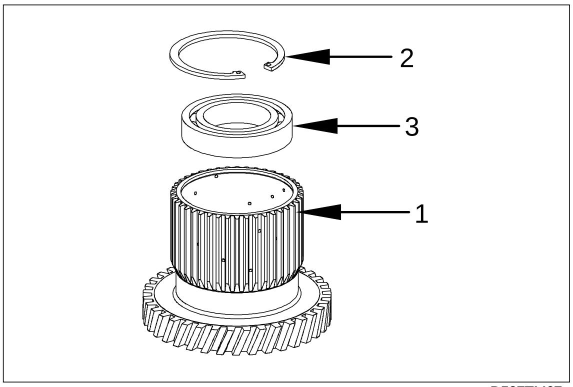
⑥ Disassemble the idler(1).



D507TM66

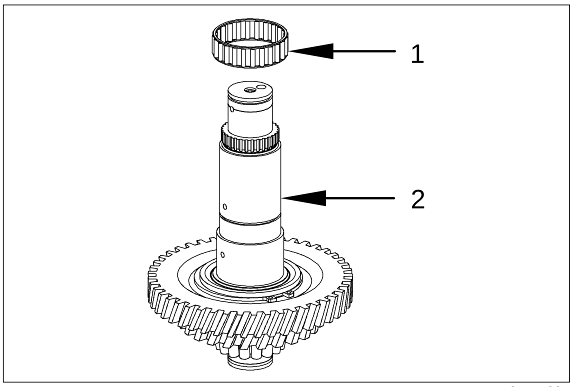
⑦ Unsnap the retaining ring(2) from the idler(1) and remove the ball bearing.

(S)Set of internal pliers 5870 900 013



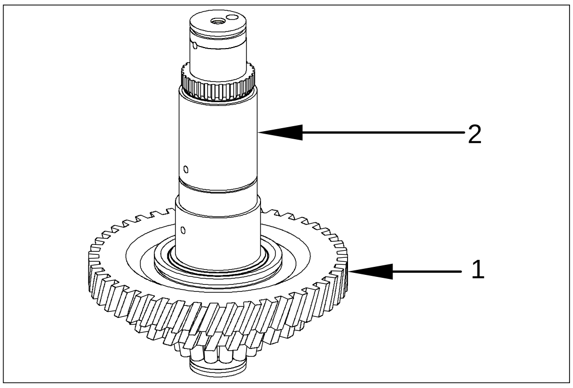
D507TM67

⑧ Remove the needle cage(1) from the shaft(2).



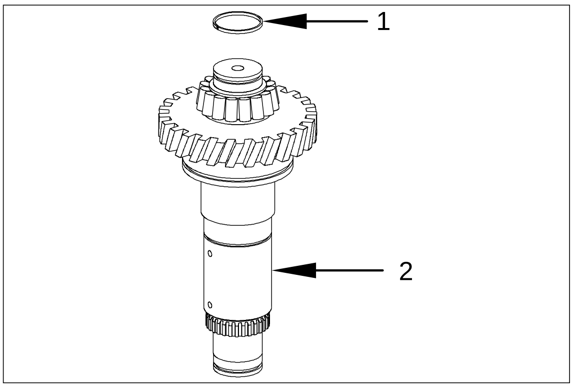
D507TM68

Shaft(2) and gear(1) cannot be separated(shrink fit).



D507TM69

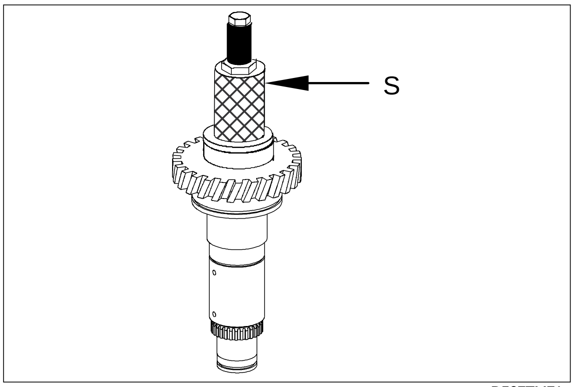
⑨ Rotated the shaft(2) by 180° and unsnap the piston ring(1).



D507TM70

⑩ Pull the taper roller bearing(inner ring) from the shaft.

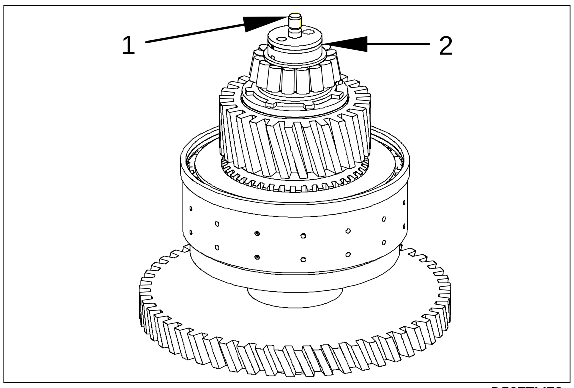
(S)Gripping insert	5873 001 057
(S)Back-off insert	5870 026 100
or	
(S)Rapid grip	5873 011 011



D507TM71

(3) Clutch K1

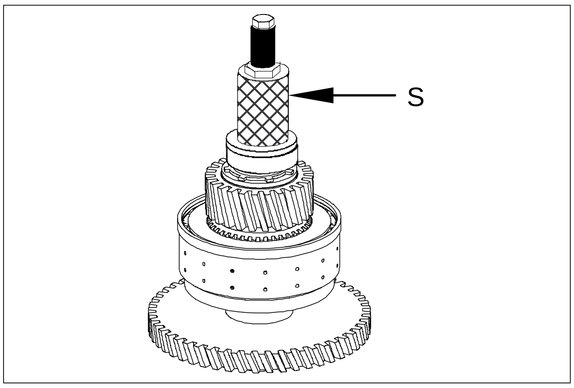
① Remove the stud(1) and unsnap the piston ring(2).



D507TM72

② Pull the taper roller bearing(inner ring) from the shaft.

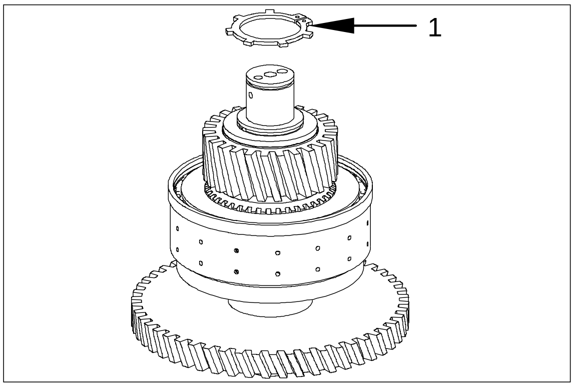
(S)Gripping insert	5873 001 057
(S)Back-off insert	5870 026 100
or	
(S)Rapid grip	5873 011 011



D507TM73

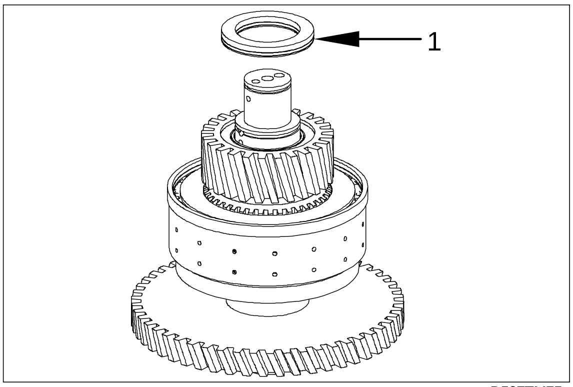
③ Unsnap the retaining ring(1).

(S)Set of internal pliers 5870 900 013



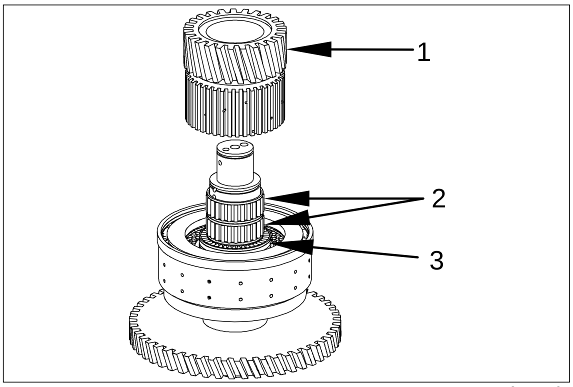
D507TM74

④ Remove the complete axial bearing(1).



D507TM75

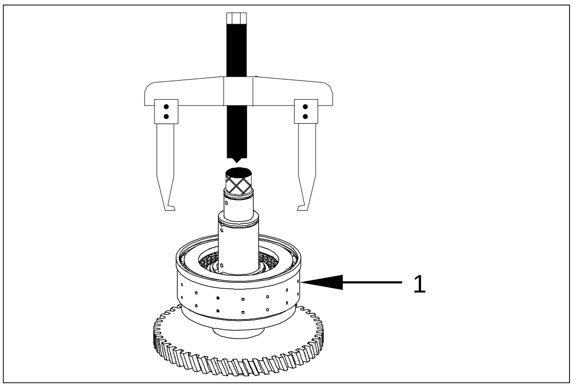
⑤ Take off idler(1), remove the needle cage(2) and the complete axial bearing(3).



D507TM76

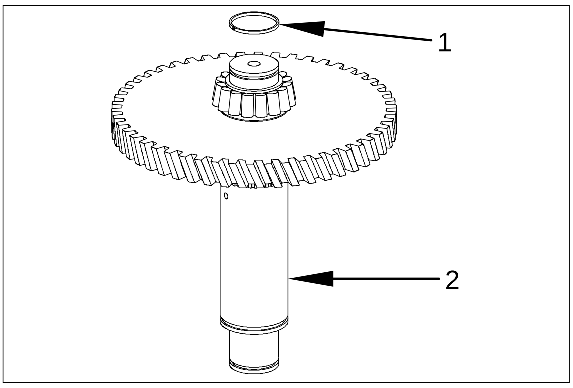
⑥ Pull the clutch(1) from the shaft.

(S)Two-armed puller 5870 970 003



D507TM77

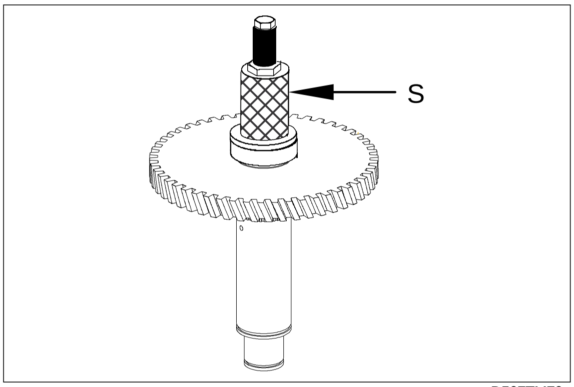
⑦ Rotated the shaft(2) by 180° and unsnap the piston ring(1).



D507TM78

⑧ Pull the taper roller bearing(inner ring) from the shaft.

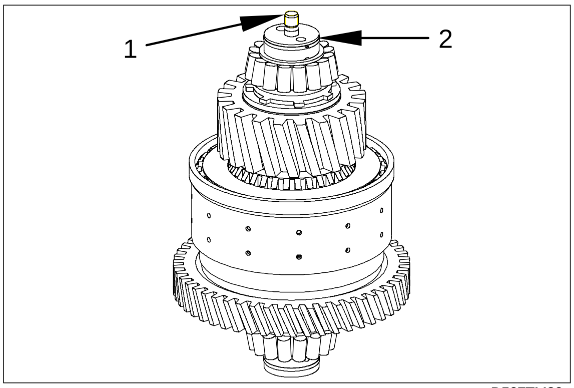
(S)Gripping insert	5873 001 057
(S)Back-off insert	5870 026 100
or	
(S)Rapid grip	5873 011 011



D507TM79

(4) Clutch K1

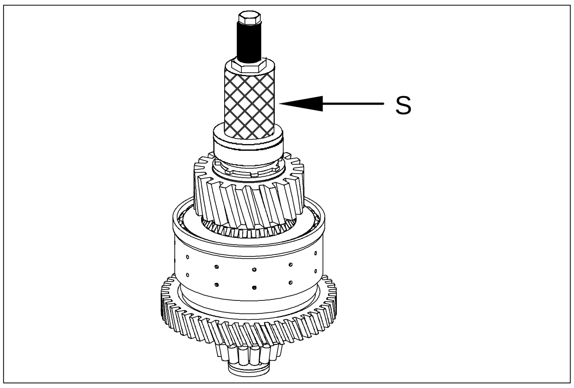
① Remove the stud(1) and unsnap the piston ring(2).



D507TM80

¤Ł Pull the taper roller bearing(inner ring) from the shaft.

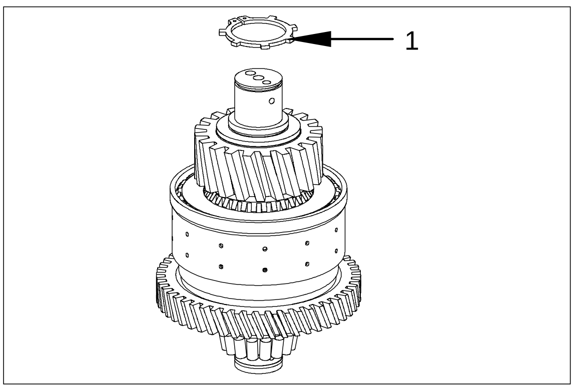
(S)Gripping insert	5873 001 057
(S)Back-off insert	5870 026 100
or	
(S)Rapid grip	5873 011 011



D507TM81

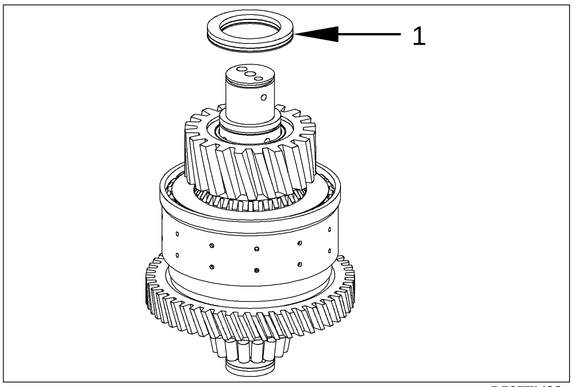
③ Unsnap the retaining ring(1).

(S)Set of internal pliers 5870 900 015



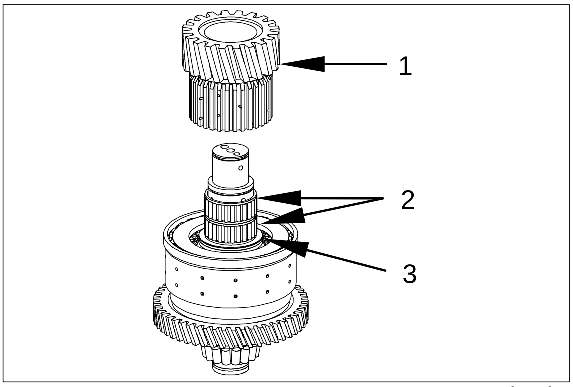
D507TM82

④ Remove the complete axial bearing(1).



D507TM83

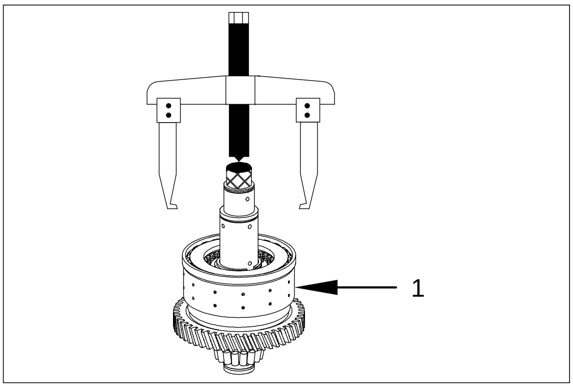
⑤ Take off idler(1), remove the needle cage(2) and the complete axial bearing(3).



D507TM84

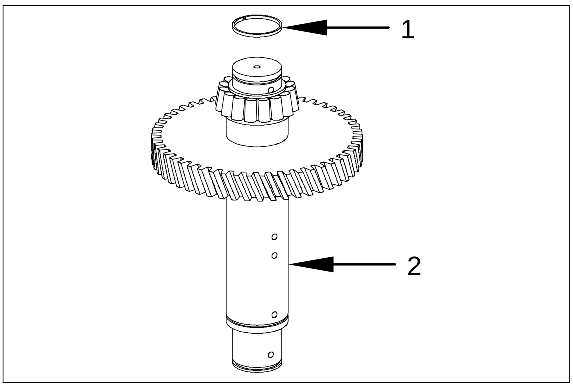
⑥ Pull the clutch(1), front the shaft.

(S)Two-armed puller 5870 970 003



D507TM85

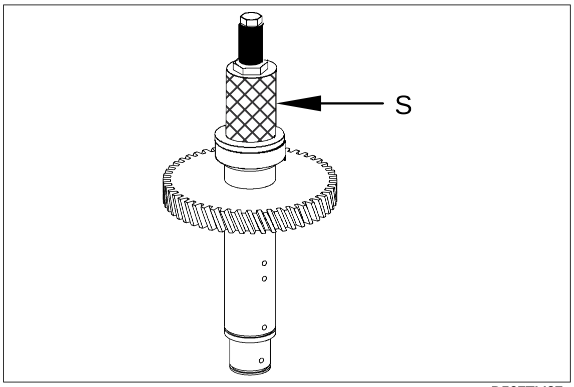
⑦ Rotated the shaft(2) by 180° and unsnap the piston ring(1).



D507TM86

⑧ Pull the taper roller bearing(inner ring) from the shaft.

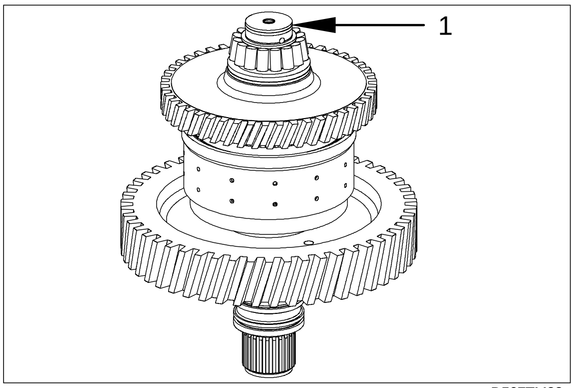
(S)Gripping insert 5873 001 057
(S)Back-off insert 5870 026 100
or
(S)Rapid grip 5873 011 011



D507TM87

(5) Clutch K3

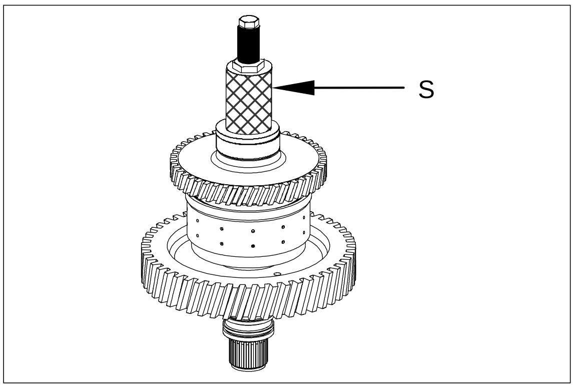
① Unsnap the piston ring(1).



D507TM88

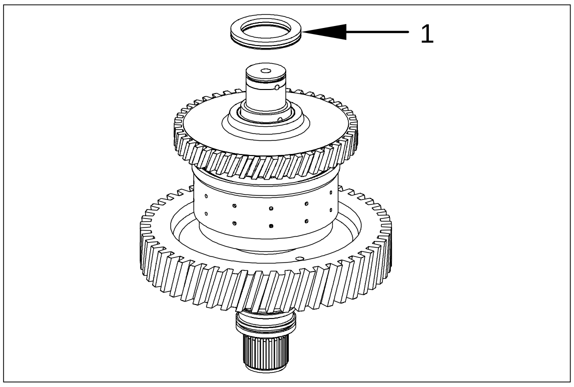
② Pull the taper roller bearing(inner ring) from the shaft.

(S)Gripping insert 5873 001 057
(S)Back-off insert 5870 026 100
or
(S)Rapid grip 5873 011 011



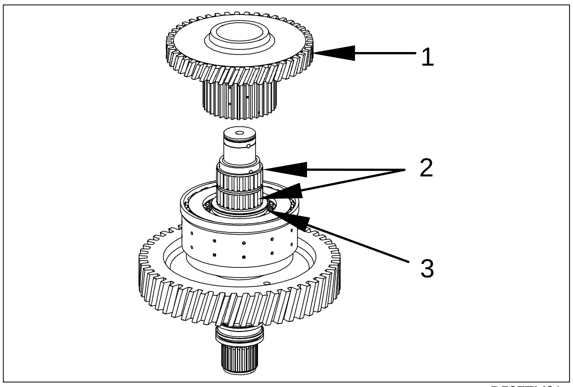
D507TM89

③ Remove the complete axial bearing(1).



D507TM90

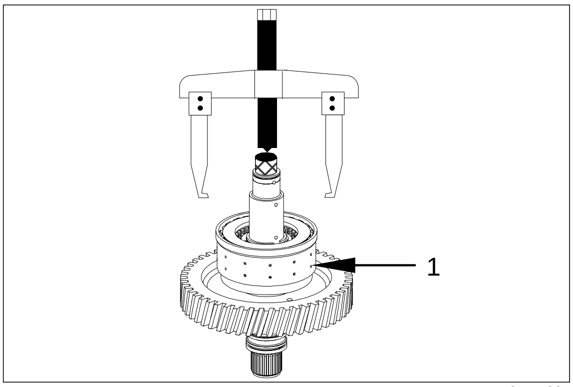
④ Take off idler(1), remove the needle cage(2) and the complete axial bearing(3).



D507TM91

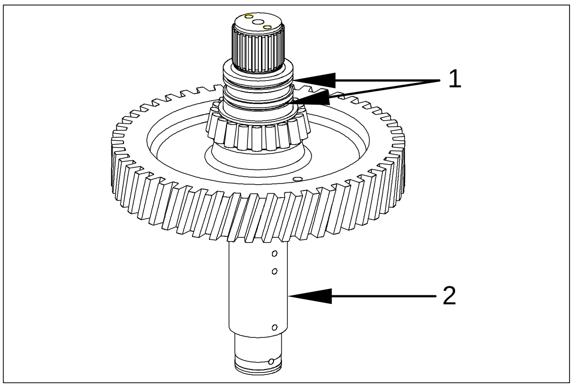
⑤ Pull the clutch(1) from the shaft.

(S)Two-armed puller	5870 970 003



D507TM92

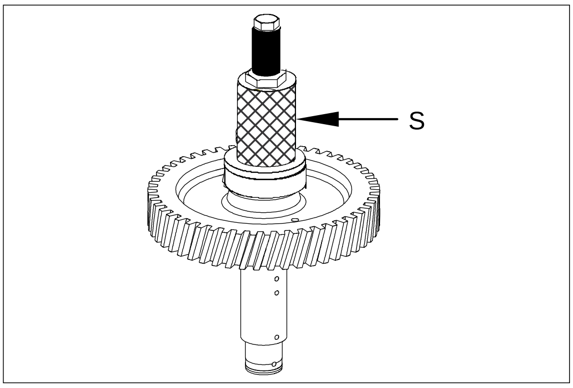
⑥ Rotated the shaft(2) by 180° and unsnap the piston ring(1).



D507TM93

⑦ Pull the taper roller bearing(inner ring) from the shaft.

(S)Gripping insert	5873 001 058
(S)Back-off insert	5870 026 100
or	
(S)Rapid grip	5873 011 014

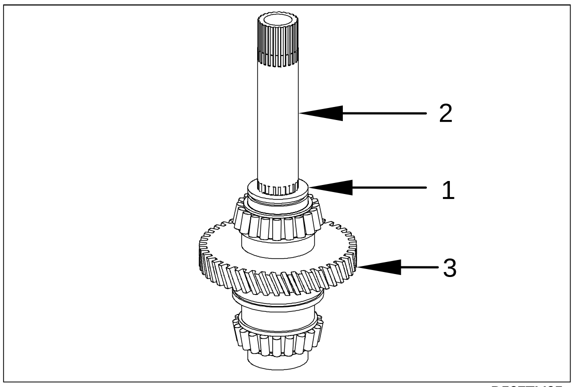


D507TM94

(6) Input

① Unsnap the piston ring(1).
The turbine wheel shaft(2) and the input gear(3) are attached with a snap ring.

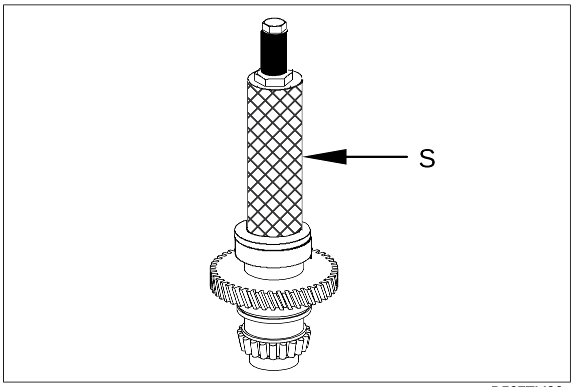
※ The components are destroyed at separation



D507TM95

② Pull the taper roller bearing(inner ring) from the input gear.

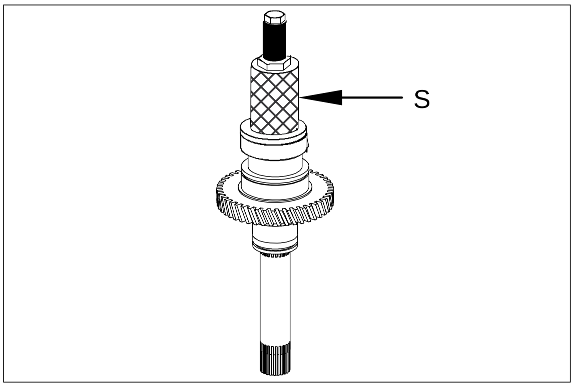
(S)Gripping insert	5873 001 058
(S)Back-off insert	5870 026 100
or	
(S)Rapid grip	5873 011 014



D507TM96

③ Pull the taper roller bearing(inner ring) from the input gear.

(S)Gripping insert	5873 001 058
(S)Back-off insert	5870 026 100
or	
(S)Rapid grip	5873 011 011



D507TM97

2. TRANSMISSION ASSEMBLY

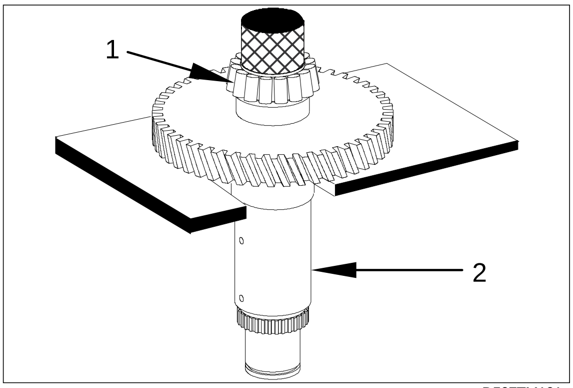
1) Clutches KV/KR/K1/K2/K3 and input

※ In the EST-37A(electronic transmission control)the gear change(filling times and pressure level) are controlled via the drive program of the transmission electronics. Additionally, the EST-37A monitors the disc clearance(clearance) of the clutches and if exceeded, a fault message is given in the transmission error display.

To ensure the shifting quality continuously, no repairs are allowed to be made on the clutches KV/KR/K1/K2/K3, which means that only the complete clutch is allowed to be replaced.

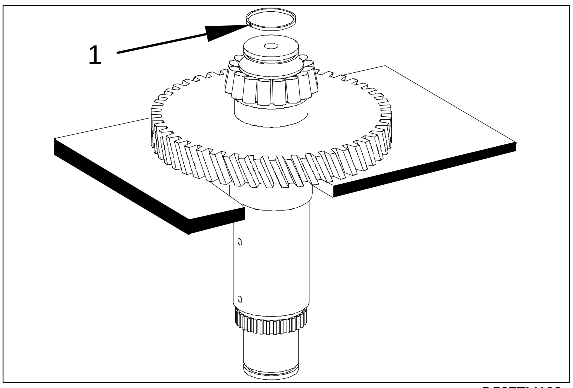
(1) Clutch KV

① Press the taper roller bearing(inner ring)(1) onto the shaft(2) until contact is obtained.



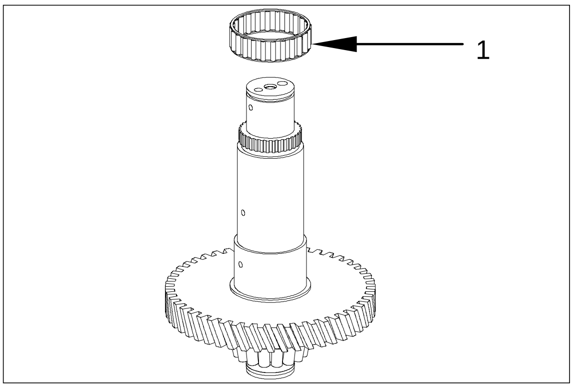
D507TM101

② Install the piston ring(1).



D507TM102

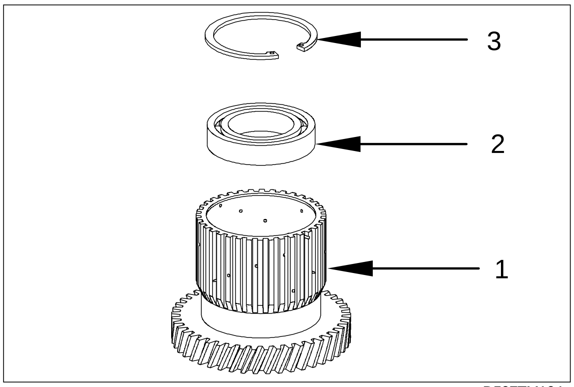
③ Mount the needle bearing(1) onto the shaft.



D507TM103

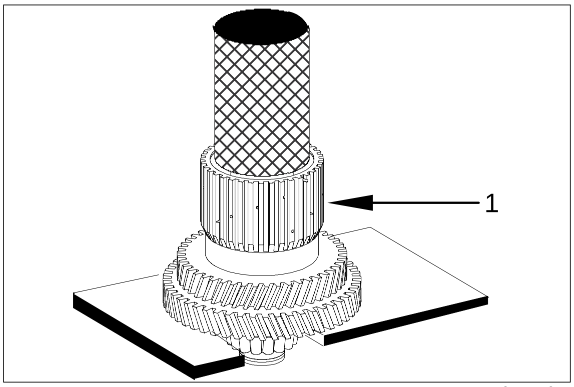
④ Put the ball bearing(2) into the idler(1) until contact is obtained and fasten it by means of retaining ring(3).

(S)Set of internal pliers



D507TM104

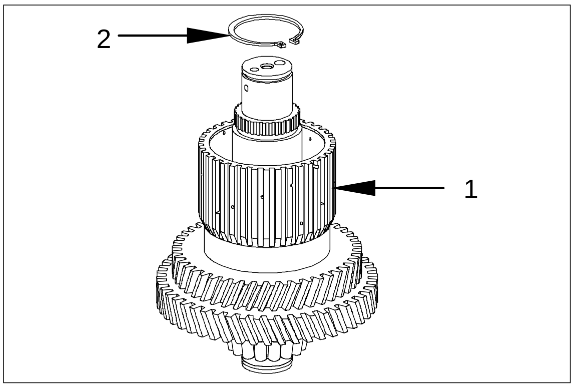
⑤ Press in preassembled idler(1) until contact.



D507TM105

⑥ Fasten the idler(1) by means of retaining ring(2).

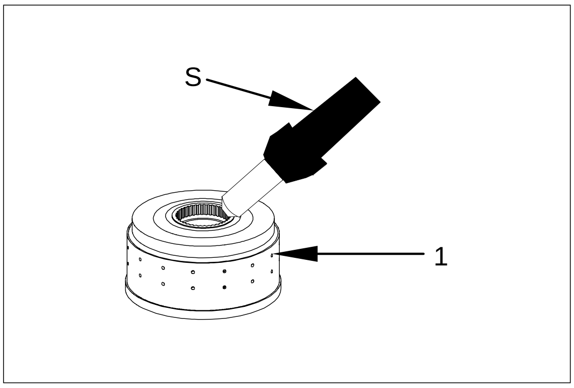
(S)Set of external pliers 5870 900 015



D507TM106

⑦ Heat up the inner diameter of the clutch(1)(approx. 120˚C).

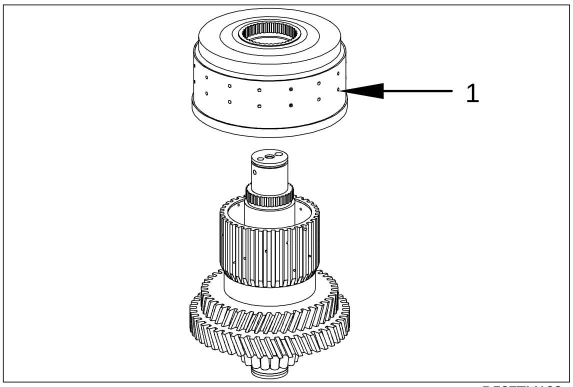
(S)Hot- air blower 220V 5870 221 500
(S)Hot- air blower 110V 5870 221 501



D507TM107

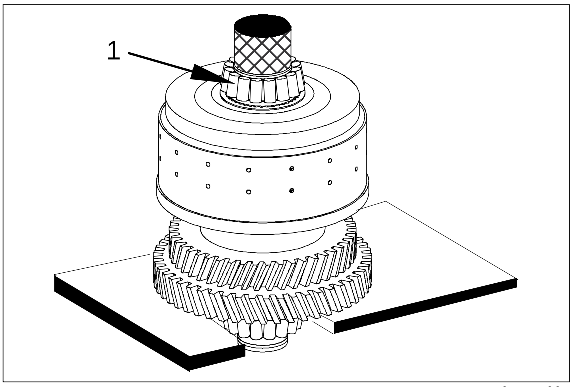
⑧ Mount the clutch(1) until contact is obtained.

⚠ **Wear safty gloves.**



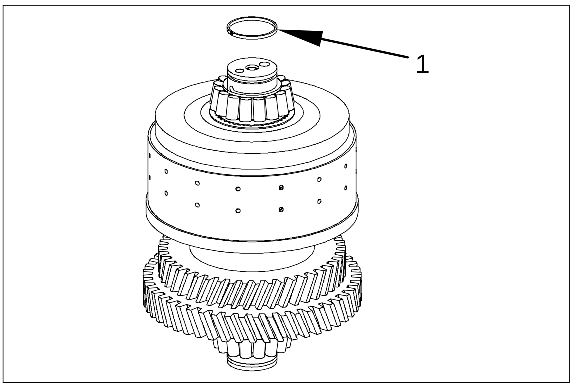
D507TM108

⑨ Press the taper roller bearing(inner ring)(1) until contact is obtained.



D507TM109

⑩ Install the piston ring(1).

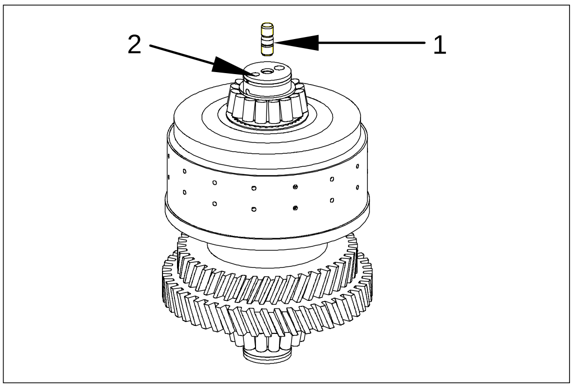


D507TM110

⑪ Install the stud(1).

Tightening torque ·············· M_A =1.7kg·m

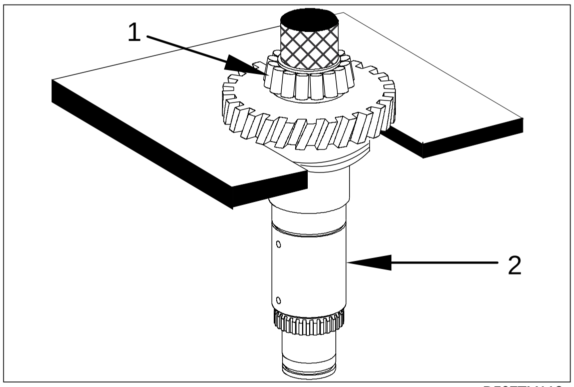
※ Check closing resp. opening of the clutch by means of compressed air at the bore(2).
Closing resp. opening of the clutch must be clearly audible.



D507TM111

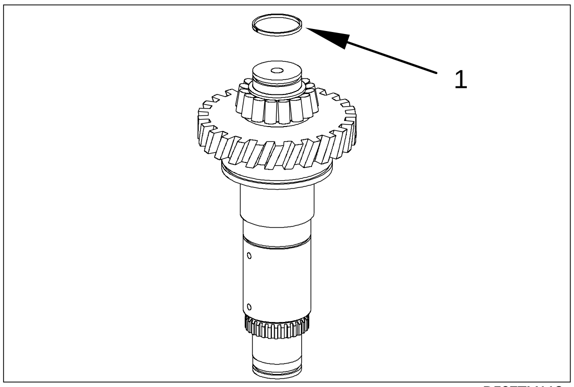
(2) Clutch KR

① Press the taper roller bearing(inner ring)(1) onto the shaft(2) until contact is obtained.



D507TM112

② Install the piston ring(1).

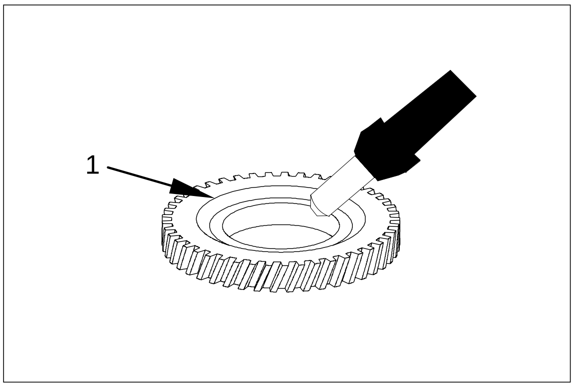


D507TM113

③ Heat up the inner diameter of the gear(1)(approx. 120°C).

(S)Hot- air blower 220V 5870 221 500
(S)Hot- air blower 110V 5870 221 501

⚠ **Wear safety gloves.**

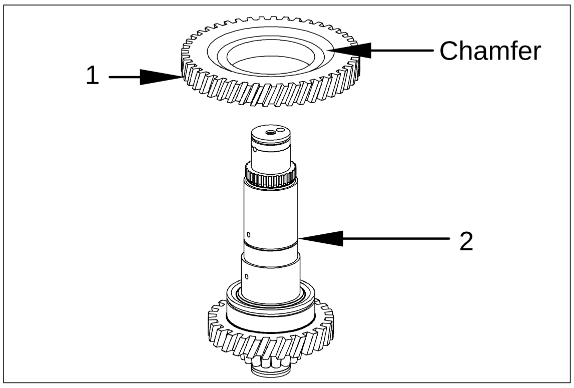


D507TM114

④ Undercool the shaft(2)(approx. 80°C).
Mount the gear until contact is obtained.

※ Install the chamfer of the gear(see arrow) showing upwards.
※ Observe the radial installation position.

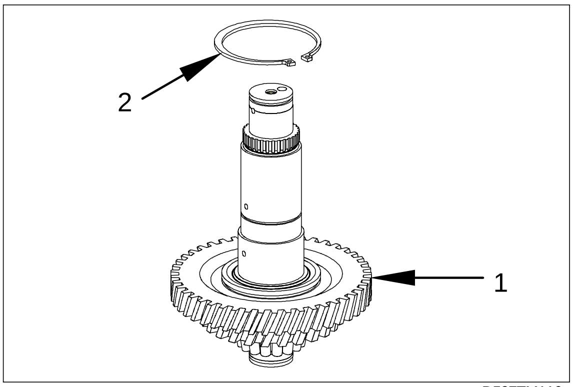
⚠ **Wear safety gloves.**



D507TM115

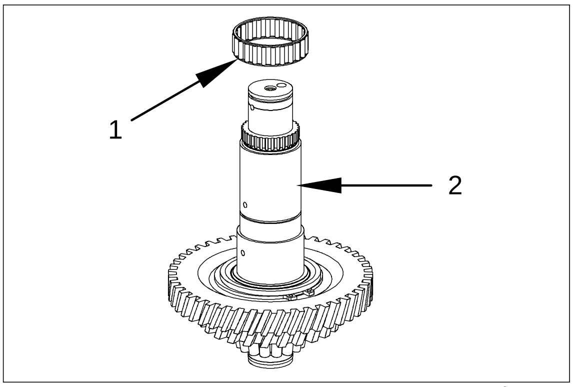
⑤ Fasten the gear(1) by means of retaining ring(2).

(S)Set of internal pliers 5870 900 015



D507TM116

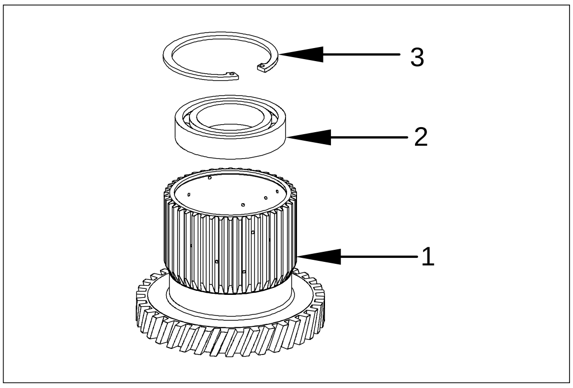
⑥ Mount the needle bearing(1) onto the shaft(2).



D507TM117

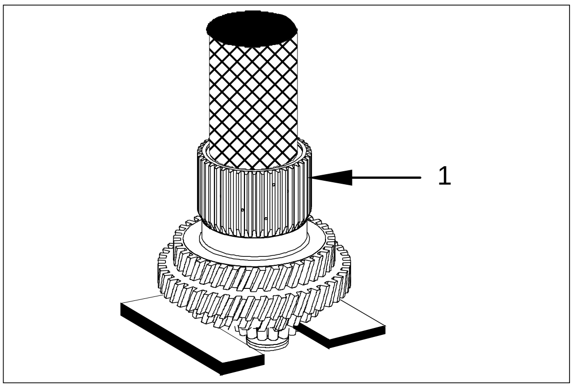
⑦ Put the ball bearing(2) into the idler(1) until contact is obtained and fasten it by means of retaining ring(3).

(S)Set of internal pliers 5870 900 013



D507TM118

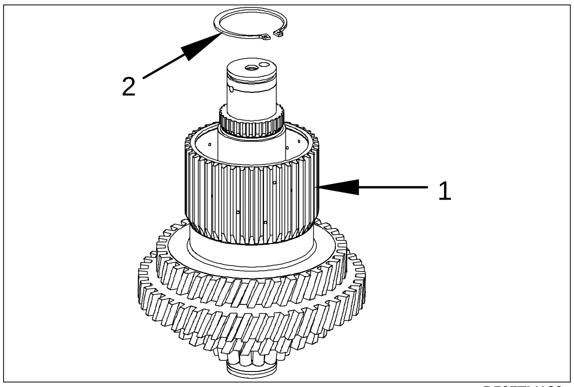
⑧ Press in the preassembled idler(1) until contact.



D507TM119

⑨ Fasten the idler(1) by means of retaining ring(2).

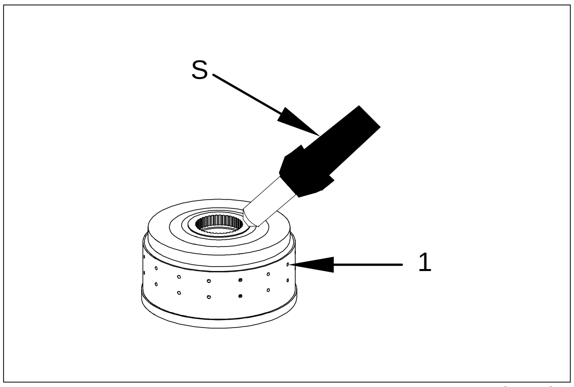
(S)Set of internal pliers 5870 900 015



D507TM120

⑩ Heat up the inner diameter of the clutch(1)(approx. 120°C).

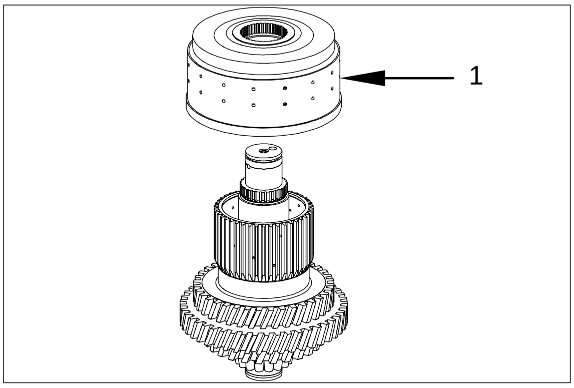
(S)Hot- air blower 220V 5870 221 500
(S)Hot- air blower 110V 5870 221 501



D507TM121

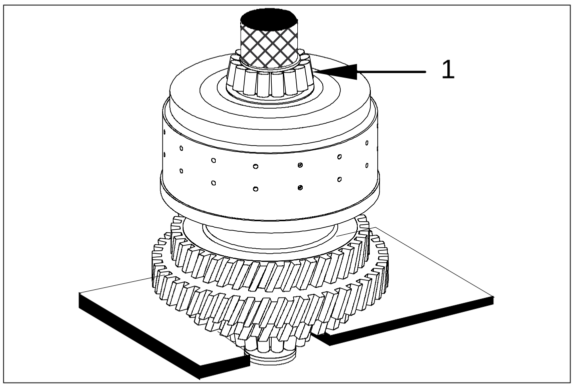
⑪ Mount the clutch(1) and press it until contact is obtained.

⚠ **Wear safety gloves.**



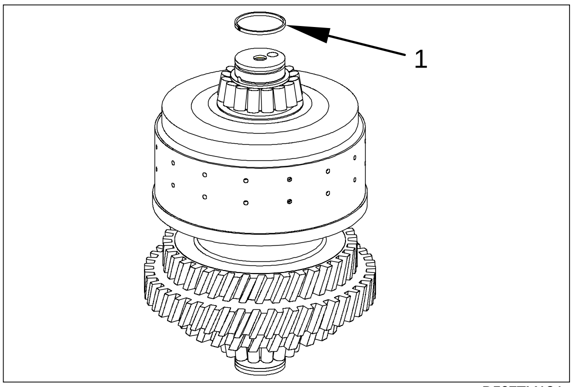
D507TM122

⑫ Press the taper roller bearing(inner ring)(1) until contact is obtained.



D507TM123

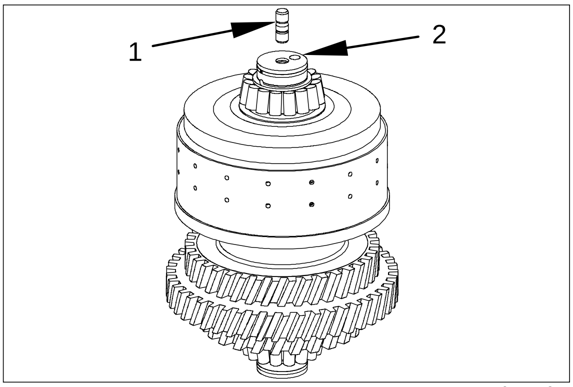
⑬ Install the piston ring(1).



D507TM124

⑭ Install the stud(1).
Tightening torque ·············· M_A =1.7kg·m

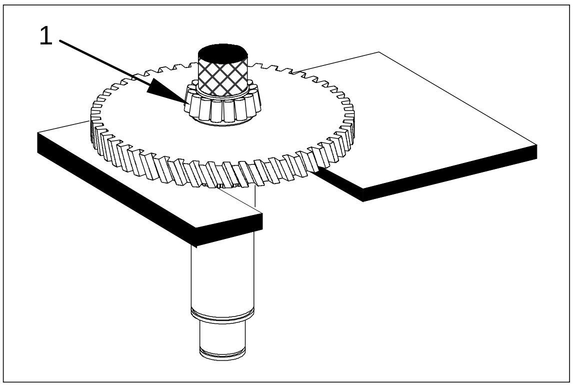
※ Check closing resp. opening of the clutch by means of compressed air at the bore(2).
Closing resp. opening of the clutch must be clearly audible.



D507TM125

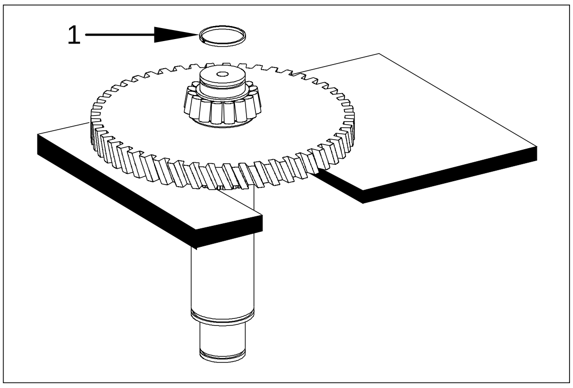
(3) Clutch K1

① Press the taper roller bearing(inner ring)(1) onto the shaft until contact.



D507TM126

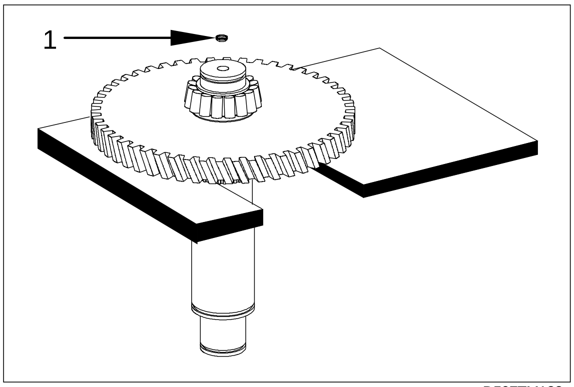
② Install the piston ring(1).



D507TM127

③ Install the sealing cap(1).

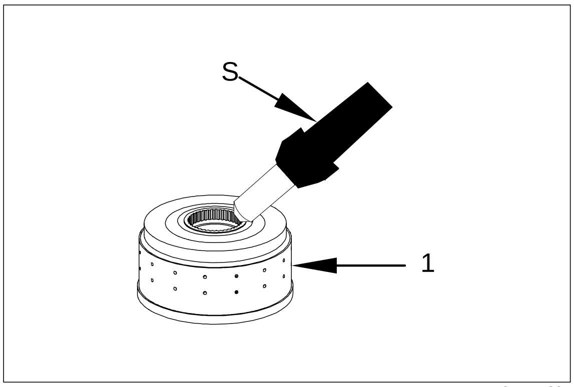
※ Wet the contact surface with(Loctite Type No. 262).



D507TM128

④ Heat up the inner diameter of the clutch(1)(approx. 120°C).

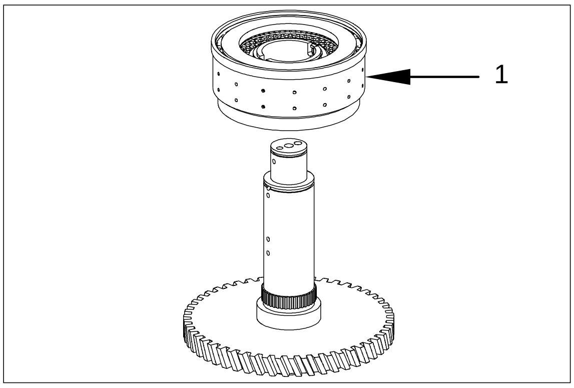
(S)Hot- air blower 220V	5870 221 500
(S)Hot- air blower 110V	5870 221 501



D507TM129

⑤ Mount the clutch(1) and press it until contact is obtained.

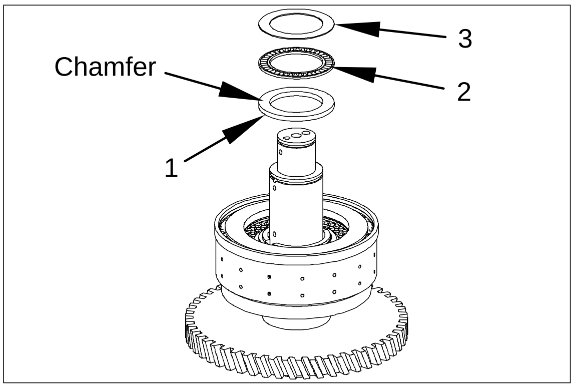
⚠ Wear safety gloves.



D507TM130

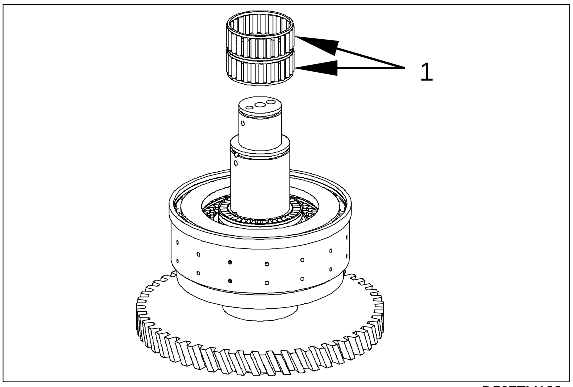
⑥ Mount the running disc(1), axial cage(2) and axial washer(3).

※ Install chamfer(see arrow) of the running disc(2) showing towards the axial cage.



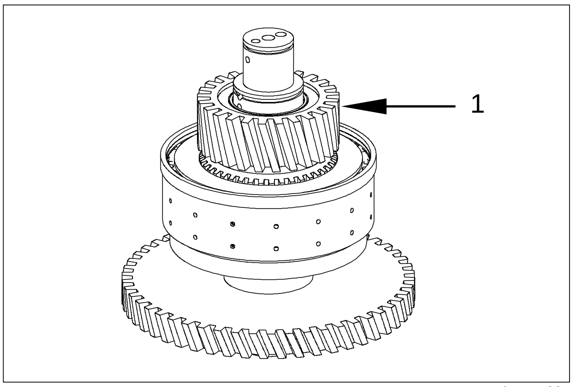
D507TM131

⑦ Mount the needle cage(1).



D507TM132

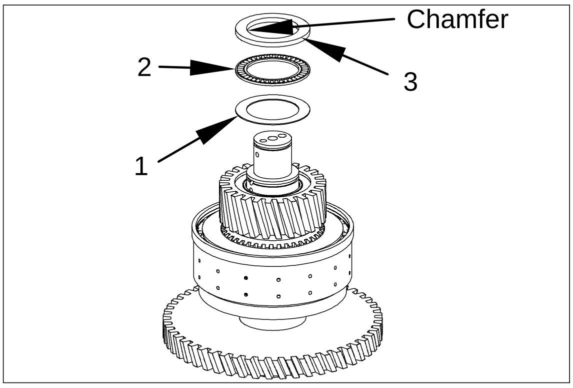
⑧ Install the idler(1).



D507TM133

⑨ Mount the axial washer(1), axial cage(2) and running disc(3).

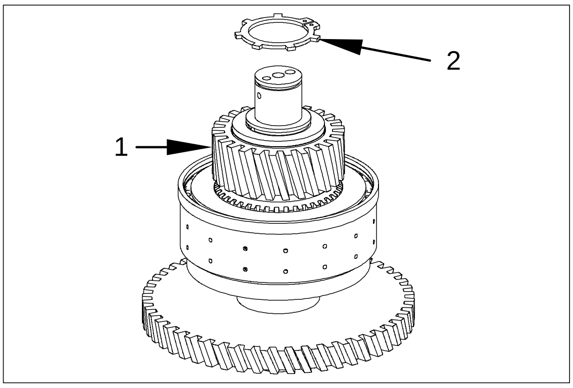
※ Install chamfer(see arrow) of the running disc(3) showing towards the axial cage



D507TM134

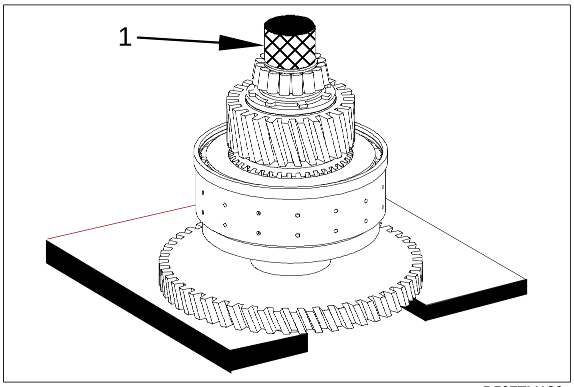
⑩ Fasten the idler(1) and the single parts by means of the retaining ring(2).

(S)Set of external pliers 5870 900 015



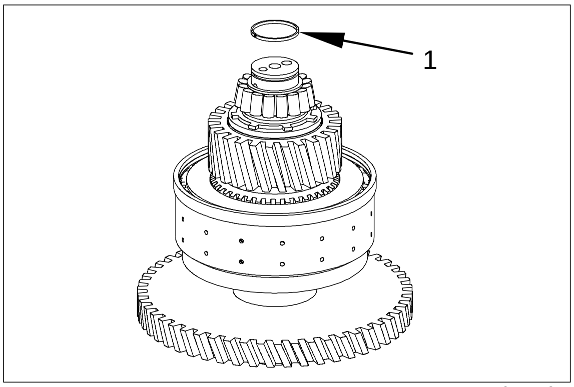
D507TM135

⑪ Press the taper roller bearing(inner ring)(1) until contact is obtained.



D507TM136

⑫ Install the piston ring(1).



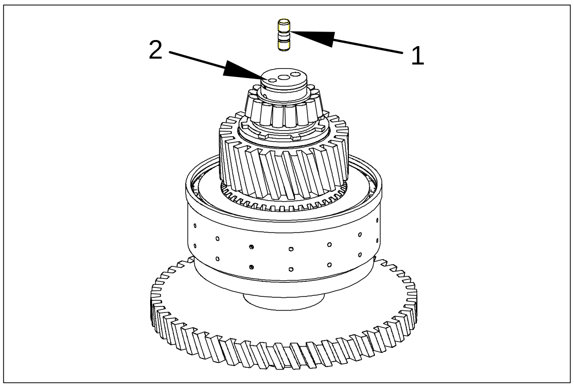
D507TM137

⑬ Install the stud(1).

Tightening torque ·············· M_A =1.7kg·m

※ Check closing resp. opening of the clutch by means of compressed air at the bore(2).

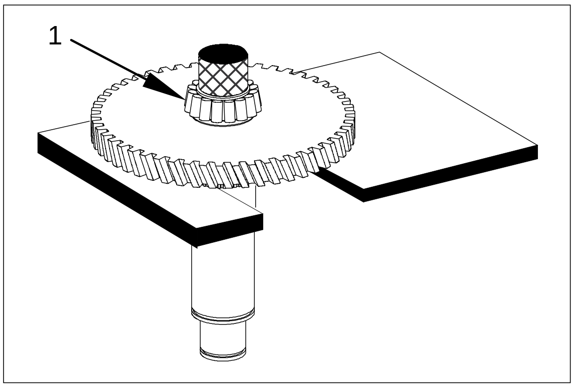
Closing resp. opening of the clutch must be clearly audible.



D507TM138

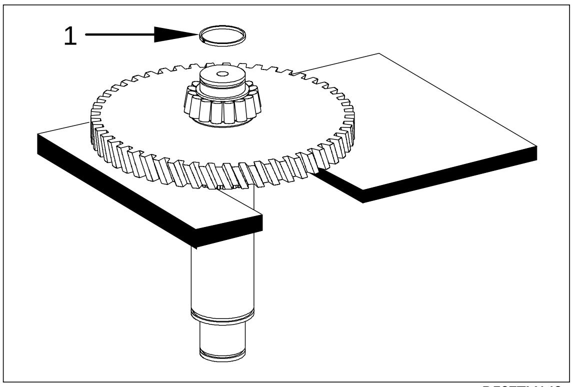
(4) Clutch K2

① Press the taper roller bearing(inner ring)(1) onto the shaft until contact.



D507TM139

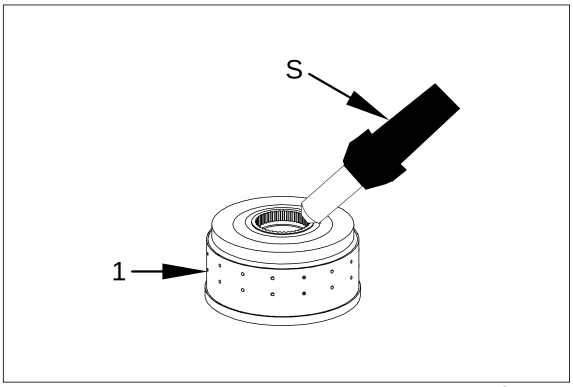
② Install the piston ring(1).



D507TM140

③ Heat up the inner diameter of the clutch(1)(approx. 120° C).

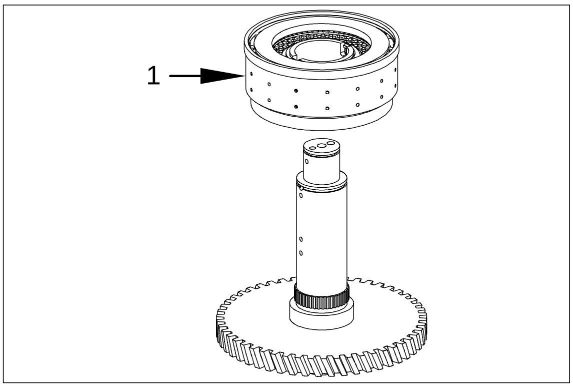
(S)Hot- air blower 220V 5870 221 500
(S)Hot- air blower 110V 5870 221 501



D507TM141

④ Mount the clutch(1) until contact is obtained.

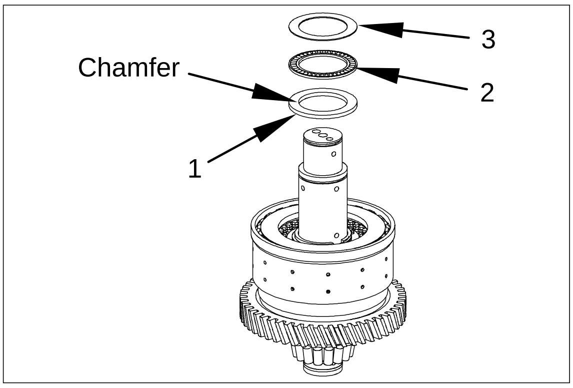
⚠ **Wear safety gloves.**



D507TM142

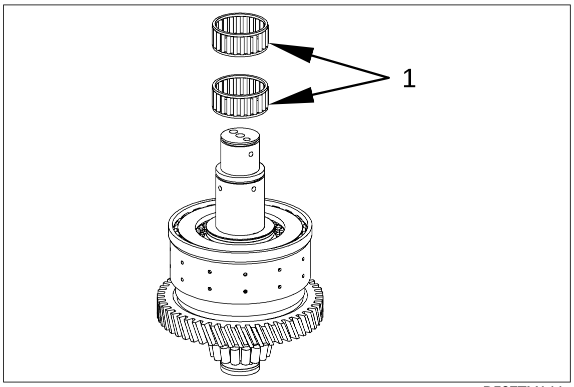
⑤ Mount the running disc(1), axial cage(2) and axial washer(3).

※ Install chamfer(see arrow) of the running disc(2) showing towards the axial cage.



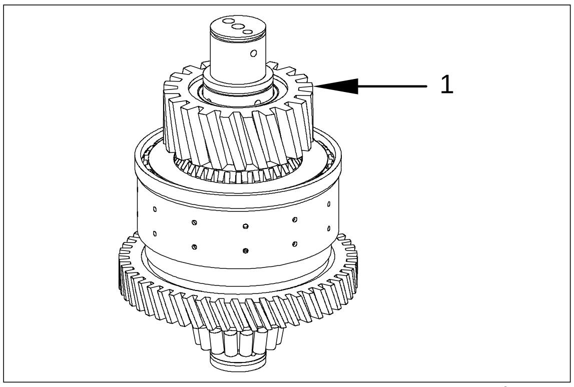
D507TM143

⑥ Mount the needle cage(1).



D507TM144

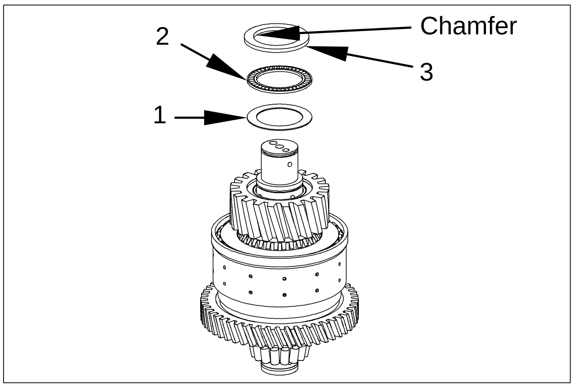
⑦ Install the idler(1).



D507TM145

⑧ Mount the axial washer(1), axial cage(2) and running disc(3).

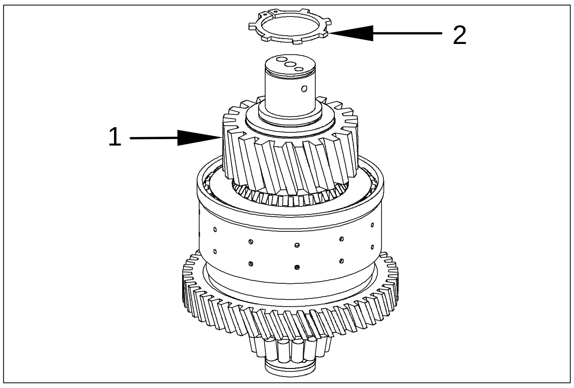
※ Install chamfer(see arrow) of the running disc(3) showing towards the axial cage.



D507TM146

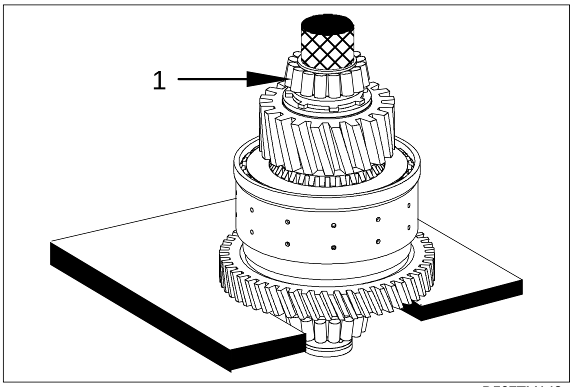
⑨ Fasten the idler(1) and the single parts by means of the retaining ring(2).

(S)Set of external pliers 5870 900 015



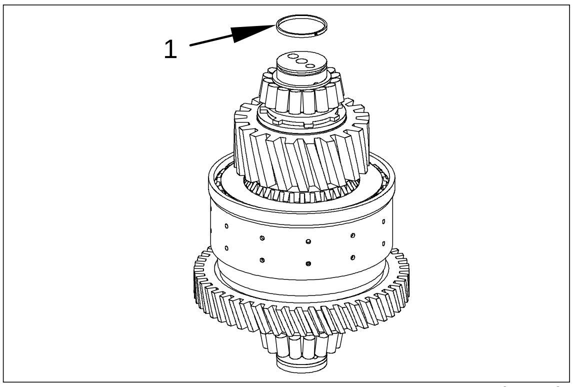
D507TM147

⑩ Press the taper roller bearing(inner ring)(1) until contact is obtained.



D507TM148

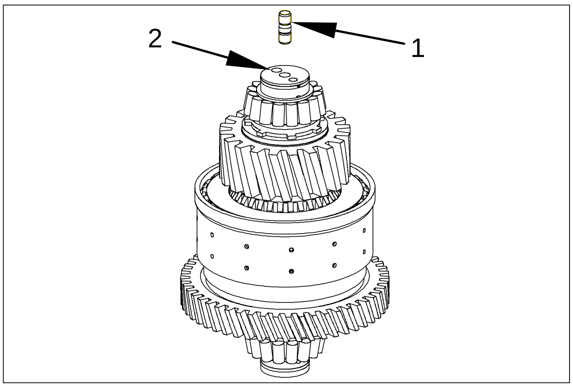
⑪ Install the piston ring(1).



D507TM149

⑫ Install the stud(1).
Tightening torque ·············· M_A =1.7㎏·m

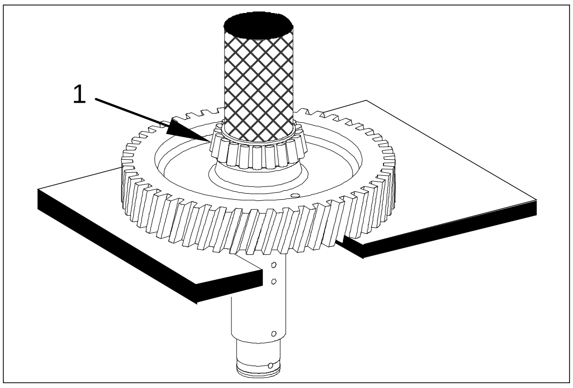
※ Check closing resp. opening of the clutch by means of compressed air the bore(2). Closing resp. opening of the clutch must be clearly audible.



D507TM150

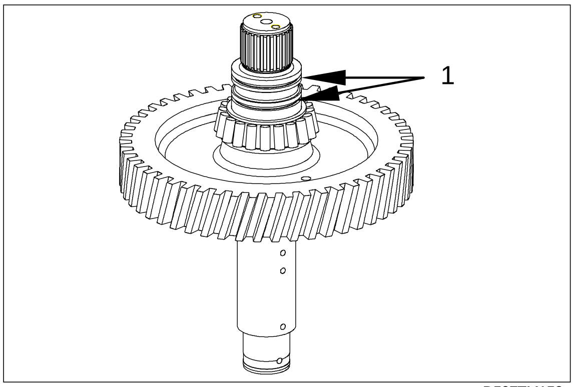
(5) Clutch K3

① Press the taper roller bearing(inner ring)(1) onto the shaft until contact.



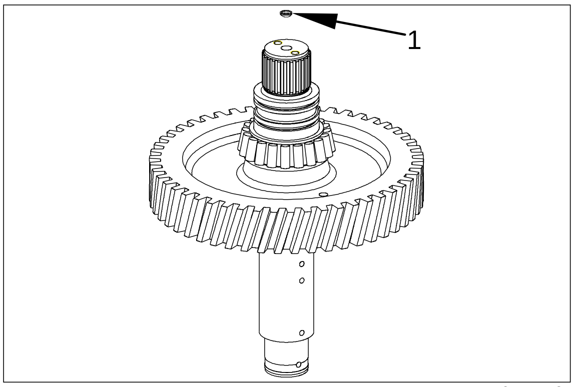
D507TM151

② Install the piston ring(1).



D507TM152

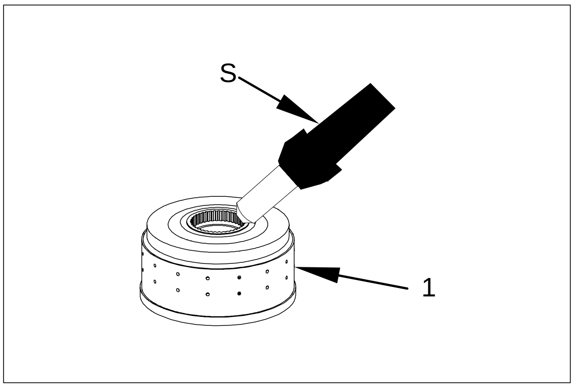
③ Install the sealing cap(1).
Wet the contact surface with loctite type No.262.



D507TM153

④ Heat up the inner diameter of the clutch(1)(approx. 120˚C).

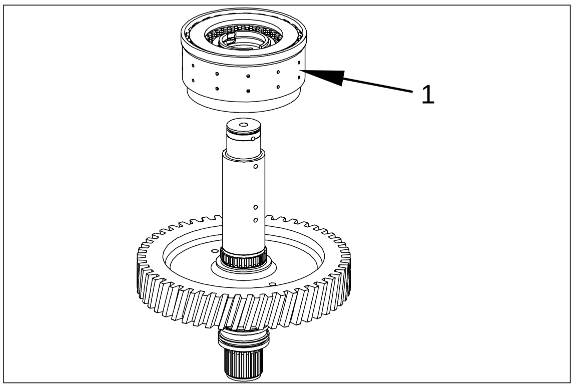
(S)Hot- air blower 220V 5870 221 500
(S)Hot- air blower 110V 5870 221 501



D507TM154

⑤ Mount the clutch(1) until contact is obtained.

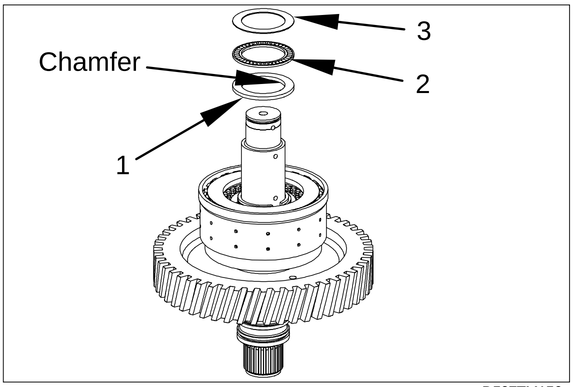
⚠ **Wear safety gloves.**



D507TM155

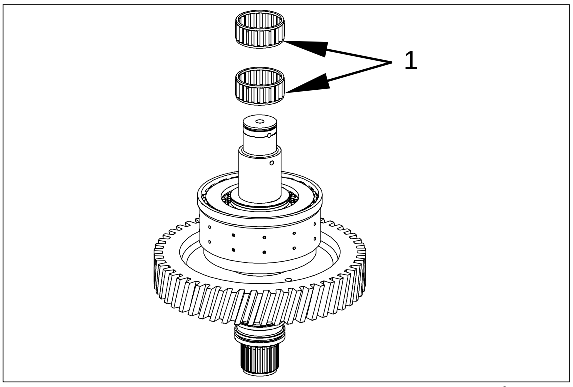
⑥ Mount the running disc(1), axial cage(2) and axial washer(3).

※ Install chamfer(see arrow) of the running disc(3) showing toward the axial cage.



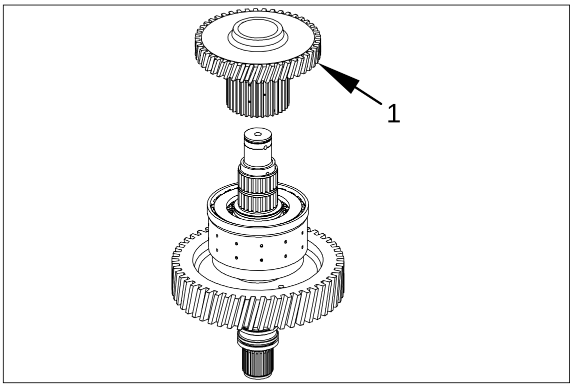
D507TM156

⑦ Mount the needle cage(1).



D507TM157

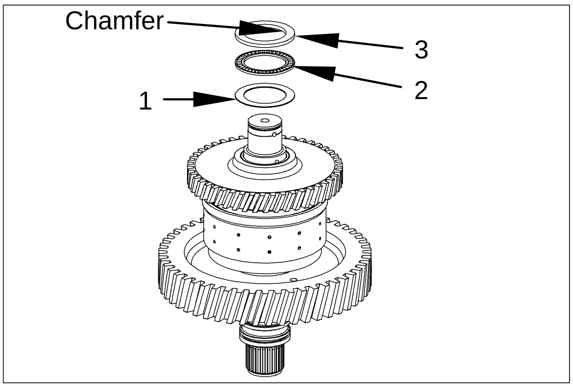
⑧ Install the idler(1).



D507TM158

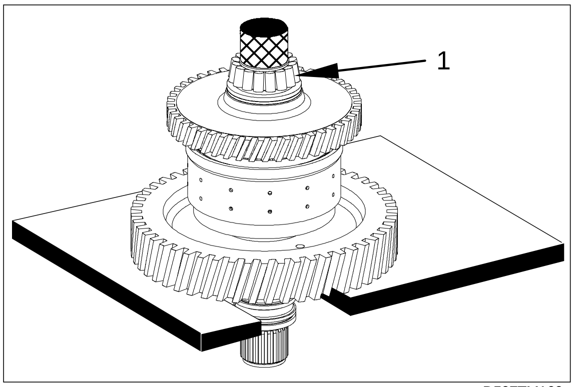
⑨ Mount the axial washer(1), axial cage(2) and running disc(3).

※ Install chamfer(see arrow) of the running disc(3) showing towards the axial cage.



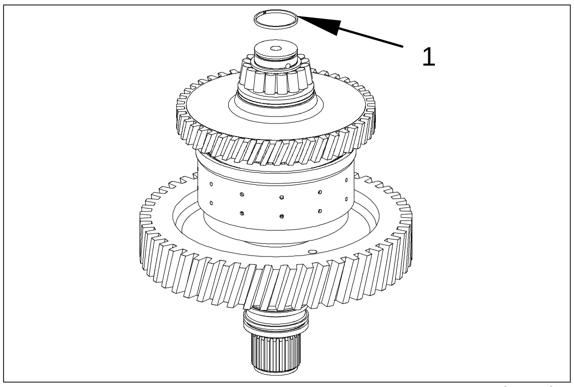
D507TM159

⑩ Press the taper roller bearing(inner ring)(1) until contact is obtained.



D507TM160

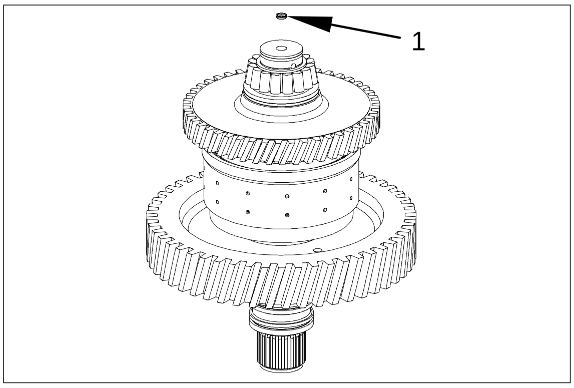
⑪ Install the piston ring(1).



D507TM161

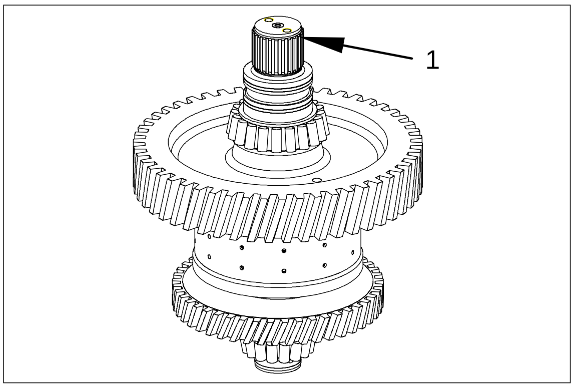
⑫ Install the screw plug(1).

(S)Lever riveting tongs 5870 320 016



D507TM162

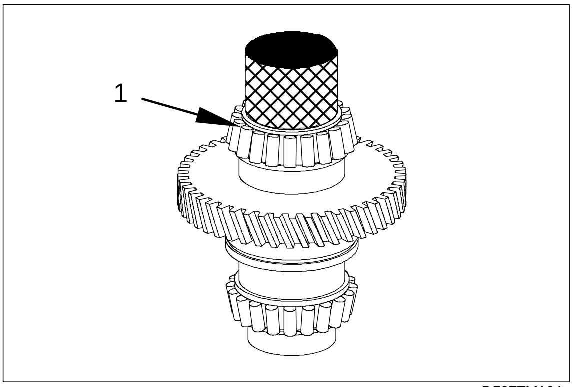
※ Check cosing resp. opening of the clutch by means of compressed air at the bore(1).
Closing resp. opening of the clutch must be clearly audible.



D507TM163

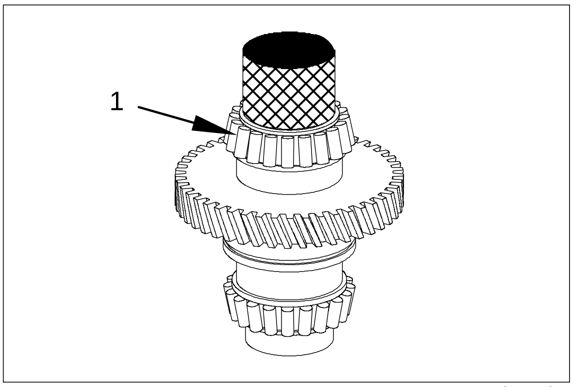
(6) Input

① Press the taper roller bearing(inner ring)(1) until contact is obtained.



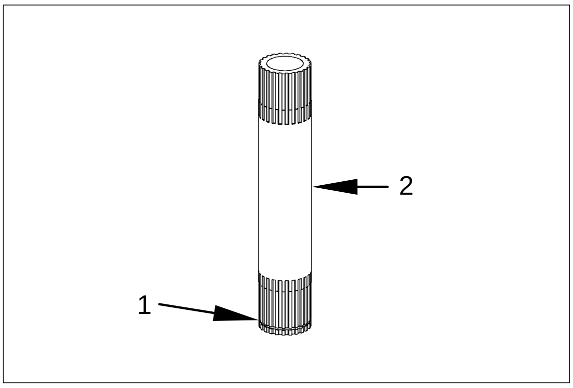
D507TM164

② Press the taper roller bearing(inner ring)(1) until contact is obtained.



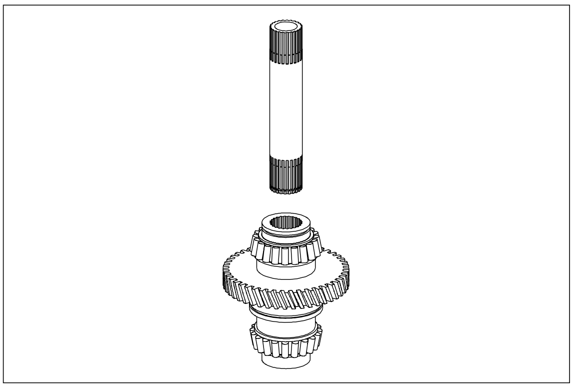
D507TM165

③ Have the snap ring(1) engaged into the annular groove of the turbine wheel shaft(2).



D507TM166

④ Mount the turbine wheel shaft until the snap ring engages into the recess of the input gear-turbine wheel shaft is axially fixed.



D507TM167

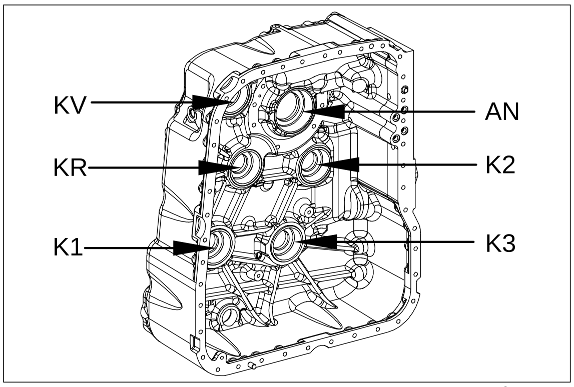
2) ENGINE CONNECTION, PRESSURE OIL PUMP AND INSTALLATION OF THE CLUTCHES

Install all bearing outer rings into the bearing bores of both transmission housing sections.

※ **Should contrary to the recommendations the taper roller bearing of the clutches as well as of the input not be replaced, the assignment(bearing inner and outer rings) has to be kept at least .**
Mark the bearing inner and bearing outer rings to each other accordingly.

(1) Transmission housing front section

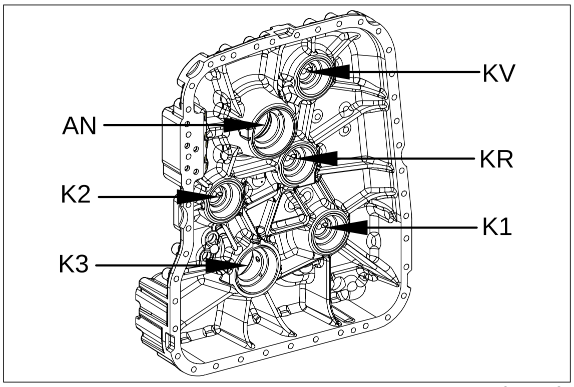
AN = Input
KV = Clutch - Forward
KR = Clutch - Reverse
K1 = Clutch - 1st gear
K2 = Clutch - 2nd gear
K3 = Clutch - 3rd gear



D507TM171

(2) Transmission housing rear section

※ Put the bearing outer rings with assembly grease into the bearing bores

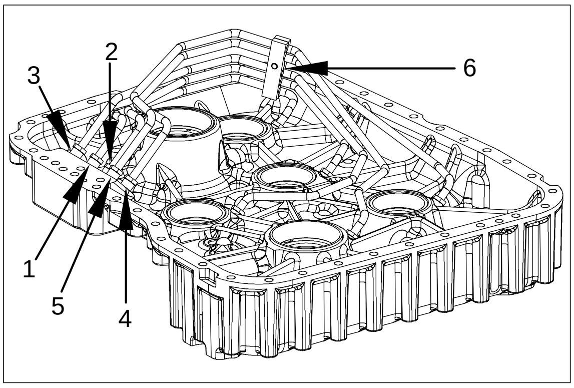


D507TM172

① Install the pipe(system pressure from the electro-hydraulic control to the respective clutch).
The pipes are to be installed in the following sequence:

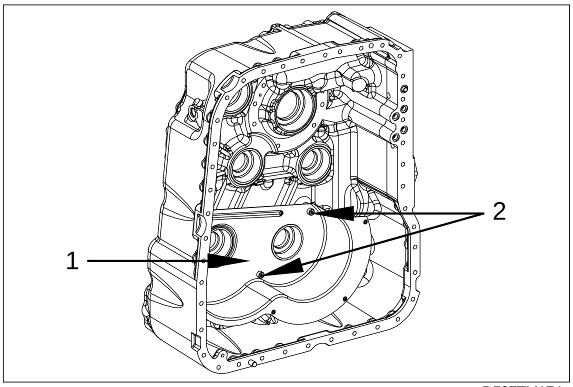
1 = Pipe KV
2 = Pipe KR
3 = Pipe K2
4 = Pipe K1
5 = Pipe K3

Tightening torque ················ M_A =4.3kg·m
Install the holding segment(6)
Tightening torque(M8/8.8) ·· M_A =2.3kg·m



D507TM173

② Fasten the screen sheet(1) by means of cap screws(2).
Tightening torque(M8/8.8) ··· M_A=2.3kg·m

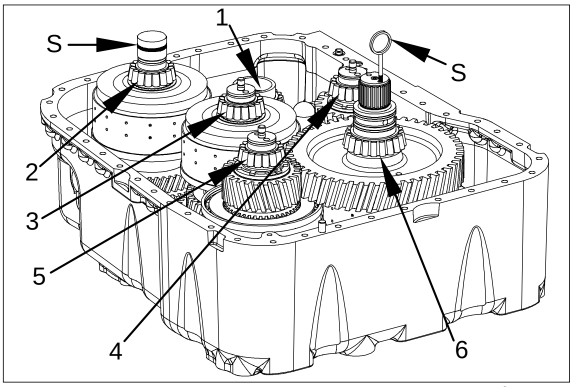


D507TM174

③ The clutch is to be put into the transmission housing front section as described in the legend.

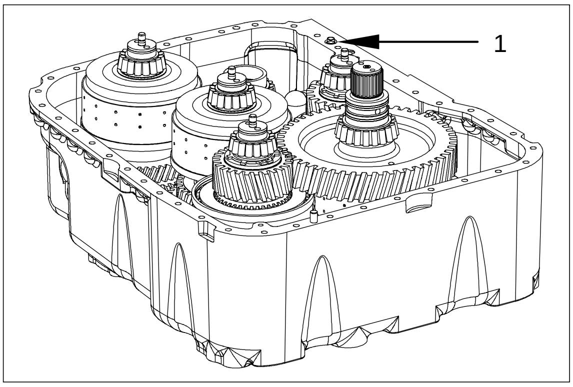
1 = Input shaft
2 = Clutch KV
3 = Clutch KR
4 = Clutch K2
5 = Clutch K1
6 = Clutch K3

(S)Handle 5870 260 010 (K1/K2/KV/KR)
(S)Eyebolt 5870 204 002



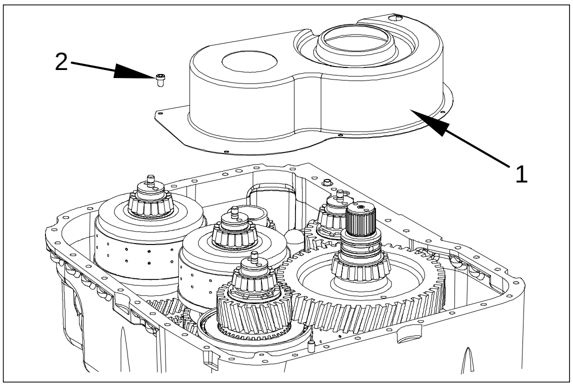
D507TM175

④ Put the pipes and O-rings into the bores and grease them.



D507TM176

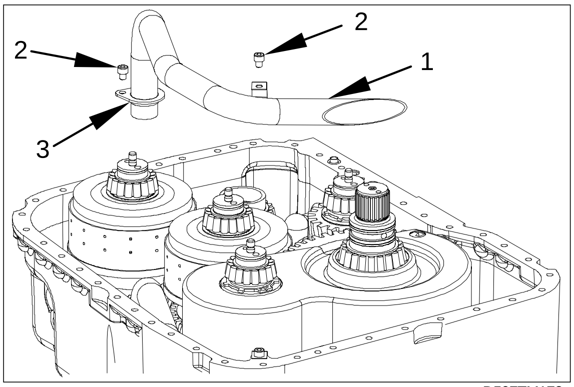
⑤ Fasten the screen sheet(1) by means of cap screws(2).
Tightening torque(M6/8.8) ·· M_A=0.97kg·m



D507TM177

⑥ Install the O-rings(3) and fasten the suction pipe(1) by means of cap screws(2).

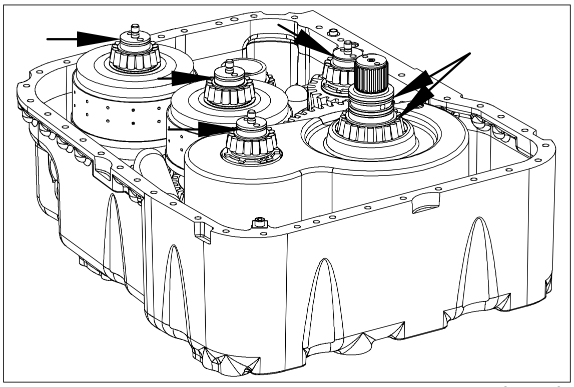
Tightening torque(M8/8.8) ··· M_A=2.3kg·m



D507TM178

⑦ Grease the rectangular rings(see arrows) and align them, centrically.

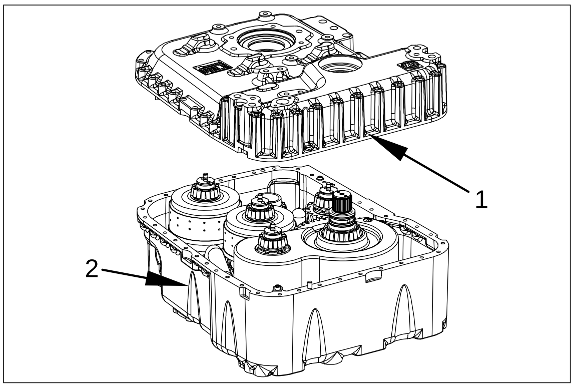
※ Wet the mounting face with sealing compound loctite(Type No.574)



D507TM179

⑧ Cautiously place the transmission housing rear section(1) by means of the lifting equipment to the transmission housing front section(2) until contact is obtained.

(S)Eyebolts 2x(M20)	0636 804 003
(S)Ring nut(M12)	0664 462 774
(S)Lifting chain	5870 281 047



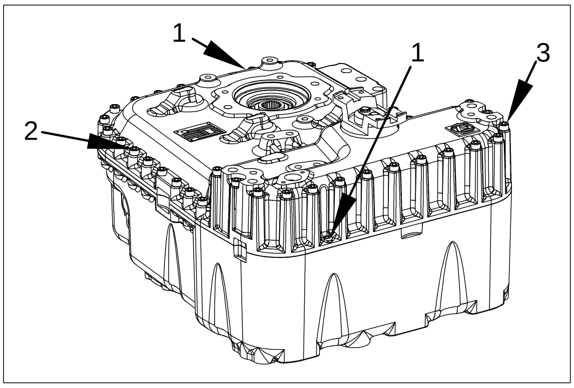
D507TM180

⑨ Install both cyl. pins(1) centrally to the mounting face.

By means of cap screws(2 and 3) fasten the transmission housing rear section to the transmission housing front section.

※ Cap screws with different lengths.

Tightening torque(M8/8) ······ M_A=4.7kg·m



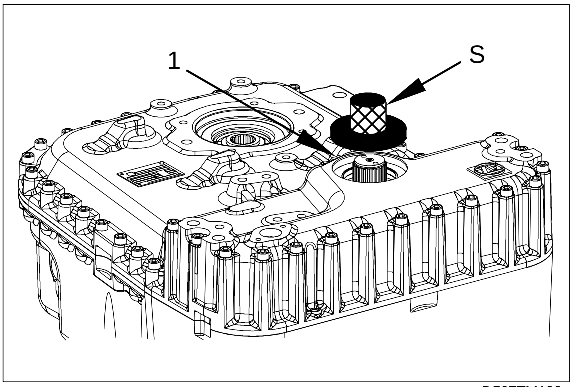
D507TM181

⑩ Install the shaft seal(1) with the sealing lip showing to the oil sump.

※ The exact installation position is obtained by using the specified mounting tool(S).

※ Fill the shaft seal between dust lip and sealing lip with grease.
Wet the outer diameter with spirit.

(S)Mounting tool	5870 048 057

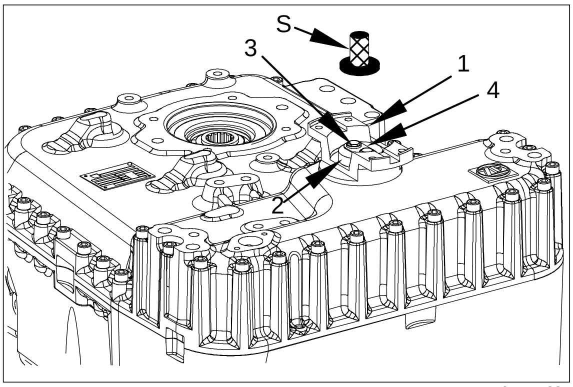


D507TM182

⑪ Insert the input flange(1) until contact and put in the O-ring. Fix the input flange(1) by means of washer(2) and hexagon screws(3).
Then fix the hexagon screws(3) with the tab washer(4) by means of the mounting tool(S).

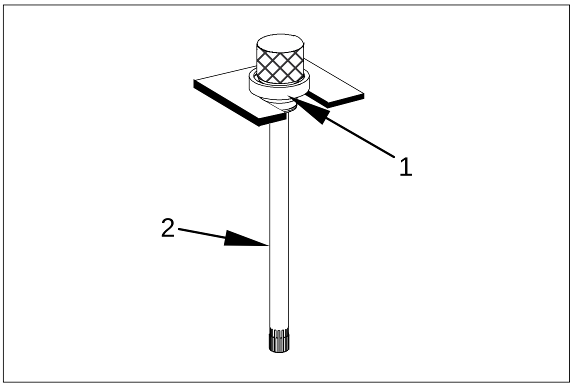
Tightening torque(M8/8.8) ··· M_A=3.5kg·m

(S)Mounting tool	5870 057 011
(S)Handle	5870 260 002



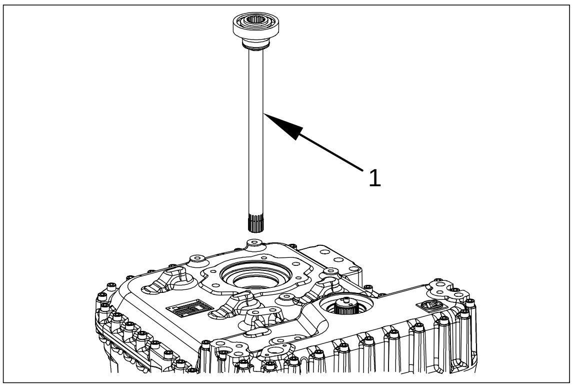
D507TM183

⑫ Press the ball bearing(1) onto the pump shaft(2) until contact is obtained.



D507TM184

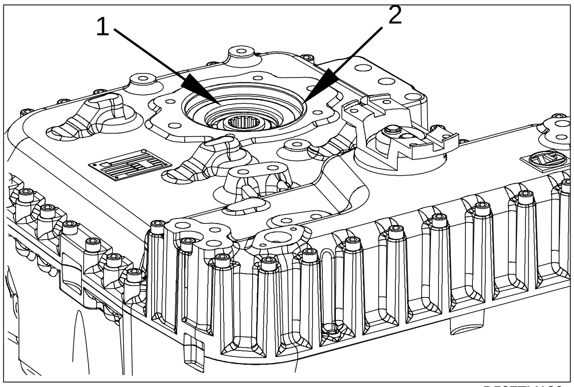
⑬ Install the pump shaft(1) until contact is obtained.



D507TM185

⑭ Install the retaining ring(1) and the O-ring(2).

※ Grease the O-ring

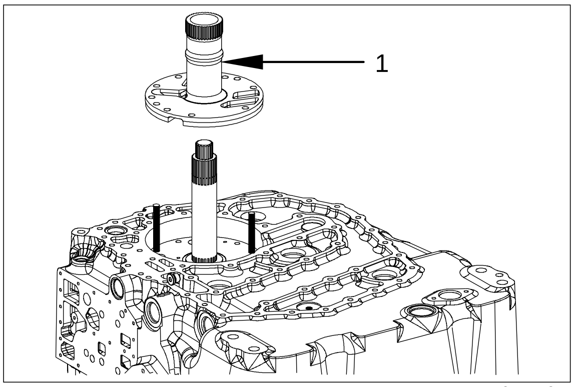


D507TM186

⑮ Install two adjusting screws and mount the stator hollw shaft(1).

※ Observe the radial installation position.

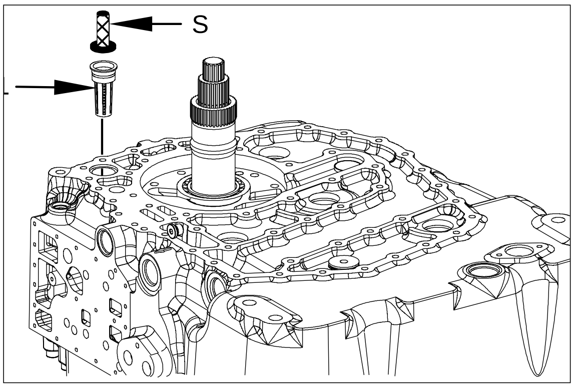
(S)Adjusting screws 5870 204 007



D507TM187

□ Install the converter safety valve(1) until contact.

(S)Drive mandrel 5870 705 012

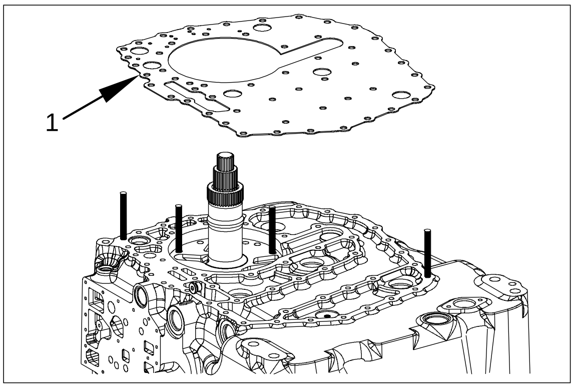


D507TM188

□ Install two adjusting screws and mount the intermediate sheet(1).

※ The intermrdiate sheet has always to be replaced.

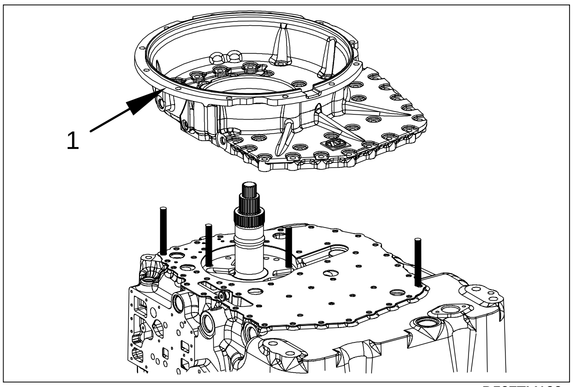
(S)Adjusting screws 5870 204 007



D507TM189

□ Cautiously place the converter bell(1) by means of the lifting equipment to the transmission until contact is obtained.

(S)Eyebolts assortment 5870 204 002
(S)Lifting chain 5870 281 047

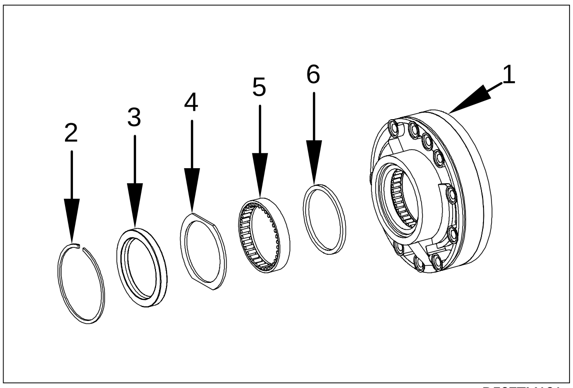


D507TM190

(3) Pressure oil pump

※ **If running-in marks should be found in the pump housing or on the cam disc, the complete pump has to be replaced.**
※ **Item 1-6 are allowed to be replaced.**

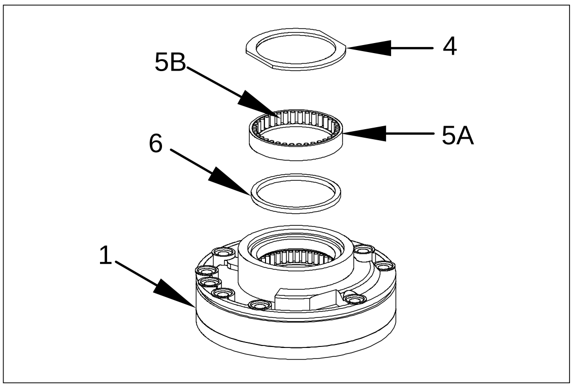
1 = Pump housing with rotor
2 = Snap ring
3 = Shaft seal
4 = Support shim
5 = Needle bearing cpl.(bearing outer ring and needle bearing)
6 = Ring



D507TM191

① Install the following parts into the pump housing(1).

6 = Ring
5A = Bearing outer ring
5B = Needle cage
4 = Support shim

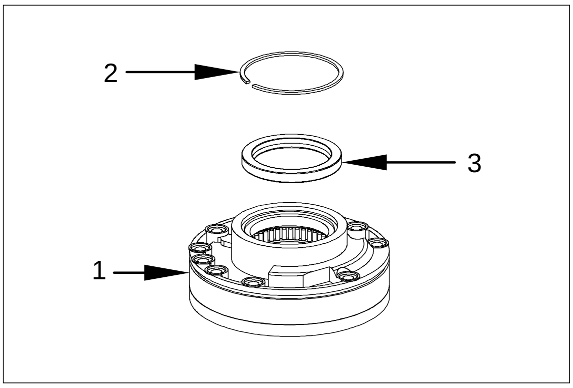


D507TM192

② Cautiously put the shaft seal(3) with the sealing lip showing downwards into the pump housing(1) until contact and fasten it by means of the snap spring(2).

※ Wet the outer diameter of the shaft seal woth spiriti.

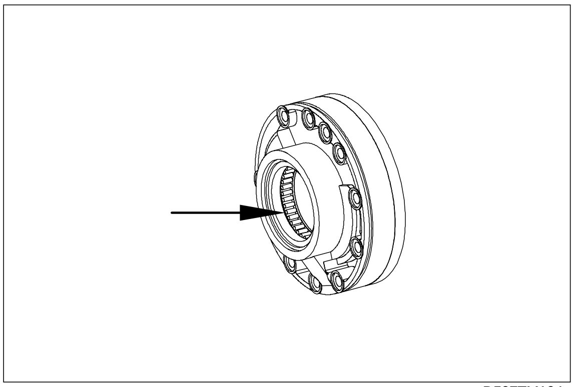
(S)Mounting tool 5870 055 070
(S)Handle 5870 260 002



D507TM193

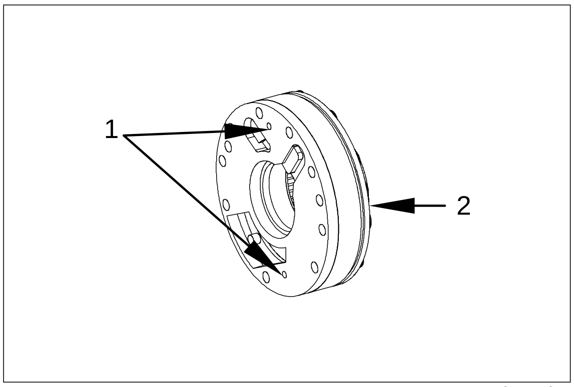
(4) Installation of the external and internal rotor

※ Install the external rotor.
Chamfer shows to the pump base (cannot be seen in the picture).
※ Install the internal rotor.
Gearing(arrow) shows downwards.



D507TM194

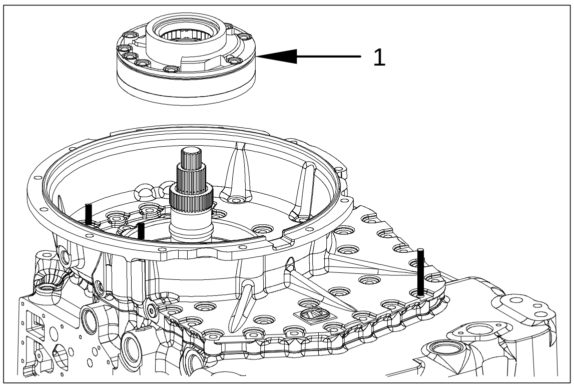
① Put on the cam disc and by means of two cap screws(1) fasten it radially.
※ **Do not tighten the cap screws - just turn then in until contact is obtained and then make approx. 1/2 rotation back.**
Observe the installation position of the cam disc.
Put the O-ring(2) into the annular groove and oil it.



D507TM195

② Mount the preassembled pressure oil pump(1) and with the cap screws(3pcs.) first place it equally until contact is obtained.

※ Observe the radial installation position.
Then remove the cap screws again.



D507TM196

③ Fasten the converter bell, pressure oil pump and stator hollow shaft together by means of cap screws.

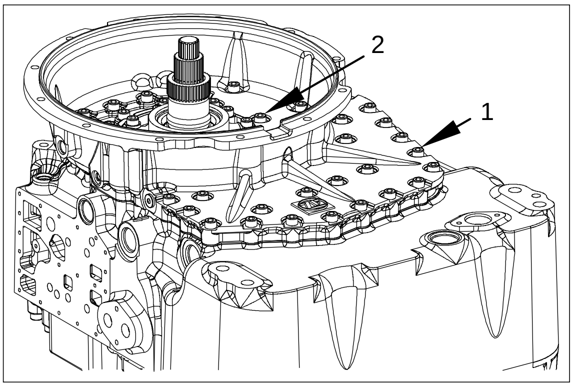
※ **Different bolted connections**.

1 = Bolted connection converter bell/transmission housing rear section.

Tightening torque(M10/8.8) ·· M_A =4.7kg·m

2 = Bolted connect. pressure oil pump/ stator hollow shaft transmission housing rear section.

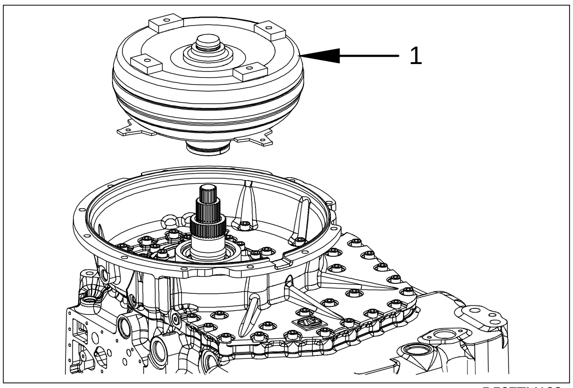
※ **Cap screws with O-rings.**
Grease the O-rings.



D507TM197

④ Mount the converter(1) by means of lifting equipment until contact is obtained.

(S)Eyebolts assortment	5870 204 002
(S)Lifting chain	5870 281 047



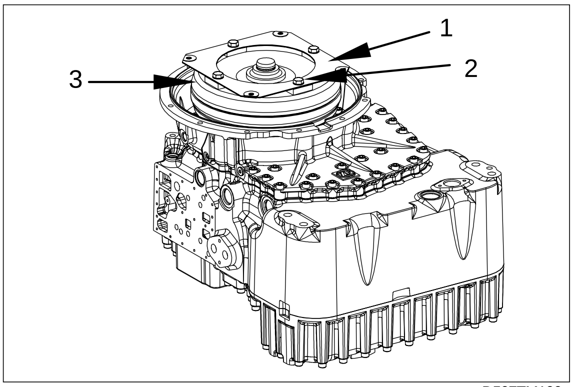
D507TM198

⑤ Fasten the flexplate(1) by means of hexagon screws(2).

※ Install washers between converter(3) and flexplate(1) under the hexagon screws.

※ Lock the hexagon screws with loctite (Type No.262).

Tightening torque(M12/10.9)··· M_A =11.7kg·m



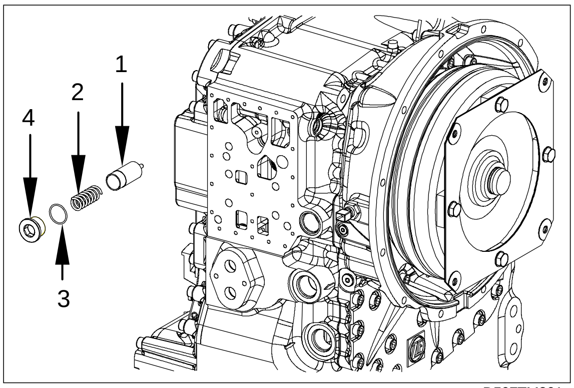
D507TM199

3) Inductive transmitters, valves, oil filters and oil drain plug, screw plugs

① Install the converter pressure back-up valve.

1 = Piston
2 = Compression spring
3 = O-ring(27x2)
4 = Screw plug(30x1.5)

※ Tightening torque ··············· M_A =10.2kg·m

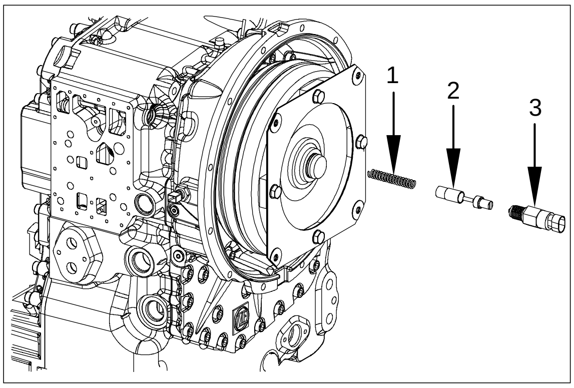


D507TM201

② Install the differential pressure switch for the pressure filter.

1 = Compression spring
2 = Piston
3 = Tappet switch

※ Tightening torque ··············· M_A =3.1kg·m

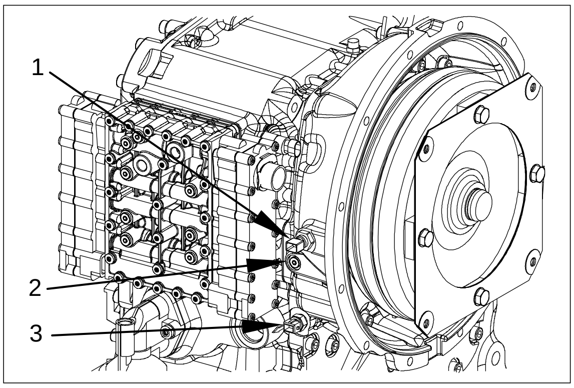


D507TM202

③ Installation of:

1 = Inductive transmitter - n Engine
2 = Screw plug M10x1.0
(measuring point pressure after converter)
3 = Temperature transmitter M14x1.5
(measuring point temperature after converter)

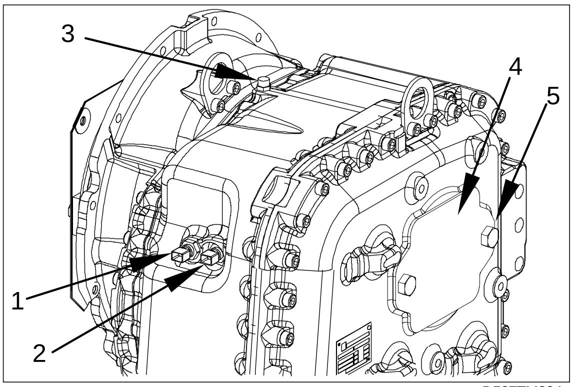
※ Tightening torque(1) ·········· M_A =3.1kg·m
Tightening torque(2) ·········· M_A =0.97kg·m
Tightening torque(3) ·········· M_A =2.6kg·m



D507TM203

④ Installation of:
1 = Inductive transmiter - n Internal speed input
2 = Inductive transmitter - n Turbine
3 = Breather

※ Tightening torque(1 and 2) ·· M_A =3.1kg·m
Tightening torque(3) ············ M_A =1.2kg·m
Fasten the coverplate(4) by means of hexagon screws(5).
Tightening torque(M16/8.8) · M_A =2.6kg·m



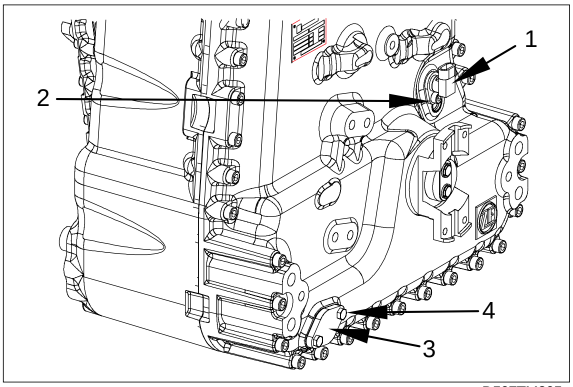
D507TM204

⑤ Installation of :
1 = Speed transmitter
2 = Cap screw

※ Tightening torque(2)(M8/8.8) ·· M_A =2.4kg·m

3 = Install the coverplate(3) with gasket.
4 = Hexagon screw

※ Tightening torque(2)(M8/8.8) ·· M_A =2.4kg·m



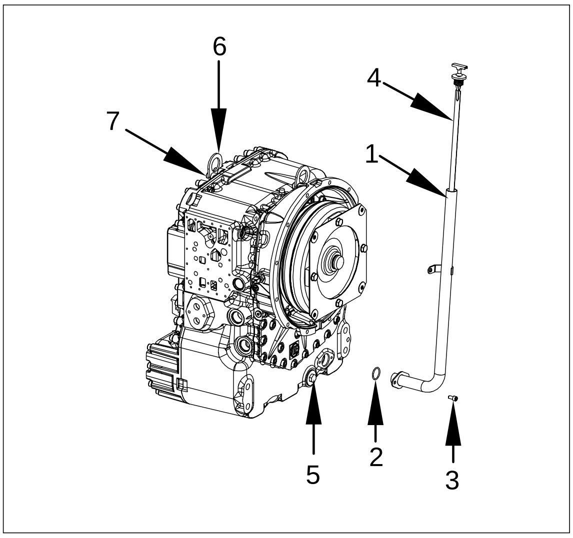
D507TM205

⑥ Fasten the oil filler tube(1) with O-ring(2) to the transmission housing by means of the hexagon screws(3).
Turn the oil dipstick(4) into the oil filler tube.

※ Tightening torque(2)(M8/8.8) ·· M_A =2.4kg·m

Install the oil drain plug(5) with the O-ring.

※ Tightening torque ··············· M_A =14.3kg·m
Fasten the fixing plate(6) by means of cap screws(7)
※ Tightening torque(M10/8.8) ···· M_A =4.7kg·m

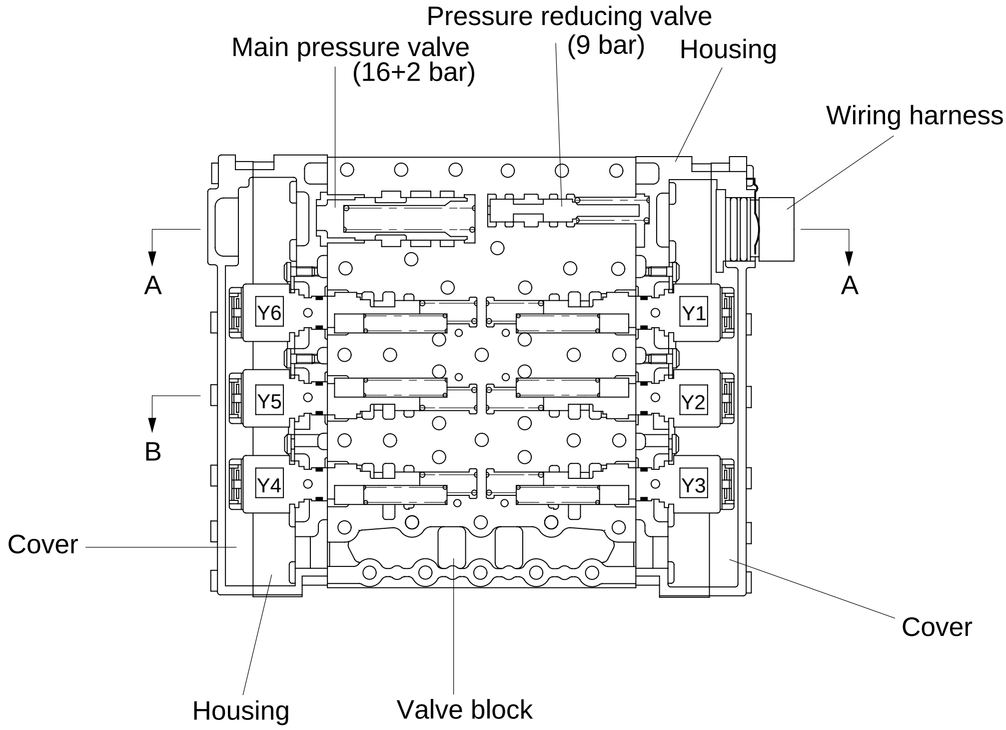


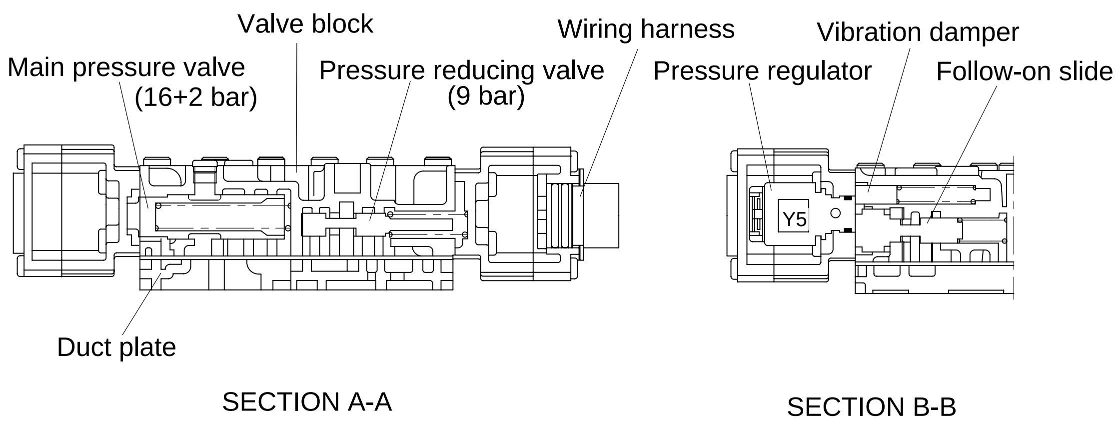
D507TM206

4) ELECTRO-HYDRAULIC CONTROL UNIT WITH PROPORTIONAL VALVES

※ **Different versions as to the positions of the wiring harness are possible.**

・ The following sketches shows the sections of the electro-hydraulic control unit.





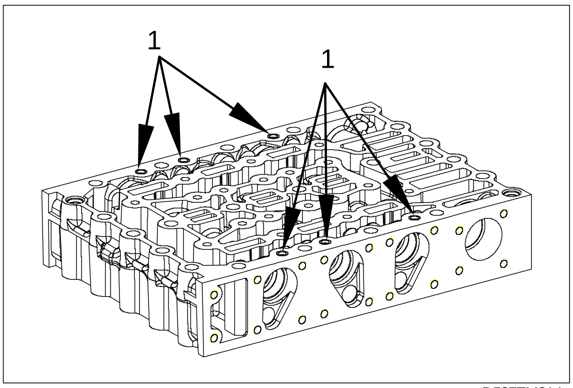
D507TM211

(1) Mounting of the electric control unit

※ All single parts are to be checked for damaged and replaced, if required.
Prior to installation check the mobile parts in the housing for functionality. Piston can be replaced individually.
Oil the single parts prior to installation acc. to the list of lubricants.

① Place the orifices(1) with the concave side showing upwards, until contact.

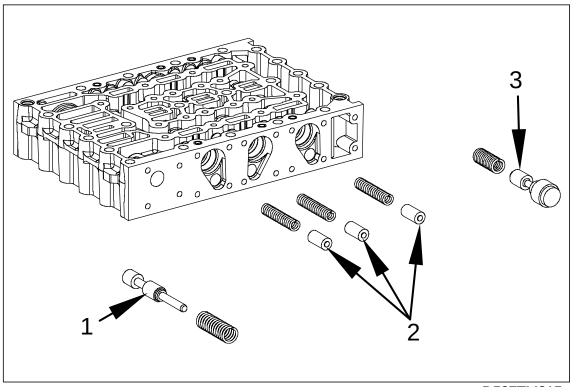
※ Installation position, see arrows.



D507TM214

② The figure on the left shows the following single parts:

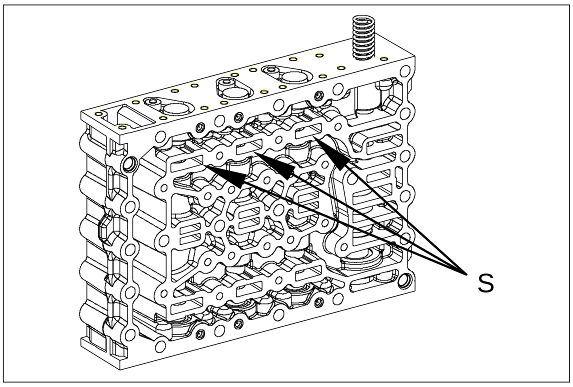
1 = Pressure reducing valve
(1x, piston a. compr. spring)
2 = Vibration damper
(3x, piston a. compr. spring)
3 = Follow-on slide
(3x, piston a. compr. spring)



D507TM215

③ Install the single parts acc to right figure.

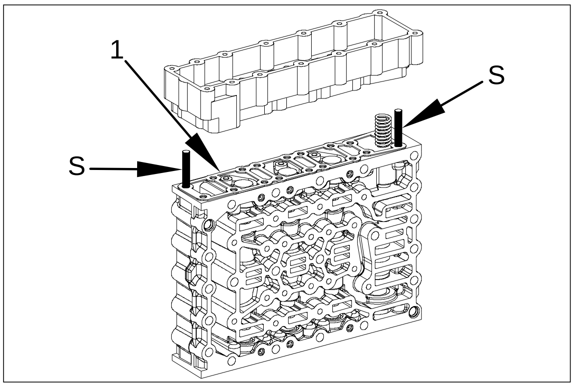
※ Preload the compression springs of the follow-on slides and fasten the piston preliminarily by means of cylindrical pins ø5.0mm(assembly aid), see arrows(s)



D507TM216

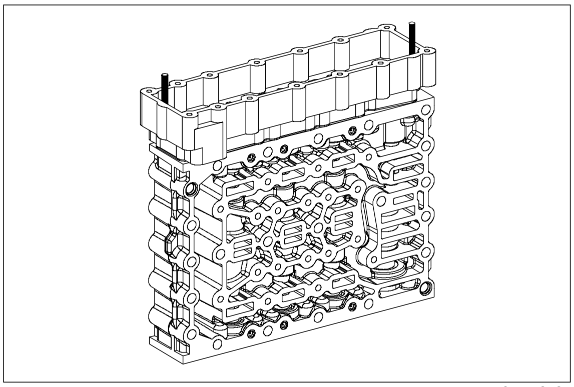
④ Install two adjusting screws.
Assembly flat gasket(1) and housing cover.
Then place the housing cover by means of adjusting screws equally until contact.

(S)Adjusting screws 5870 204 036



D507TM217

⑤ Preload the pistons with cap screws and remove the cyl. pins(assembly aid)again.

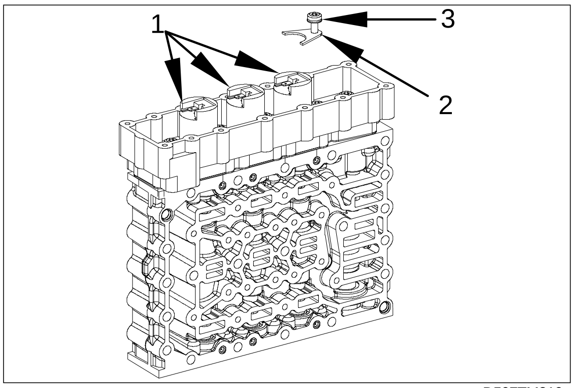


D507TM218

⑥ Fasten the housing cover by means of cap screws(1).

※ Tightening torque ············· M_A=0.56kg·m

(S)Torque spanner	5870 203 031
(S)Reducer	5870 656 056
(S)Socket spanner TX-27	5873 042 002



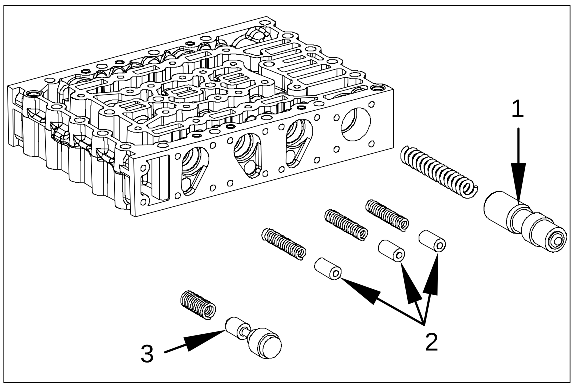
D507TM219

⑦ Mount the pressure regulators(1) and fasten them by means of fixing plates(2) and cap screws(3).

※ **Install the fixing plate with the neck showing downwards**
Observe radial installation position of the pressure reglators.

Tightening torque ············· M_A=0.56kg·m

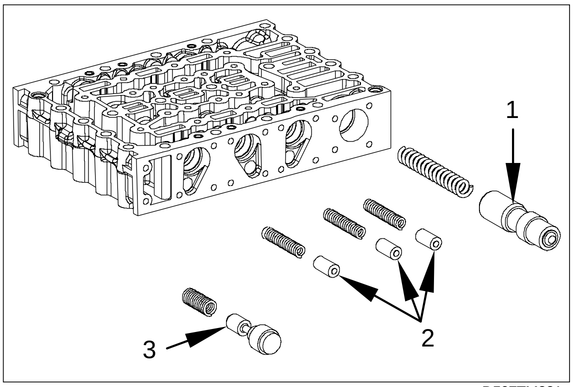
(S)Torque spanner	5870 203 031
(S)Reducer	5870 656 056
(S)Socket spanner TX-27	5873 042 002



D507TM220

· **Preassemble the oppsite side**

⑧ The figure on the right shows the following single parts:
1 = Main pressure valve
(1x, piston a. compr. spring)
2 = Vibration damper
(3x, piston a. compr. spring)
3 = Follow-on slide
(3x, piston a. compr. spring)



D507TM221

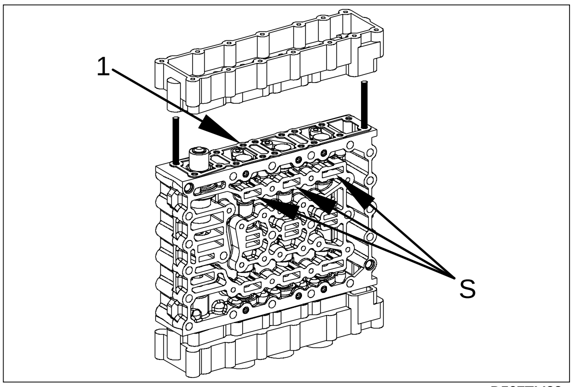
⑨ Install the single parts acc to right figure.

※ **Preload the compression springs of the follow-on slides and fasten the pistons preliminarily by means of cylindrical pins(S) ø 5.0mm(assembly aid), see arrows(S).**

Install two adjusting screws.

(S)Adjusting screws M5　　5870 204 036

Assemble flat gasket(1) and housing cover. Then place the housing cover by means of adjusting screws equally until contact.

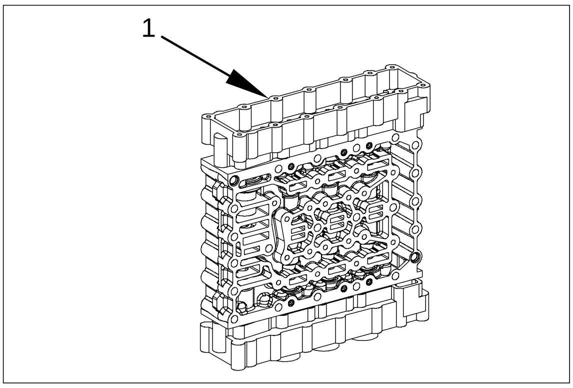


D507TM22

⑩ Preload the pistons with cap screws and remove the cyl. pins(assembly aid) again. Then fasten the housing cover by means of cap screws(1).

Tightening torque ············· M_A=0.56kg·m

(S)Adjusting screws	5870 204 036
(S)Torque spanner	5870 203 031
(S)Reducer	5870 656 056
(S)Socket spanner TX-27	5873 042 002

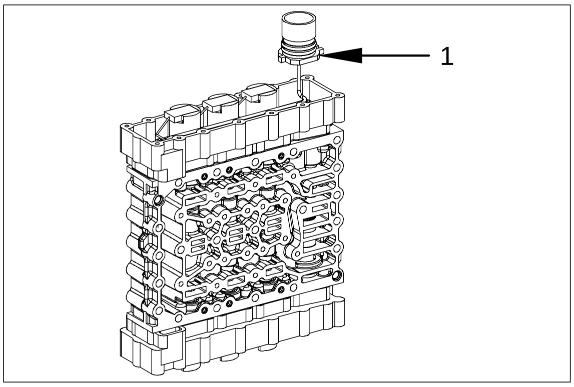


D507TM223

⑪ Mount the pressure regulators(1) and fasten them by means of fixing plates and cap screws.

※ **Install the fixing plate with the neck showing downwards**
Observe radial installation position of the pressure regulators.

Tightening torque ············· M_A =0.56kg·m

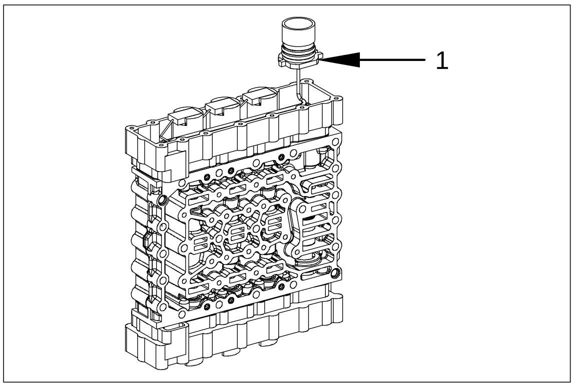


D507TM224

⑫ Assemble the wiring harness(1) and connect the pressure regulators(6x).

※ Installation position of pressure regulators.

※ Pay attention to the installation position of the wiring harness, also see markings ③ page 3-108.

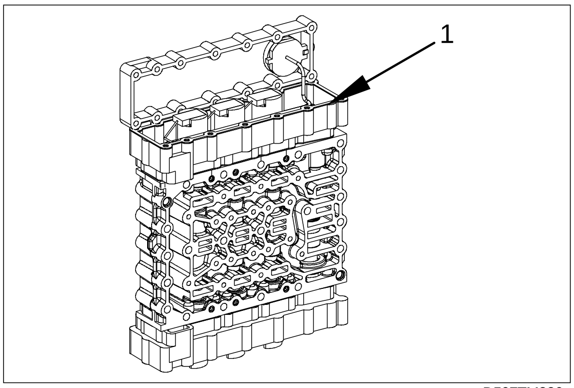


D507TM225

⑬ Put on the plate gasket(1).
Assemble the plug socket with the slot showing to the lug of the cover until contact.
Fasten the cover by means of cap screws.

Tightening torque ············· M_A =0.56kg·m

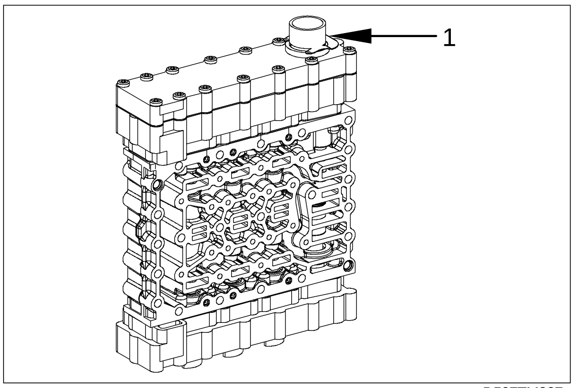
(S)Torque spanner	5870 203 031
(S)Socket spanner TX-27	5873 042 002



D507TM226

⑭ Fix the wiring harness by means of retaining clamp(1).

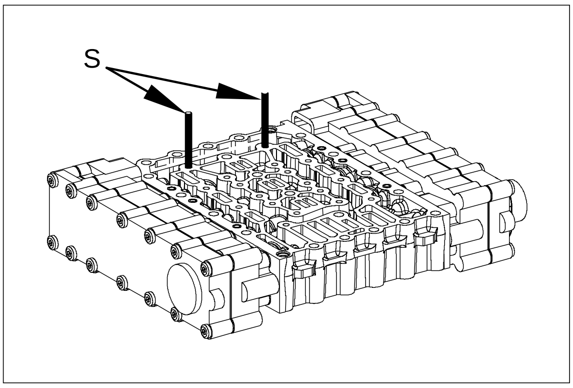
※ Install the opposite cover



D507TM227

⑮ Install two adjusting screws.

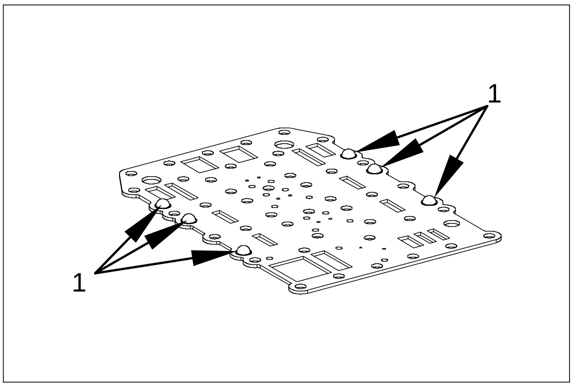
(S)Adjusting screws 5870 204 063



D507TM228

- Screens(1) are to be flush mounted into the bores of the intermediate sheet, see arrows.

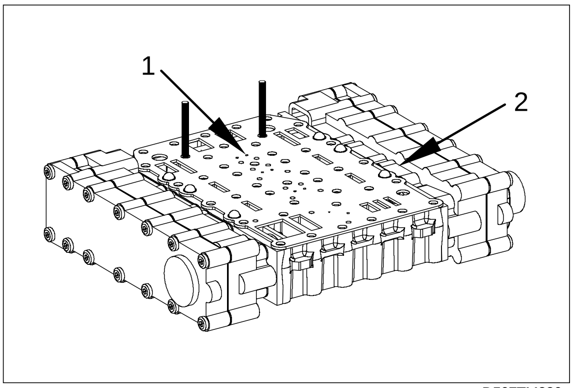
  Observe the installation position-the screens are showing upwards(to the duct plate).



D507TM229

- Put on the intermediate sheet(1)

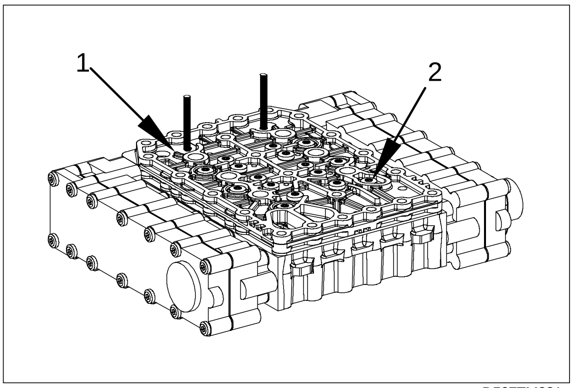
※ Screens(2) must show upwards.



D507TM230

- Put on the duct plate(1) and tighten it equally with torx screw(2).

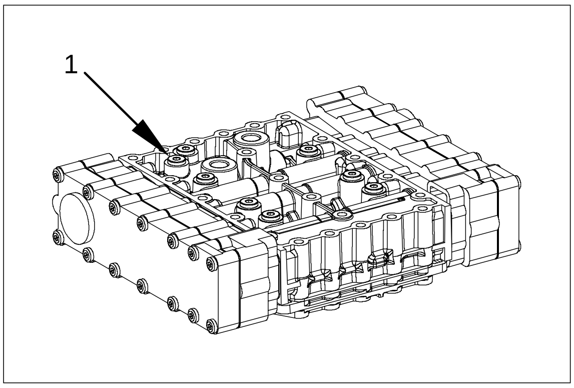
※ Tightening torque ············· M_A =0.97kg·m
(S)Socket spanner TX-27 5873 042 002



D507TM231

□ Provide the screw plugs(1) with new O-rings and install them.

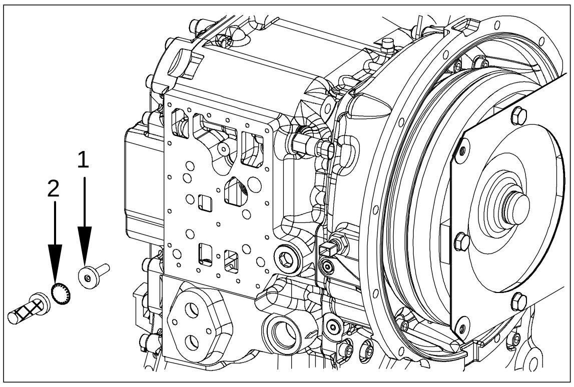
※ Tightening torque ············· M_A=0.61kg·m



D507TM232

□ Insert the pressure relief valve(1) and lock it with the indented ring(2).

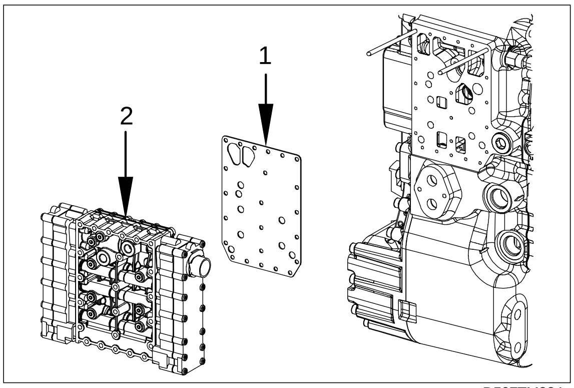
(S)Drive mandrel 5870 705 012



D507TM233

Mount the gasket(1) and the cpl. shift system(2).

(S)Adjusting screws M6 5870 204 063

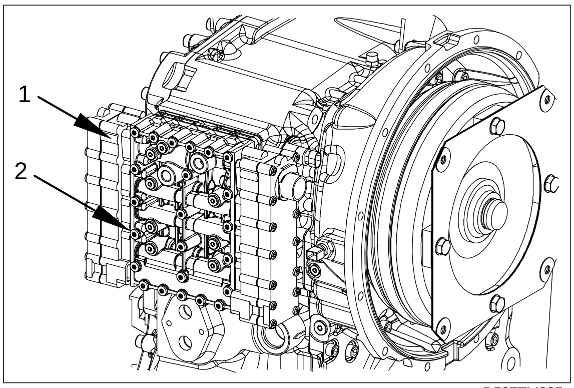


D507TM234

Fasten the electro-hyraulic control unit(1) equally by means of Torx screws(2).

※ Tightening torque ············· M_A=0.56kg·m

(S)Torque spanner	5870 203 031
(S)Reducer	5870 656 056
(S)Socket spanner TX-27	5873 042 002



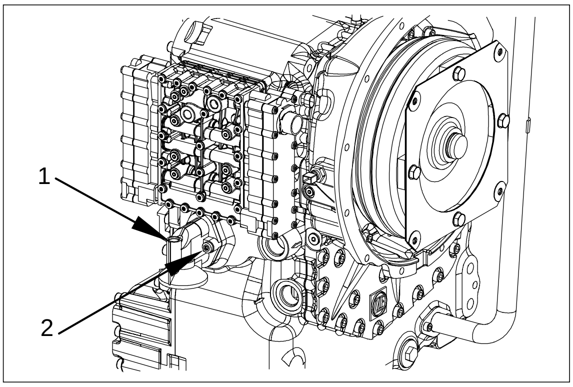
D507TM235

(2) Mounting of the filter(pressure filter)

Fasten the filter head(1) with new O-rings ① by means of cap screws(2) to the transmission housing.

Tightening torque(M8) ········ M_A=2.4kg·m

(S)Torque spanner	5870 203 034
(S)Socket spanner TX-40	5870 042 004

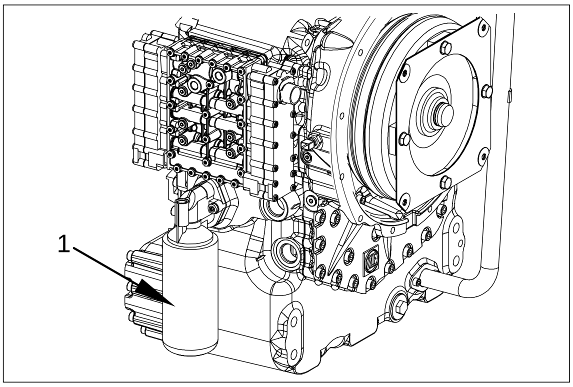


D507TM236

⚠ The filter is to be installed as follows:

- Oil the gasket slightly
- Turn in the filter until contact with the sealing surface is obtained and then tighten it by hand with an approx. 1/3 to 1/2 rotation.

Prior to initial operation of the transmission make the oil filling in accordance with the operating instructions.



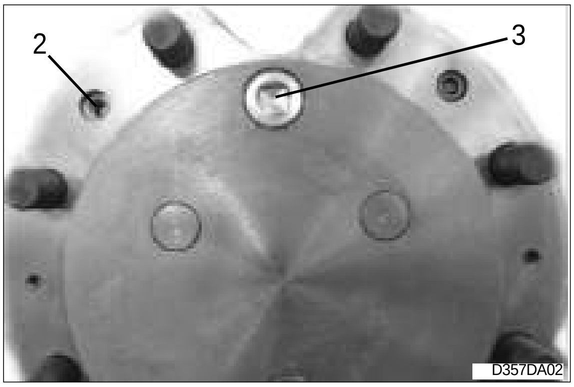
D507TM237

3. DISASSEMBLY OF DRIVE AXLE

1) REMOVAL AND DISASSEMBLY OF WHEEL HUB

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

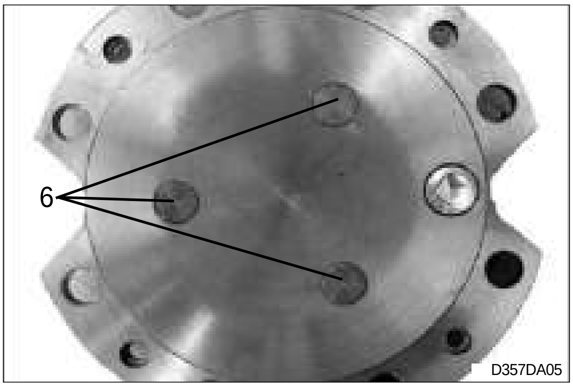
(2) Loosen 4 socket head bolts(2) and a plug(3) from the housing of planetary.



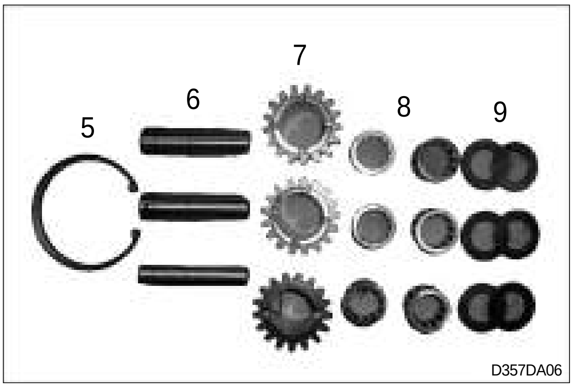
(3) Fit socket head bolt(2) into the 2 tap holes(4) and remove housing of planetary.

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

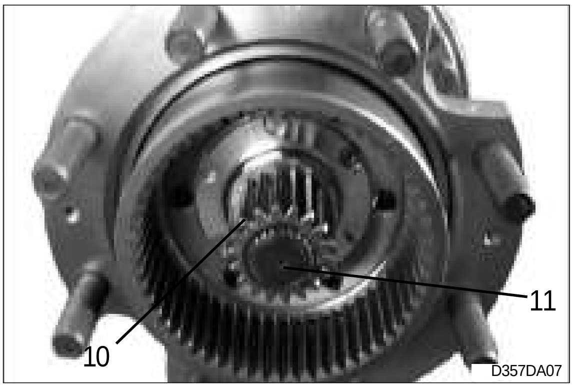
(5) Remove 3 pins(6) with a plastic hammer.



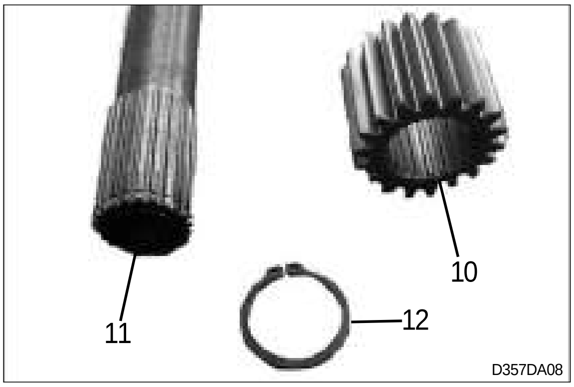
(6) Remove needle bearing(8), planet gear(7) and thrust washer(9).



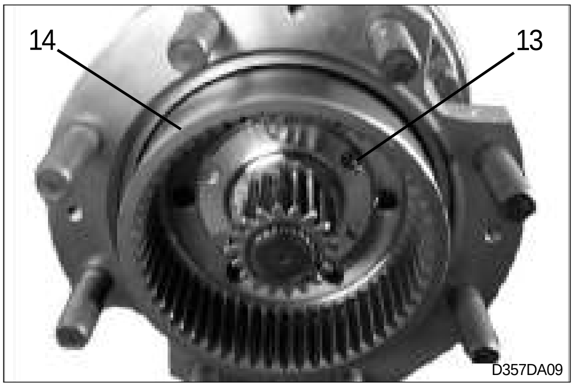
(7) Remove sun gear(10) and drive shaft(11).



(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.

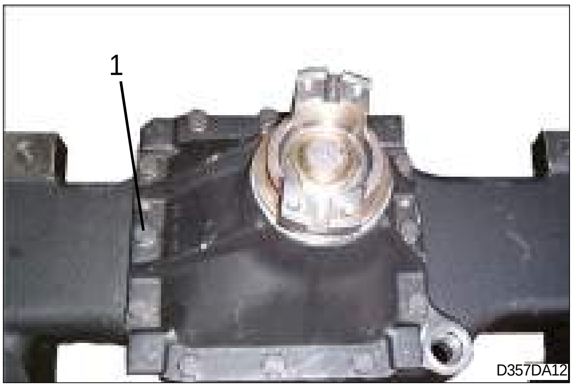


(10) Remove snap ring from the ring gear(14) and disassemble internal gear carrier.

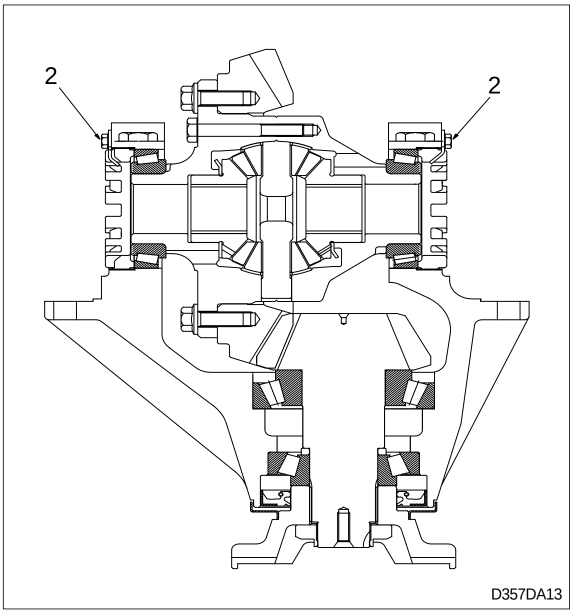
(11) Remove bearing cup from the wheel hub by using jig and hammer. Shaft seal will be damaged.

2) REMOVAL AND DISASSEMBLY OF AXLE HOUSING

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

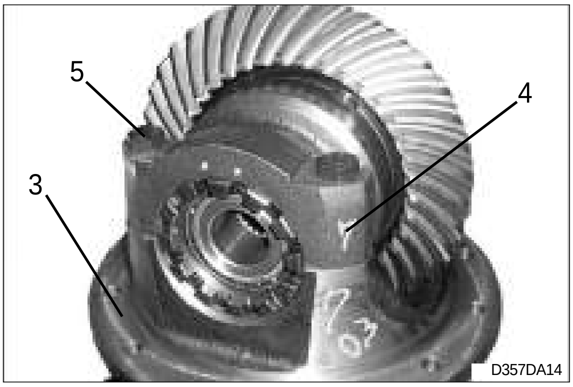


(2) For the reassembly, check rolling resistance and record it. Remove backing plate(2).

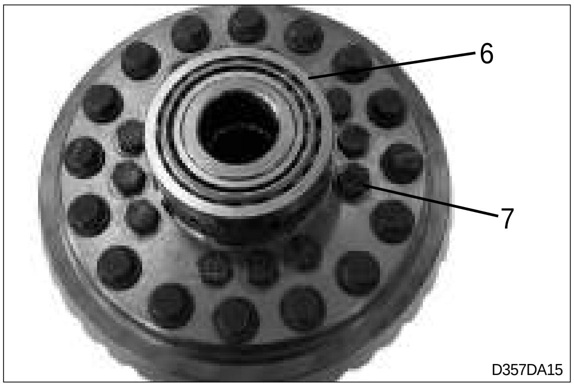


(3) Before removing differential assembly from carrier(3), check the location of cap(4) and mark it for reassembly.

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

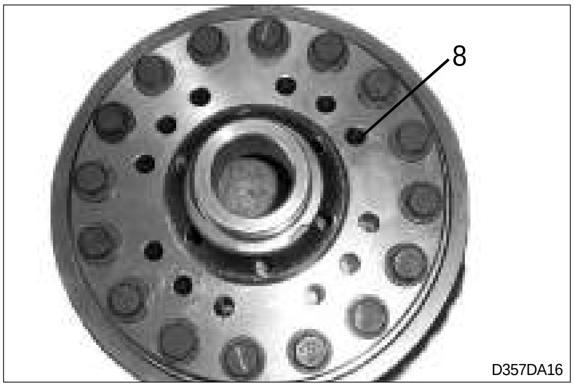


(5) Disassemble bearing(6) from the differential housing and remove 12 bolts (7).



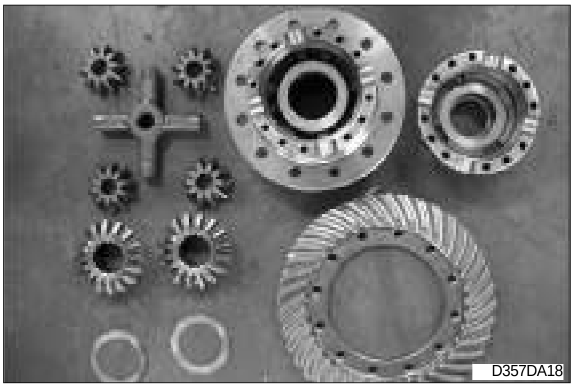
(6) Remove differential assembly from the carrier.

(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.

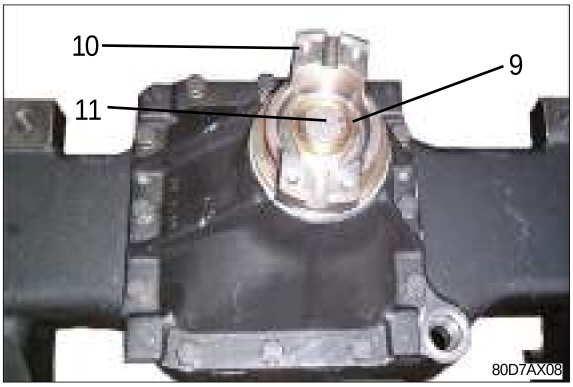
(9) Remove thrust washer, side gear, pinion gear and spider and then place them on the clean bench.



(10)After loosening lock nut(9), remove yoke(11).

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

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



(12)Remove shim(12) and spacer(13) 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

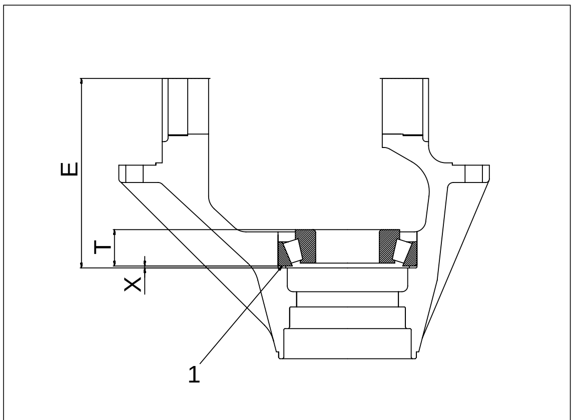
Clean all of the parts with cleaner and then remove remained loctite.

※ **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.



80D7AX12

(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** ± **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.


80D7AX10

(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.


80D7AX13

· **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 "**S**" : Distance from bearing outer race surface to inner race surface.
From the below equation, define required shim thickness **Z**.

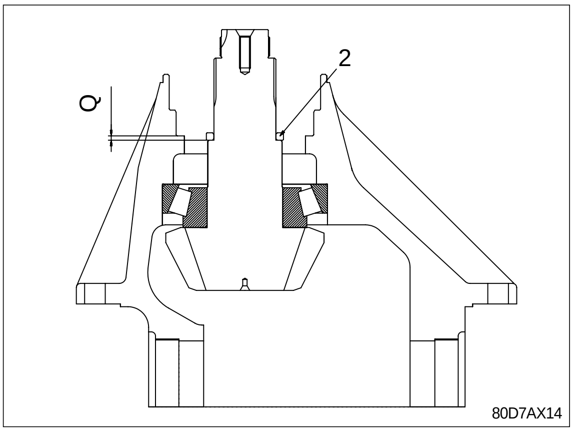
" **Z** = **S** + **Q** "

EX) : From the bearing
S = 2.25mm (0.09in)
From the housing
Q = 3.15mm (0.12in)
Required shim thickness **Z** :

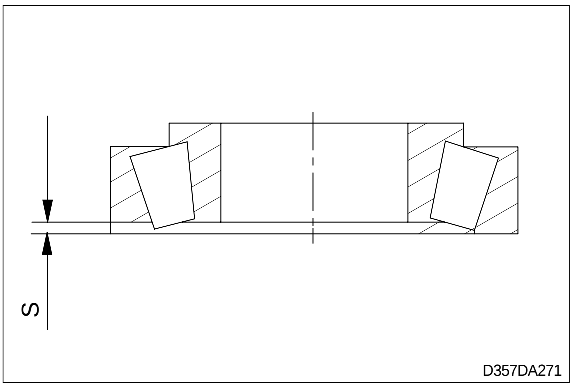
Z = 2.25 + 3.15 = 5.40mm (0.21in)

Unit : mm(in)

P	Q	Z
2.25(0.089)	3.15(0.124)	5.40(0.213)
2.30(0.091)	3.15(0.124)	5.45(0.215)
2.35(0.093)	3.15(0.124)	5.50(0.217)
2.40(0.094)	3.15(0.124)	5.55(0.219)
2.45(0.096)	3.15(0.124)	5.60(0.220)



80D7AX14



D357DA271

2) ADJUSTMENT OF PINION SHAFT

(1) Assemble bearing cup.
Assemble spacer to the pinion shaft and then install measured shims onto the spacer.

80D7AX11

80D7AX091

(2) Insert pinion shaft into the carrier.
Assemble bearing cone, yoke and lock nut.

80D7AX08

Apply loctite #271 or #277 on the thread of pinion and then tighten lock nut.

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

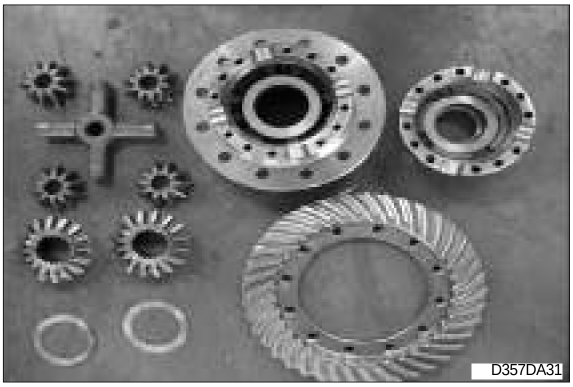
Measure rolling resistance of pinion shaft.
Adjust shim thickness.

· 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 : 5.0~7.5kgf · m
(36~54lbf · ft)

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

· Tightening torque : 12.5~14.5kgf · m
(90~105lbf · 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 : 15.0~17.0kgf · m (108~123lbf · 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 : 15.0~17.0kgf · m(108~123lbf · 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 0.80~1.20 kgf · m(5.8~8.7lbf · ft).
※ **Assemble oposite 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 11~13kgf · m(79.6~94.0lbf · ft).

80D7AX17

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.**

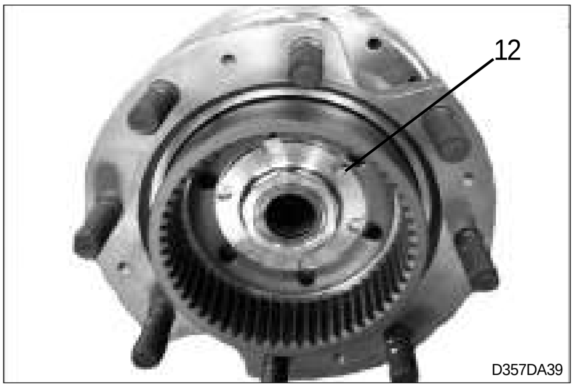
(2) Install wheel hub assembly to the tube flange of axle completely.
Install bearing cone.

D357DA38

D357DA37

(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 on the tapped side of bolt(12) and tighten at the tightening torque of 1.5~1.7kgf · m(108~123lbf · ft).

Apply grease on the bushing.

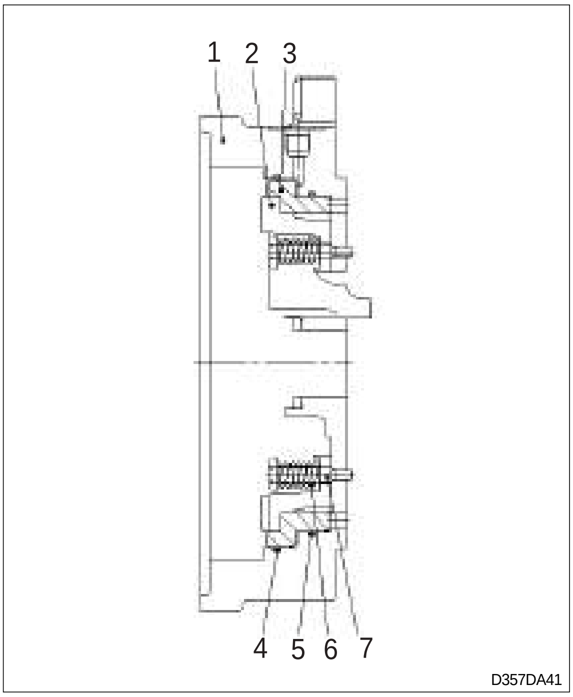


D357DA39

(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

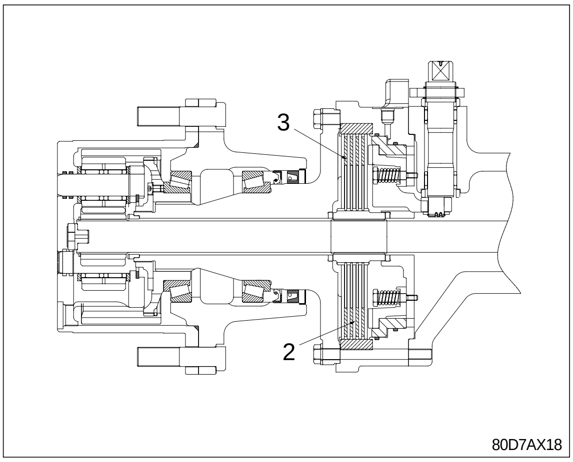
① Assemble 4 plates(8) and 3 disks(9) into the brake housing(1).

② Before assembling, clean all of the parts completely and remove burrs.

③ Disk must be assembled after 12 hours of infiltrate.(MOBILFLUID #424)

④ After assembling plate and disk, confirm that the tolerance with brake housing surface is 2.1~2.6mm(0.08~0.10in). (Spindle protrusion is 1.4mm(0.06in) and operation stroke of plate(8) and disk(9) assembly is 1.0~1.5mm(0.04~0.06in))

⑤ After tightening the bolt(10), confirm that parking lever(11) stroke is 17~32mm (0.67~1.26in) 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.



Unit : mm(in)

Spline	Parking lever operation distance
1 pitch	17(0.67)

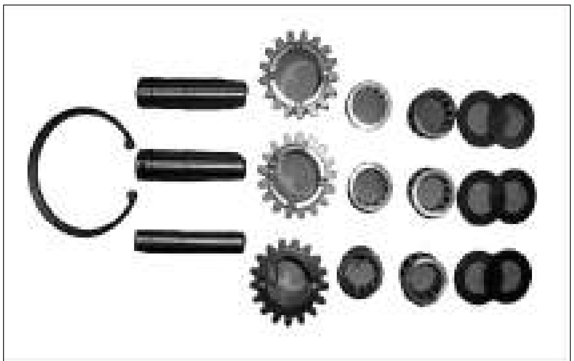
⑥ Apply loctite #5127 to spindle side of brake housing(1)

(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.


D357DA43

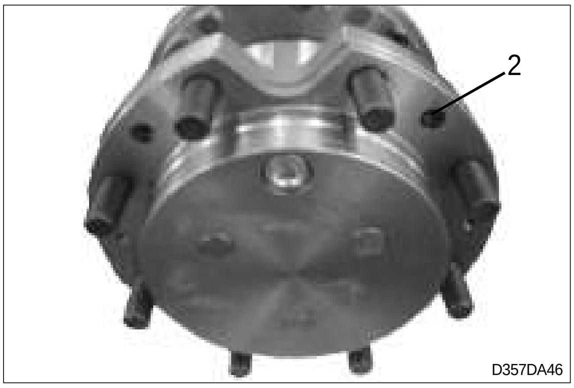
(6) Assemble internal components of planetary carrier in the reverse order to disassembly.


D357DA44


D357DA45

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

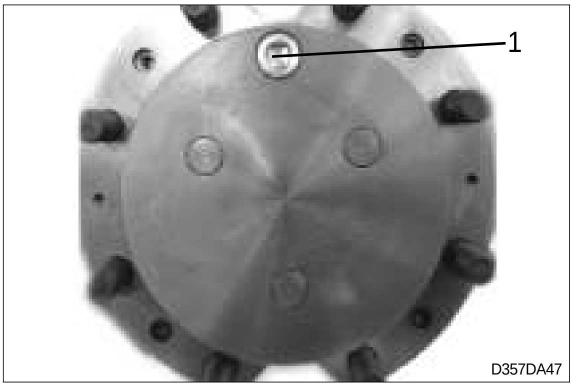
· Tightening torque : 2.5~4.0kgf · m
(18.1~28.9lbf · ft)



D357DA46

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

· Tightening torque : 3.5~6.0kgf · m
(25.3~43.4lbf · ft)



D357DA47

GROUP 4 ADJUSTMENT

1. Checking the ring gear backface runout

Runout specification : 0.20㎜(0.008-inch) maximum

1) Attach a dial indicator on the mounting flange of the carrier.

2) Adjust the dial indicator so that the plunger or pointer is against the back surface of the ring gear.

3) Set the dial indicator to zero(0).

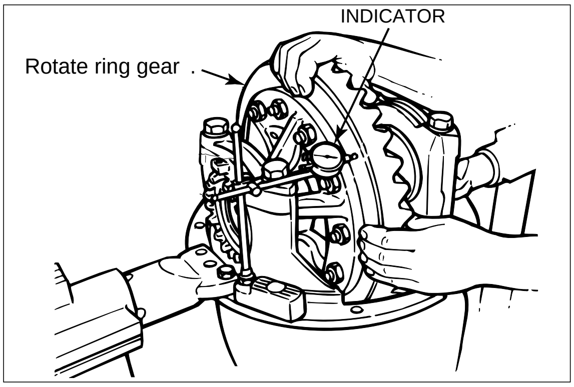
4) Rotate the ring gear and read the dial indicator. The runout must not exceed 0.20㎜(0.008inch).

   If runout exceeds specification, remove the differential and ring gear assembly from the carrier.

5) Check the differential parts, including the carrier, for problems that may cause the ring gear runout to exceed specifications. Repair or replace parts.

6) Re-install the differential and ring gear into the carrier.

7) Repeat the preload adjustment of the differential bearings.



D507AX53

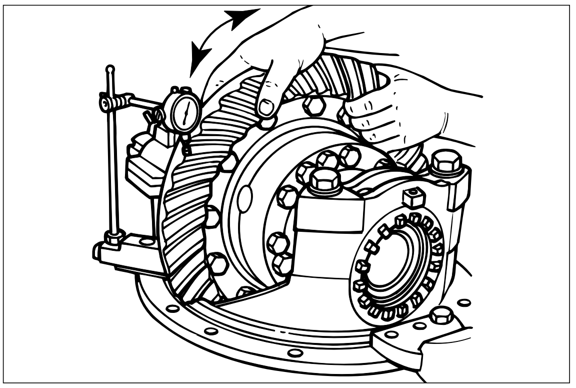
2. Adjusting the gearset backlash

Backlash specification : 0.13~0.18mm
(0.005-0.007inch)

If the old gearset is installed, adjust the backlash to the setting that was measured before the carrier was disassembled.

If a new gearset is installed, adjust the backlash to the correct specification for new gearsets.

1) Attach a dial indicator on the mounting flange of the carrier.



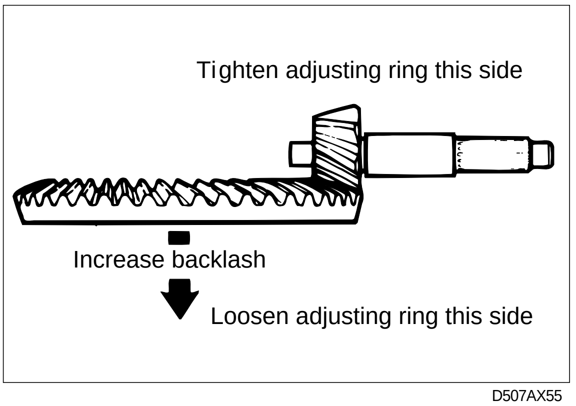
D507AX54

2) Adjust the dial indicator so that the plunger or pointer is against the tooth surface, near the heel end of the gear tooth. Set the indicator dial to zero(0).

3) Hold the drive pinion in position.

4) Read the dial indicator, while rotating the ring gear a small amount in both directions, against the drive pinion teeth.

※ When you adjust backlash, move the ring gear ONLY. DO NOT move the drive pinion.

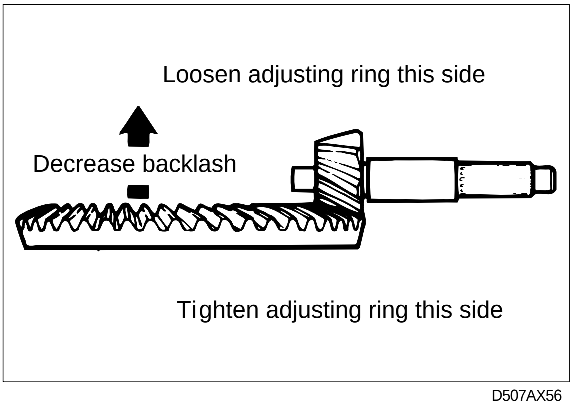


D507AX55

5) If the backlash reading is within specification, continue checking tooth contact patterns.
Otherwise, adjust backlash. Refer to step 6), and check, following steps 1)-4).

※ Backlash is increased by moving the ring gear away from the drive pinion. Backlash is decreased by moving the ring gear toward the drive pinion.

6) Loosen one bearing adjusting ring one notch, then tighten the opposite ring the same amount.

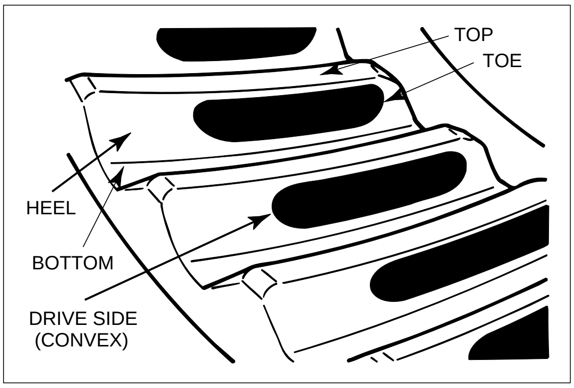


D507AX56

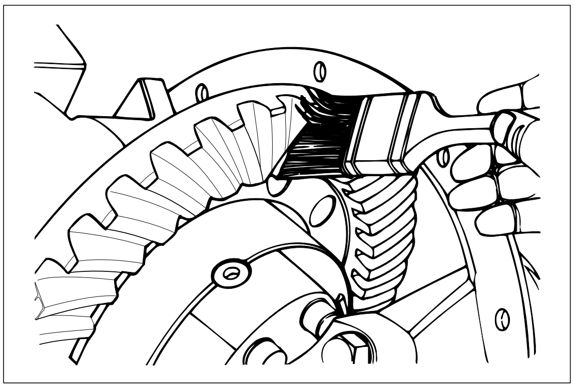
3. ADJUSTING TOOTH CONTACT PATTERN OF THE GEARSET

Always check tooth contact pattern on the drive side of the gear teeth.

1) Apply marking compound to approximately 12 teeth of the ring gear.



D507AX57



D507AX58

2) Rotate ring gear forward and backward so that the 12 marked teeth go past the drive pinion six times to get a good contact pattern.

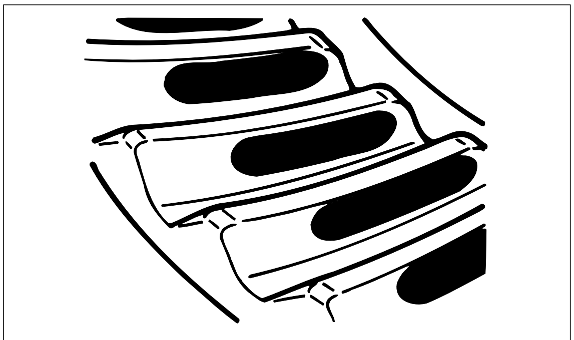
3) Compare the contact patterns.

   In new gearsets, a good contact pattern is toward the toe of the tooth, and centered between the top and bottom of the tooth.

   In used gearsets, a good contact pattern fills approximately the full length of the tooth. The top of the pattern is near the top of the tooth. The location should match the wear pattern on the tooth.

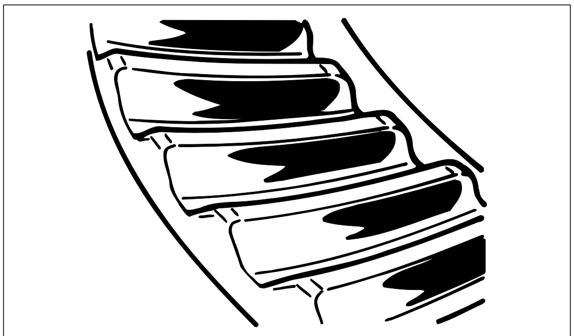
   If the contact patterns require adjustment along the width of tooth(top/bottom), follow steps 4)-5).

   If the contact patterns requires adjustment along the length of tooth(toe/heel), follow step 6)-7).



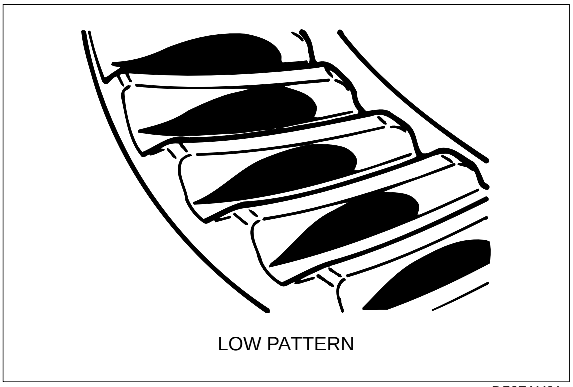
GOOD HAND-ROLLED PATTERN

D507AX59

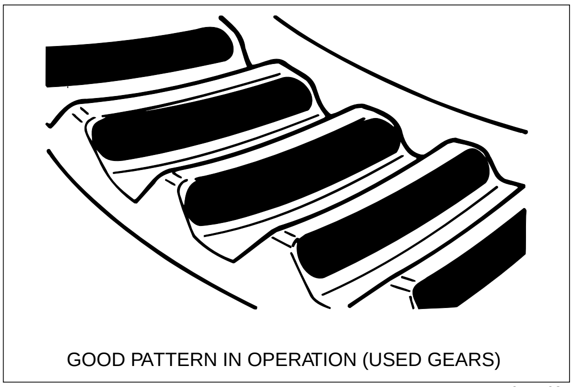


HIGH PATTERN

D507AX60



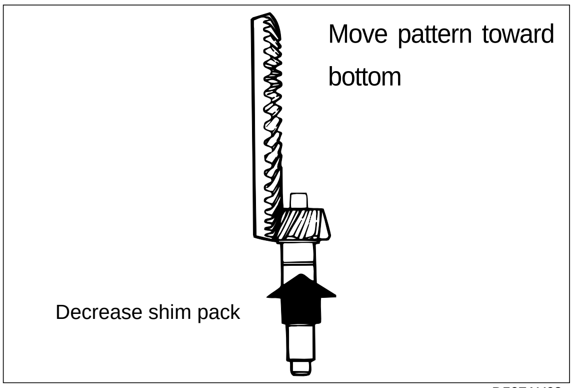
D507AX61



D507AX62

4) **High pattern :** A high contact pattern indicates that the pinion was installed too shallow into the carrier.

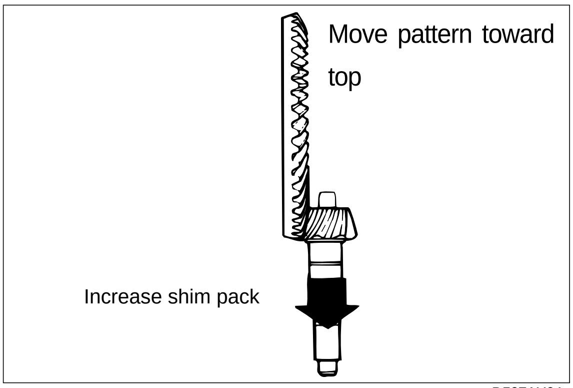
   To correct, move the pinion toward the ring gear by decreasing the shim pack between pinion spigot and inner bearing cone.



D507AX63

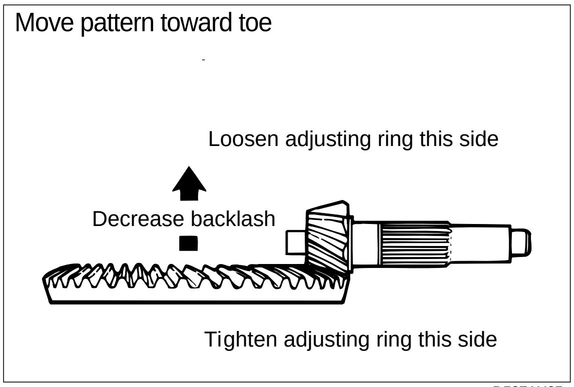
5) **Low pattern :** A low contact pattern indicates that the pinion was installed too deep into the carrier.

   To correct, move the pinion away from the ring gear by increasing the shim pack between pinion spigot and inner bearing cone.



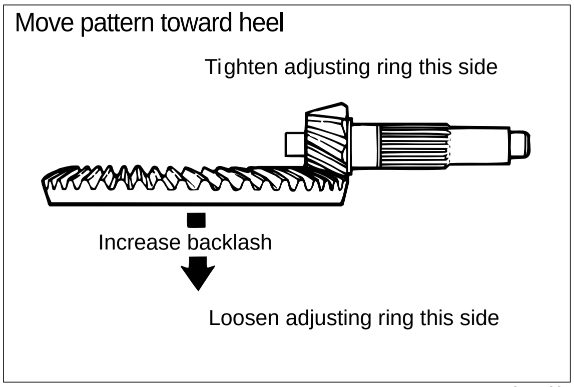
D507AX64

6) **Heel pattern :** Decrease the gearset backlash(within specified range) to move contact pattern toward toe and away from heel.



D507AX65

7) **Toe pattern :** Increase the gearset backlash(within specified range) to move contact pattern toward heel and away from toe.



D507AX66

SECTION 4 BRAKE SYSTEM

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 (wheel) 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 wheel brake assembly.

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

2. SPECIFICATION

1) WHEEL BRAKE(DRY TYPE)

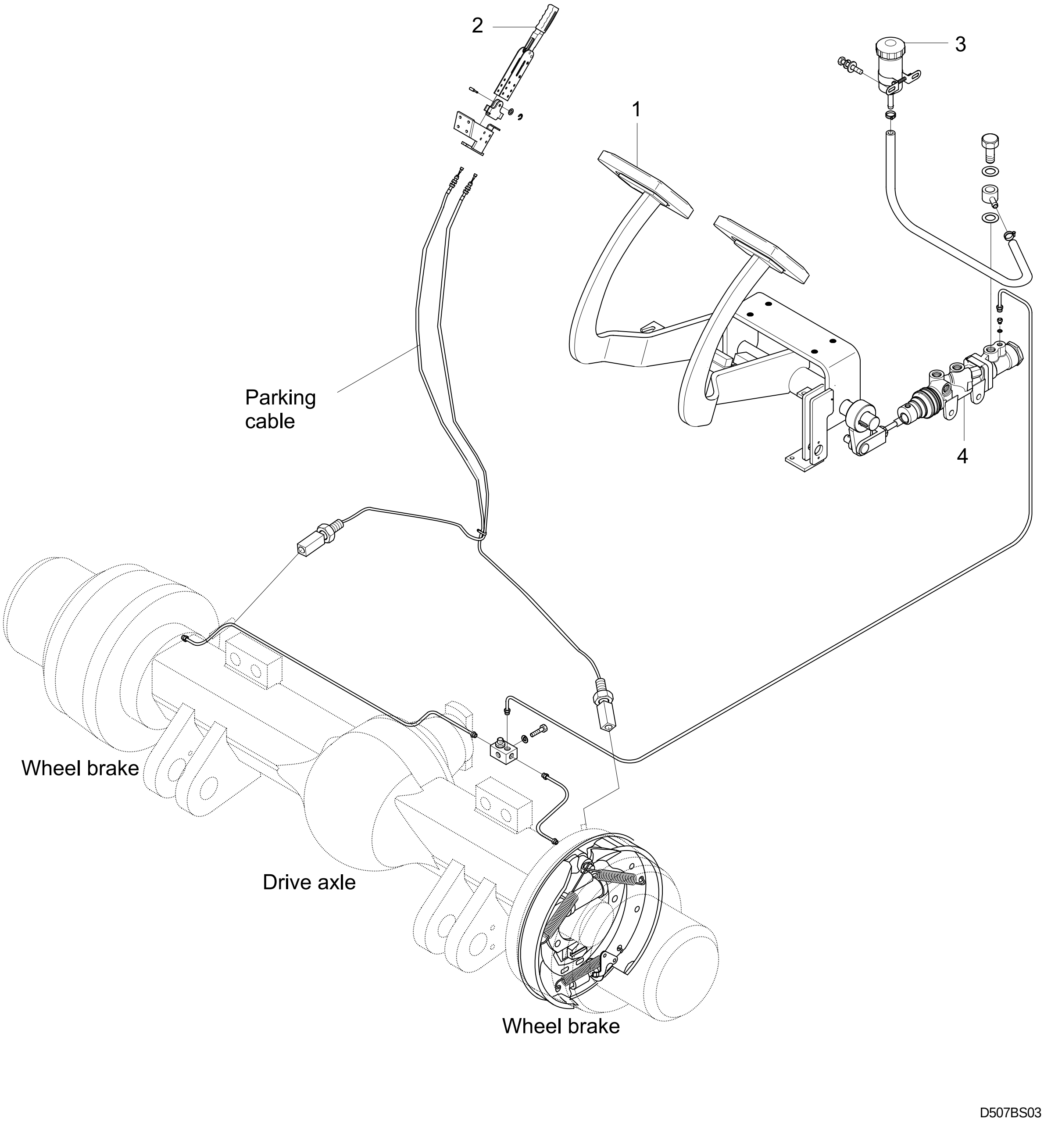
Item		Specification
Type		Front wheel, duo-servo & auto adjustment type
Service brake shoe size		ø 314×80mm(12.4×3.15in)
Wheel cylinder bore diameter		ø 34.93mm(1.37in)
Master cylinder bore diameter		ø 40mm(1.57in)
Pedal adjustment	Free height	122~128mm(4.8~5.0in)
	Idle strock	4~6.5mm(0.16~0.25in)
Brake drum diameter	Normal	315mm(12.4in)
Wheel cylinder installation torque		2.04~2.55kgf · m(14.8~18.4lbf · ft)
Backing plate installation torque		15~17kgf · m(108~123lbf · ft)
Brake oil		Only use for brake fluid DOT3

2) PARKING BRAKE

Item	Specification	
	Dry type	Wet type
Type	Toggle, internal expanding mechanical type	
Parking lever stroke	281mm	322mm
Parking cable stroke	20mm	48mm

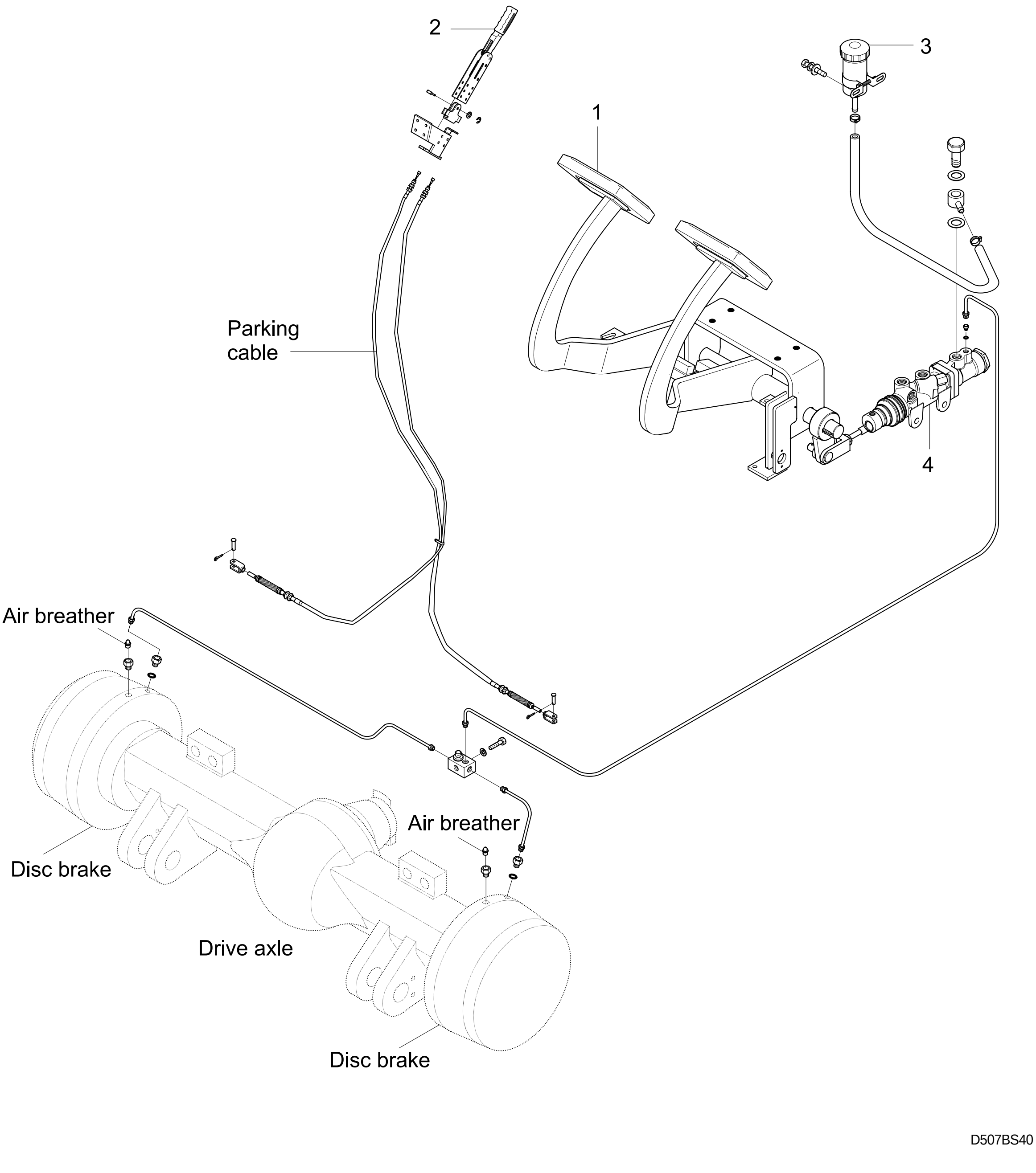
3. BRAKE PEDAL AND PIPING

1) STRUCTURE(DRY TYPE)



1	Brake pedal & bracket assembly	3	Reservoir tank assembly
2	Parking lever assembly	4	Brake master cylinder

2) STRUCTURE(WET TYPE)



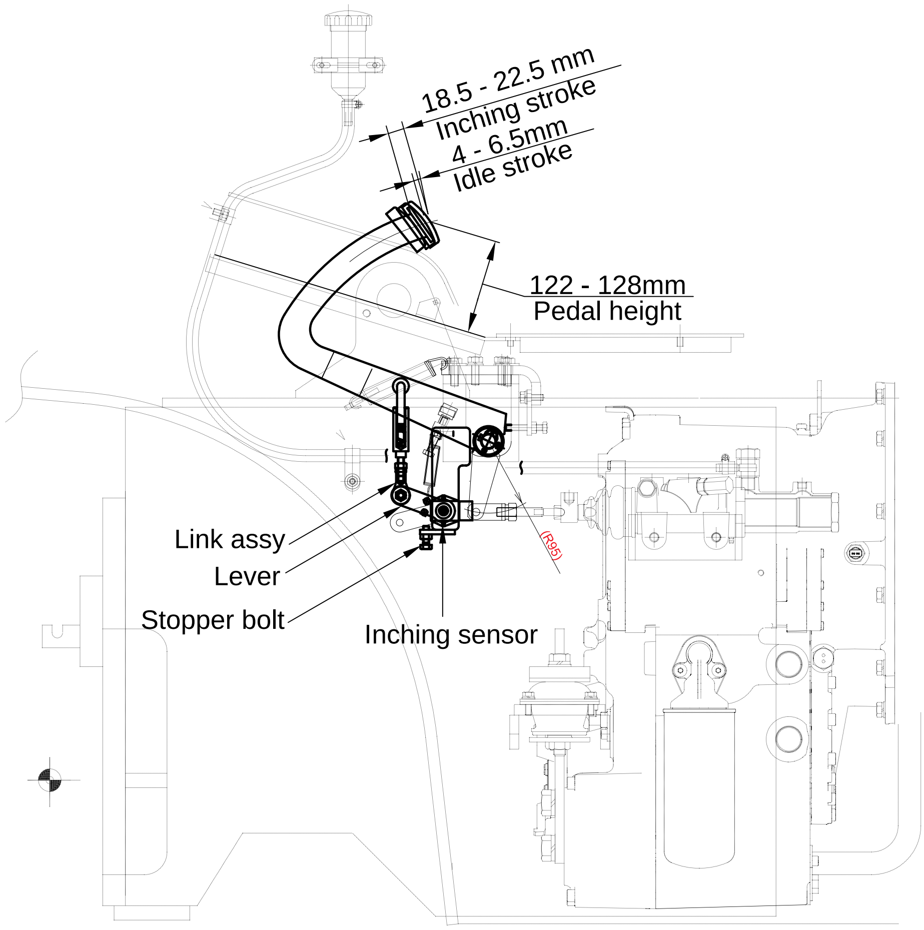
1	Brake pedal & bracket assembly	3	Reservoir tank assembly
2	Parking lever assembly	4	Brake master cylinder

3) DO AEB WORK

(1) Start engine after parking the machine on flat floor and blocking wheels.
(2) Release parking brake.
(3) With stepping on the service brake, operate T/M STALL(3 stage).
(To avoid defect of clutch pack, repeat 10 sec of operation and 10 sec of placing neutral)
(4) When the T/M oil temperature reaches 75~80˚C, lock the parking brake and then shift gear to neutral position to keep the machine at LOW RPM.
(5) Connect the AEB STARTER to T/M controller.
(6) Push AEB STARTER over 3 seconds.
(7) Confirm the status of AEB from the DISPLAY.
  · Normal operation shows "ST, KR, KV, K1, K2, K3" orderly for 3~5minutes.
  · After the successful completion, it displays " OK".
  · With a new controller, it may display "F6" error code before AEB, but after AEB, it will disappear.
(8) In case of abnormal running, it may display "STOP" with the appropriate error code.
(9) After troubleshooting, start the machine again to repeat above.
※ As the STALL operation has to be done, the SERVICE BRAKE must be locked perfectly to avoid the fatal accident.

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.



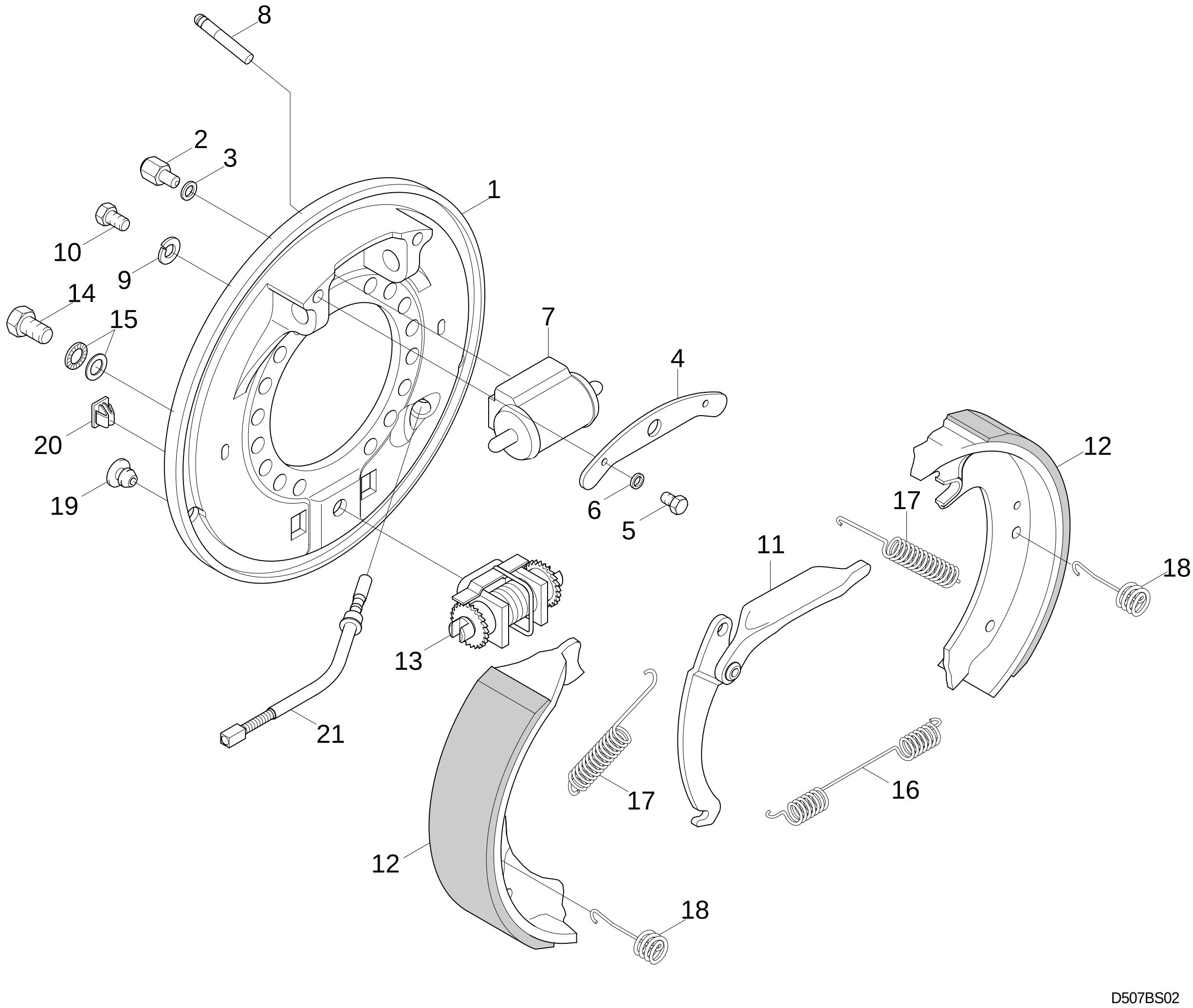
D507BS01

1) INITIALIZING THE INCHING SENSOR

(1) Start engine after parking the machine on flat floor and blocking wheels.
(2) Release parking brake and keep neutral gear shift.
(3) Adjust the inching sensor linkage so that the regular voltage is supplied to inching sensor when operating the pedal.
(Regular voltage ; Before pedal operation(1 ± 0.1V),
After pedal operation(3.5 ± 0.1V))
(4) Stop the engine and then just KEY ON.(Release parking brake, keep neutral gear)
(5) Connect the AEB STARTER to the T/M controller.
(6) Push AEB STARTER over 3 seconds.
(7) If display shows "▼IP", Step on the pedal fully.
(8) If display shows "▲IP", release "OK"
(9) After the successful completion, it displays "OK".
(10) In case of abnormal running, it may display "STOP" with the appropriate error code.
(11) After troubleshooting, start the machine again to repeat above.
※ Above works are to be done with the parking brake released, so machine's wheels must be blocked for safety.

5. WHEEL BRAKE

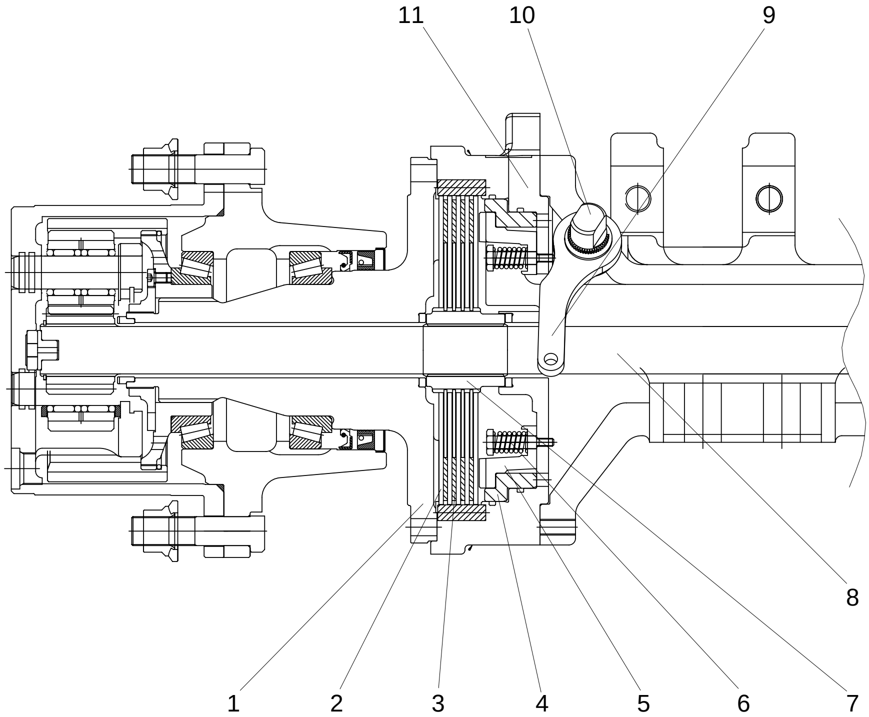
1) STRUCTURE(DRY TYPE)



1	Back plate(LH, RH)	8	Air breather	15	Lock washer
2	Adapter	9	Spring washer	16	Return spring
3	Washer	10	Cylinder bolt	17	Return spring
4	Holder	11	Lever shoe assembly	18	Pressure spring
5	Spring washer	12	Brake shoe assembly	19	Plug
6	Holder bolt	13	Adjuster assembly	20	Plug
7	Cylinder assembly	14	Adjuster bolt	21	Parking cable(LH, RH)

6. WET DISK BRAKE

1) STRUCTURE



D507TM238

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.

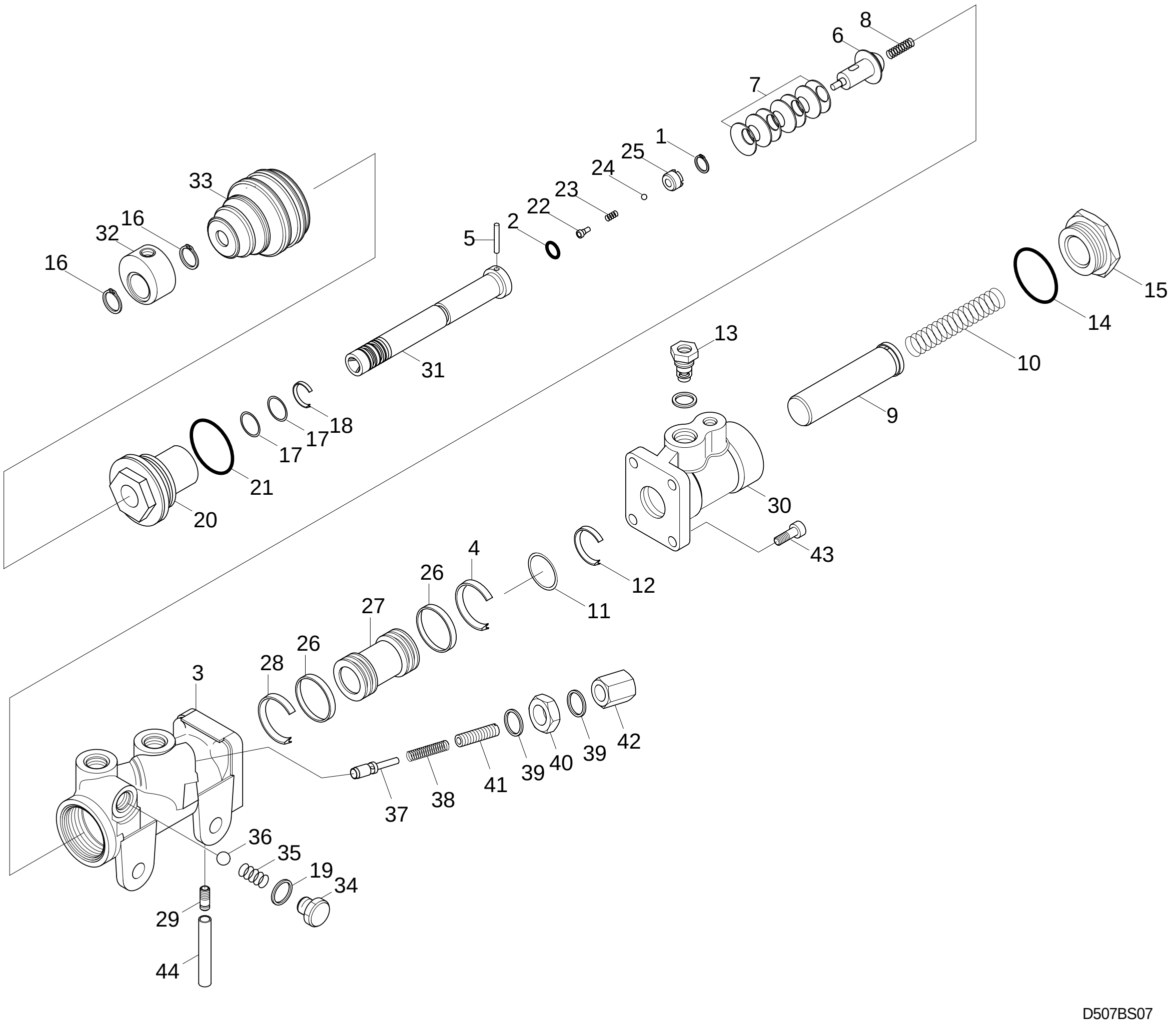
Major components are 4 disk plates(3), 5 steel plates(2), service piston(4), parking piston(5), parking lever(9) and brake housing(11).

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

7. BRAKE VALVE

A. BRAKE VALVE(DRY TYPE)

1) STRUCTURE

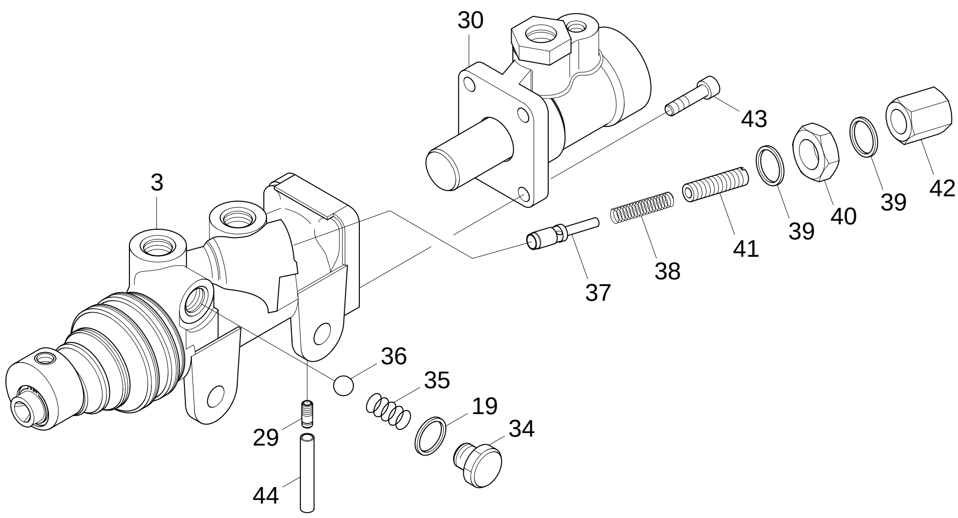


1	Stop ring	16	Stop ring	31	Push rod
2	Seal	17	Seal	32	Connector
3	Booster housing	18	Seal	33	Dust cover
4	Seal	19	Seal	34	Plug
5	Cylindrical thorn	20	Guide plug	35	Spring
6	Flow valve	21	Seal	36	Ball
7	Spring	22	Spring guide	37	Relief valve body
8	Push rod spring	23	Spring	38	Spring
9	Main piston	24	Ball	39	Washer
10	Spring	25	Check valve housing	40	Nut
11	Seal	26	Sliding guide	41	Adjusting screw
12	Seal	27	Seal	42	Plug
13	Valve plug	28	Seal	43	Fixing screw
14	Seal	29	Vent hole fitting	44	Rubber pipe
15	Closing plug	30	Master cylinder housing		

2) DISASSEMBLY

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

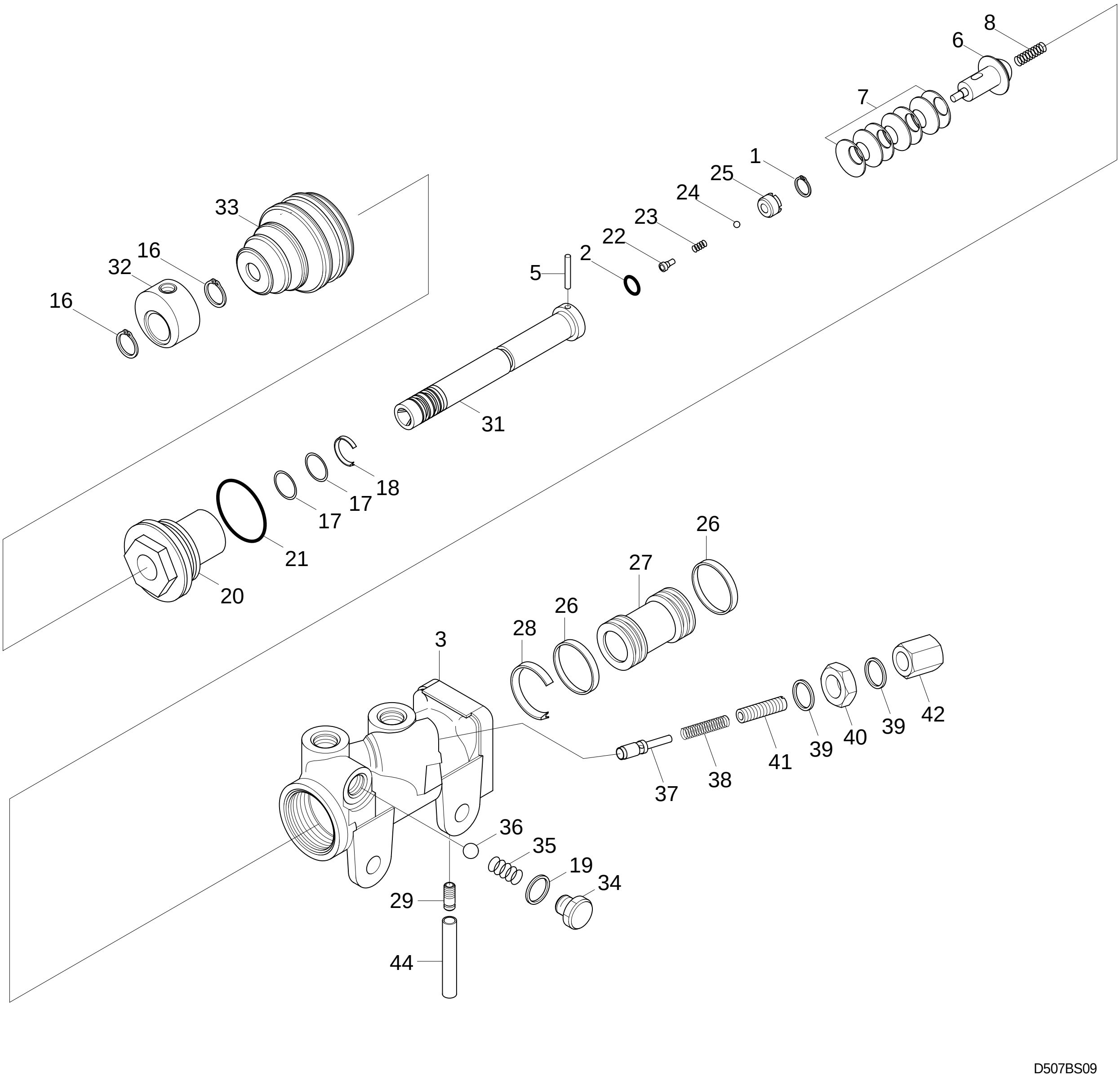
(1) Unscrew the 4 screws(43), in order to be able to separate the front housing(3) from the rear housing(30).
Then disassemble the check valve and the limiting pressure valve composed of parts(19, 34~42).

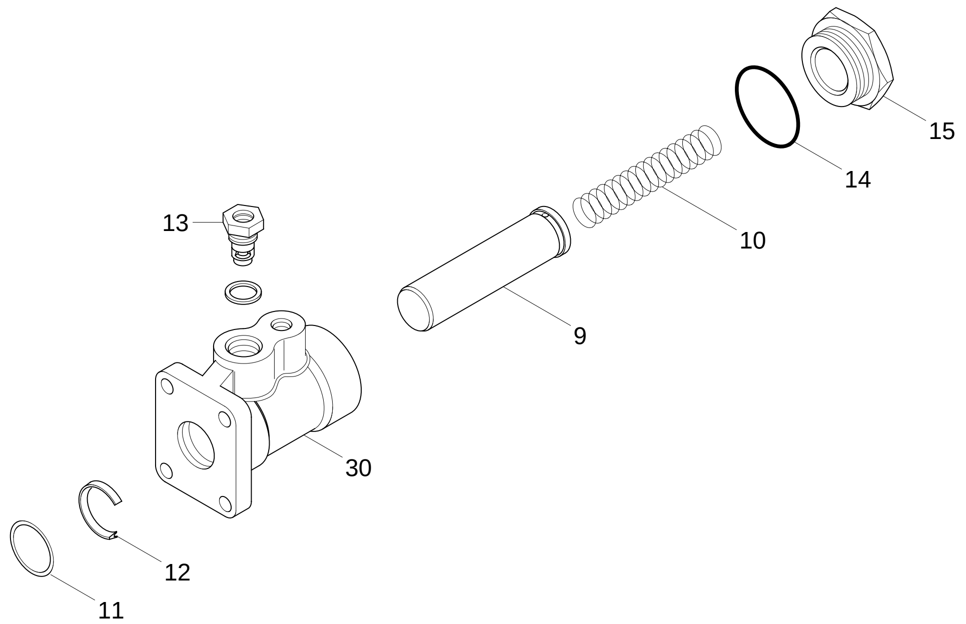


D507BS08

(2) By means of retaining ring pinces remove retaining ring(16), accurnulator fitting(32) and then the second retaining ring(16).
Remove rubber cap(33).

(3) Unscrew guide cap(20) and then extract rod(31) and spring(8).
After the extraction of the rod(31) remove pin(5) and disassemble parts(1, 2, 6, 7, 22~25).
Remove piston(27), extracting it from the side opposite to the threaded hole.





(4) Unscrew rear cap completely(15) by making sure that it's not being disconnected abruptly; remove then O-ring, spring(10) and the joints(9).
In order to remove the piston(9), knock the cylinder body on a piece of wood.
Only at last unscrew valve(13).

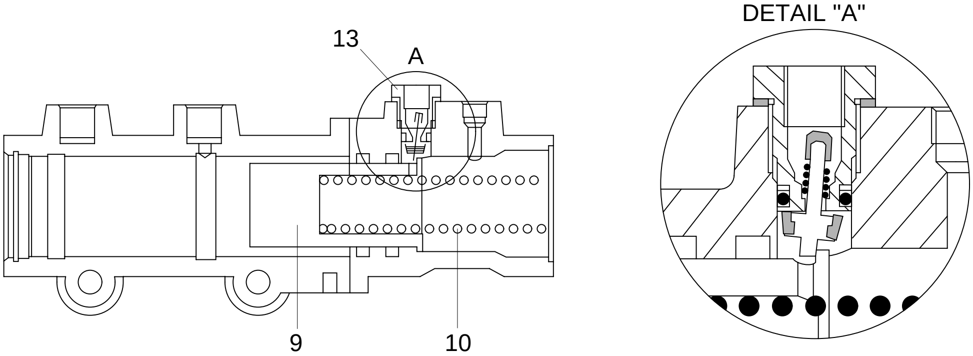
(5) Remove the O-ring and the lip seal still inside the pump body with the aid of an "L" iron.
Remove all of the other gaskets from the disassembled components, namely the drive rod(31), the piston(27).

(6) Clean all the components thoroughly and check that there is no ribbing inside the piston slide cylinder(27) of the pump body; smooth if necessary.
Lubricate the components either with mineral or with hydraulic oil, according to their use destination.

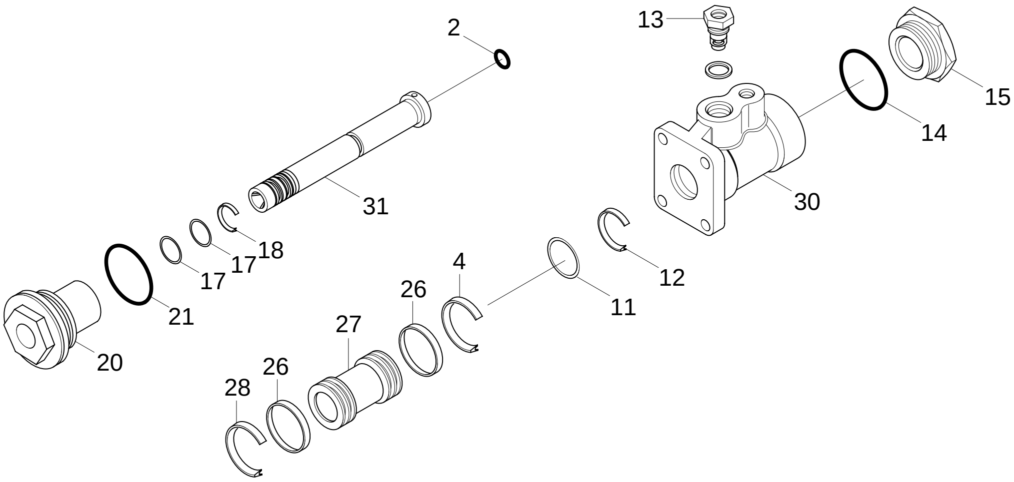
3) ASSEMBLY

※ 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.

※ Take the utmost care in assembling the components shown at stage 4, by assembling first of all valve(13), then piston(9), spring(10) and only afterwards the other components.



D507BS11



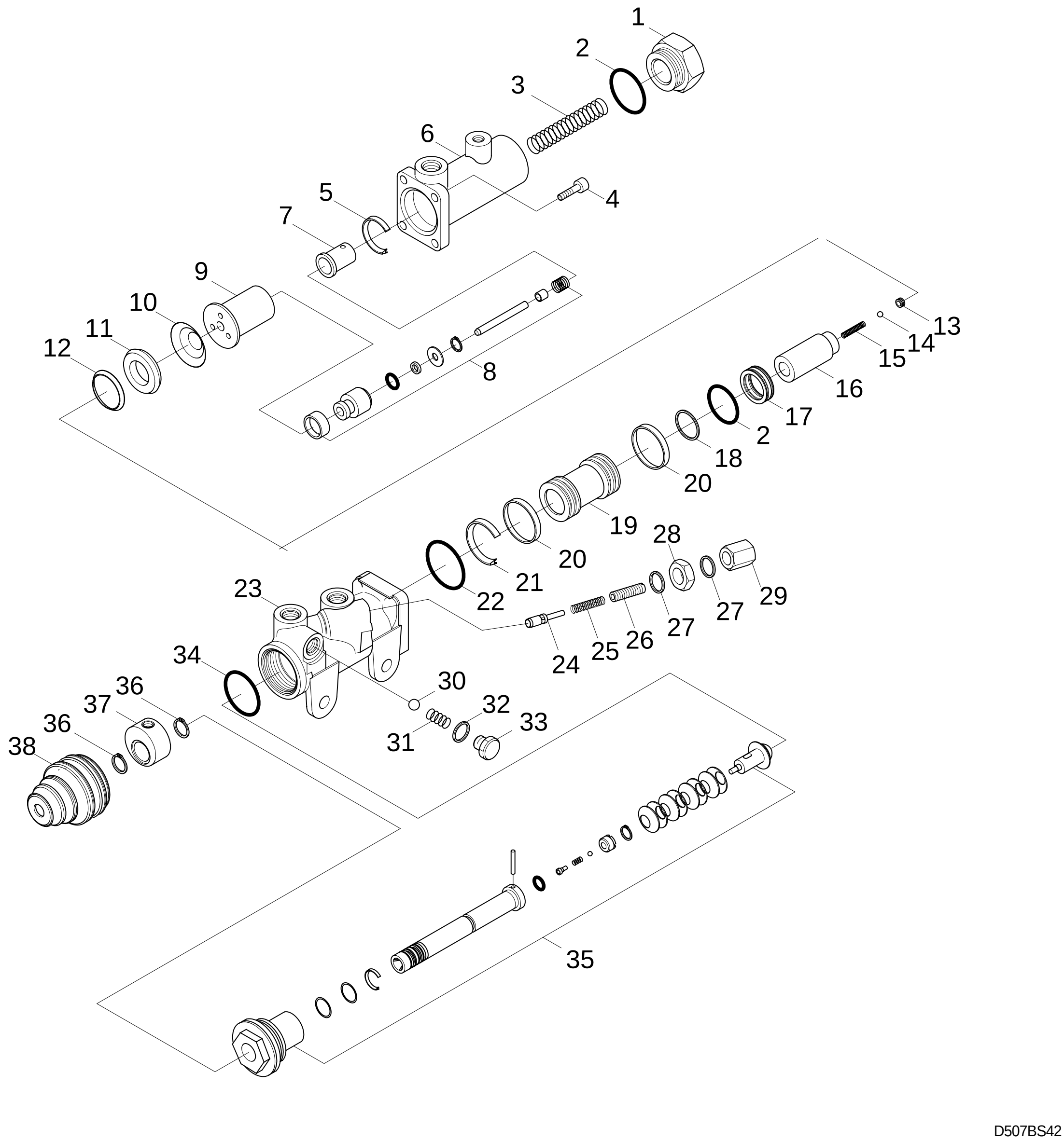
D507BS12

· SEAL KIT : ZTAX-00077

⚠ Use only brake fluid(DOT3) in the compensation reservoirs.

B. BRAKE VALVE(WET TYPE)

1) STRUCTURE

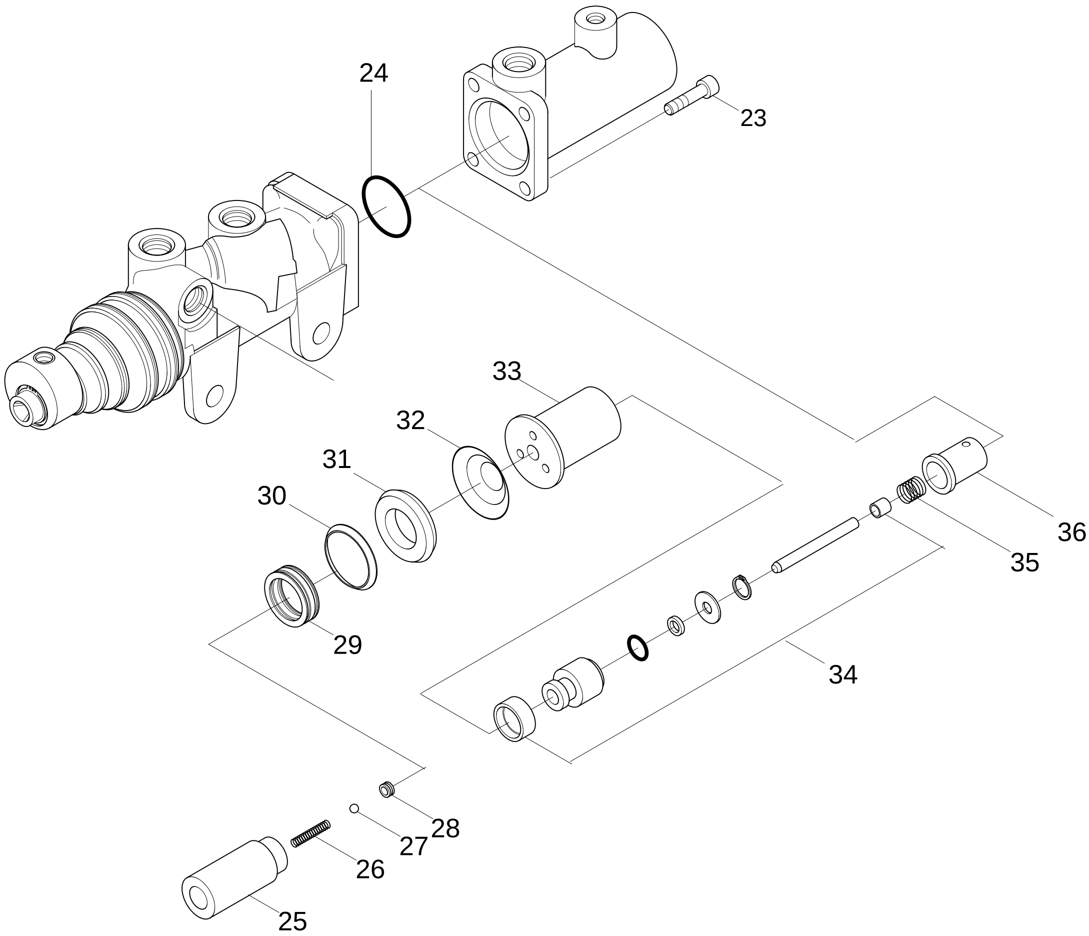


1	Plug	11	Seal	21	Seal	31	Spring
2	Seal	12	Ring	22	Seal	32	Seal
3	Spring	13	Seal	23	Booster housing	33	Plug
4	Screw	14	Ball	24	Relief valve body	34	Seal
5	Seal	15	Spring	25	Spring	35	Push rod
6	B/Cyl Housing	16	Auxiliary piston	26	Adjustment screw	36	Stop ring
7	Spring guide	17	Ring	27	Washer	37	Connector
8	Valve	18	Seal	28	Nut	38	Dust cover
9	Piston	19	Booster piston	29	Plug		
10	Spring	20	Sliding guide	30	Ball		

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(23), in order to separate the booster from the brake cylinder housing. Separate the two parts and remove the components that are inside from(25) to(36), in order to remove spring(26) and ball(27), you should remove seal(28) from piston containing the seal(25).

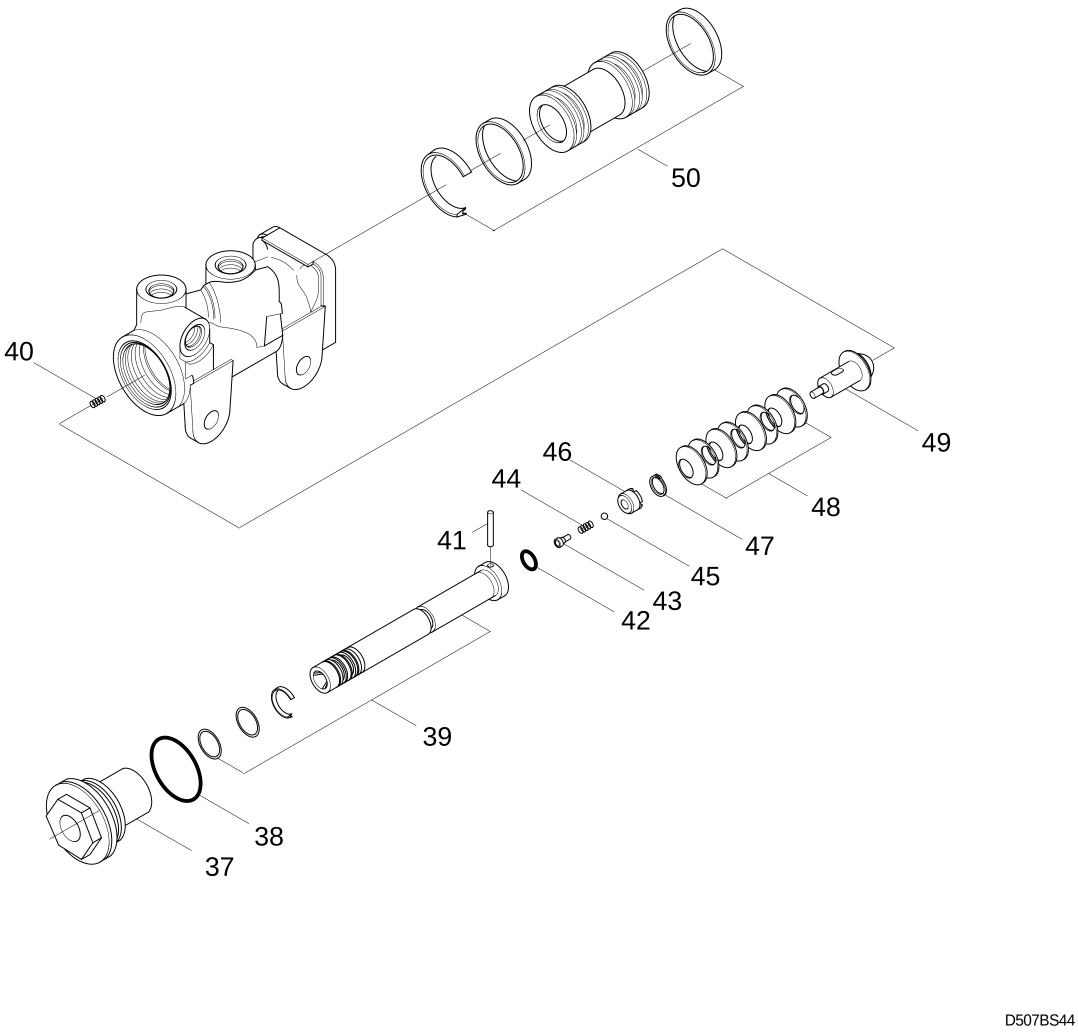


D507BS43

(2) Unscrew guide cap(37) and then remove O-ring(38), rod(39), spring(40) and the piston(50).
Once rod(39) has been removed, take out pin(41) and all the components that are inside the rod from(42) to(49).

(3) Remove the lip seal inside the brake cylinder housing by means of on L-Iron.
Remove all other seals from the disassembled components, namely drive(39), piston(50), O-ring housing(29) and valve(34).

(4) Clean all the components thoroughly and check that there is no ribbing inside the pisiton slide cylinder(50) of the brake cylinder housing ; Smooth if necessary.
Lubricate the components, particularly the seals by means of proper oil, or better with grease suitable for ATE(Automatic test equipment) braking systems. Take great care not to contaminate components operating on brake fluid with mineral oil and vice-versa.

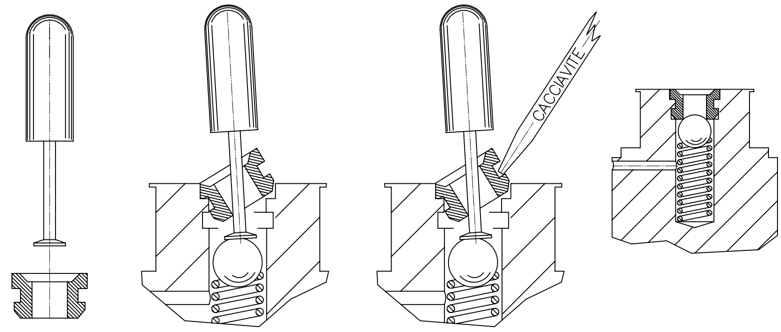


3) ASSEMBLY

※ **The assembly procedure must be carried out by following the sequence described before in reverse order, taking great care not to fit the new seals back to front or upside down.**

(1) In order to fit the valve inside the piston containing the seal(25) following these instructions.

Fit the seal into the appropriate tool and press ball and spring into the seat;
Fit one end of the seal (as shown in the picture) and then fit the rest of the seal with a screwdriver.
Make sure that the seal is fitted proplely by inserting the screwdriver into the hole and by checking that seal is not misshappen in any way.

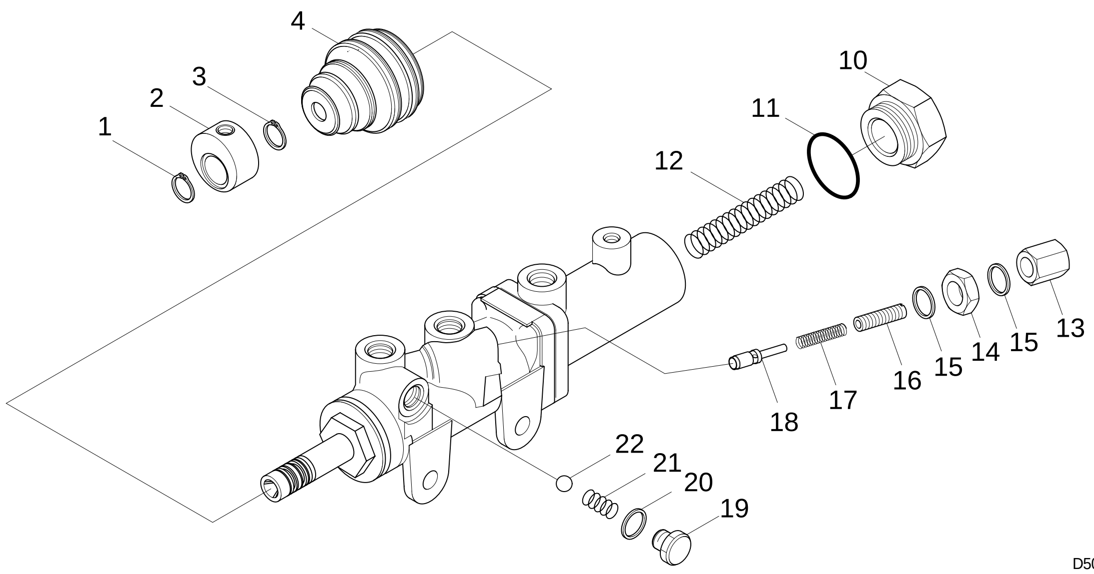


D507BS52

4) SEALS REPLACEMENT IN BRAKE CYLINDERS WITH HYDRAULIC BOOSTER

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

(1) After disassembling retaining ring(1), accumulator fitting(2) and then the second retaining ring(3), remove rubber cap(4).
Then disassemble the check valve composed of parts(19~22) and the relief valve composed of parts(13~18) only in case of failure.
Unscrew rear cap completely(10) by making sure that it's not being disconnected abrupty; remove then O-ring (11), spring (12).



D507BS45

· **SEAL KIT : ZTAX-00040**

⚠ **Use only brake fluid(SAE10W) in the compensation reservoirs.**

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

A. DRY TYPE

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 in depressed. Check also change in operating force, and change in position of pedal when pedal is kept depressed.

2) WHEEL BRAKE

Compact wheel base chassis

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

3) BRAKE DRUM

(1) Measure inside diameter of drum, and check that it is within 315mm(12.4in).
(2) Tighten mounting bolt of drum 2.5 ~ 4.0kgf · m(18 ~ 29lbf · ft).

4) BACKING PLATE

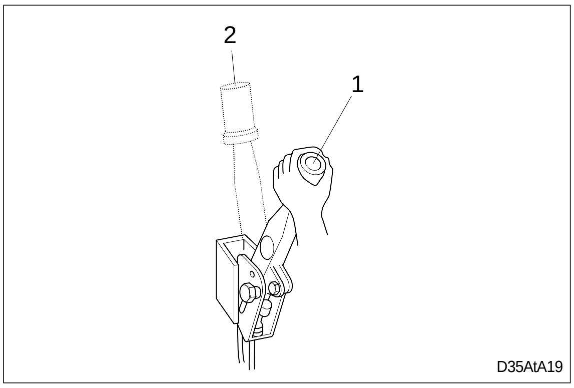
(1) Check visually for deformation or cracks.
Check particularly for deformation at outside circumference of plate and at mounting bolt.
(2) Coat mounting bolt with loctite and tighten : 15 ~ 17kgf · m(108 ~ 123lbf · ft).

5) BRAKING FORCE

(1) Select a dry, flat, paved surface and drive truck at maximum speed. When signal is given, stop truck immediately and measure distance from point where signal was given to point where truck stopped. (unloaded)
· Stopping distance : Within 5m(197in)
(2) Check that there is no pulling of steering wheel, pulling by brakes to one side or abnormal noise when making emergency stops.

6) PARKING BRAKE

(1) Operating force of parking lever is 35 - 40 kgf · m(253 - 290lbf · 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.



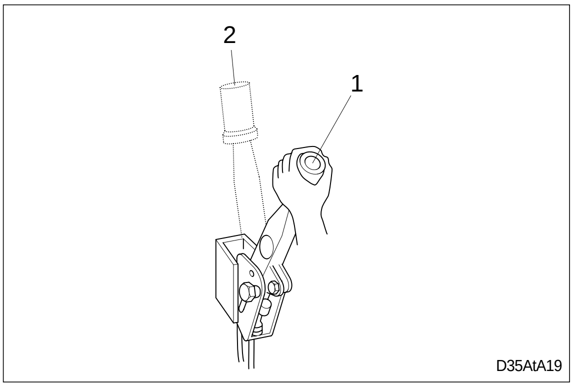
B. WET TYPE

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 in 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 - 290lbf · 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

A. DRY TYPE

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

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

B. WET TYPE

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.

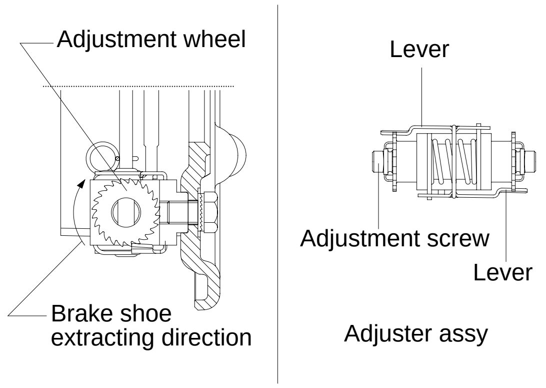
GROUP 3 TESTS AND ADJUSTMENTS

1. ADJUSTMENT OF WHEEL BRAKE (DRY TYPE)

⚠ Adjust with engine stopped.

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

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



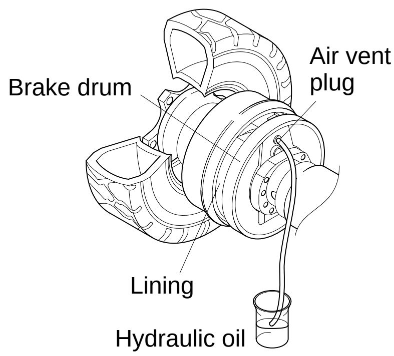
D353BS04

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

2. AIR BLEEDING OF BRAKE SYSTEM

A. DRY TYPE

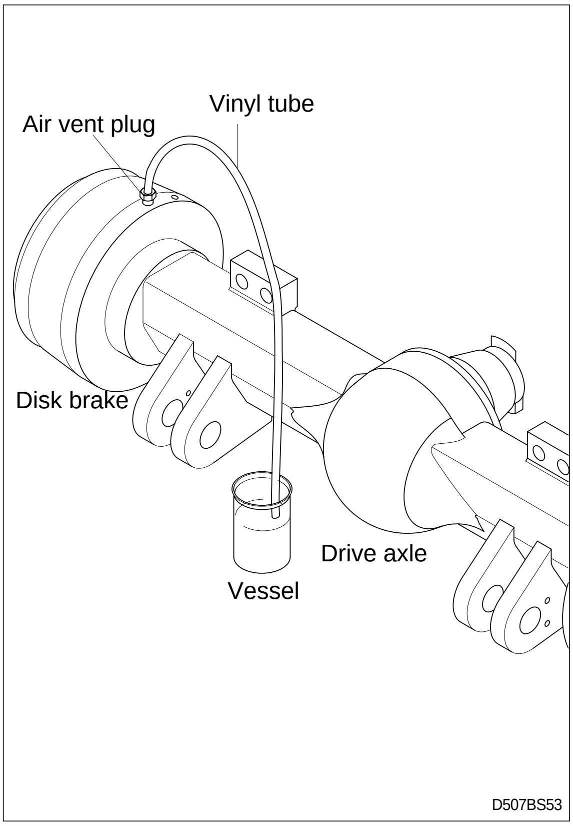
1) Air bleeding should be performed by two persons :
   One rides on truck for depressing and releasing brake pedal : the other person is on the ground and removes cap from air vent plug on wheel cylinder.
2) Block the front wheel securely and apply parking brake.
3) Start the engine.
4) Attach a vinyl 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.



D507BS071

B. WET TYPE

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.
8) Same way for the opposite side.



3. ADJUSTMENT OF PEDAL

1) BRAKE PEDAL

(1) Pedal height from floor plate

Adjust with stopper bolt.

· Pedal height : 122~128㎜(4.8~5.0in)

(2) Idle stroke

Adjust with rod of master cylinder

· Play : 4~6.5㎜(0.16 ~ 0.25in)

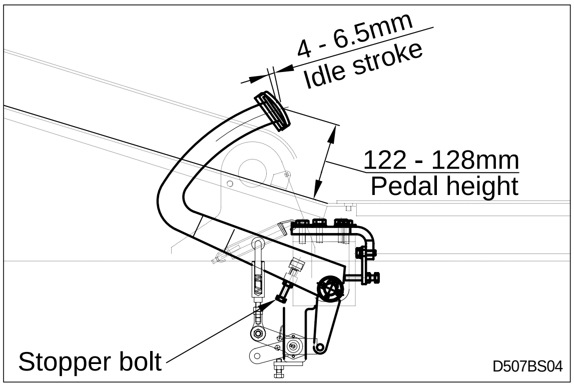
(3) Micro switch for parking brake (if equipped)

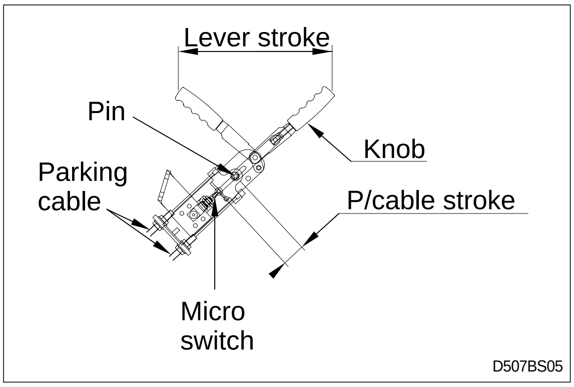
① After assembling parking brake and parking cable, put the parking brake lever released.

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 : 2~3㎜(0.08 ~ 0.1in)





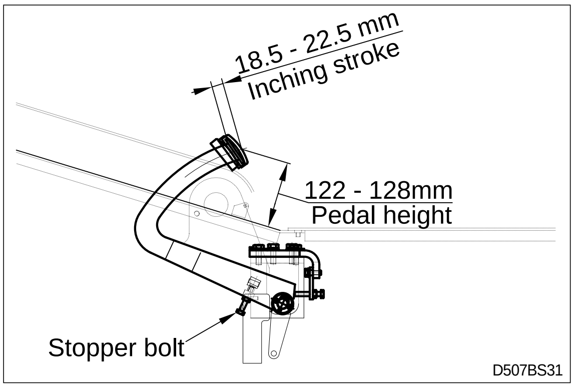
2) INCHING PEDAL

(1) Pedal height from floor plate

Adjust with stopper bolt.

· Pedal height : 122~128㎜(4.8~5.0in)

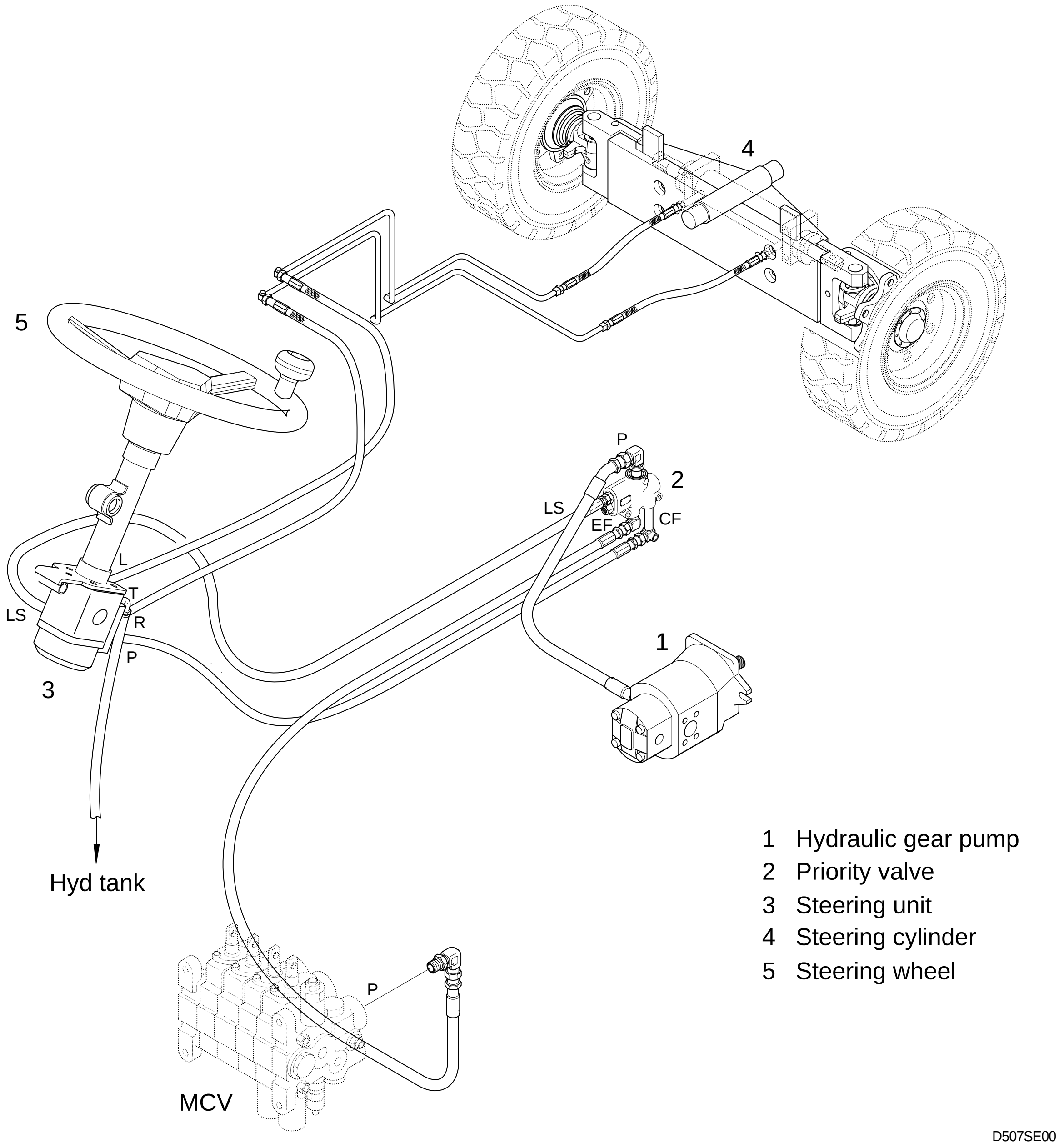
(2) Adjust bolt so that brake pedal interconnects with inching pedal at inching pedal stroke 18.5~22.5㎜(0.72~0.88in).



SECTION 5 STEERING SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

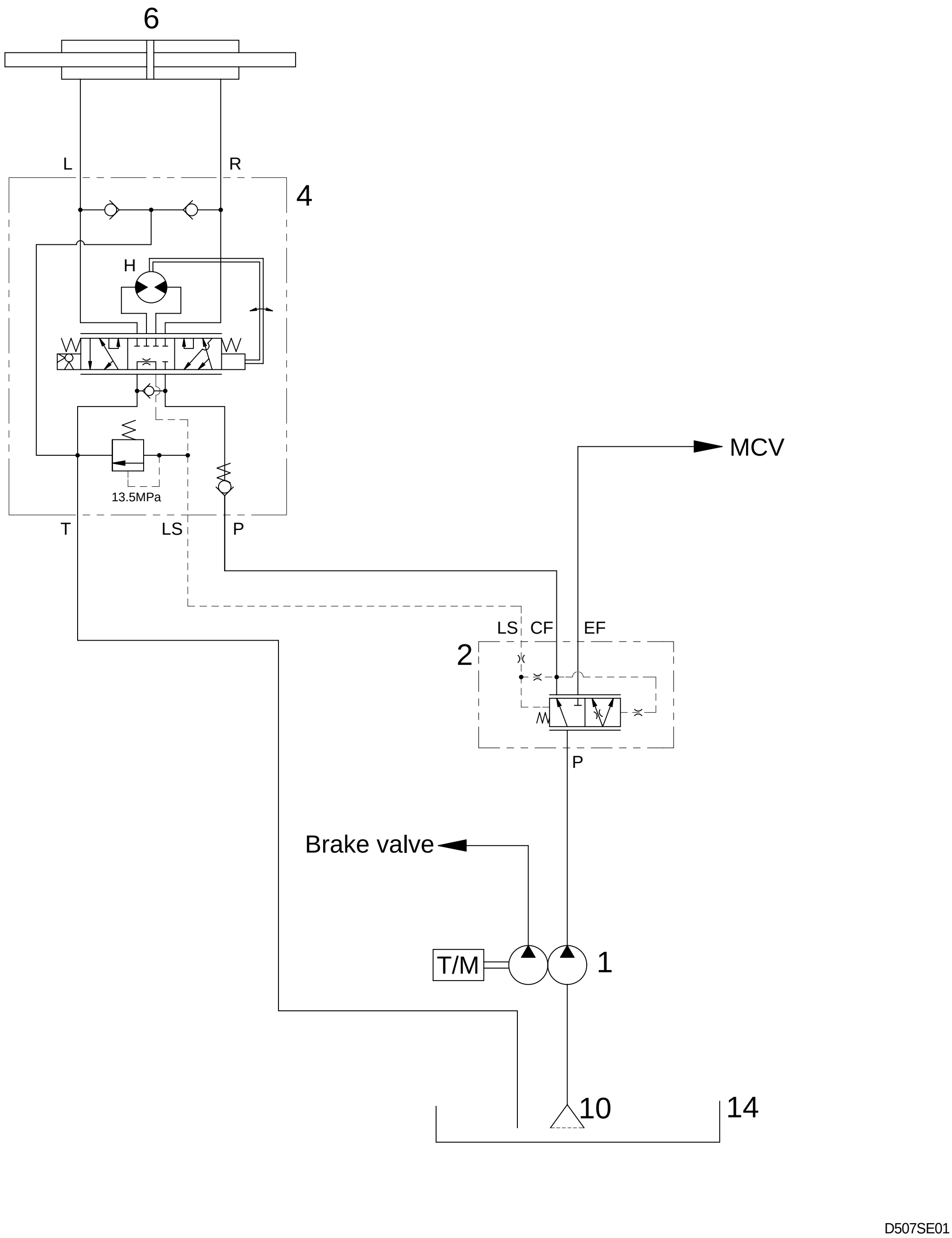
1. OUTLINE



1 Hydraulic gear pump
2 Priority valve
3 Steering unit
4 Steering cylinder
5 Steering wheel

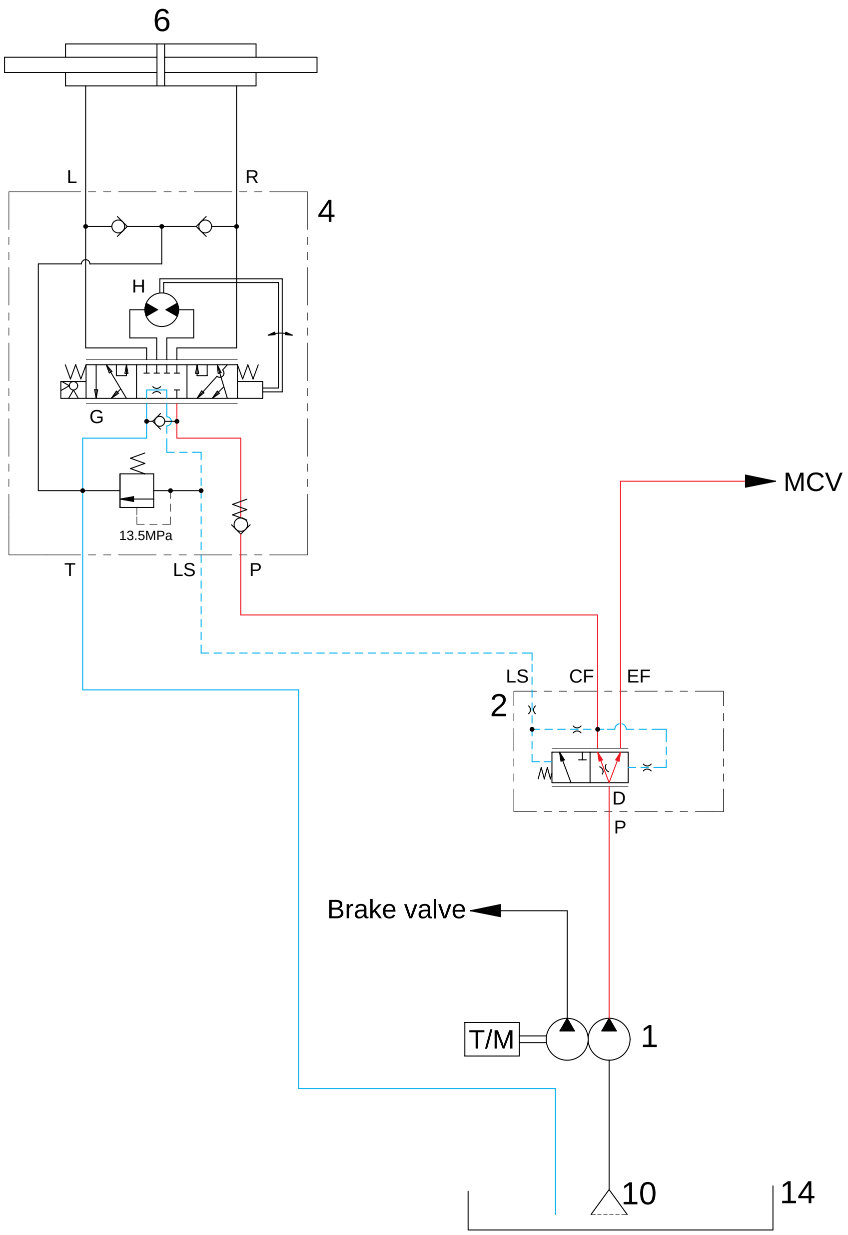
The steering system for this machine is composed of steering wheel assembly, steering unit, steering cylinder, trail axle and piping. The steering force given to the steering wheel enters the steering unit through the steering column. The required oil flow is sensed by the function of the control section 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. HYDRAULIC CIRCUIT



1	Hydraulic gear pump	6	Steering cylinder
2	Priority valve	10	Suction filter
4	Steering unit	14	Hydraulic tank

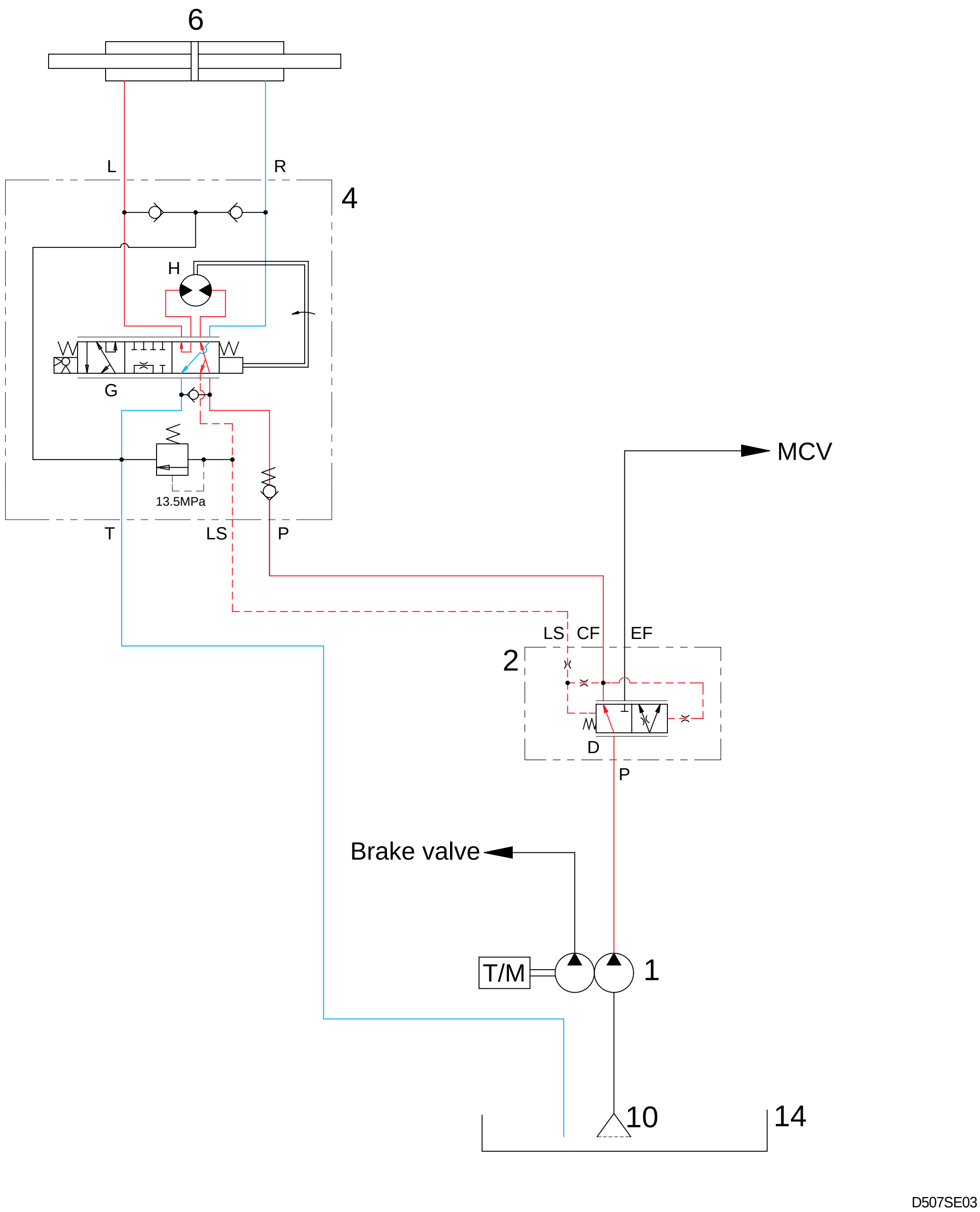
1) NEUTRAL



D507SE02

The steering wheel is not being operated, so control spool(G) does not move.
The oil from hydraulic gear pump(1) enters the port P of priority valve(3) and the inlet pressure oil moves the spool(D) to the left.
Oil flow into LS port to the hydraulic tank(14), so the pump flow is routed to the main control valve through the EF port.

2) LEFT TURN



When the steering wheel is turned to the left, the spool(G) within the steering unit(4) connected with steering column turns in left hand direction.

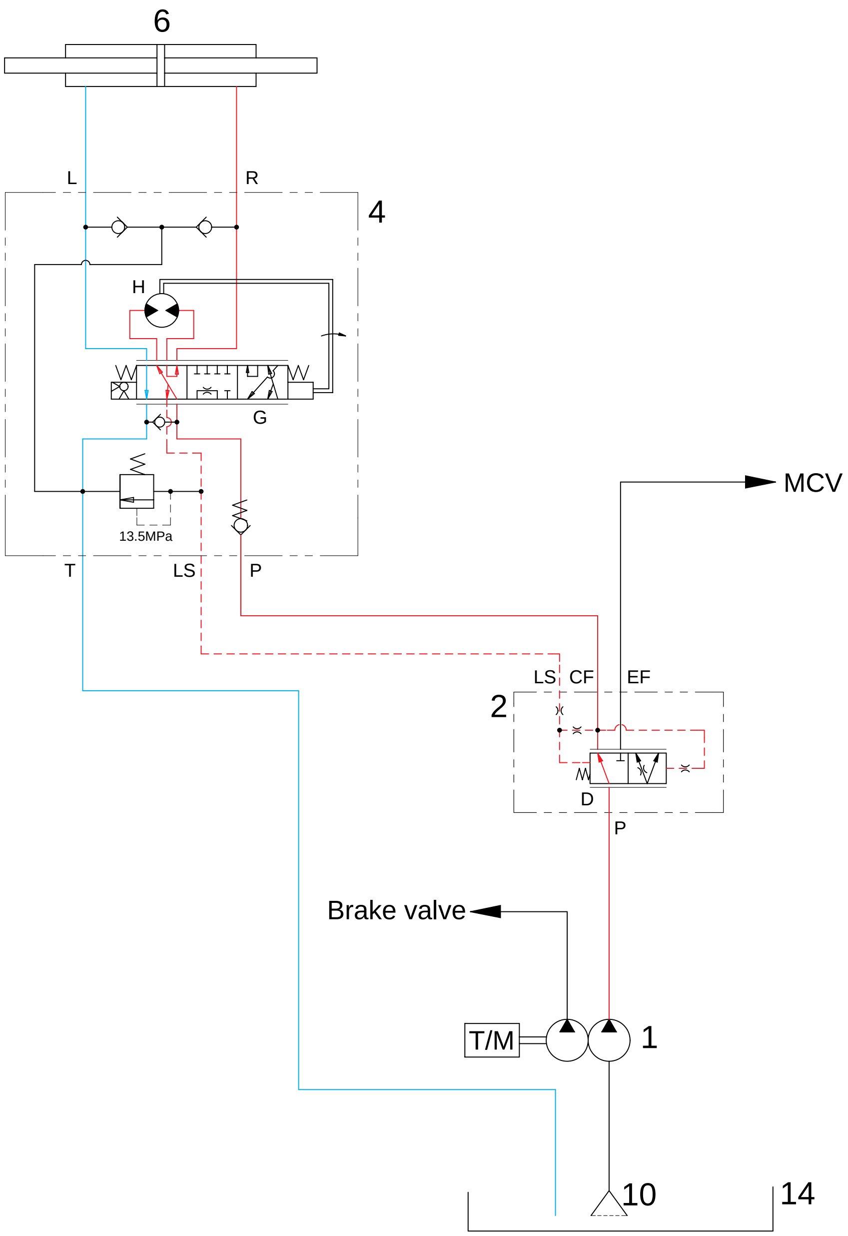
At this time, the oil discharged from the pump flows into the spool(G) the steering unit through the spool(D) of priority valve and flows the gerotor(H).

Oil flow from the gerotor 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) RIGHT TURN



D507SE04

When the steering wheel is turned to the right, the spool(G) within the steering unit(4) connected with steering column turns in right hand direction.

At this time, the oil discharged from the pump flows into the spool(G) the steering unit through the spool(D) of priority valve and flows the gerotor(H).

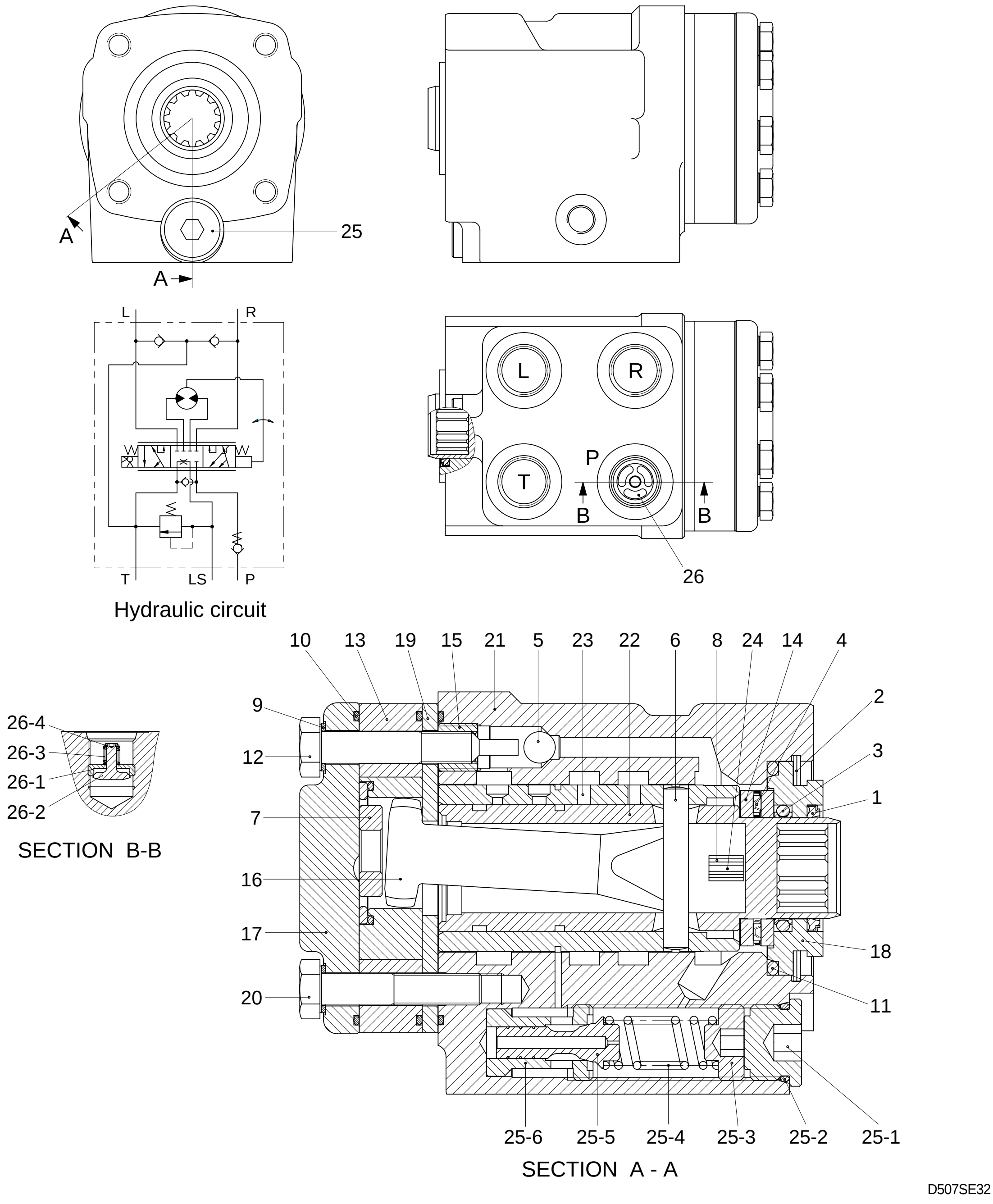
Oil flow from the gerotor flows back into the spool(G) where it is directed out the right work port(R).

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

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

3. STEERING UNIT

1) STRUCTURE



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

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.

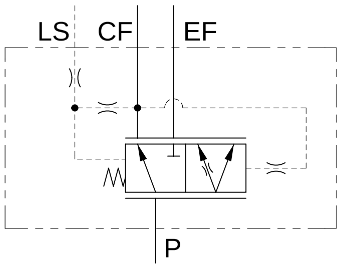
When the steering wheel is turned, the spool turns, the oil path is switched and the oil is fed into the metering device. As a result, the rotor is caused to run by oil pressure, and the sleeve is caused to run through the drive shaft and cross pin. Therefore, when the spool is turned, the spool turns 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.**

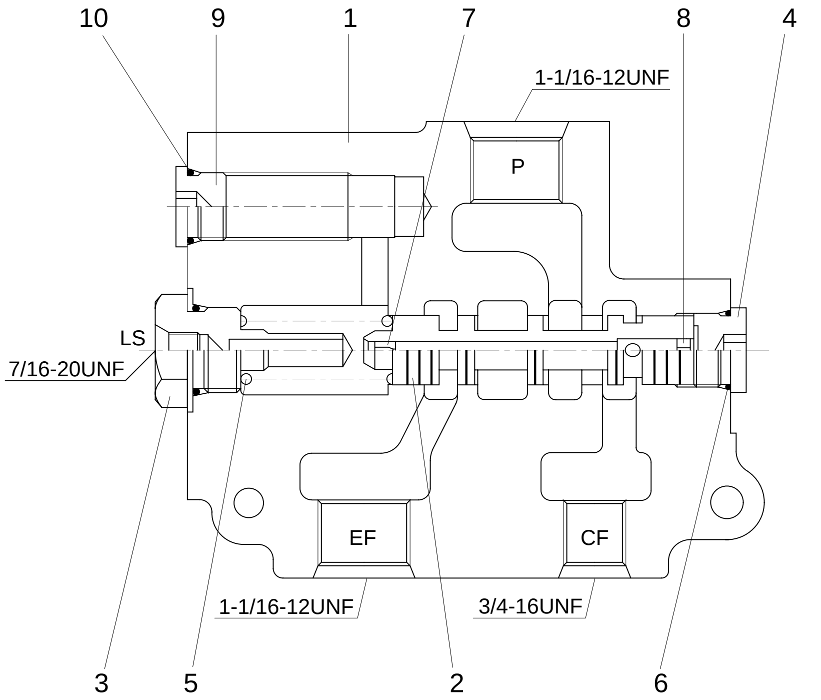
The centering spring for the spool and sleeve is provided to cause the valve to return to the neutral position. It is therefore possible to obtain a constant steering feeling, which is transmitted to the hands of the driver. Return to the center position occurs when the steering wheel is released.

4. PRIORITY VALVE

1) STRUCTURE



HYDRAULIC CIRCUIT



D353SE06

1	Body	5	Spring	9	End plug
2	Spool	6	O-ring	10	O-ring
3	Spring pulg	7	Orifice		
4	End plug	8	Orifice		

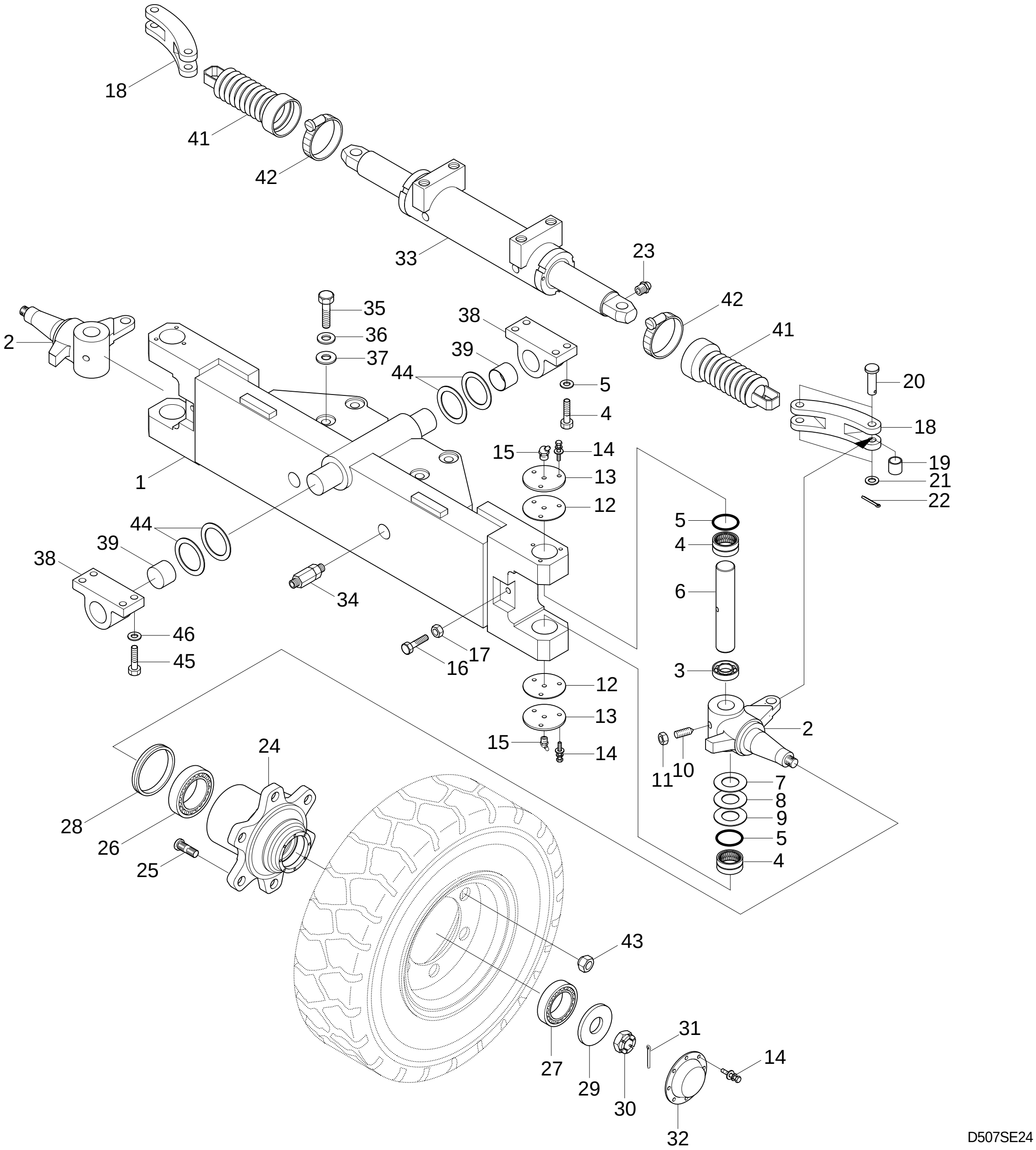
2) OPERATION

The oil from the hydraulic gear pump flows to the priority valve.
The priority valve supplies a flow of oil to the steering system and lift, tilt system.
The steering flow is controlled by the steering unit to operate the steering cylinder.
The remainder of the oil flow from the pump flows to the main control valve.

5. TRAIL AXLE

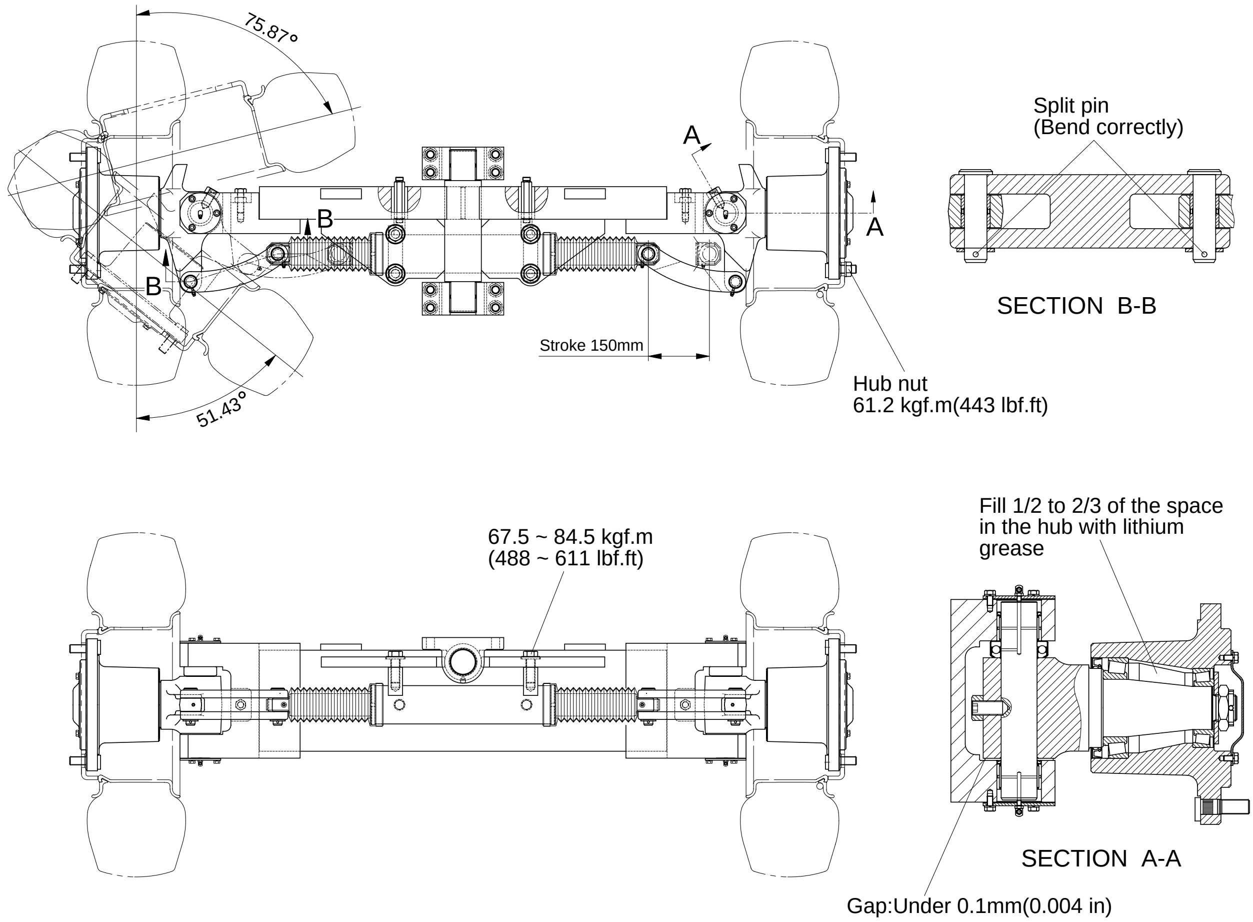
1) STRUCTURE

※ Do not remove the stopper bolt unless necessary.



1	Steer axle wa	12	Gasket	23	Grease nipple	34	Adaptor
2	Knuckle	13	Cover	24	Hub	35	Cover
3	Thrust bearing	14	With washer bolt	25	Hub bolt	36	Hexagon bolt
4	Needle bearing	15	Grease nipple	26	Taper roller bearing	37	Shim
5	Oil seal	16	Hexagon bolt	27	Taper roller bearing	38	Support
6	King pin	17	Hexagon nut	28	Oil seal	39	Bushing
7	Thrust washer	18	Link	29	Special washer	41	Steer cylinder boot
8	Shim washer	19	Inner race bushing	30	Lock nut	42	Clamp
9	Shim washer	20	Link pin	31	Split pin	43	Hub nut
10	Set screw	21	Special washer	32	Hub cap	44	Shim
11	Hexagon nut	22	Split pin	33	Steer cylinder assy	45	Hexagon bolt
						46	Hardened washer

2) TIGHTENING TORQUE AND SPECIFICATION

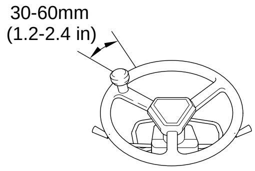


D507SE07

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	75.87/ 51.43
Tread	mm(in)	1604(63.1)

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

<table>
<tr><th>Check item</th><th>Checking procedure</th></tr>
<tr><td>Steering wheel

</td><td>· Set rear wheels facing straight forward, then turn steering wheel to left and right. Measure range of steering wheel movement before rear wheel starts to move. Range should be 30~60mm at rin of steering wheel. If play is too large, adjust at gear box.
Test steering wheel play with engine at idling.</td></tr>
<tr><td>Knuckle</td><td>· Check knuckle visually or use crack detection method. If the knuckle is bent, the tire wear is uneven, so check tire wear.</td></tr>
<tr><td>Steering axle</td><td>· Put camber gauge in contact with hub and measure camber.
If camber is not within 0±0.5° ; rear axle is bent.
· Ask assistant to drive machine at minimum turning radius.
· Fit bar and a piece of chalk at outside edge of counterweight to mark line of turning radius.
· If minimum turning radius is not within±100mm (±4in)of specified value, adjust turning angle stopper bolt.
Min turning radius(Outside)<table><tr><td>HDF 50-7S</td><td>3290mm(130in)</td></tr><tr><td>HDF 70-7S</td><td>3370mm(133in)</td></tr></table></td></tr>
<tr><td>Hydraulic pressure of power steering</td><td>Remove plug from outlet port of flow divider and install oil pressure gauge.
Turn steering wheel fully and check oil pressure.
※ Oil pressure : 135 ~ 140 kgf/cm² (132 ~ 137bar)</td></tr>
</table>

2. TROUBLESHOOTING

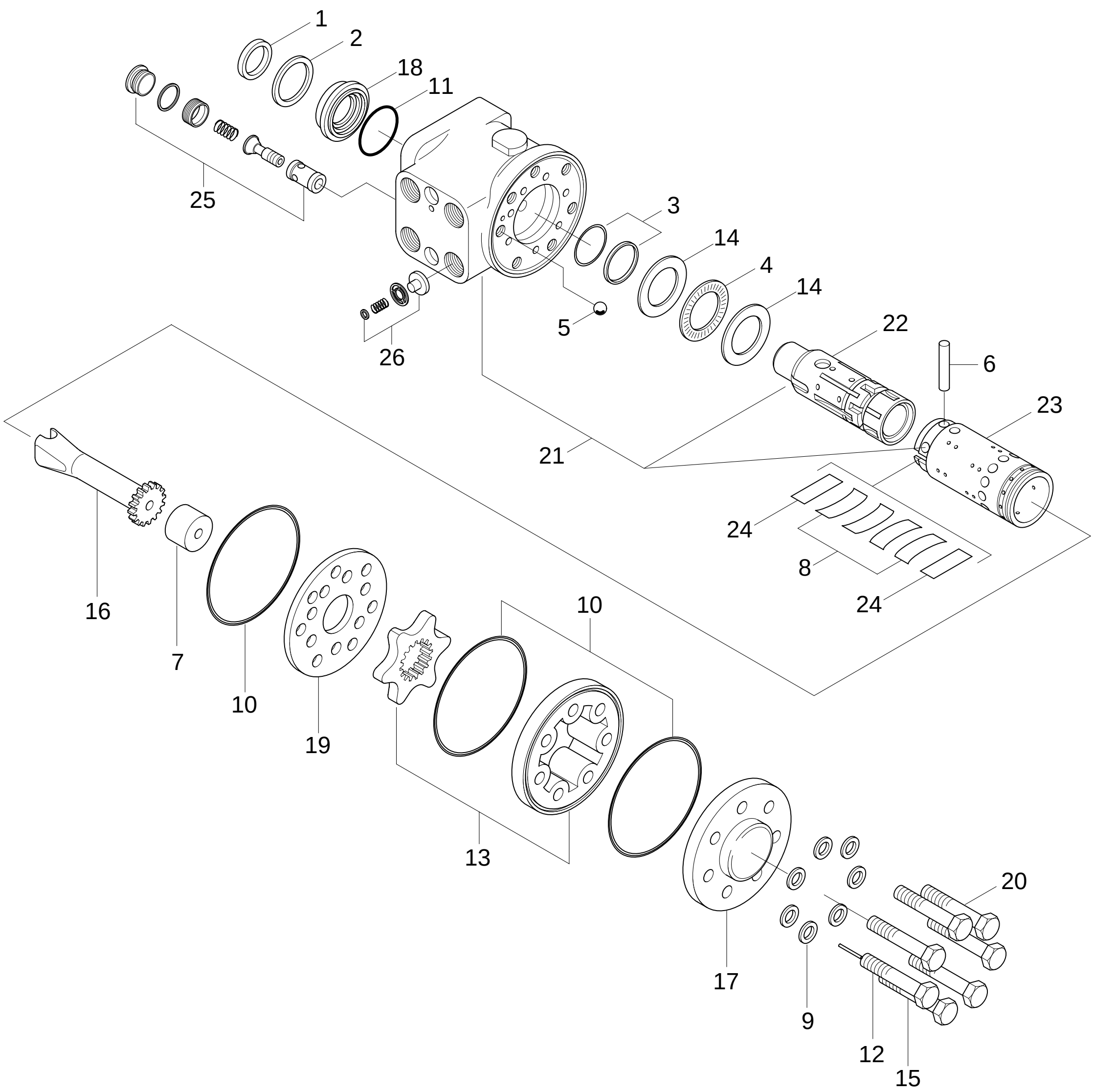
Problem	cause	Remedy
Steering wheel drags.	· Low oil pressure. · Bearing faulty. · Spring spool faulty. · Reaction plunger faulty. · Ball-and-screw assembly faulty. · Sector shaft adjusting screw excessively tight. · Gears poorly meshing. · Flow divider coil spring fatigued.	· Check lockout. Repair.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

Problem	cause	Remedy
Steering wheel turns unstea-dily. Steering system makes abn-ormal 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 dischar-ge pressure.	Piping · Pipe(from tank to pipe) dented or clogged.	· Repair or replace.
Steering cylinder head leakage (Piston rod)	· Packing foreign materal. · Piston rod damage. · Rod seal damage and distortion. · Chrome gilding damage.	· Replace · Grind surface with oil stone. · Replace · Grind
Steering cylinder head thread (A little bit leak is no problem)	· O-ring damage.	· Replace
Welding leakage	· Cylinder tube damage.	· Tube replace.
Rod	· Tube inside damage. · Piston seal damage and distortion	· Grind surface with oil store. · Replace
Piston rod bushing inner diameter excessive gap	· Bushing wear.	· Replace

GROUP 3 DISASSEMBLY AND ASSEMBLY

1. STEERING UNIT

1) STRUCTURE

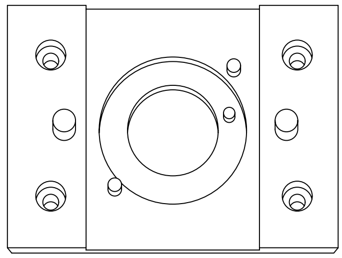


D507SE05

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

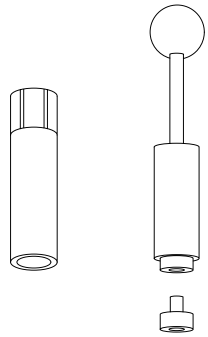
2) TOOLS

(1) Holding tool.



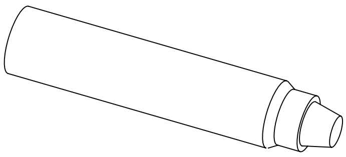
5-69(1)

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



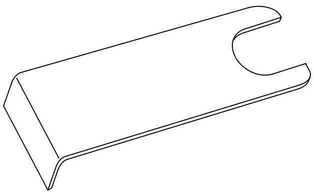
5-69(2)

(3) Assembly tool for lip seal.



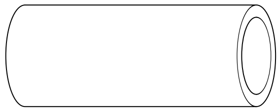
5-69(3)

(4) Assembly tool for cardan shaft.



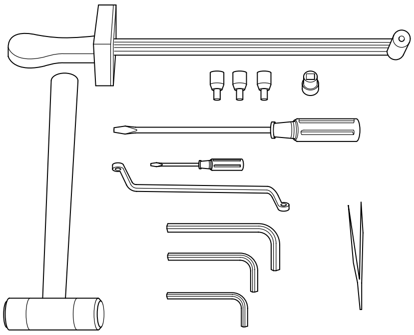
5-69(4)

(5) Assembly tool for dust seal.



5-70(1)

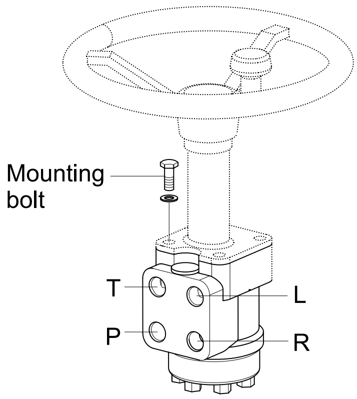
(6) Torque wrench 0~7.1kgf · m
(0~54.4lbf · ft)
13mm socket spanner
6, 8mm and 12mm hexagon sockets
12mm screwdriver
2mm screwdriver
13mm ring spanner
6, 8 and 12mm hexagon socket spanners
Plastic hammer
Tweezers



5-70(2)

3) TIGHTENING TORQUE

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

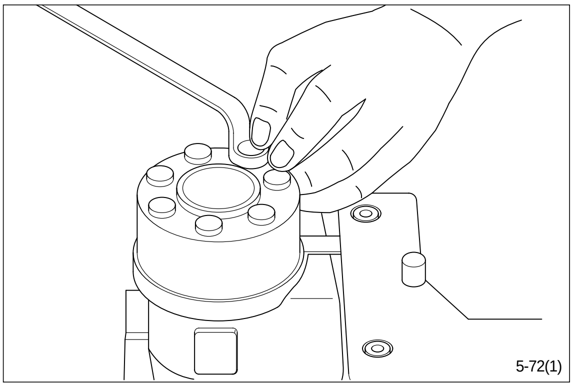


D353SE23

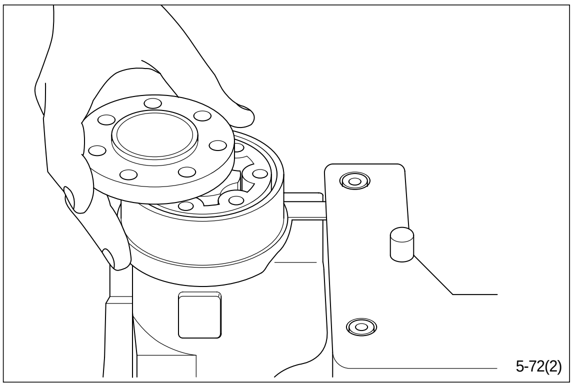
Port	Size	Torque [kgf · m(lbf · ft)]
L	3/4 - 16UNF	6.1±0.6 (44±4.3)
R	3/4 - 16UNF	6.1±0.6 (44±4.3)
T	3/4 - 16UNF	6.1±0.6 (44±4.3)
P	3/4 - 16UNF	6.1±0.6 (44±4.3)
Mounting bolt	M10×1.5	4.0 ±0.5 (29±3.6)

4) DISASSEMBLY

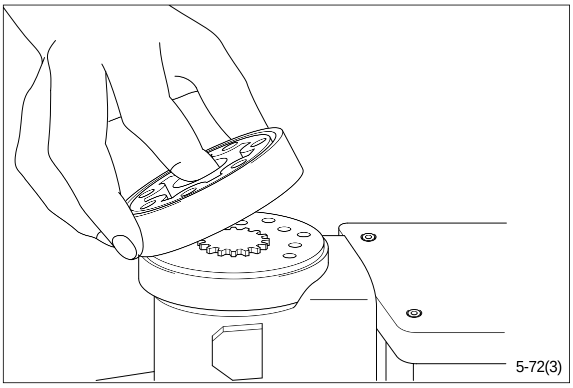
(1) Disassemble steering column from steering unit and place the steering unit in the holding tool.
Screw out the screws in the end cover(6-off plus one special screw).


5-72(1)

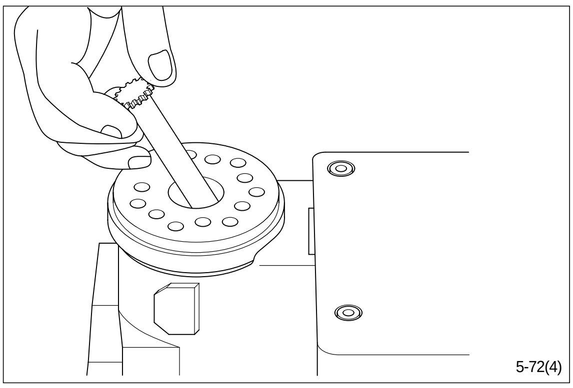
(2) Remove the end cover, sideways.


5-72(2)

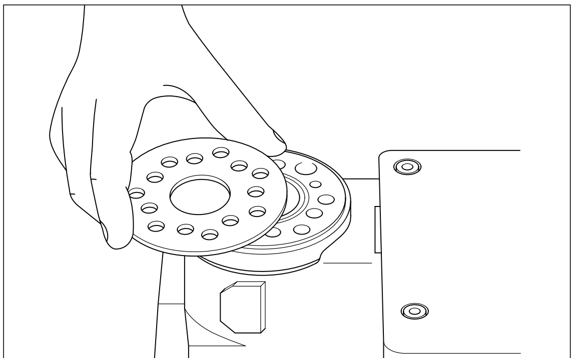
(3) Lift the gearwheel set(With spacer if fitted) off the unit.
Take out the two O-rings.


5-72(3)

(4) Remove cardan shaft.

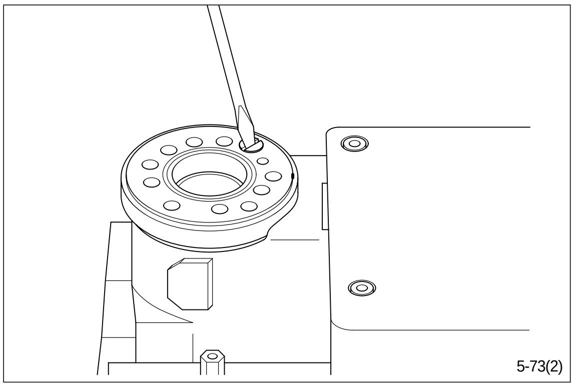

5-72(4)

(5) Remove distributor plate.



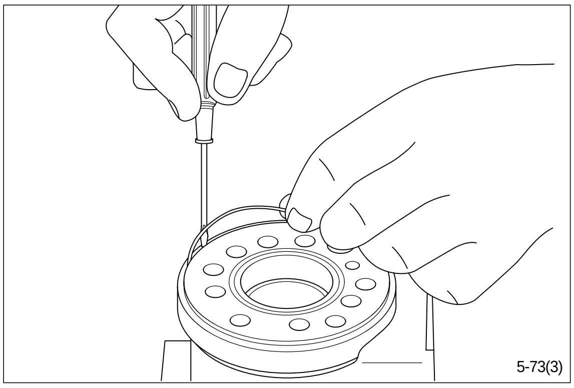
5-73(1)

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



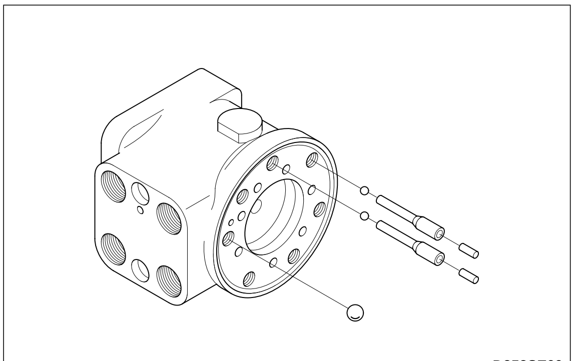
5-73(2)

(7) Remove O-ring.



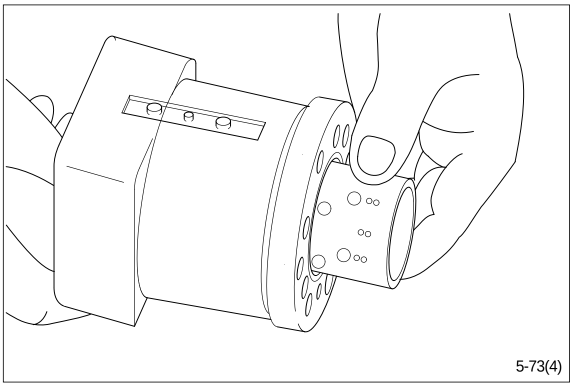
5-73(3)

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



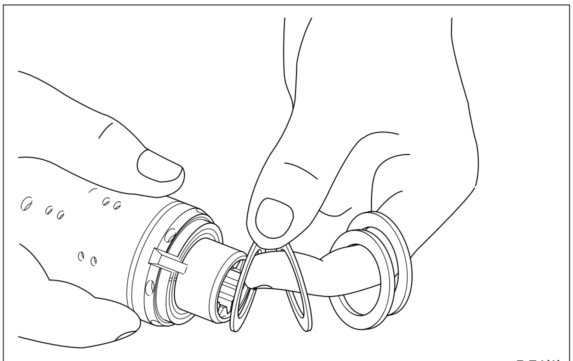
D353SE09

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



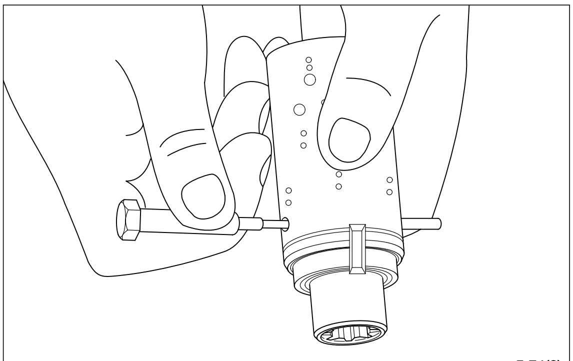
5-73(4)

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



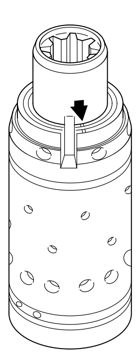
5-74(1)

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



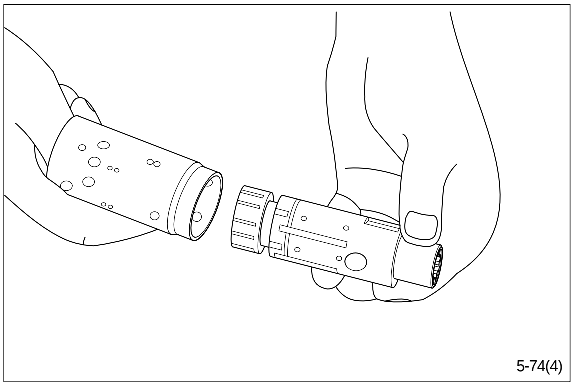
5-74(2)

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

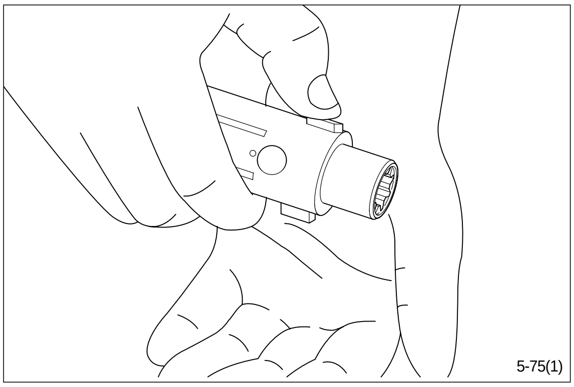


5-74(3)

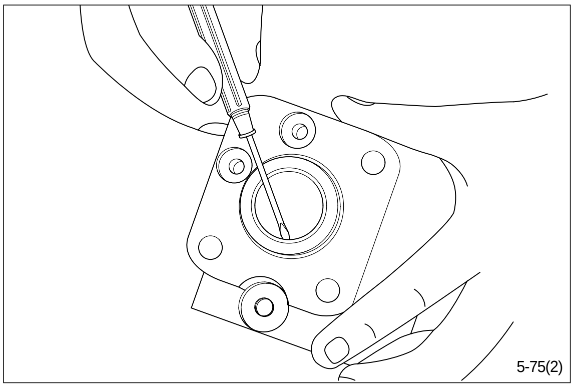
(12) Carefully press the spool out of the sleeve.



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

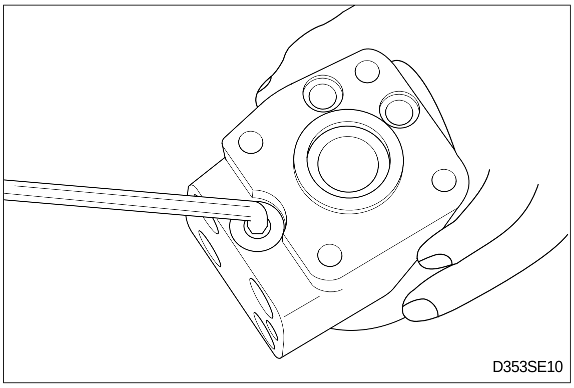


(14) Remove dust seal and O-ring.

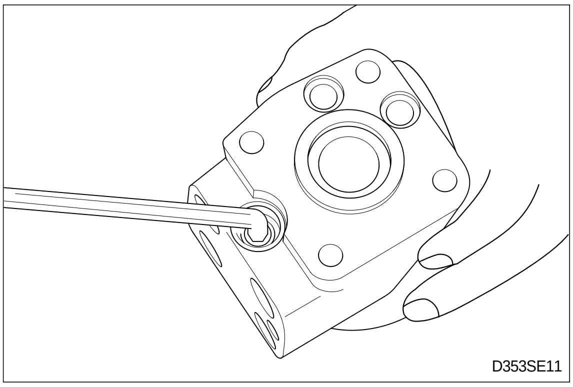


Disassembling the pressure relief valve

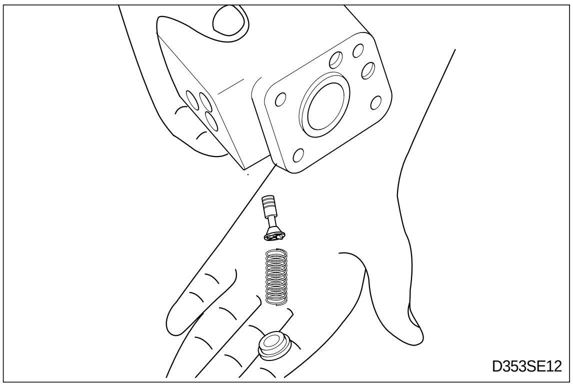
(15) Screw out the plug using an 8㎜ hexagon socket spanner.
Remove seal washers.



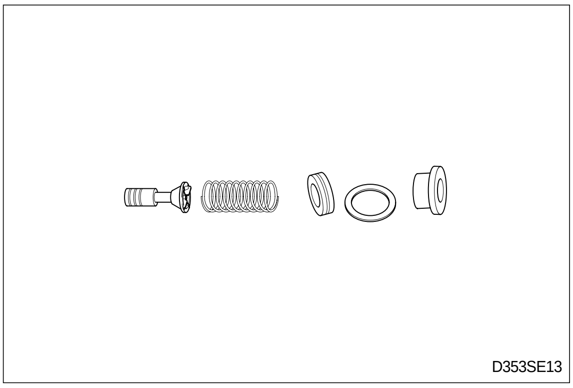
(16) Unscrew the setting screw using an 8㎜ hexagon socket spanner.



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



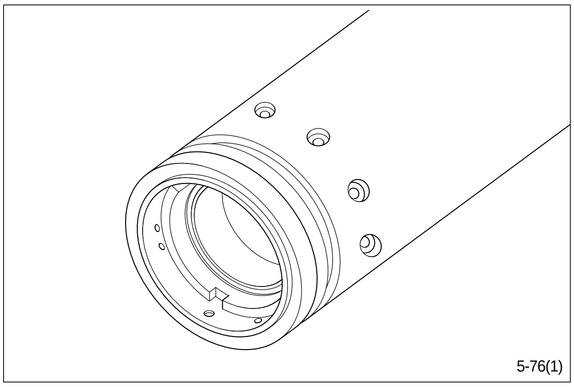
(18) The pressure relief valve is now disassembled.



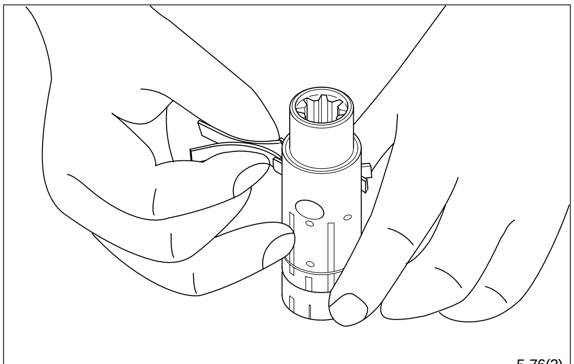
5) ASSEMBLY

(1) Assemble spool and sleeve.

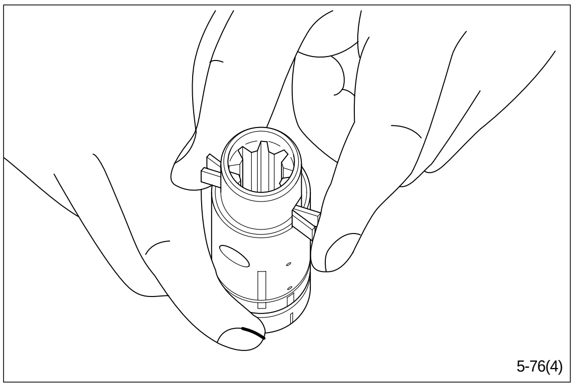
※ When assembling spool and sleeve only one of two possible ways of positioning the spring slots is correct. There are three slots in the spool and three holes in the sleeve in the end of the spool / sleeve opposite to the end with spring slots. Place the slots and holes opposite each other so that parts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


5-76(1)

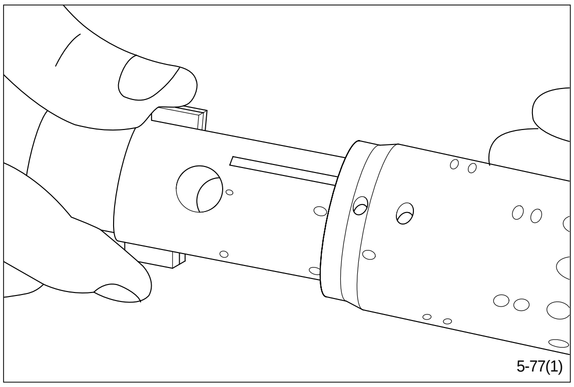
(2) Place the two flat neutral position springs in the slot.
Place the curved springs between the flat ones and press them into place (see assembly pattern).


5-76(2)

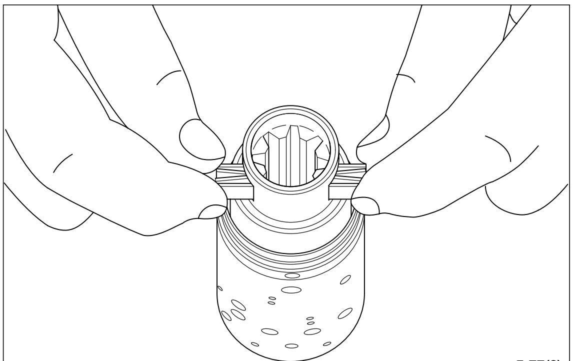
(3) Line up the spring set.


5-76(4)

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

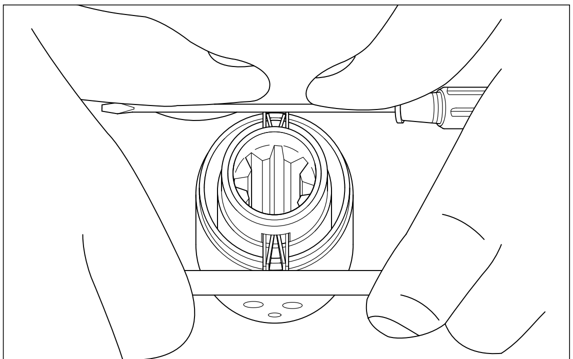

5-77(1)

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



5-77(2)

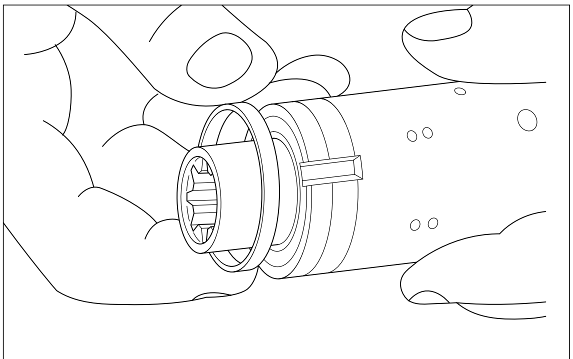
(6) Line up the springs and center them.



5-77(3)

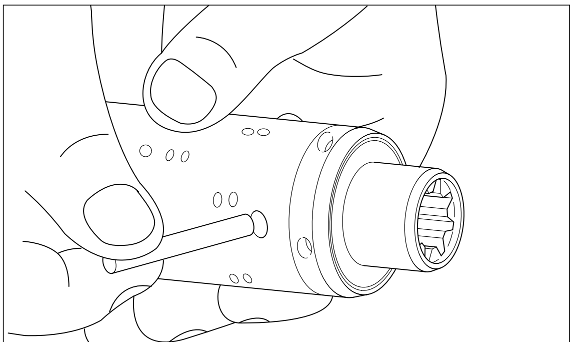
(7) Guide the ring down over the sleeve.

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



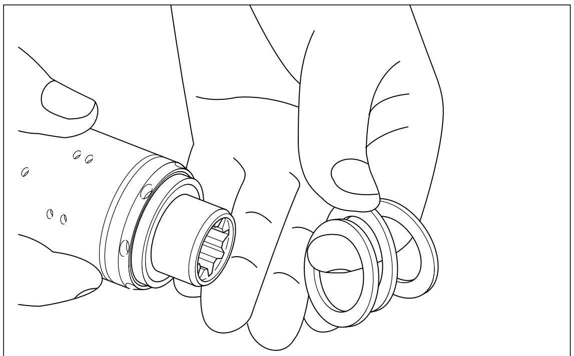
5-77(4)

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



5-78(1)

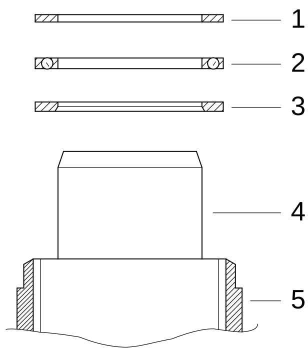
(9) Fit bearing races and needle bearing as shown on below drawing.



5-78(2)

※ **Assembly pattern for standard bearings**

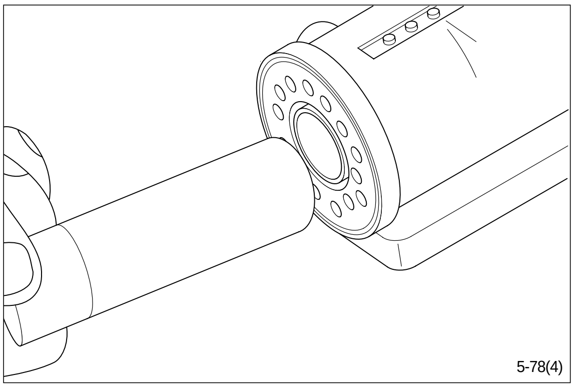
1 Outer bearing race
2 Thrust bearing
3 Inner bearing race
4 Spool
5 Sleeve



5-78(3)

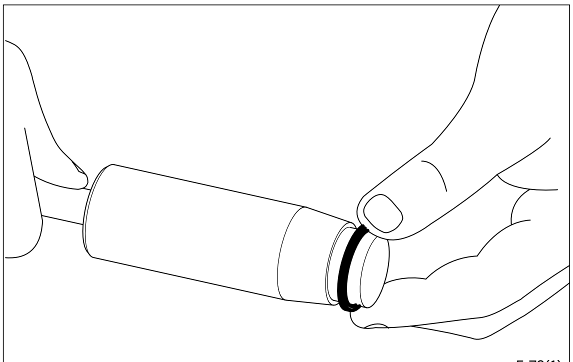
Installation instruction for O-ring

(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.

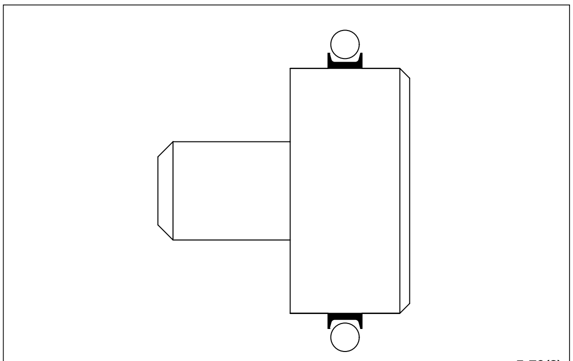


5-78(4)

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

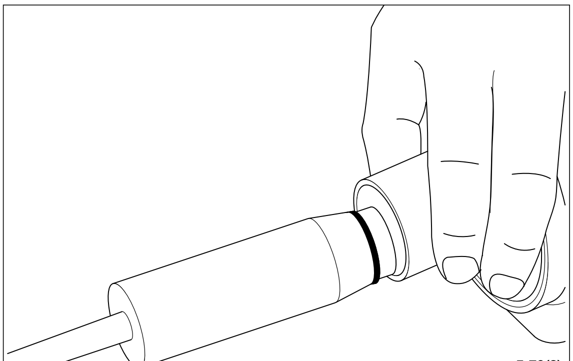


5-79(1)



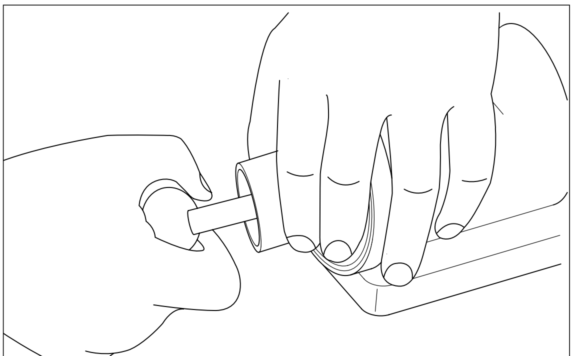
5-79(2)

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



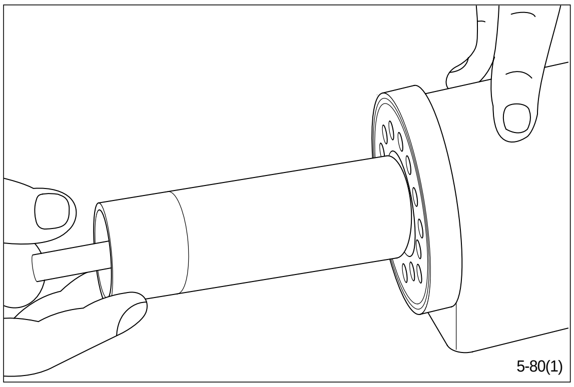
5-79(3)

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



5-79(4)

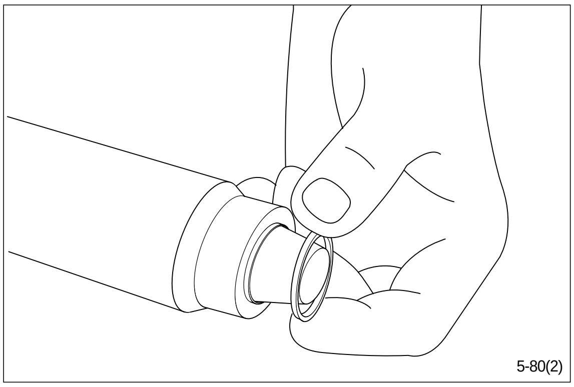
(14) Draw the inner and outer parts of the assembly tool out of the steering unit bore, leaving the guide from the inner part in the bore.



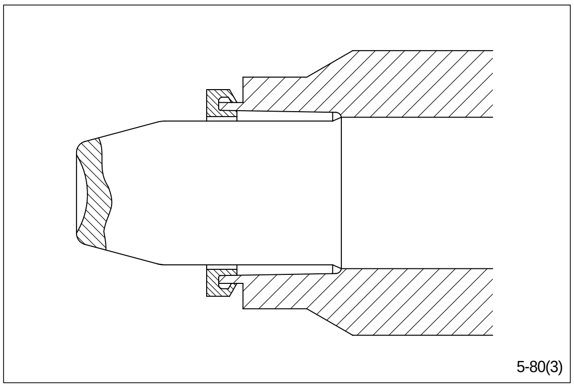
5-80(1)

Installation instructions for lip seal

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

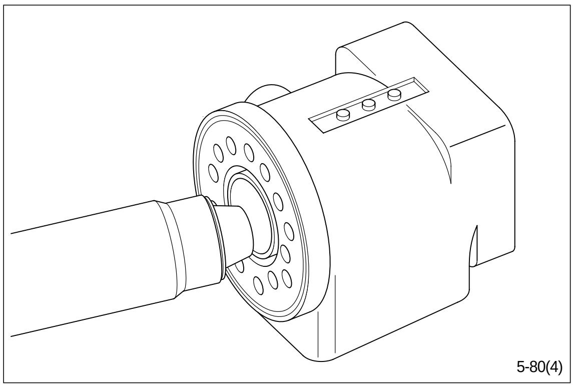


5-80(2)



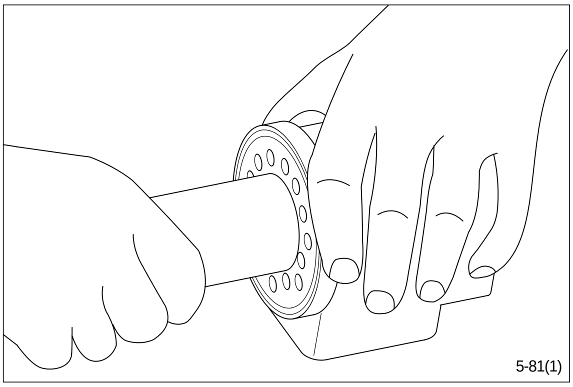
5-80(3)

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



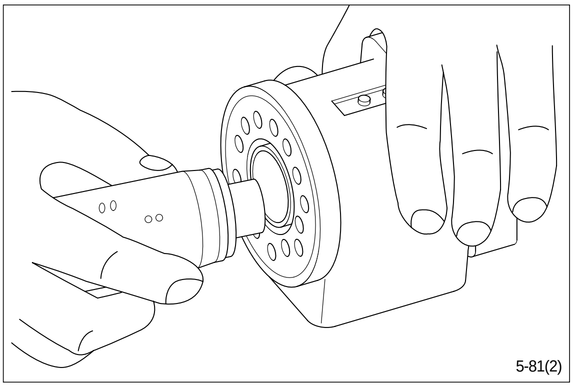
5-80(4)

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

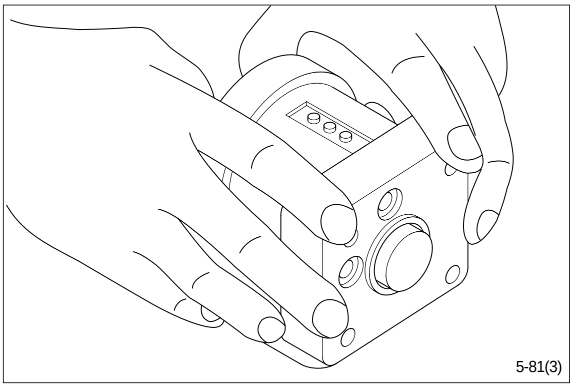


(18) With a light turning movement, guide the spool and sleeve into the bore.

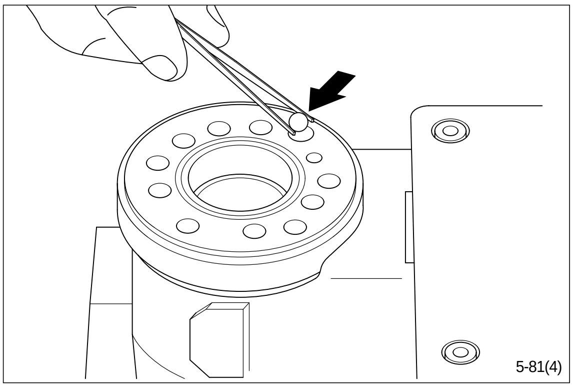
※ Fit the spool set holding the cross pin horizontal.



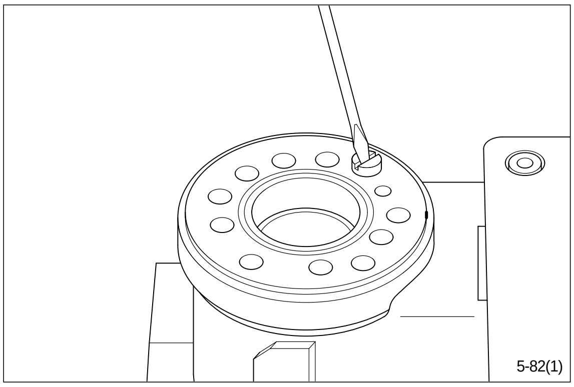
(19) The spool set will push out the assembly tool guide. The O-ring are now in position.



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

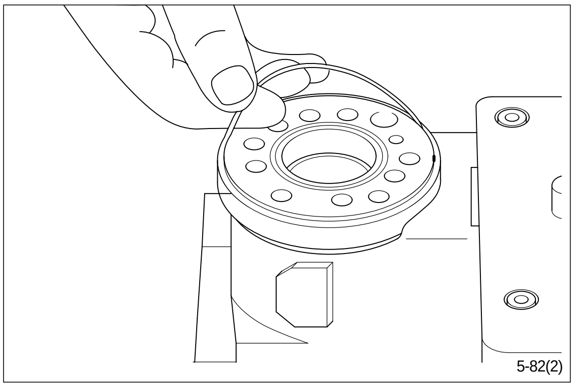


(21) Screw the threaded bush lightly into the check valve bore. The top of the bush must lie just below the surface of the housing.



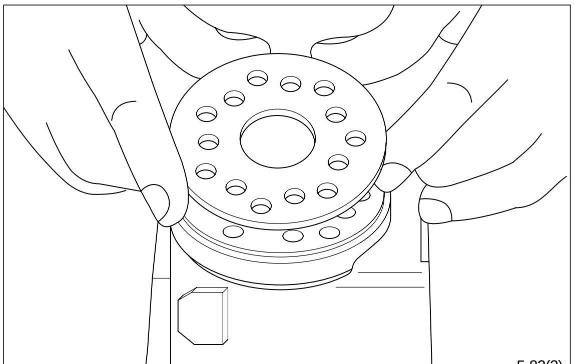
5-82(1)

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



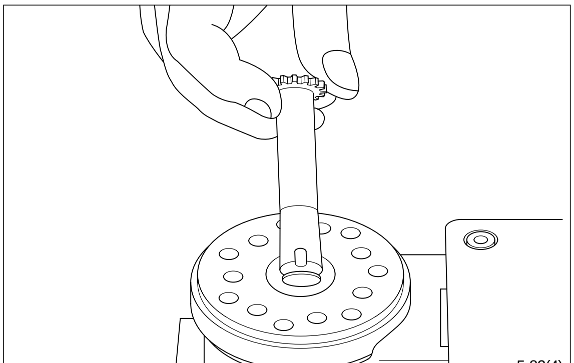
5-82(2)

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



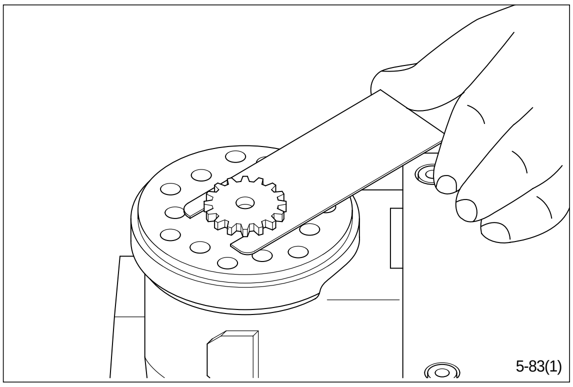
5-82(3)

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



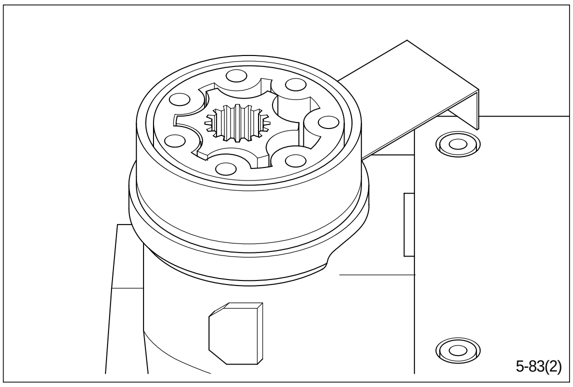
5-82(4)

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



5-83(1)

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

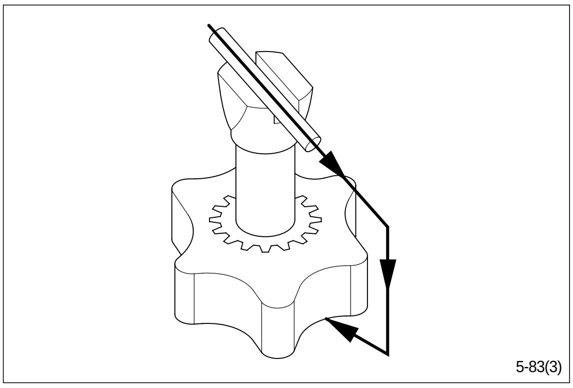


5-83(2)

(27) **Important**

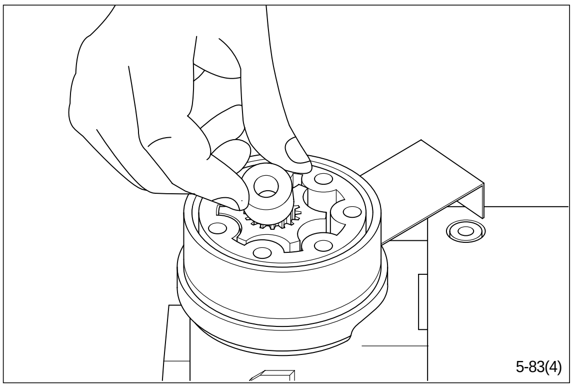
Fit the gearwheel(Rotor) and cardan shaft so that a tooth base in the rotor is positioned in relation to the shaft slot as shown.

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



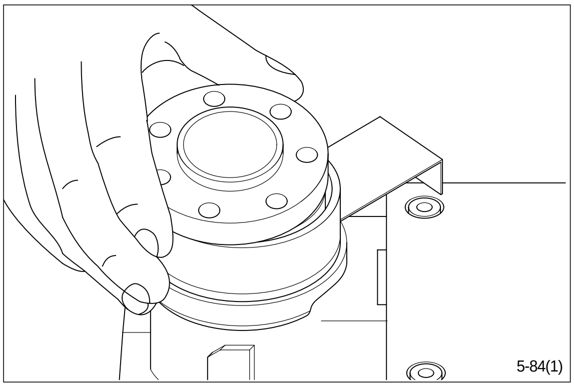
5-83(3)

(28) Fit the spacer, if any.

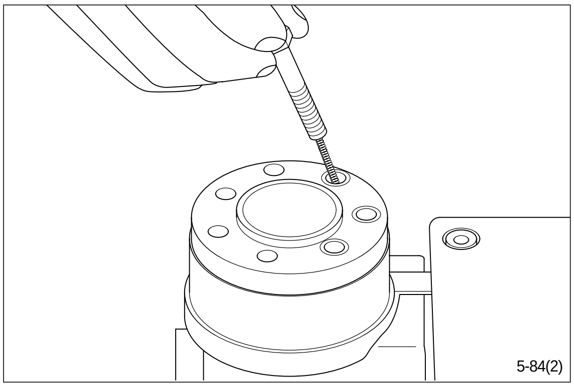


5-83(4)

(29) Place the end cover in position.

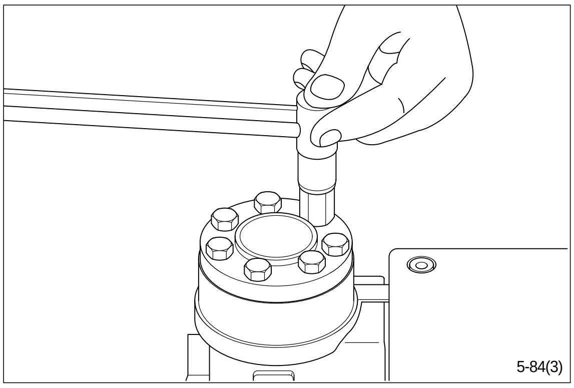


(30) Fit the special screw with washer and place it in the hole shown.

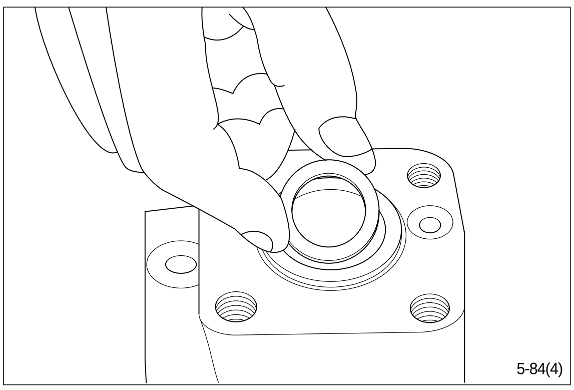


(31) Fit the six screws with washers and insert them. Cross-tighten all the screws and the rolled pin.

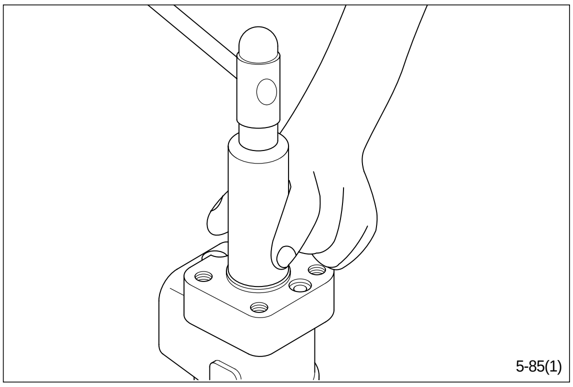
· Tightening torque : 4.0 ± 0.5kgf · m
(28.9 ± 3.6lbf · ft)



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

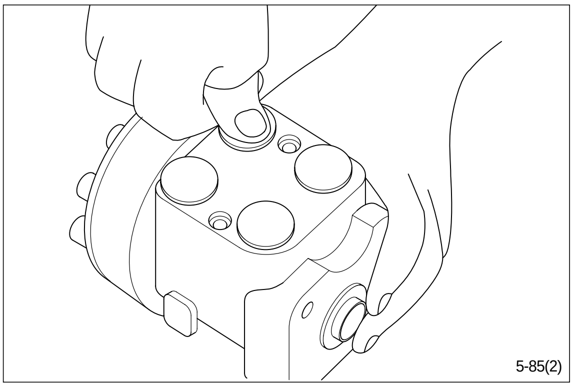


(33) Fit the dust seal ring in the housing.


5-85(1)

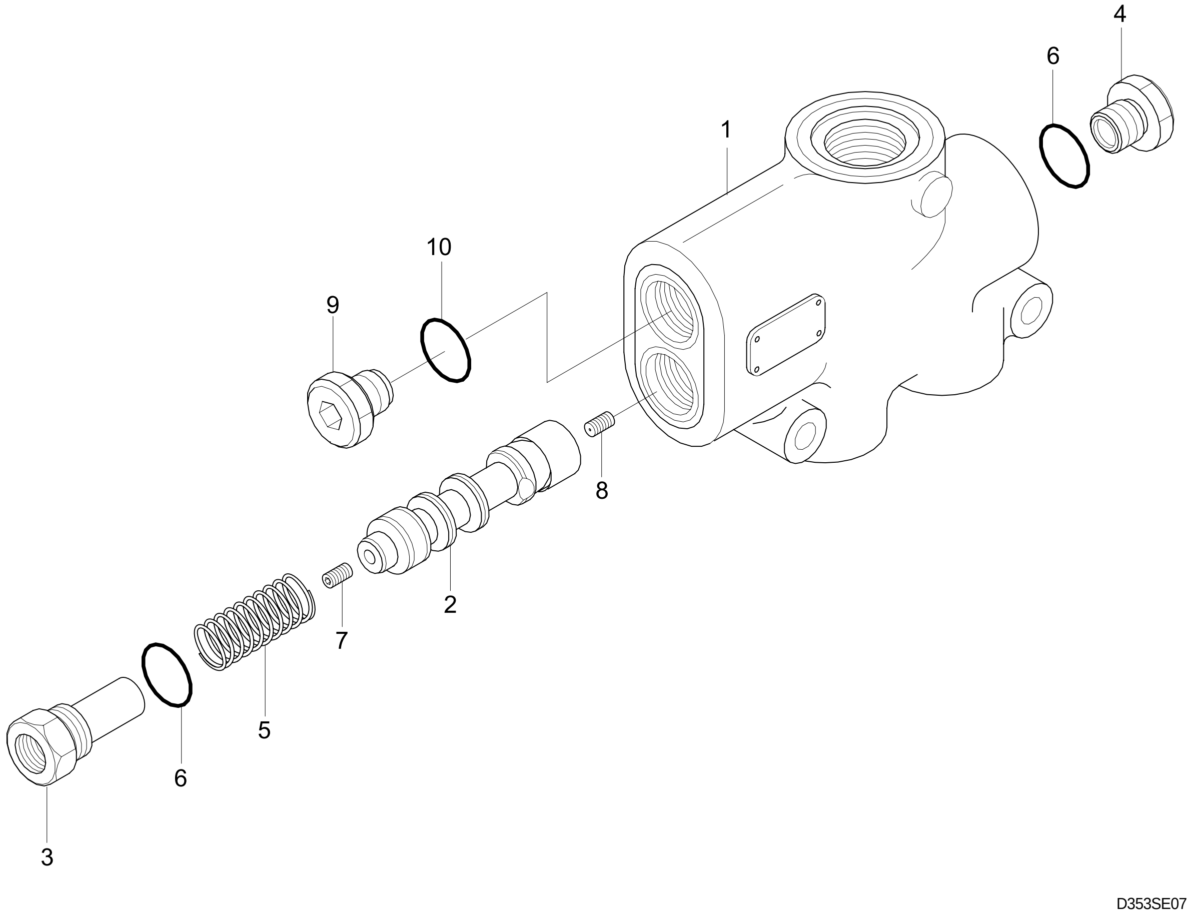
(34) Press the plastic plugs into the connection ports.

※ Do not use a hammer!


5-85(2)

2. PRIORITY VALVE

1) STRUCTURE



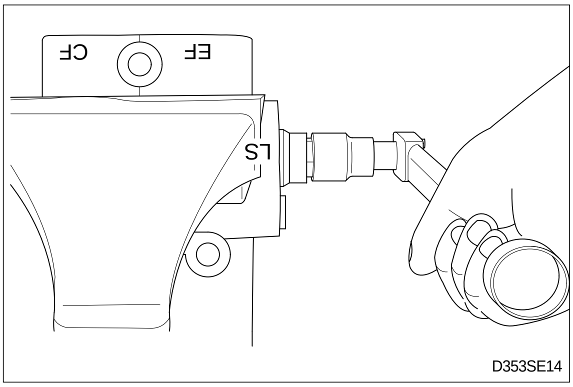
1	Body	5	Spring	9	End plug
2	Spool	6	O-ring	10	O-ring
3	Spring plug	7	Orifice		
4	End plug	8	Orifice		

2) DISASSEMBLY

※ Cleanliness is the primary means of assuring satisfactory the priority valve life. Select clean place.
Before removing the piping, clean the surrounding area of valve ports.

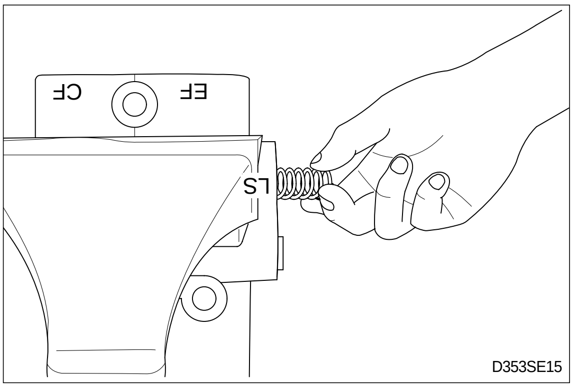
(1) Fix the body(1) in a vise with copper or lead sheets.
Do not over tighten jaws.

(2) Loosen plug(3) for LS port.



D353SE14

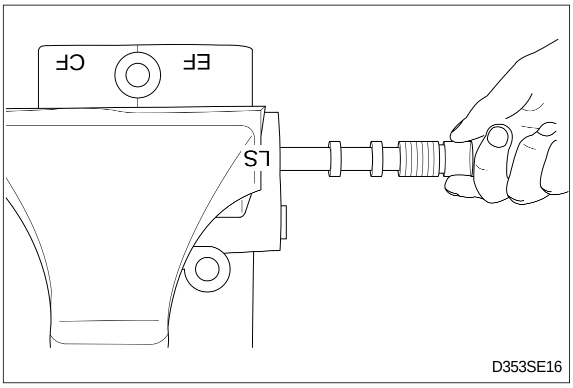
(3) Remove spring(5).



D353SE15

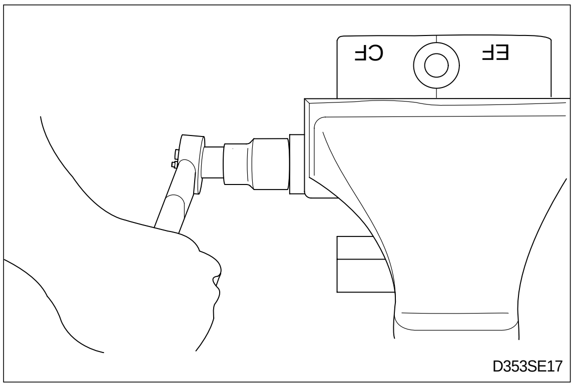
(4) Remove spool assy(2).

※ Can't remove the orifice(7) and orifice(8) from spool(2), because the orifices were locked at the spool.



D353SE16

(5) Remove plug(4) and separate O-ring(6) and plug(3, 4) individually.



3) ASSEMBLY

※ Clean all metal parts in clean solvent and blow dry with air and correct any damage, burrs and rust.

※ Do not wipe dry with cloth or paper towel.

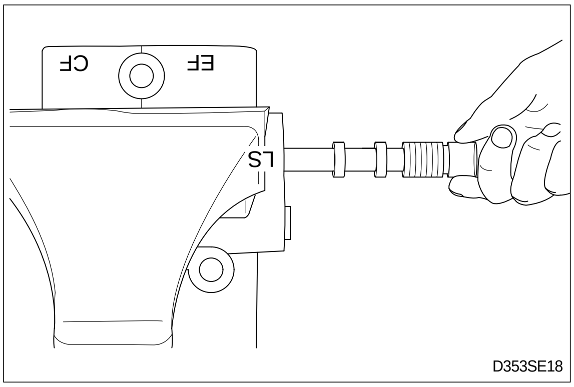
※ Replace seals such as O-ring with new ones as a rule and coat with grease.

(1) Fix the body(1) in a vise.

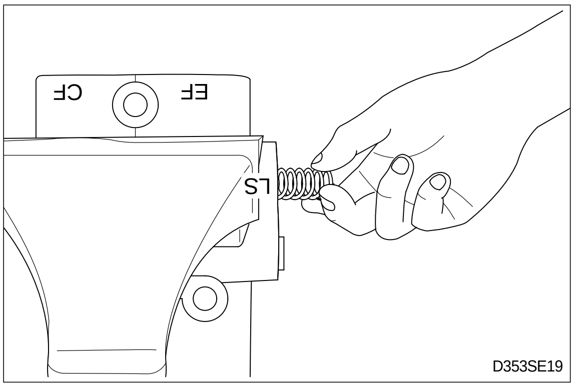
(2) Insert the spool(2).

※ Secure the spool(2) remain in their correct direction.

※ Secure the spool(2) to move smoothly by finger.

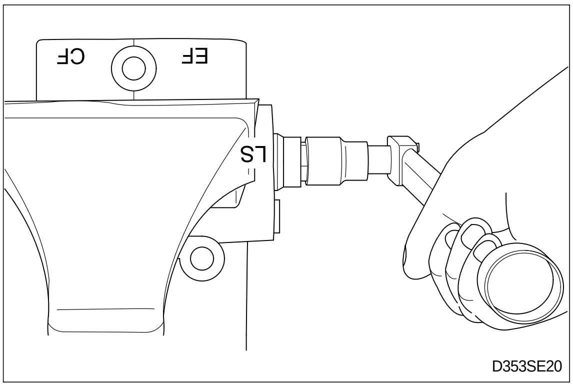


(3) Insert the spring(5) into the body(1).



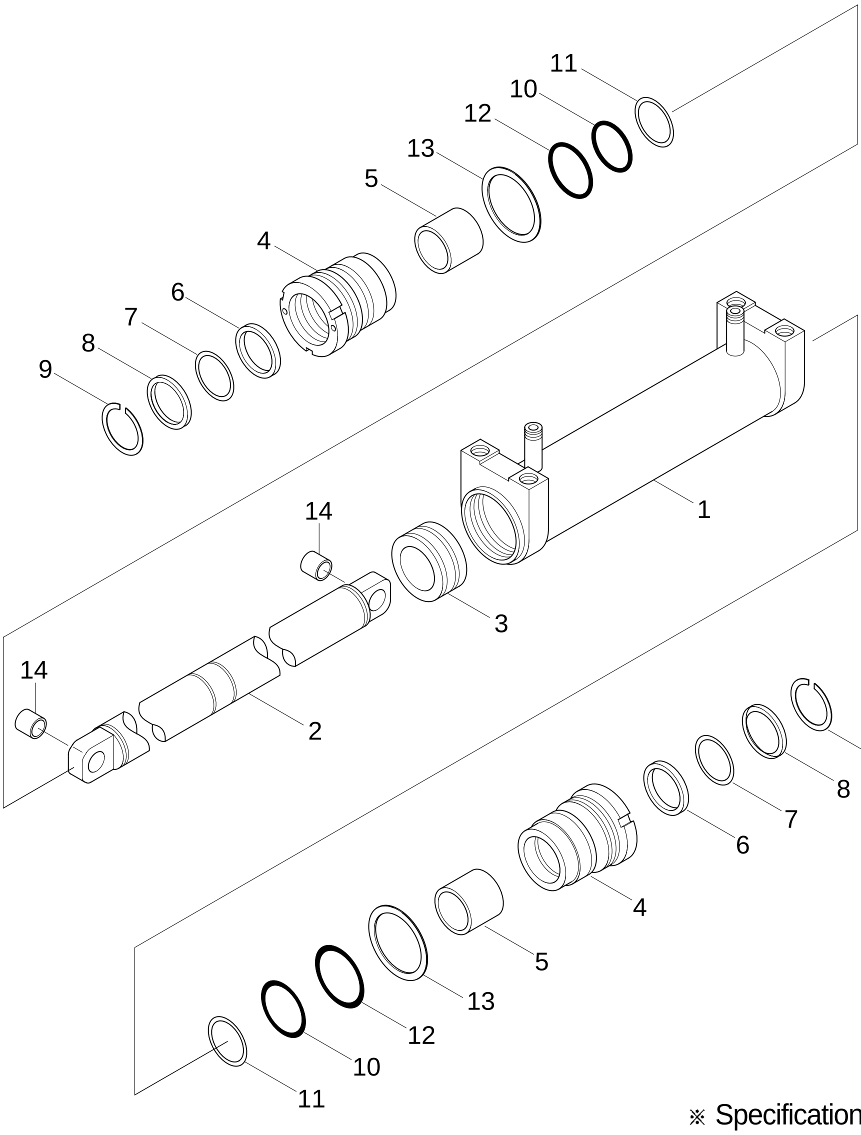
(4) Install the O-ring(6) onto plug(3, 4) and install the plug(3, 4) into the body(1).

· Tighten torque : 4.5kgf · m(32.5lbf · ft)



3. STEERING CYLINDER

1) STRUCTURE



※ Specifications
- Cylinder bore : 80mm
- Outer diameter : 94mm
- Stroke(half) : 150mm
- Rod diameter : 55mm

D507SE21

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

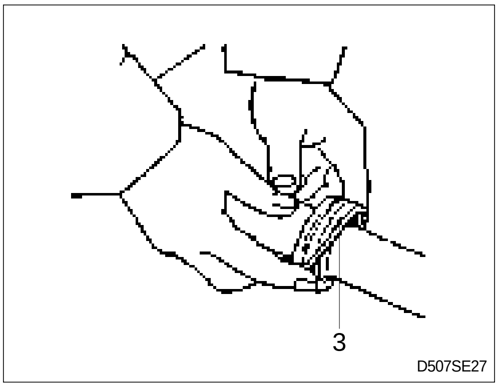
mm(in)

Check item	Criteria		Remaks
	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

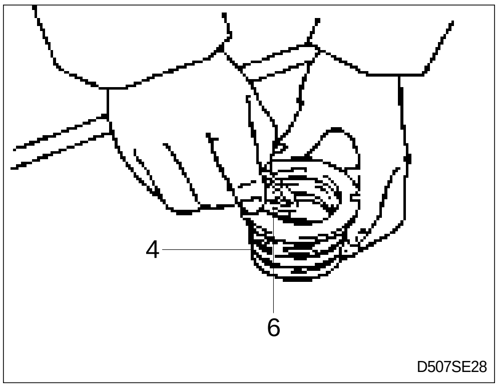
4) ASSEMBLY

(1) Install a new piston seal(3) around the groove on the piston.

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

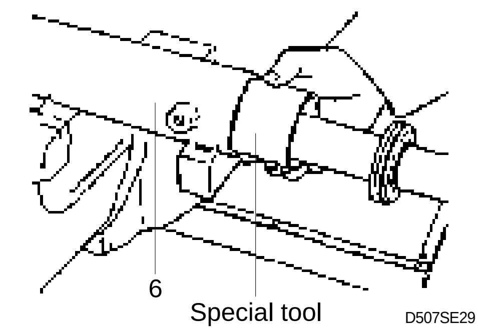


(2) Install the rod seal(6) to the position in the gland(4) applying a slight coat with grease prior to install.



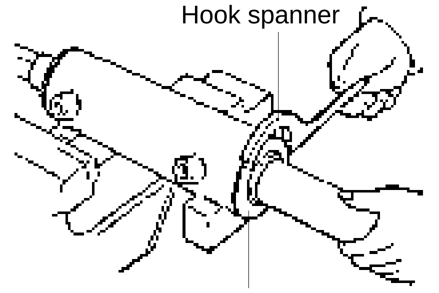
(3) Install the dust wiper(8) to the gland(4) using a special installing tool. Coat the dust wiper with grease slightly before installing.

(4) Using a special tool, install gland assembly into the cylinder tube(1).



D507SE29

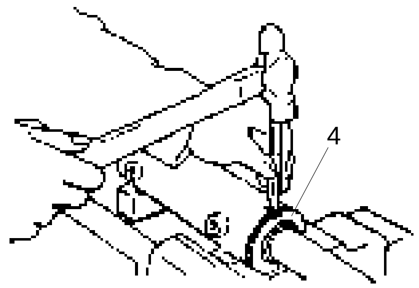
(5) Using a hook spanner, install the gland(4) assembly, and tighten it with torque 60±6kgf · m (434±43lbf · ft).



D507SE30

(6) After the gland(4) assembly was installed to the cylinder tube(1), calk at the tube end into the groove on the gland to prevent screw loos-ening.

※ If it is needed to calk again, never calk on the same place.



D507SE31

(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.

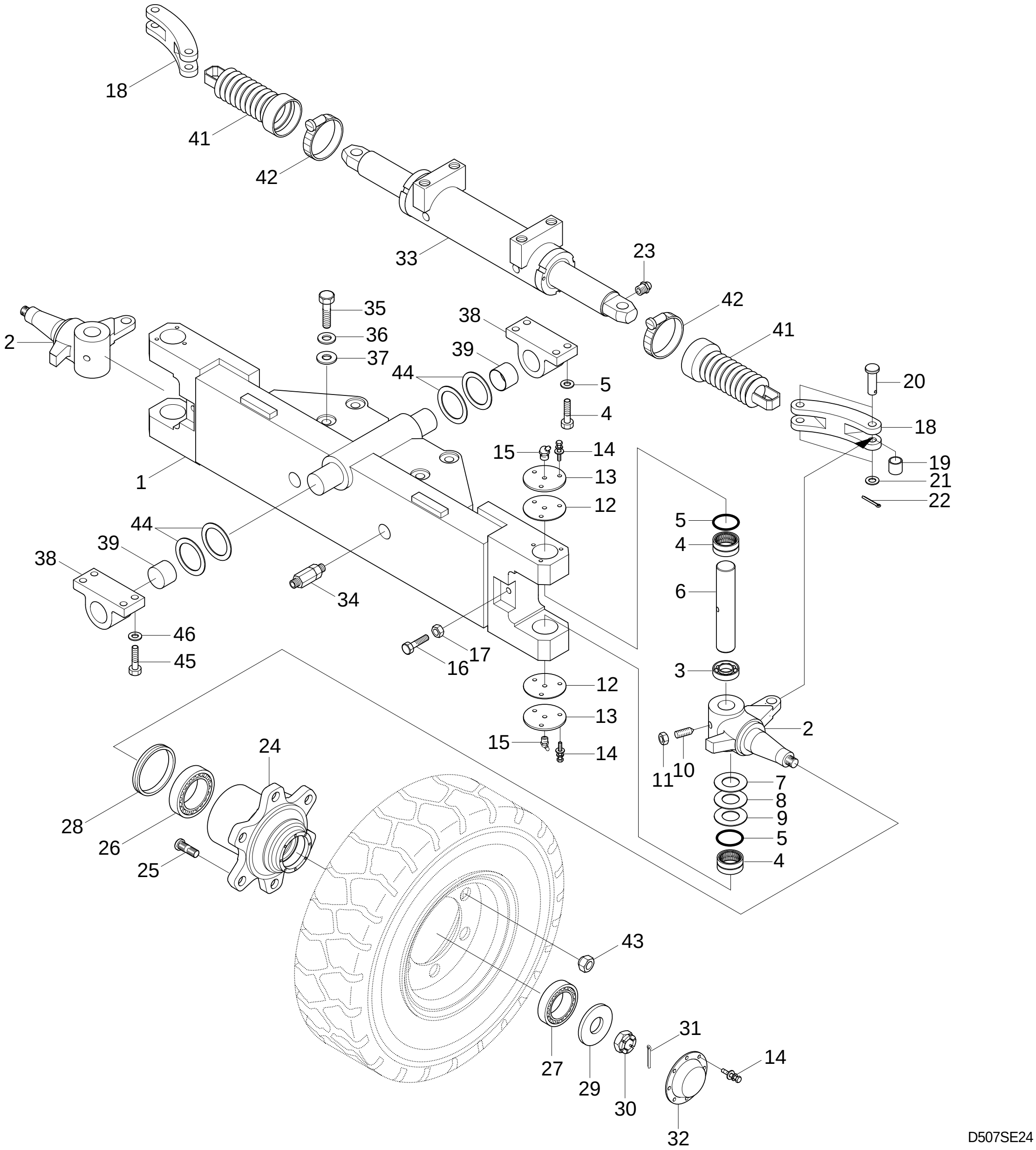
※ Then, repeat the above operation at gradually increasing engine rpm. This releases air from the system and completes preparation for operation.

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

4. TRAIL AXLE

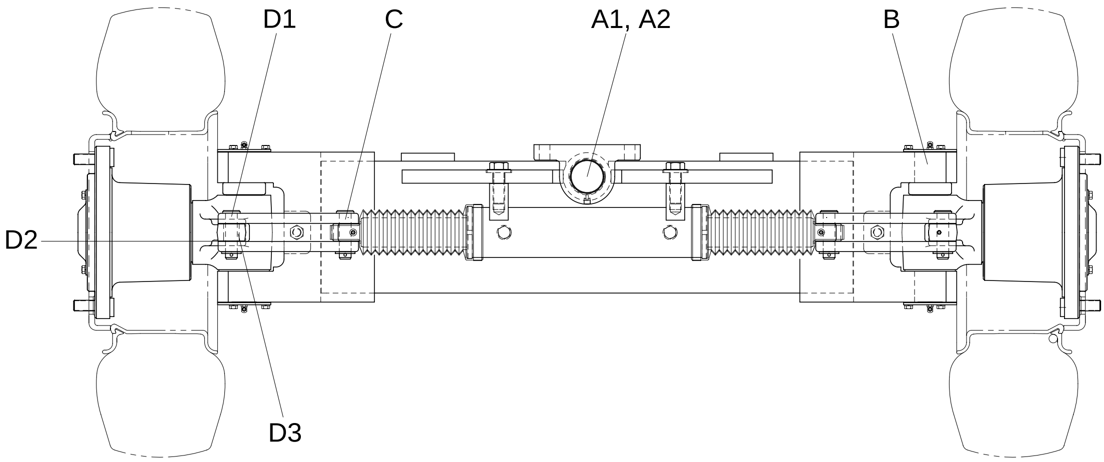
1) STRUCTURE

※ Do not remove the stopper bolt unless necessary.



1	Steer axle wa	12	Gasket	23	Grease nipple	34	Adaptor
2	Knuckle	13	Cover	24	Hub	35	Cover
3	Thrust bearing	14	With washer bolt	25	Hub bolt	36	Hexagon bolt
4	Needle bearing	15	Grease nipple	26	Taper roller bearing	37	Shim
5	Oil seal	16	Hexagon bolt	27	Taper roller bearing	38	Support
6	King pin	17	Hexagon nut	28	Oil seal	39	Bushing
7	Thrust washer	18	Link	29	Special washer	41	Steer cylinder boot
8	Shim washer	19	Inner race bushing	30	Lock nut	42	Clamp
9	Shim washer	20	Link pin	31	Split pin	43	Hub nut
10	Set screw	21	Special washer	32	Hub cap	44	Shim
11	Hexagon nut	22	Split pin	33	Steer cylinder assy	45	Hexagon bolt
						46	Hardened washer

2) CHECK AND INSPECTION



D507SE25

unit : mm(in)

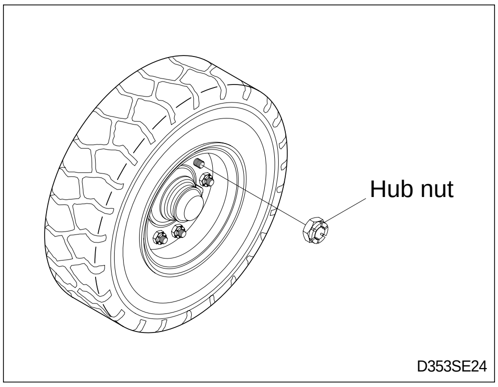
No.	Check item			Criteria		Remarks
				Standard size	Repair limit	
A	Shaft	A1	OD of shaft	60(2.4)	59.5(2.3)	Replace
		A2	ID of bushing	60(2.4)	59.5(2.3)	
B	OD of king pin			50(2.0)	49.8(2.0)	
C	OD of steering cylinder pin			22(0.9)	21.9(0.9)	
D	Knuckle	D1	OD of pin	22(0.9)	21.9(0.9)	
		D2	Vertical play	-	0.2(0.008)	Adjust shim
		D3	ID of bushing	22(0.9)	22.5(0.9)	Replace

· 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 balance 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, washer.

(4) Using the puller, take off the hub together with the roller bearing.

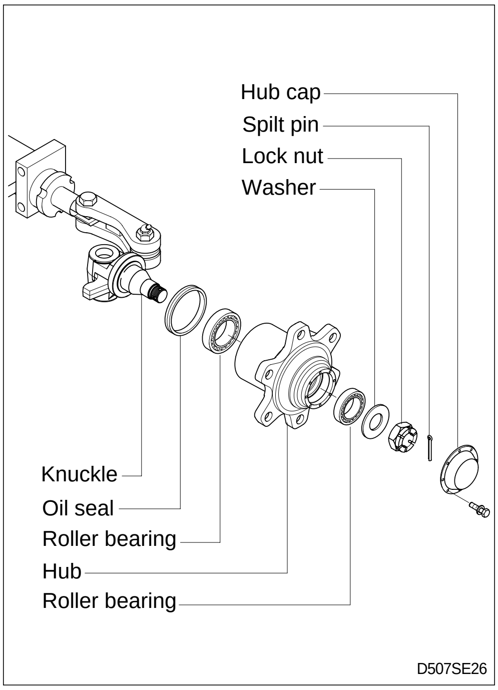
※ Be very careful because just before the hub comes off, tapered roller bearing will fall out.

(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 set screw(10) and nut(11).

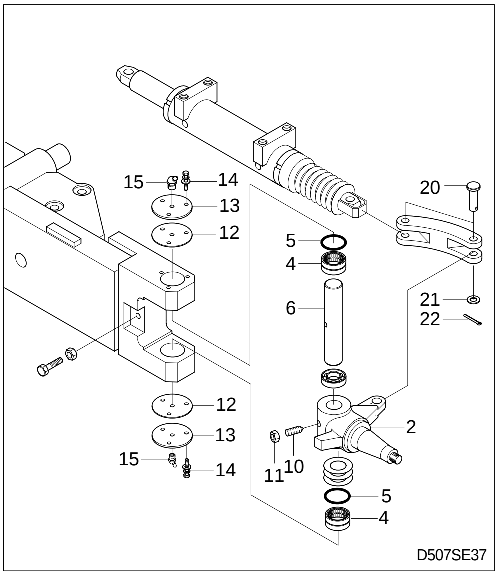
(9) Loosen with washer bolt(14) and remove cover (13), gasket(12). Remove grease nipple(15).

(10) Push out the king pin(6) without damaging the knuckle arm(2).

(11) At the same time the king pin is removed, pull out the oil seal(5).

(12) If defect is observed in needle bearing(4), pull it out by using extractor.

(13) Remove spilt pin(22), special washer(21) and link pin(20).



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 set screw(10) of king pin(6).

(2) There is a notch in the middle of the king pin(6), make sure that this notch is on the set screw side.

(3) Do not hammer to drive in needle bearing(4) because it will break.
Always use drive-in tool. In assembling the thrust bearing(3), be sure that the fixed ring of the bearing is placed in position facing the knuckle(2).

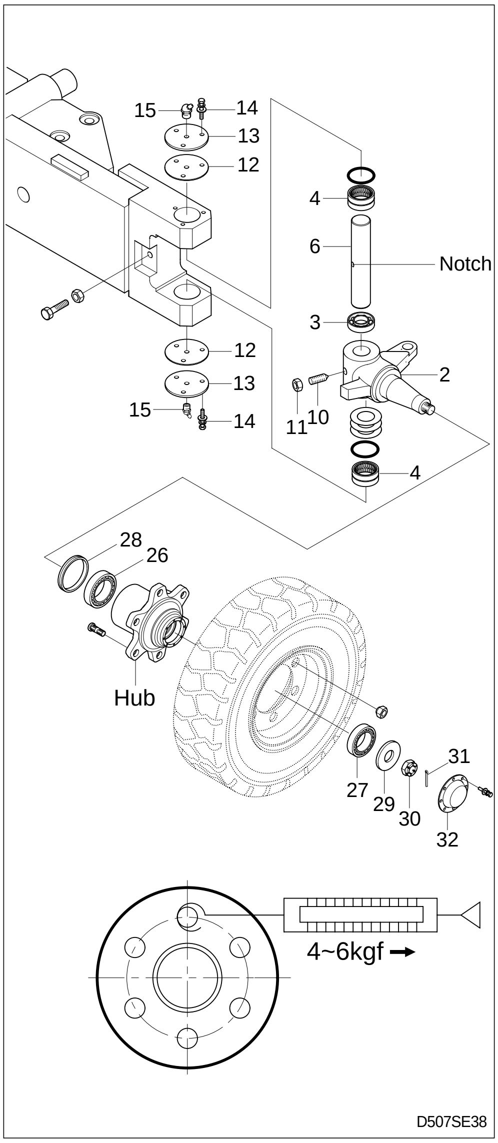
(4) Hub

① Mount oil seal(28) and inner race of tapered roller bearing(26) on the knuckle. The bearing should be well greased before assembling.

② Install the outer race of the bearing(27) in the wheel center and assemble to the knuckle.

③ Put washer(29) in place, tighten with nut(31) and locked with split pin(30). 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.

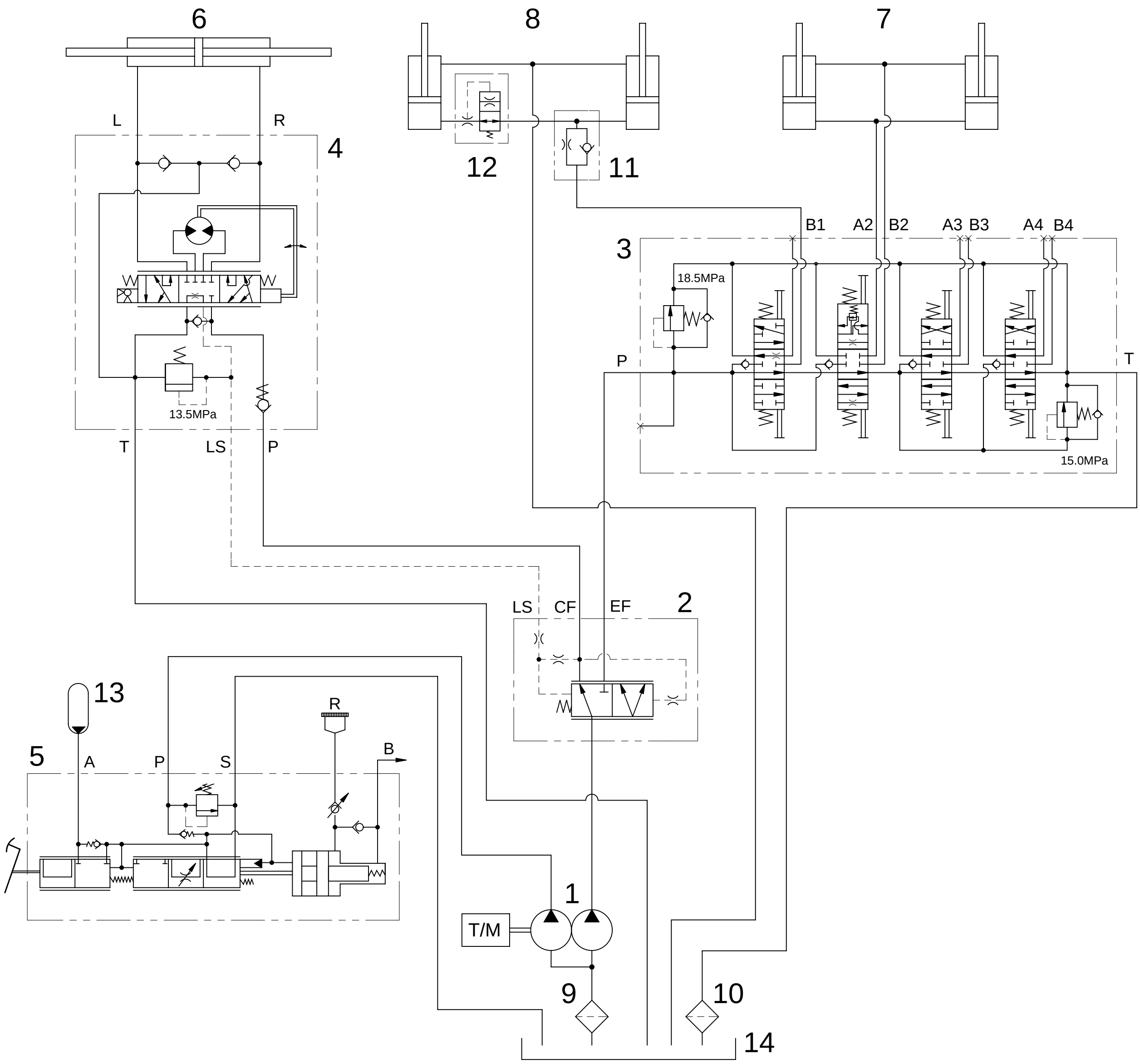
④ Mount the hub cap(32).
Bearing should be well greased before assembling.



SECTION 6 HYDRAULIC SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

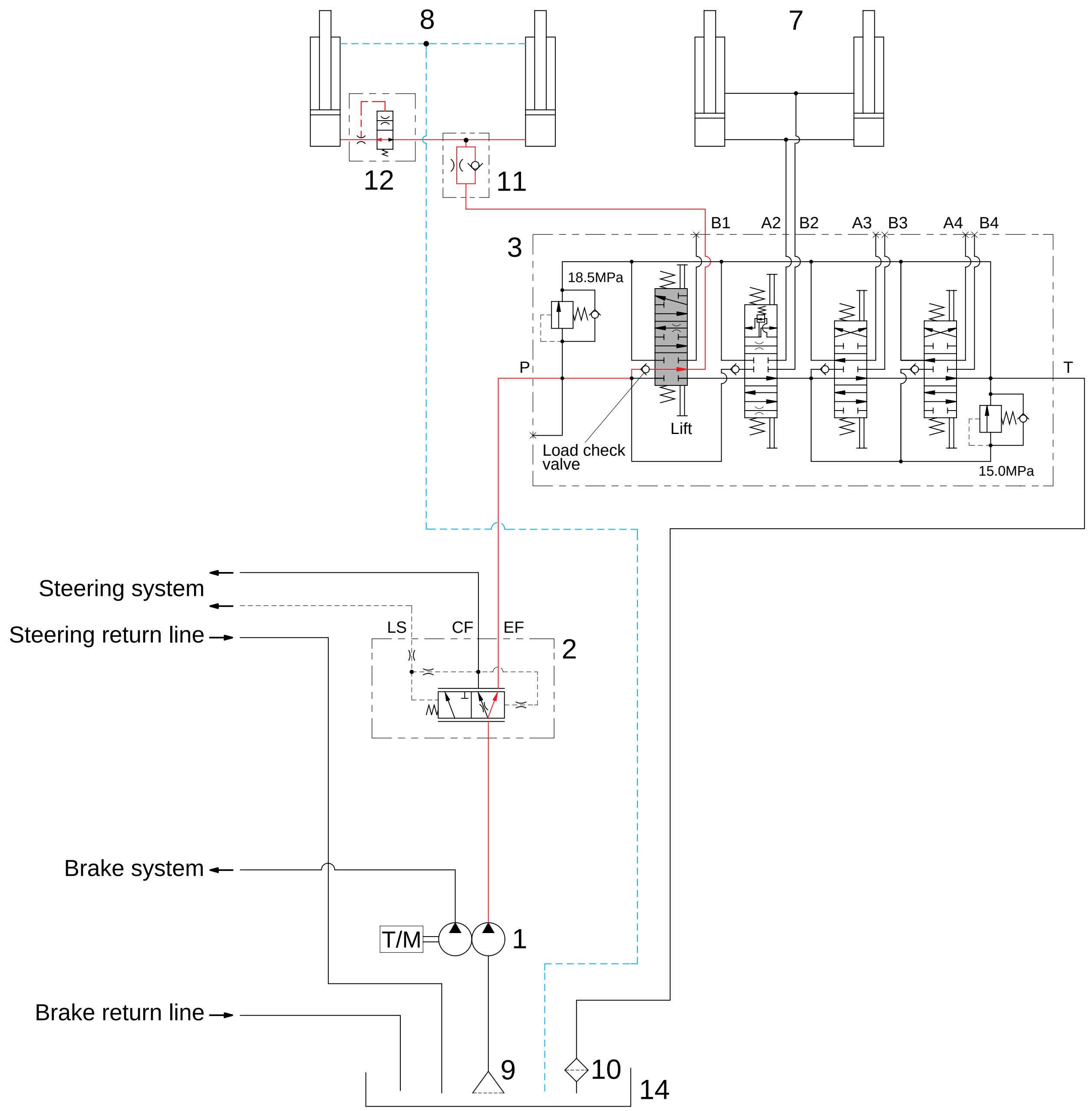
1. HYDRAULIC CIRCUIT



D507HS01

1	Hydraulic gear pump	8	Lift cylinder
2	Priority valve	9	Suction filter
3	Main control valve	10	Return filter
4	Steering unit	11	Down control valve
5	Brake valve	12	Down safety valve
6	Steering cylinder	13	Accumulator
7	Tilt cylinder	14	Hydraulic tank

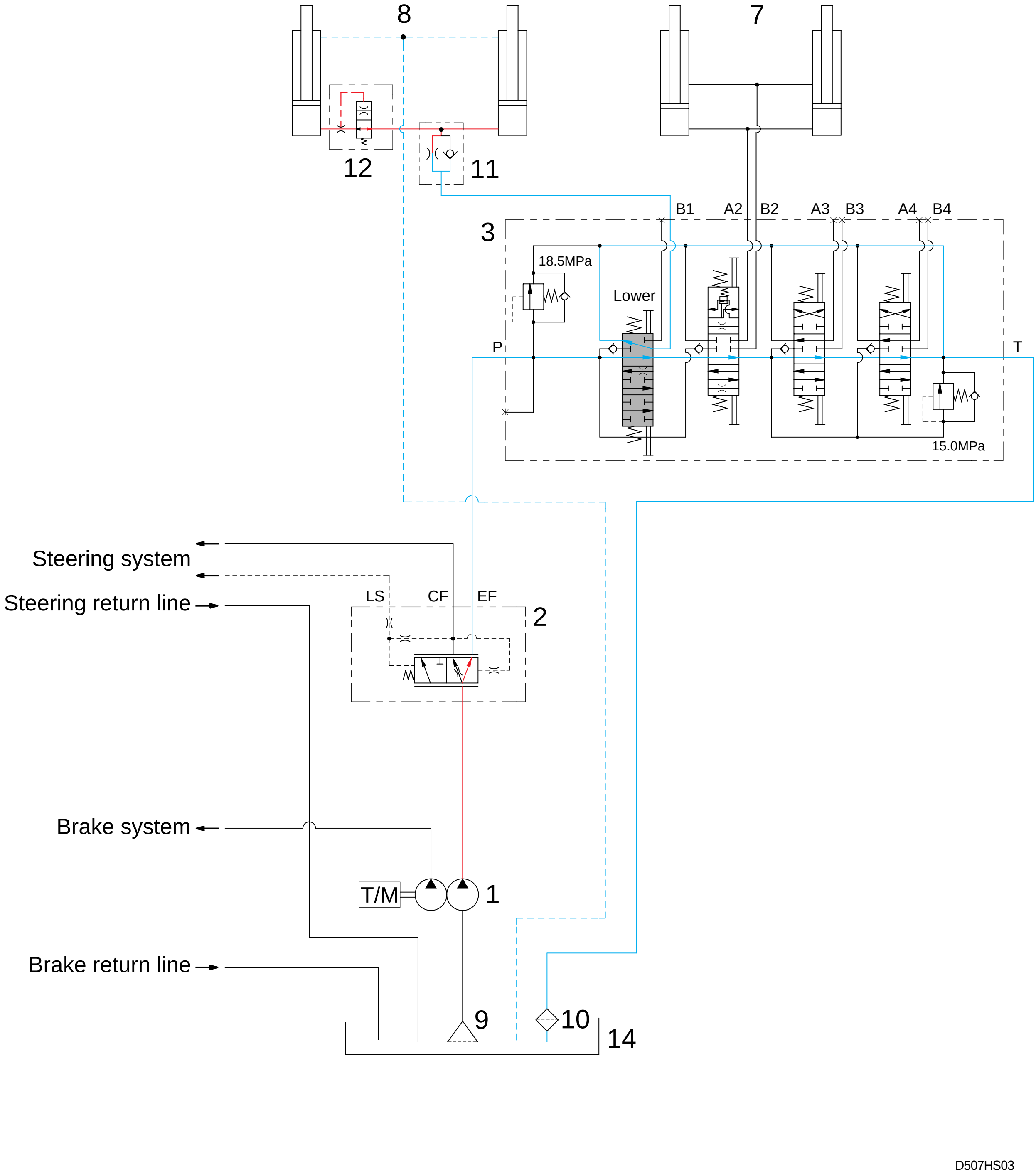
1) WHEN THE LIFT CONTROL LEVER IS IN THE LIFT POSITION



D507HS02

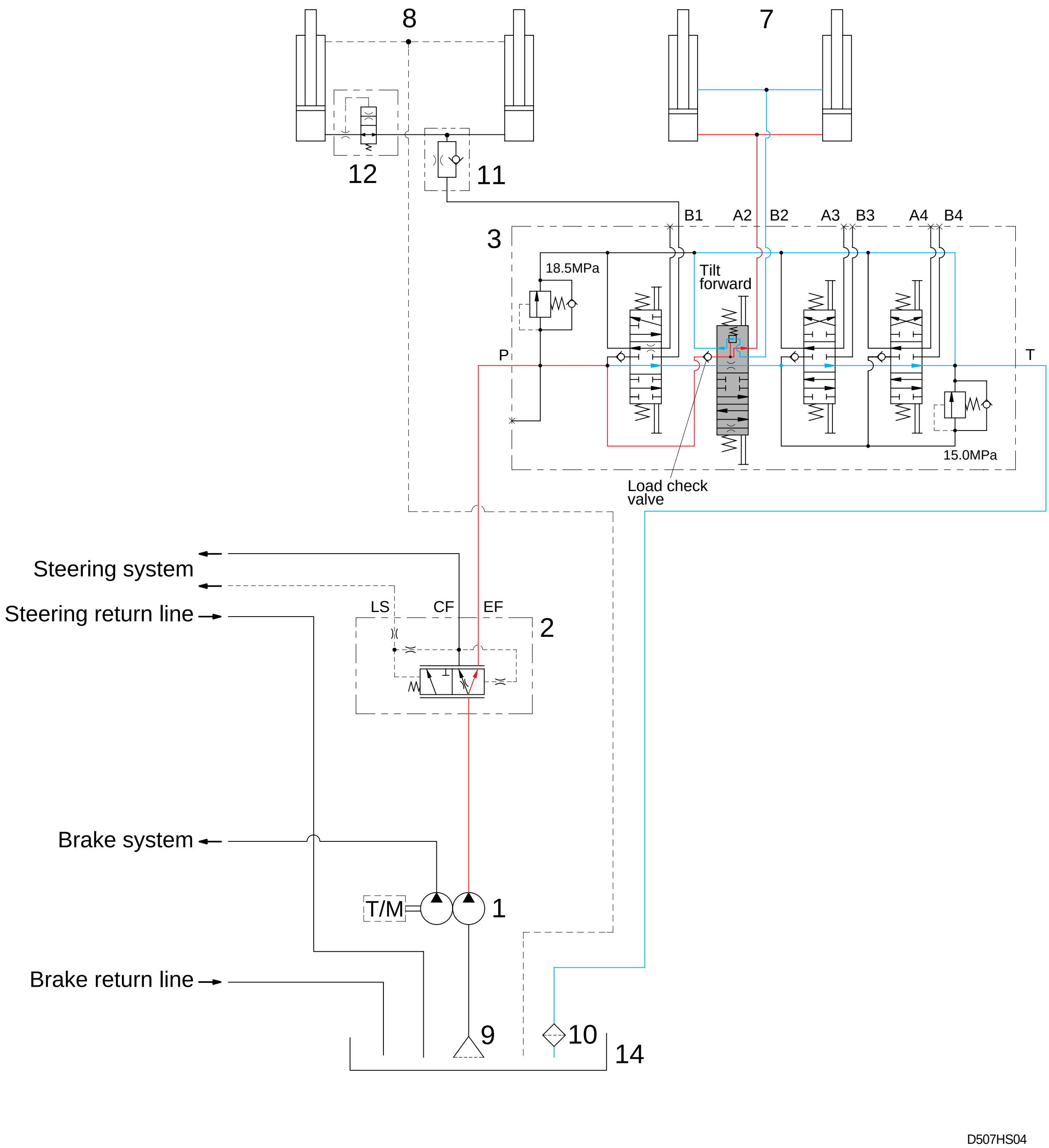
When the lift control lever is pulled back, the spool on the first block is moves to lift position.
The oil from hydraulic gear pump(1) flows into main control valve(3) and then goes to the large chamber of lift cylinder(8) by pushing the load check valve of the spool.
The oil from the small chamber of lift cylinder(8) returns to hydraulic oil tank(14) at the same time.
When this happens, the forks go up.

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



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



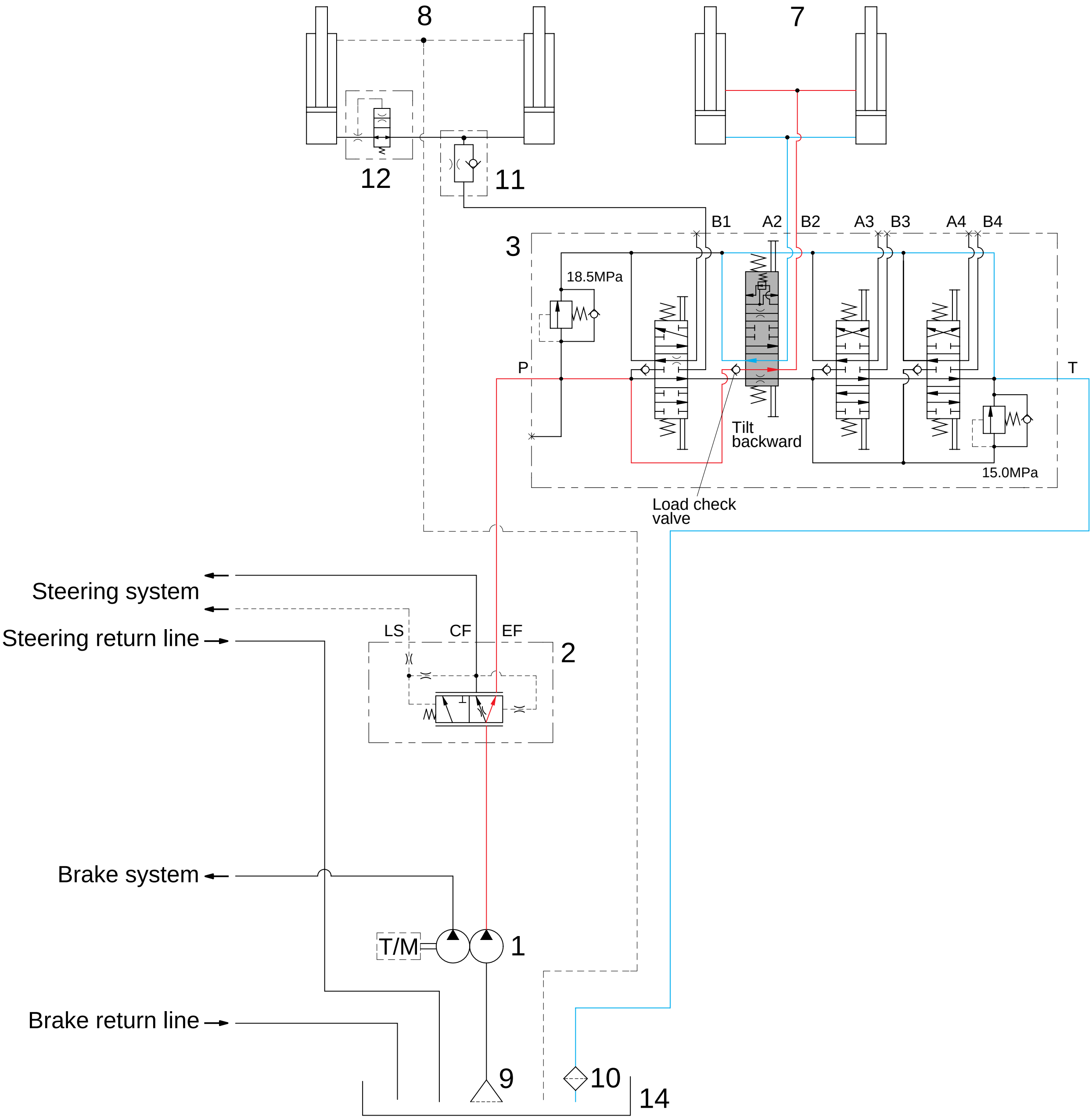
When the tilt control lever is pushed forward, the spool on the second block is moved to tilt forward position.

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

The oil at the small chamber of tilt cylinder(7) returns to hydraulic tank(14) at the same time.

When this happens, the mast tilt forward.

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



D507HS05

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

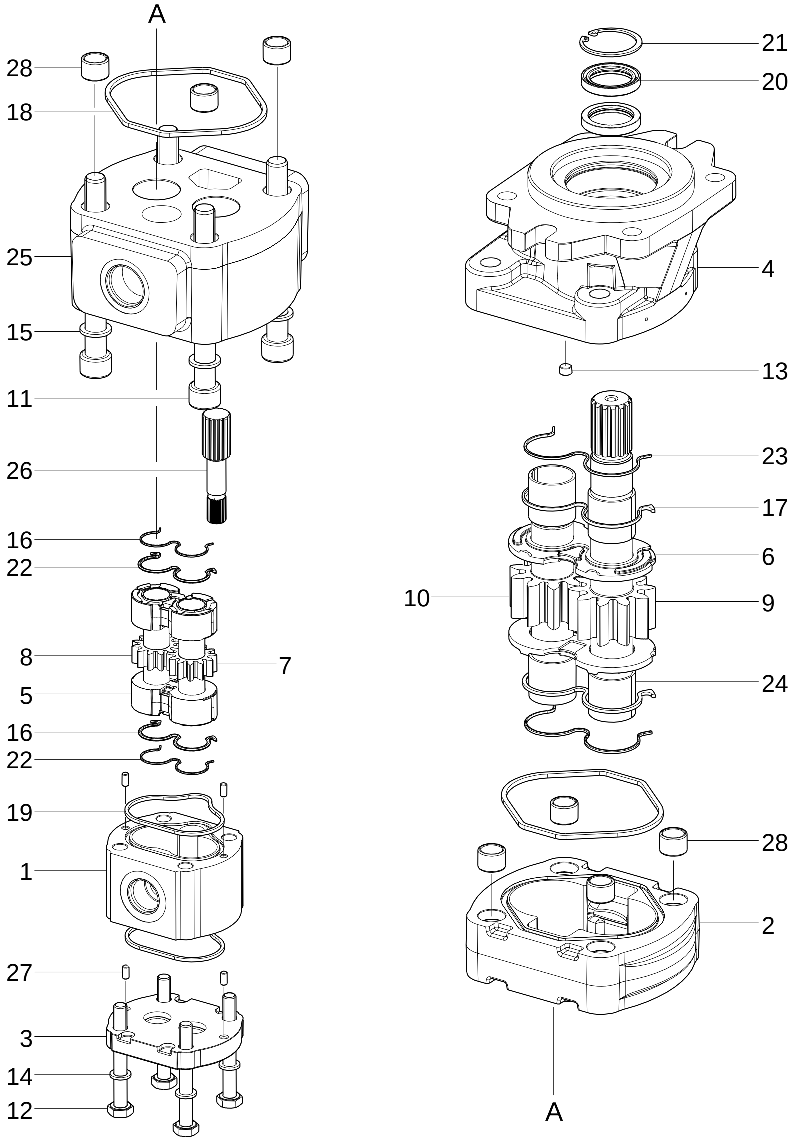
The oil from hydraulic gear pump(1) flows into main control valve(3) and then goes to the small chamber of tilt cylinder(7) by pushing the load check valve of spool.

The oil at the large chamber of tilt cylinder(7) returns to hydraulic tank(14) at the same time.

When this happens, the mast tilt backward.

2. HYDRAULIC GEAR PUMP

1) STRUCTURE

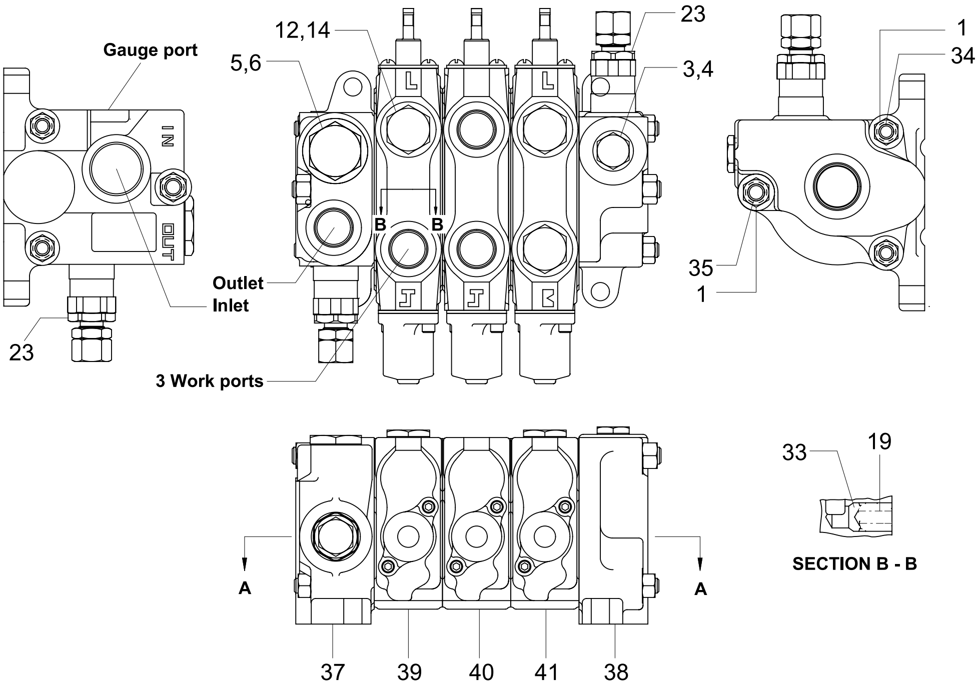


D507HS06

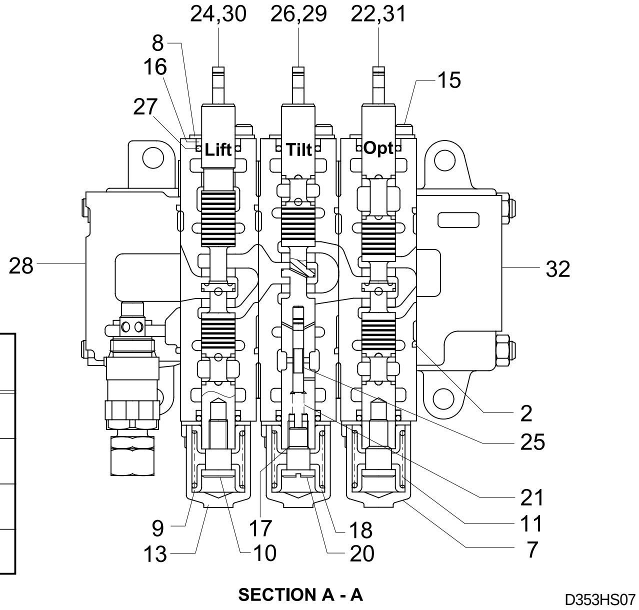
1	Body	11	Screw	21	Ring
2	Body	12	Screw	22	Back up ring
3	Rear cover	13	Grub screw	23	Back up ring
4	Cover	14	Washer	24	Sleeve bearing
5	Thrust plate	15	Washer	25	Flange
6	Thrust plate	16	Seal	26	Hub
7	Drive gear	17	Seal	27	Dowel pin
8	Driven gear	18	Parker ring	28	Steel bushing
9	Drive shaft	19	Seal		
10	Driven gear	20	Shaft seal		

3. MAIN CONTROL VALVE

1) STRUCTURE (3 Spool)



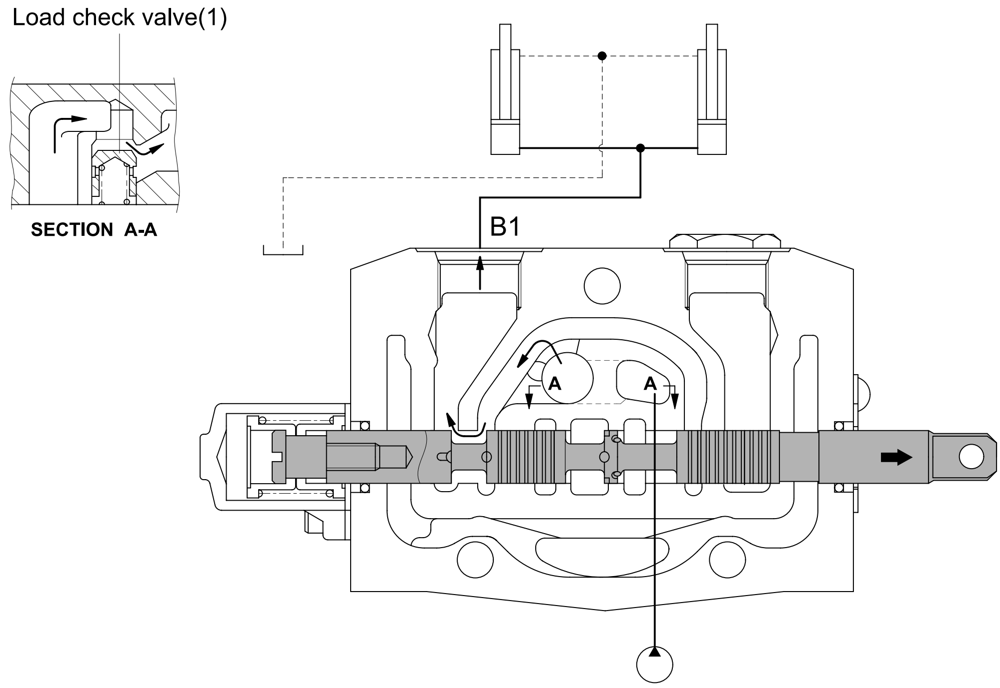
Port name	Size
Inlet port	1-5/16-12UNF
Outlet port	1-5/16-12UNF
Gauge port	PF1/4
Work port	1-1/16-12UNF



1	Special nut	15	Screw	29	Spool housing
2	O-ring	16	Wiper	30	Spool housing
3	Plug	17	O-ring	31	Spool housing
4	O-ring	18	Spring seat	32	Outlet housing
5	O-ring	19	Spring	33	Poppet
6	Plug	20	Spool end	34	Tie rod
7	Spool cap	21	Spring	35	Tie rod
8	Seal plate	22	Spool	36	Special nut
9	Spring seat	23	Main relief valve	37	Inlet section assy
10	Spool end	24	Spool	38	Outlet section assy
11	Spring	25	Piston	39	Spool section assy
12	O-ring	26	Spool	40	Spool section assy
13	Cap screw	27	O-ring	41	Spool section assy
14	Plug	28	Inlet housing		

2) LIFT SECTION OPERATION

(1) Lift position



D353HS08

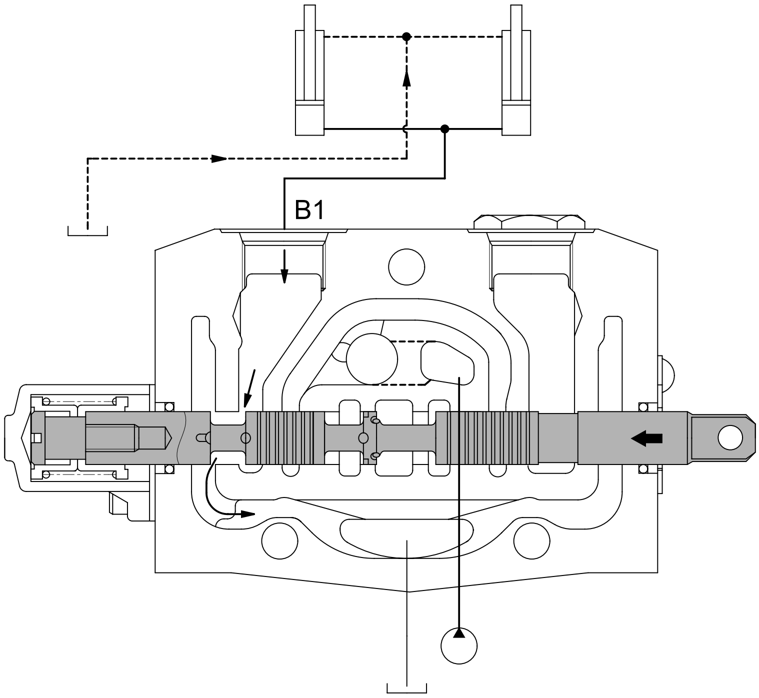
When the lift control lever is pulled back, the spool moves to the right and the neutral passage is closed.

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

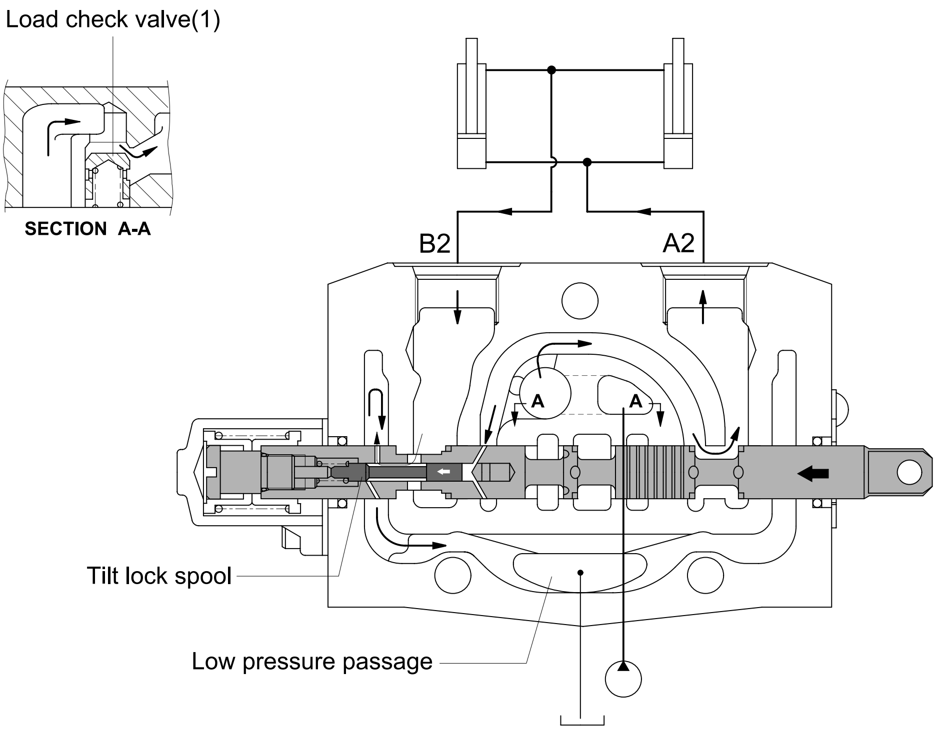


D353HS09

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

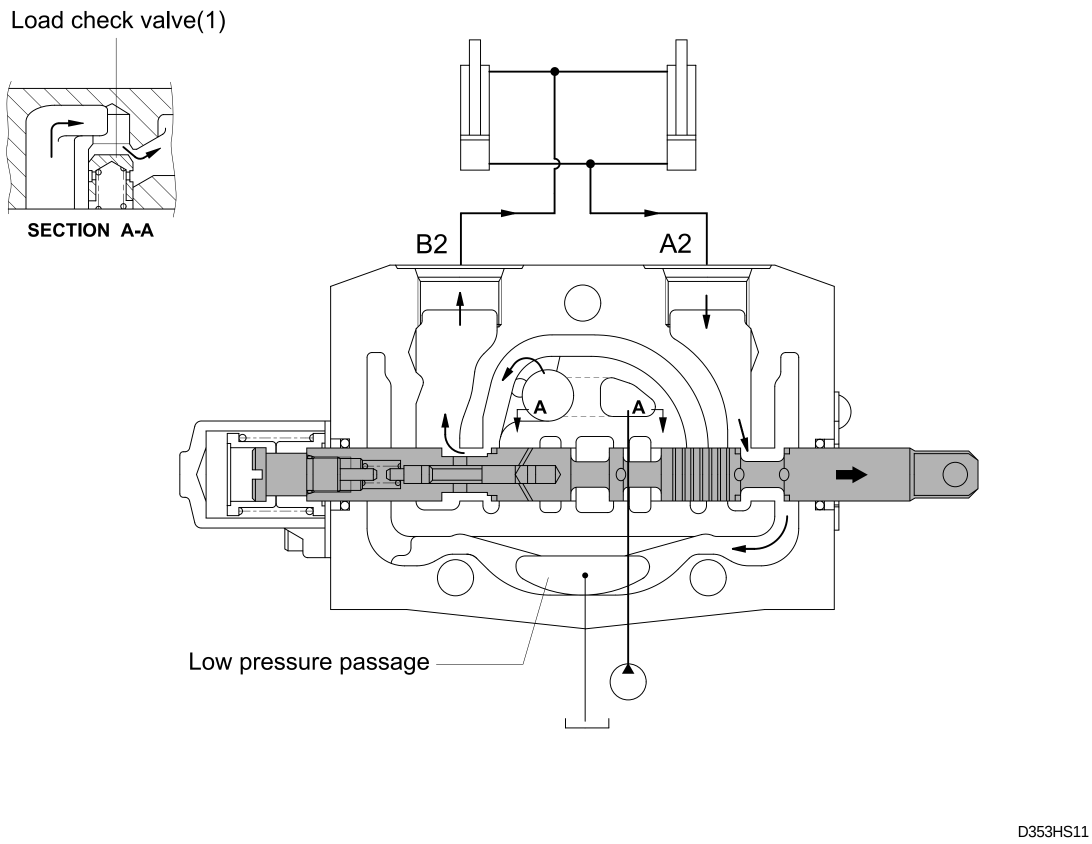
When the tilt control lever is pushed forward, the spool moves to the left and the neutral passage is closed.

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



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

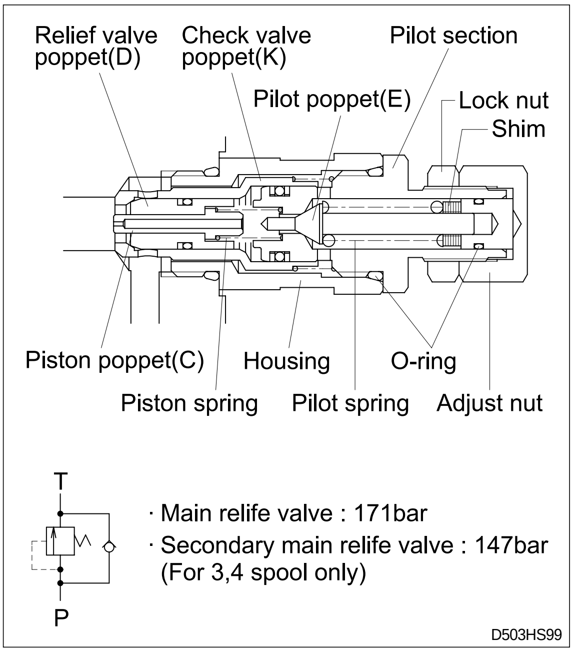
① Loosen lock nut.

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.

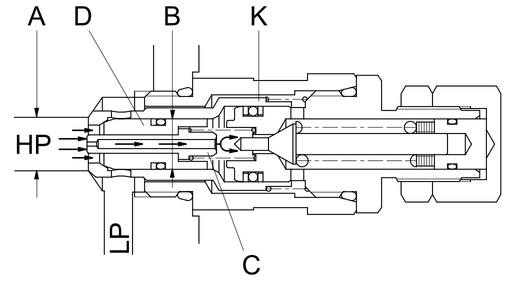


D503HS99

(2) Function

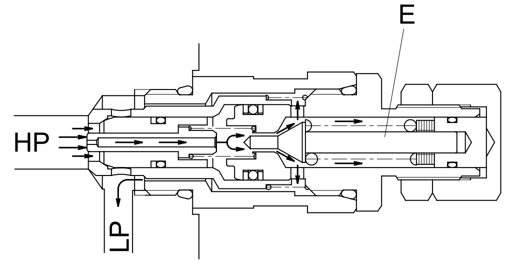
① As work port relief

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.



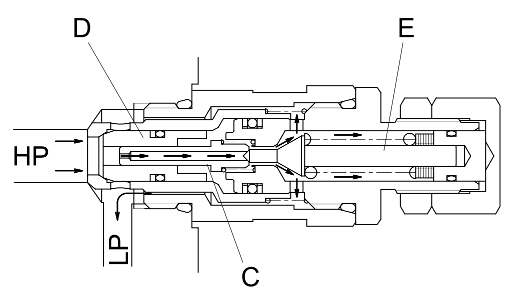
D353HS18

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.



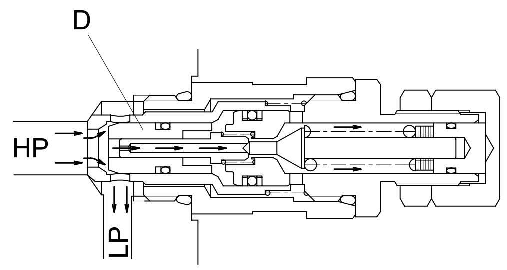
D353HS19

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.



D353HS20

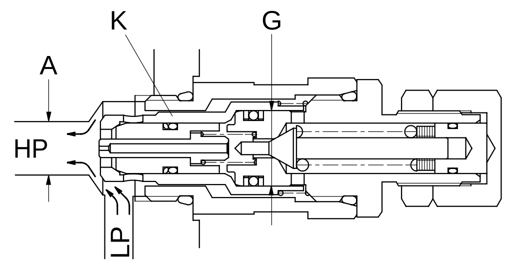
The imbalance of pressure on the inside as compared to that of the high pressure port HP, forces the relief valve poppet D to open and relieve the oil directly to the low pressure chamber LP in the valve.



D353HS21

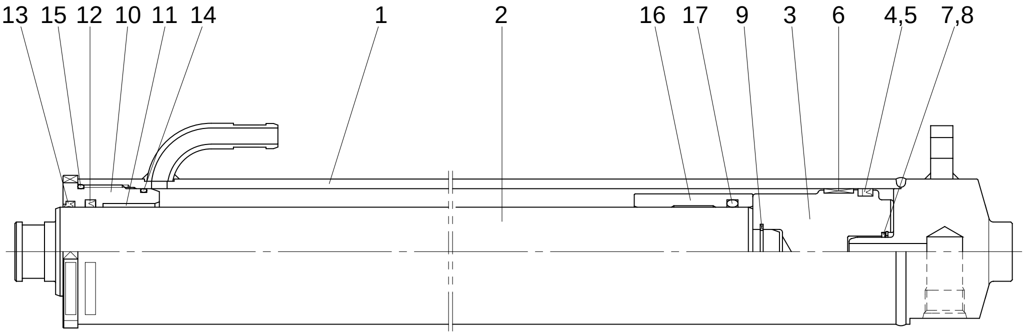
② As anti void

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.



7406S6-28(1)

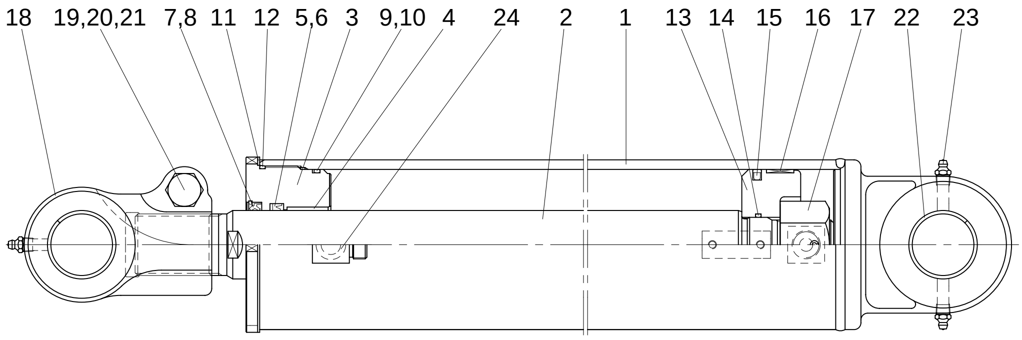
4. LIFT CYLINDER



D507HS12

1	Tube assy	7	Cushion seal	13	Dust wiper
2	Rod	8	Retaining ring	14	O-ring
3	Piston	9	Retaining ring	15	O-ring
4	Piston seal	10	Gland	16	Spacer
5	Back up ring	11	Du bushing	17	O-ring
6	Wear ring	12	Rod seal		

5. TILT CYLINDER



D507HS13

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

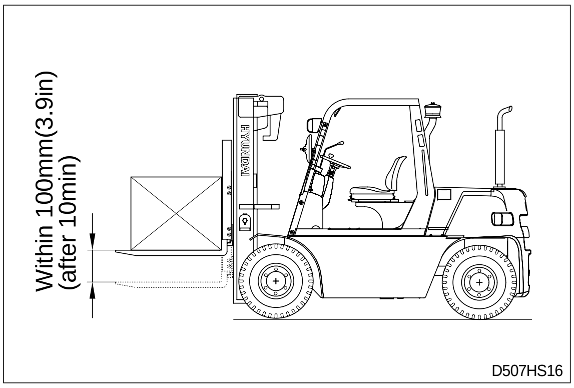
- Down(Downward movement of forks)
  : Within 100mm(3.9in)
- Forward(Extension of tilt cylinder)
  : Within 5°

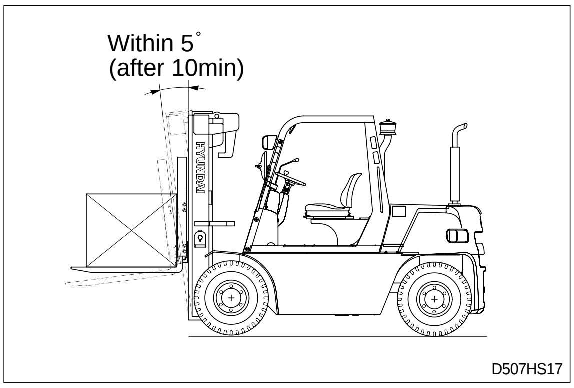
If the hydraulic drift is more than the specified value, replace the control valve or cylinder packing.

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

mm (in)

Standard	Under 0.6 (0.02)

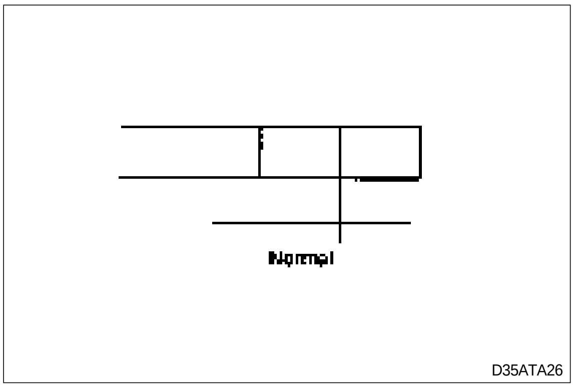




2) HYDRAULIC OIL

(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 175kgf/cm^2.
(2538psi)

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.

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.

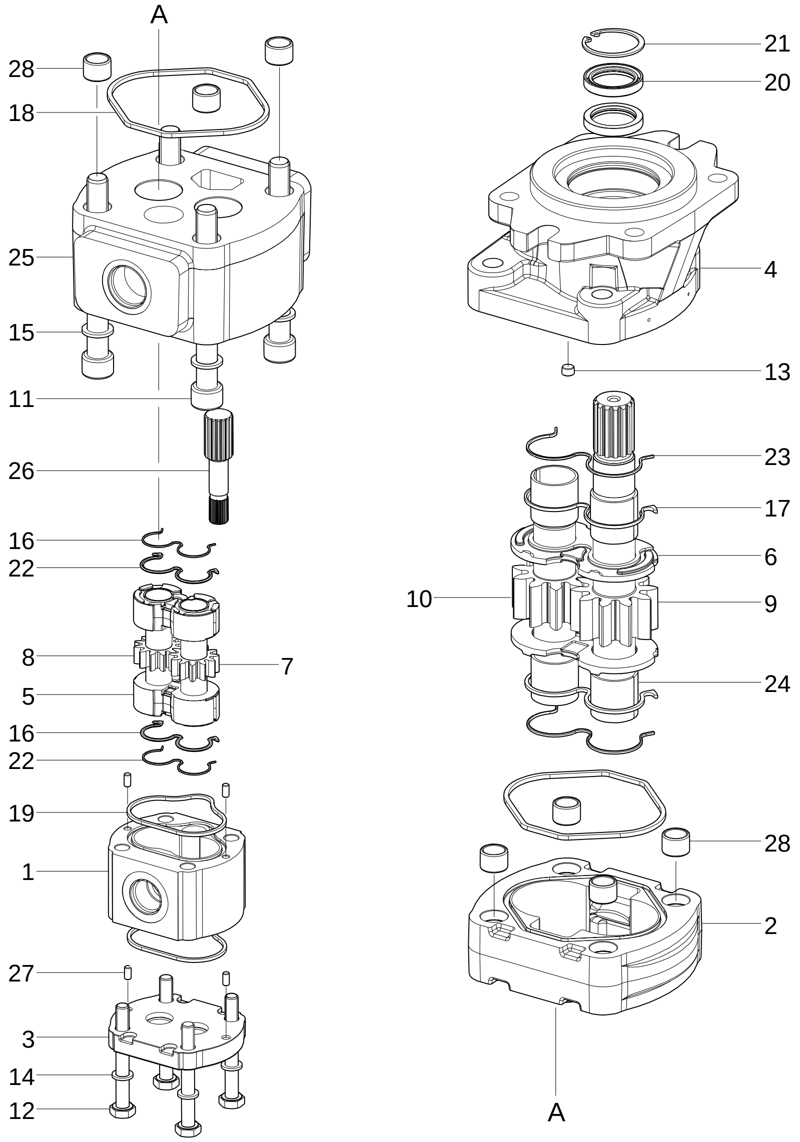
4) LIFT CYLINDER

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 suface of tube. · Foreign matters in piston seal.	· Smooth rod surface with an oil stone. · Replace cylinder tube. · Replace piston seal.
Wear(clearance between cylinder tube and wear ring)	· Excessive clearance between cylinder tube and wear ring.	· Replace wear ring.
Abnormal noise is produced during tilting operation.	· Insufficient lubrication of anchor pin or worn bushing and pin. · Bent tilt cylinder rod.	· Lubricate or replace. · Replace.

GROUP 3 DISASSEMBLY AND ASSEMBLY

1. MAIN PUMP

1) STRUCTURE



D507HS06

1	Body	11	Screw	21	Ring
2	Body	12	Screw	22	Back up ring
3	Rear cover	13	Grub screw	23	Back up ring
4	Cover	14	Washer	24	Sleeve bearing
5	Thrust plate	15	Washer	25	Flange
6	Thrust plate	16	Seal	26	Hub
7	Drive gear	17	Seal	27	Dowel pin
8	Driven gear	18	Parker ring	28	Steel bushing
9	Drive shaft	19	Seal		
10	Driven gear	20	Shaft seal		

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.

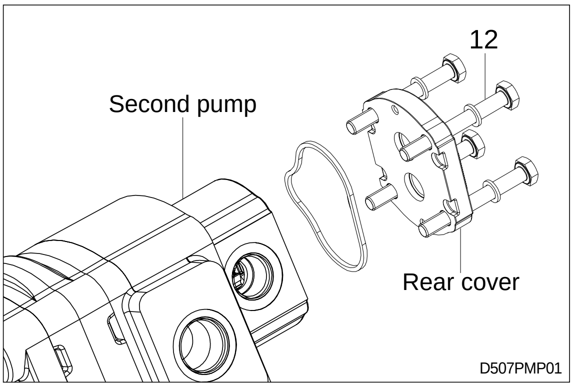
(3) Tools required for assembly

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

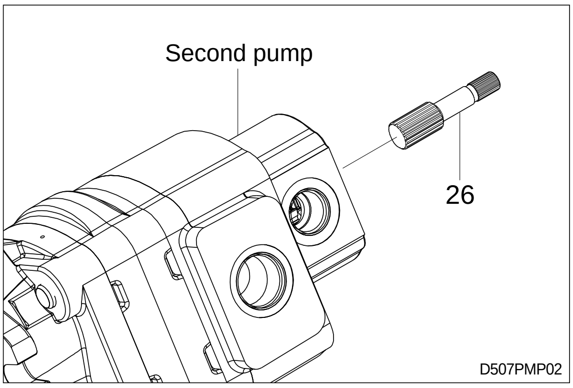
3) DISASSEMBLY

(1) Rear section

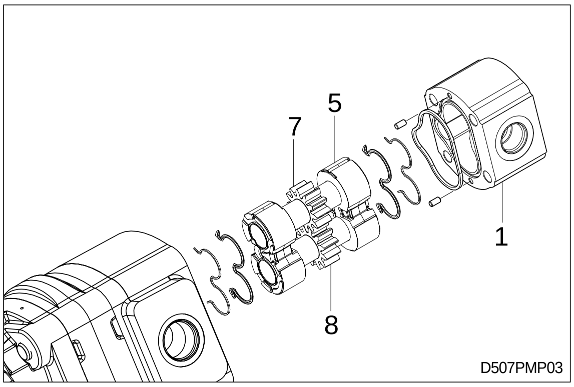
① Loosen and remove the clamp bolts(12) of second pump.



② Remove hub(26) and ease the drive gear (7) up to facilitate removal the thrust plate(5).



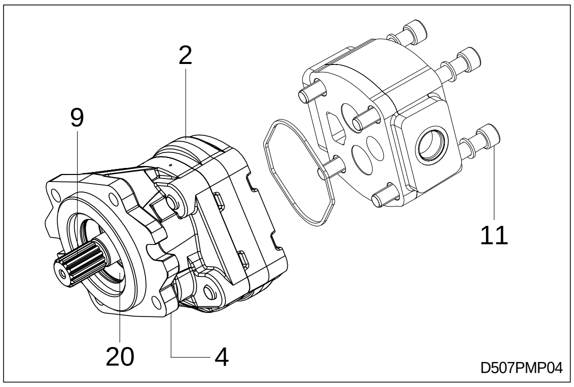
③ And remove drive gear(7), driven gear(8), thrust plate(5), keeping gears as straight as possible, and body(1) also.



(1) Front section

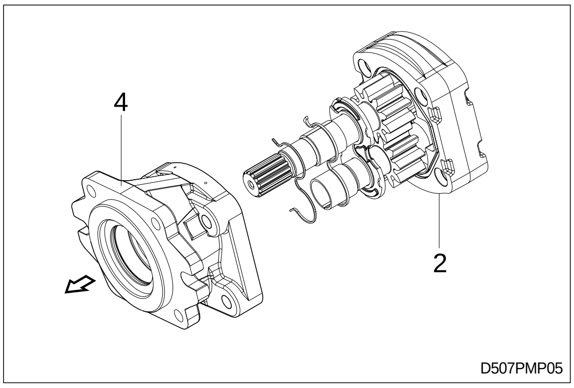
① Loosen and remove the clamp bolts(11) from the body(2).

※ Coat the sharp edges of the drive shaft (9) with adhesive tape and smear a clean grease on the shaft end extension to avoid any damaging lip of the shaft seal(20) when removing the cover(4).



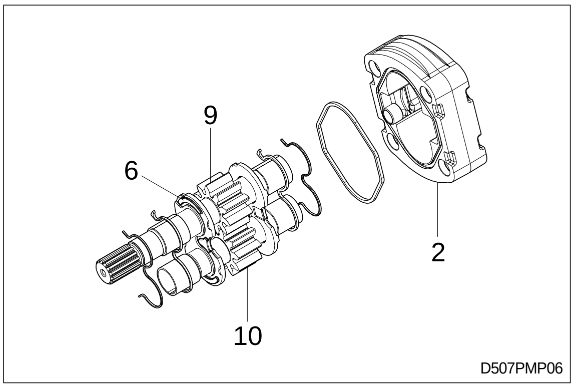
② Remove the cover(4) taking care to keep the cover as straight as possible during removal. If cover(4) is stuck, tap around the edge with rubber mallet in order to break away from the body(2).

※ Ensure that while removing cover(4) shaft and other components remain position.



③ Ease the drive gear(9) up to facilitate removal the thrust plate(6).

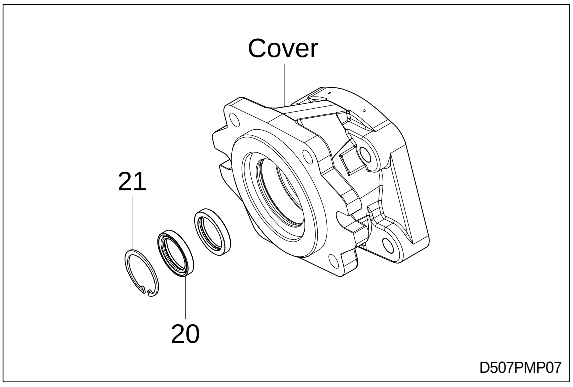
④ Remove drive gear(9), driven gear(10), thrust plate(6), keeping gears as straight as possible, and body(2) also.



(3) Cover assembly

① Remove snap ring(21) with proper tool(Only when it is needed to replace shaft seal).

② Remove the shaft seal(20) taking care not to give any damage on the surface of shaft hole(Only when it is needed to replace shaft seal).

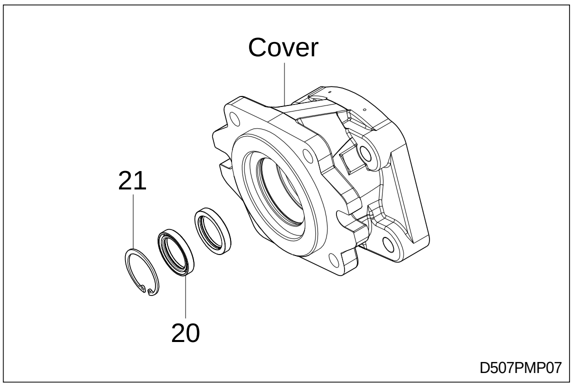


4) REASSEMBLY

(1) Cover assembly

① Insert the shaft seal(20) carefully and fit it inside of cover with proper tool.

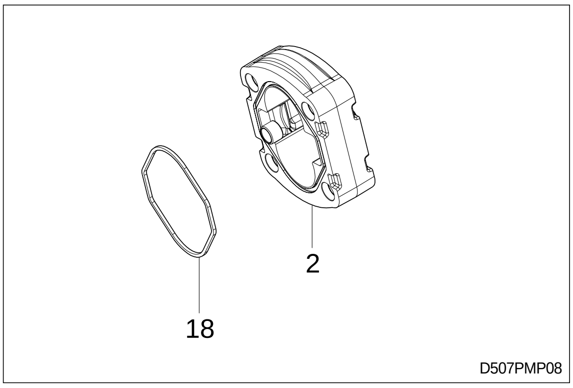
② Fit the snap ring(21) in pre-arranged position with proper tool.



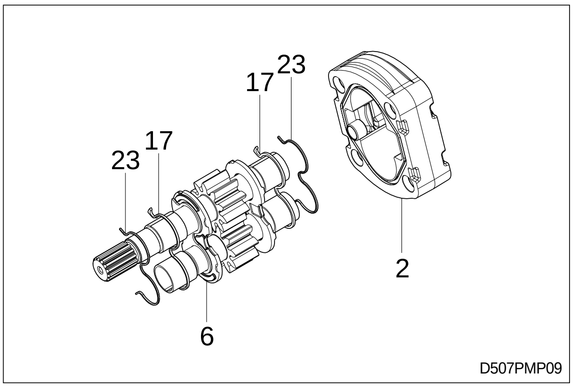
(2) Front section

① Fit the parker ring(18) on the pre-arranged groove of the body(2).

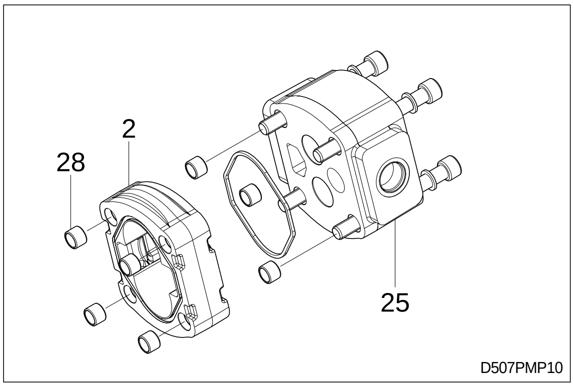
※ Smear clean grease on the parker ring to avoid drifting away of parker ring from the body.



② Locate the seals(17) on the groove pre-arranged on the thrust plate(6).
Then, locate back-up ring(23) on the groove pre-arranged on the seals(17).
Smear clean grease on the seals(17, 23).
(The front and rear thrust plates and seals and back-up rings are same).



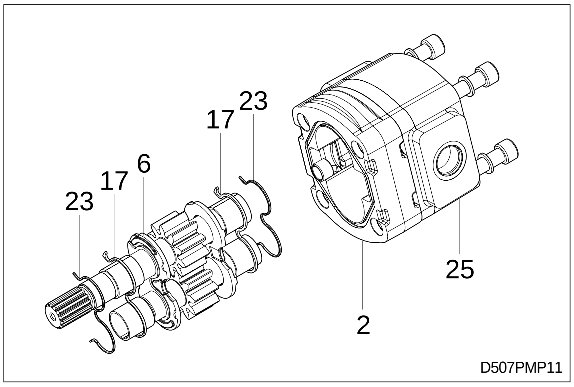
③ Insert the steel bushing(28) into body(2) and assemble middle section and flange(25).



④ Insert the complete pressure plate (6+17+23) into body(2) while keeping the plate straight.

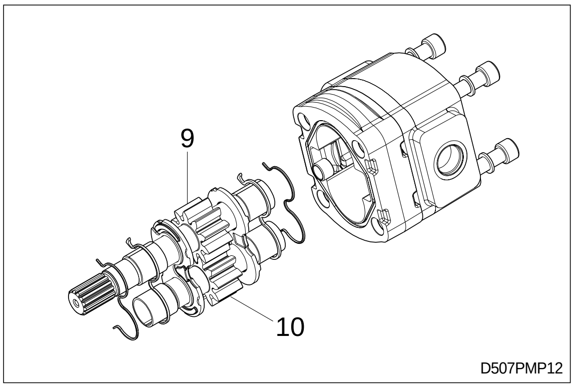
※ Seal side should face to the flange(25), opposite side of gears.

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



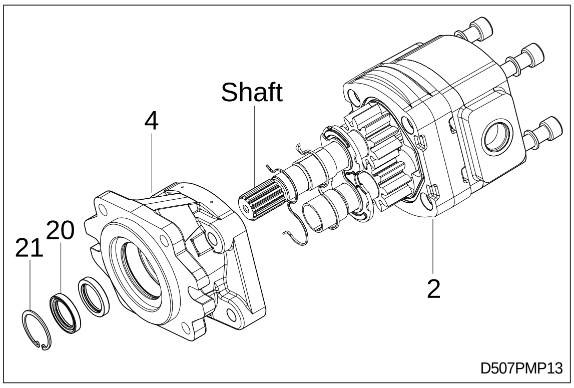
⑤ Locate driving gear(9) and driven gear(10) while keeping the gears straight.

※ Locate pressure plate(6+17+23) with care for the direction.

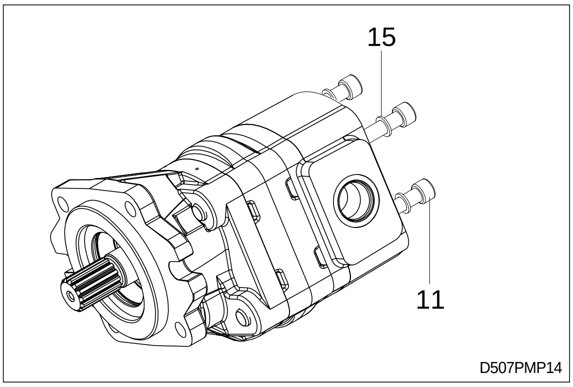


⑥ Locate complete cover(4+20+21) while taking care not to give any damage on the shaft seal by edge of shaft.

And tap around the cover(4) with rubber mallet.

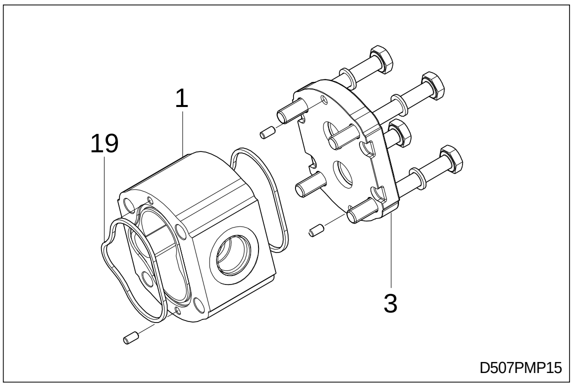


⑦ Tighten the bolts(11) with washer(15) in a crisscross pattern to torque value of 28.6kgf.m(207lbf.ft).



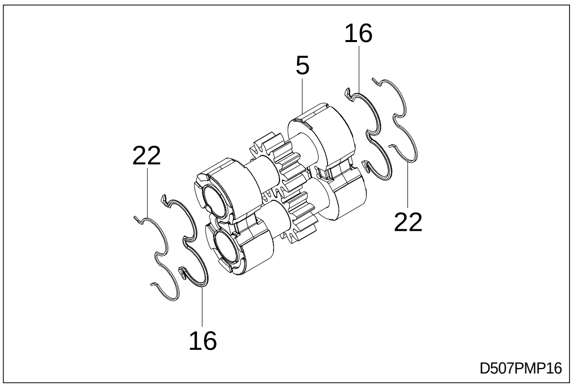
(3) Rear section

① Smear clean grease on the seal(19) to avoid drifting away of seal from the body(1) and assemble middle section and rear cover(3).



② Locate the seals(16) on the groove pre-arranged on the thrust plates(5).
Then, locate back-up ring(22) on the groove pre-arranged on the seals(16).

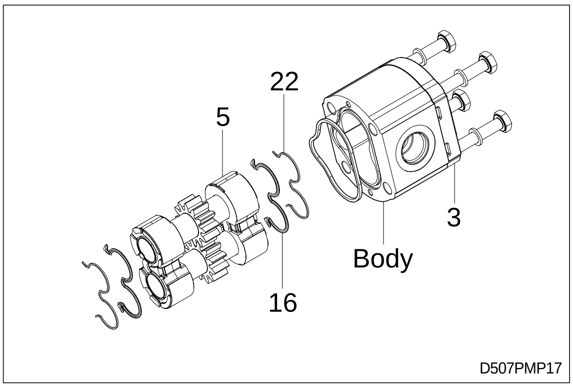
※ Smear clean grease on the seals (22+16).
(The front and rear thrust plates and seals and back-up rings are same)



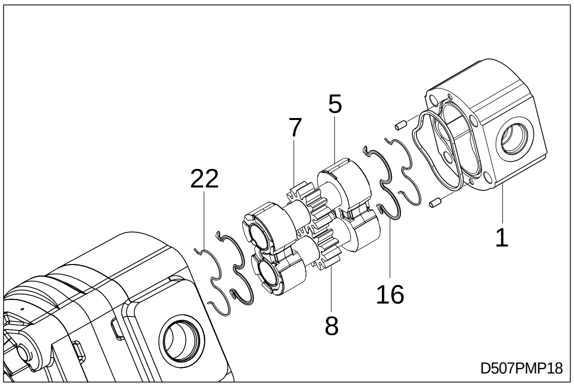
③ Insert the complete pressure plate (5+22+16) into body while keeping the plate straight.

※ Seal side should face to the rear cover (3), opposite side of gears.

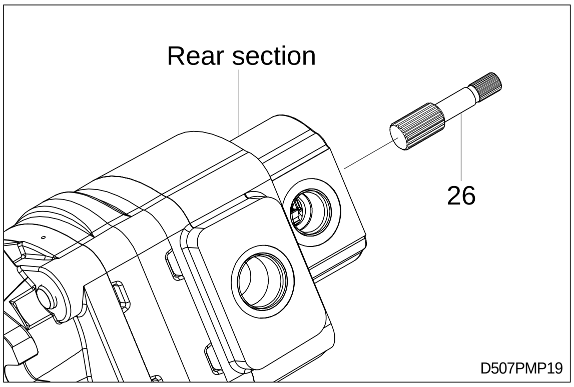
※ Pay attention to the direction of seal. (opened side should face suction side always)



④ Locate driving gear(7) and driven gear(8) while keeping the gears straight.
Locate pressure plate(5+22+16) with care for the direction.

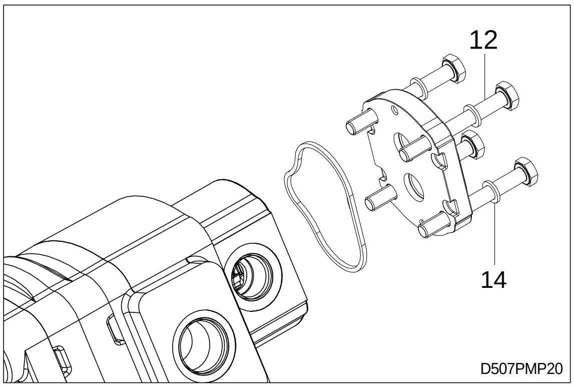


⑤ Locate hub(26) into rear section.



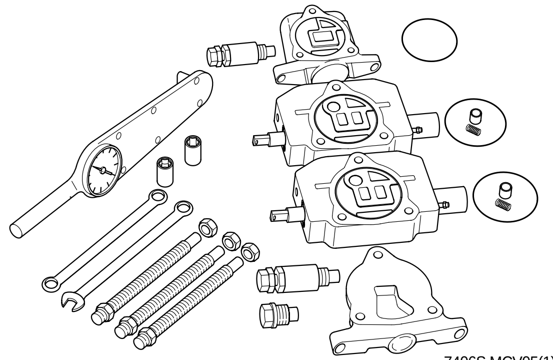
⑥ Tighten the bolts(12) with washer(14) in a crisscross pattern to torque value of 4.6kgf.m(33.3lbf.ft).

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



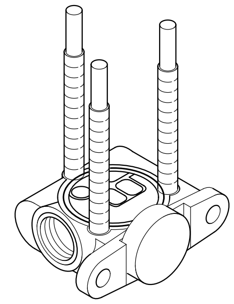
2. MAIN CONTROL VALVE

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.



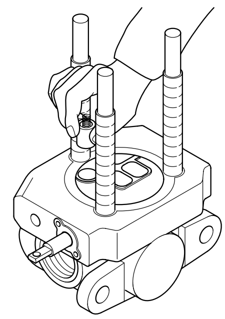
7406S MCV05(1)

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.



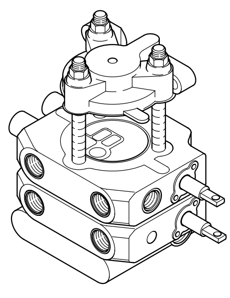
7406S MCV05(2)

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.



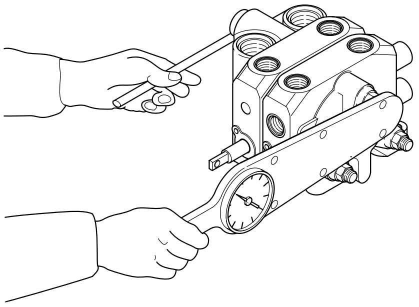
7406S MCV05(3)

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.



7406S MCV05(4)

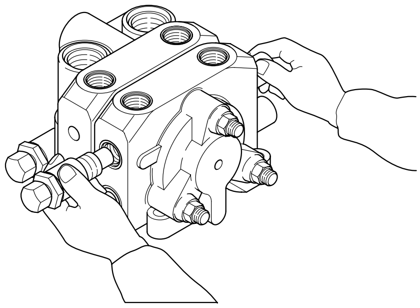
5) Position valve assembly with the mounting pads of the end sections on a flat surface. To obtain proper alignment of end sections relative to the spool sections apply downward pressure to the end sections ; Snug tie rod nuts to about 10lbf · ft.
Final torque the two 11/16 nuts to 48± 5lbf · ft ; Final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



7406S MCV06(1)

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

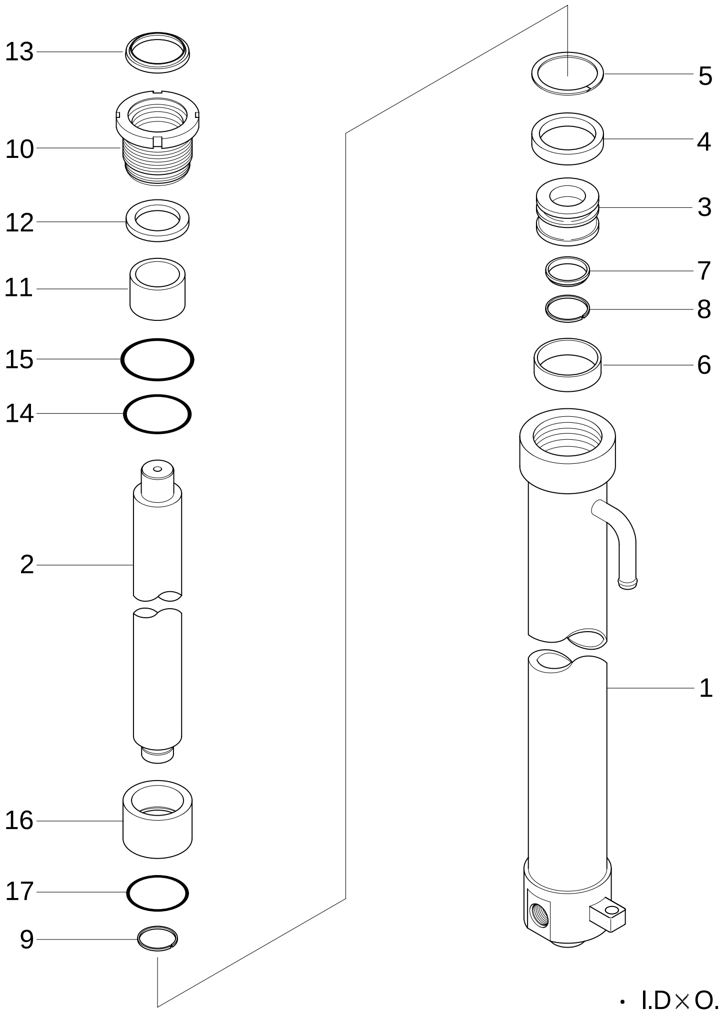
※ **General assembly notes**:
A. Lever assemblies can be installed on section before or after complete valve assembly.
B. The load check and spring may be omitter from assembly in certain circuit conditions(i.e., motor spools).



7406S MCV06(2)

3. LIFT CYLINDER

1) STRUCTURE



· I.D × O.D × stroke(standard)
85 × 98 × 1335mm
(3.3 × 3.9 × 52.6in)

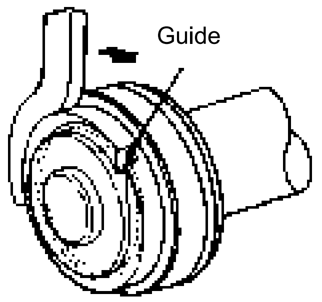
· Rod O.D : 60mm(2.4in)

D507HS19

1	Tube assy	10	Gland
2	Rod	11	Du bushing
3	Piston	12	Rod seal
4	Piston seal	13	Dust wiper
5	Back up ring	14	O-ring
6	Wear ring	15	O-ring
7	Cushion seal	16	Spacer
8	Retainning ring	17	O-ring
9	Retainning 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.



D503HS20

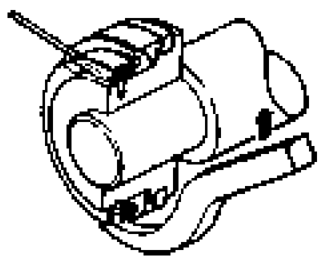
2) CHECK AND INSPECTION

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

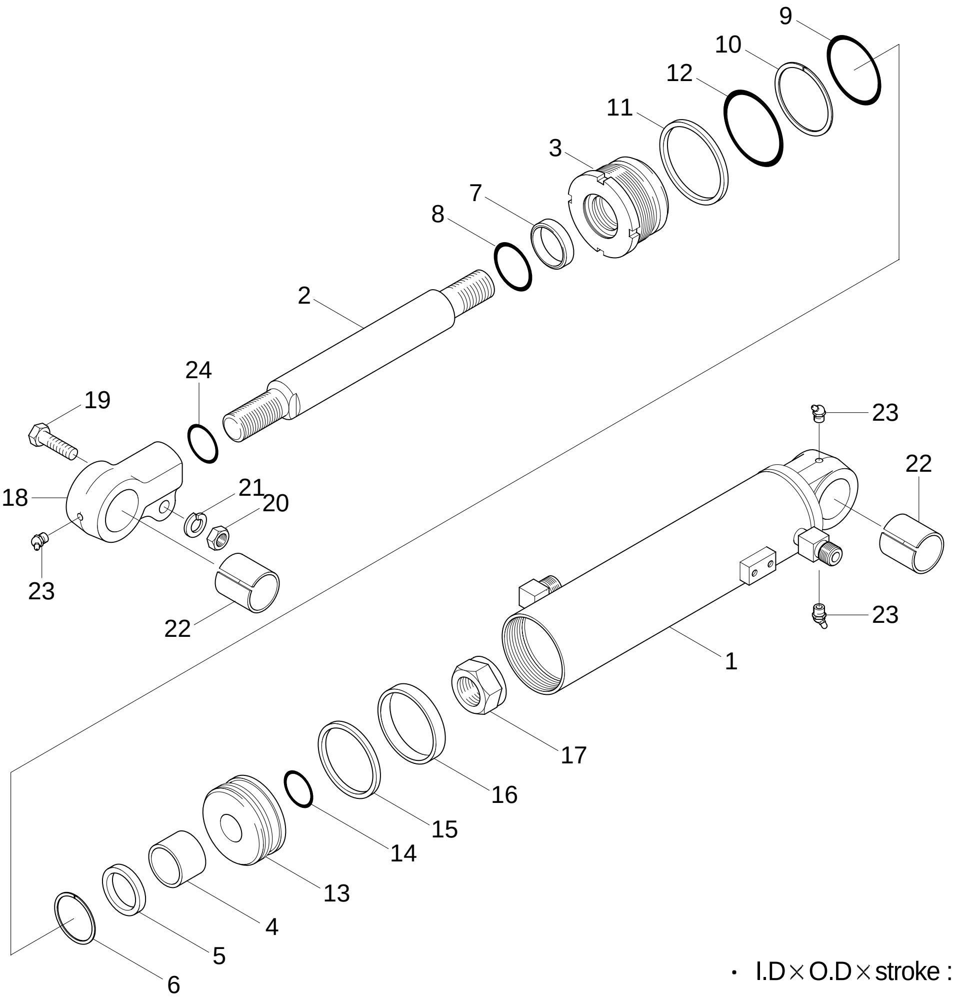
3) ASSEMBLY

(1) Soak the piston ring in hydraulic oil at a temperature of 40 to 50℃, 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.


D503HS21

4. TILT CYLINDER

1) STRUCTURE



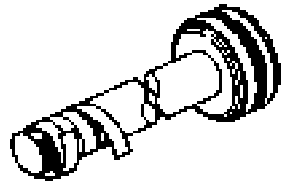
· I.D×O.D×stroke :
110×124×338mm
(4.3×4.9×13.3in)
· Rod O.D : 50mm(2.0in)

D507HS22

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



D503HS23

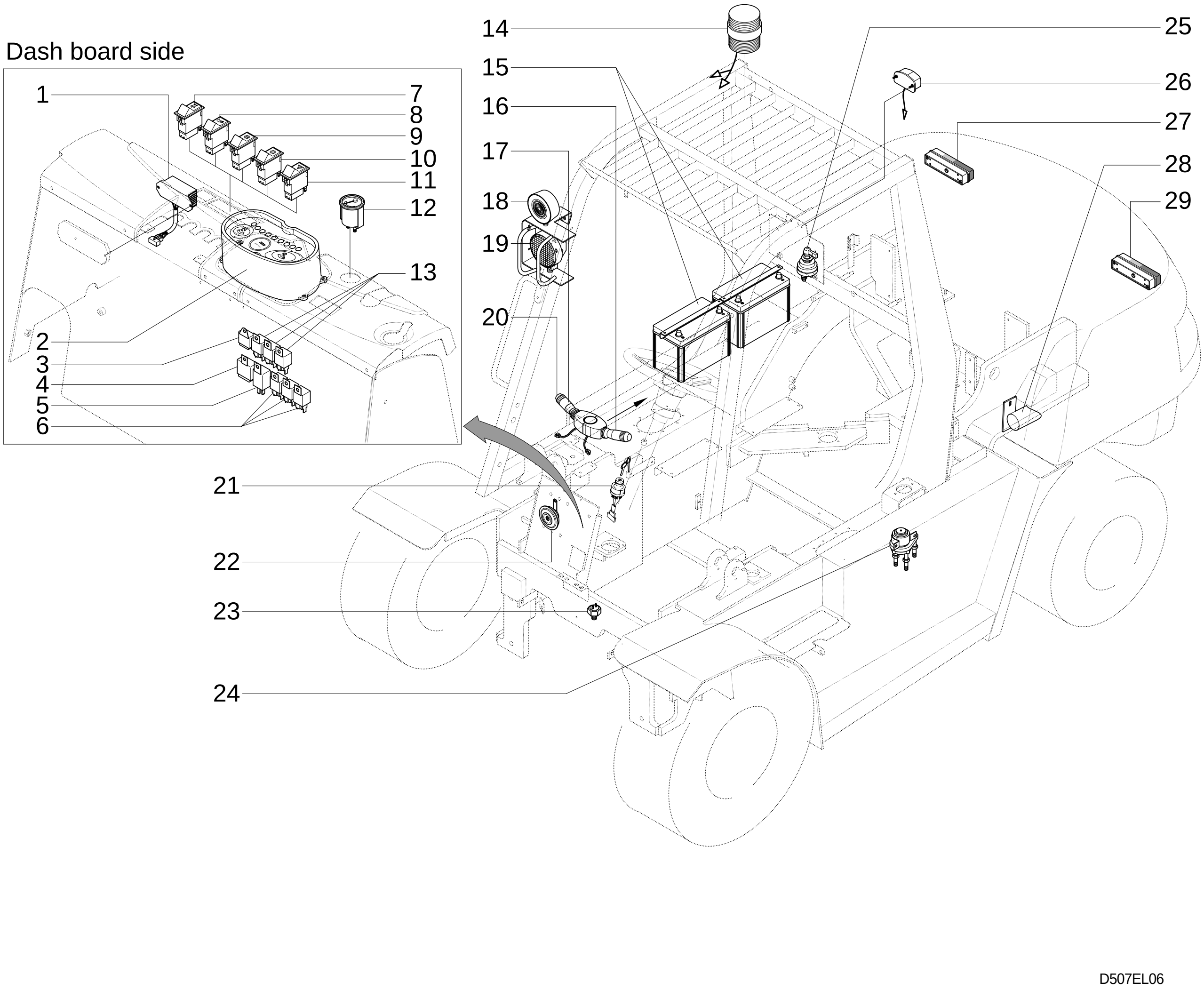
3) CHECK AND INSPECTION

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

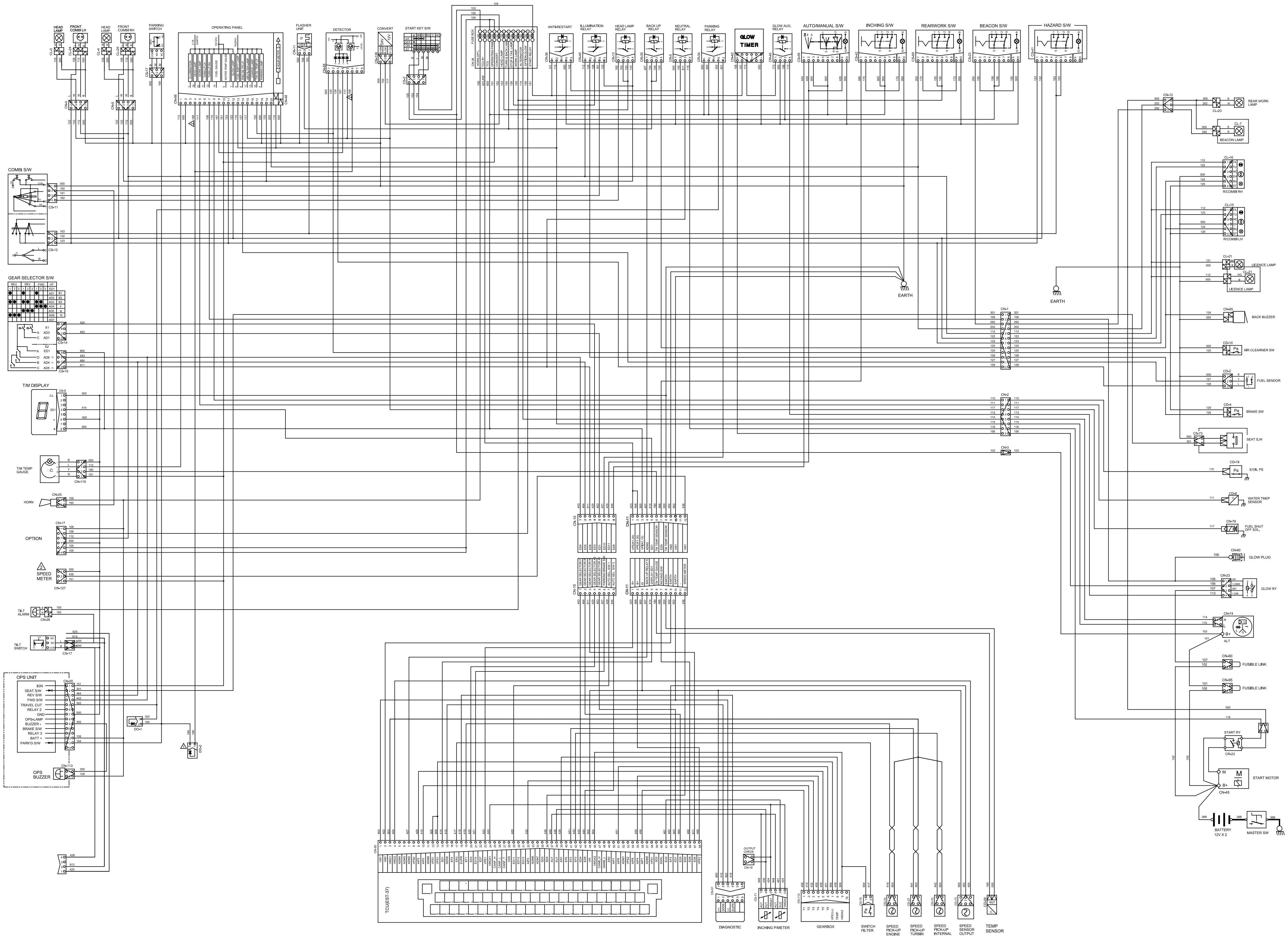
GROUP 1 COMPONENT LOCATION



1	Convert	11	Hazard switch	21	Start switch
2	Operating panel	12	Transmission temp gauge	22	High horn
3	Glow timer	13	Relay 4P	23	Brake switch
4	Detector	14	Beacon lamp	24	Glow relay
5	Flasher unit	15	Battery	25	Master switch
6	Relay 5P	16	Gear selector	26	License lamp
7	Beacon switch	17	Combination switch	27	RH combination lamp
8	Work lamp switch	18	Work lamp	28	Back horn
9	Inching switch	19	Flasher unit	29	LH combination lamp
10	Auto manual switch	20	Horn switch		

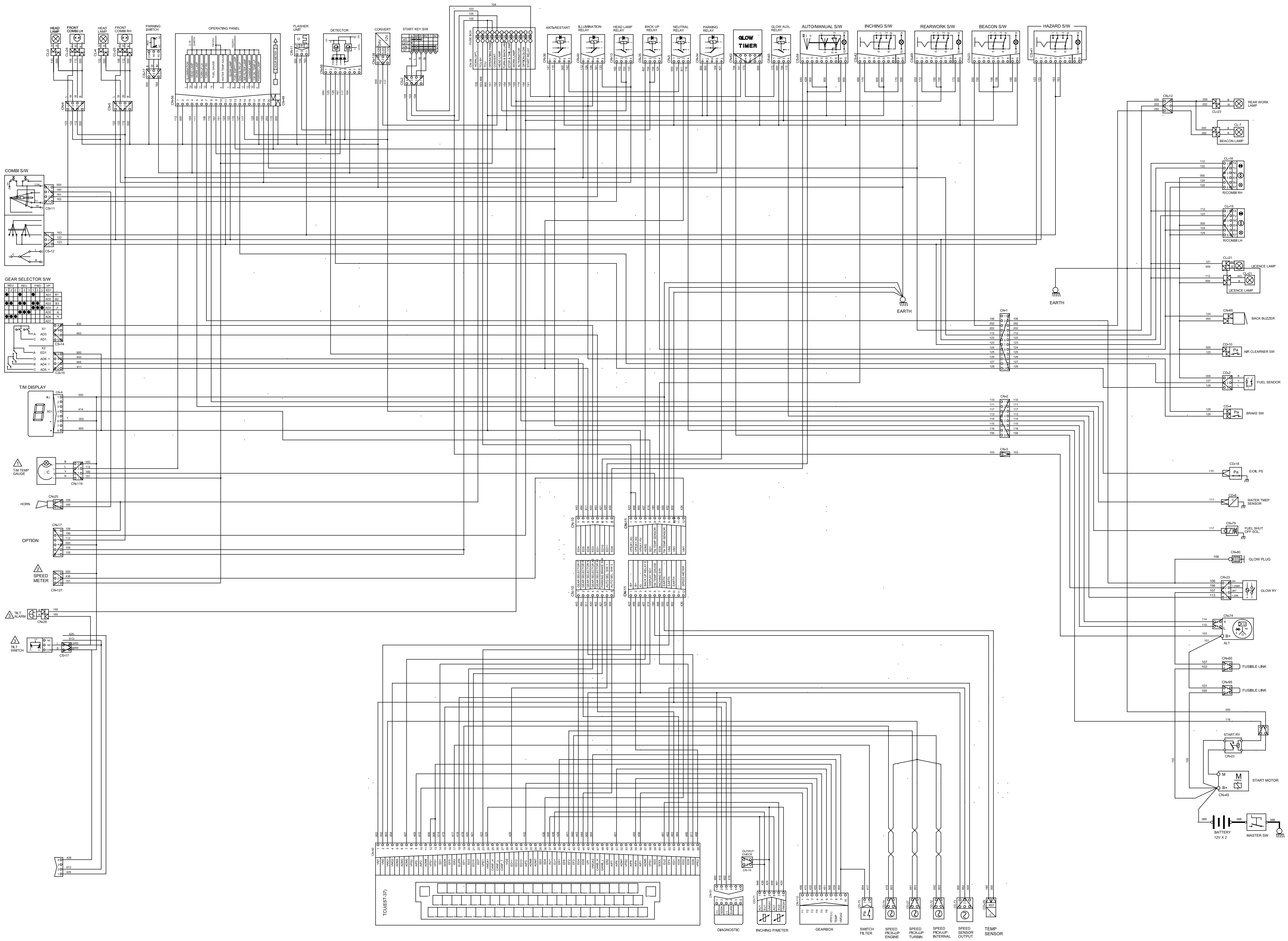
GROUP 2 ELECTRICAL CIRCUIT

1. HDF50/70-7S



D507SEL011

2. HDF50/70-7



MEMORANDUM

HYUNDAI HEAVY INDUSTRIES CO., LTD.
CONSTRUCTION EQUIPMENT DIV.

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

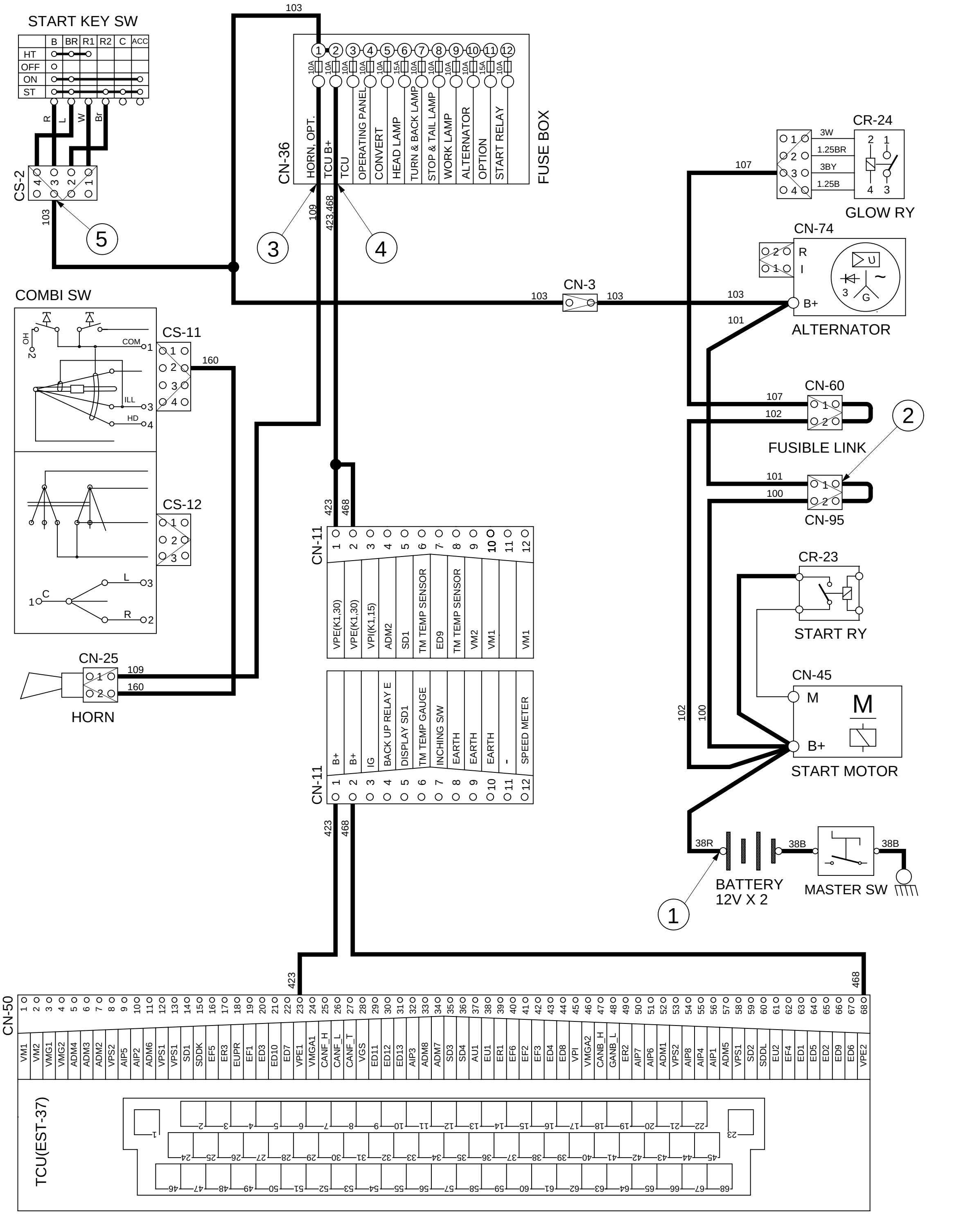
Battery(+) → Start motor[CN-45(B+)]
- → Fusible link[CN-60] → Glow relay[CR-24(3)]
- → Start relay[CR-23]
- → Fusible link[CN-95] → Alternator[CN-74(B+)] → [CN-3]
  - → I/conn[CS-2(3)] → Start switch OFF
  - → Fuse box[CN-36(1)] → Combi switch[CS-11(2)]
  - → Fuse box[CN-36(2)] → I/conn[CN-11(1, 2)] → TCU[CN-50]

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.2) ⑤ - GND (Start key)	10 ~ 13V

※GND : Ground

POWER CIRCUIT



D507EL02

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.5 →3] → Gear selector switch[CS-15(3)]

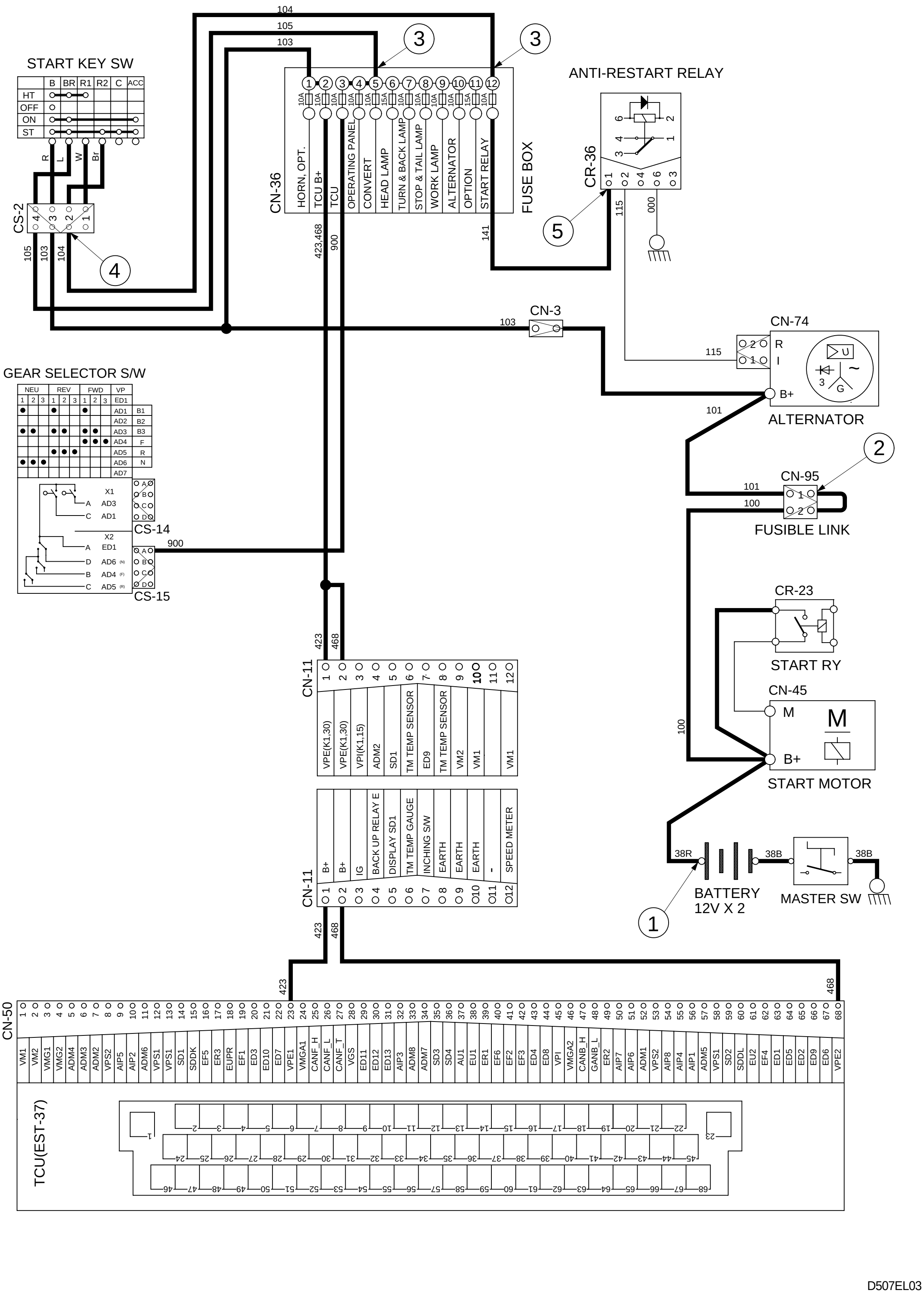
(2) **When start key switch is START position**
Start switch START[CS-2(2)] → Fuse box[No. 12] → Anti restart relay[CR-36(1) →(2)]

2) CHECK POINT

Engine	Key switch	Check point	Voltage
Running	ON	① - GND (Battery B+) ② - GND (Fusible link) ③ - GND (Fuse box No.5, 12) ④ - GND (Start key) ⑤ - GND (Anti restart relay)	10 ~ 14.5V

※GND : Ground

STARTING CIRCUIT



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(I)] → I/conn[CN-2(6)] → Cluster charging warning lamp ON [CN-56(13)]

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

2) CHECK POINT

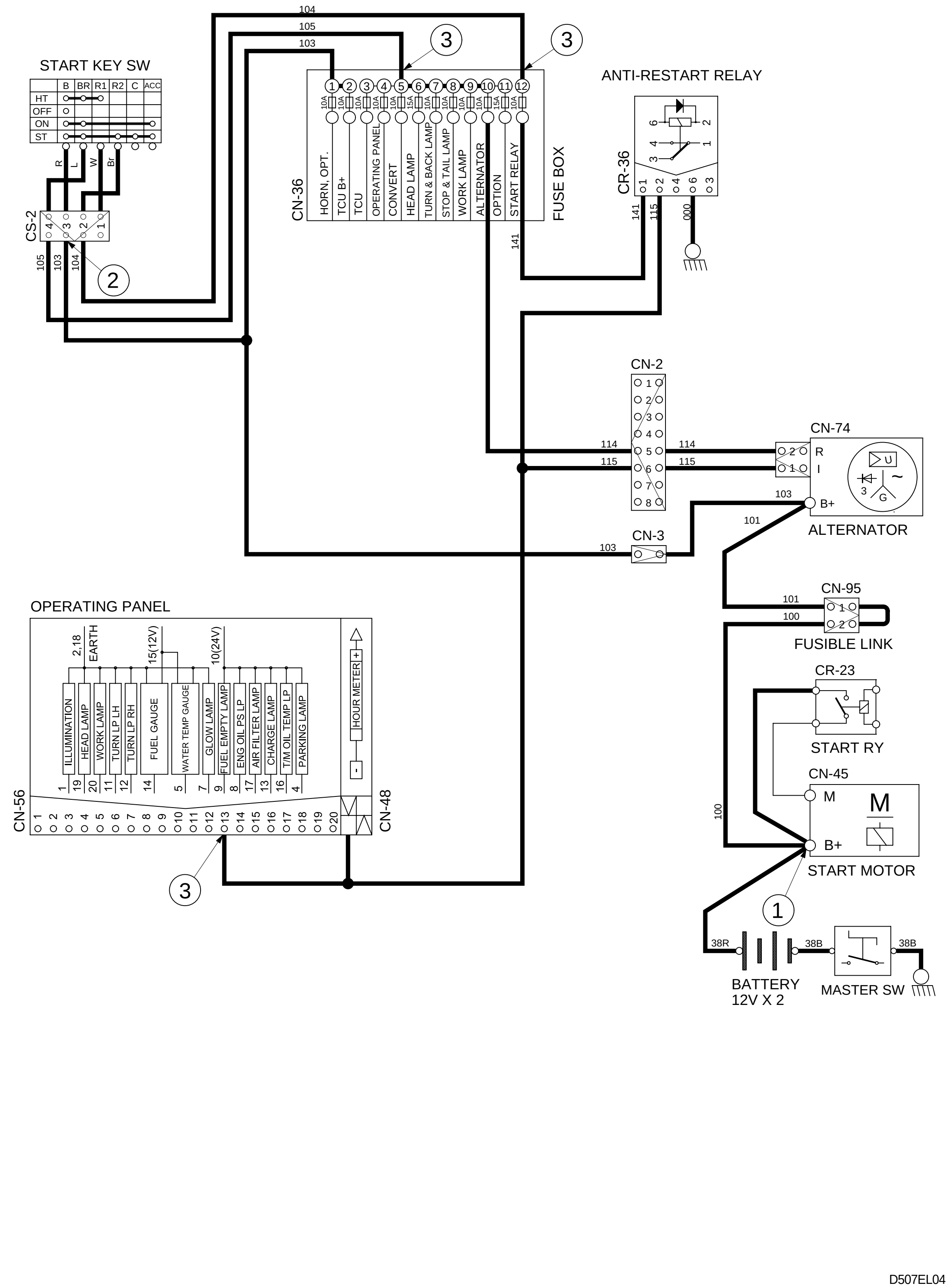
Engine	Key switch	Check point	Voltage
ON	ON	① - GND (Alternator B+) ② - GND (Start switch) ③ - GND (Cluster)	10 ~ 14.5V

※ GND : Ground

※ **Cautions**

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

CHARGING CIRCUIT



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)
→ Glow relay[CR-24]

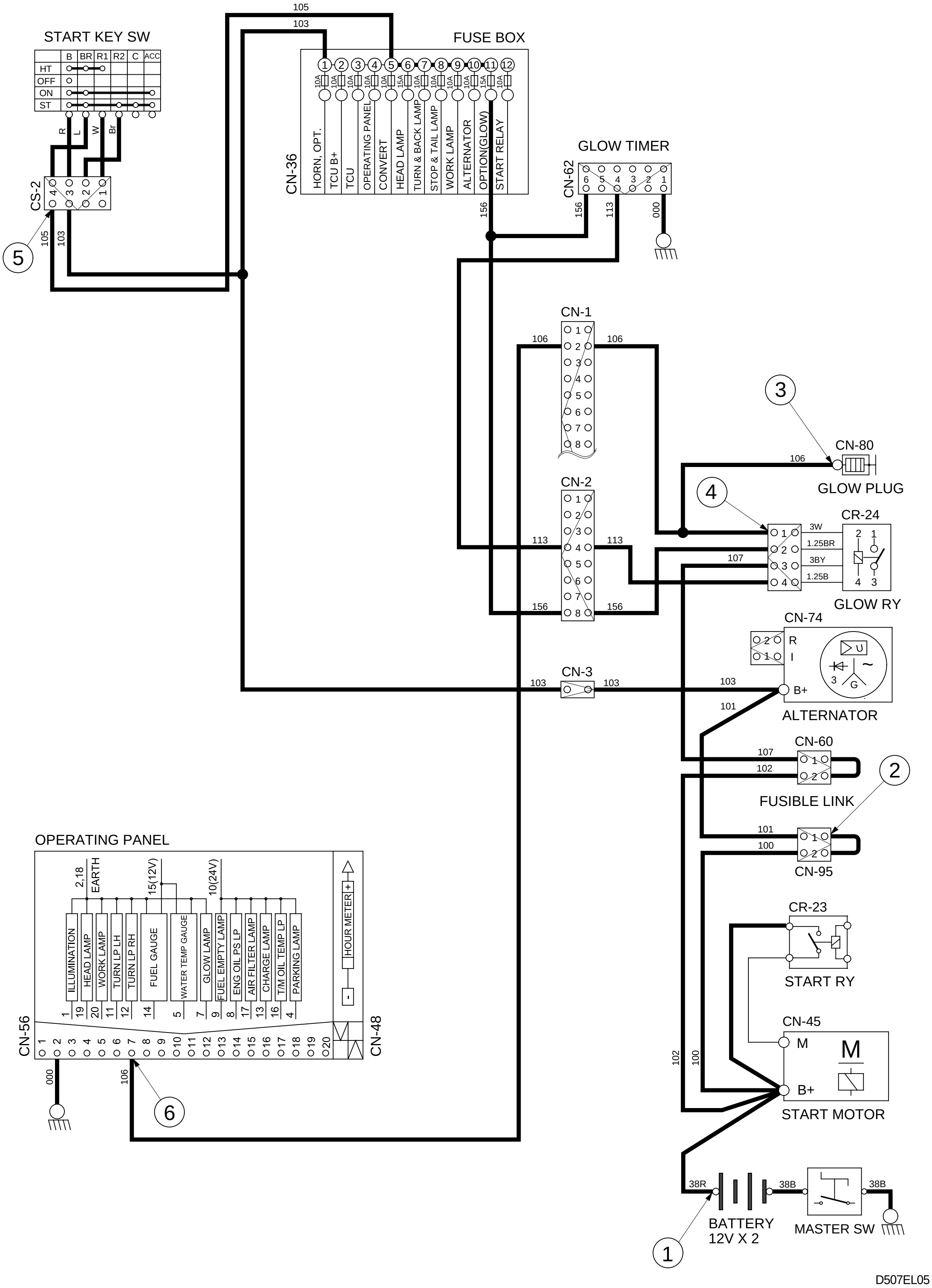
※ When you turn the start switch to the ON position, the glow relay makes the glow plugs operated and the glow lamp of the cluster turned ON.

Start switch ON [CS-2(4)] → Fuse box [NO.5→10] → Glow timer[CN-62(6)→(4)] →
I/conn[CN-2(4)] → Glow relay ON [CR-24]
→ Glow plug operating[CN-80]
→ I/conn[CN-1(2)] → Operatring panel[CN-56(7)] → 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)	10 ~ 13V

PREHEATING CIRCUIT



GROUP 3 COMPONENT SPECIFICATION

<table>
<tr><th>No</th><th>Part name</th><th>Qty</th><th>Specification</th></tr>
<tr><td>1</td><td>Battery</td><td>2</td><td>12V×90AH
RC : 130min
CCA : 630A</td></tr>
<tr><td>2</td><td>Working lamp</td><td>1</td><td>24V, 70W</td></tr>
<tr><td>3</td><td>License lamp</td><td>1</td><td>24V, 3W x 2</td></tr>
<tr><td>4</td><td>Rear Combination lamp</td><td>2</td><td>24V, 25/10W (Stop/Tail)
24V, 25W (Turn)
24V, 10W (Back Up)</td></tr>
<tr><td>5</td><td>Head lamp</td><td>2</td><td>24V, 70W</td></tr>
<tr><td>6</td><td>Flasher lamp</td><td>2</td><td>24V, 25/10W</td></tr>
<tr><td>7</td><td>Glow relay</td><td>1</td><td>24V, 300A</td></tr>
<tr><td>8</td><td>Relay (4P)</td><td>3</td><td>24V, 20A</td></tr>
<tr><td>9</td><td>Relay (5P)</td><td>3</td><td>24V, 6A</td></tr>
<tr><td>10</td><td>Flasher Unit</td><td>1</td><td>85±10CM, (21W + 21W) x 2 + 3W x 2</td></tr>
<tr><td>11</td><td>Detector</td><td>1</td><td>12V, 2A</td></tr>
<tr><td>12</td><td>Converter</td><td>1</td><td>Input 24V, Output 12V, 10A</td></tr>
<tr><td>13</td><td>Back buzzer</td><td>1</td><td>24V, 90±5dB, 60±10C/M</td></tr>
<tr><td>14</td><td>Horn</td><td>1</td><td>24V, 1.5A, 105 ~ 115 dB</td></tr>
<tr><td>15</td><td>Fuel level sender</td><td>1</td><td><table>
<tr><td>Float indicate</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></td></tr>
<tr><td>16</td><td>Master Switch</td><td>1</td><td>24V, 180A</td></tr>
<tr><td>17</td><td>Combination Switch</td><td>1</td><td>Direction 4.5A, Tail 5A
Head 6A, Horn 4A</td></tr>
<tr><td>18</td><td>Brake Switch</td><td>1</td><td>24V, 50W</td></tr>
<tr><td>19</td><td>Working Lamp Switch</td><td>1</td><td>24V, 8A</td></tr>
<tr><td>20</td><td>Hazard Switch</td><td>1</td><td>24V, 8A</td></tr>
<tr><td>21</td><td>Beacon Inching</td><td>1</td><td>24V, 8A</td></tr>
<tr><td>22</td><td>Auto manual Switch</td><td>1</td><td>24V, 8A</td></tr>
<tr><td>23</td><td>Start switch</td><td>1</td><td>24V, 30A</td></tr>
</table>

GROUP 4 CONNECTOR DESTINATION

Connector number	Type	No. of pin	Destination	Connector part No.	
				Female	Male
CN-1	KET	12	I/conn(Dashboard harness-frame harness)	S814-012001	S814-012100
CN-2	KET	8	I/conn(Dashboard harness-frame harness)	S814-008001	S814-008100
CN-3	KET	1	I/conn(Dashboard harness-frame harness)	MG640944-5	MG650943-5
CN-4	KET	4	LH support harness	S810-004201	-
CN-5	KET	4	Support harness	S810-004201	-
CN-8	AMP	8	Transmission display	929504-3	-
CN-10	AMP	8	I/conn(Dashboard harness-T/M harness)	S816-008002	S816-108002
CN-11	AMP	12	I/conn(Dashboard harness-T/M harness)	S816-012002	S816-112002
CN-12	KET	3	Rear support harness	S810-003201	-
CN-17	KET	6	Option	MG640515-4	-
CN-18	KET	2	Inching sensor	-	S814-102100
CN-19	KET	2	Output check	S814-002100	MG610320
CN-25	MOLEX	2	Horn	35825-0211	-
CN-36	-	2	Fuse box	F12890010	-
CN-45	RING TERM	2	Start motor	S820-308000	-
CN-48	KET	2	Hour meter	S822-014000	S822-114000
CN-50	AMP	68	Transmission control unit	963598-1	-
CN-51	AMP	6	Diagnostic	926682-3	-
CN-56	MOLEX	20	Operating panel	35109-2010	-
CN-58	KET	8	Detector(Indicator)	S810-008201	-
CN-60	-	2	Fusible link	21N4-01311	S813-130201
CN-62	-	6	Glow timer	S810-006202	-
CN-65	KET	2	Back buzzer	S822-014000	S822-114000
CN-74	KET	2	Alternator	MG640188-4	-
CN-79	SUMITOMO	1	Fuel shut off solenoid	6180-1181	-
CN-80	RING TERM	1	Glow plug	S820-204000	-
CN-95	AMP	2	Fusible link	21N4-01320	S813-130201
CN-112	ZF	16	Gearbox	21L7-60290	-
CN-119	KET	4	Transmission temperature gauge	S810-004201	-
CN-138	KET	3	Converter	S810-003201	-
Switch					
CS-2	KET	4	Start switch	S810-004201	-
CS-11	KET	4	Combination switch	S810-004201	-
CS-12	KET	3	Combination switch	S810-003201	-
CS-14	PACKARD	4	Gear selector switch	12010974	-
CS-15	PACKARD	4	Gear selector switch	12015797	-
CS-17	KET	3	Parking switch	S810-003201	-

Connector number	Type	No. of pin	Destination	Connector part No.	
				Female	Male
CS-23	SWF	10	Beacon lamp switch	593757	-
CS-41	SWF	10	Hazard switch	593757	-
CS-42	SWF	10	Inching switch	593757	-
CS-59	SWF	10	Auto manual switch	593757	-
CS-69	SWF	10	Rear work switch	593757	-
Lamp					
CL-15	KET	6	Combination lamp-LH	S814-006100	-
CL-16	KET	6	Combination lamp-RH	S814-006100	-
CL-21	KET	1	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-34	-	6	Parking relay	S810-006202	-
CR-35	KET	4	Back up relay	S810-004201	-
CR-36	-	6	Anti restart relay	S810-006202	-
CR-40	-	6	Illumination relay	S810-006202	-
Sensor and pressure switch					
CD-2	KET	3	Fuel sendor	S810-003201	-
CD-4	AMP	2	Brake switch	150656-1	-
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-27	AMP	2	Turbin speed sensor	963040-3	-
CD-29	-	2	T/M temperature sensor	21FF-10170	-
CD-71	AMP	6	Inching sensor	1-967616-1	-
CD-72	AMP	2	Gear train speed sensor	963040-3	-
CD-73	AMP	3	Output speed sensor	282087	-
CD-74	AMP	2	Engine speed sensor	963040-3	-
CD-75	AMP	2	Oil filter switch	282080	-

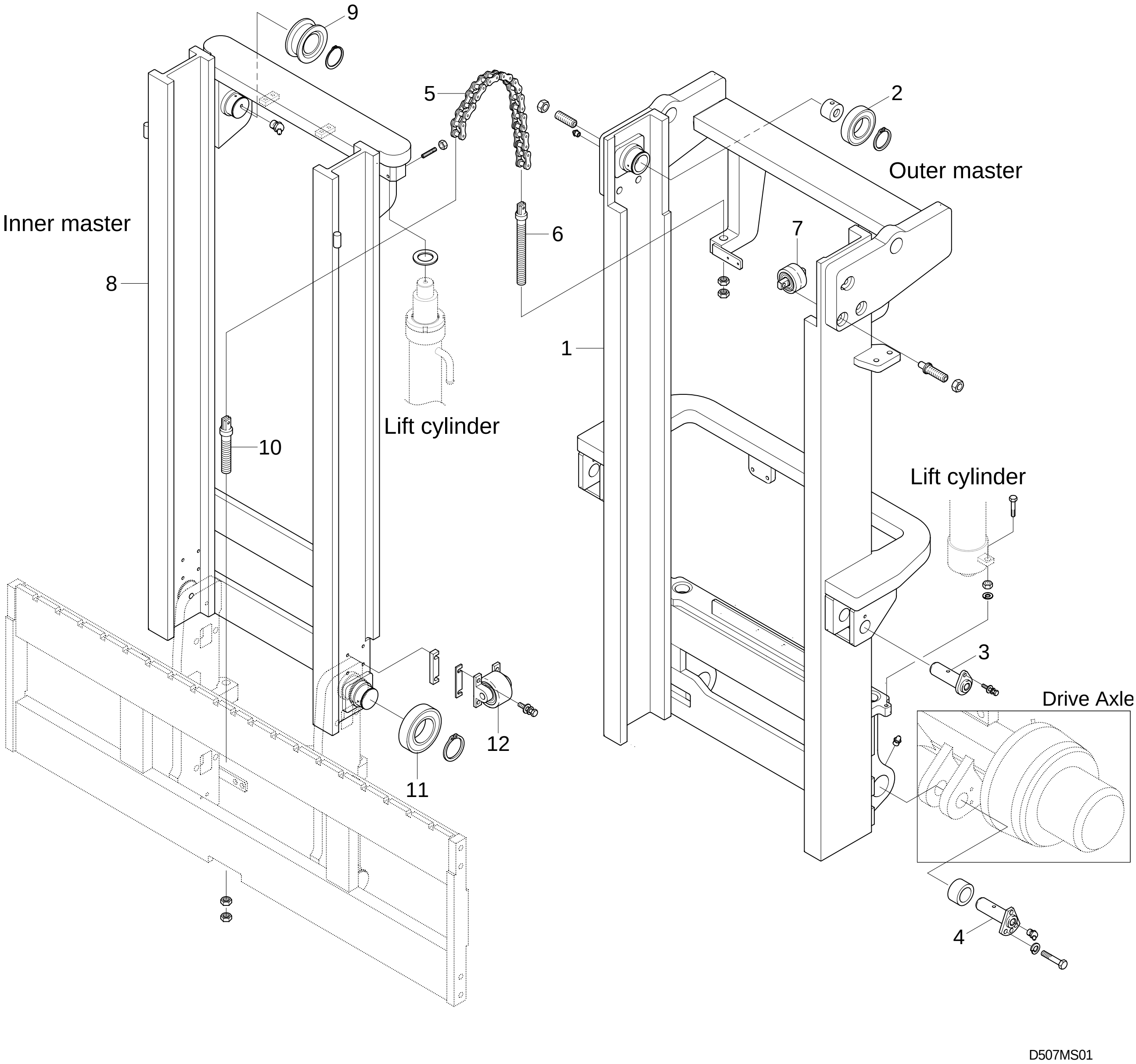
GROUP 5 TROUBLESHOOTING

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

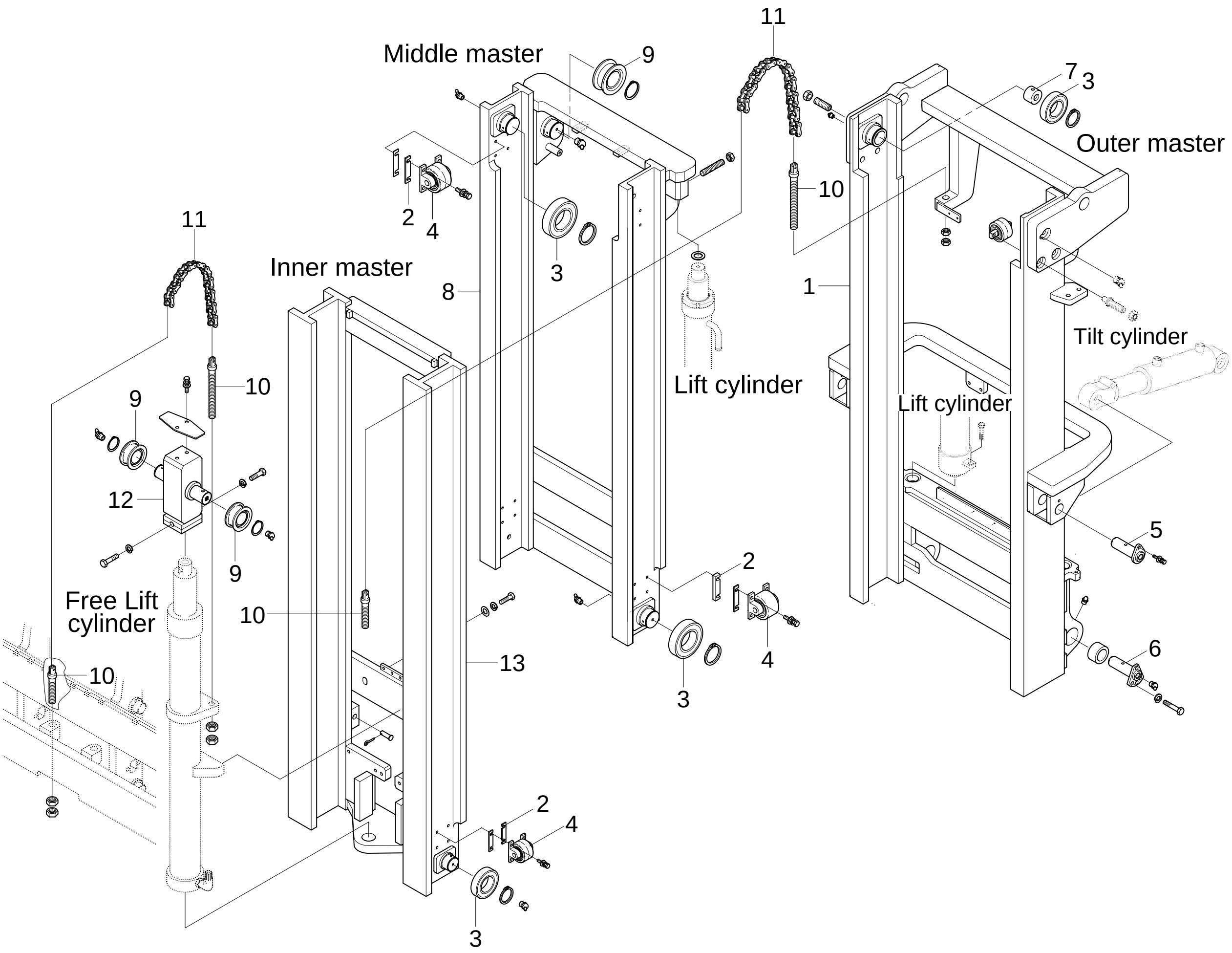
GROUP 1 STRUCTURE

1. 2 STAGE MAST(V MAST)



1	Outer mast	5	Lift chain	9	Chain sheave bearing
2	Roller bearing	6	Anchor bolt	10	Anchor bolt
3	Tilt cylinder pin	7	Side roller bearing	11	Roller bearing
4	Mast mounting pin	8	Inner mast	12	Side roller bearing

2. 3 STAGE MAST(TF MAST)

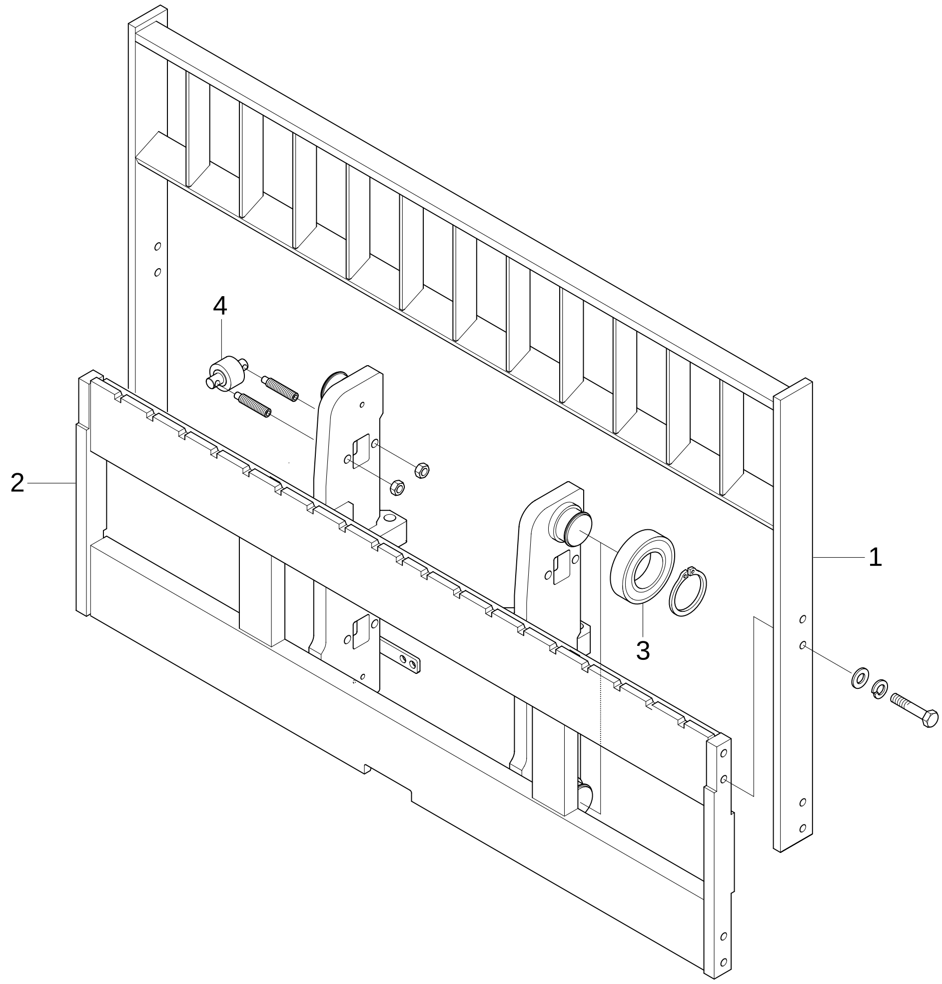


D507MS011

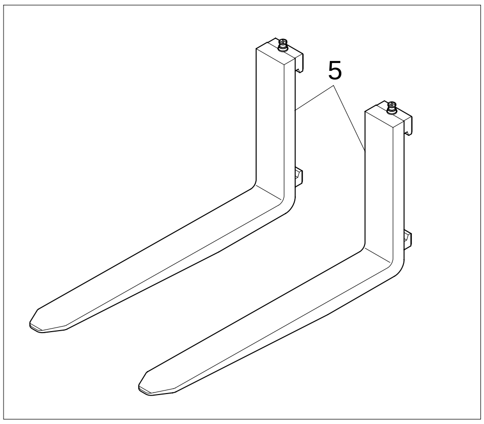
1	Outer mast	6	Mast mounting pin	11	Chain
2	Shim	7	Wear plug	12	Sheave bracket
3	Roller bearing	8	Middle mast	13	Inner mast
4	Side roller bearing	9	Sheave		
5	Tilt cylinder pin	10	Anchor bolt		

3. CARRIAGE, BACKREST AND FORK

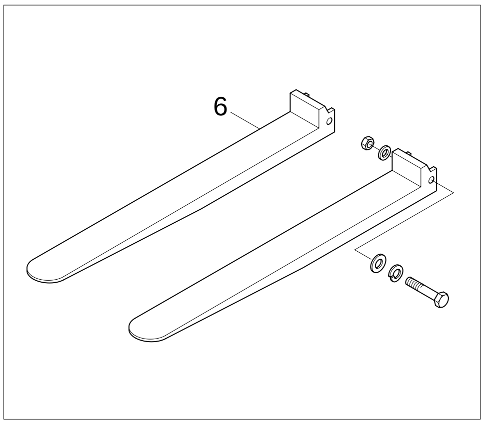
1) HOOK ON TYPE(STD)



Hook on type fork



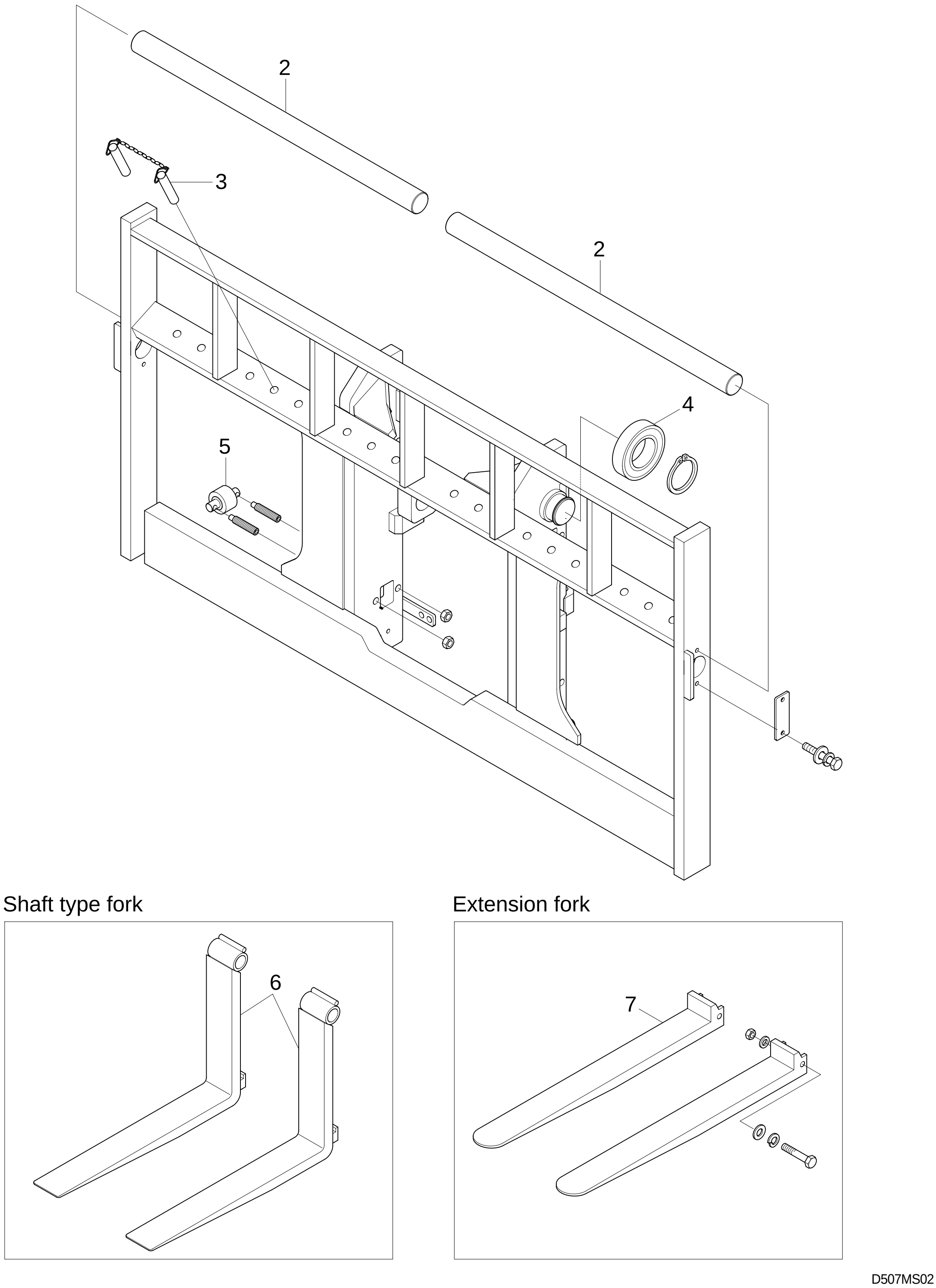
Extension fork



D507MS03

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

2) SHAFT TYPE(OPTION)



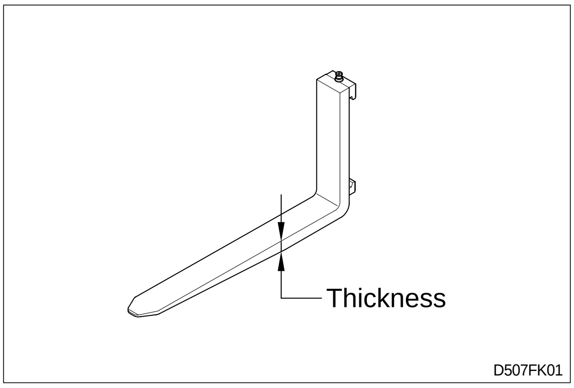
1	Carriage & backrest	5	Side roller
2	Hanger bar	6	Fork
3	Fork retaining	7	Extension fork
4	Roller		

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

1) FORKS

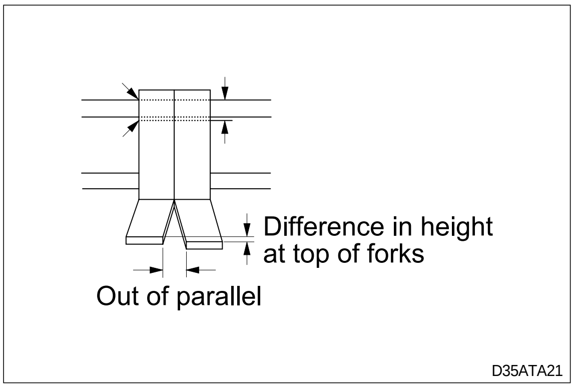
(1) Measure thickness of root of forks and check that it is more than specified value.
EX : l =1200mm(47in)



mm(in)

STD Fork assy	Applicable model	Standard	Limit
F14710011	HDF50-7S	60(2.4)	48(1.9)
F14710111	HDF70-7S	65(2.6)	53(2.1)

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



mm(in)

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

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

2. MAST

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

2. TROUBLESHOOTING

1) MAST

Problem	cause	Remedy
Forks fail to lower.	· Deformed mast or carriage.	· Disassemble, repair or replace.
Fork fails to elevate	· Faulty hydraulic equipment. · Deformed mast assembly.	· See troubleshooting hydraulic pump and cylinders in section 6, hydraulic system. · Disassemble mast and replace damag-ed 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 damag-ed 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 lower-ed.	· Broken load roller bearings. · Broken side roller bearings. · Deformed masts. · Bent lift cylinder rod. · Deformed carriage. · Broken sheave bearing.	· Replace. · Replace. · Disassemble, repair or replace. · Replace. · Replace. · Replace.
Abnormal noise is produced during tilting operation.	· Insufficient lubrication of anchor pin, or worn bushing and pin. · Bent tilt cylinder rod.	· Lubricate or replace. · Replace.

2) FORKS

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

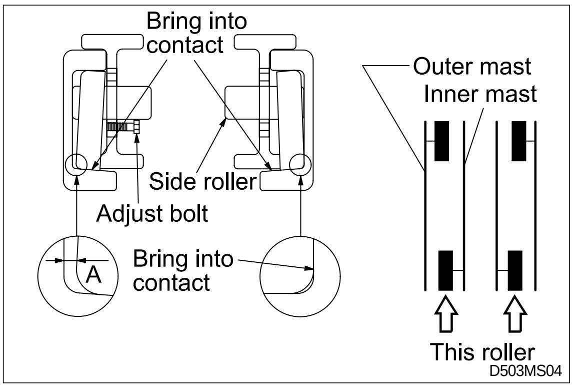
1. MAST LOAD ROLLER

1) INNER/OUTER MAST ROLLER CLEARANCE ADJUSTMENT

(1) Measure the clearance with the mast overlap at near 480mm(19in).

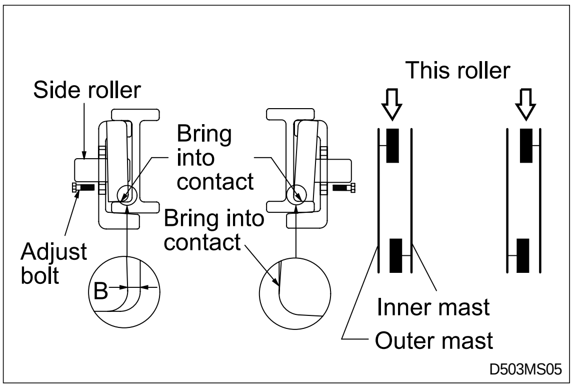
(2) Shift the inner mast to one side to bring the roller into contact with the outer mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by adjust bolt.

· Standard clearance A, B = 0~0.6mm



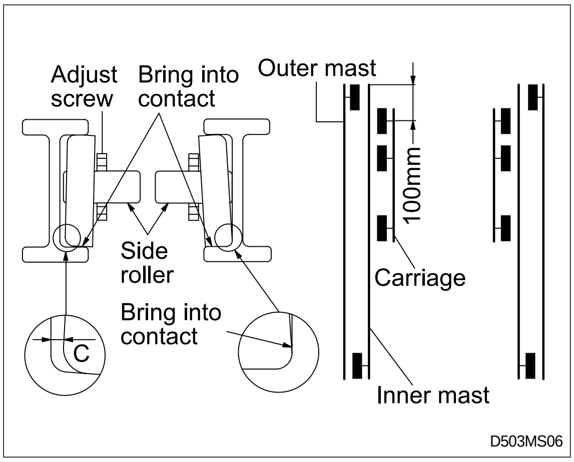
(3) Distribute the roller clearance equally to the left and right roller.

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



2) 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 adjust screw.

- Standard clearance C = 0~0.6mm

(3) Distribute the roller clearance equally to the left and right roller.

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

GROUP 4 REMOVAL AND INSTALLATION

1. FORKS

1) HOOK ON TYPE

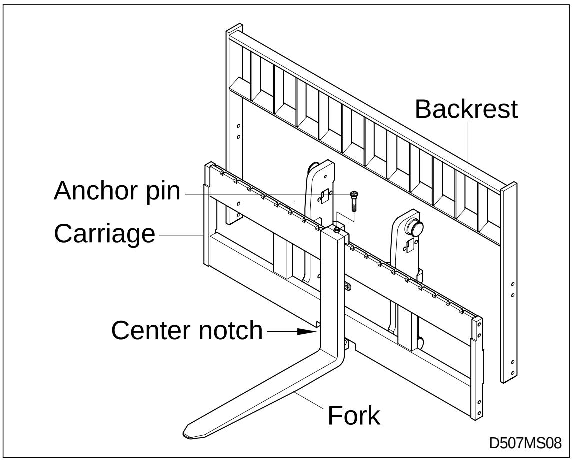
(1) Lower the fork carriage until the forks are approximately 25mm(1in) from the floor.

(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.

(4) Reverse the above procedure to install load forks.



2) SHAFT TYPE(Option)

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

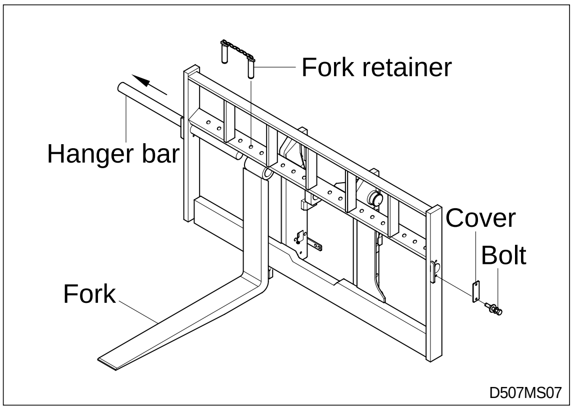
(2) Release fork retainer and remove cover.

(3) Slide one hanger bar at a time out of carriage assembly.

(4) Remove only one fork at a time.

※ On larger forks it may be necessary to use a block of wood.

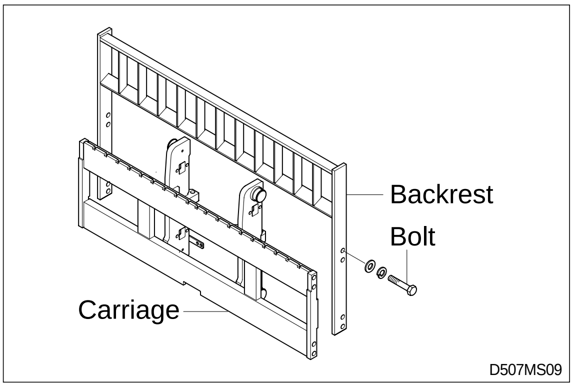
(5) Reverse the above procedure to install load forks.



2. BACKREST(Hook on type)

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 inner mast 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 removal paragraph.

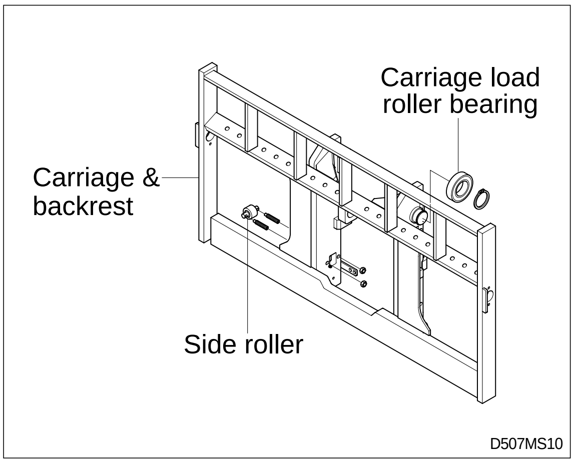
(2) Loosen and remove nuts, adjust screws and side rollers from carriage side plate.

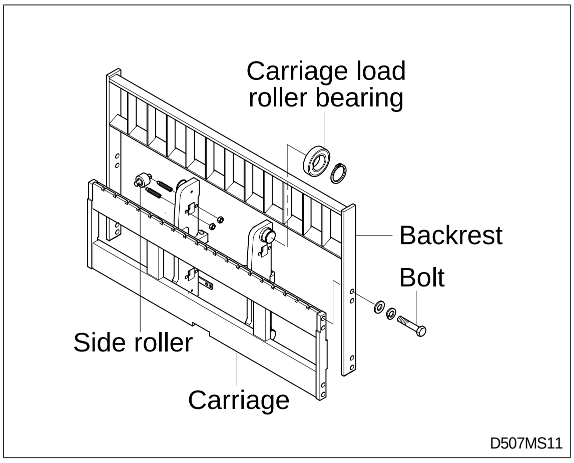
(3) Thoroughly clean, inspect and replace all worn or damaged parts.

(4) Reverse the above procedure to assembly.

※ **Adjustment**

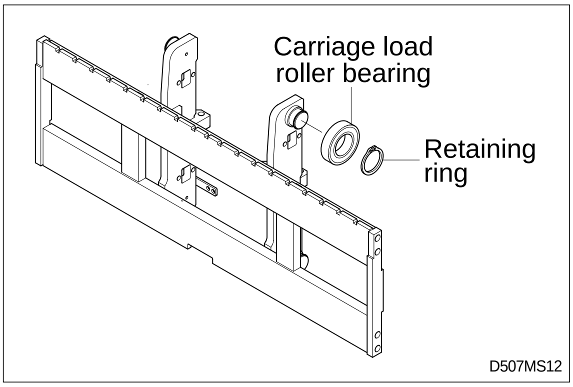
- Once carriage is properly installed, loosen nuts and adjust screws, (if not already done) allowing carriage to be centered in the inner mast.
- Adjust side roller by tightening screw until side roller just makes contact with mast. Back off approximately 1/10 turn on screw and tighten nut to lock screw in place.
- Run carriage up and down along 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 BEARING

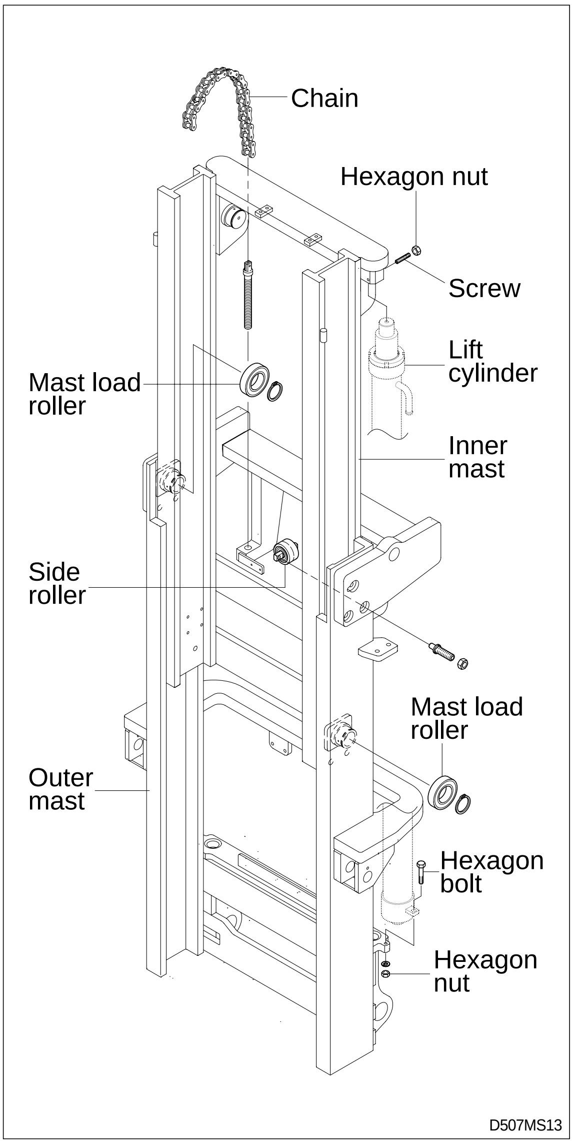
(1) Remove carriage as outlined in the carriage removal paragraph.
(2) Using the plier, remove retaining rings from load roller bearing bracket.
(3) Using a plier, remove load roller bearings from load roller bearing bracket.
(4) Reverse the above procedure to assemble. Refer to MAST ROLLER ADJUSTMENT paragraph.



4. MAST LOAD ROLLER

1) 2 STAGE MAST(V MAST)

(1) Remove the carriage assembly and move them to one side.
(2) Loosen and remove hexagon nuts and screws securing lift cylinders to inner mast.
(3) Loosen and remove hexagon bolts and nuts securing lift cylinders to outer 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) with ropes to the outer mast.
(6) Using the overhead hoist, lower inner mast until top and bottom rollers are exposed.
(7) Using a plier, remove load rollers from load roller bracket. Remove side rollers.
(8) Thoroughly clean, inspect and replace all worn or damaged parts.
(9) Reverse the above procedure to assemble. Refer to MAST ROLLER ADJUSTMENT paragraph.
(10) After completing all necessary steps for load rollers removal, use an overhead hoist to remove sling or chain around upper crossmember of the inner mast section. Lift inner mast upright straight up and out of outer mast section.
(11) Replace and reverse above procedure to install.
(12) Make all necessary measurements and adjustments.



2) 3 STAGE MAST(TF MAST)

(1) Remove the carriage assembly and move it to one side.

(2) Loosen and remove hexagon bolt securing bottom cylinder from outer mast.

(3) Loosen and remove set screws and nuts 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 4inch block of wood under the free lift cylinder bracket of the inner mast then lower mast sections(this will create slack in the chains).

(7) Remove retaining rings securing chain sheaves to sheave support brackets while supporting chains, remove chain sheaves and let chains hang free.

The upper outer and lower middle mast rollers and back up liners are now exposed.

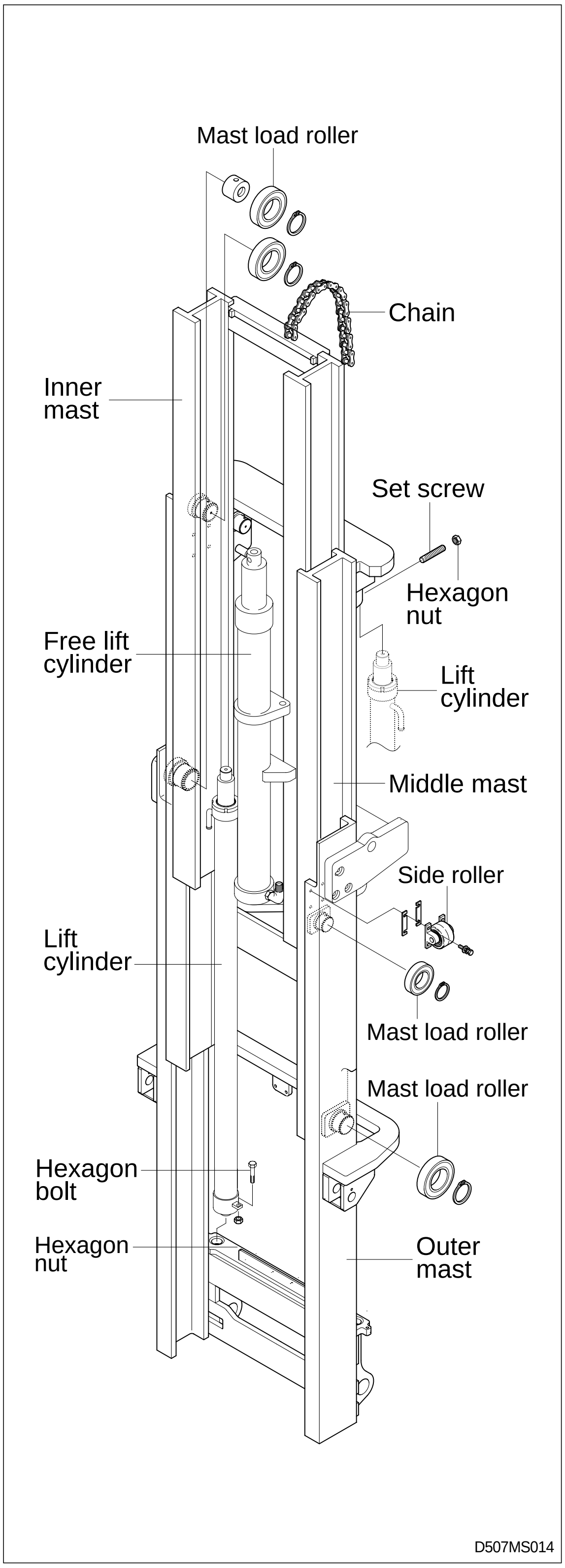
(8) Using a plier, remove load rollers from load bracket. Remove side rollers from mast.

(9) Attach chains or sling to the middle mast section at top crossmember. Using an overhead hoist, slowly raise the middle mast until top and bottom rollers are exposed.

(10) Using a plier, remove load rollers from roller bracket.

(11) Thoroughly clean, inspect and replace all worn or damaged parts.

(12) Reverse the above procedure to assemble. Refer to MAST LOAD ROLLER ADJUSTMENT Paragraph.



5. CHAIN

1) CHAIN SHEAVE

(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.

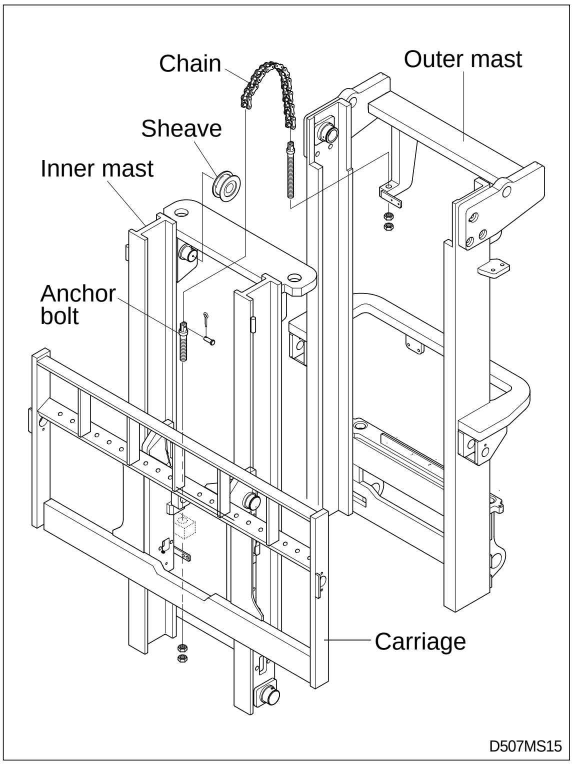
(2) Remove the split pin securing the chain anchor pins and discard. While supporting the chains, remove the chain anchor pins and drape the chain over the carriage.

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

(4) Remove bearing retaining ring from sheave and press bearings from sheaves.

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

(6) Reverse the above to assemble and install. Use new split pins in chain anchor pins.



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.

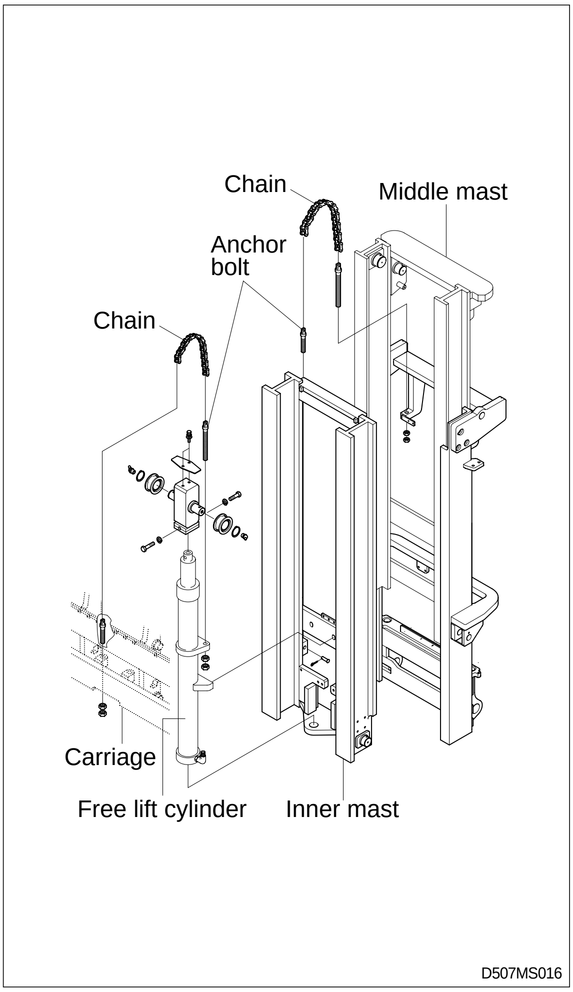
(3) Remove chains.

(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.



3) Sheave support(TF mast)

(1) Remove the carriage assembly and move to one side.
(2) After removing bolt to securing sheave support assembly to free lift cylinder.
Attach a sling to the sheave 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 sheave to sheave support.
(4) Remove bearing retaining ring from sheave and press bearings from sheaves.
(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 sheaves, 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 out the worn section and splicing in a new piece. If part of the chain is worn, replace all the chains on the truck.

(2) Rust and corrosion

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

(3) Cracked plate

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

(4) Tight joints

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

Tight joints in lift chains can be caused by :

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

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

(5) Protruding or turned pins

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

(6) Chain side wear

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

(7) Chain anchors and sheaves

An inspection of the chain system includes a close examination of chain anchors and sheaves. 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. Sheaves with badly worn flanges and outside diameter should be replaced. Heavy flange wear indicates chain misalignment.

(8) Chain wear scale

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

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

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

7) Load chain lubrication and adjustment

(1) Lubrication

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

- Wipe off the old oil with a clean cloth and blow out the remaining dirt with compressed air.

⚠ **Wear eye protection.**

- With a clean brush, apply EP-140 extreme pressure lubricant or heavy motor oil(40W).

(2) Replacement

Replace chains as a pair. It will be virtually impossible to maintain uniform loading between the strands if a new chain is put into service opposite an old chain. The jonts in the old chain will be greater than that on the new chain, greatly complicating the problem of maintaining equal chain tension. The new chain will wear more slowly causing it to bear the major portion of the load resulting in premature wear and fatigue failure. Don’t steam clean or decrease new chains.

The manufacturer’s grease is effective in reducing wear and corrosion. If the original factory lube is dried out or wiped off, soak the new chain in heavy engine oil for at 1/2 hour prior to installing on truck. After the old chains have been stripped from the mast, very carefully inspect chain anchors and sheaves. 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

S6S-Y3T61HF S6S-Y3T62HF

for HYUNDAI HEAVY INDUSTRIES CO.,LTD.

Pub. No. 99616-25000

SERVICE MANUAL

MITSUBISHI DIESEL ENGINES

S6S-Y3T61HF
S6S-Y3T62HF

for HYUNDAI HEAVY INDUSTRIES CO.,LTD.

August 2008

MITSUBISHI
HEAVY INDUSTRIES, LTD.

Printed in Japan

Pub. No. 99616-25000

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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.

Pub.No. 99616-25000

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.

DANGER

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

WARNING

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

CAUTION

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

CAUTION

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.

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/cm^2
- 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 cmH_2O (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.

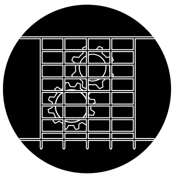
Keep a first-aid kit at the designated place where it is easily accessible by anyone at any time.

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.

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.

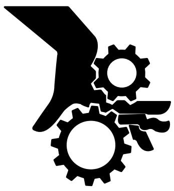
Never remove protective covers.

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

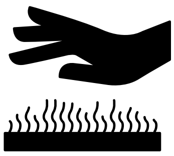
Do not forget to remove the tools which have been used for turning the engine during inspection or servicing, after the procedure is finished. Remember also that the turning gear must be returned to the operating condition before starting the engine.

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.

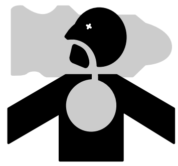
Never remove heat shields

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

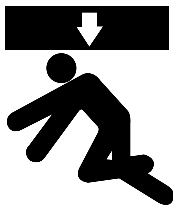
Wear ear plugs

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

⚠ 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.

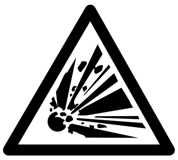
Proper disposal of waste oil and coolant (LLC)

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.

⚠ 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.

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.

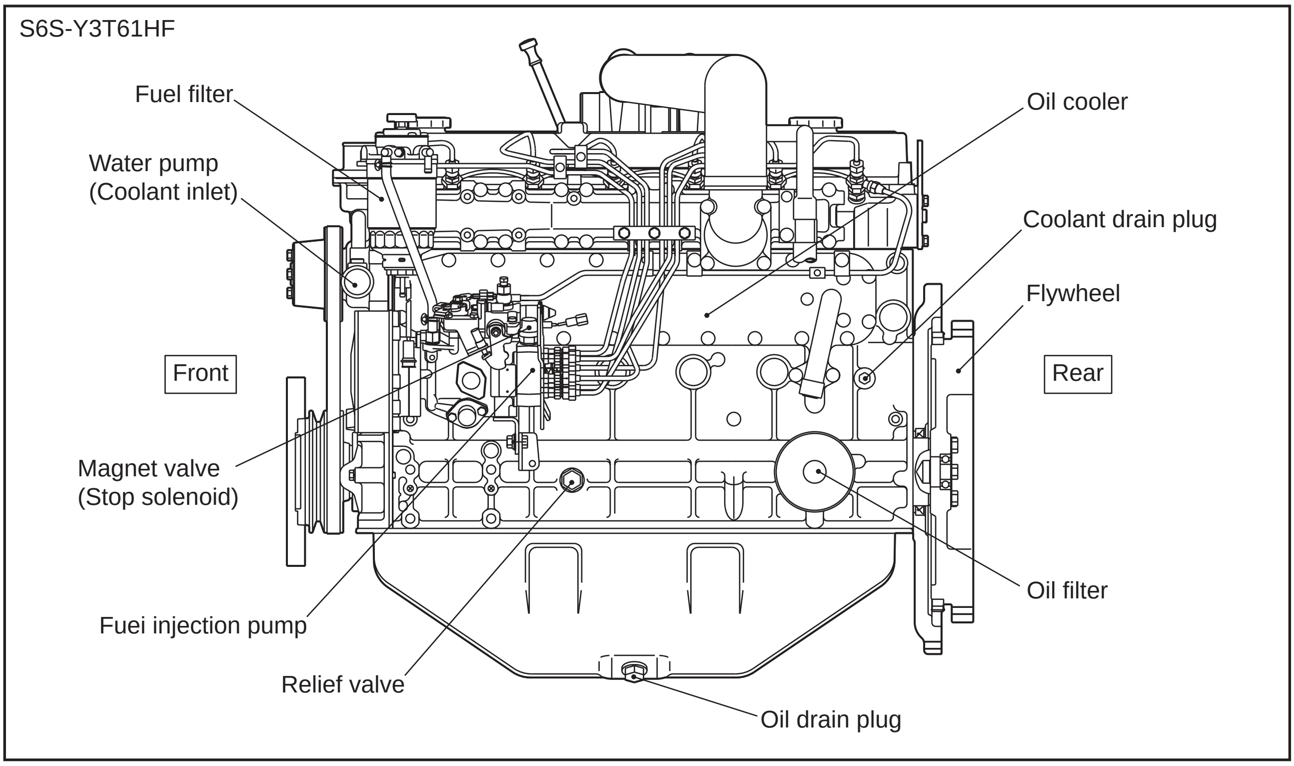
If any engine part on which a warning label is attached is replaced with a new one, attach a new identical warning label to the new part.

Warning labels

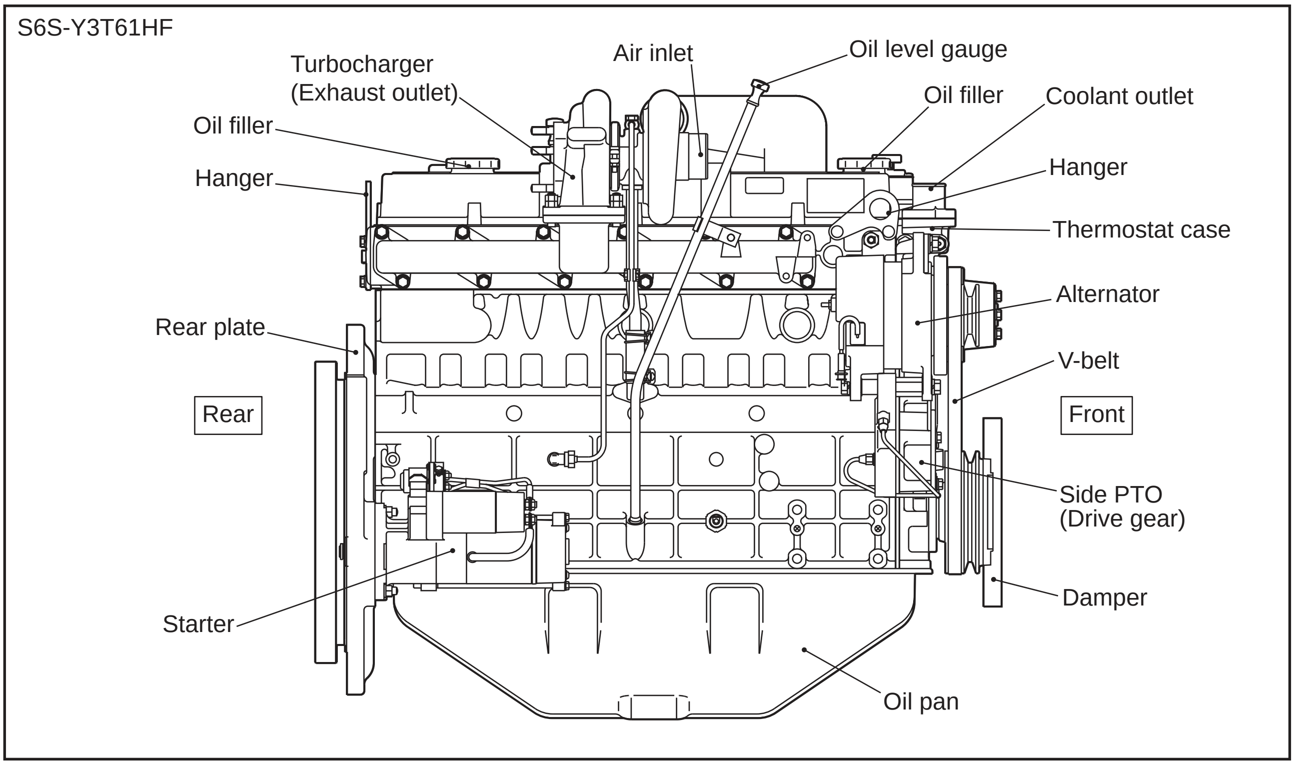
GENERAL CONTENTS

GENERAL

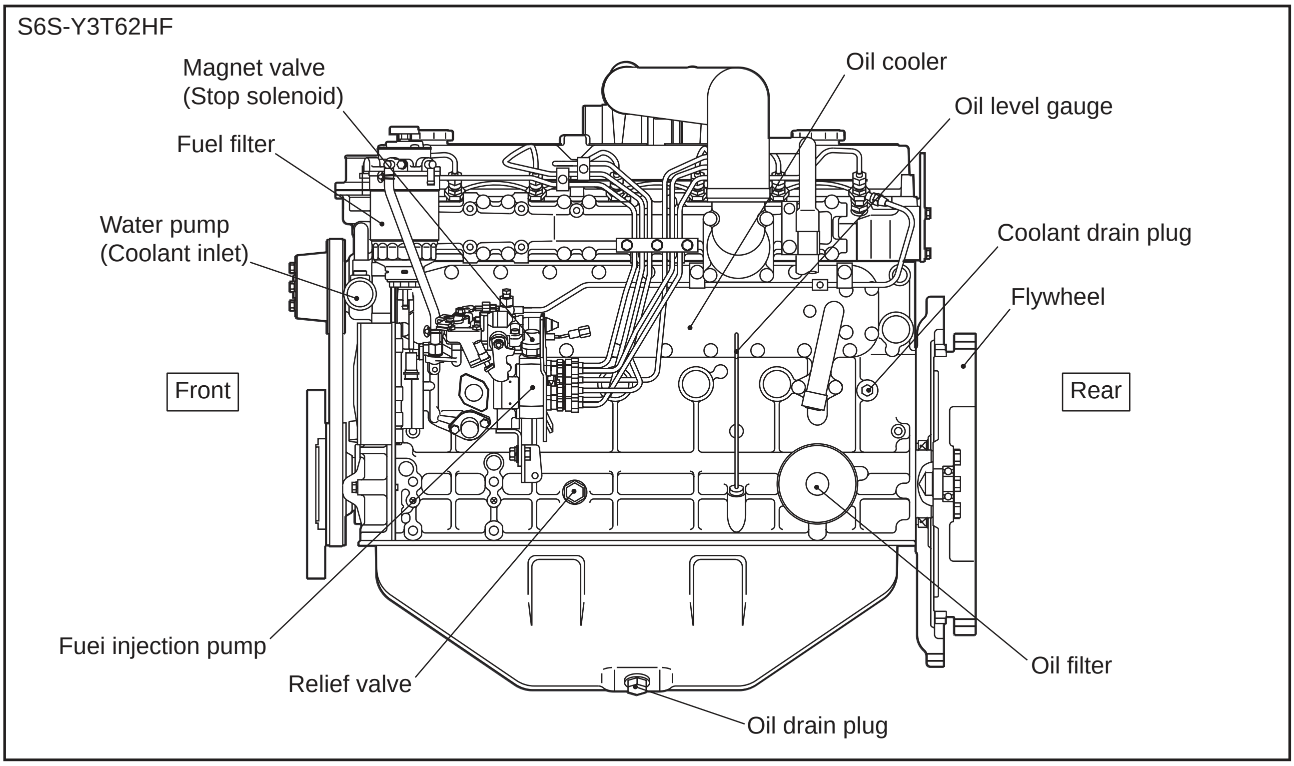
1. External view



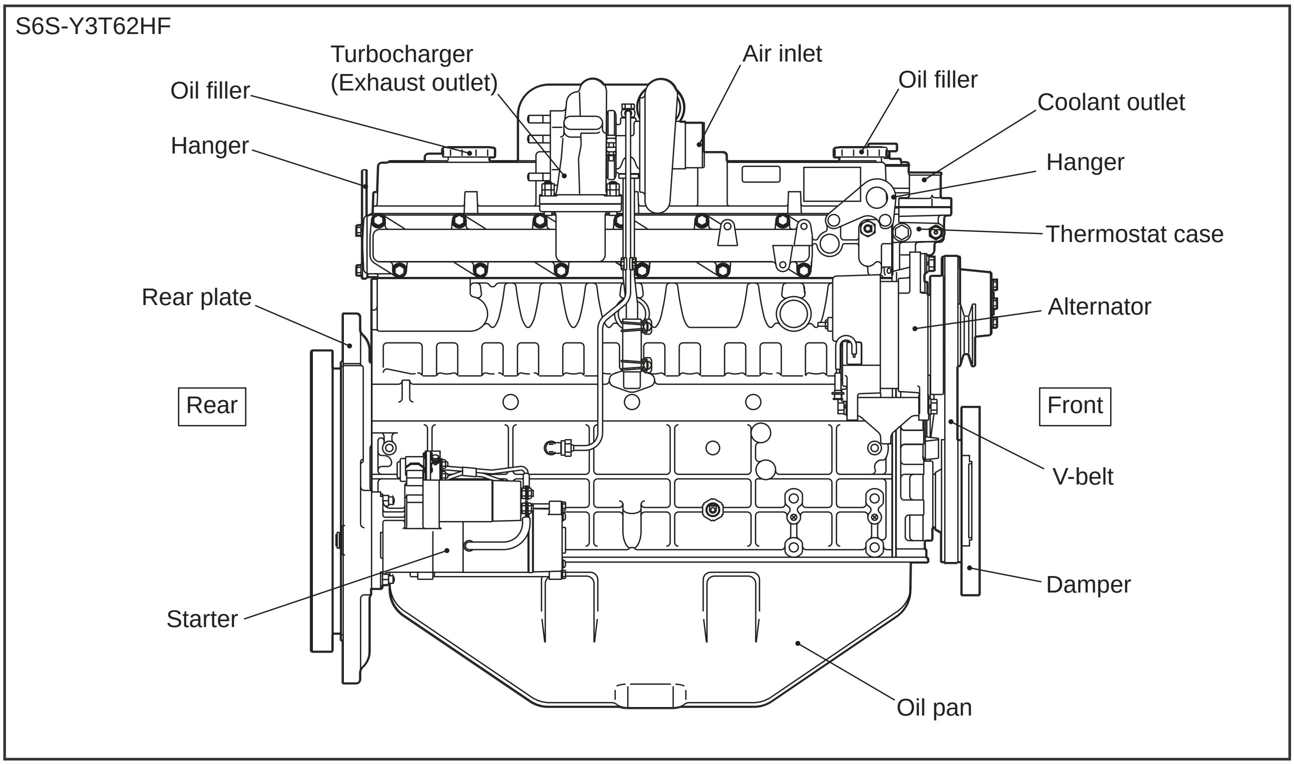
Engine left view



Engine right view



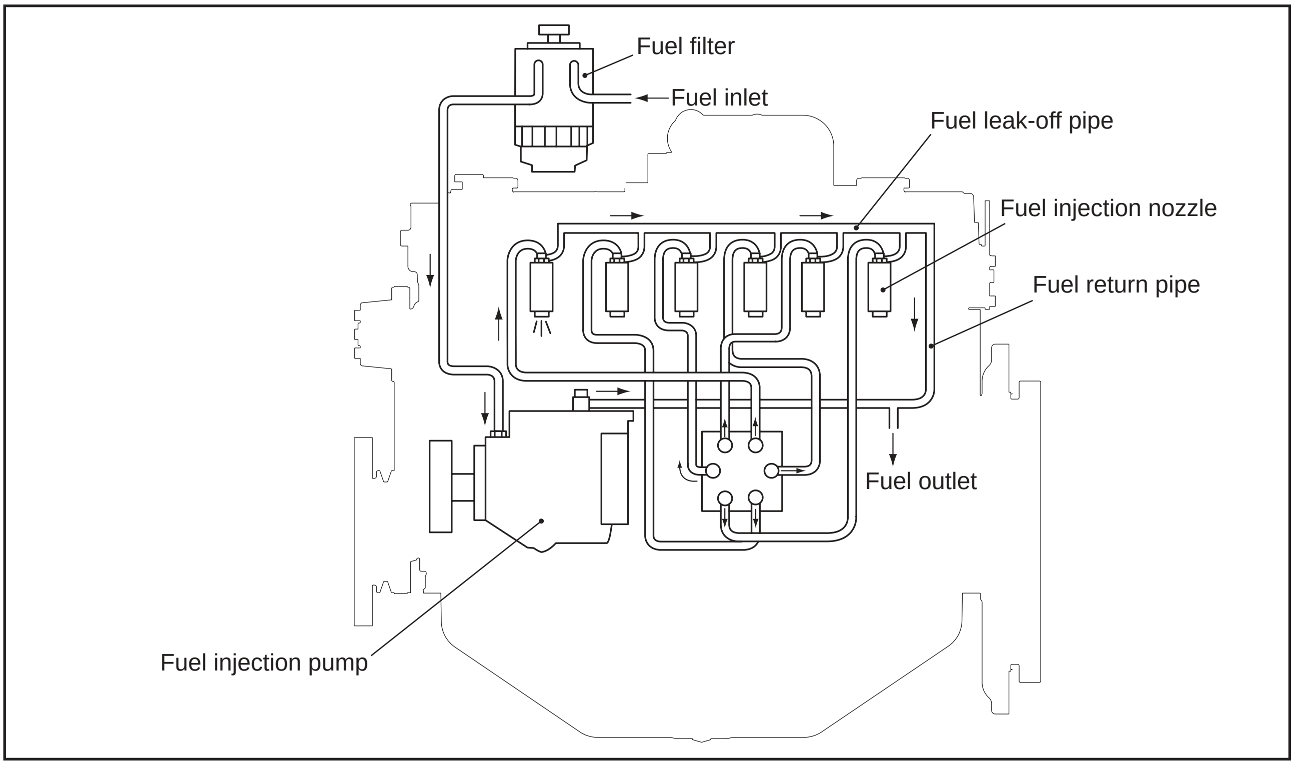
Engine left view



Engine right view

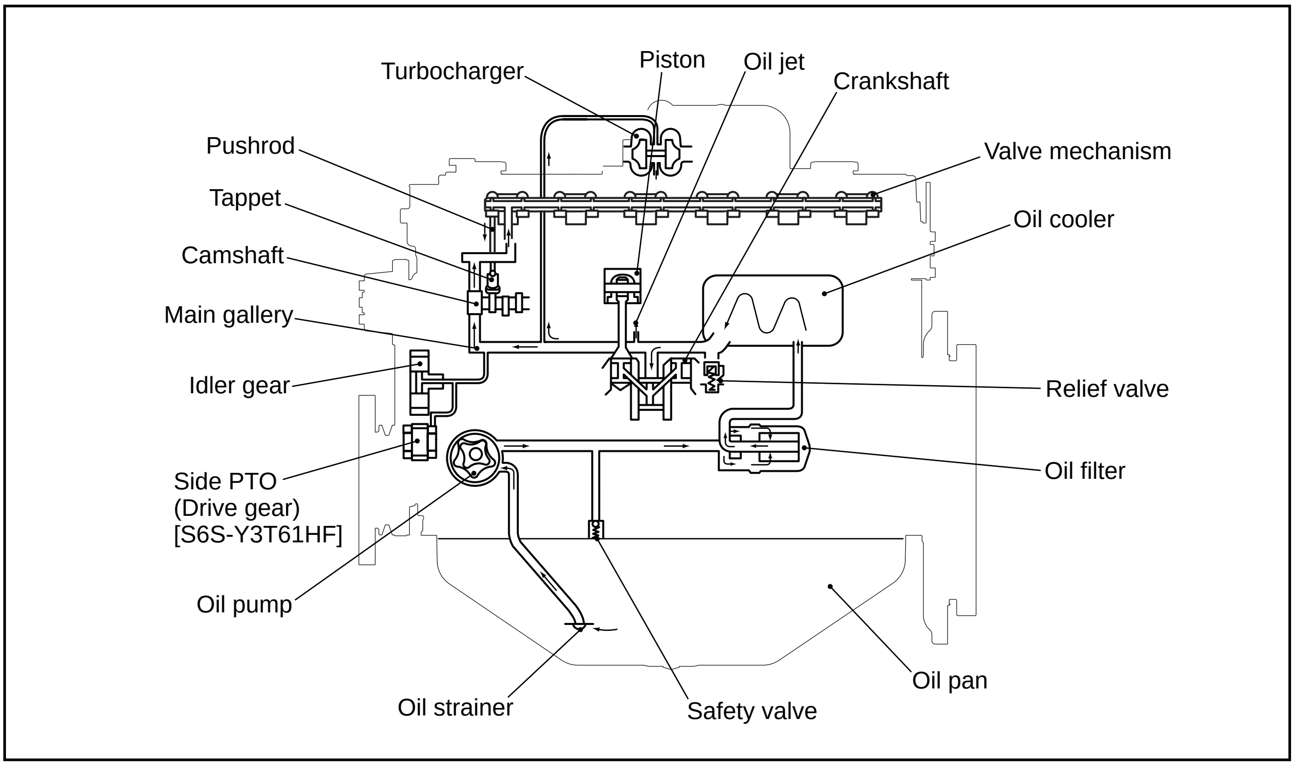
2. System flow diagrams

2.1 Fuel system - flow diagram



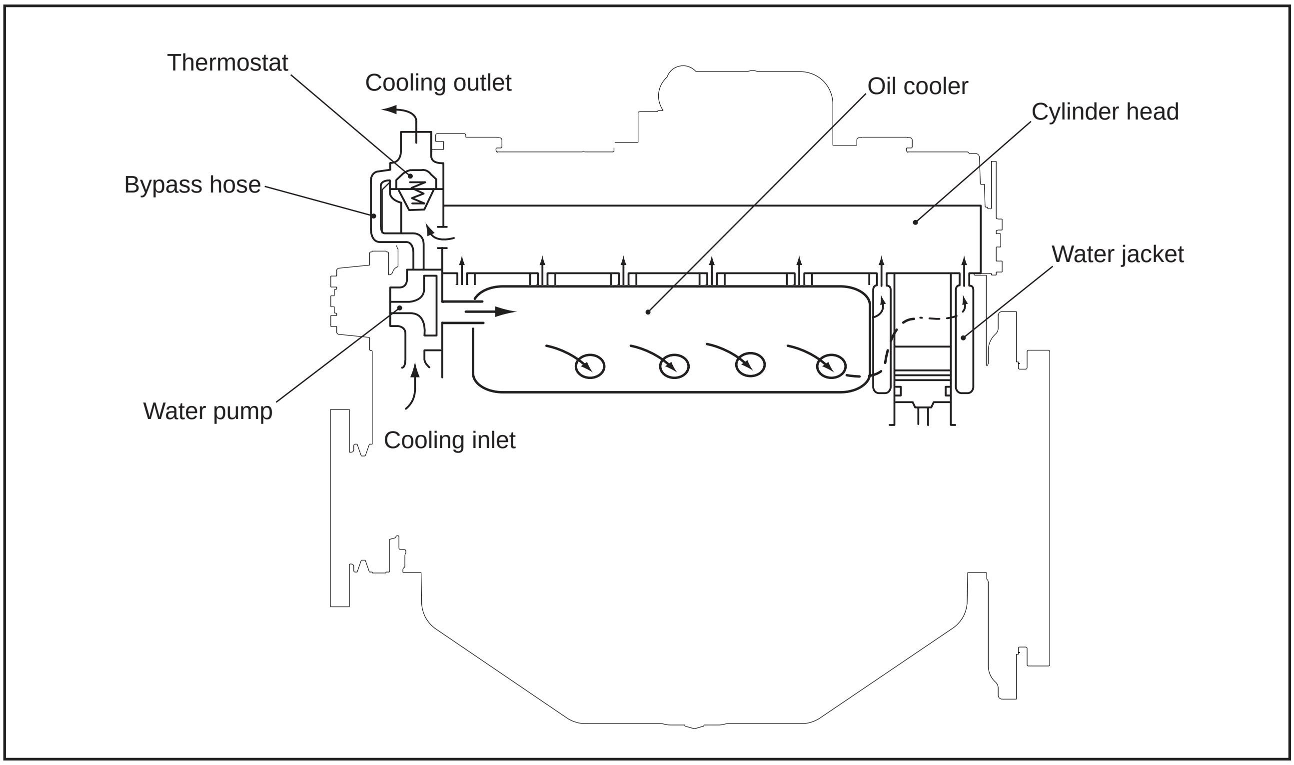
Fuel system - flow diagram

2.2 Lubrication system - flow diagram



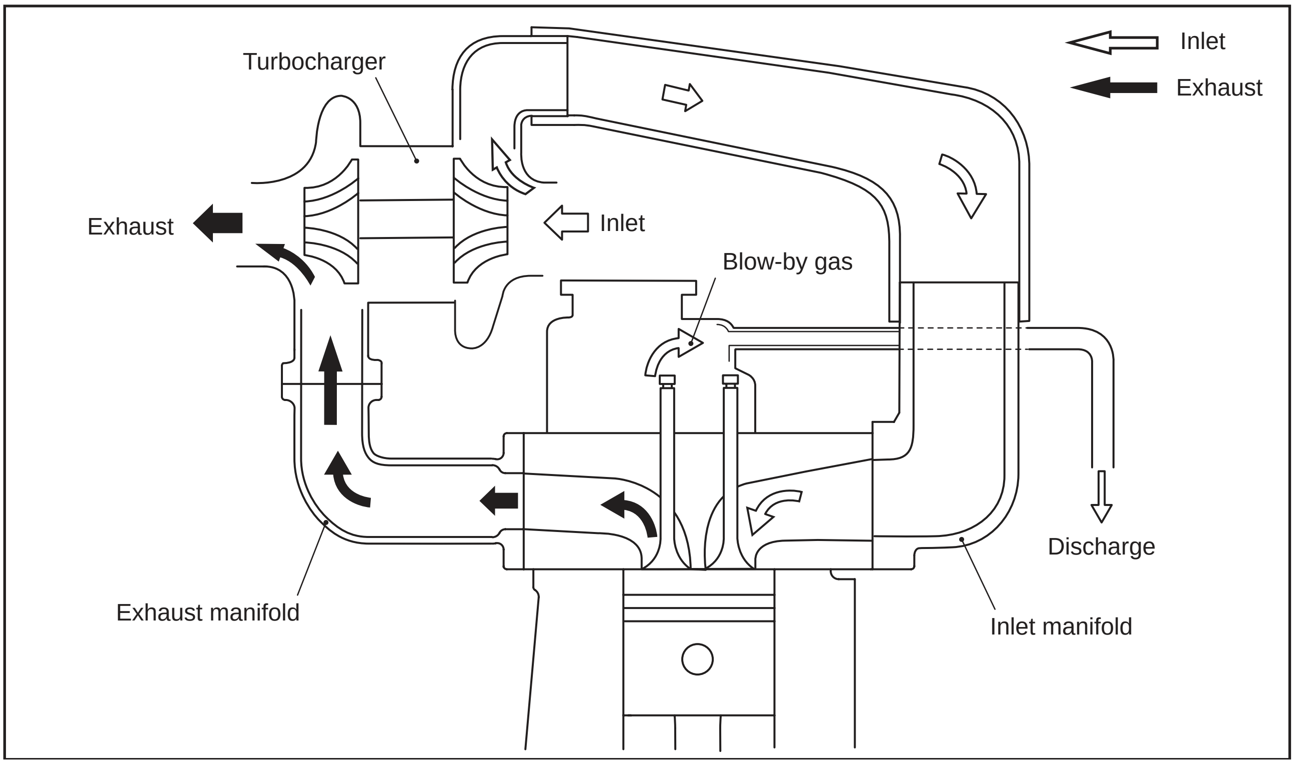
Lubrication system - flow diagram

2.3 Cooling system - flow diagram



Cooling system - flow diagram

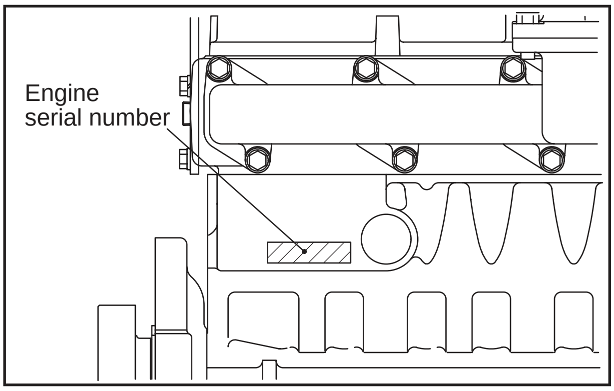
2.4 Inlet and exhaust system - flow diagram



Inlet and exhaust system - flow diagram

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	

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/cm²} [42.67 psi])	
	Relief valve	Type	Piston valve type	
		Valve opening pressure	0.35 ± 0.05 MPa {3.5 ± 0.5 kgf/cm²} [49.78 ± 7.11 psi]	
	Safety valve	Opening pressure	1.1 MPa {11 kgf/cm²} [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/cm²} [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)

<table>
<tr><th colspan="3">Engine model</th><th>S6S-Y3T61HF</th><th>S6S-Y3T62HF</th></tr>
<tr><td rowspan="19">Electrical system</td><td colspan="2">Voltage - polarity</td><td colspan="2">24V - negative (-) ground</td></tr>
<tr><td rowspan="5">Starter</td><td>Model number</td><td colspan="2">M008T60373</td></tr>
<tr><td>Pinion meshing type</td><td colspan="2">Pinion shift</td></tr>
<tr><td>Output</td><td colspan="2">24 V - 5 kW</td></tr>
<tr><td>Qty</td><td colspan="2">1</td></tr>
<tr><td>Ring gear and pinion ratio</td><td colspan="2">10/122</td></tr>
<tr><td rowspan="6">Alternator</td><td>Type</td><td colspan="2">3-phase alternating current, with rectifier</td></tr>
<tr><td>Output</td><td colspan="2">24 V - 35 A</td></tr>
<tr><td>Speed in use</td><td colspan="2">to 8000 min^{-1}</td></tr>
<tr><td>Rated generating speed</td><td colspan="2">5000 min^{-1}</td></tr>
<tr><td>Permissible speed</td><td colspan="2">10000 min^{-1}</td></tr>
<tr><td>Speed ratio to crankshaft</td><td colspan="2">1.85</td></tr>
<tr><td rowspan="2">Glow plug</td><td>Type</td><td colspan="2">Electric</td></tr>
<tr><td>Rated voltage - current</td><td colspan="2">22 V - 4.4 A (15-second duration)</td></tr>
<tr><td rowspan="5">Magnetic valve
(Stop solenoid)</td><td>Rated voltage</td><td colspan="2">24 V</td></tr>
<tr><td>Power consumption</td><td colspan="2">14 W</td></tr>
<tr><td>Starting voltage</td><td colspan="2">13 V or below</td></tr>
<tr><td>Return voltage</td><td colspan="2">5 V or more</td></tr>
<tr><td>Coil resistance</td><td colspan="2">37 Ω</td></tr>
</table>

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.

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/cm²} [469 psi] or more	2.8 MPa {29 kgf/cm²} [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/cm²} [43 to 71 psi]	0.15 MPa {1.5 kgf/cm²} [21 psi] or less	Oil temperature at 60 to 70°C [140 to 158°F]
	Idling speed			0.10 MPa {1.0 kgf/cm²} [14 psi] or more	0.05 MPa {0.5 kgf/cm²} [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.]

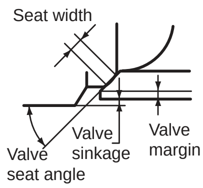
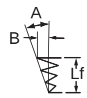
Inspection point			Nominal	Standard	Limit	Remark
Rocker	Rocker bushing inside diameter		ø 19 [0.75]	19.010 to 19.030 [0.7484 to 0.7492]		
	Rocker shaft outside diameter		ø 19 [0.75]	18.980 to 19.000 [0.7472 to 0.7480]		
	Clearance between rocker bushing and shaft			0.010 to 0.050 [0.0004 to 0.0020]	0.070 [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 gaule 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		
	Cylindricality			0.015 [0.0006] or less		

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 replac-ing the piston rings until reach-ing 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 connect-ing 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-gring 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 assem-bly 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]	

Table 2-2 Maintenance service data table - Basic engine (3 / 4) Unit: mm [in.]

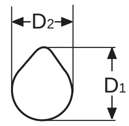
Inspection point			Nominal	Standard	Limit	Remark
Camshaft	Runout			0.04 [0.0016] or less	0.10 [0.0039]	TIR
	Cam lift	Inlet	6.682 [0.2631]	6.382 to 6.782 [0.2513 to 0.2670]	6.182 [0.2434]	
		Exhaust	6.722 [0.2646]	6.422 to 6.822 [0.2528 to 0.2686]	6.222 [0.2450]	
	Journal outside diameter	No. 1, 2, 3	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]	
	Cylindericity 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 following oversize thrust plates; +0.25 [+0.0098], +0.50 [+0.0197], +0.75 [+0.0295]

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 crank-shaft journal		0.050 to 0.110 [0.0020 to 0.0043]	0.200 [0.0079] crank journal outside diameter (ø 78 [3.0709]) -0.9 [-0.0354]	Replace bearings before limit is reached. Regrind 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/cm²} [1707 psi]	11.77 to 12.75 MPa {120 to 130 kgf/cm²} [1707 to 1849 psi]		Make shim adjustment. Pressure varies by 1 MPa {10 kgf/cm²} [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/cm²} [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)	ø 16 [0.63]	15.985 to 16.000 [0.6293 to 0.6299]		
	Main shaft outside diameter (between oil pump bushing)	ø 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/cm²} [51.20 psi]	0.35 ± 0.05 MPa {3.5 ± 0.5 kgf/cm²} [49.78 ± 7.11 psi]		
Safety valve	Valve opening pressure		1.1 MPa {11 kgf/cm²} [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]		

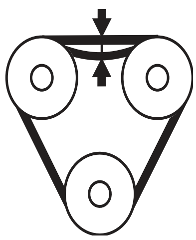
1.6 Inlet and exhaust system

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]		

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	

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

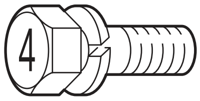
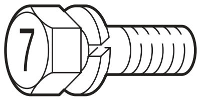
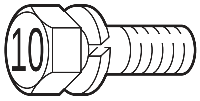
Table 2-13 Tightening torque table - Electrical system

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

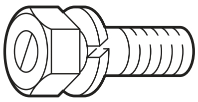
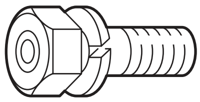
2.2.1 Metric automobile screw thread

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 ±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

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

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

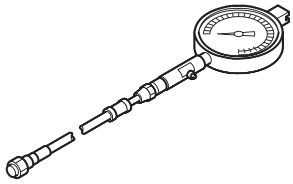
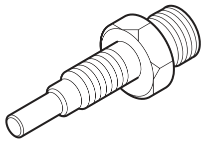
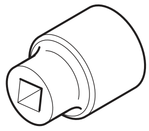
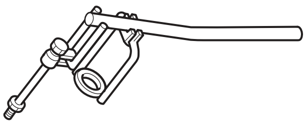
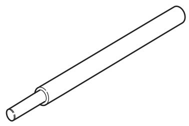
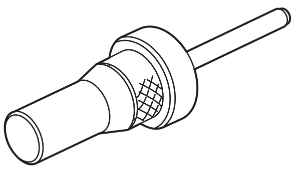
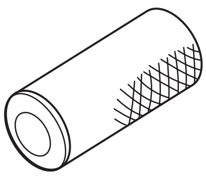
Tool name	Part No.	Shape	Use
Compression gauge	33391-02100		Engine compression pressure measuring 0 to 7 MPa {0 to 71.4 kgf/cm²} [0 to 1015.54 psi]
Gauge adapter	30691-21100		Engine compression pressure measuring
Socket	58309-73100		Engine turning
Valve spring pusher	30691-04500		Valve spring removal/installation
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)

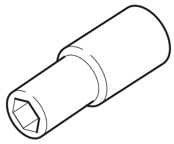
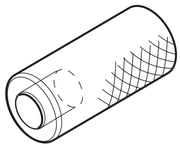
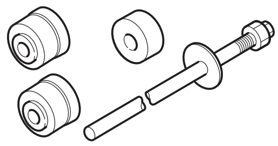
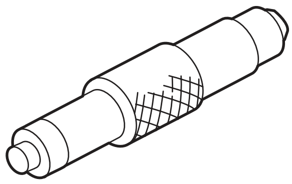
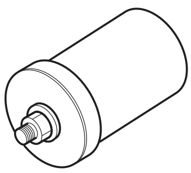
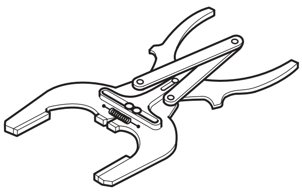
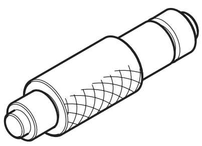
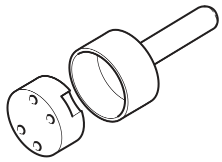
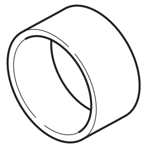
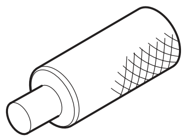
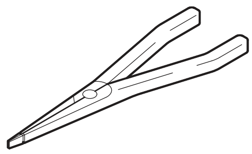
Tool name	Part No.	Shape	Use
Socket	34491-00300		Camshaft, thrust plate and rocker bracket installation
Valve guide installer	32A91-00100		Valve guide installation
Camshaft bushing installer set	30691-00010		Camshaft bushing removal/installation
Idler bushing installer	30091-07300		Idler bushing removal/installation
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

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

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.

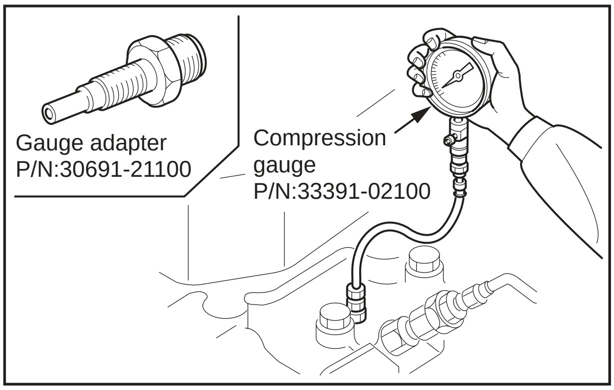
2. Testing compression pressure

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.

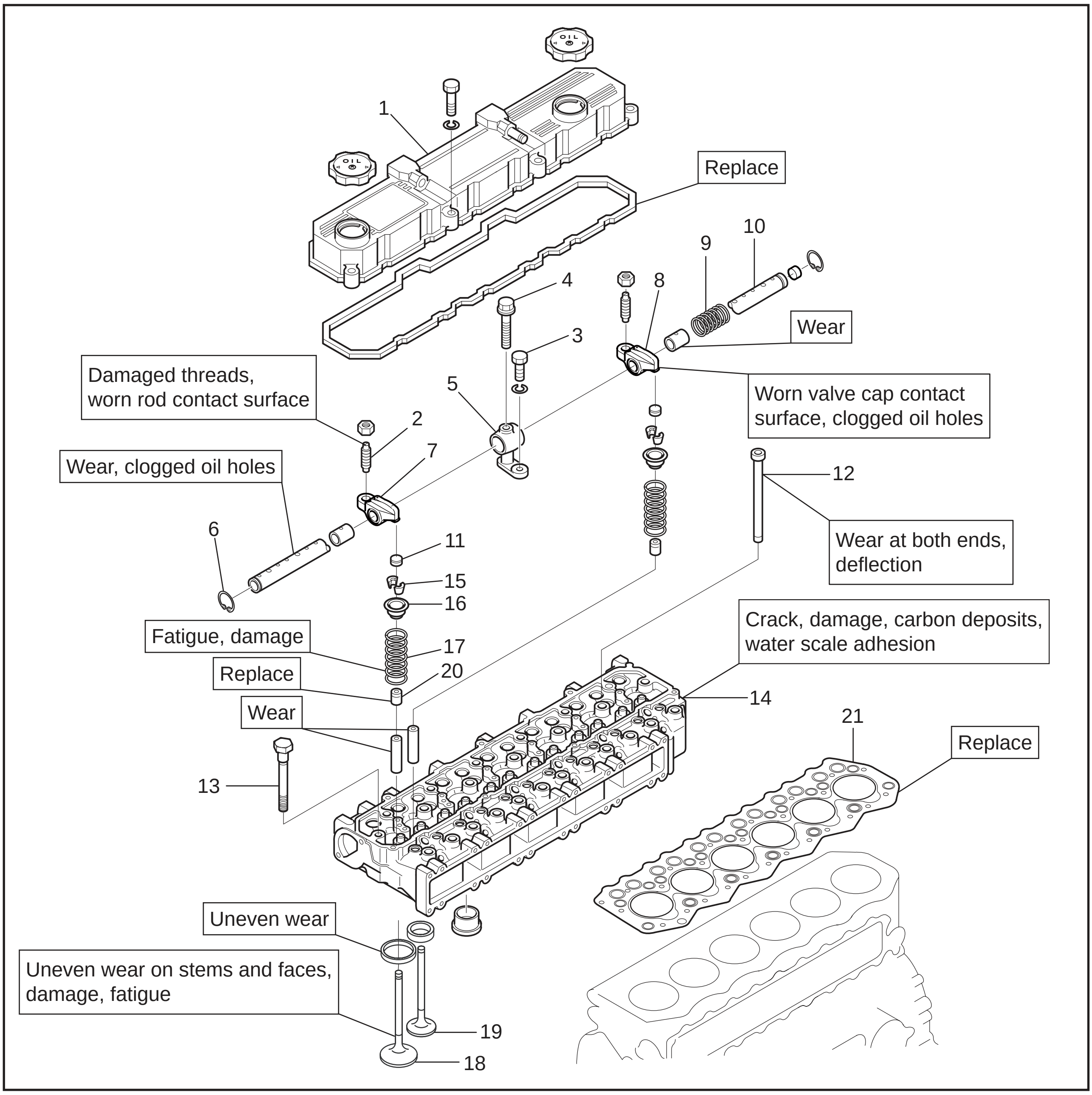
Item	Standard	Limit
Compression pressure	3.2 MPa {33 kgf/cm²} [469 psi] or more	2.8 MPa {29 kgf/cm²} [412 psi] or less
Engine speed	300 min^{-1}	-
Oil and water temperatures	20 to 30°C [68 to 86°F]	-



Testing compression pressure

DISASSEMBLY OF BASIC ENGINE

1. Disassembling and inspecting cylinder head and valve mechanism



Disassembling and inspecting cylinder head and valve mechanism

Disassembling sequence

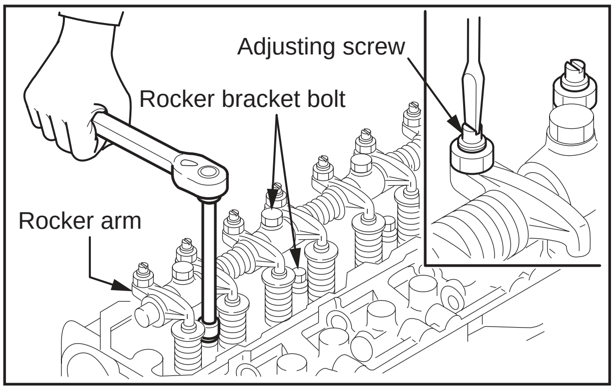
1 Rocker cover
2 Adjusting screw
3 Bolt (short)
4 Bolt (long)
5 Rocker shaft bracket
6 Snap ring
7 Rocker arm (IN)
8 Rocker arm (EX)
9 Rocker shaft spring
10 Rocker shaft
11 Valve cap
12 Push rod
13 Cylinder head bolt
14 Cylinder head
15 Valve cotter
16 Valve retainer
17 Valve spring
18 Valve (IN)
19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



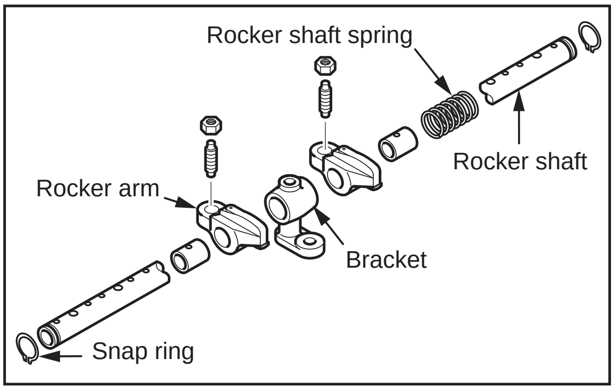
Removing rocker shaft assembly

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.

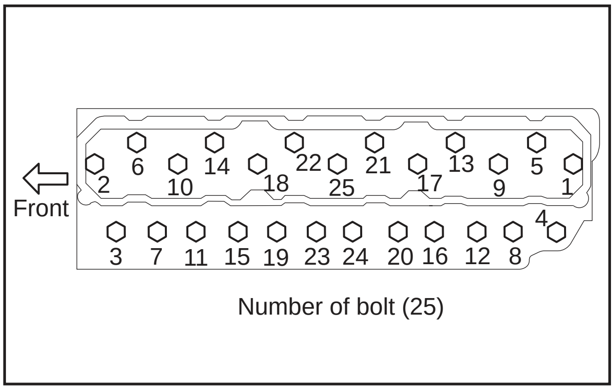
(b) Do not remove the rocker bushing if it is not faulty, and its inside diameter does not exceed the limit.



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

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.

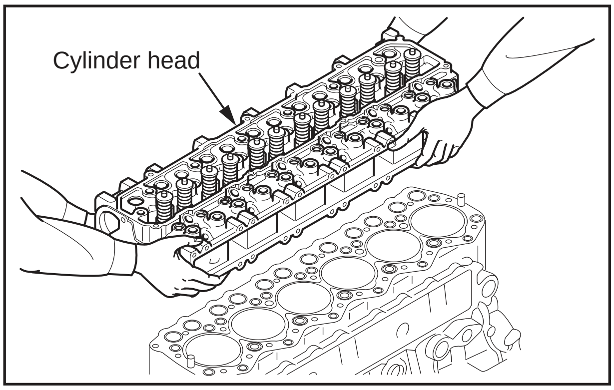
(1) Remove the cylinder head bolt.

(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.

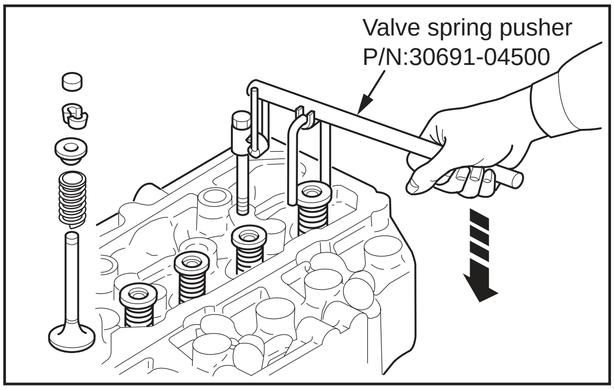


Removing cylinder head assembly

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.

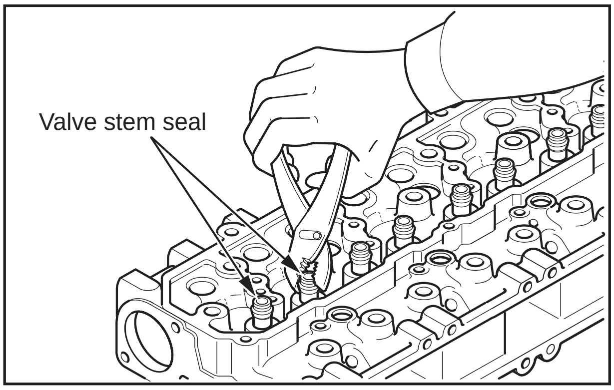


Removing valve and valve spring

1.6 Removing valve stem seal

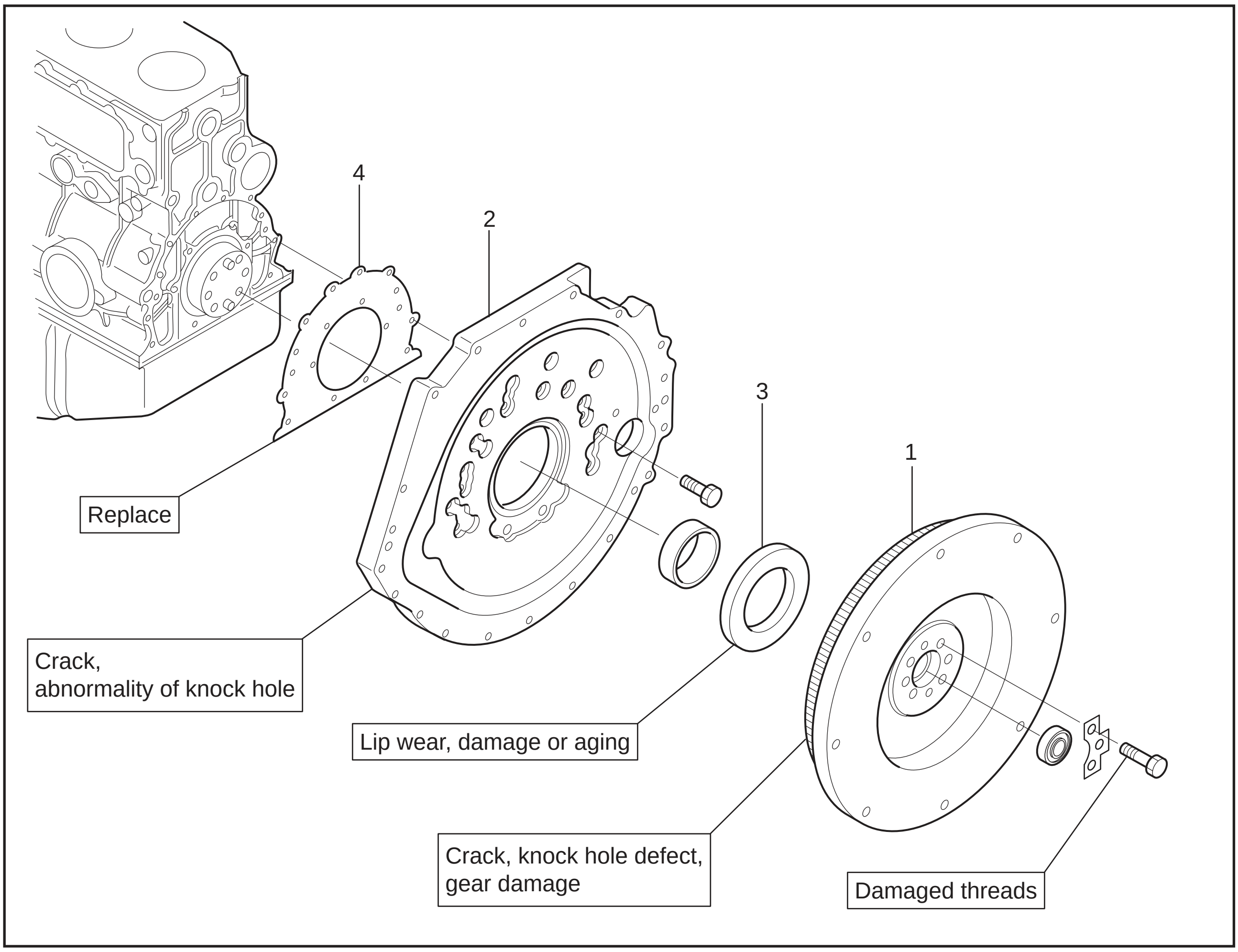
Grab the valve stem seal with pliers and remove.

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

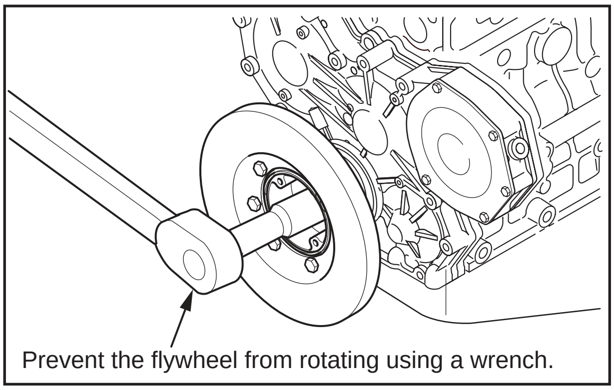
1 Flywheel 2 Rear plate 3 Oil seal 4 Gasket

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.



Locking the flywheel

(1) One personnel must firmly hold the pulley with a wrench to prevent the flywheel from turning.

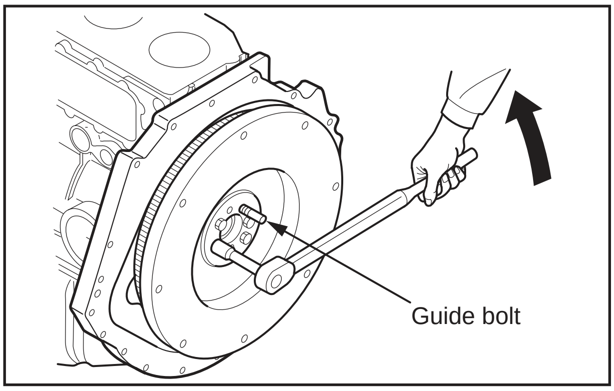
(2) Remove one bolt from the flywheel.

(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.



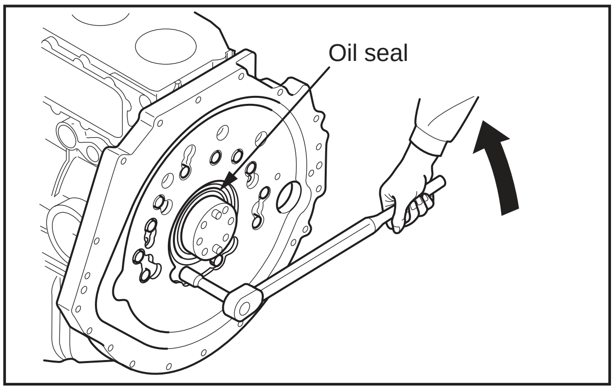
Removing flywheel

2.2 Removing rear plate

CAUTION

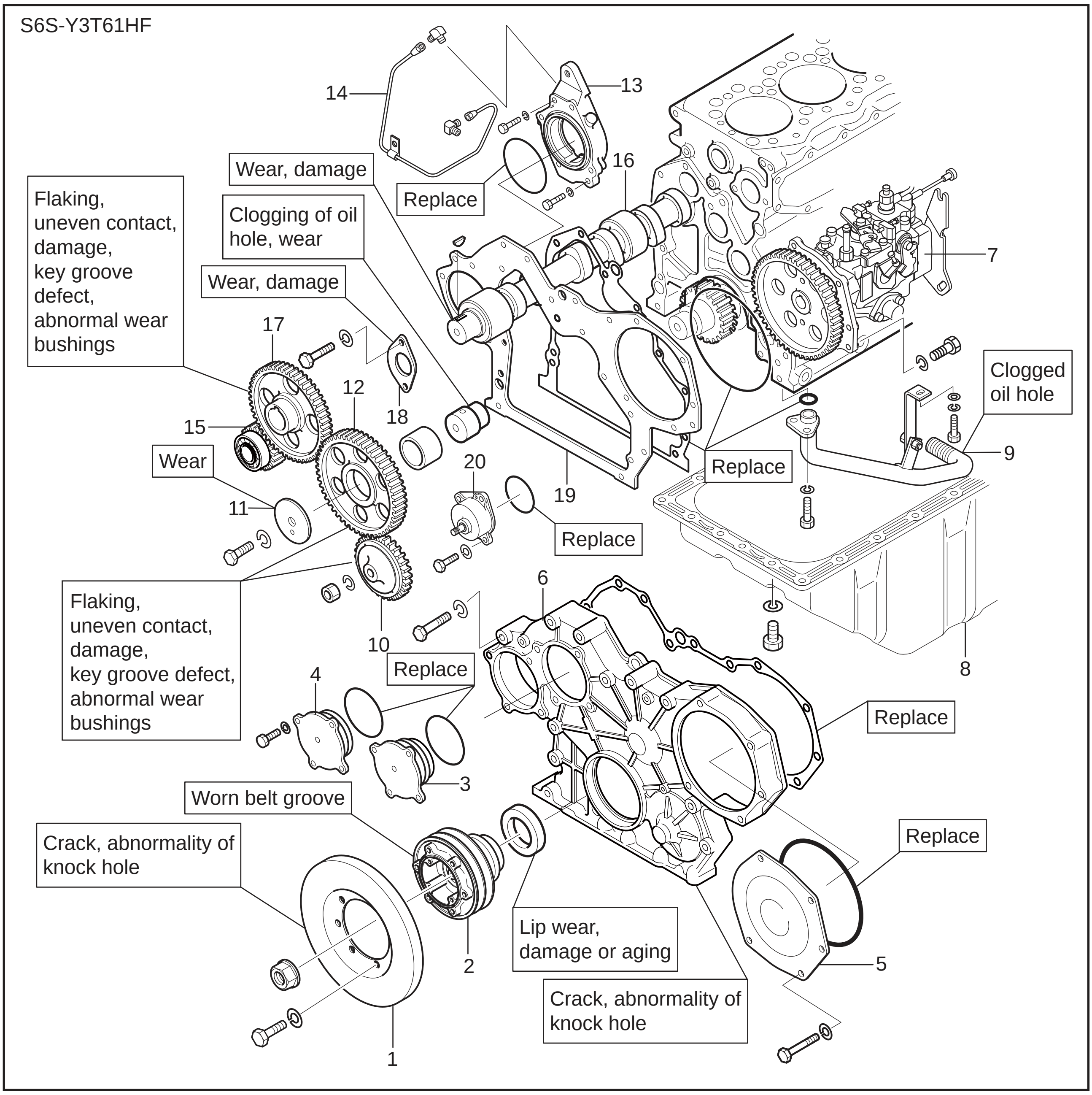
Be very careful not to damage the oil seal.

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



Removing rear plate

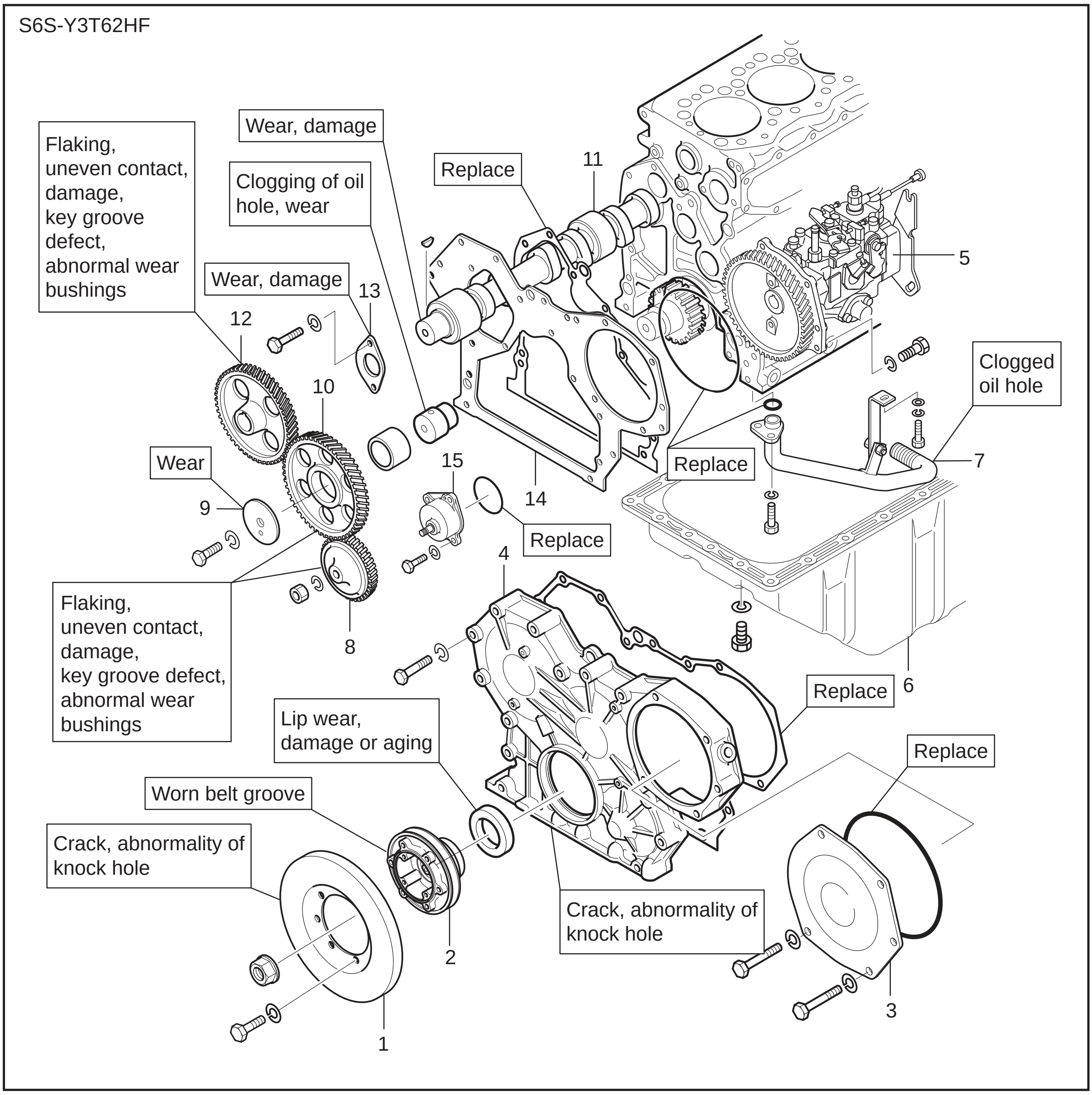
3. Disassembling and inspecting damper, gear case, timing gear and camshaft



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		



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

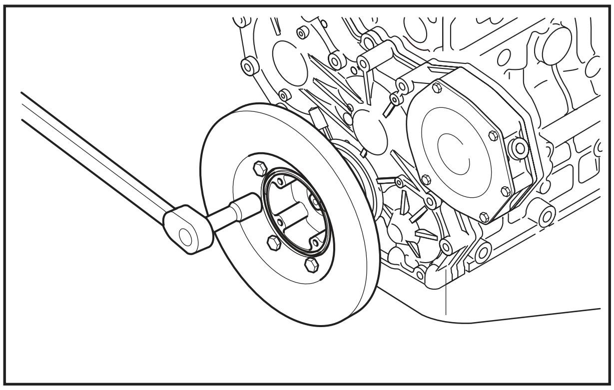
3.1 Removing crankshaft pulley and damper

⚠ CAUTION

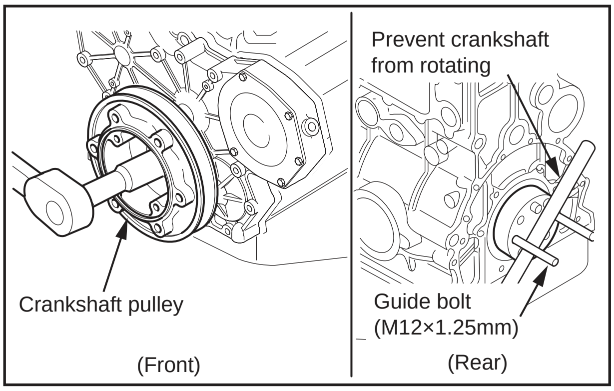
The bar that stops the crankshaft from turning may come off. Pay special attention to safety.

(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.



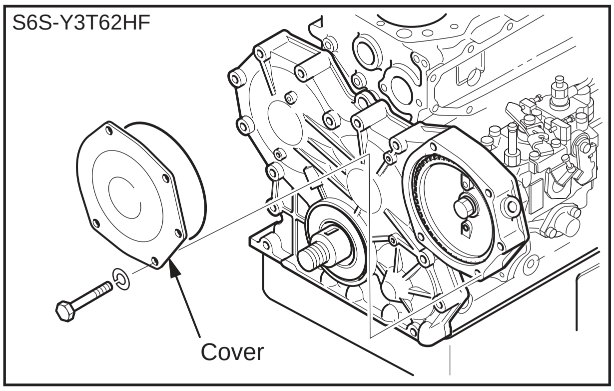
Removing damper



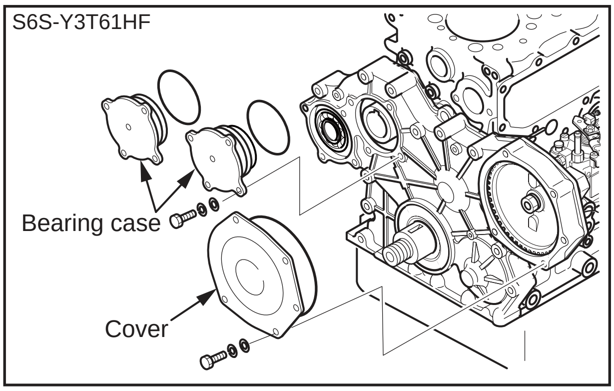
Removing crankshaft pulley

3.2 Removing cover

Unscrew the cover mounting bolts, and remove the cover.



Removing cover



Removing cover

3.3 Removing timing gear case

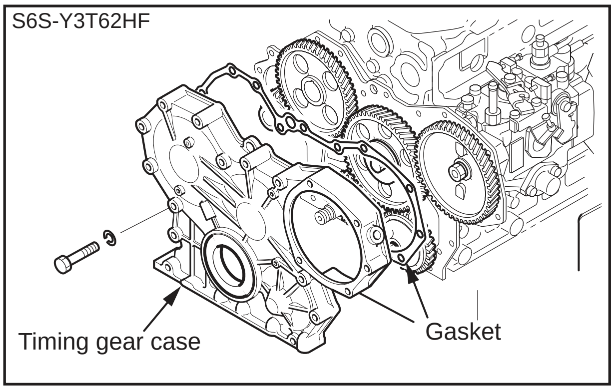
CAUTION

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.

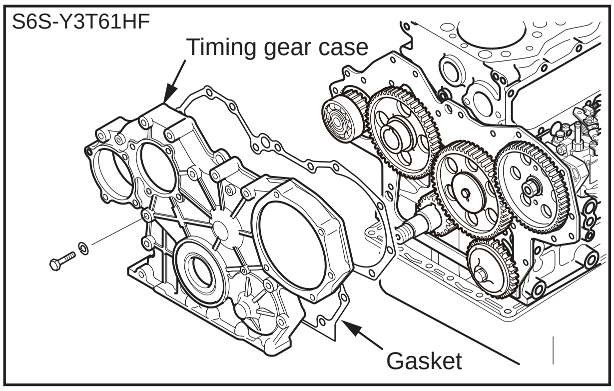
(1) Remove bolts from the timing gear case.

(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



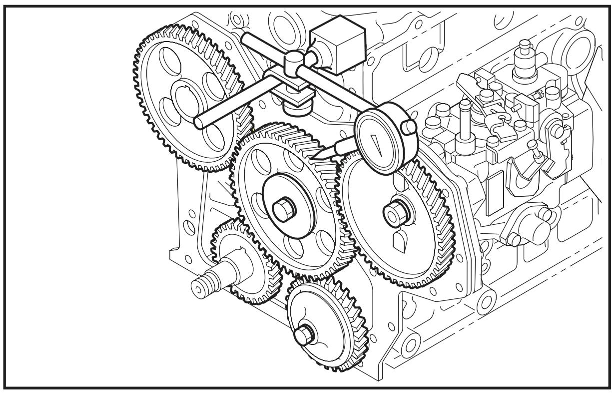
Removing timing gear case

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.

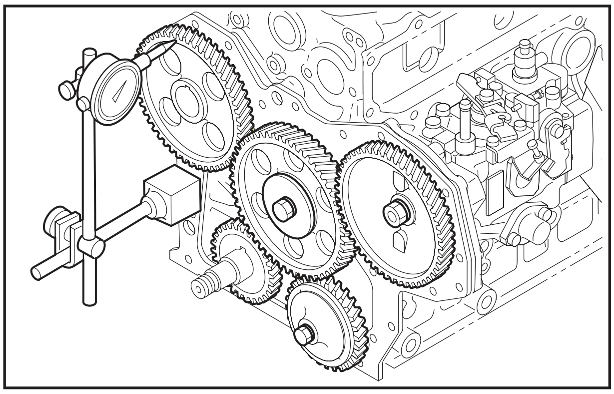

Measuring backlash timing gear

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.]

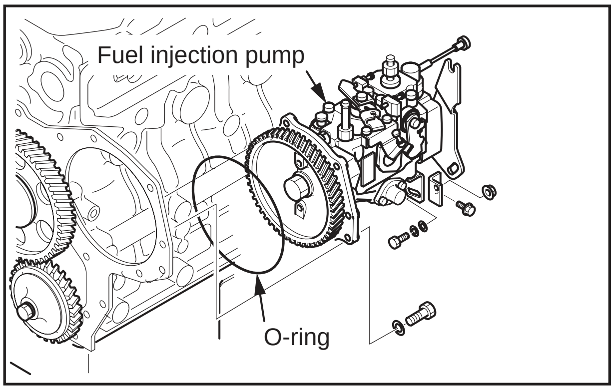


Measuring idler gear and camshaft gear end play

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

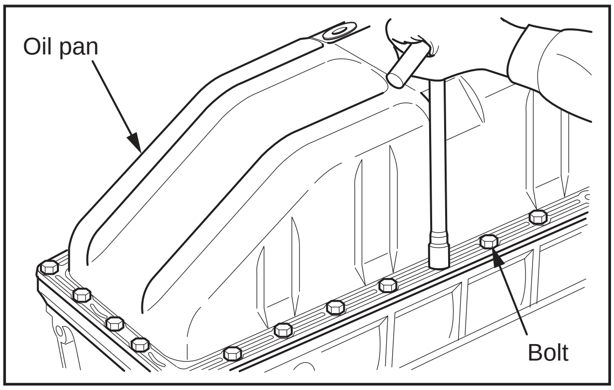
CAUTION

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.

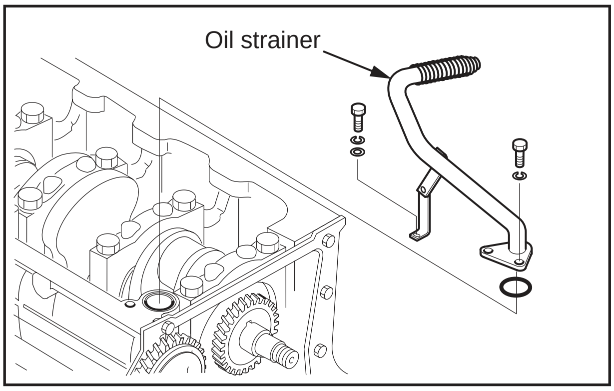


Removing oil pan

3.8 Removing oil strainer

(1) Remove the oil strainer mounting bolts.

(2) Remove the oil strainer from the crankcase.

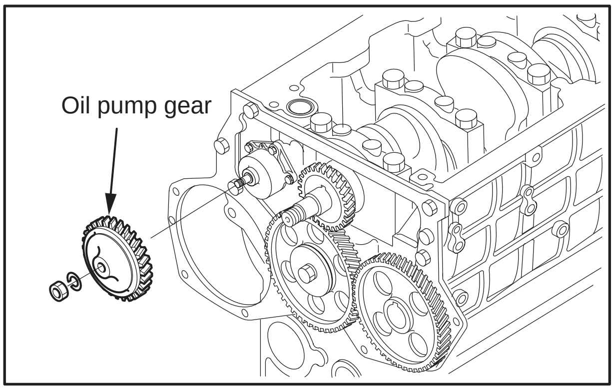


Removing oil strainer

3.9 Removing oil pump gear

(1) Remove the oil pump gear tightening nut.

(2) Remove the oil pump gear.

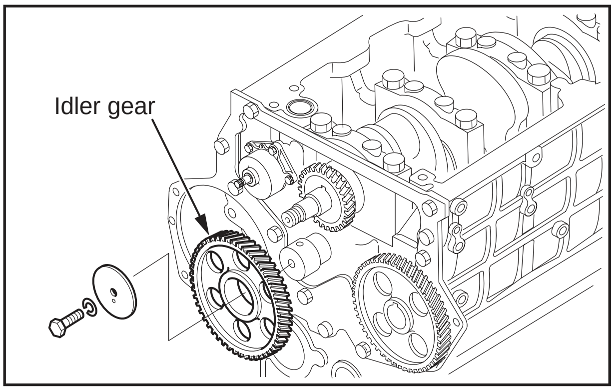


Removing oil pump gear

3.10 Removing idler gear

(1) Remove the thrust plate bolt.

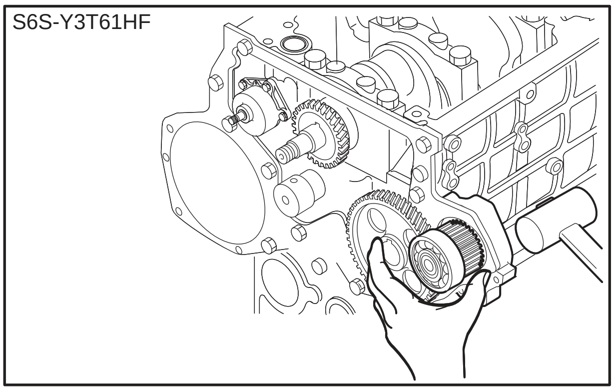
(2) Remove the idler gear while turning the gear.



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

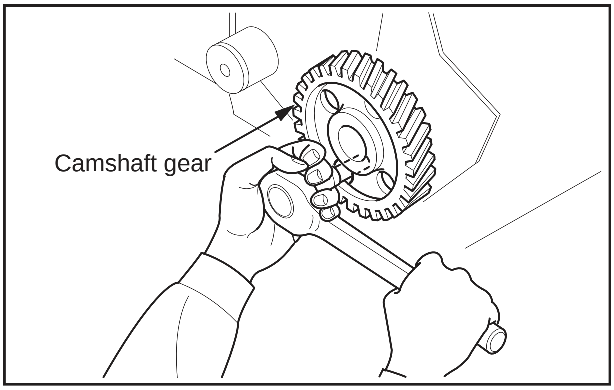
Be careful not to damage the cams of camshaft and the bushings.

(1) Reverse the crankcase.

(2) Remove the thrust plate bolt.

(3) Remove the camshaft from the crankcase.

(4) Remove the tappet.

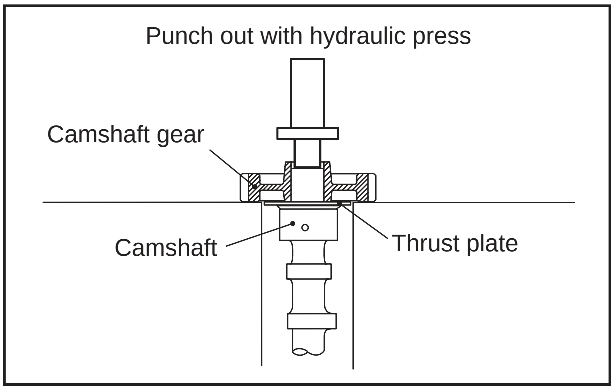


Removing camshaft

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

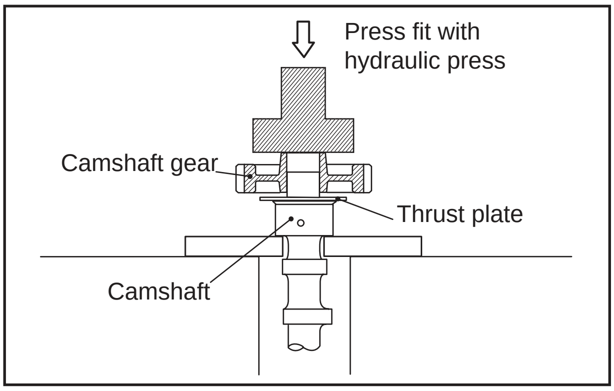
3.14 Installing camshaft gear and thrust plate

(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.



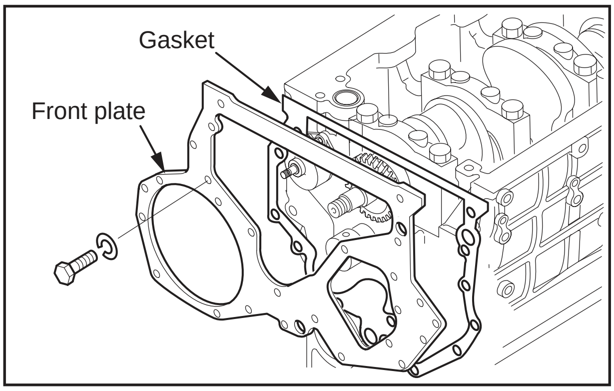
Installing camshaft gear and thrust plate

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.

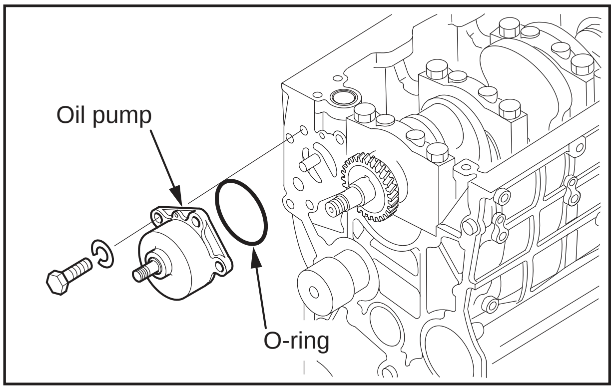


Removing front plate

3.16 Removing oil pump

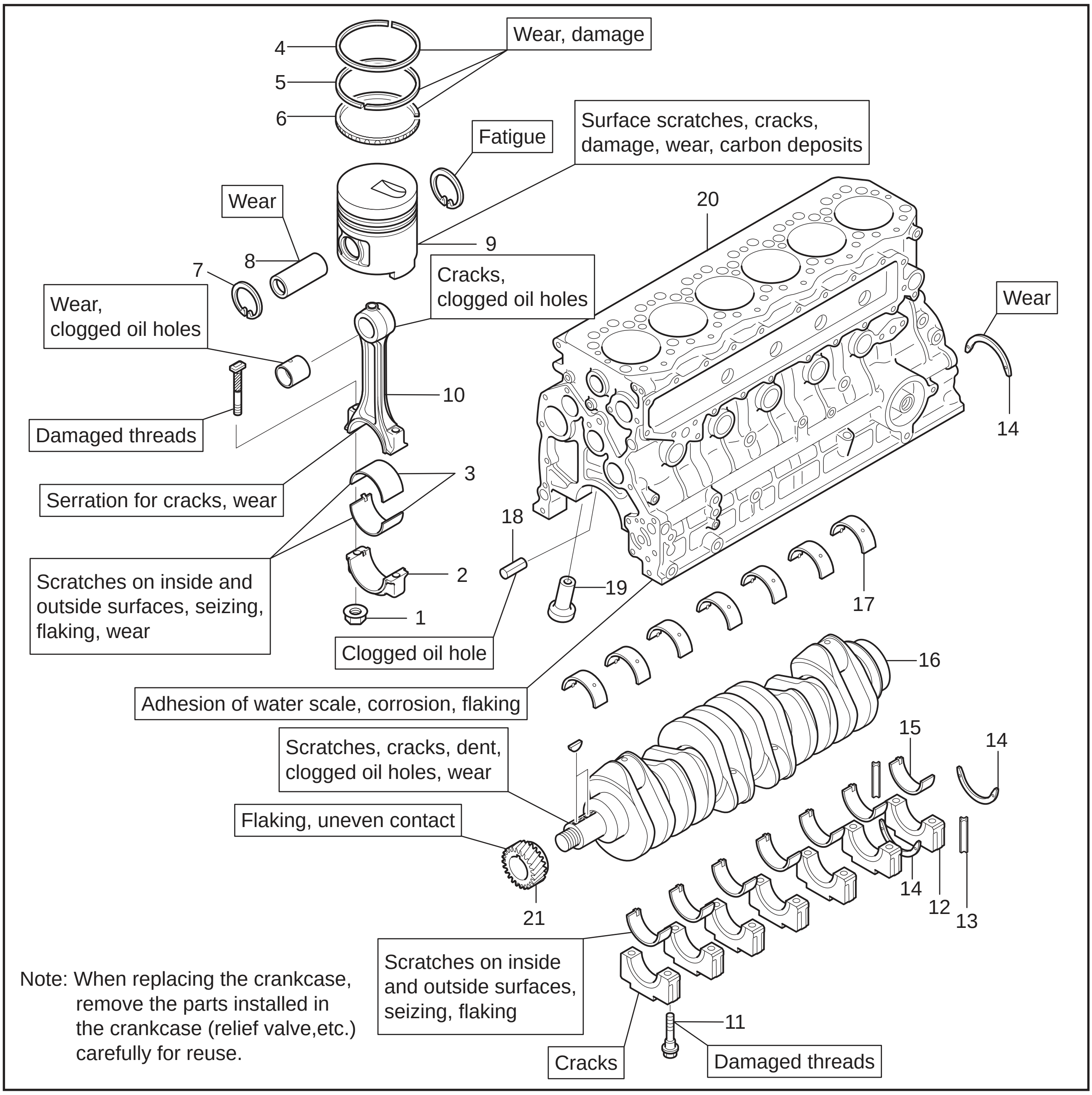
(1) Remove the oil pump mounting bolts.

(2) Remove the oil pump.



Removing oil pump

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

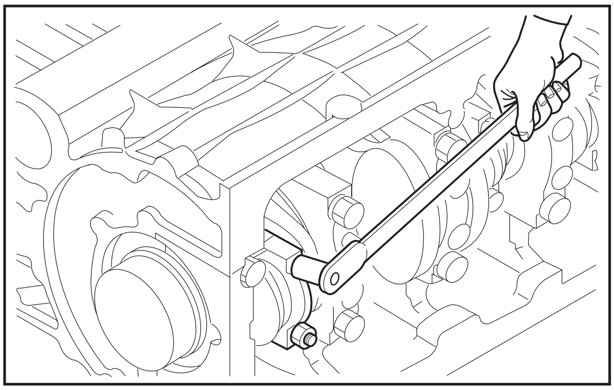
4.1 Removing connecting rod cap

(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

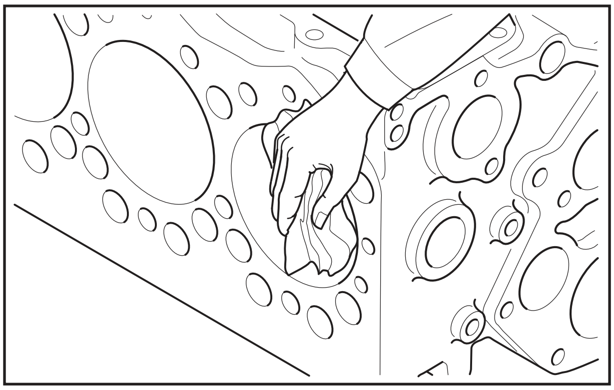
4.2 Removing carbon deposits from the upper part of cylinder liner

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.

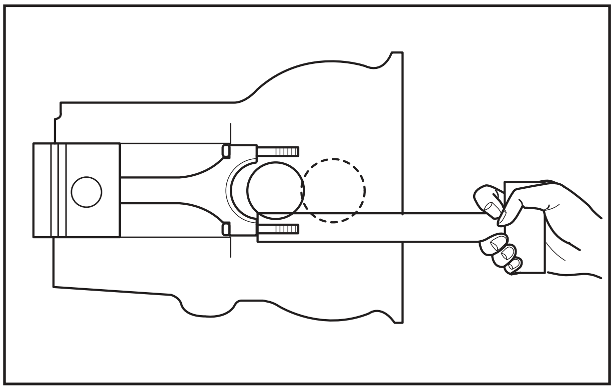


Removing carbon deposits from the upper part of cylinder liner

4.3 Pulling out piston

(1) Turn the crankshaft to bring the piston to top dead center.

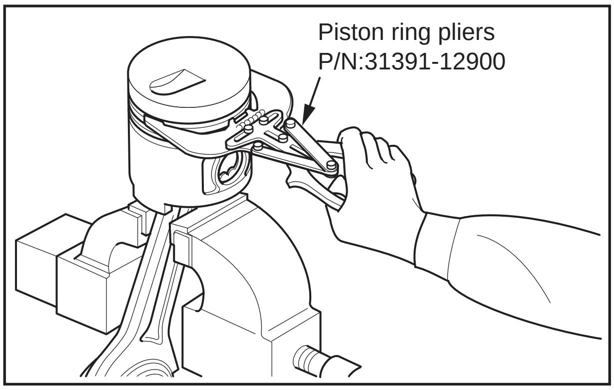
(2) Using a piece of wood such a hammer handle, push the mating surface of the connecting rod cap, and pull the piston and connecting rod upward from the cylinder.



Removing piston

4.4 Removing piston ring

Remove the piston rings using piston ring pliers.



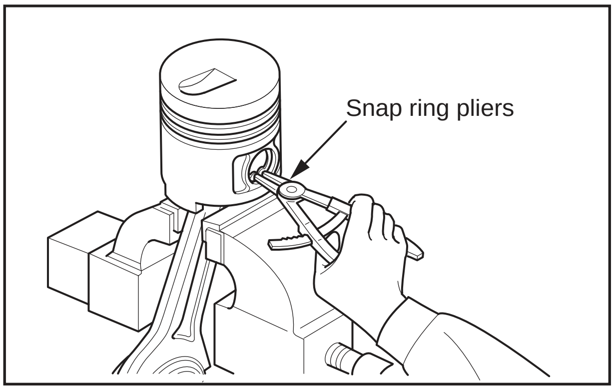
Removing piston ring

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.



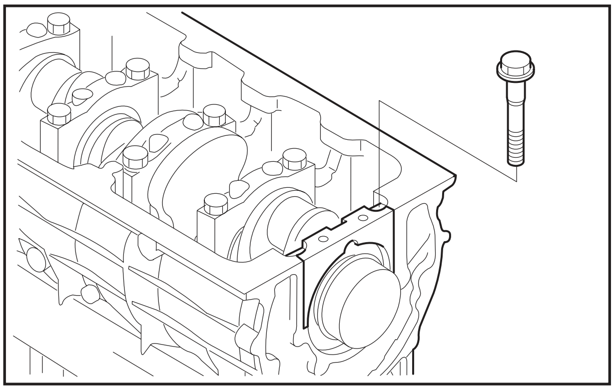
Removing piston pin

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

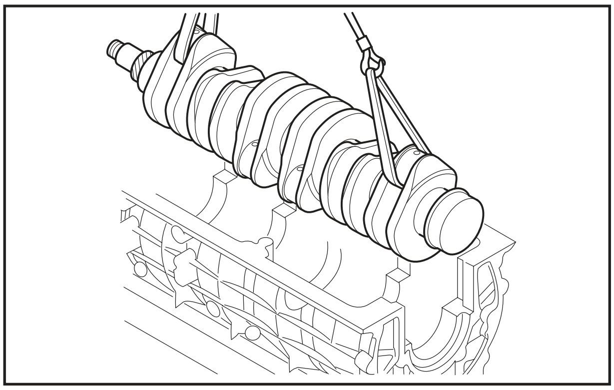
Be careful not to damage bearings when removing the crankshaft.

(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.

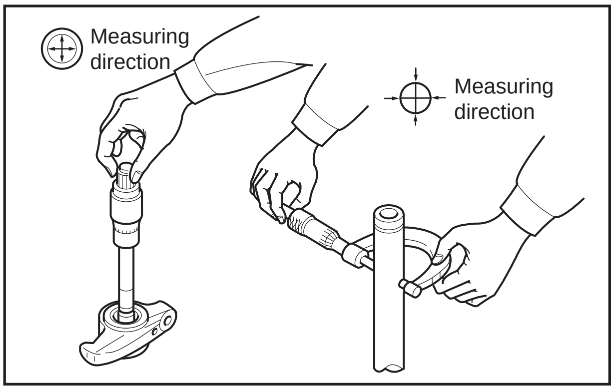
INSPECTION AND REPAIR OF BASIC ENGINE

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.]

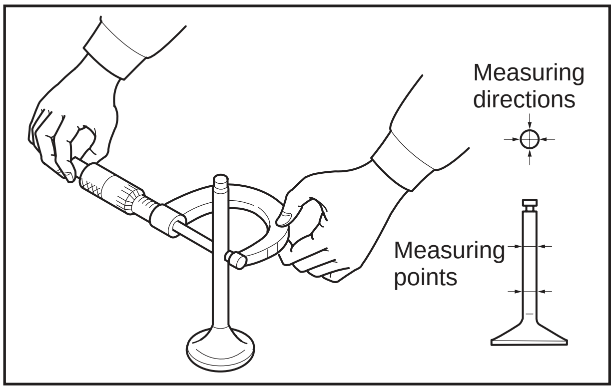


Measuring clearance between rocker bushing and rocker shaft

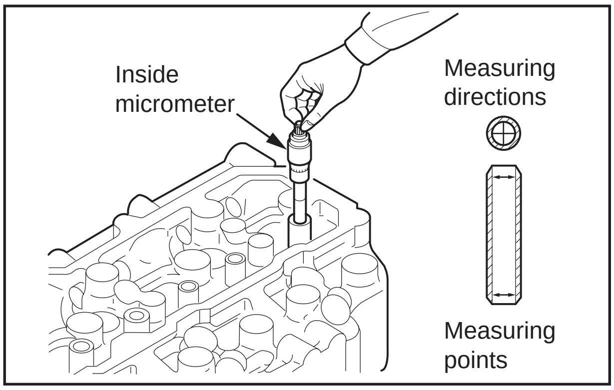
1.2 Measuring valve stem outside diameter and valve guide inside diameter

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



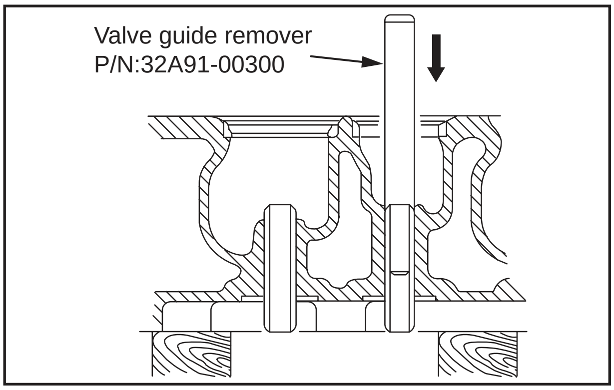
Measuring valve guide inside diameter

1.3 Replacing valve guide

CAUTION

Because valve guides must be inserted to the specified amount, be sure to use a valve guide installer.

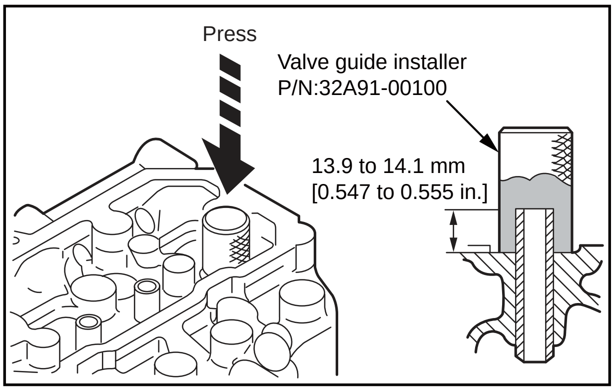
(1) To remove valve guides, use a valve guide remover.



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

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.

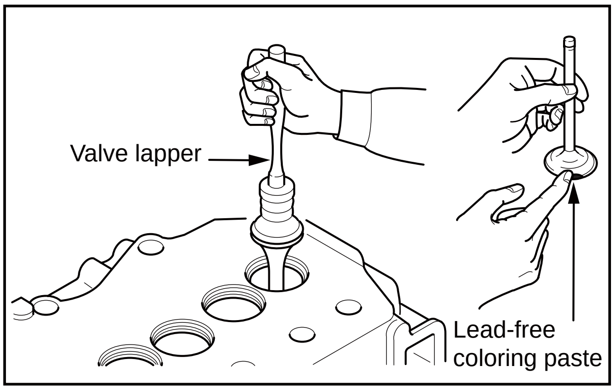
If the contact is not even, or any defects are found, or if the limit is exceeded, reface or replace the valve.

Note: (a) Inspect the valve face after the valve guide is repaired or replaced.

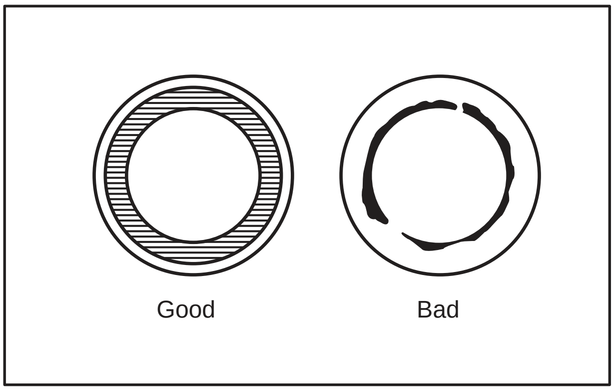
(b) Do not rotate the valve when pressing the valve face coated with lead-free coloring paste against the valve seat.

(c) Always lap the valve and valve seat after the valve has been refaced or replaced.

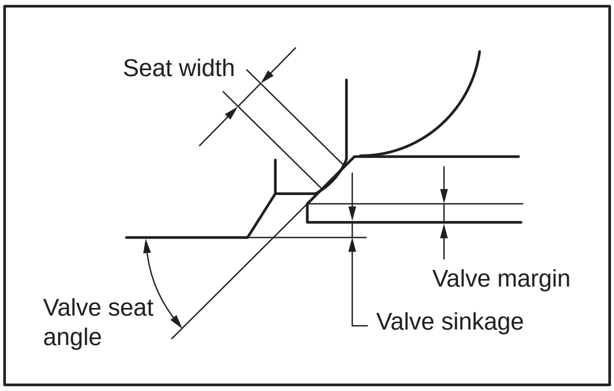
<table>
<tr><th colspan="3">Item</th><th>Nominal</th><th>Standard</th><th>Limit</th></tr>
<tr><td rowspan="4">Valve seat</td><td colspan="2">Valve seat angle</td><td>30°</td><td>-</td><td>-</td></tr>
<tr><td rowspan="2">Valve sinkage</td><td>Inlet</td><td>0.4 mm [0.016 in.]</td><td>0.3 to 0.5 mm [0.012 to 0.020 in.]</td><td>1.0 mm [0.039 in.]</td></tr>
<tr><td>Exhaust</td><td>0.5 mm [0.020 in.]</td><td>0.4 to 0.6 mm [0.016 to 0.024 in.]</td><td>1.0 mm [0.039 in.]</td></tr>
<tr><td colspan="2">Seat width</td><td>1.4 mm [0.055 in.]</td><td>1.26 to 1.54 mm [0.0496 to 0.0606 in.]</td><td>1.8 mm [0.071 in.]</td></tr>
<tr><td colspan="3">Valve margin</td><td>-</td><td>2.13 mm [0.0839 in.]</td><td>Refacing permissible up to 1.83 mm [0.0720 in.]</td></tr>
</table>



Checking valve face



Valve-to-valve seat contact



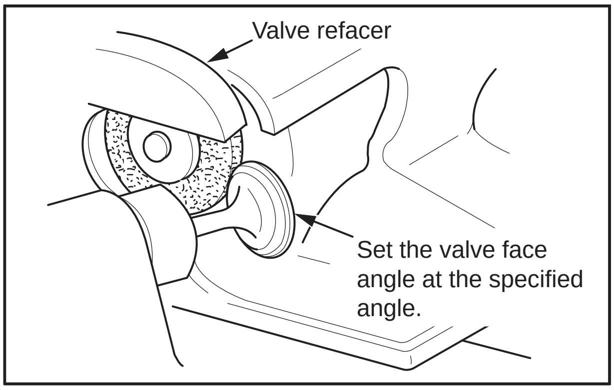
Measuring positions of valve seat and valve

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

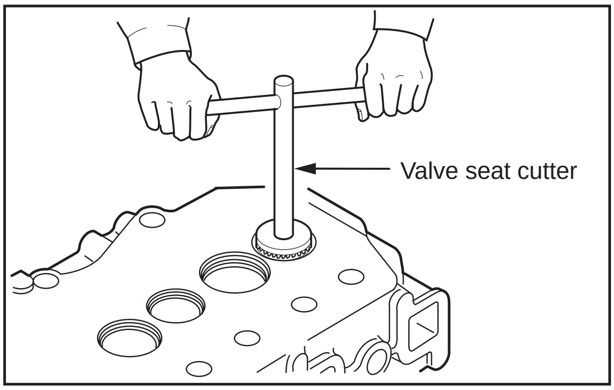
(1) Use the valve seat cutter or valve seat grinder to reface the valve seat. After refacing, sand the valve seat lightly using 400 grit sandpaper, inserting it between the cutter and valve seat.

(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

1.7 Replacing valve seat

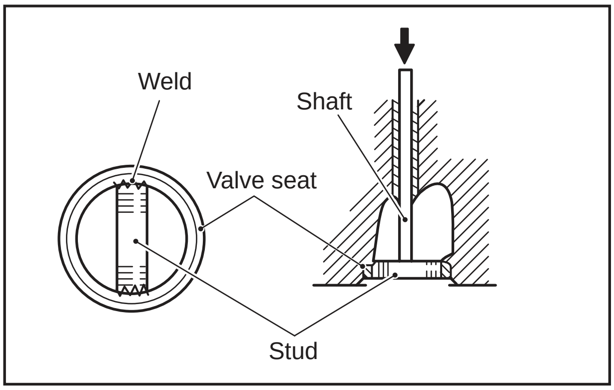
(1) To remove the valve seat, weld a stud to the valve seat as illustrated. Then, insert a rod into the valve guide hole from the top of the cylinder head, and press out the valve seat with the rod.

Note: Be careful not to allow spatters to adhere to the machined surface of the cylinder head during welding.

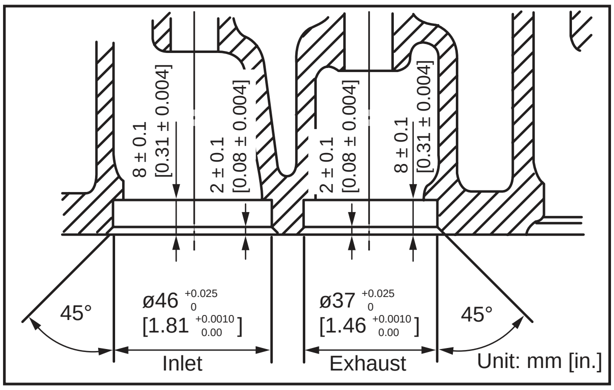
(2) Before inserting a new valve seat, measure valve seat fitting bore diameter and valve seat outside diameter to make sure the interference meets the specified value.

(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.

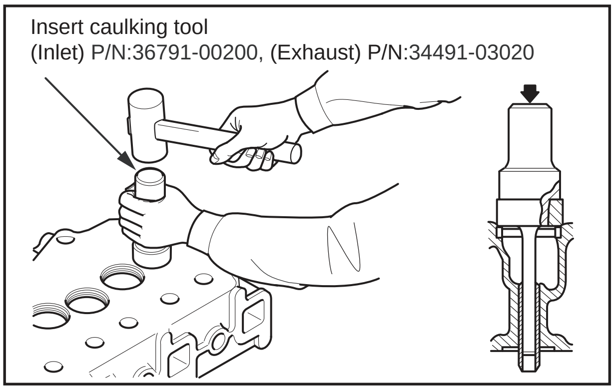
(4) Fit the cold valve seat into the cylinder head using a insert caulking tool.



Replacing valve seat



Valve seat fitting bore



Driving in valve seat

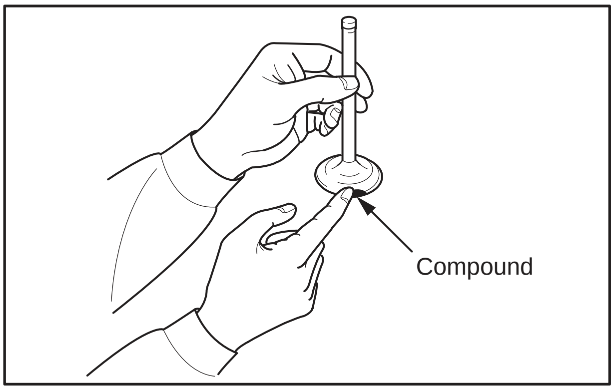
1.8 Lapping valve and valve seat

Always lap the valve against the valve seat after refacing the valve seat or after replacing the valve.

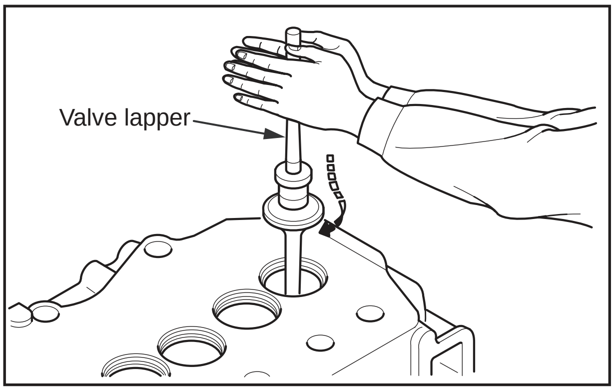
(1) Apply a thin coat of lapping compound evenly to the valve face.

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.



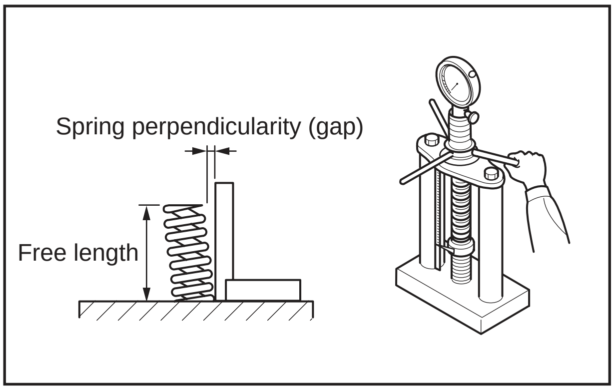
Coating valve with lapping



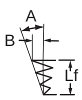
Lapping valve and valve seat

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.



Squareness and free length of spring

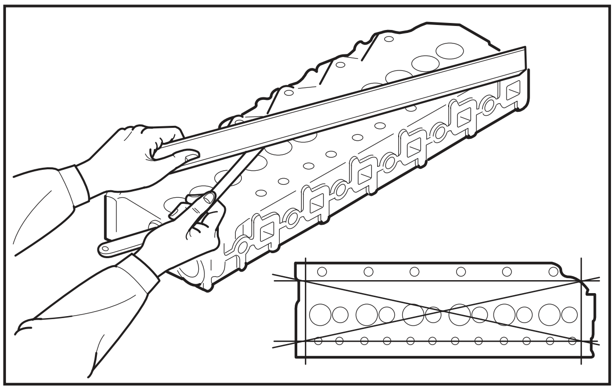
Item	Standard	Limit
Free length	48.85 mm [1.9232 in.]	47.60 mm [1.8740 in.]
Perpendicu-larity	 A = 1.5° or less B = 1.3 mm [0.051 in.] or less Lf = 48.85 mm [1.9232 in.]	B = 1.5 mm [0.059 in.] at the end
Set length/set load	43 mm [1.69 in.]/ 176 to 196 N {18 to 20 kgf} [39 to 44 lbf]	43 mm [1.69 in.]/ 147 N {15 kgf} [33 lbf]

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.


Measuring distortion of the bottom surface of the cylinder head

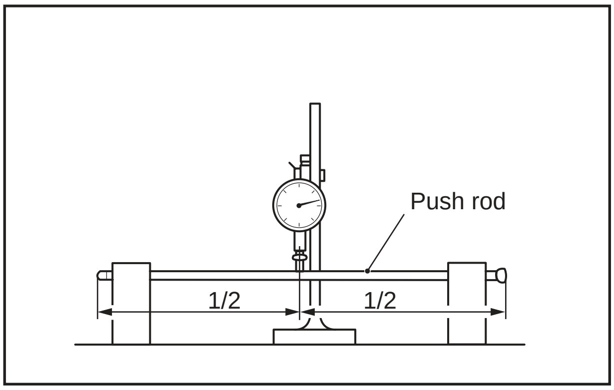
Item	Standard	Limit
Distortion of bottom face	0.05 mm [0.0020 in.] or less	0.20 mm [0.0079 in.]

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)

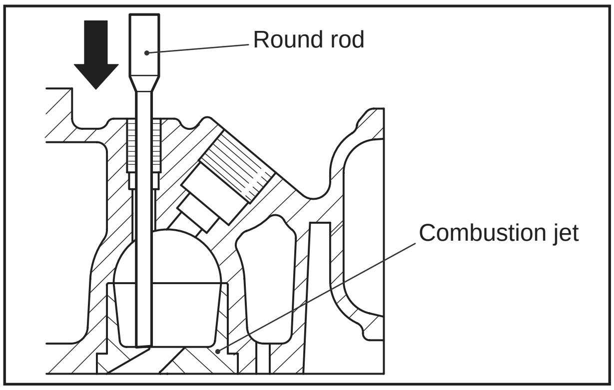


Measuring push rod runout

1.12 Removing combustion jet

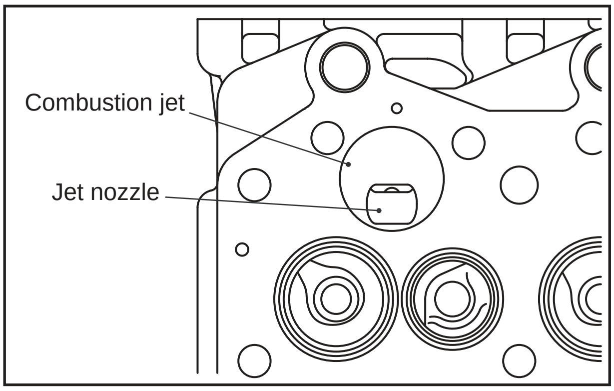
Replace the combustion jet only when it has a defect or crack.

(1) Insert a round bar (approx; ø6 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

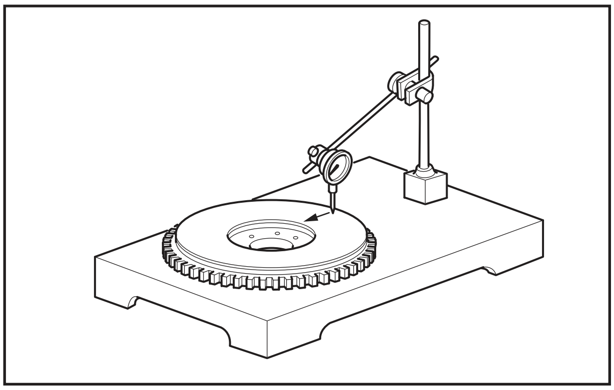
2. Inspecting and repairing flywheel

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.]

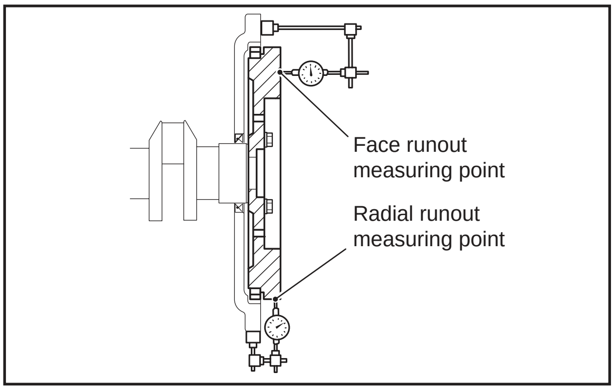


Measuring flatness of flywheel

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

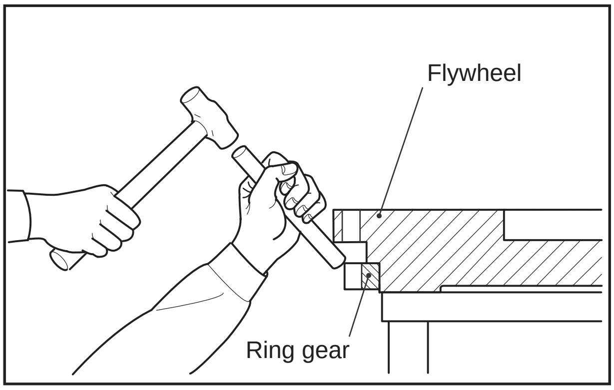
Inspect the ring gear for a missing tooth or worn teeth, and if defects are found, replace the ring gear.

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.



Removing 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.

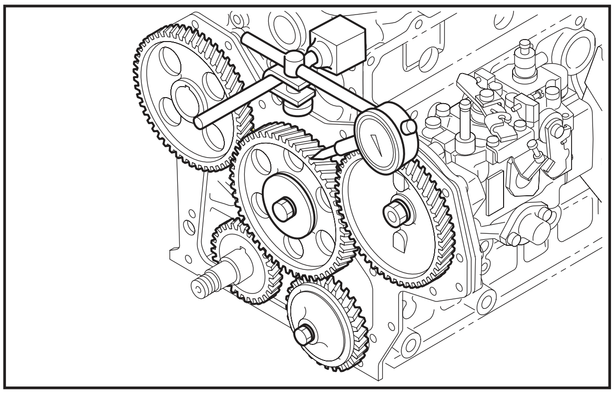
3. Inspecting and repairing timing gear and camshaft

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.]

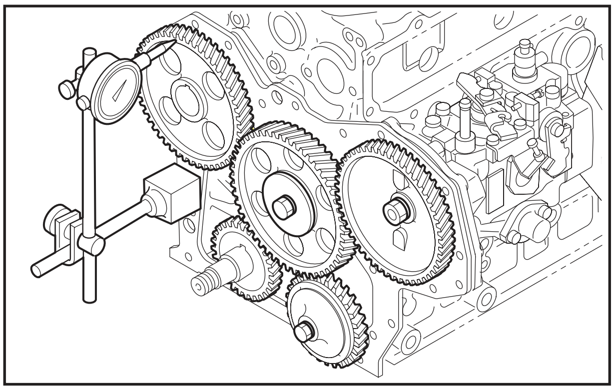
Note: With the injection pump gear attached to the pump, install the injection pump gear to the front plate.


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.

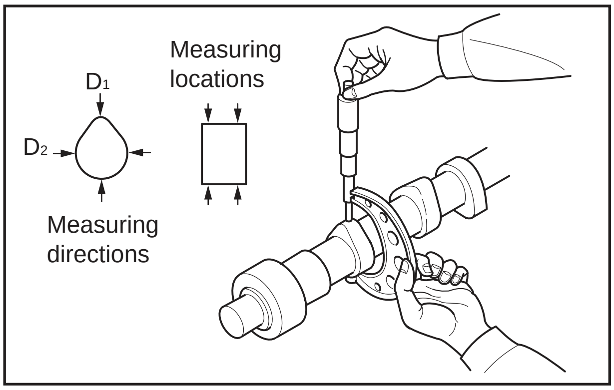
Item		Standard	Limit
End play	Idler gear	0.05 to 0.20 mm [0.0020 to 0.0079 in.]	0.35 mm [0.0138 in.]
	Camshaft	0.10 to 0.25 mm [0.0039 to 0.0098 in.]	0.30 mm [0.0118 in.]


Measuring idler gear and camshaft gear end play

3.3 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
Cam lift	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.]



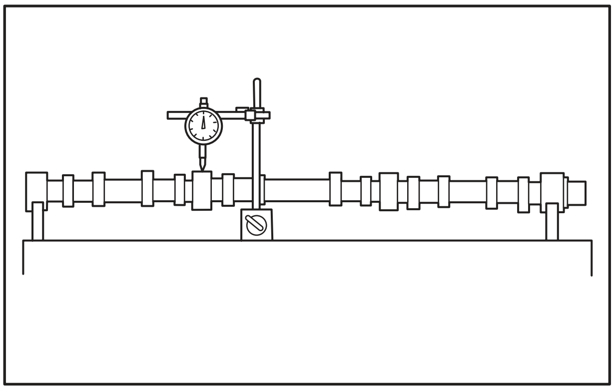
Measuring cam lift

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

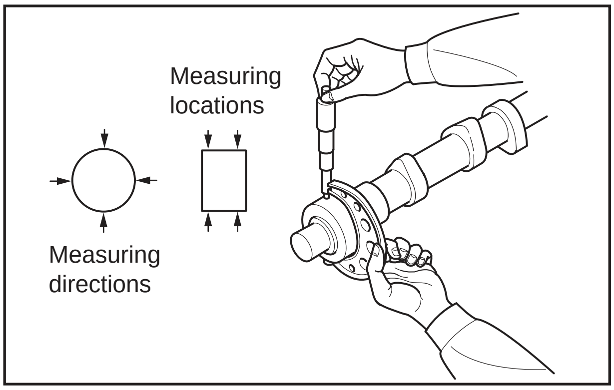


Measuring camshaft runout

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.]

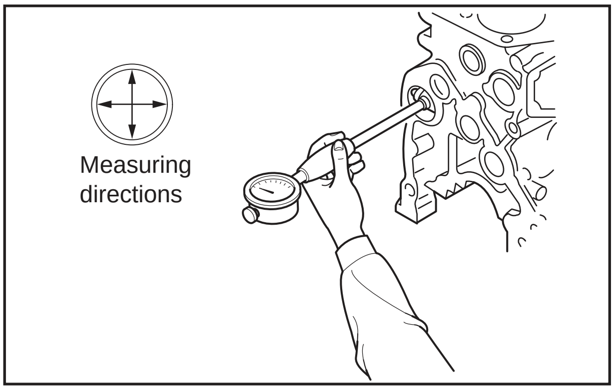


Measuring camshaft journal outside diameter

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.]

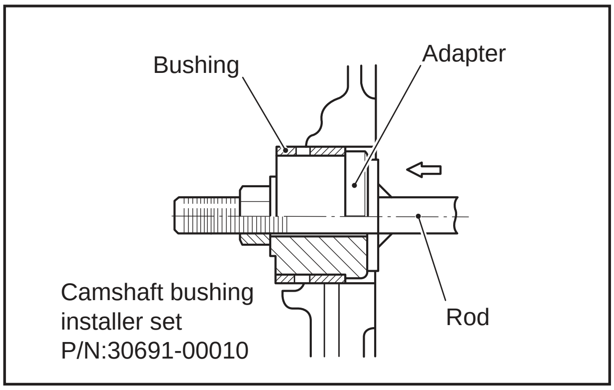


Measuring camshaft bushing inside diameter

3.7 Replacing camshaft bushing

3.7.1 Removing camshaft bushing

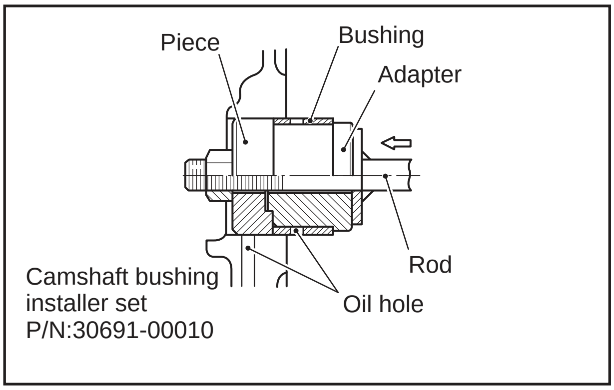
(1) Install a camshaft bushing installer set to the camshaft bushing.
(2) Remove the camshaft bushing by tapping the end of the rod of camshaft bushing installer set.



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.

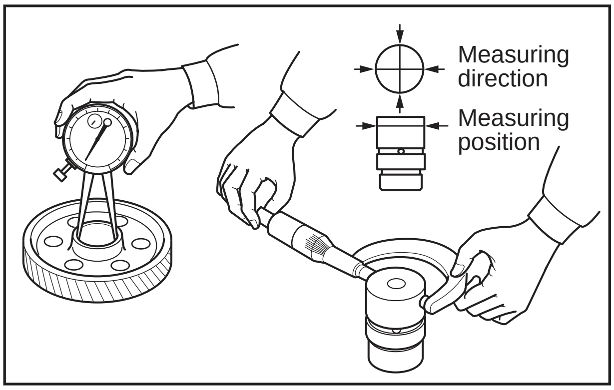


Installing camshaft bushing

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.]



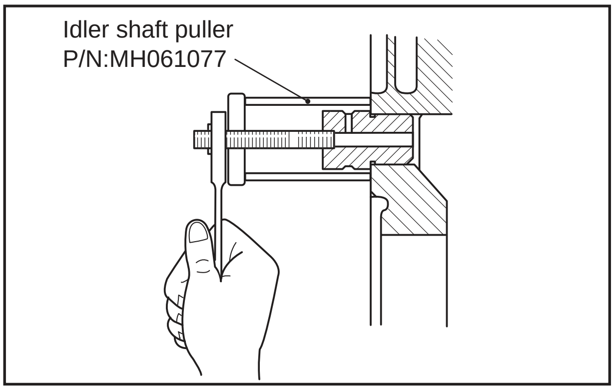
Measuring idler bushing inside diameter and idler shaft outside diameter

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.]



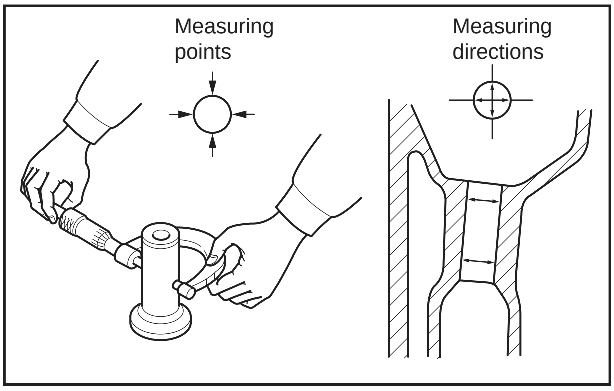
Replacing idler shaft

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.]

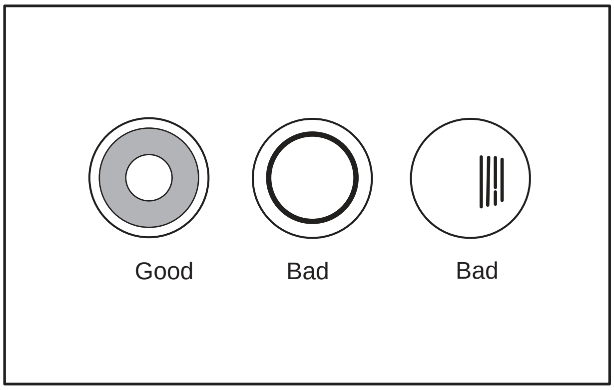


Measuring clearance between tappet and tappet guide hole

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.

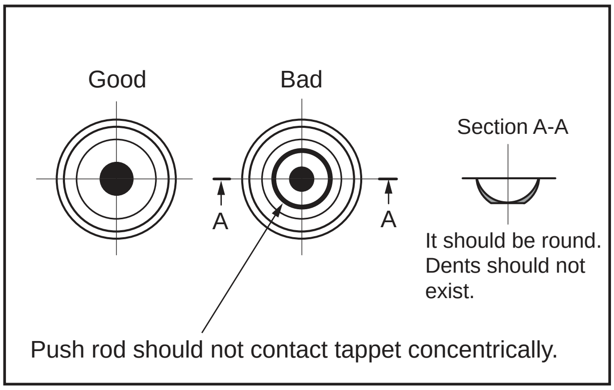


Contact surface of camshaft

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.



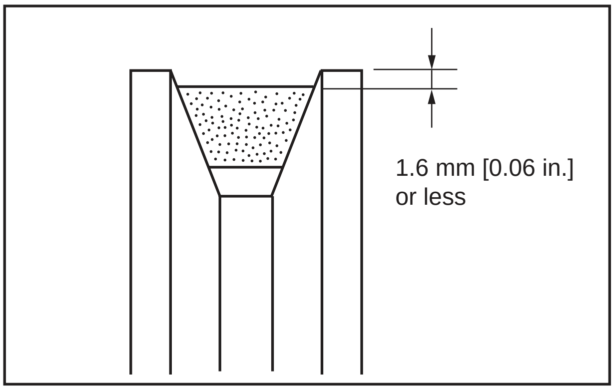
Contact surface of push rod

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.

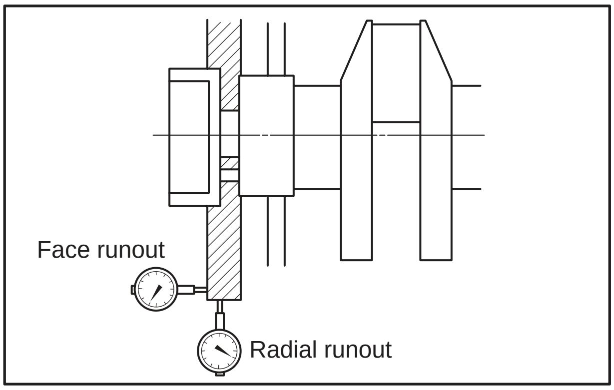


Inspecting V-belt groove wear

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.]	

4. Inspecting and repairing piston, connecting rod, crankshaft and crankcase

4.1 Measuring crankcase top surface distortion

CAUTION

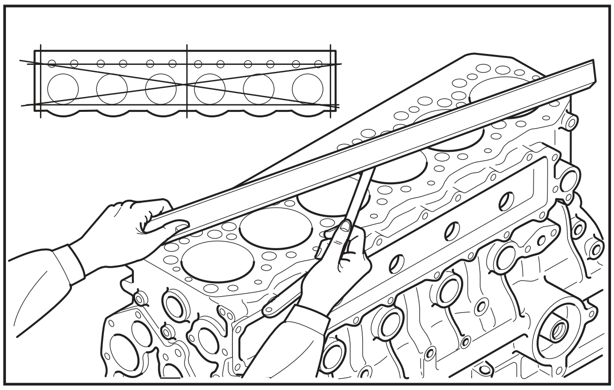
Refacing of cylinder head should be kept to an absolute minimum.
Excessive grinding of the cylinder head may result in defects such as defective combustion and stamping (contact between piston and valve).

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.

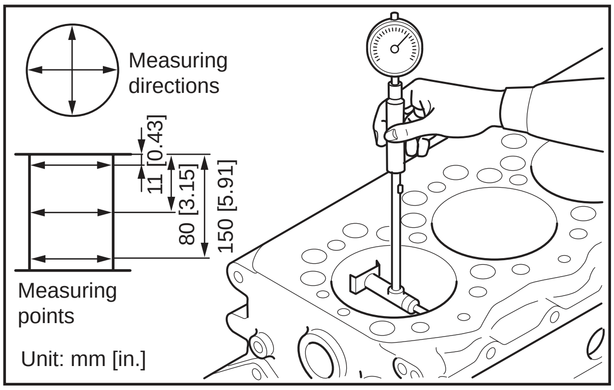
(2) If the measurement is between the repair limit and replacement limit, re-bore the cylinder to +0.25 mm [0.0098 in.] or +0.5 mm [0.0197 in.] oversize. Hone the re-bored cylinder to the accuracy of the standard.

(3) Use an oversize piston and piston rings to fit the re-bored cylinder.

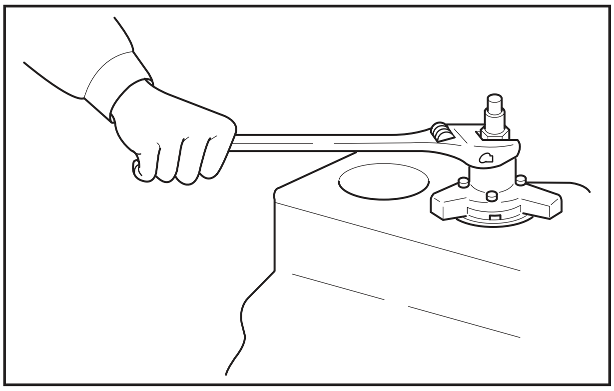
(4) If the cylinder is worn unevenly, select an oversize diameter that ensures complete roundness when the cylinder is re-bored to the maximum. All cylinders must be re-bored to the same oversize diameter if one cylinder is re-bored.

(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	-



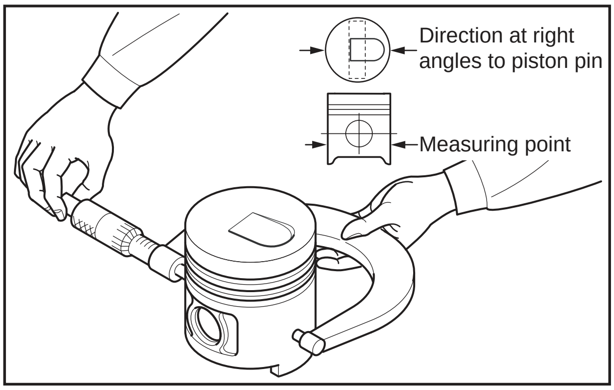
Measuring cylinder sleeve inside diameter



Refacing using a ridge reamer

4.3 Measuring piston outside diameter

(1) 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.

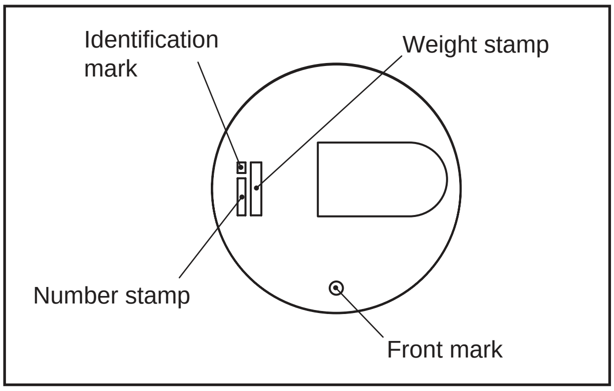


Measuring piston outside diameter

(2) 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.



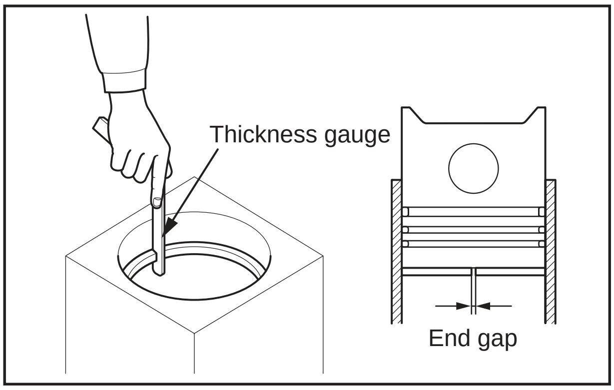
Piston weight stamp location

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.]	



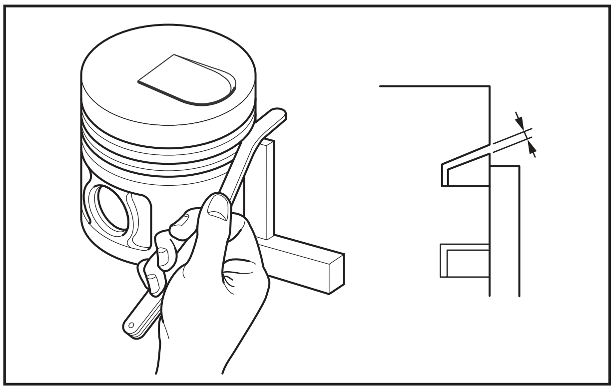
Measuring piston ring end gap

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.

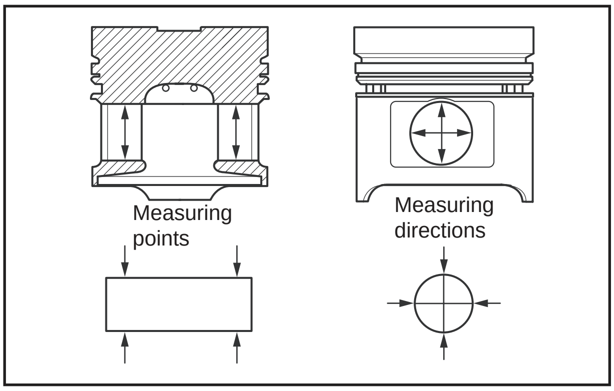


Measuring clearance between piston ring groove and piston ring

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.



Measuring piston pin bore diameter and piston pin outside diameter

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.]

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.

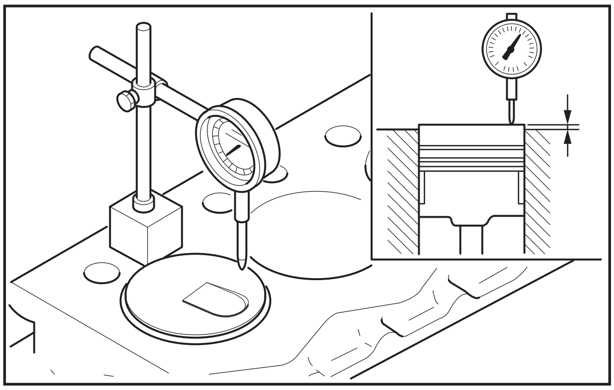
(1) Bring the piston to top dead center.

(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.]



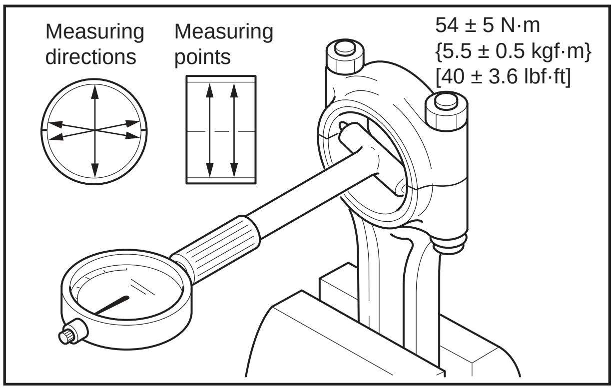
Measuring piston protrusion

4.8 Measuring clearance between connecting rod bearing and crankpin

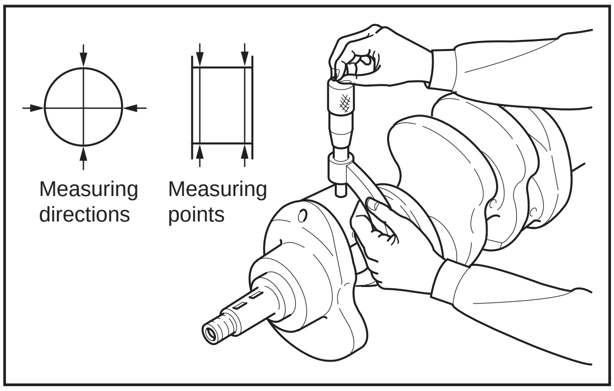
CAUTION

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



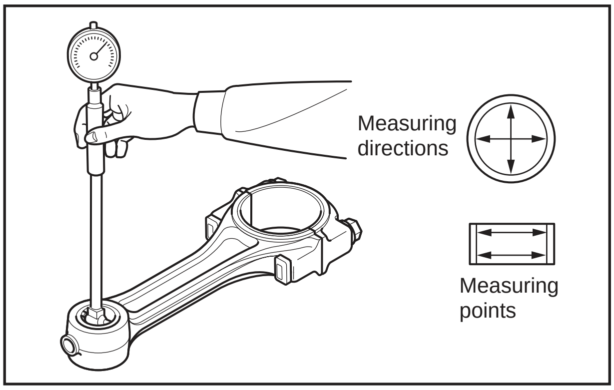
Measuring crankpin diameter

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.]



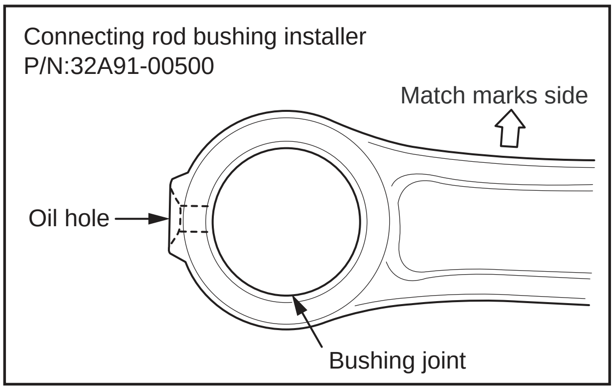
Measuring connecting rod bushing inside diameter

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

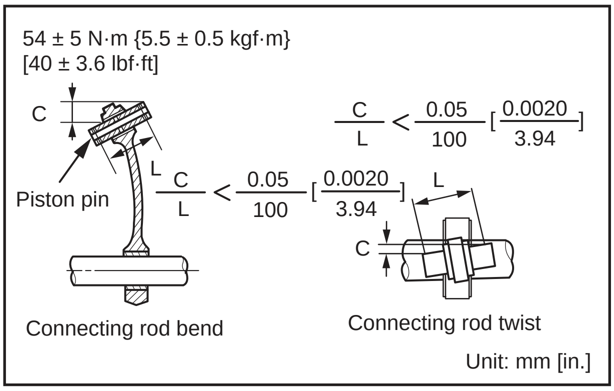
(1) Measure the dimensions of C and L in the illustration to check bend and twist of the connecting rod. Straighten the connecting rod with a press to meet the standard.
If the standard is exceeded after correction, replace the connecting rod with a new one.

(2) In general, a connecting rod aligner is used to check bend and twist.

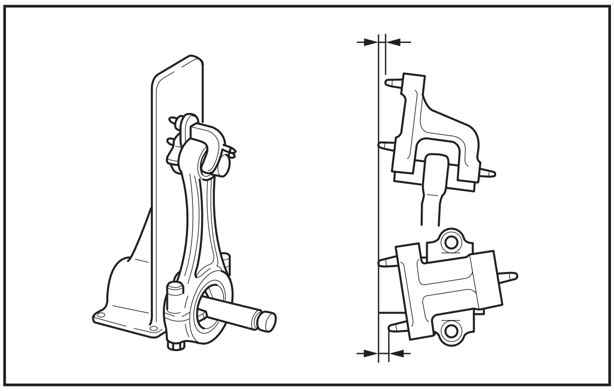
Note: Before checking bend, tighten the connecting rod cap to the specified torque.

(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.

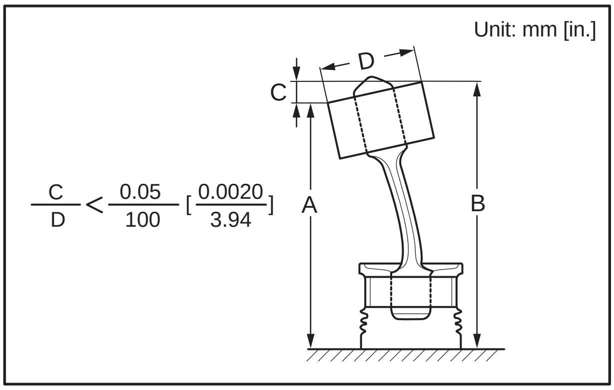
Item	Standard	Limit
Connecting rod bend and twist	0.05/100 mm [0.0020/3.94 in.] or less	0.15 mm [0.0059 in.]



Inspecting connecting rod bend and twist



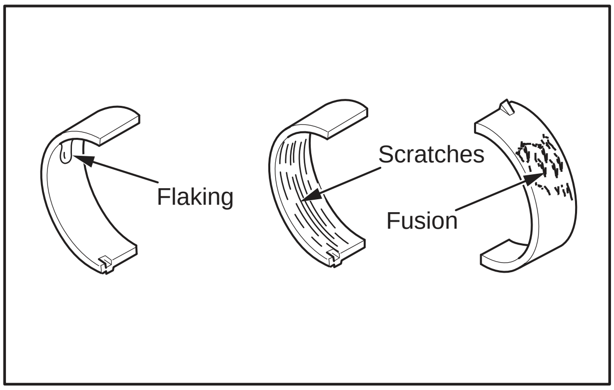
Using a connecting rod aligner to measure rod bend and twist



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

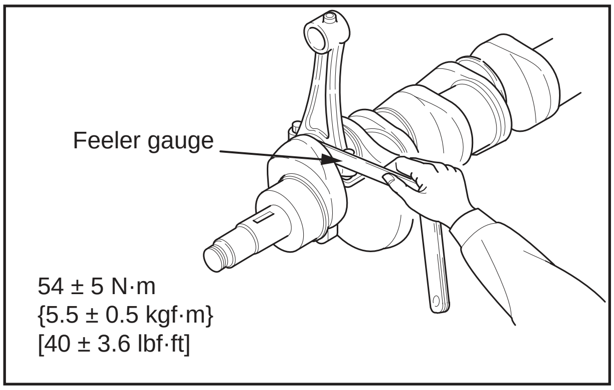
4.13 Measuring connecting rod end play

(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.]

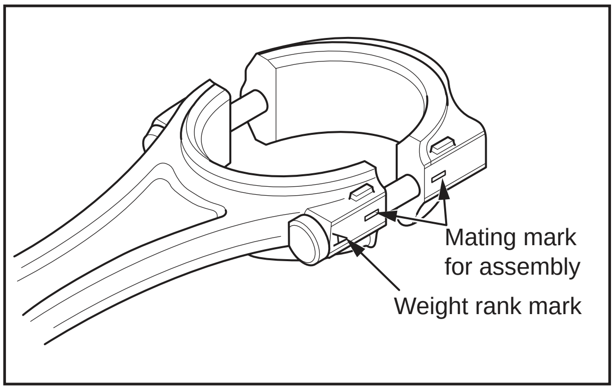


Measuring connecting rod end play

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.

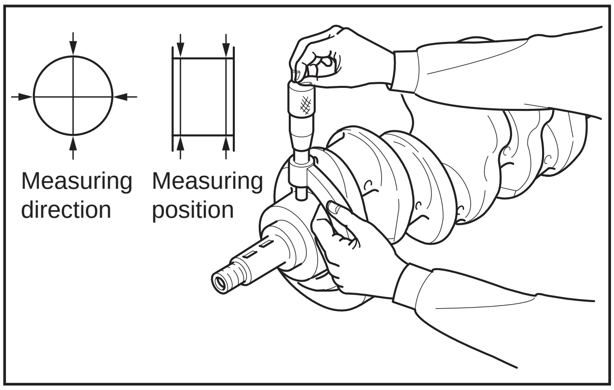
Item	Tolerance on weight
Weight difference of connecting rod assembly	10 g [0.35 oz.] or less



Weight difference in connecting rod assembly

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.

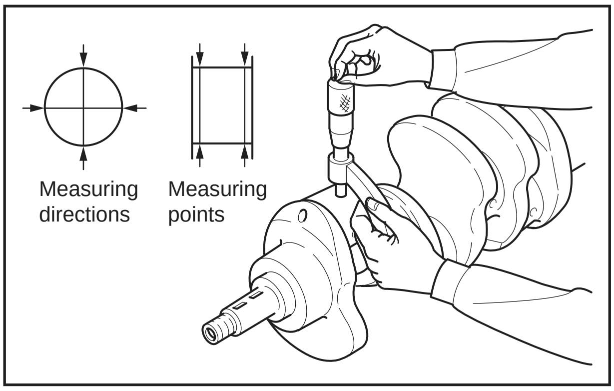


Measuring crankshaft journal outside diameter

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	-

4.16 Measuring crankshaft crankpin outside diameter

Measure the crankpin outside diameter using a micrometer. Check the crankpin for roundness, cylindricality, 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.



Measuring crankpin diameter

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	-

4.17 Grinding crankshaft

CAUTION

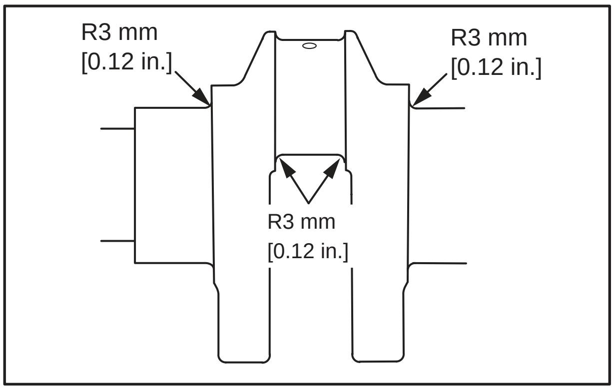
(a) When grinding crank journals, be sure to grind all the journals to the same size.
(b) Finish the fillet radius to the specified dimension.

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.

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.]



Finished dimension of fillet R

4.18 Measuring crankshaft end play

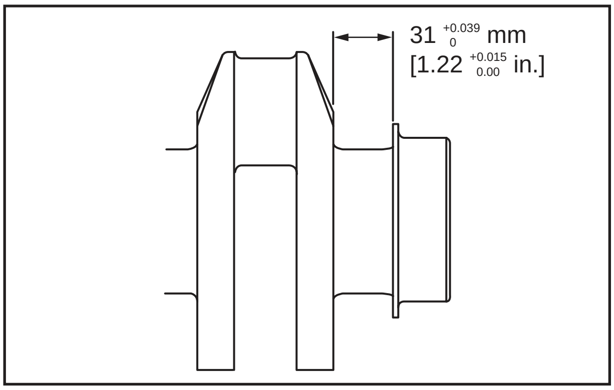
(1) Measure the crankshaft end play (clearance between the crank arm at the thrust force receiving journal and the bearing cap with thrust plate attached). If the limit is exceeded, replace the thrust plate with a new one.

(2) If the limit is still exceeded after a new thrust plate has been installed, use an oversize thrust plate.

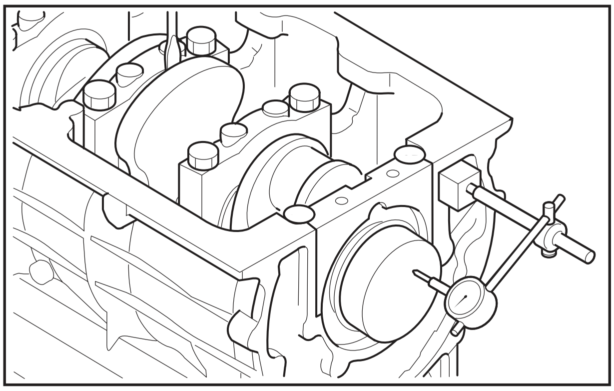
Note: In general, the rear thrust bearing wears faster than the front thrust bearing. Therefore, in most cases, the correction is achieved by replacing the rear thrust plate with the next oversize one.

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

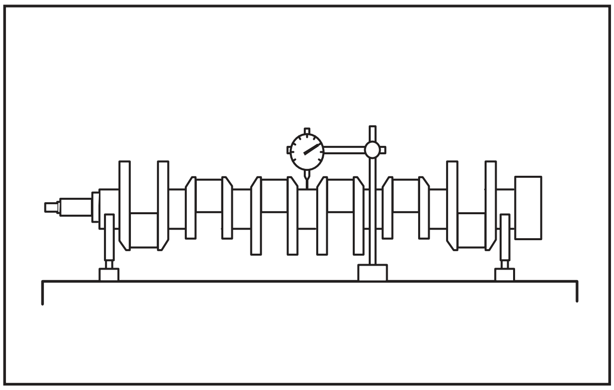
4.19 Measuring crankshaft runout

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



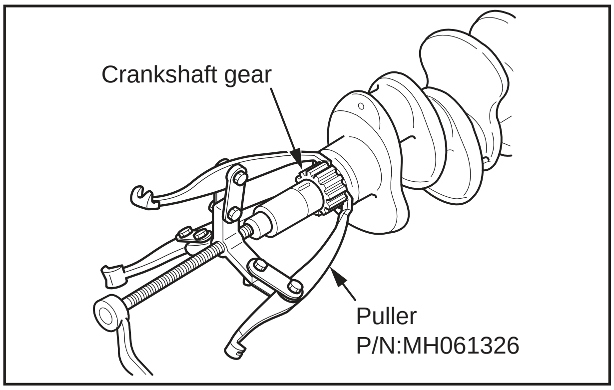
Measuring crankshaft runout

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.

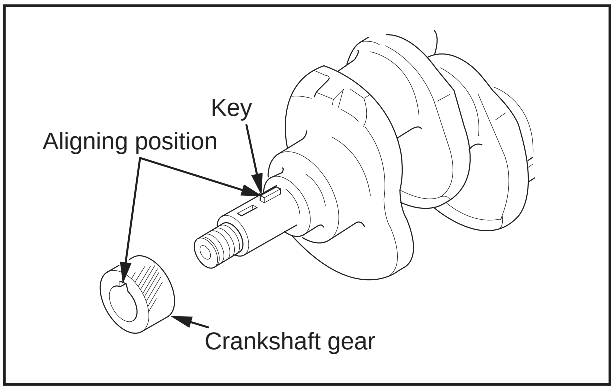


Removing crankshaft gear

4.20.2 Installing crankshaft gear

(1) Install the key on the crankshaft.

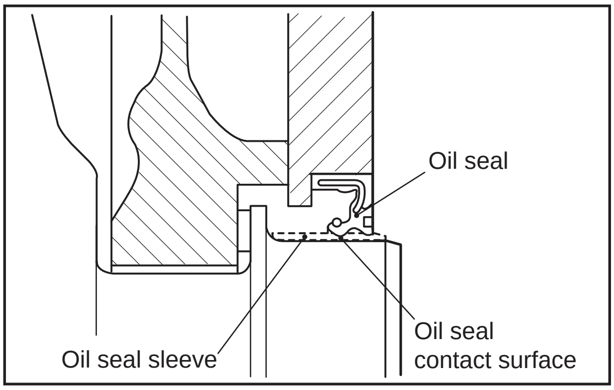
(2) Press-fit the gear fully in alignment with the key.



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)

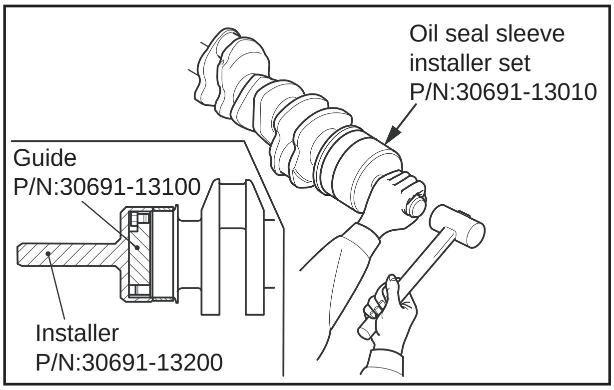
4.22 Installing oil seal sleeve

CAUTION

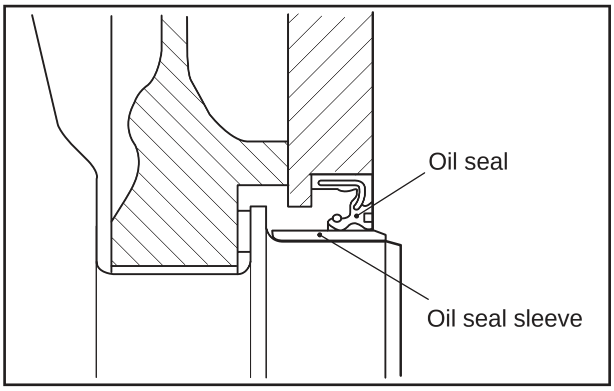
Be careful not to dent or damage the oil seal sleeve circumference.

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)

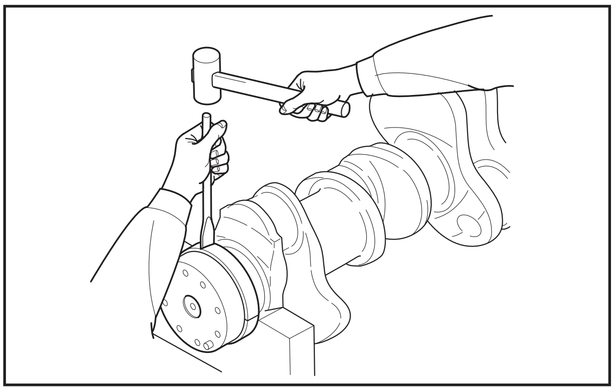
4.23 Removing oil seal sleeve

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.

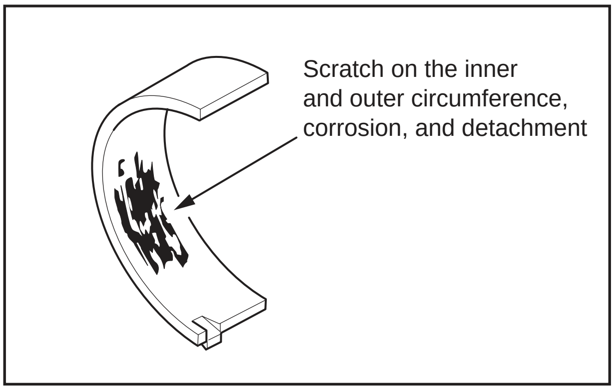
If the sleeve can not be removed by the above procedure, hold the chisel against the sleeve in the axial direction and tap on it lightly to make the sleeve expand. Once the interference between the crankshaft and sleeve is eliminated, the sleeve can be removed easily.



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.

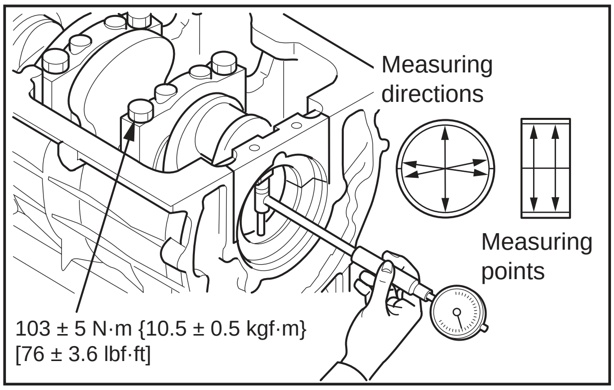


Inspecting main bearing surface

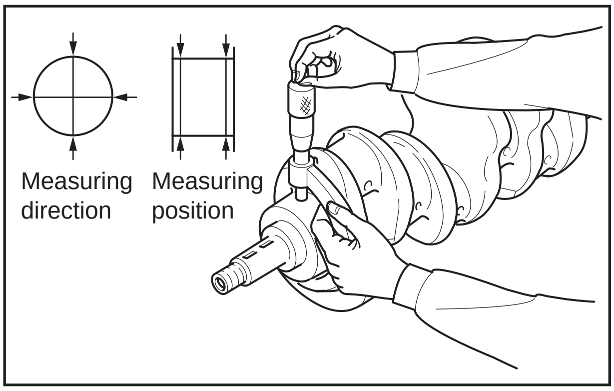
4.25 Measuring clearance between main bearing and crankshaft journal

(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

1. Reassembling piston, connecting rod, crankshaft and crankcase

1.1 Installing main bearing

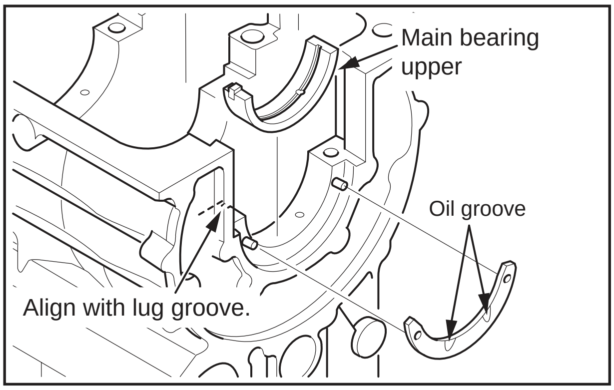
CAUTION

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.

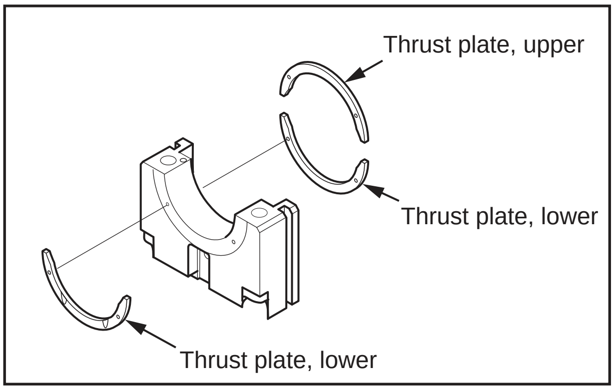
(2) Apply a small amount of engine oil to each bearing.



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.



Installing thrust plate

1.3 Installing tappet

Apply engine oil onto the periphery of tappets, insert them into the tappet holes.

1.4 Installing crankshaft

(1) Install the wood ruff key on the crankshaft.

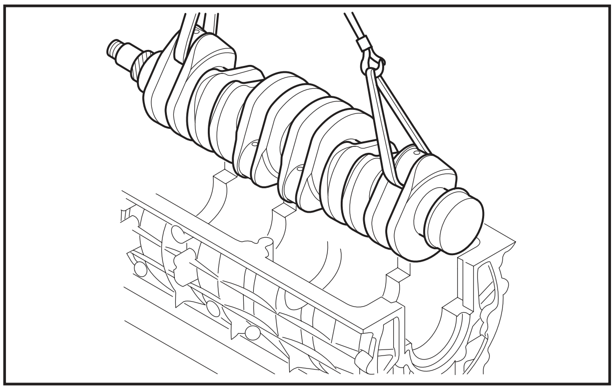
(2) Make sure that the main bearing upper shells that are installed in the crankcase bores have their inner periphery (the surface comes into contact with the journal) lubricated with an even coat of fresh engine oil.

(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.

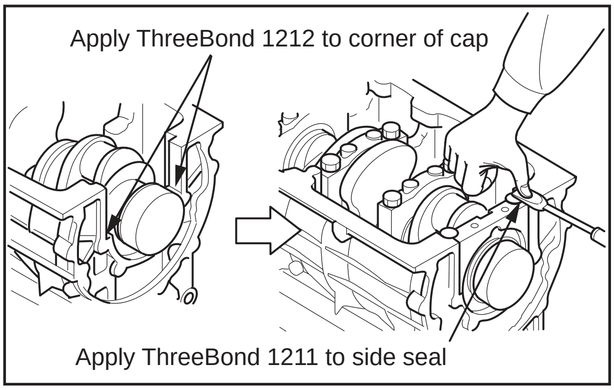
Install the main bearing caps from the front side in the order of the numbers marked on them.

(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

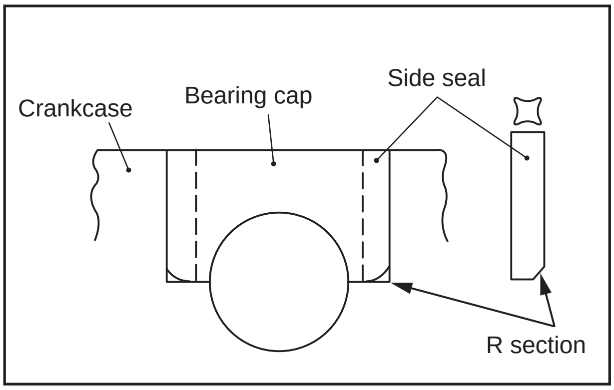
(1) Apply a sealant to the outer periphery of new side seals.

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.

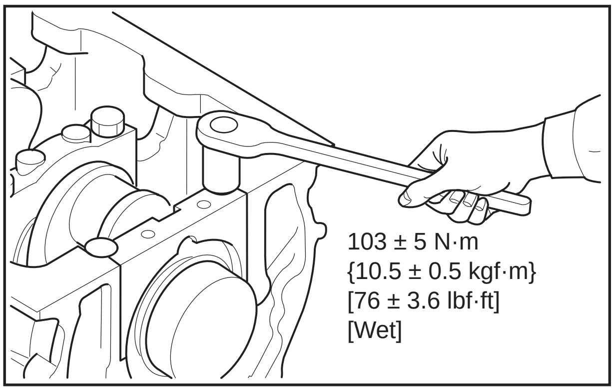


Inserting side seal

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.

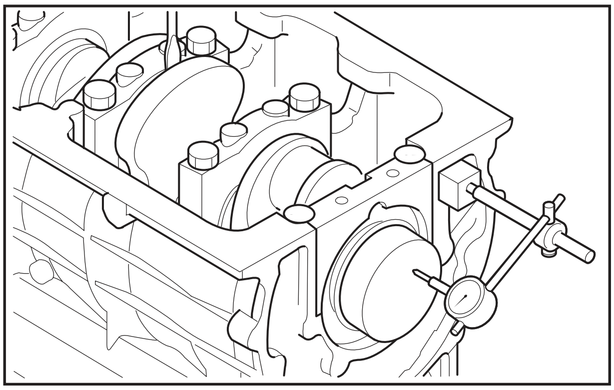


Installing main bearing cap bolt

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

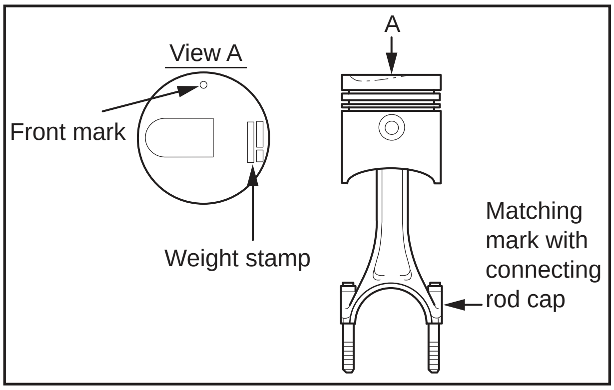
1.9 Reassembling piston and connecting rod

(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.

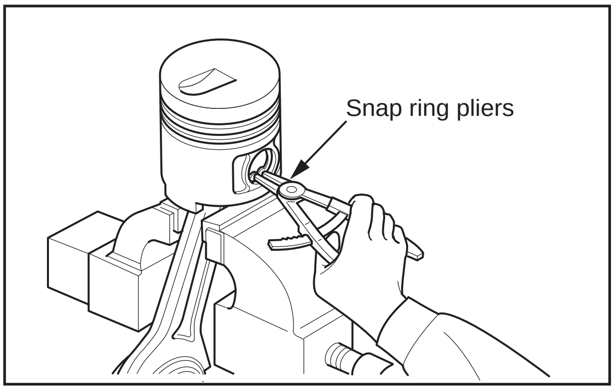
Note: The pistons and piston pins are assembled to each other in clearance fit. However, the piston pins are more easily inserted into the pistons if the pistons are warmed up with a heater or in hot water.

(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



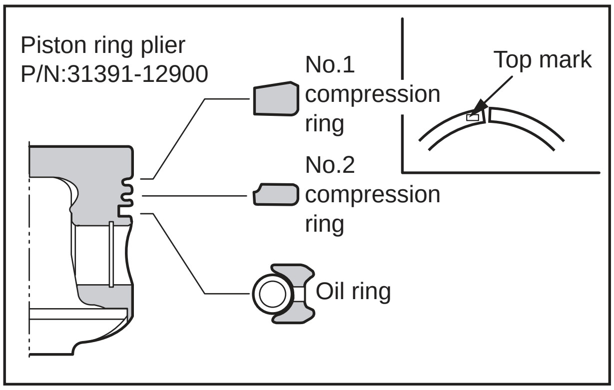
Installing snap ring

1.10 Installing piston ring

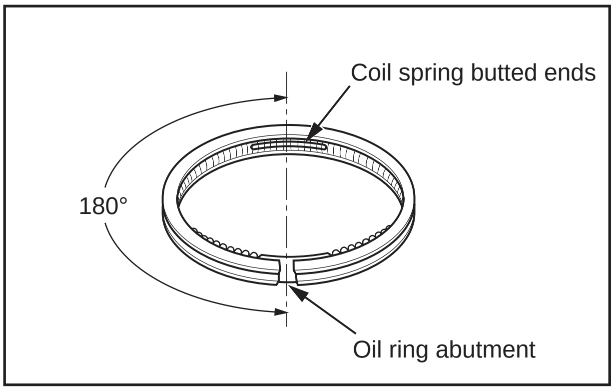
CAUTION

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.



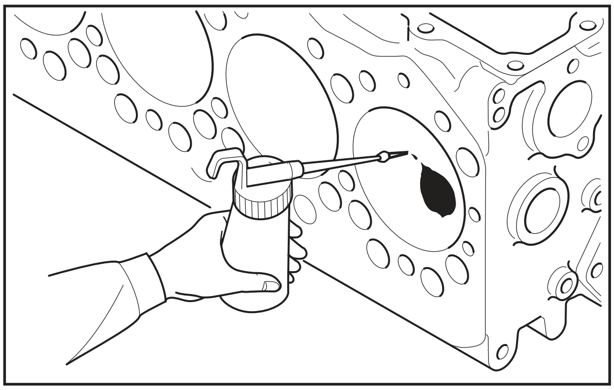
Piston/piston ring orientation



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

1.12 Installing connecting rod bolt and connecting rod bearing

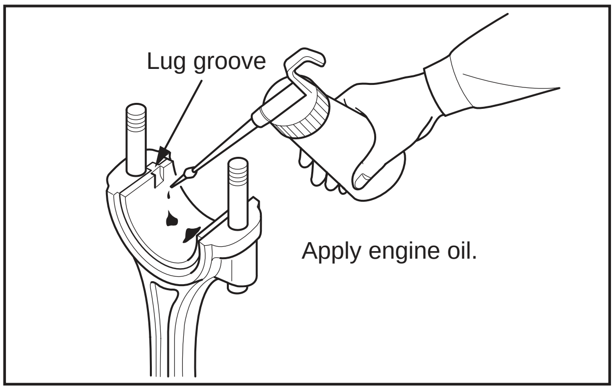
(1) Press fit the connecting rod bolts into the connecting rod.

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.

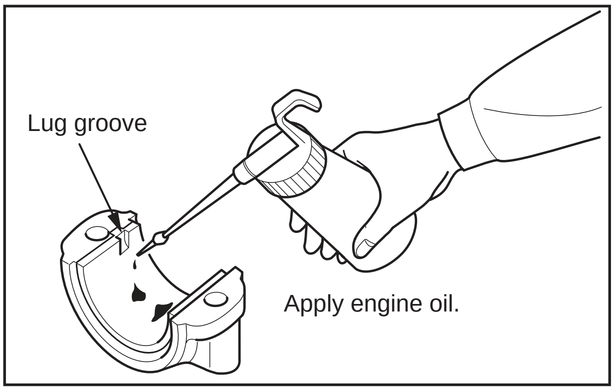
(2) Install the upper connecting rod bearing with its lug fitted in the lug groove of connecting rod.

(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.

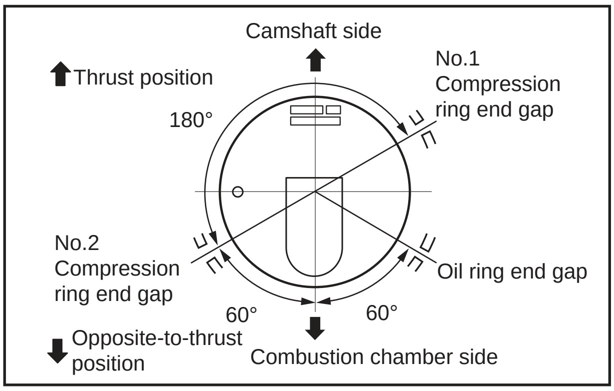
(1) Apply engine oil to the circumference of the piston and piston rings.

(2) Orient the ring end gaps diagonally opposite each other avoiding the piston pin direction and its right angle direction.

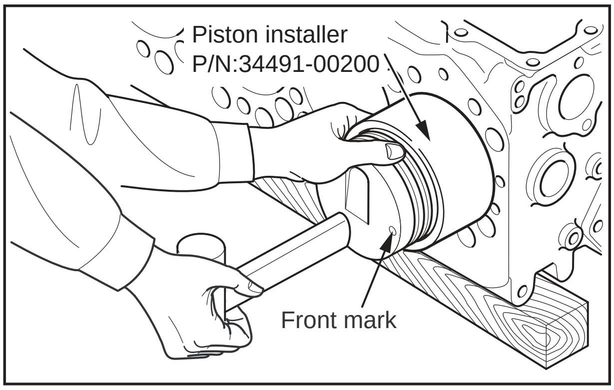
(3) Turn the crankshaft to bring the crank pin of the cylinder to bottom dead center.

(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



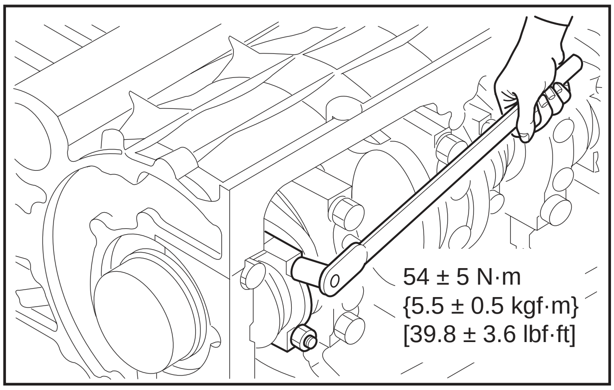
Installing piston

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.

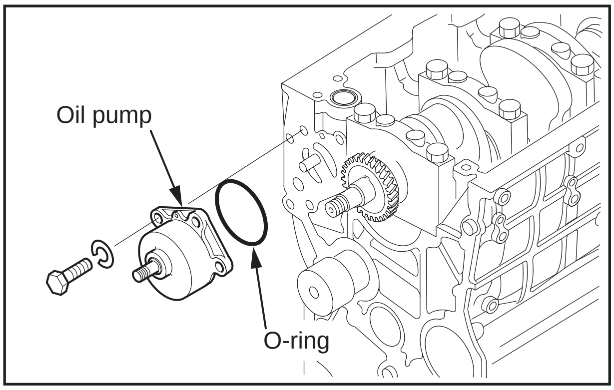


Installing connecting rod cap

2. Reassembling timing gear and camshaft

2.1 Installing oil pump

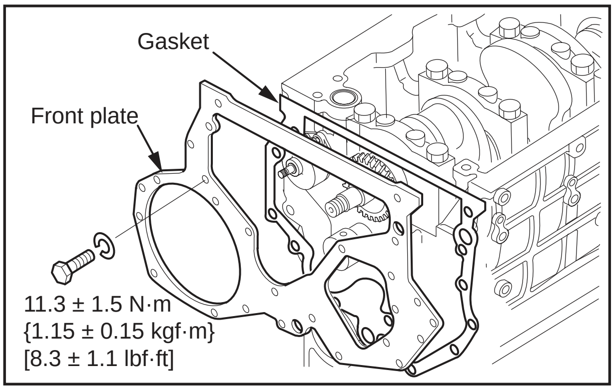
Install a new O-ring to the oil pump case, and install the oil pump to the crankcase.



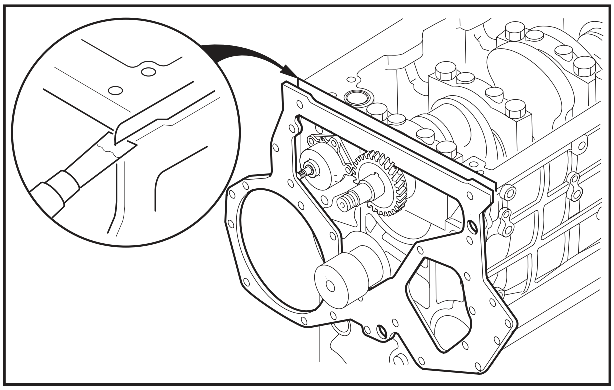
Installing oil pump

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)



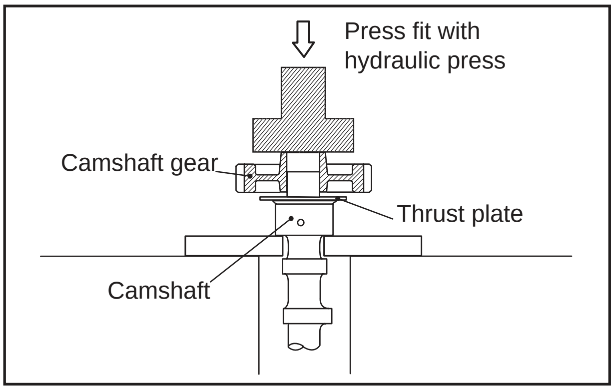
Installing front plate (2)

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.



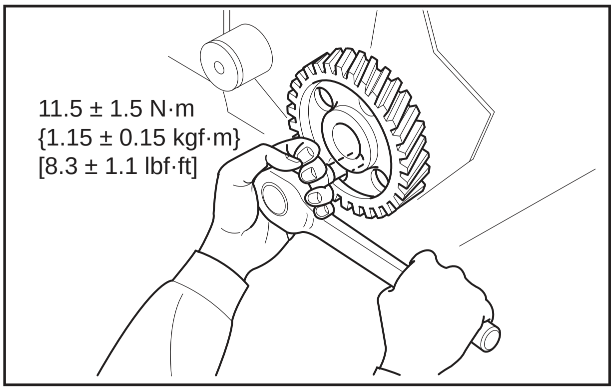
Installing camshaft gear and thrust plate

2.4 Installing camshaft

CAUTION

Be careful not to damage camshaft journals, cams and camshaft holes during insertion.

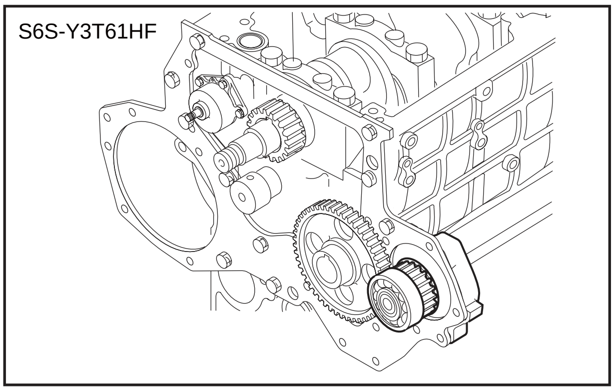
(1) Apply engine oil to the camshaft journals and cams.
(2) Slowly insert the camshaft assembly.
(3) Tighten the thrust plate bolt to the specified torque.
(4) Make sure that the camshaft rotates lightly. Move the camshaft gear back and forth, and make sure there is end play.



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.



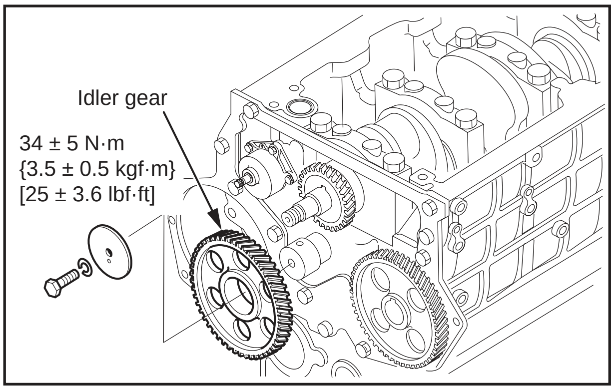
Installing PTO drive gear

2.6 Installing idler gear

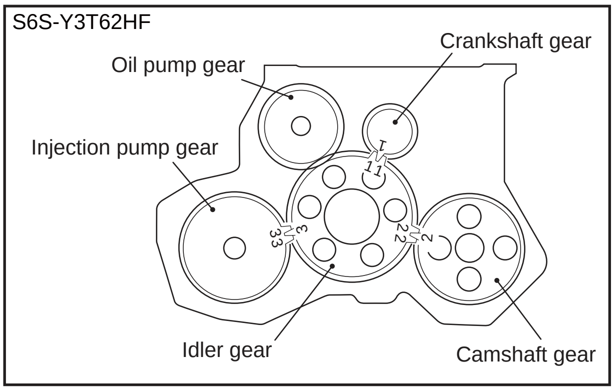
(1) Apply engine oil to the idler gear shaft.

(2) Install the idler gear with its match marks aligned with the marks on the crankshaft gear and camshaft gear.

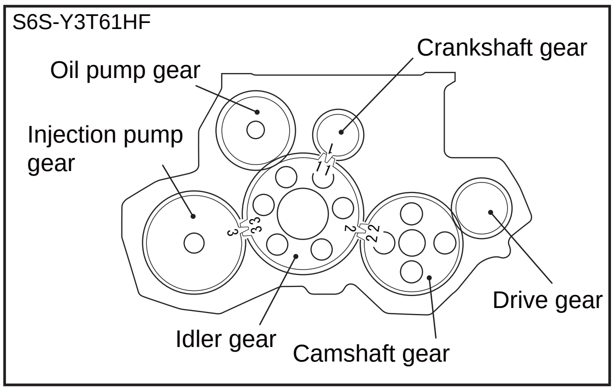
(3) Attach the thrust plate to the idler gear and tighten the mounting bolt to the specified torque.



Installing idler gear



Timing gear train

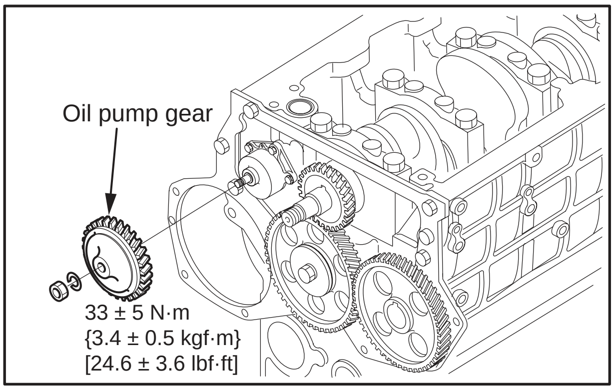


Timing gear train

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.

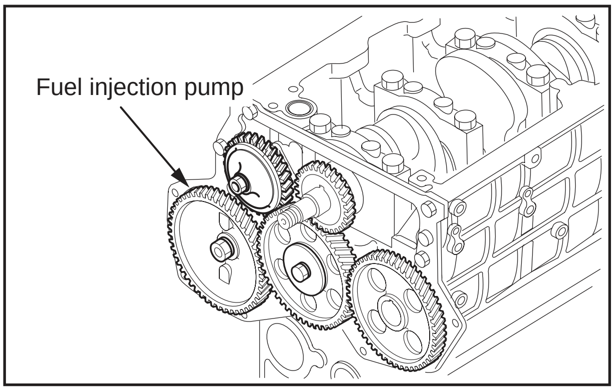


Installing oil pump gear

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.



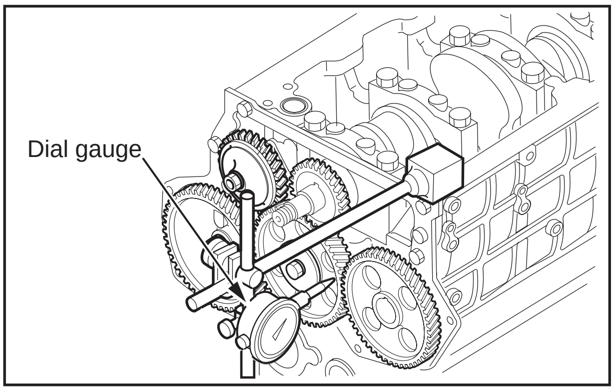
Installing fuel injection pump

2.9 Inspecting and adjusting timing gear after installation

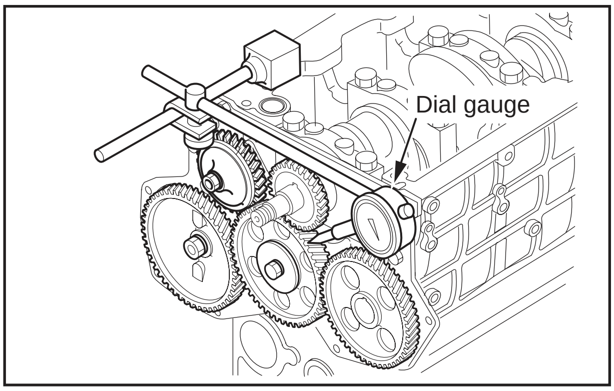
Be sure to inspect and adjust the timing gear when the timing gear has been reassembled.

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.



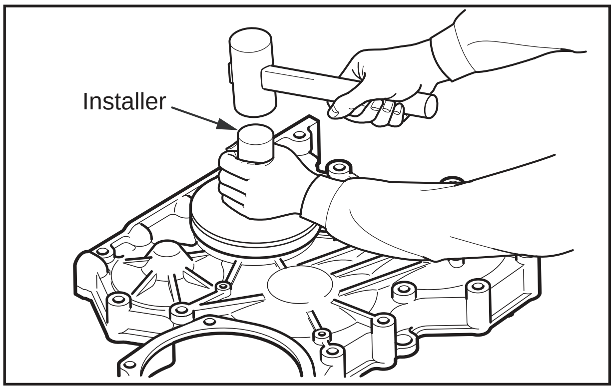
Measuring idler gear end play



Measuring timing gear backlash

2.10 Installing front oil seal

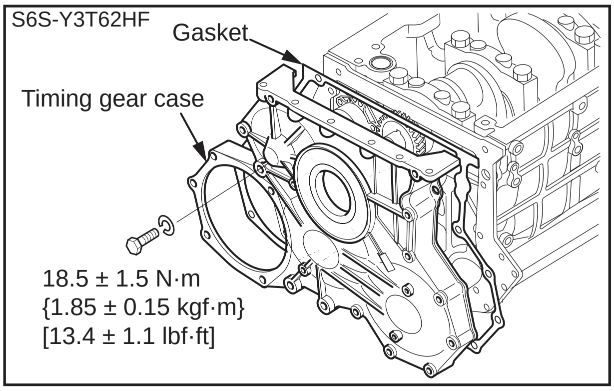
Using an installer, install new oil seal in the timing gear case. Make sure the oil seal is flush with the gear case.



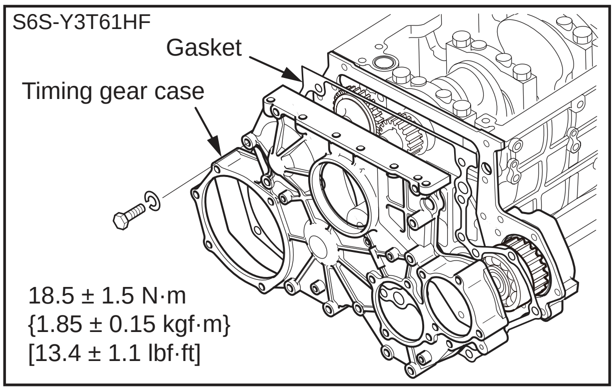
Installing front oil seal

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.



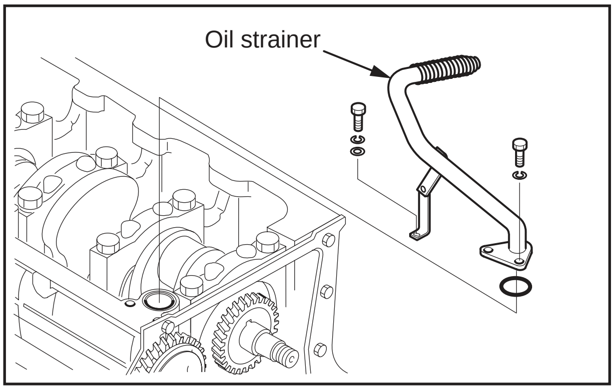
Installing timing gear case



Installing front plate

2.12 Installing oil strainer

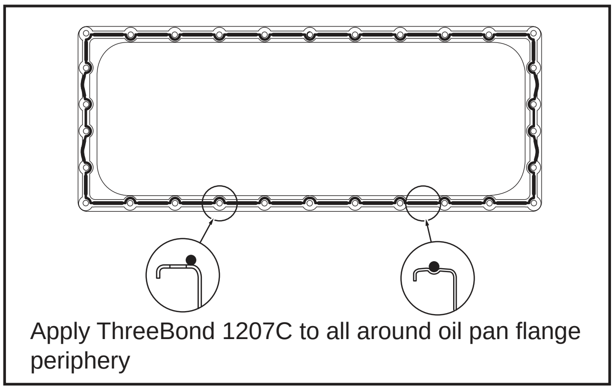
Install a new O-ring to the oil strainer, and install the oil strainer to the crankcase.



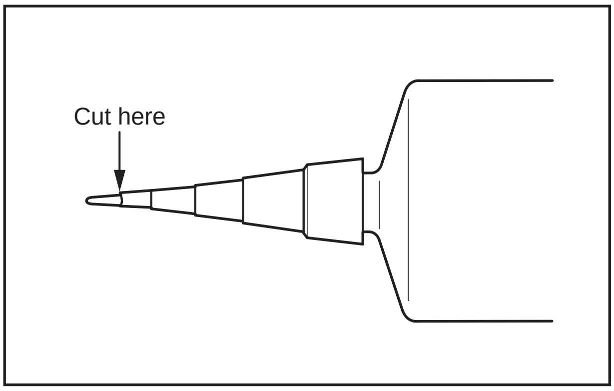
Installing oil strainer

2.13 Installing oil pan

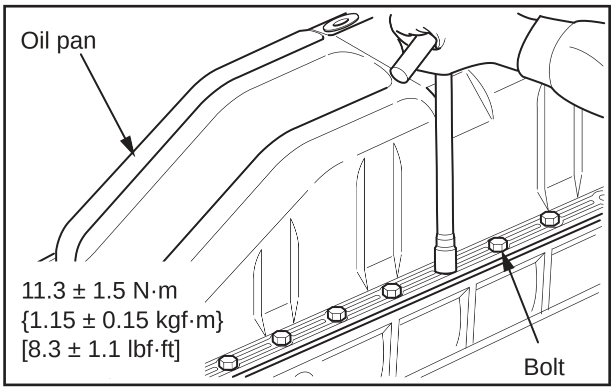
(1) Clean the mount surfaces of the crankcase, timing gear case, and oil pan.
(2) Squeeze ThreeBond 1207C (32A91-05100: liquid gasket) in a 4 mm [0.16 in.] diameter bead all around the oil pan flange periphery, and spread it.
(3) Install the oil pan to the crankcase within five minutes of applying the liquid gasket.
(4) Tighten the mounting bolts to the specified torque.



Liquid gasket application position



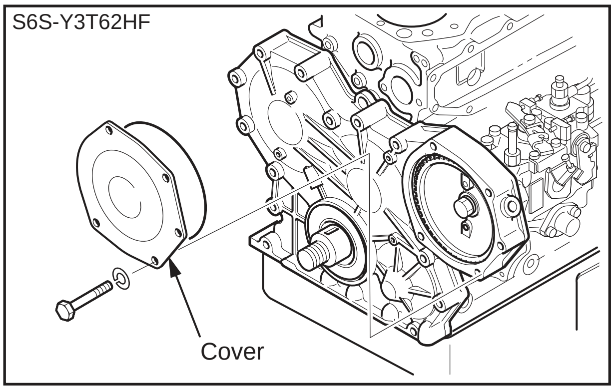
Cutting end of sealant tube



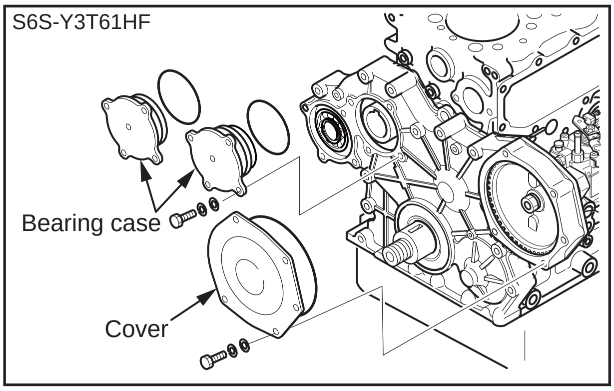
Installing oil pan

2.14 Installing cover

Tighten the cover mounting bolts evenly.



Installing cover



Installing cover

2.15 Installing crankshaft pulley and damper

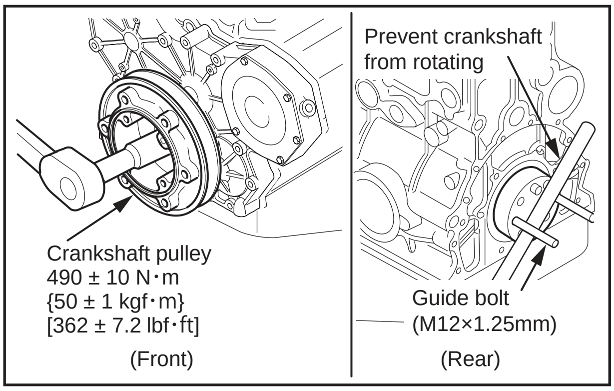
⚠ CAUTION

The bar could come off. Be very careful.

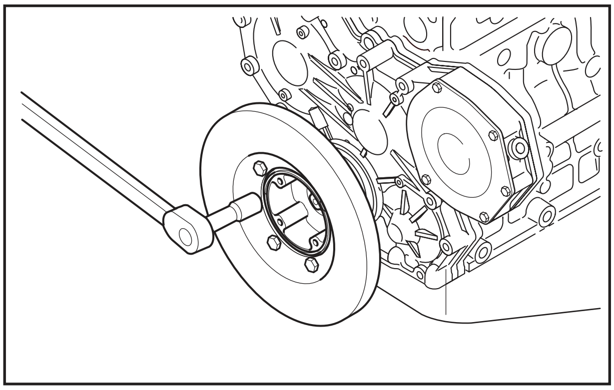
(1) Screw two guide bolts into the threaded holes at the rear end of the crankshaft. Place a bar across the two guide bolts so that the crankshaft does not turn.

(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

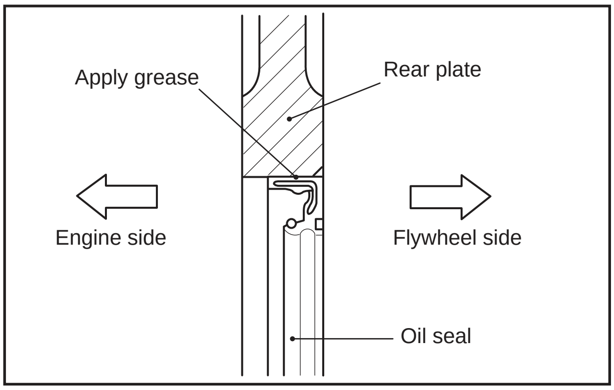
3. Reassembling flywheel

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

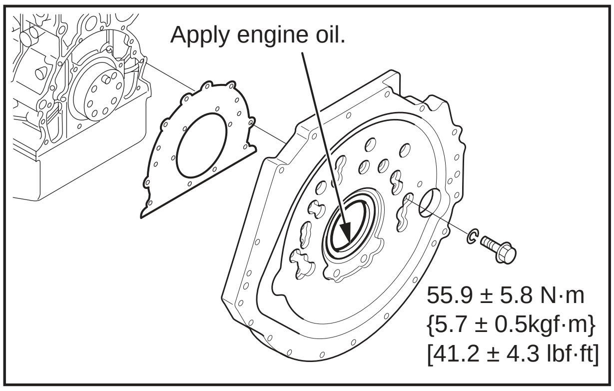
(1) Clean the mounting surface of the gasket.

(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.

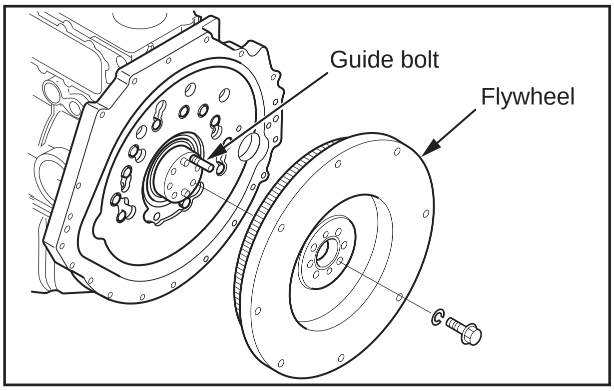
(2) Screw the guide bolt into the rear end of the crankshaft.

(3) Align the bolt hole of flywheel with the guide bolt and install the flywheel to the crankshaft.

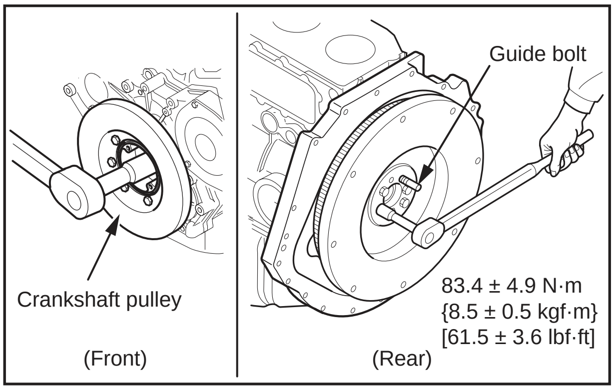
(4) Temporarily tighten bolts.

(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)

4. Reassembling cylinder head and valve mechanism

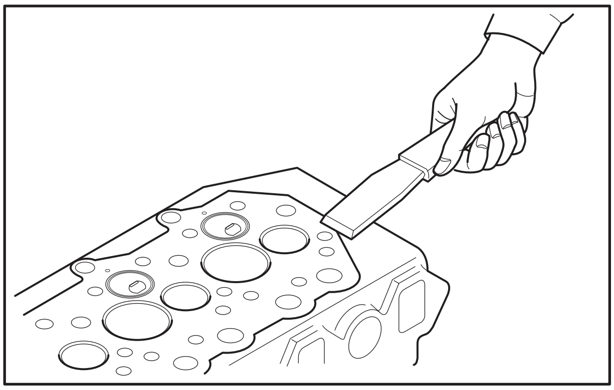
4.1 Cleaning cylinder head bottom surface

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

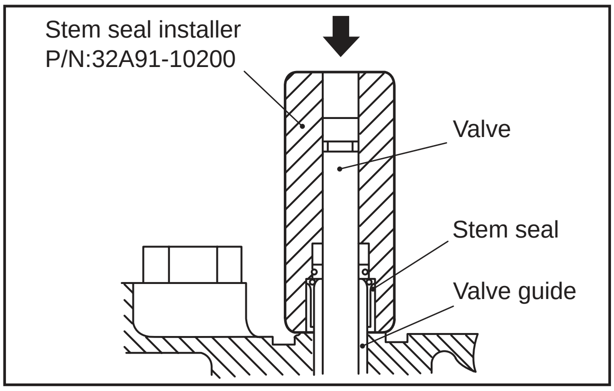
CAUTION

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 steal into the valve guide.

(3) Insert the valve stem seal into the valve guide using the valve stem seal installer.

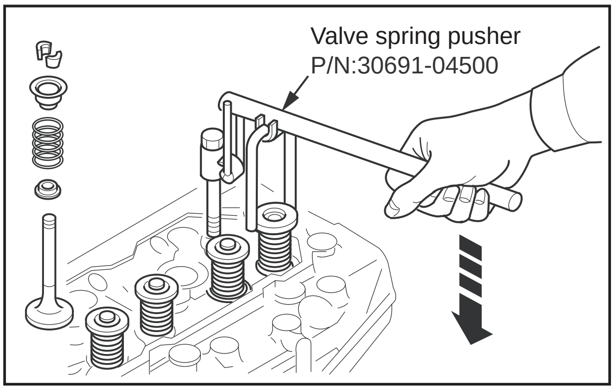


Installing valve stem seal

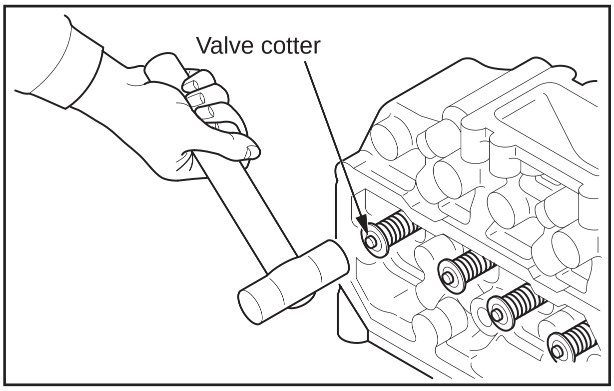
4.3 Installing valve and valve spring

(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.

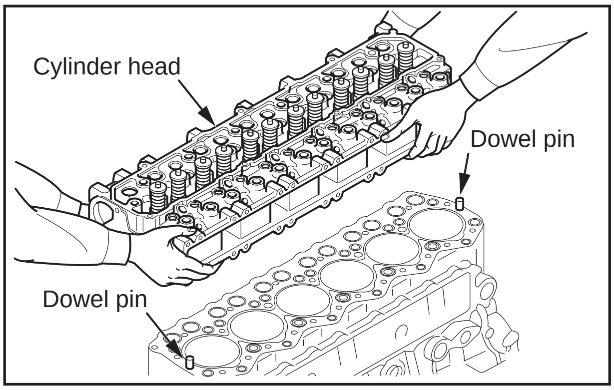
(2) Place new gasket on the crankcase by aligning it with dowel pins on the crankcase.

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.

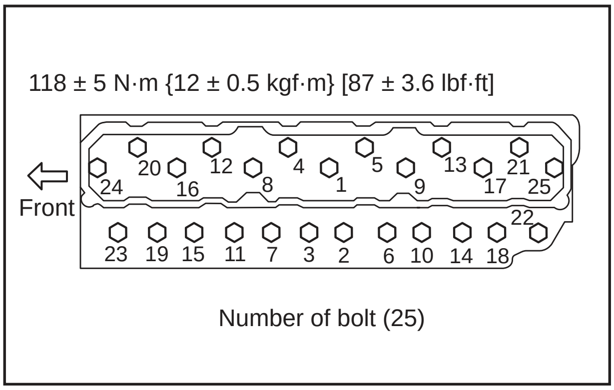
(b) Do not lift up cylinder head by one person. Use crane or lift up by two persons.



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.

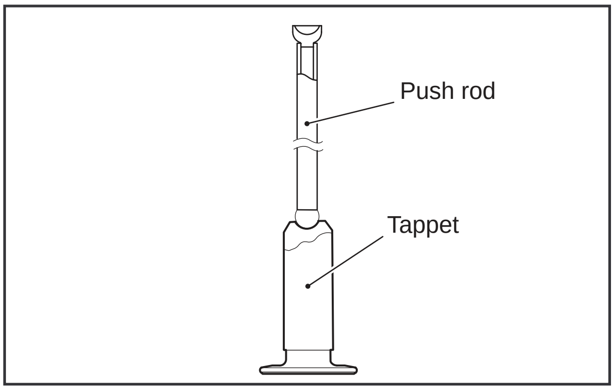


Tightening order of cylinder head bolt

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

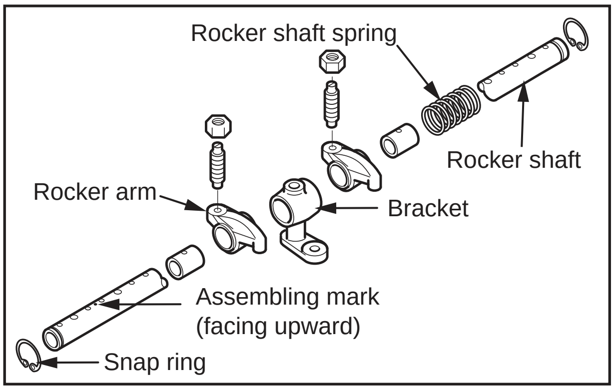
4.8 Reassembling rocker shaft assembly

(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.



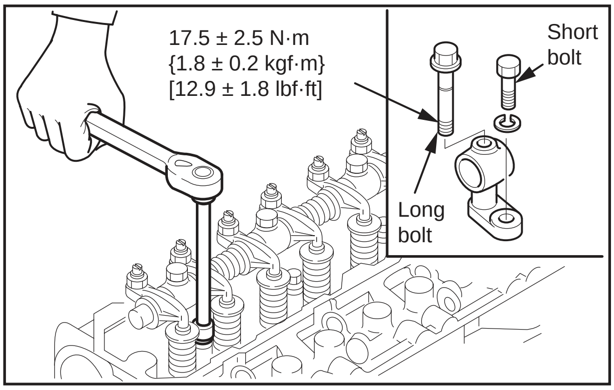
Reassembling rocker shaft assembly

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.

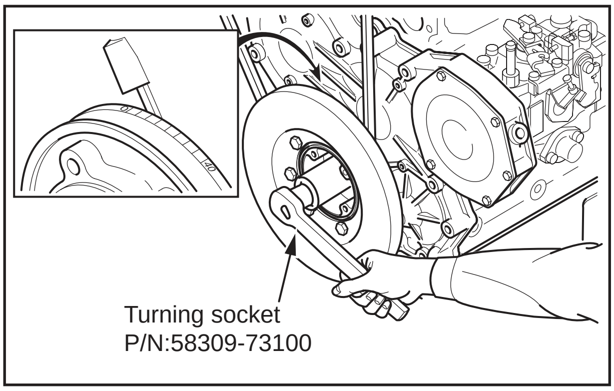
4.10.2 When replacing the damper with a new one

(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.

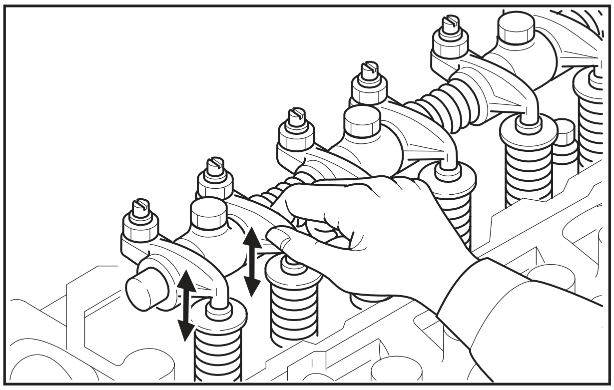
(2) Attach the dial gauge to the inlet valve and rotate the crankshaft to determine the compression top dead center, when determined, stop rotating the crankshaft.

(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)

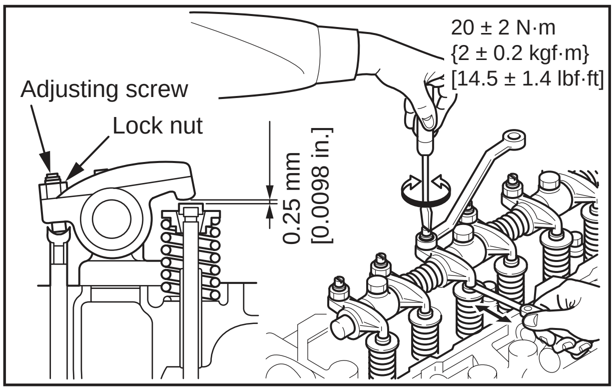


Determining top dead center of No. 1 cylinder compression stroke (2)

4.11 Adjusting valve clearance

Adjust the valve clearance.

For adjusting procedures, refer to "Adjustment and Operation."

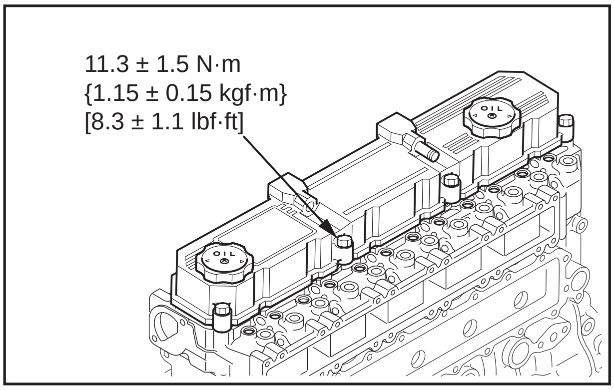


Adjusting valve clearance

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

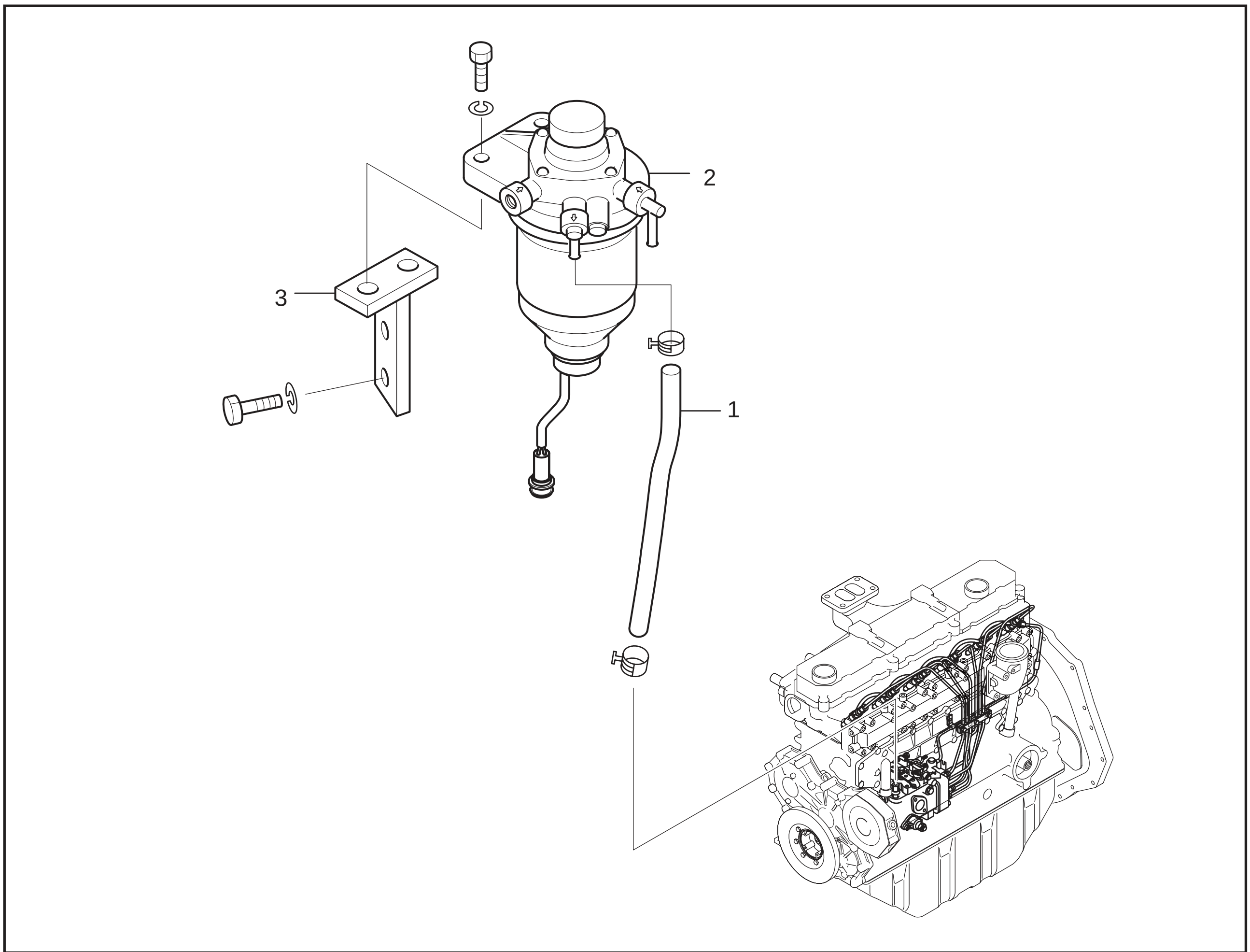
FUEL SYSTEM

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

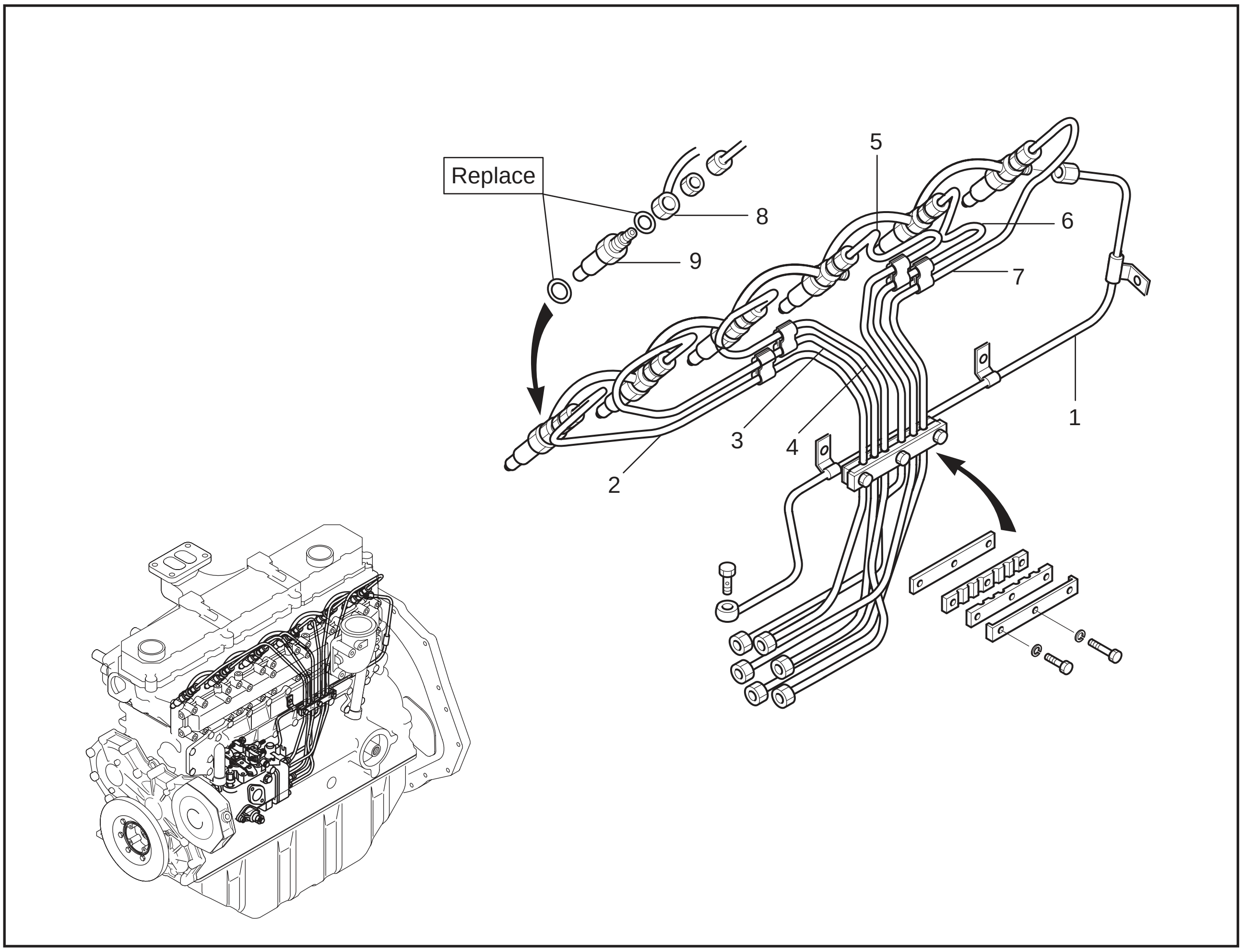


Removing fuel filter

Removing sequence

1 Fuel hose
2 Fuel filter
3 Fuel filter bracket

1.2 Removing fuel injection pipe

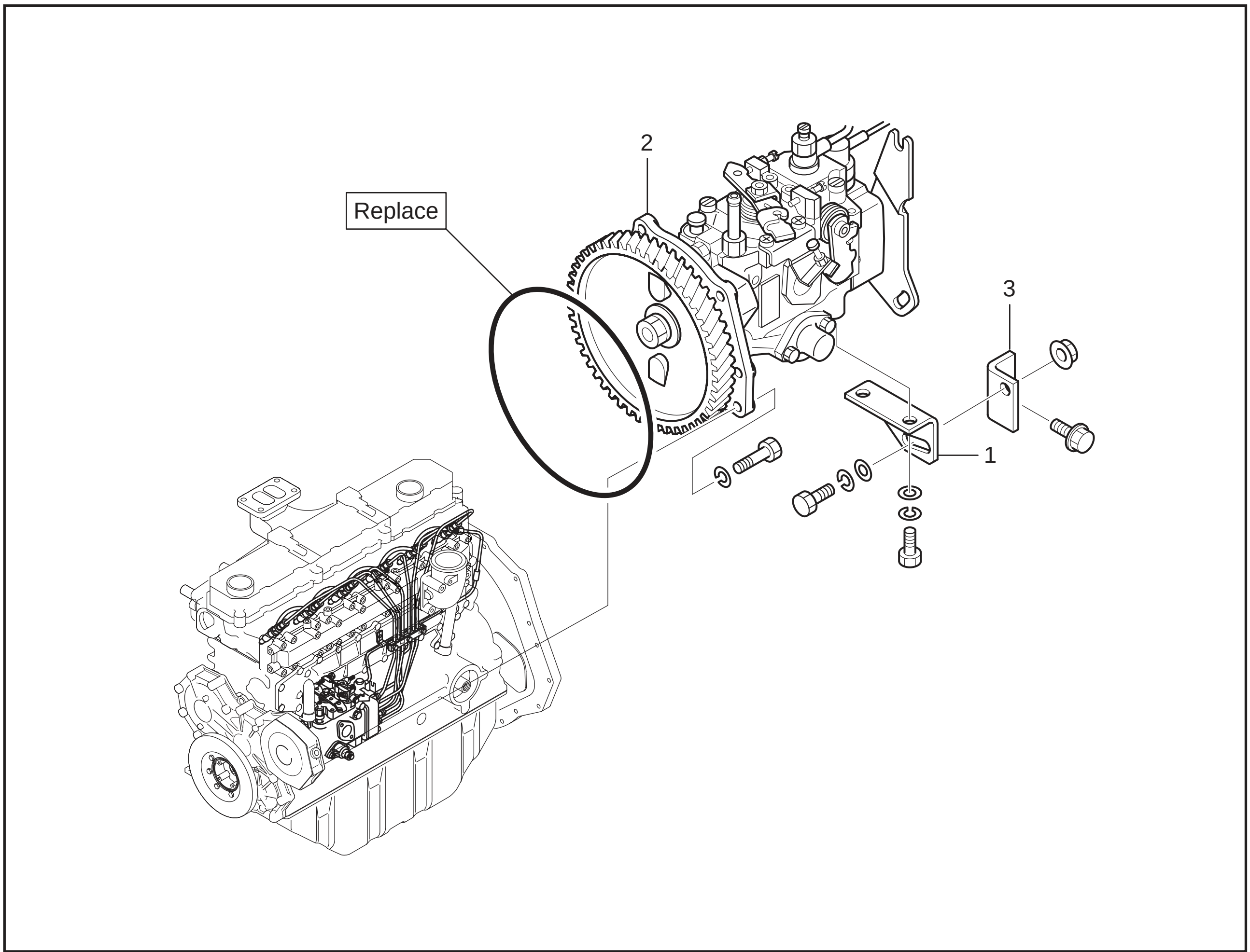


Removing fuel injection pipe

Removing sequence

1 Fuel return pipe
2 No. 1 fuel injection pipe
3 No. 2 fuel injection pipe
4 No. 3 fuel injection pipe
5 No. 4 fuel injection pipe
6 No. 5 fuel injection pipe
7 No. 6 fuel injection pipe
8 Fuel leak-off pipe
9 Fuel injection nozzle

1.3 Removing fuel injection pump



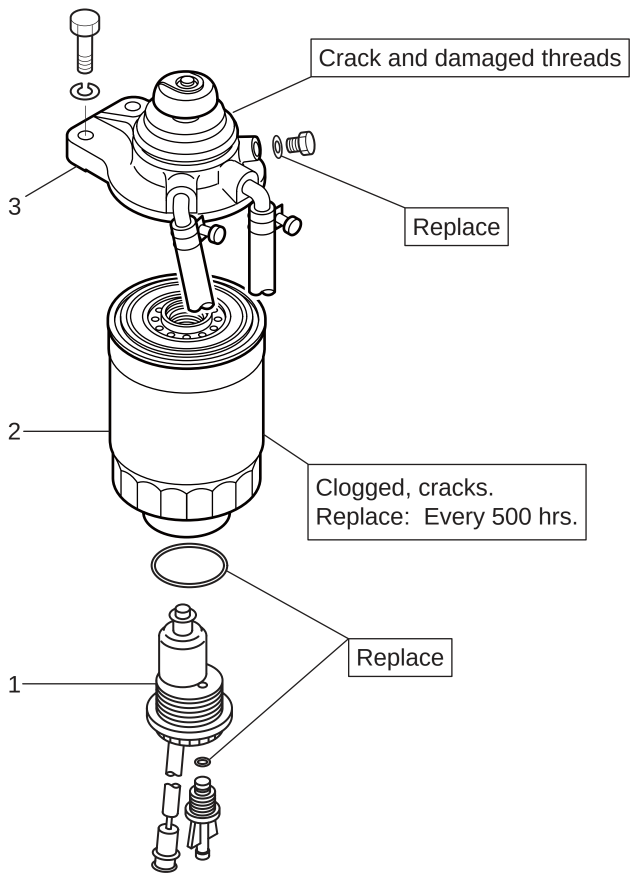
Removing fuel injection pump

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

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

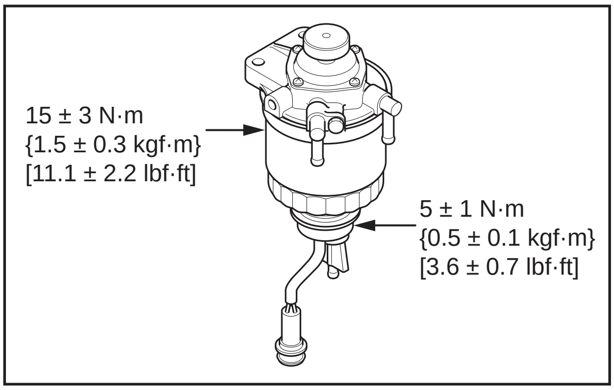
Be careful not to dent or damage the fuel filter case.

(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.

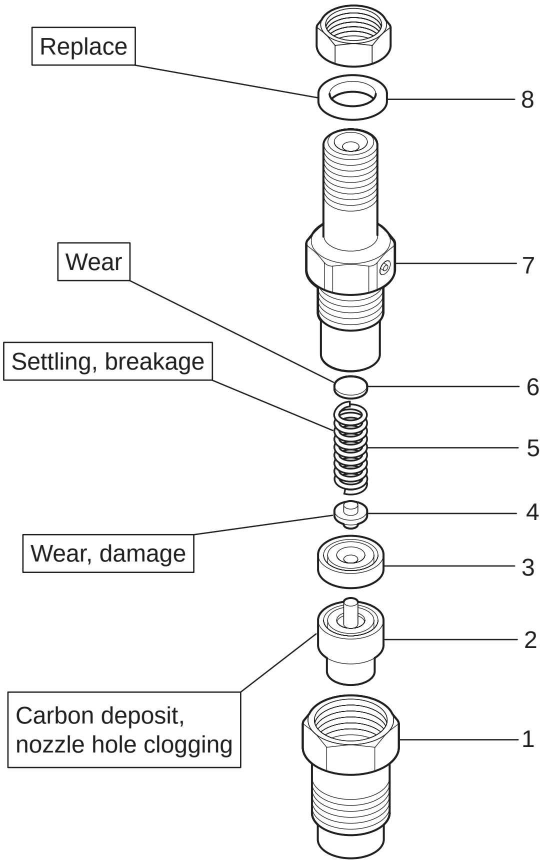
(12) Start the engine and run at idling speed for a few minutes.

(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
2 Nozzle tip assembly
3 Distance piece
4 Pressure pin
5 Pressure spring
6 Washer
7 Nozzle holder
8 Gasket

2.4 Inspecting and adjusting fuel injection valve opening pressure

⚠ CAUTION

Never touch the spray hole during injection

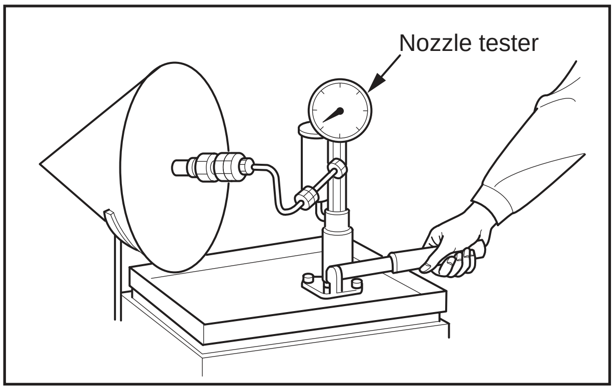
(1) Mount the nozzle on the nozzle tester.

(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.



Inspecting fuel injection nozzle with nozzle tester

Item	Nominal	Standard
Valve opening pressure	11.77 MPa {120 kgf/cm²} [1707 psi]	11.77 to 12.75 MPa {120 to 130 kgf/cm²} [1707 to 1849 psi]

Note: (a) Standard is a value of new parts.

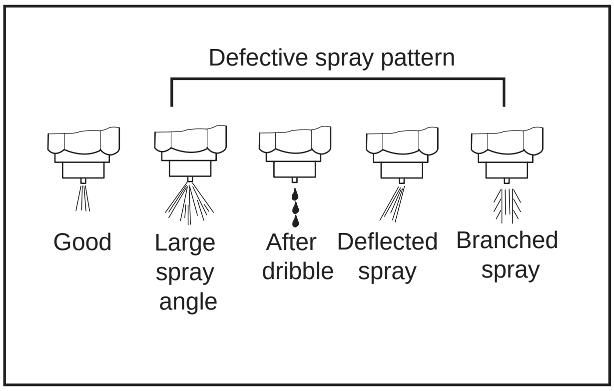
(b) A change in thickness of the shim by 0.1 mm [0.004 in] results in a change in the fuel injection pressure by 1.0 MPa {10kgf/cm² } [142 psi]. There are ten different sizes of shims available 1.25 to 1.70 mm [0.0492 to 0.0669 in.] to obtain proper pressure.

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.

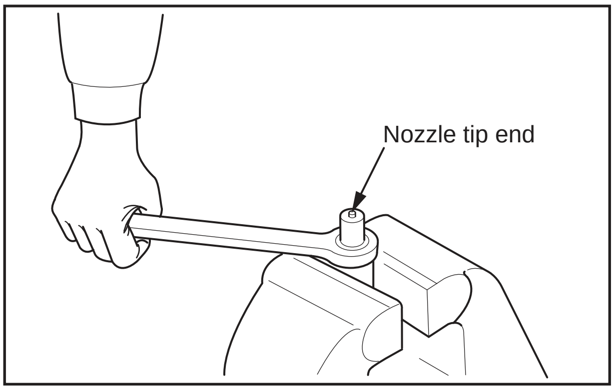
(2) After cleaning, assemble the needle valve and the body in a clean diesel oil.

Note: The needle valve and body are precision parts. Handle them carefully, and do not change the combination of the valve and body.

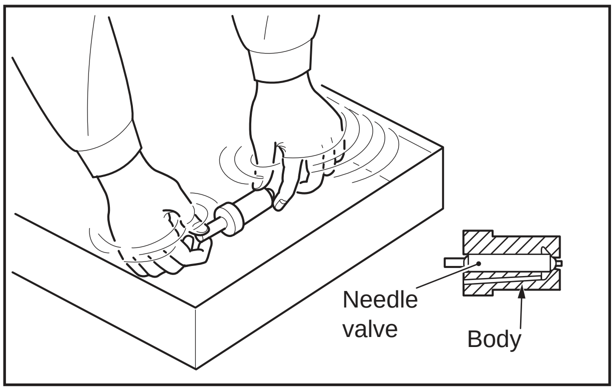
(3) Tighten the nozzle tip tightening retainer nut to the specified torque.

(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.

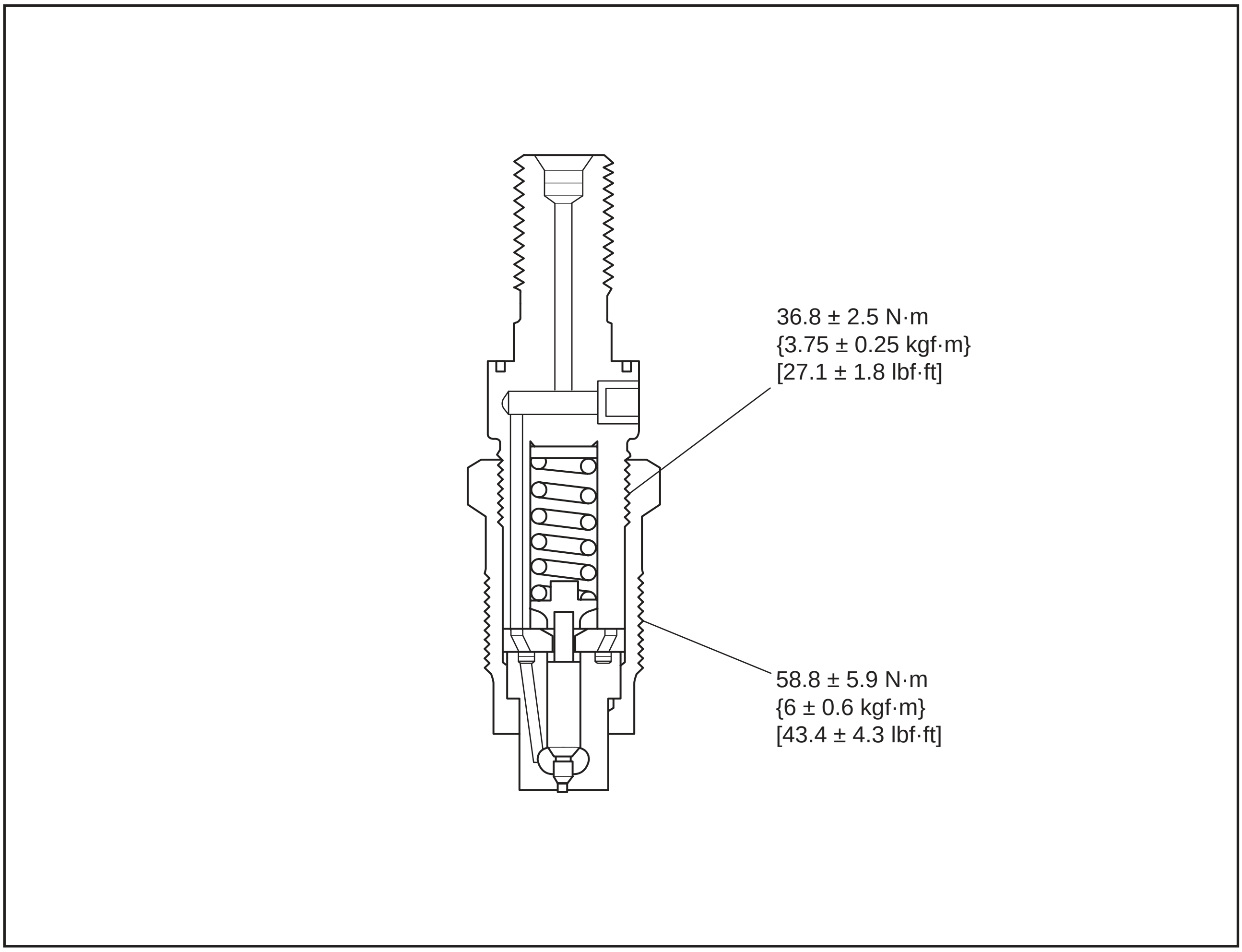


Replacing fuel injection nozzle tip



Cleaning nozzle tip assembly

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.

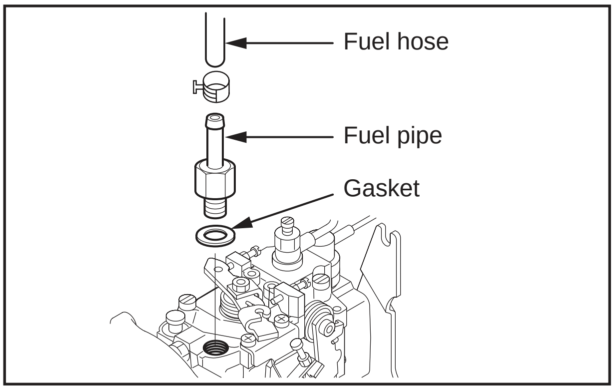
(3) Remove the spring with a tweezer.

(4) Remove the gauze filter with a tweezer.

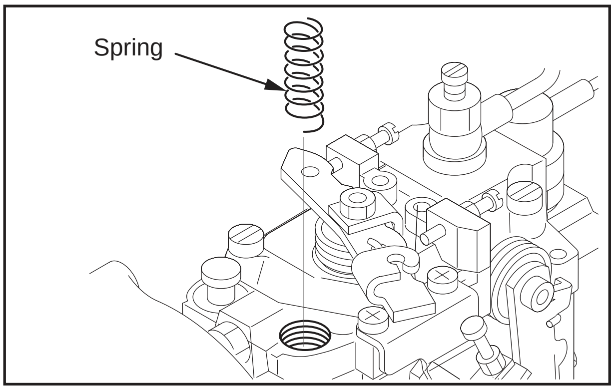
Note: When removing the gauze filter, be careful not to damage the metal mesh of the gauze filter.

(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.

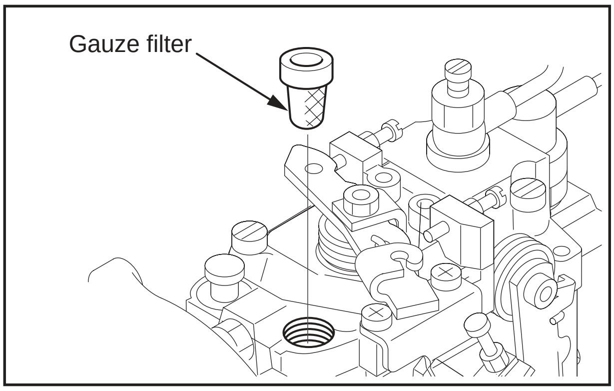
(6) Install the cleaned gauze filter and new gasket, and in reverse order of disassembly, install the fuel pipe and fuel hose.



Removing fuel hose and fuel pipe



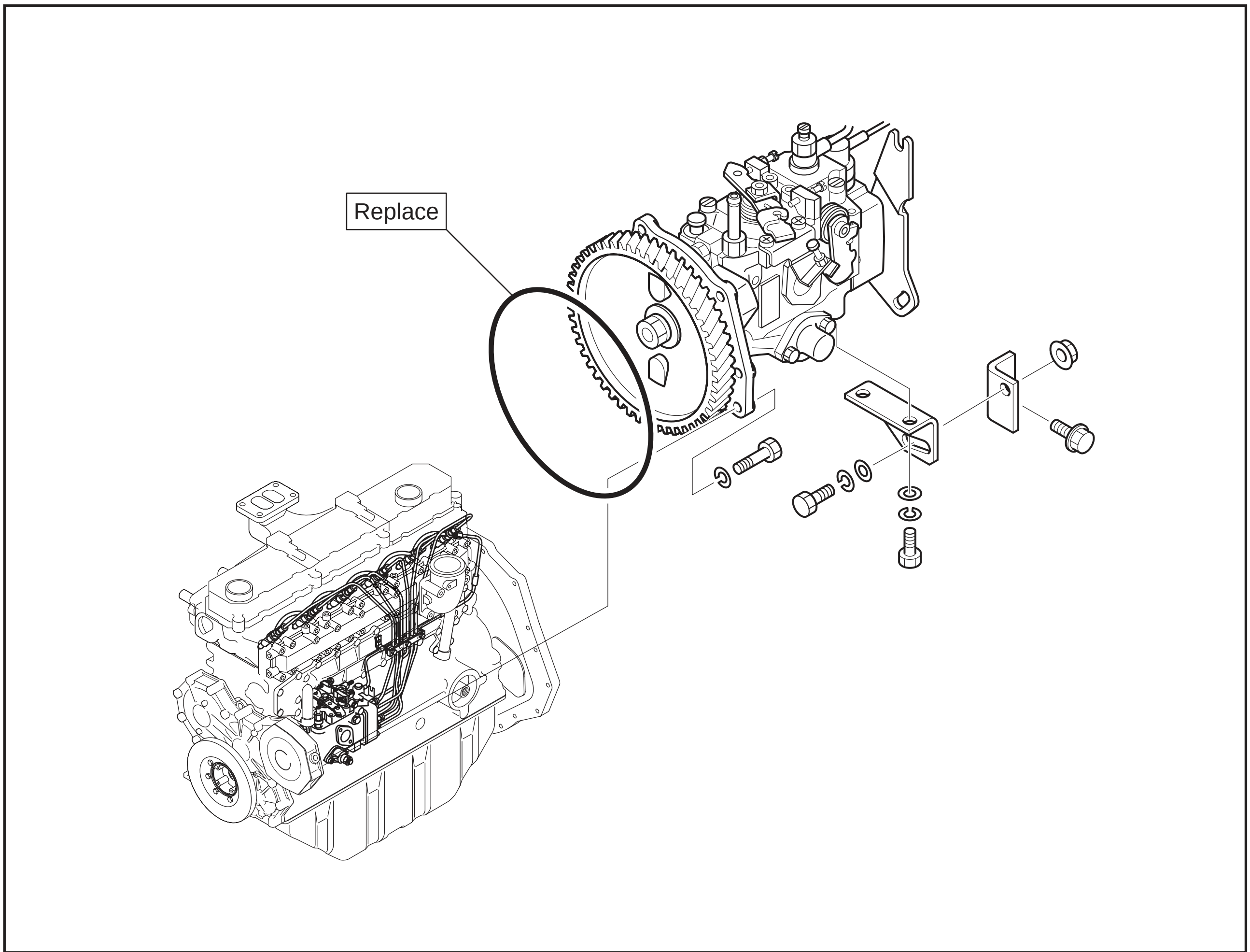
Removing spring



Removing gauze filter

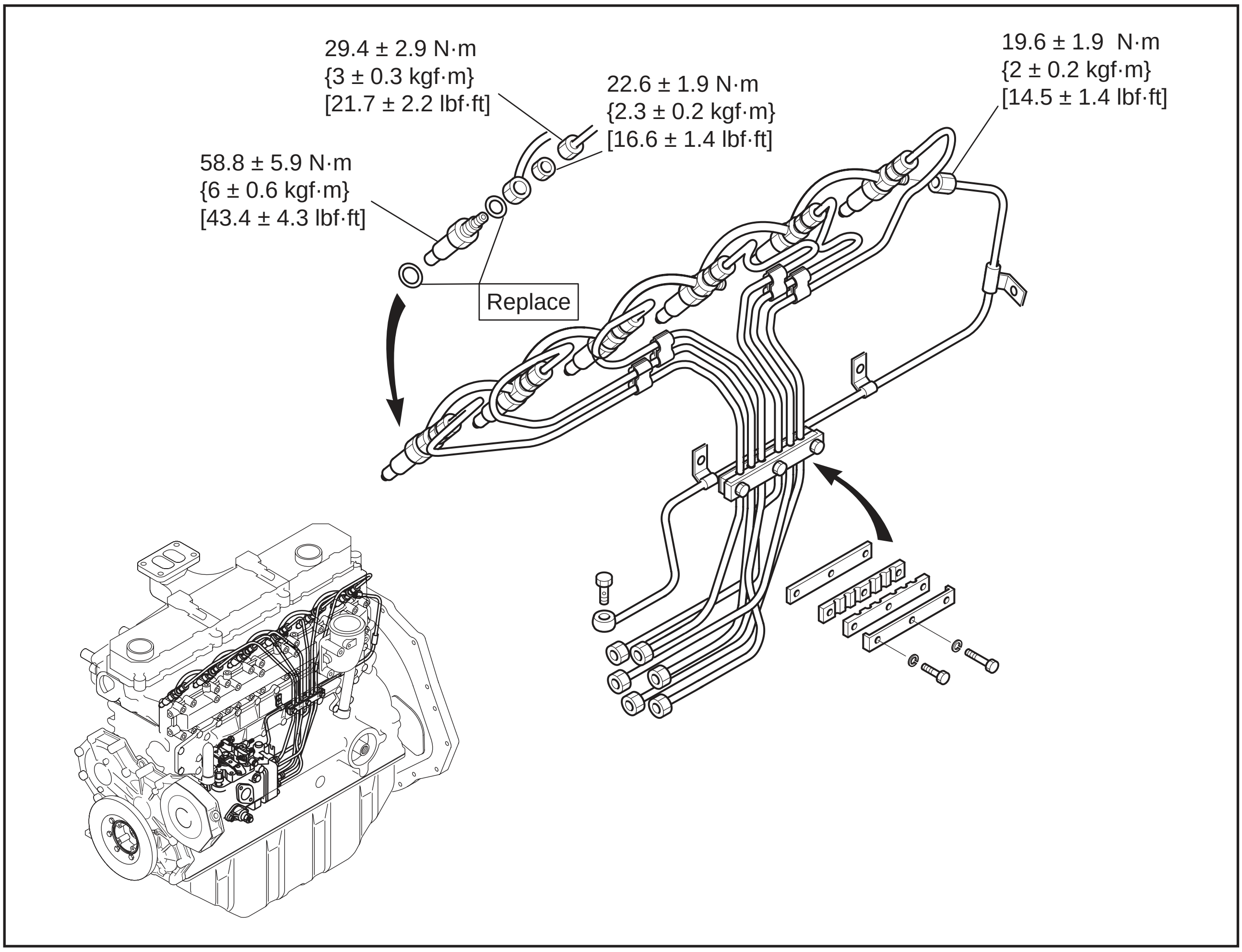
3. Installing fuel system

3.1 Installing fuel injection pump



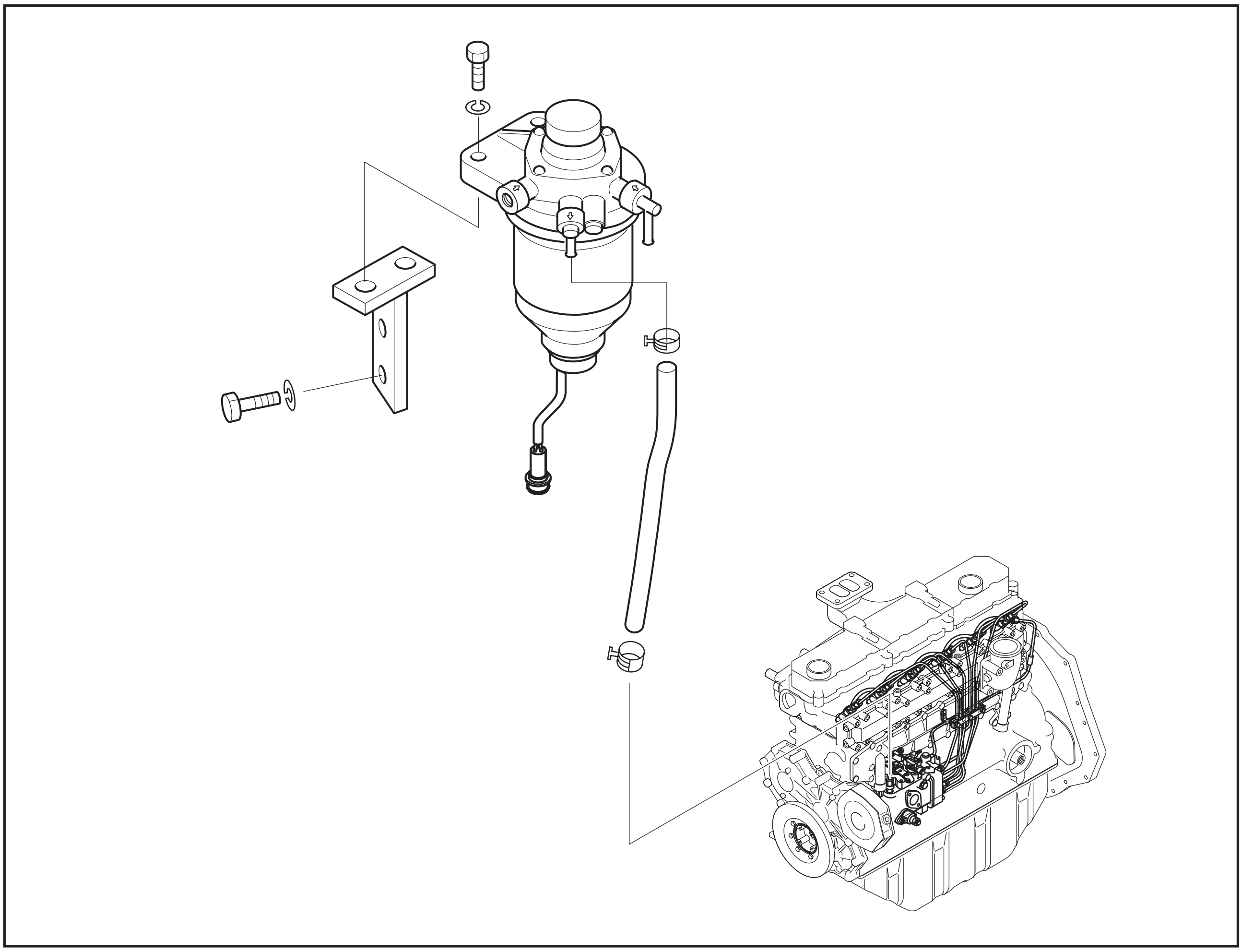
Installing fuel injection pump

3.2 Installing fuel injection pipe



Installing fuel injection pipe

3.3 Installing fuel filter

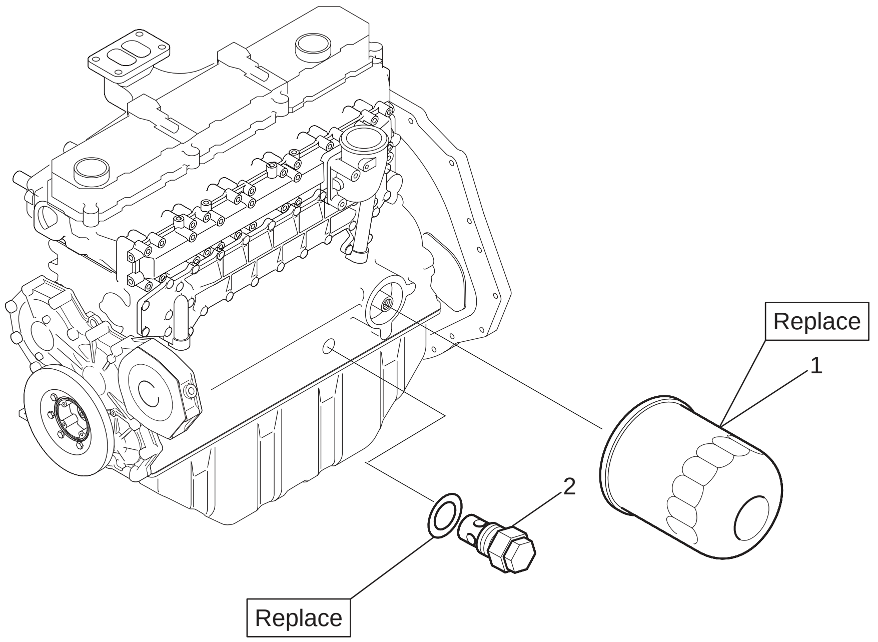


Installing fuel filter

LUBRICATION SYSTEM

1. Removing lubrication system

1.1 Removing oil filter and relief valve



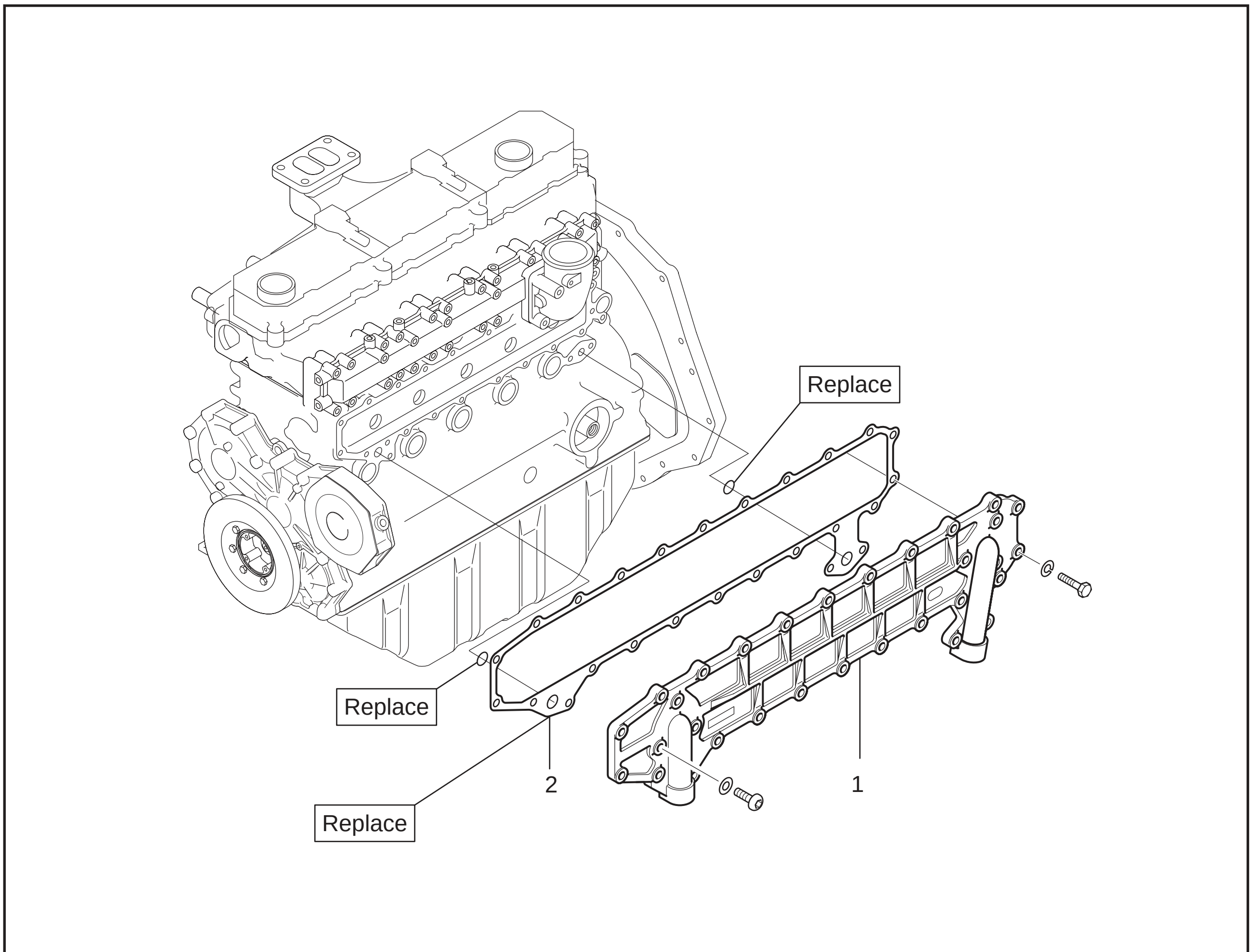
Removing oil filter and relief valve

Removing sequence

1 Oil filter

2 Relief valve

1.2 Removing oil cooler



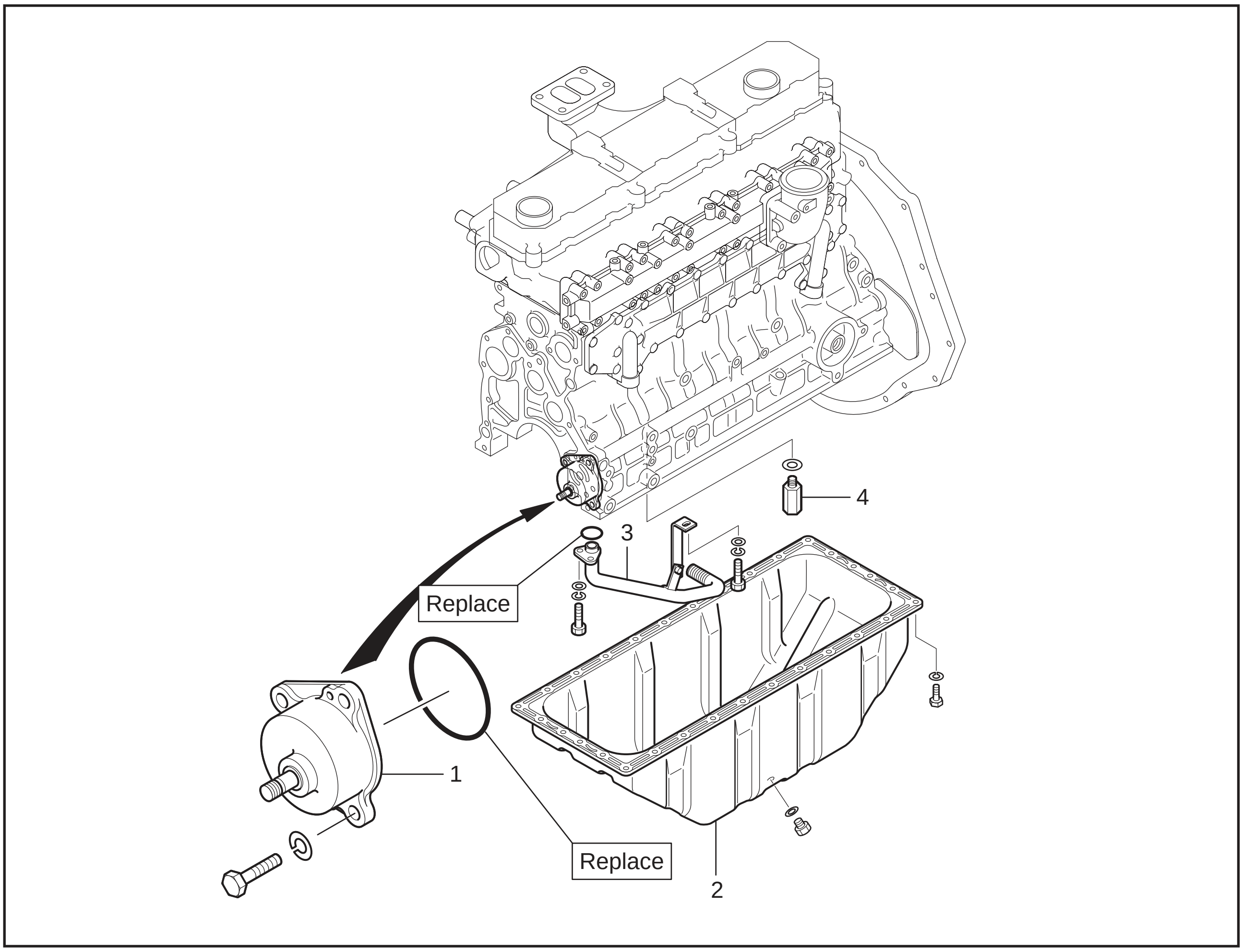
Removing oil cooler

Removing sequence

1 Oil cooler assembly

2 Oil cooler gasket

1.3 Removing oil pump, oil pan and oil strainer



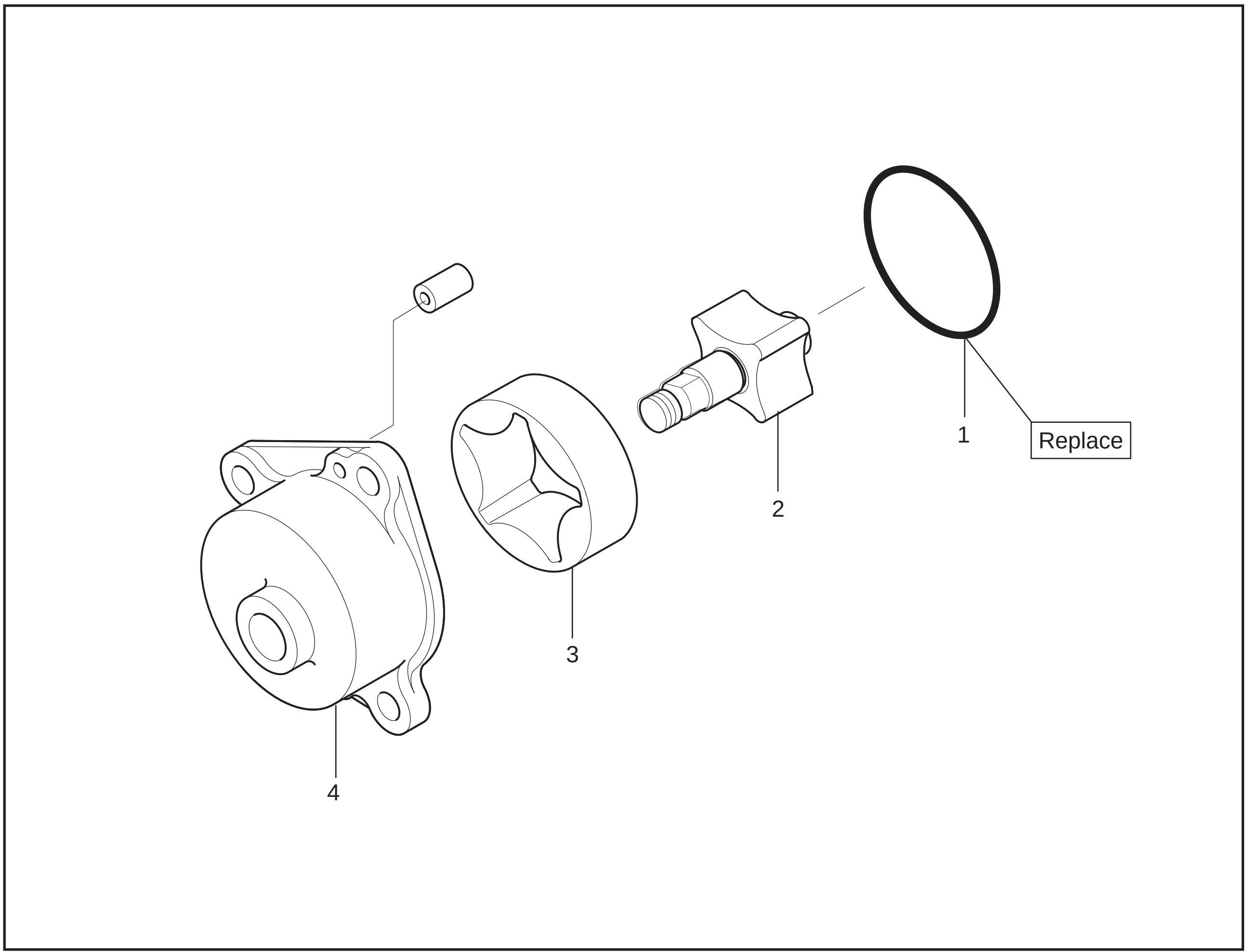
Removing oil pump, oil pan and oil strainer

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

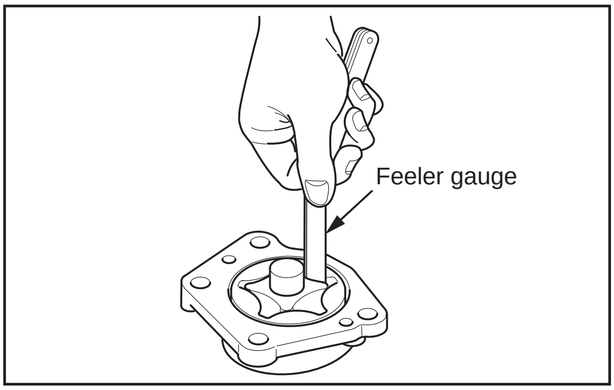
1 O-ring   2 Shaft assembly   3 Outer rotor   4 Pump case

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.]

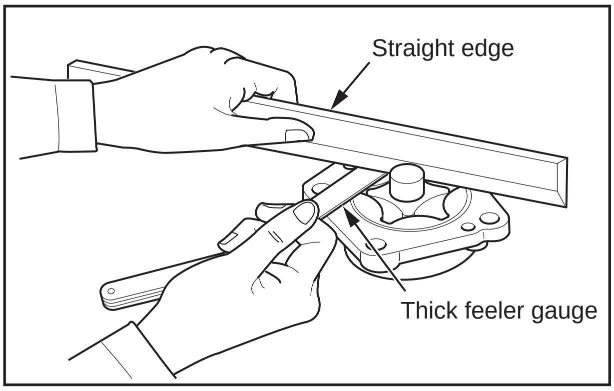


Measuring clearance between outer rotor and inner rotor

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.]

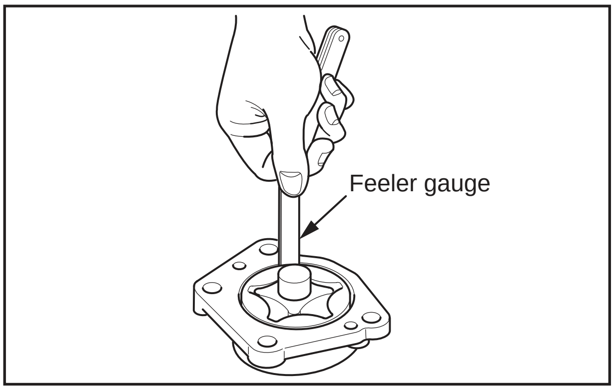


Measuring end play of rotor and pump case

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.]

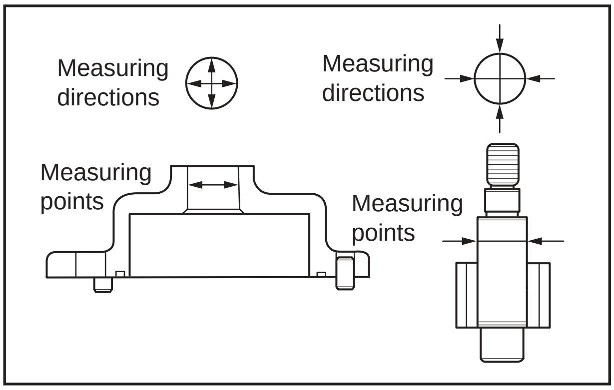


Measuring clearance between outer rotor and pump case

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.]

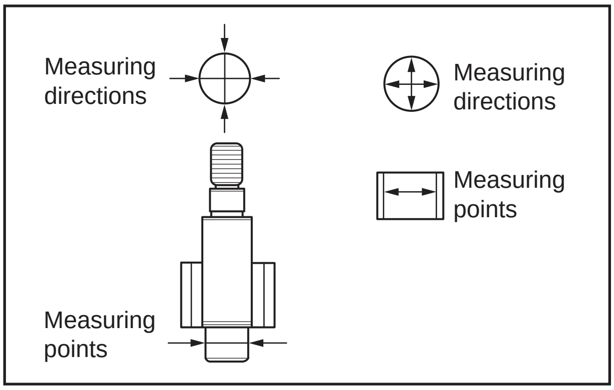


Measuring clearance between main shaft and pump case

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.]



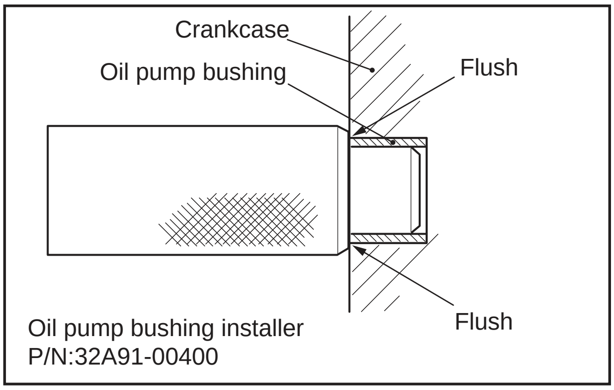
Measuring clearance between main shaft and bushing

2.2.6 Installing oil pump bushing

CAUTION

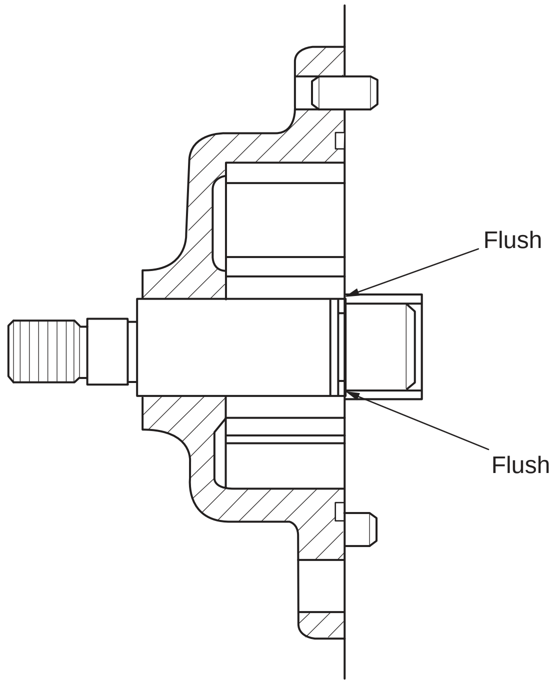
Install the oil pump bushing in the crankcase so that it is even with the front face of the crankcase.

Install the oil pump bushing by using the oil pump bushing installer.



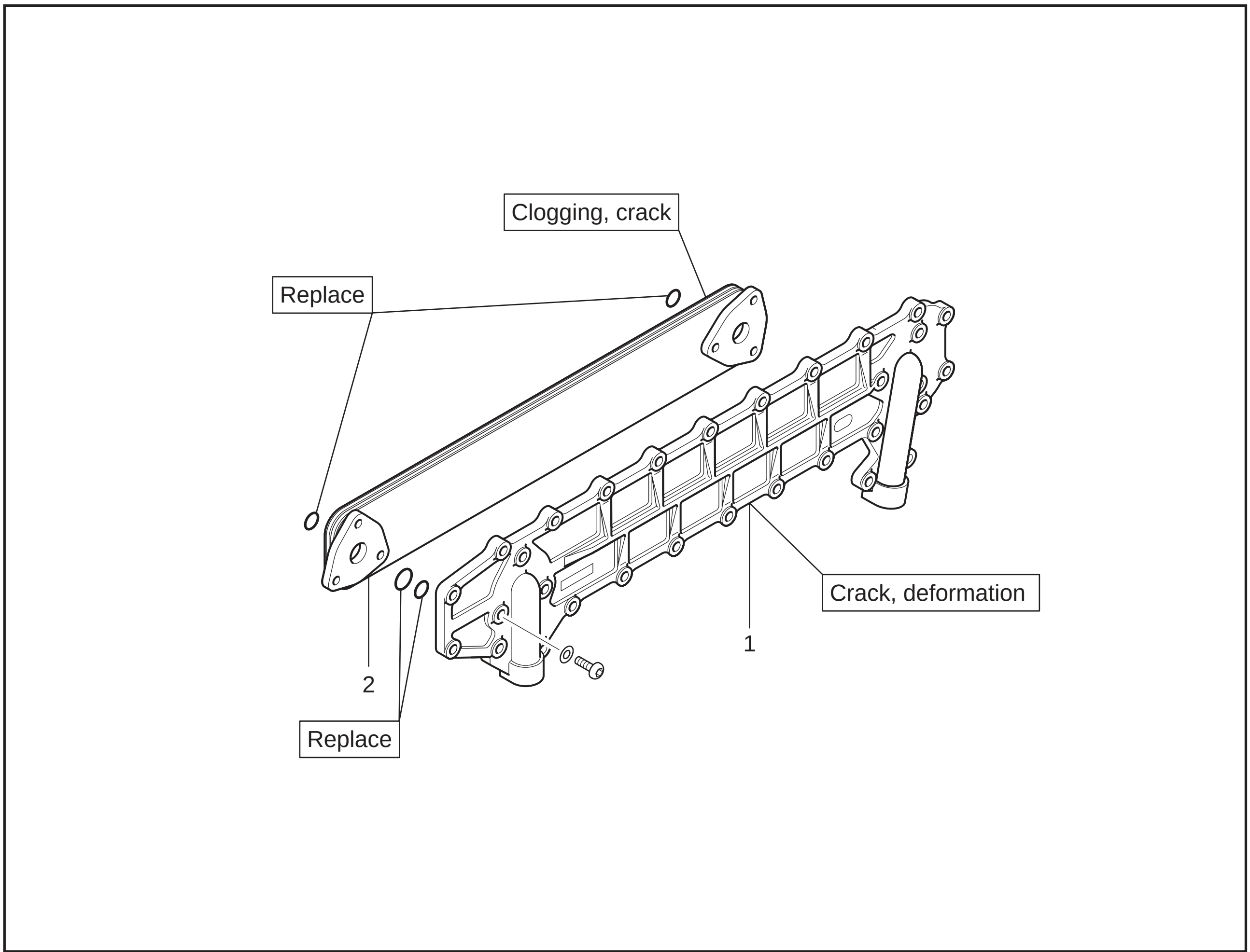
Installing oil pump bushing

2.3 Reassembling oil pump



Reassembling oil pump

2.4 Disassembling and inspecting oil cooler

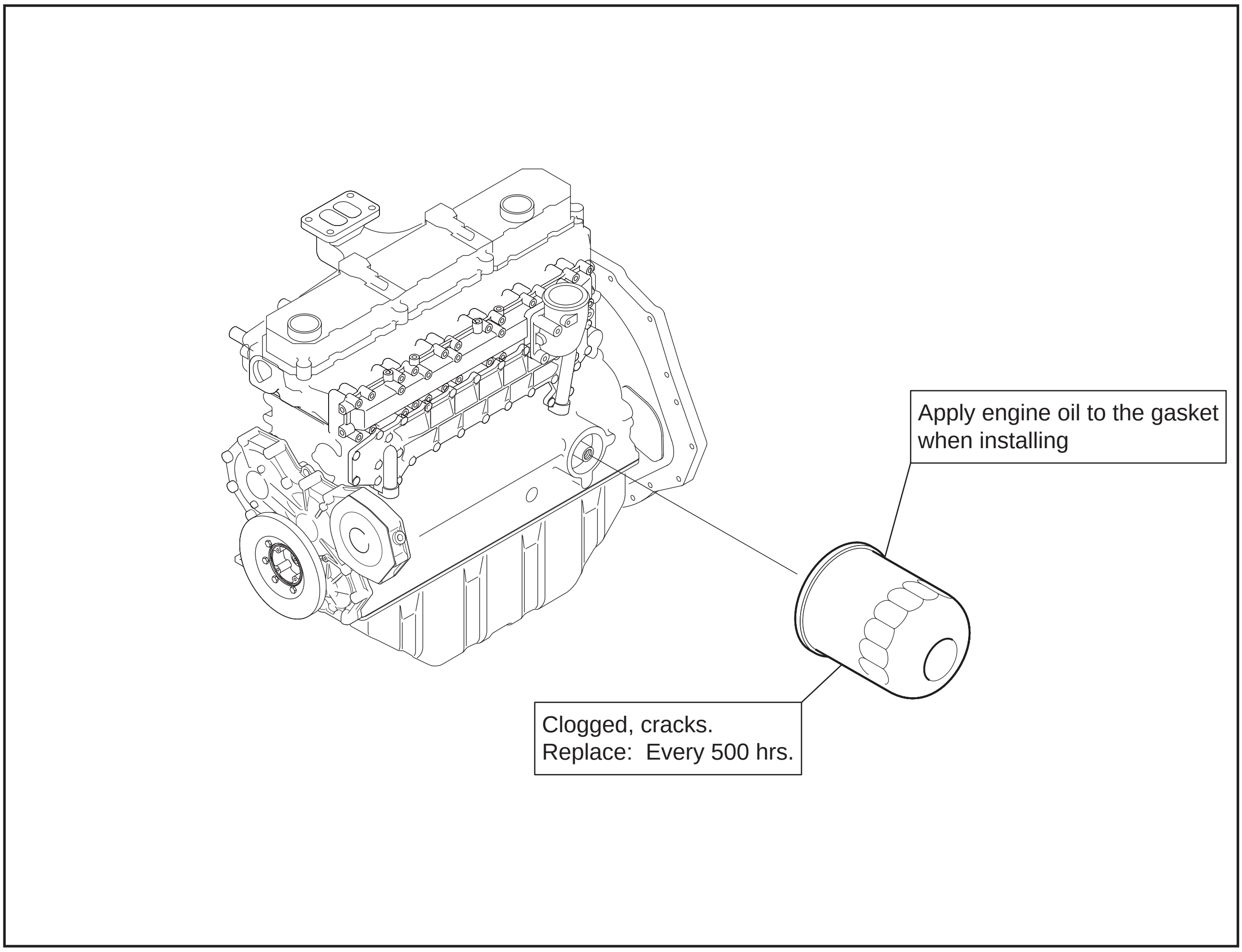


Disassembling and inspecting oil cooler

Disassembling sequence

1 Oil cooler case
2 Oil cooler element

2.5 Inspecting oil filter



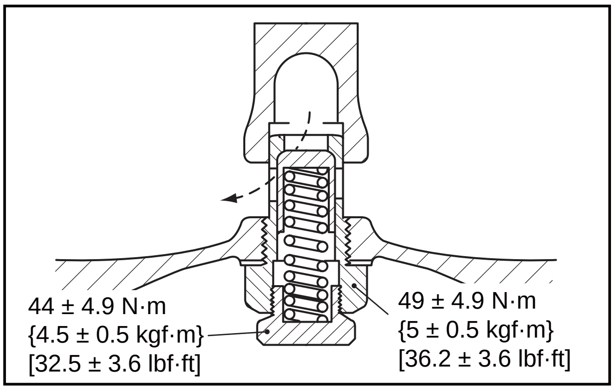
Inspecting oil filter

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 ± 0.05 MPa {3.5 ± 0.5 kgf/cm²} [49.8 ± 7.1 psi]



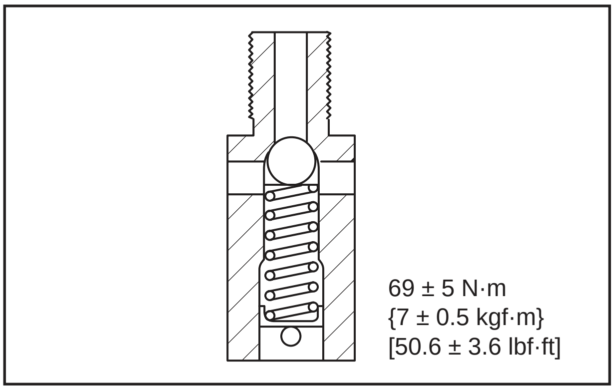
Inspecting relief valve

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.

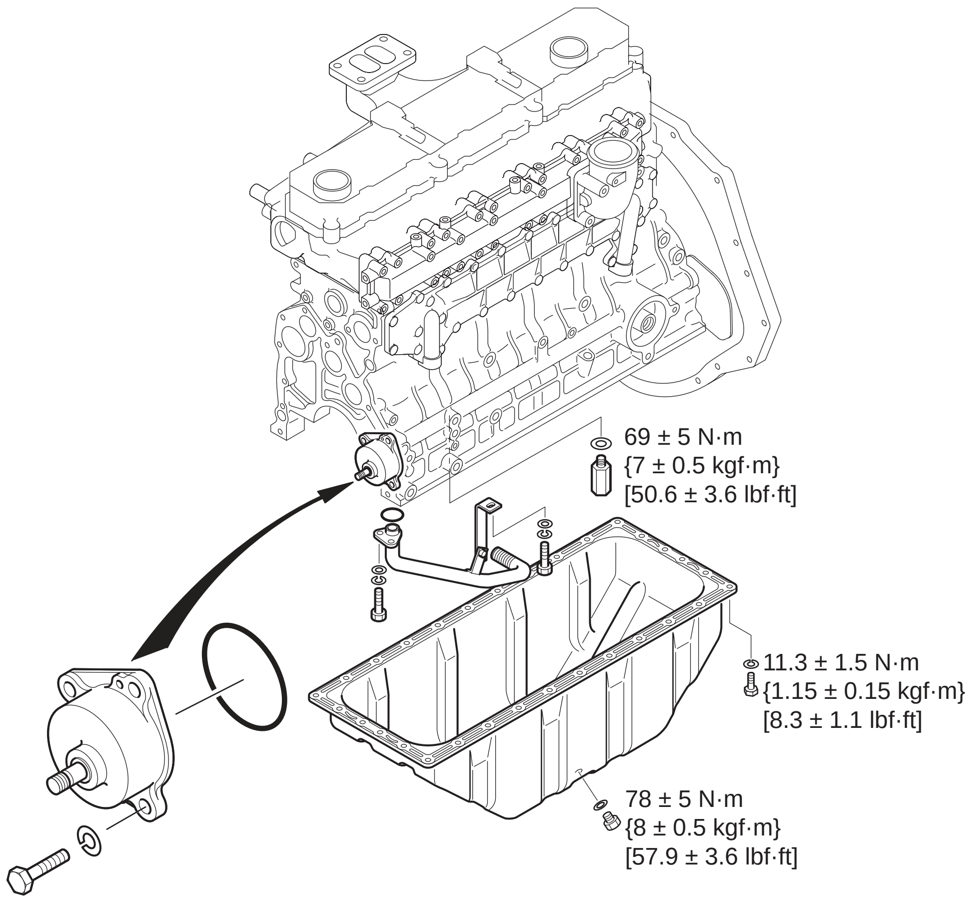
Item	Standard
Safety valve opening pressure	1.1 MPa {11 kgf/cm² } [157 psi]



Inspecting safety valve

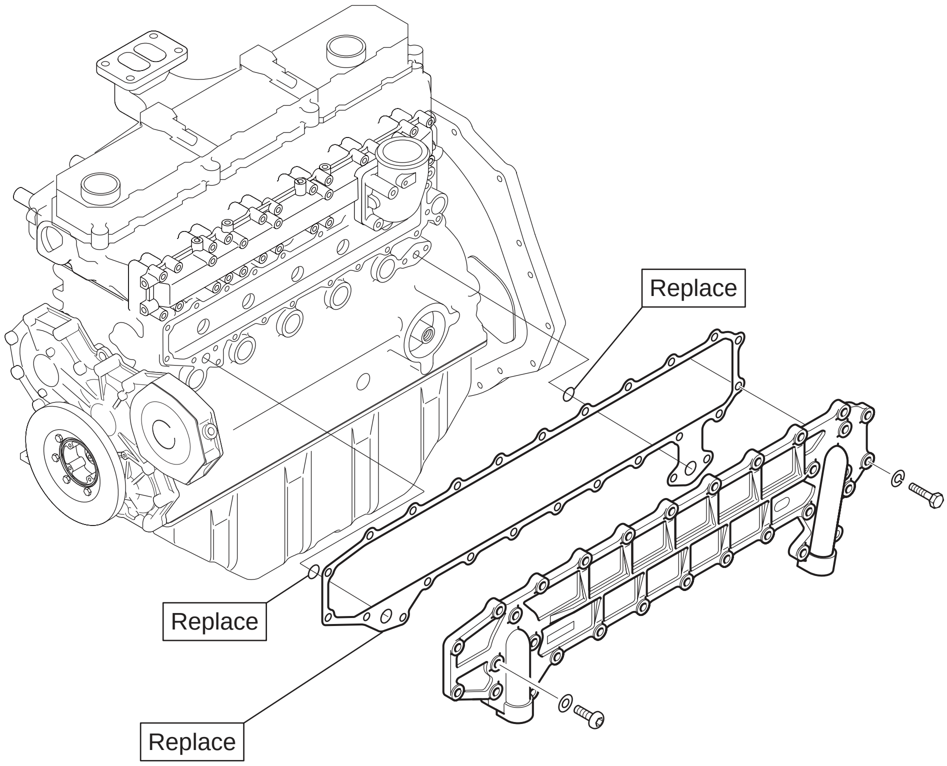
3. Installing lubrication system

3.1 Installing oil pump, oil pan and oil strainer



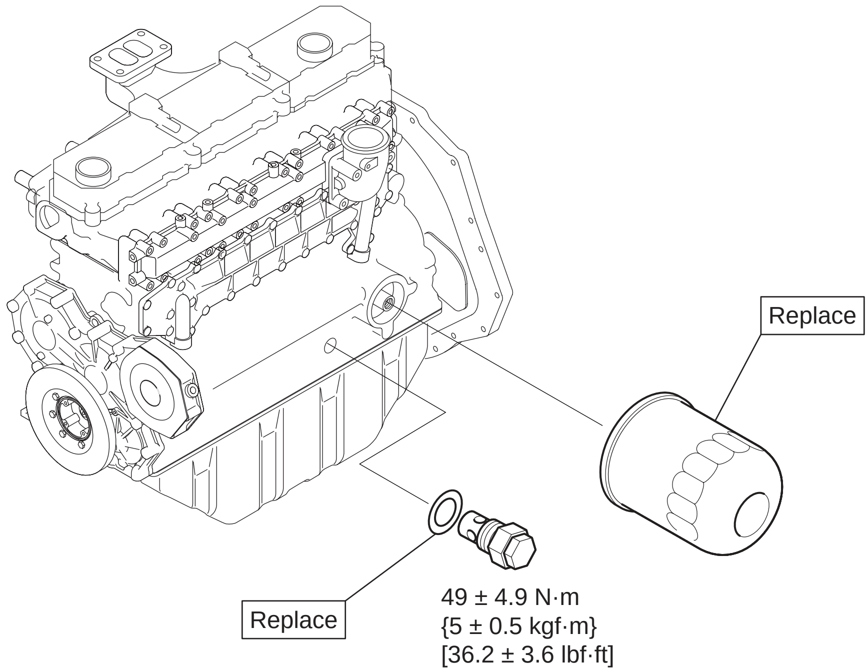
Installing oil pump, oil pan and oil strainer

3.2 Installing oil cooler



Installing oil cooler

3.3 Installing oil filter and relief valve

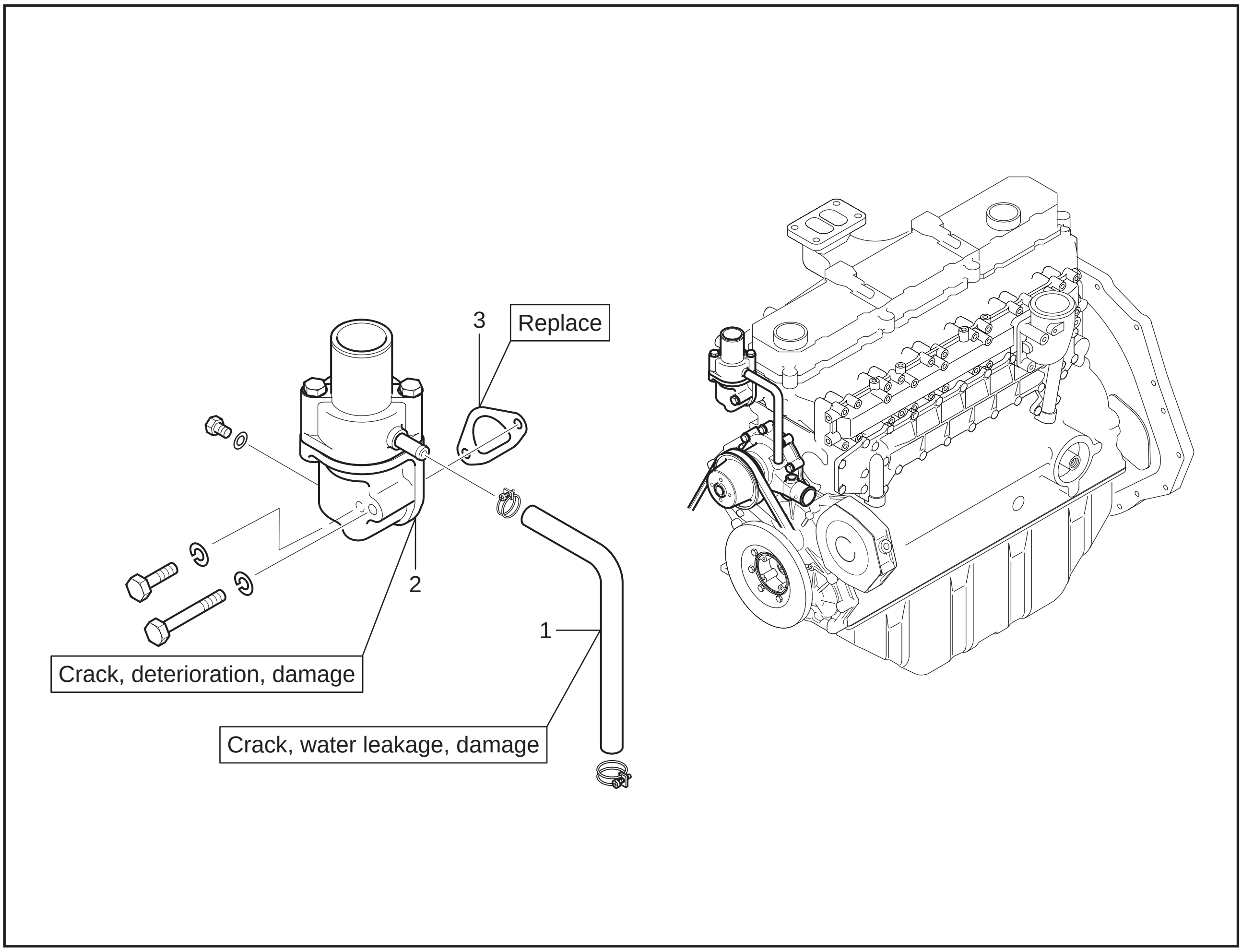


Installing oil filter and relief valve

COOLING SYSTEM

1. Removing cooling system

1.1 Removing thermostat

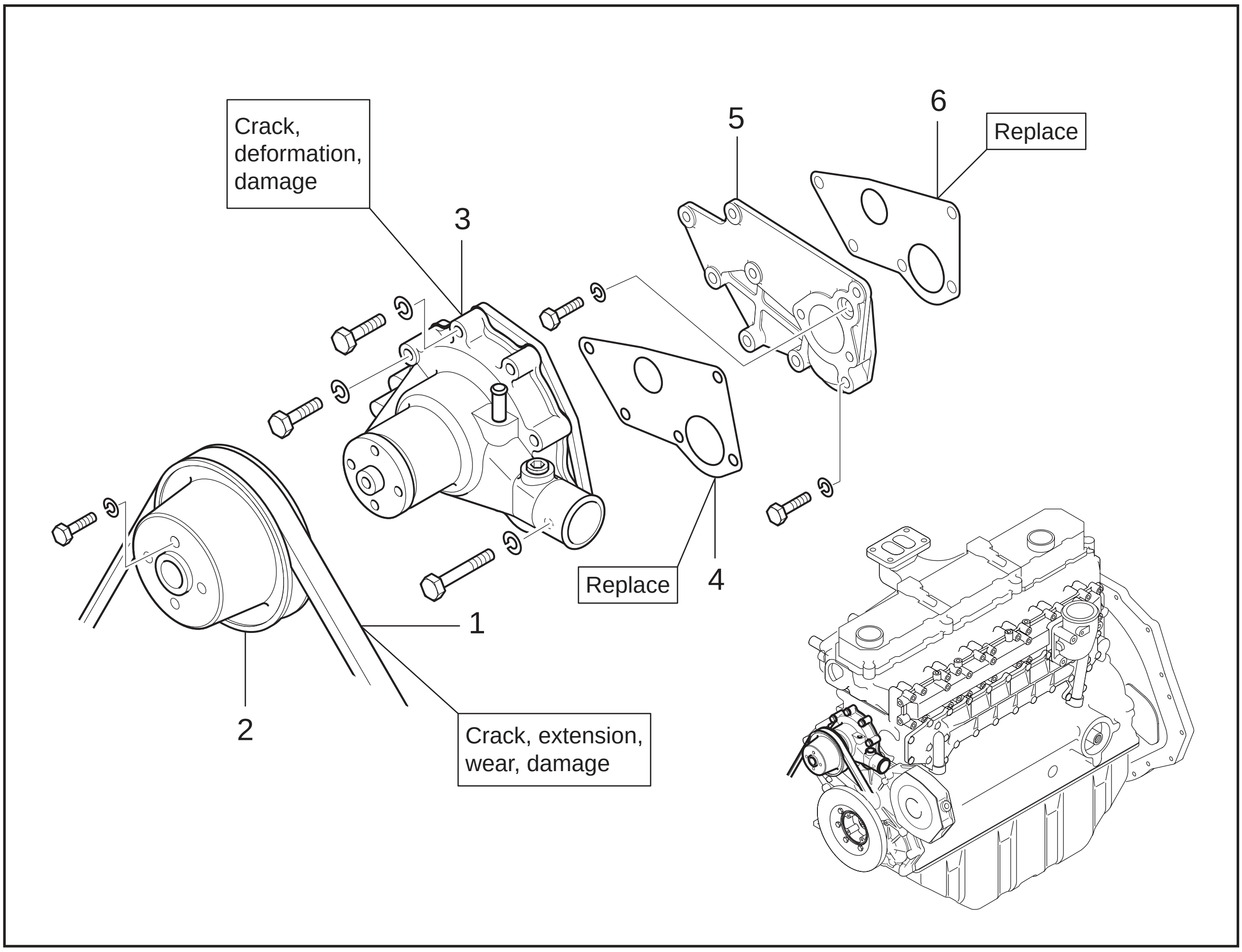


Removing thermostat

Removing sequence

1 Hose   2 Thermostat assembly   3 Gasket

1.2 Removing water pump, water pump pulley and V-belt



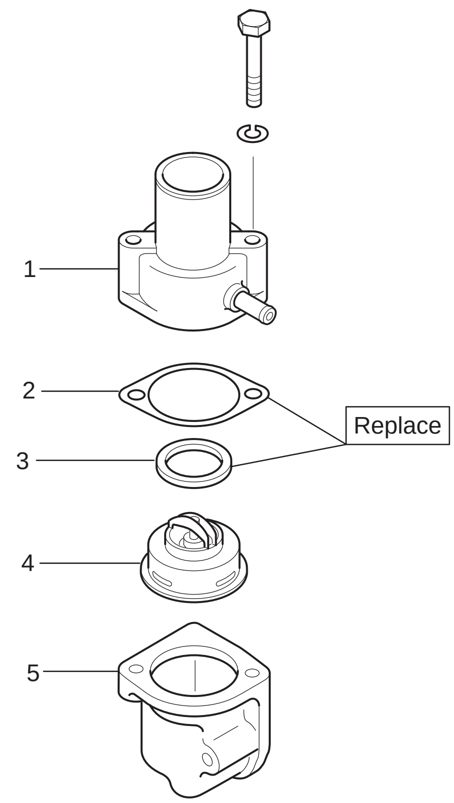
Removing water pump, water pump pulley and V-belt

Removing sequence

1	V-belt	3	Water pump assembly	5	Water pump spacer
2	Water pump pulley	4	Gasket	6	Gasket

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

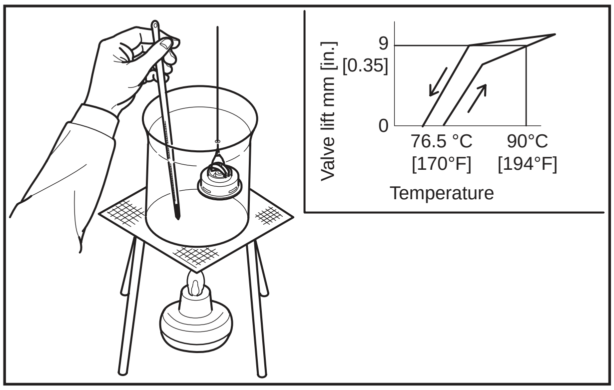
Be careful of burns or a fire when measuring temperature, as it involves a high-temperature and open flame.

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.

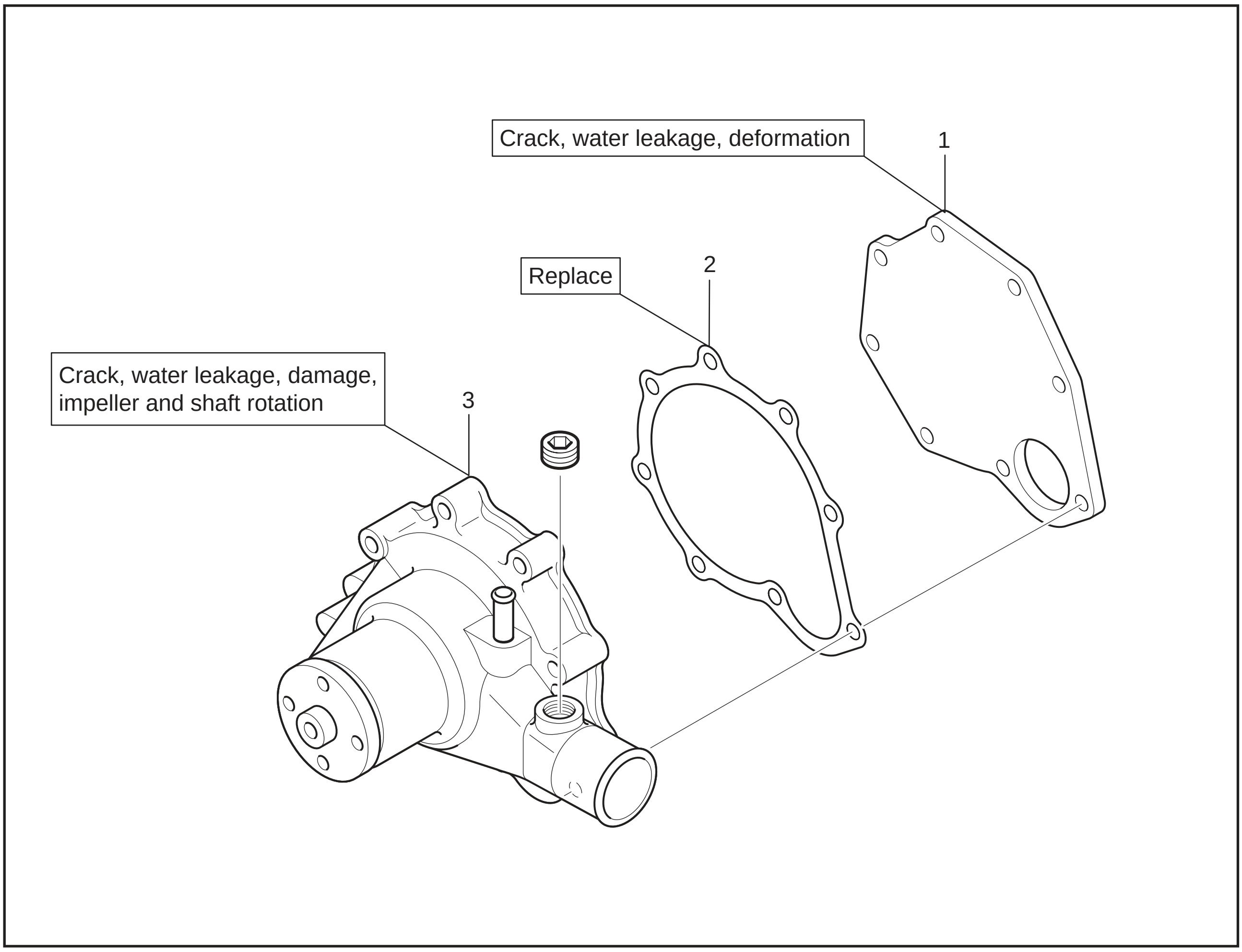
(b) Before installing the thermostat, be sure to check the valve opening temperature stamped on the thermostat valve side face.

Item	Standard
Temperature at which valve starts opening	76.5 ± 1.5°C [170 ± 3.5°F]
Temperature at which valve lift becomes 9 mm [0.35 in.] or more.	90 ± 1.5°C [194 ± 2.7°F]



Inspecting thermostat

2.3 Disassembling water pump



Disassembling water pump

Disassembling sequence

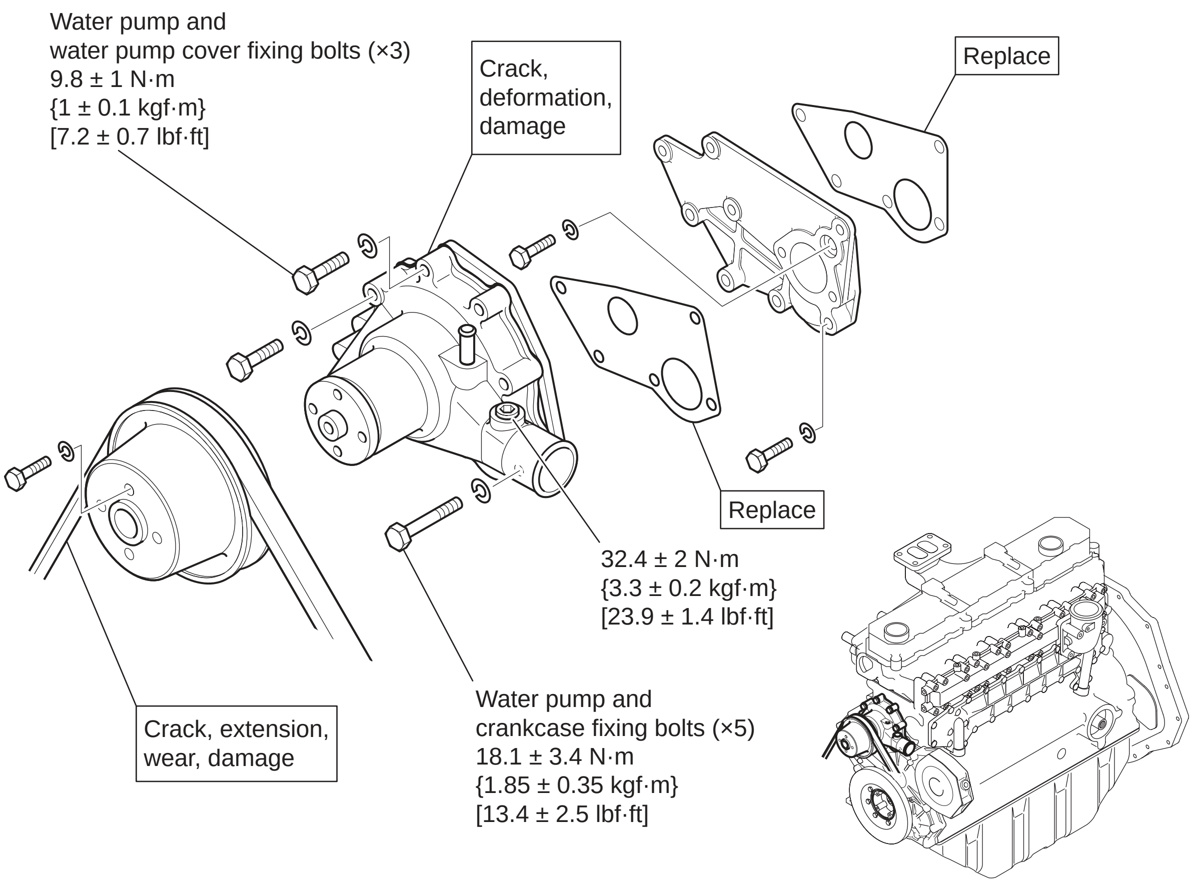
1 Water pump cover
2 Gasket
3 Water pump

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



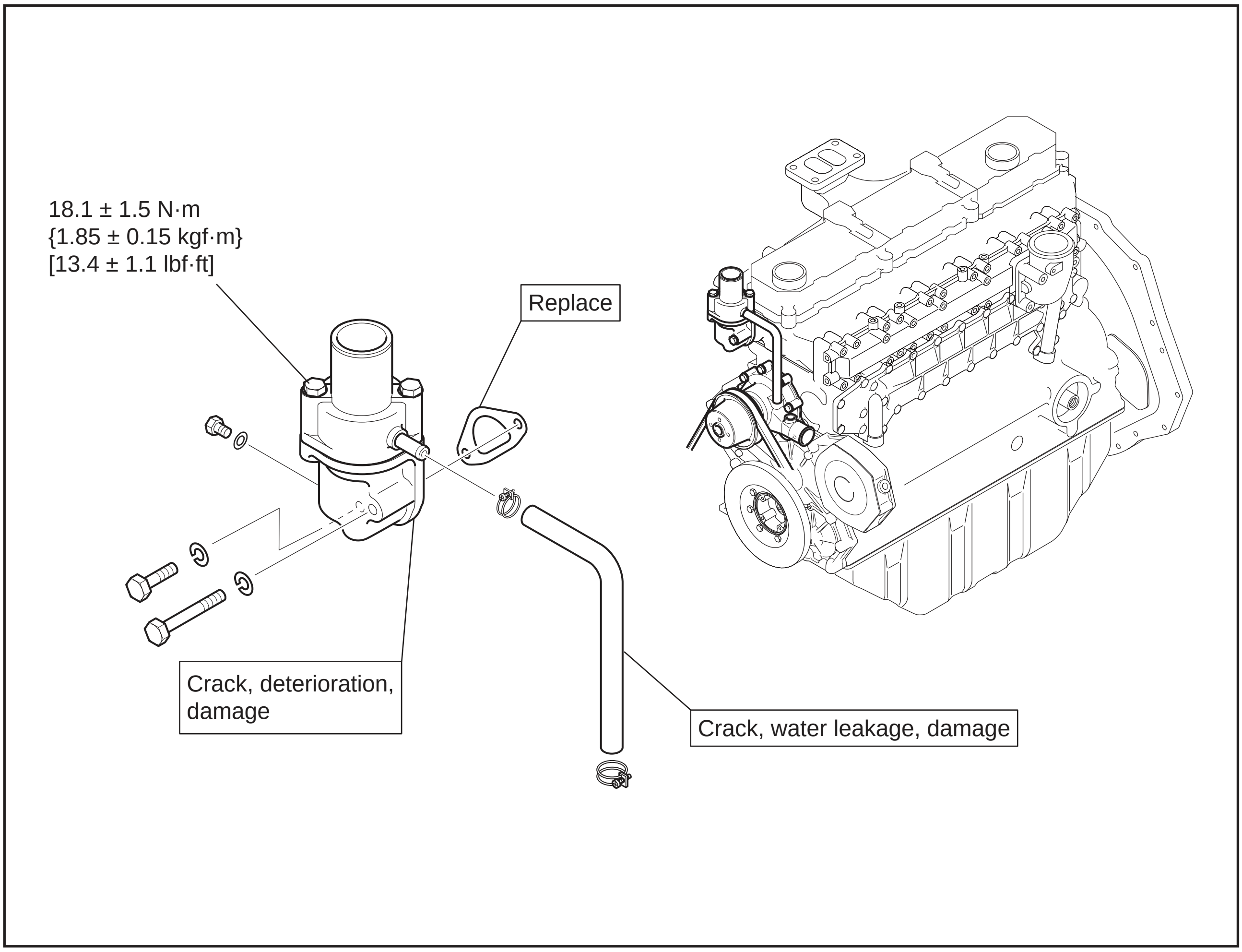
Installing water pump, water pump pulley and V-belt

CAUTION

Inspect and adjust the V-belt every 200 hours of operation.

Depending on the operating condition, inspecting and adjusting interval may shorten.

3.2 Installing thermostat

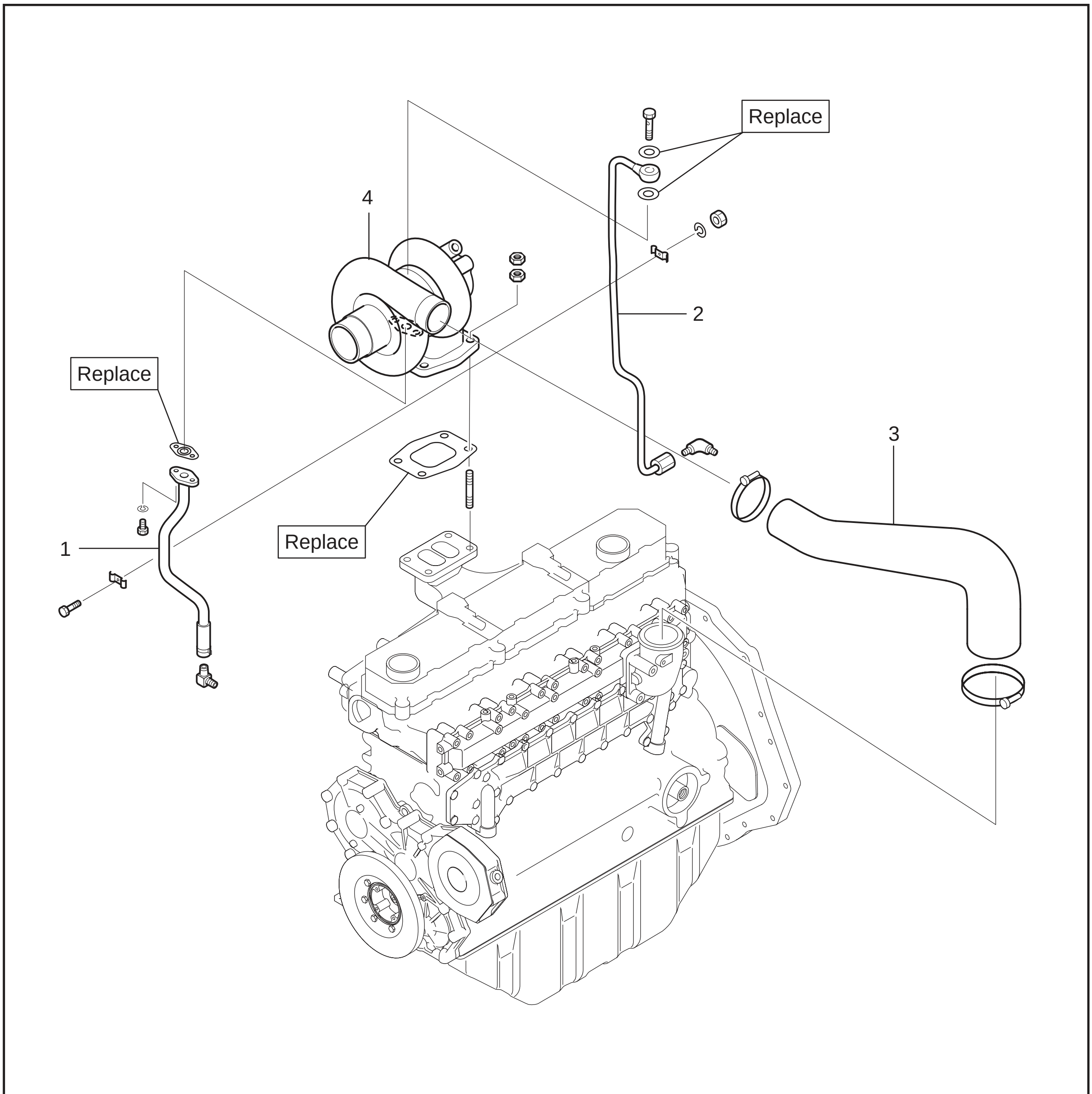


Installing thermostat

INLET AND EXHAUST SYSTEMS

1. Removing turbocharger, inlet and exhaust systems

1.1 Removing turbocharger

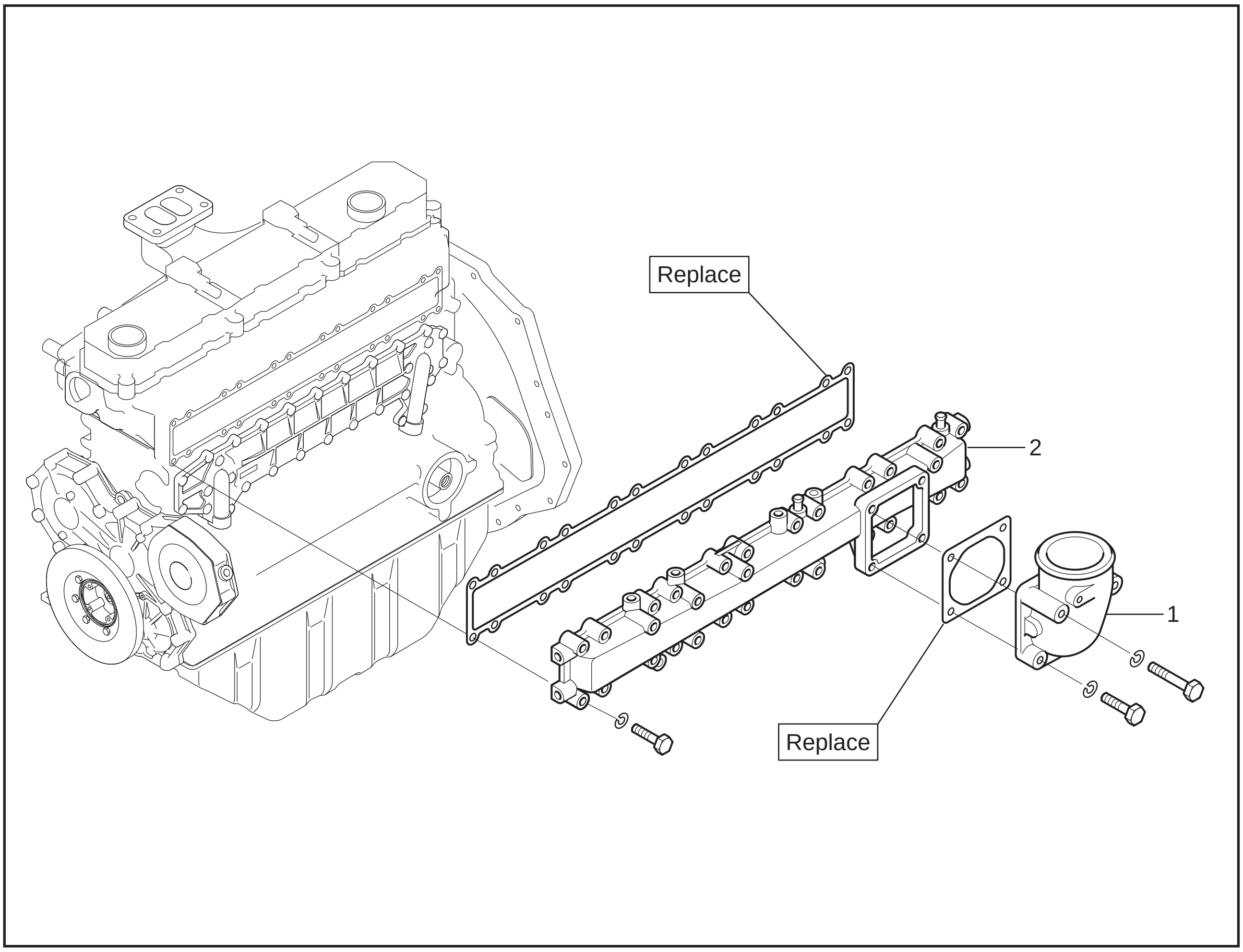


Removing turbocharger

Removing sequence

1 Oil pipe	2 Oil pipe	3 Air hose	4 Turbocharger

1.2 Removing inlet manifold

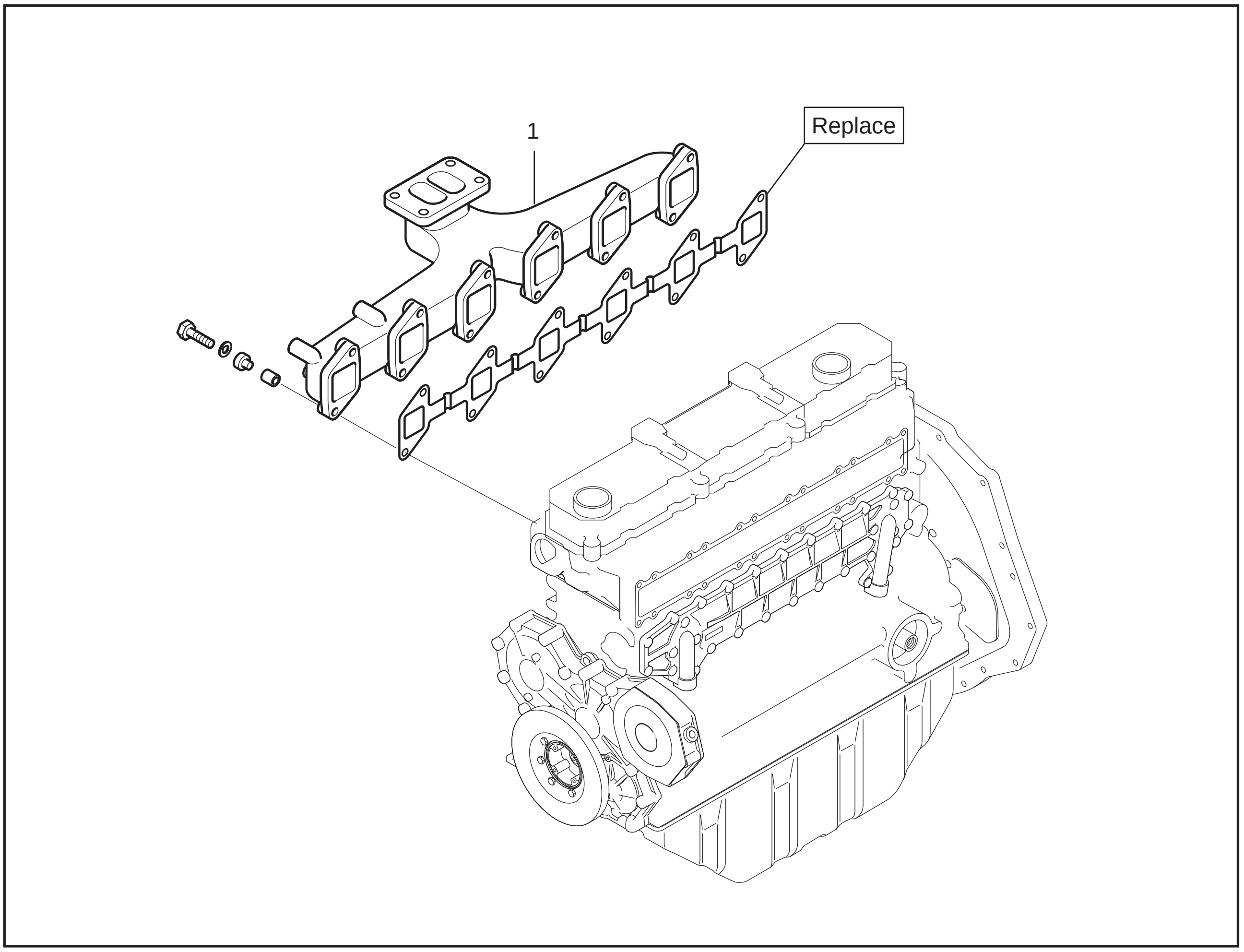


Removing inlet manifold

Removing sequence

1 Air inlet elbow
2 Inlet manifold

1.3 Removing exhaust manifold



Removing exhaust manifold

Removing sequence

1 Exhaust manifold

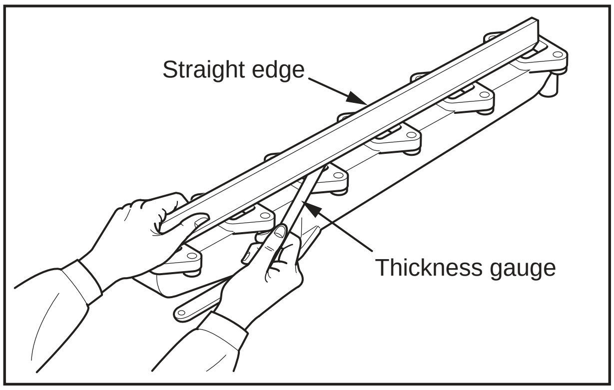
2. Disassembling, inspecting and reassembling inlet and exhaust systems

2.1 Measuring exhaust manifold distortion

(1) Check the flange for crack.

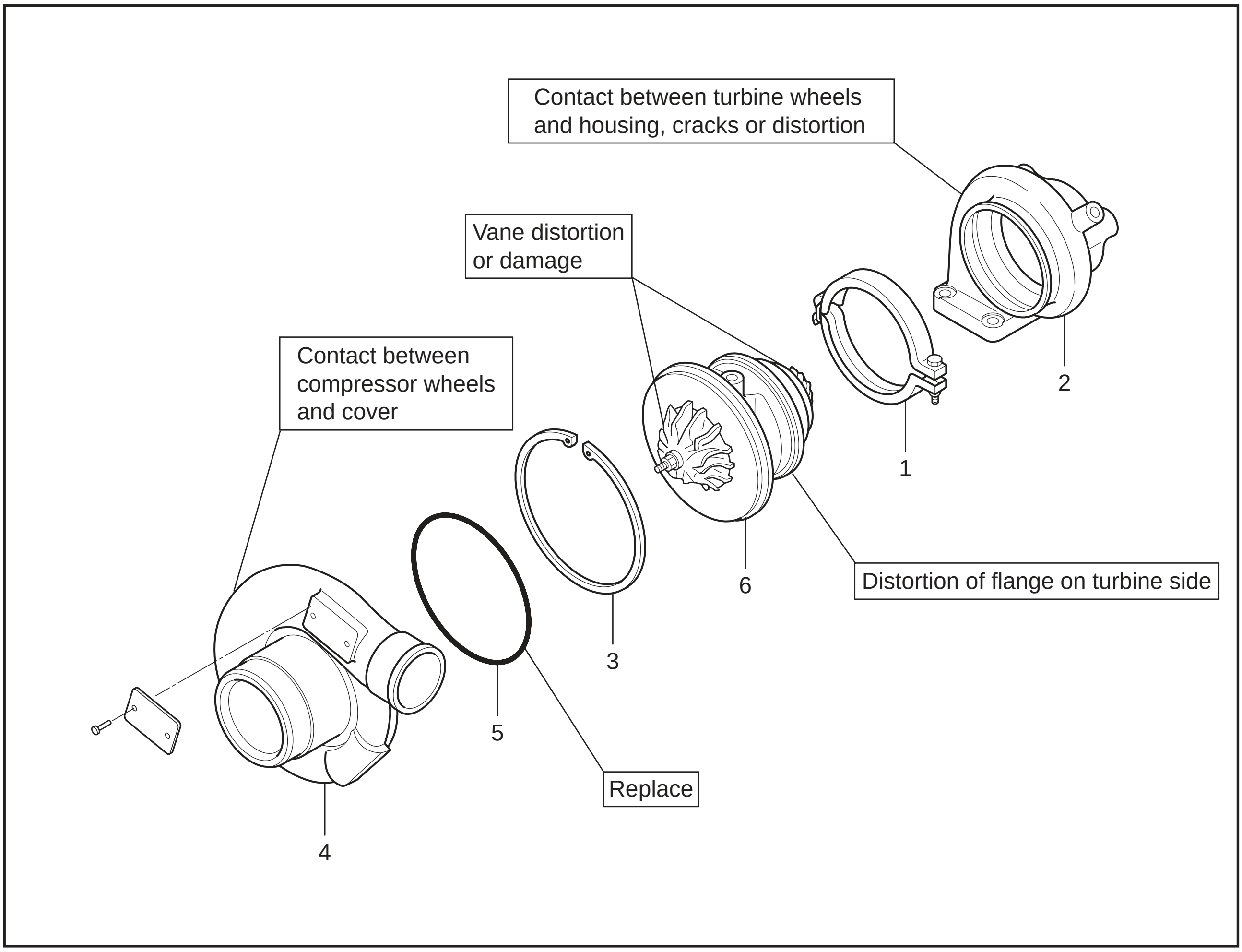
(2) Check the flange surface for distortion. If the distortion exceeds the standard, retouch the surface or replace it.

Item	Standard
Exhaust manifold distortion	0.2 mm [0.008 in.] or less



Measuring distortion on exhaust manifold

2.2 Disassembling and inspecting turbocharger



Disassembling and inspecting turbocharger

Disassembling sequence

1 Coupling assembly
2 Turbine housing
3 Snap ring
4 Compressor cover
5 O-ring
6 Cartridge assembly

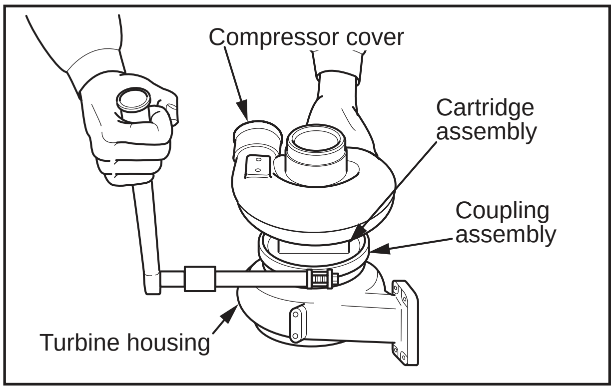
CAUTION

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.

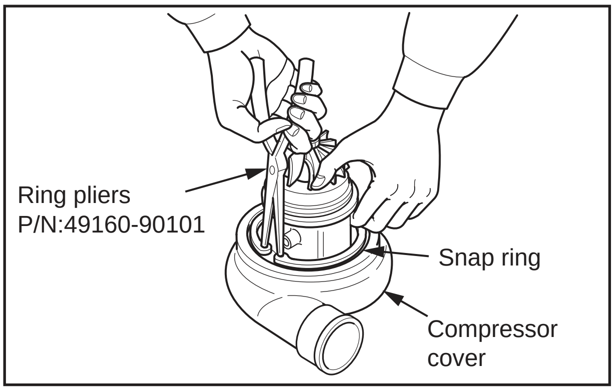
CAUTION

Be careful not to hit the vane of compressor wheel against the cover.

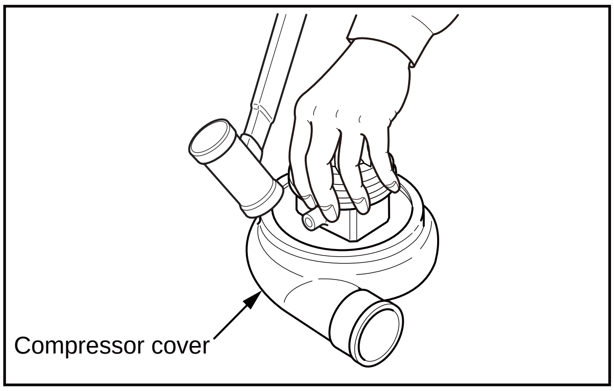
(1) Lay the compressor cover flat on the table as shown. Using the ring pliers, remove the snap ring.

(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.



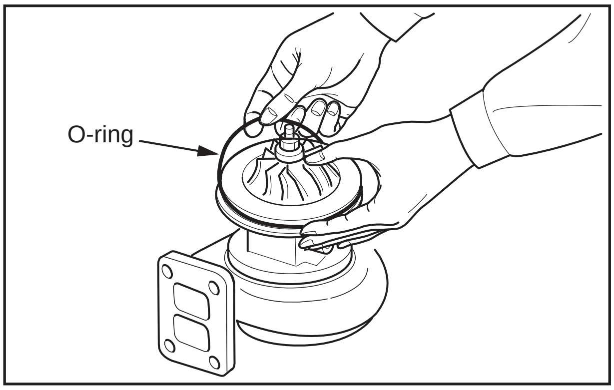
Removing compressor cover (1)



Removing compressor cover(2)

2.2.3 Installing O-ring

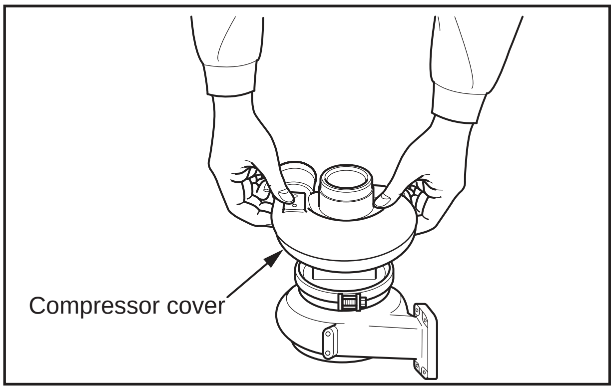
Apply grease to the O-ring, and install the O-ring to the cartridge.



Installing O-ring

2.2.4 Installing compressor cover

Install the compressor cover, paying attention to its orientation.



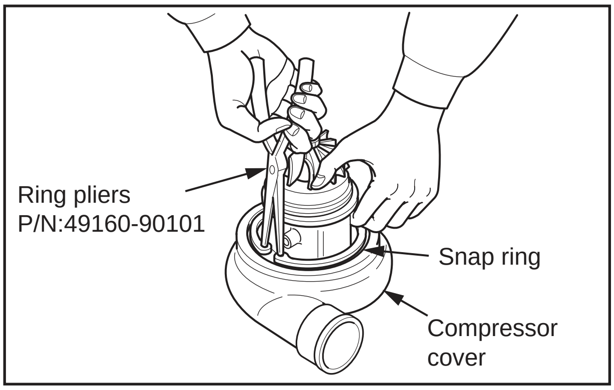
Installing compressor cover

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

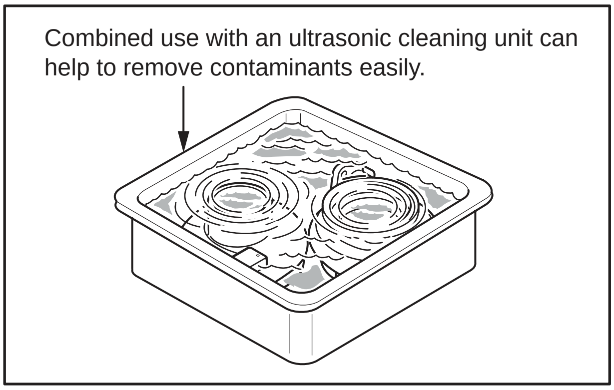
(a) When using a commercial neutral detergent, be sure to use non-corrosive type.
(b) Be careful not to damage components.

When cleaning the compressor cover and the turbine housing, observe the followings:

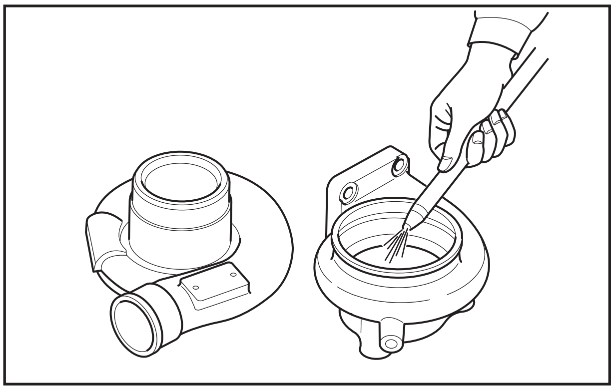
(1) Visually check the parts condition before cleaning to note any burns or abrasions, which may not be observable after cleaning.

(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.

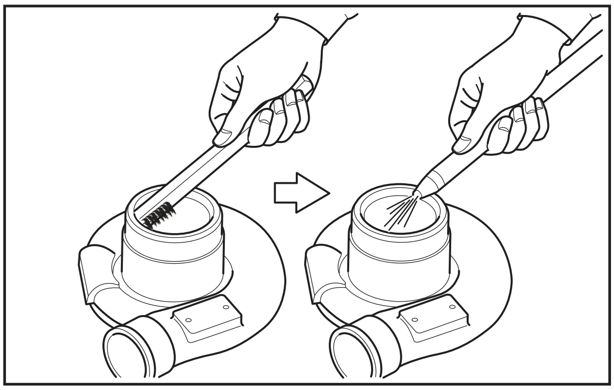


Cleaning turbocharger



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

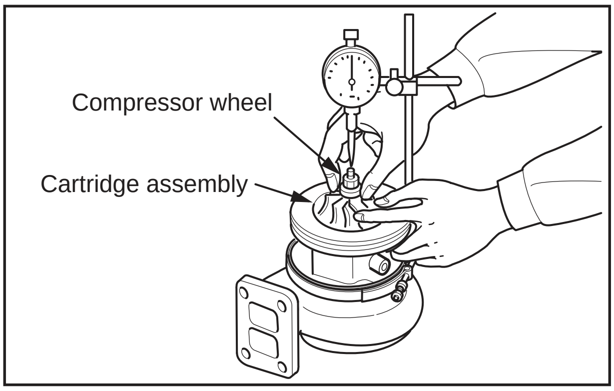
2.3.1 Measuring axial clearance of cartridge assembly

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.

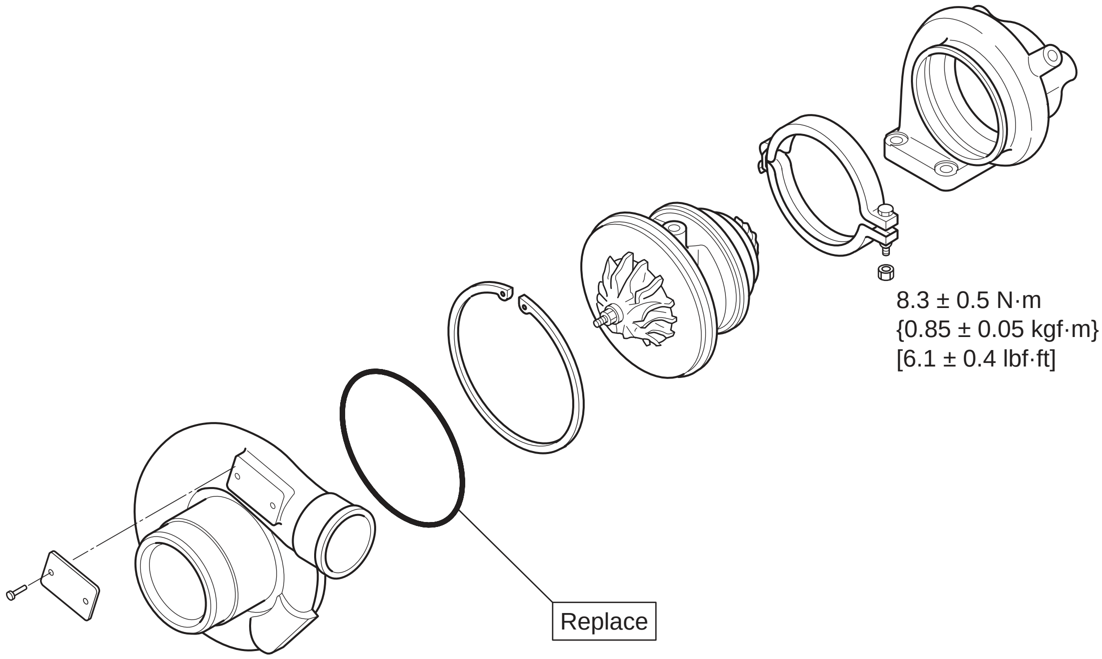
If the clearance is out of standard, replace the cartridge assembly, with a new one.

Item	Standard
Axial clearance of cartridge assembly	0.057 to 0.103 mm [0.0022 to 0.0041 in.]



Measuring axial clearance of cartridge assembly

2.3.2 Reassembling turbocharger



Reassembling turbocharger

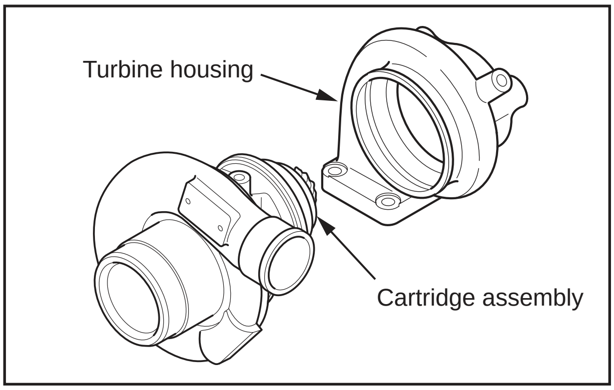
⚠ CAUTION

(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

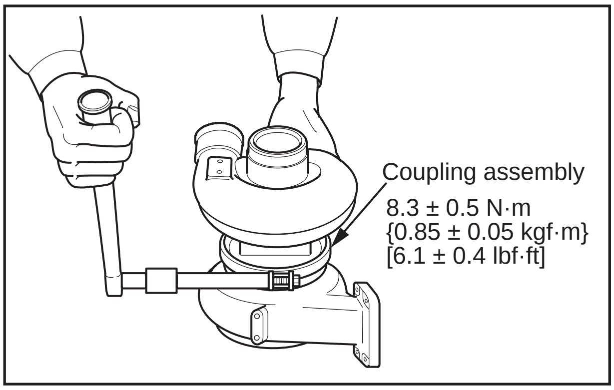
Install the turbine housing to the cartridge assembly by aligning the marks put during disassembly.



Installing turbine housing

2.3.4 Installing coupling assembly

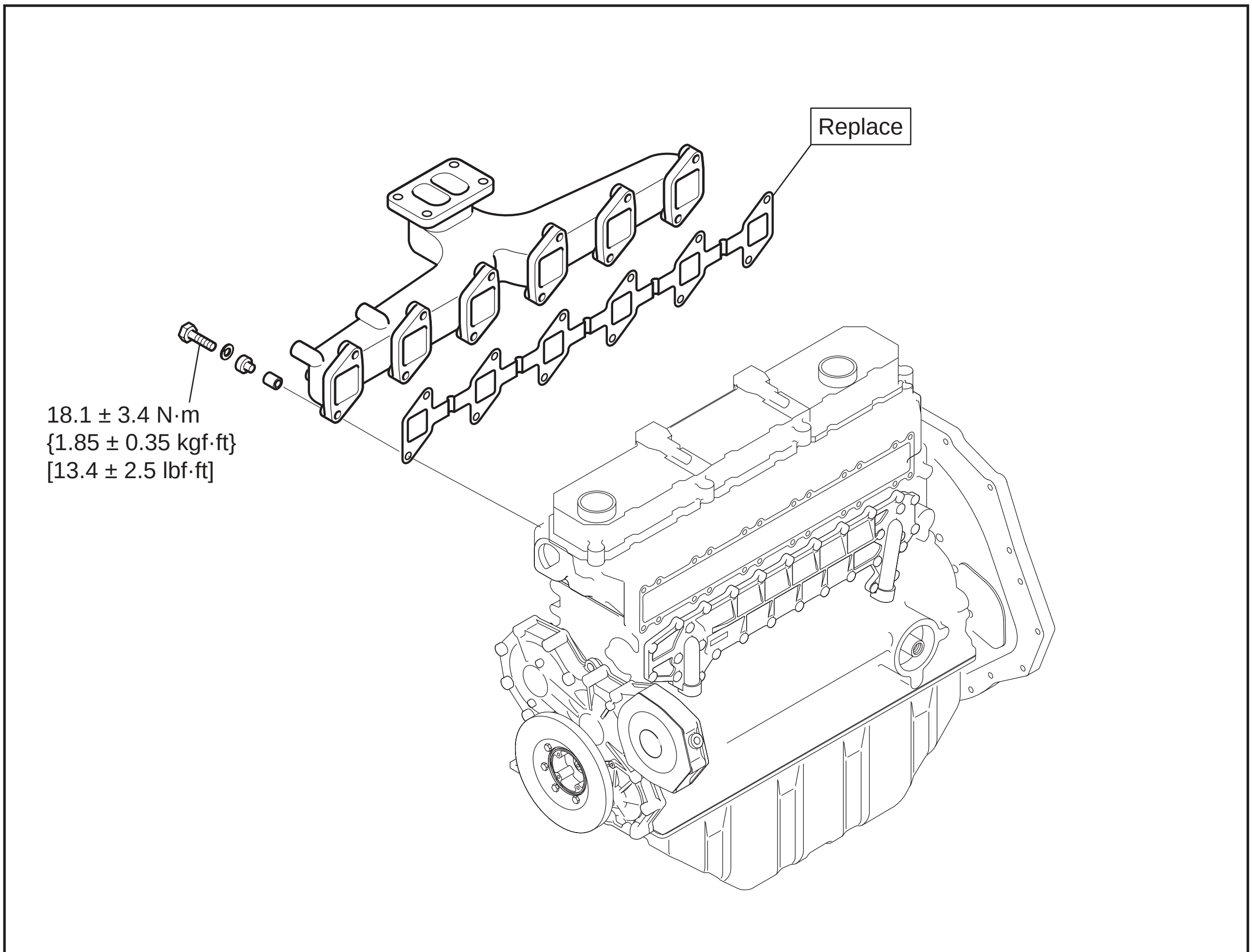
Apply Molykote grease or equivalent to threads of the coupling assembly nut, and tighten the nut to the specified torque.



Installing coupling assembly

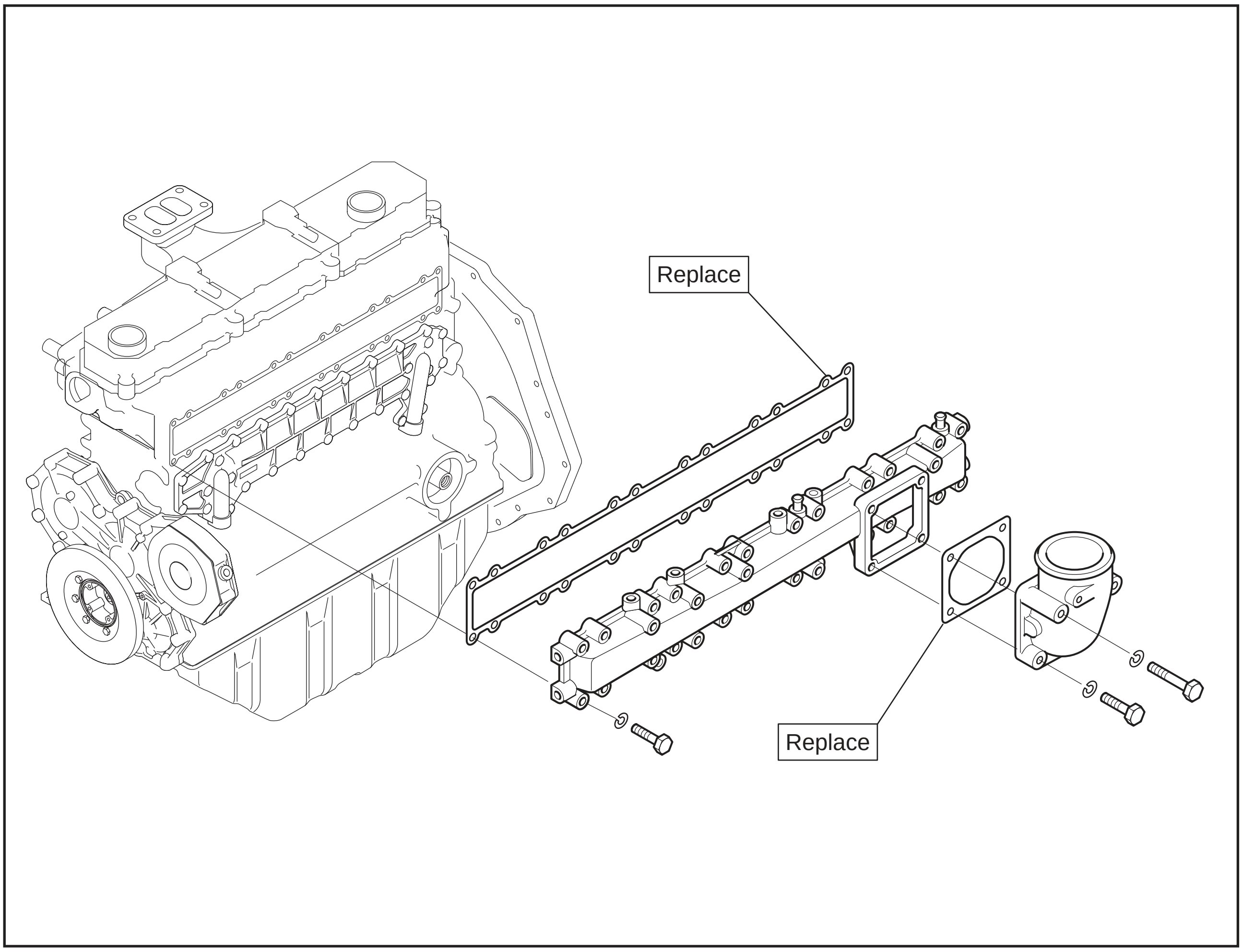
3. Installing turbocharger, inlet and exhaust systems

3.1 Installing exhaust manifold



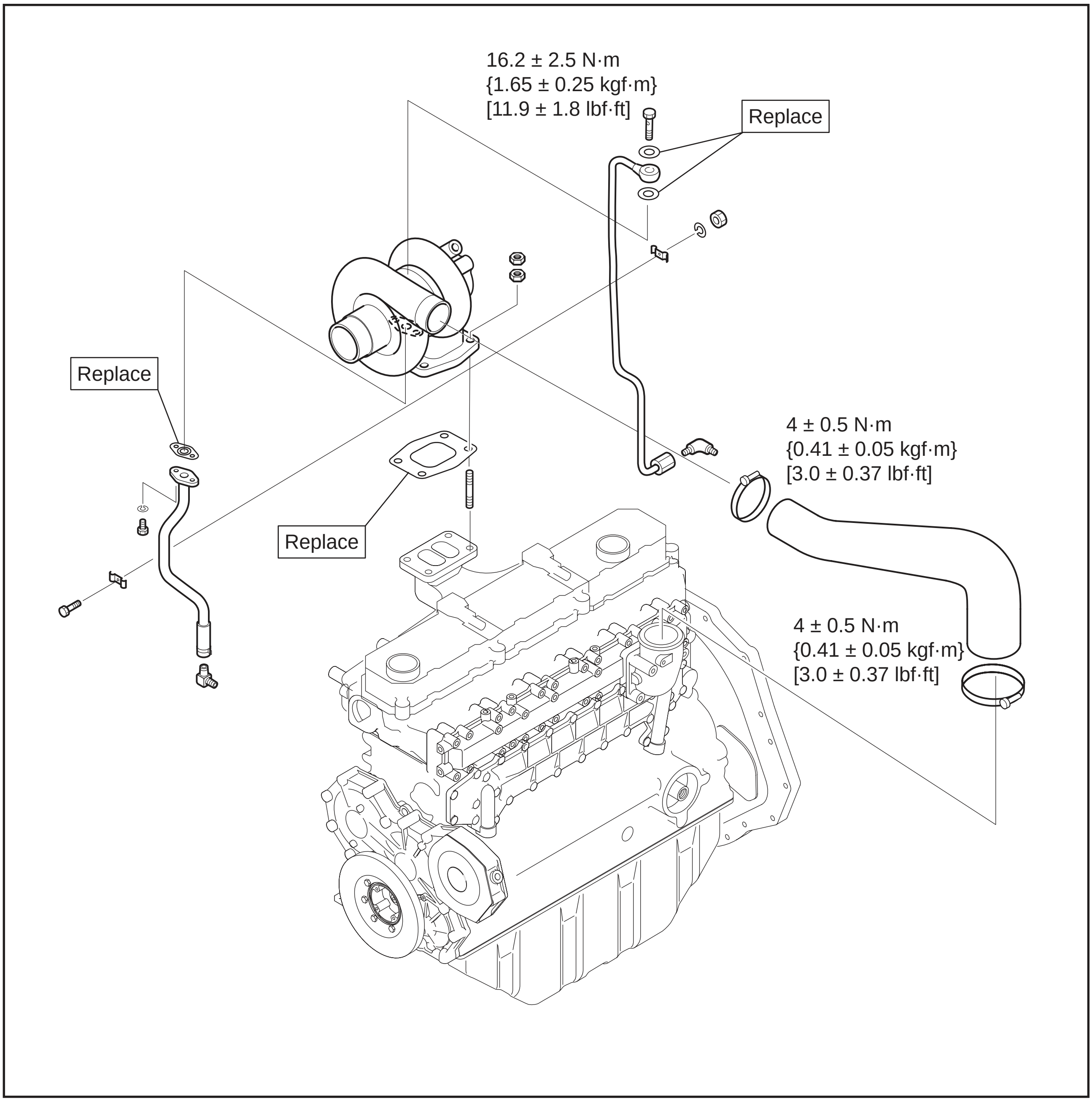
Installing exhaust manifold

3.2 Installing inlet manifold



Installing inlet manifold

3.3 Installing turbocharger

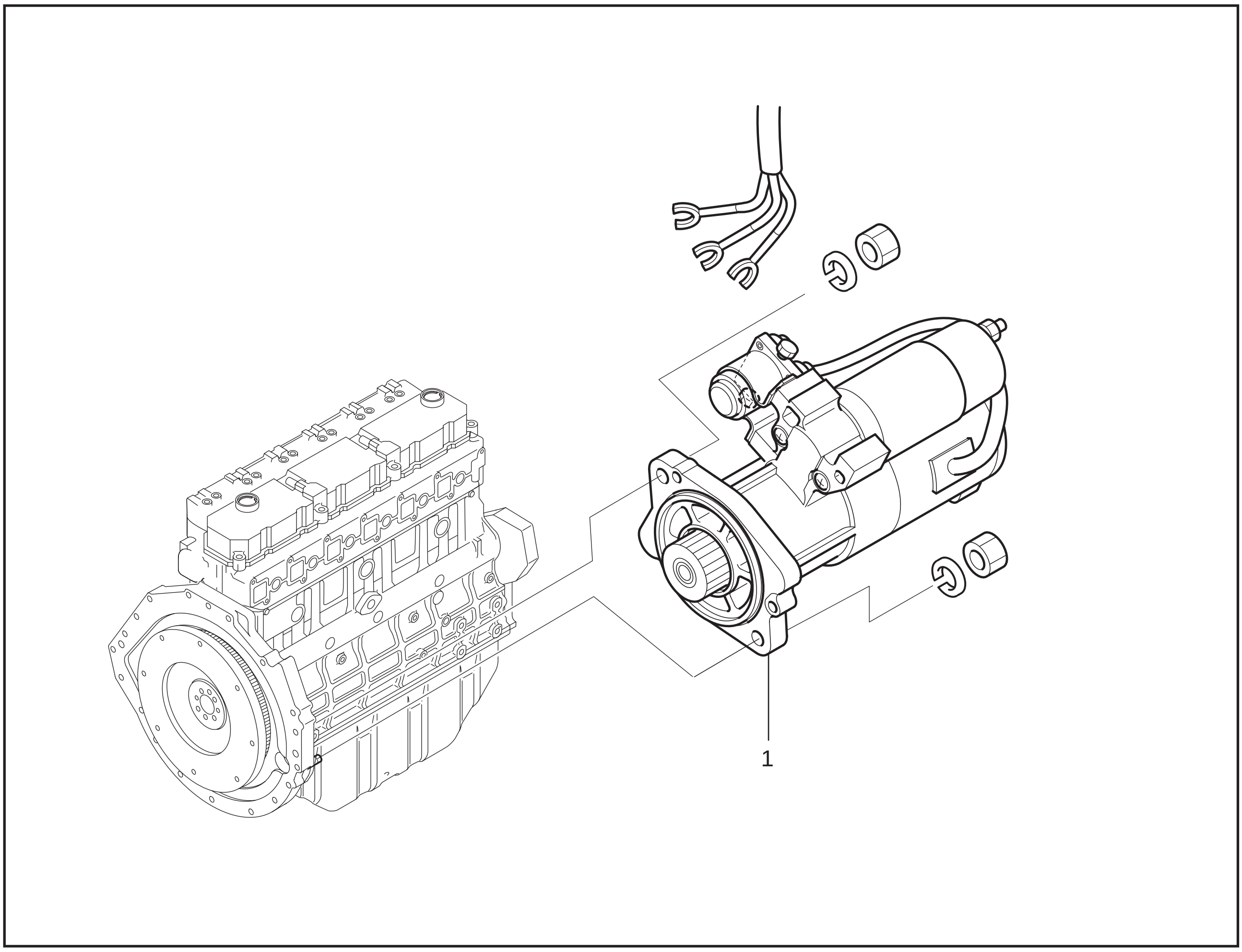


Installing turbocharger

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 dis-charge	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.

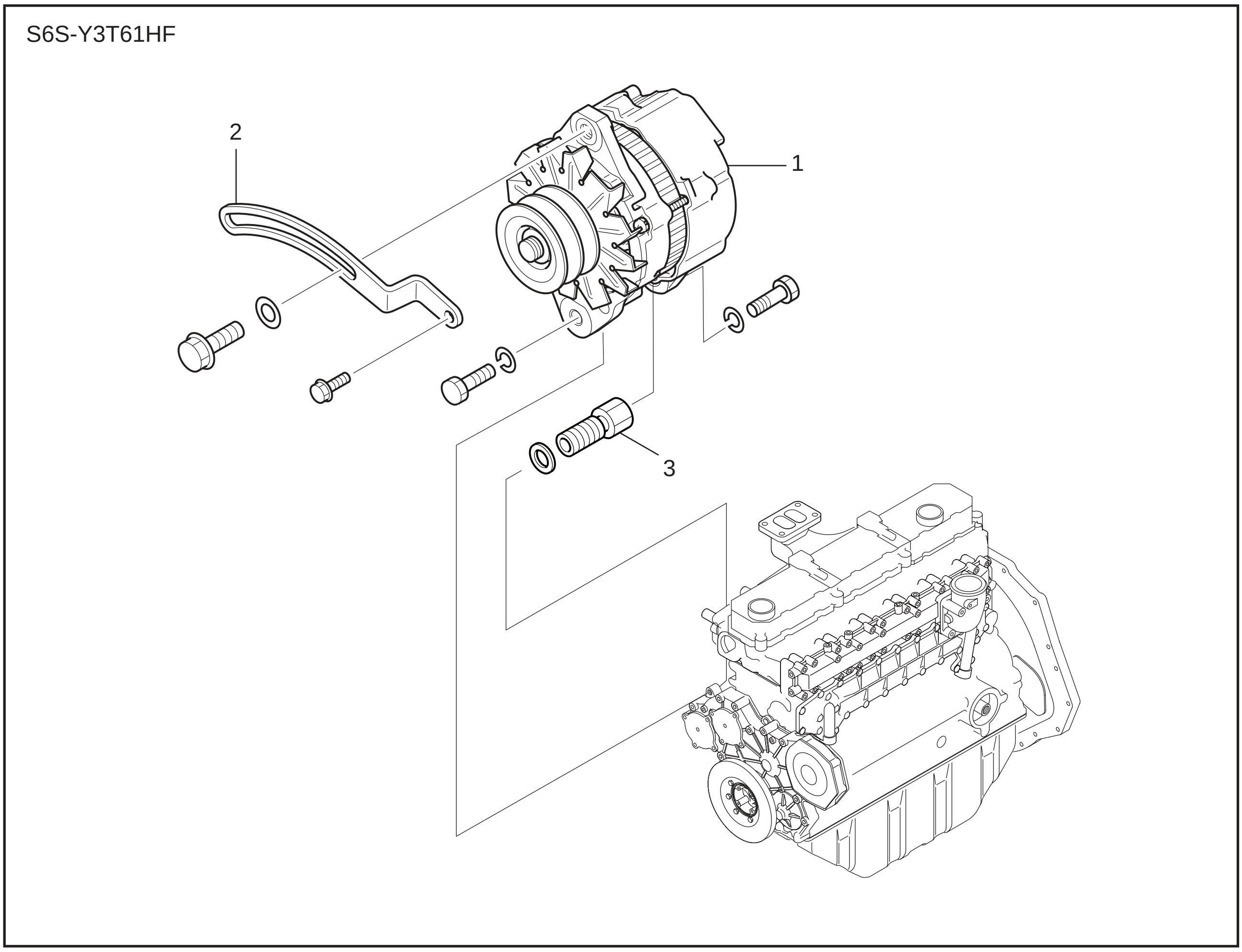
(3) Do not disconnect lead wire from B terminal of the alternator while the engine is running.

(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.

1.3 Removing alternator

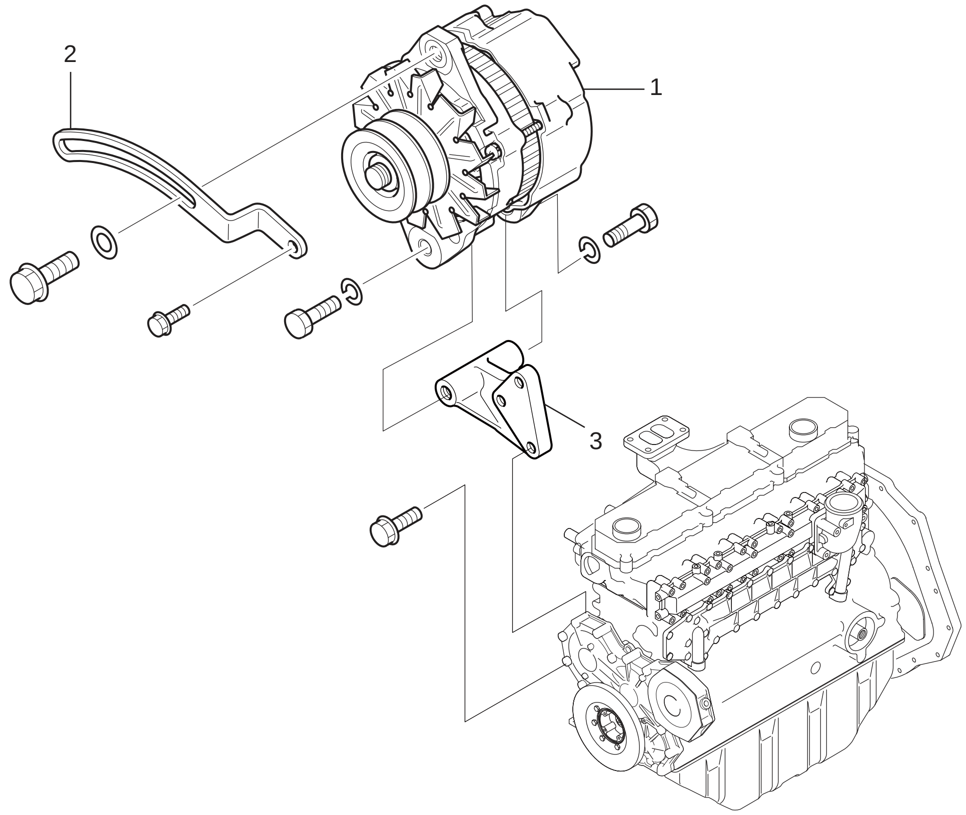


Removing alternator

Removing sequence

1 Alternator
2 Adjusting plate
3 Bracket

S6S-Y3T62HF

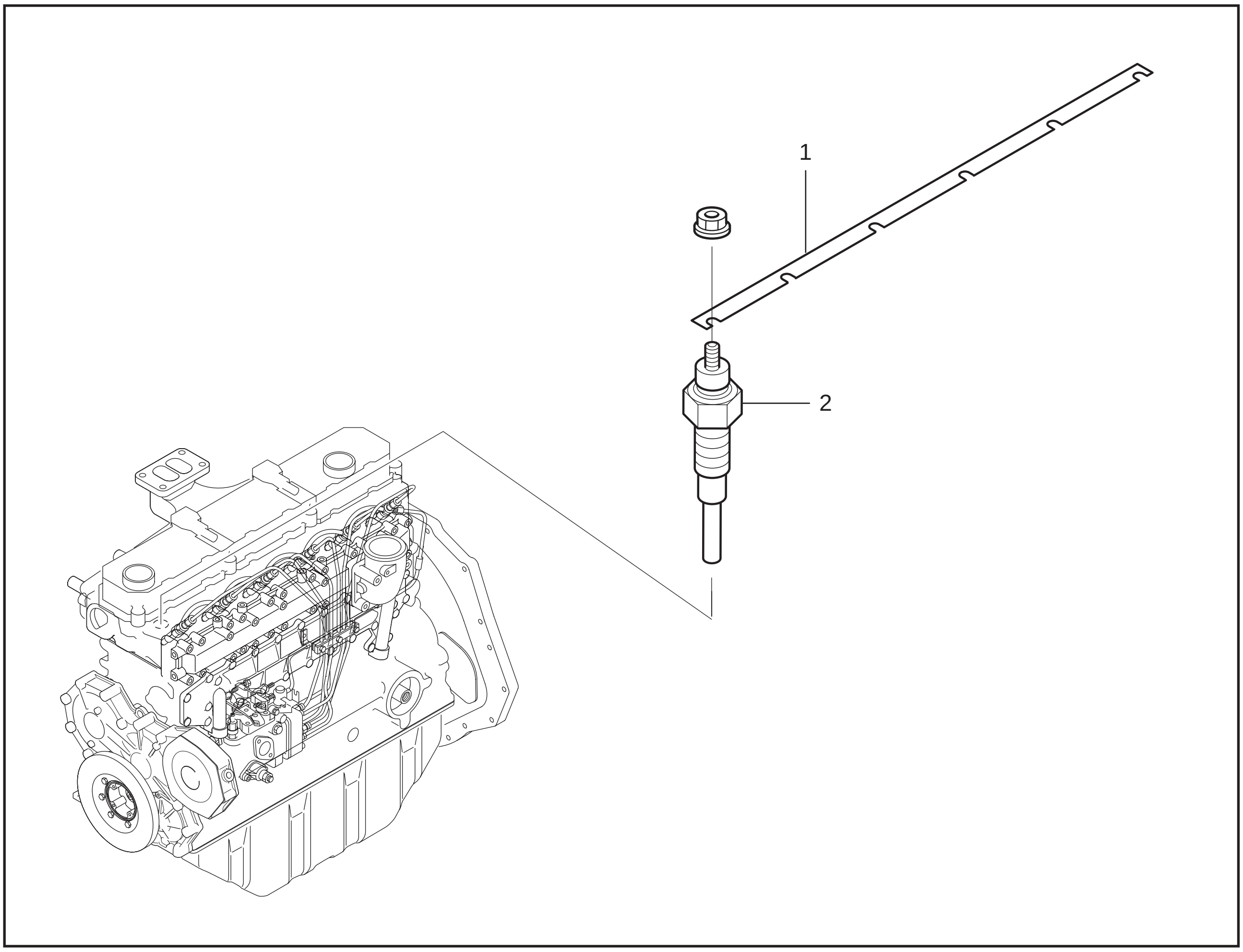


Removing alternator

Removing sequence

1 Alternator
2 Adjusting plate
3 Bracket

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.

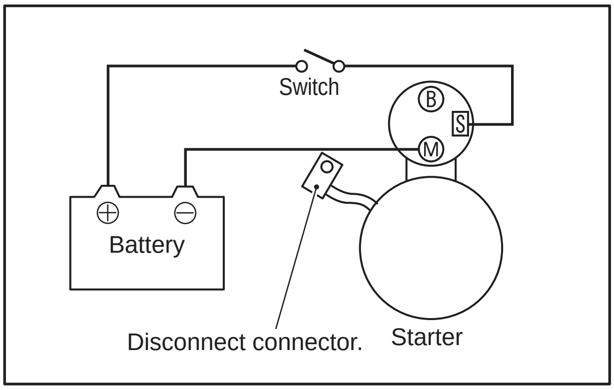
CAUTION

Do not apply current continuously for longer than 10 seconds.

(1) Disconnect the connector of M terminal.

(2) Pull-in test

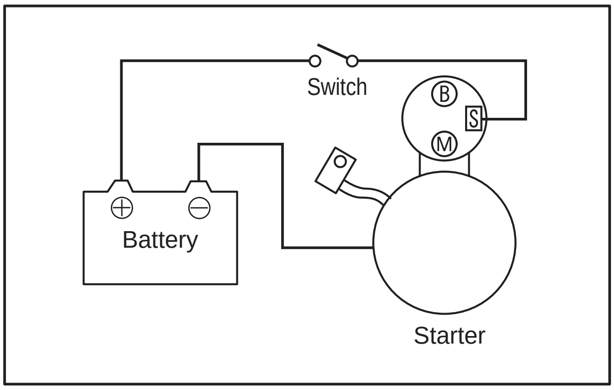
Connect the starter to the circuit as shown in the illustration. The magnetic switch is normal if the pinion springs out when the switch is turned ON.



Pull-in test

(3) Holding test

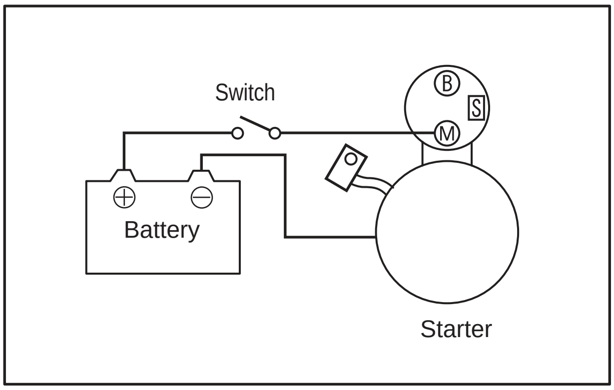
Connect the starter to the circuit as shown in the illustration. Pull out the pinion fully by hand. The magnetic switch is normal if the pinion does not return when it is released.



Holding test

(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.



Return test

2.1.2 No load test

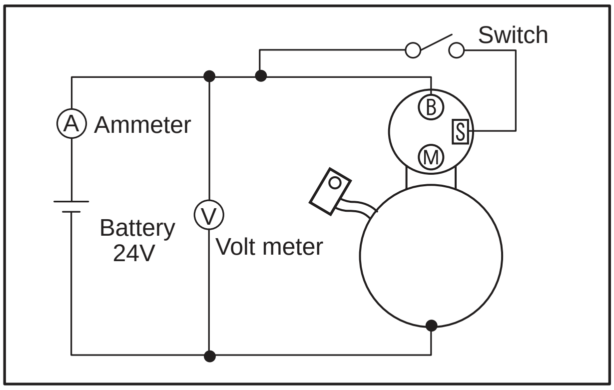
CAUTION

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.

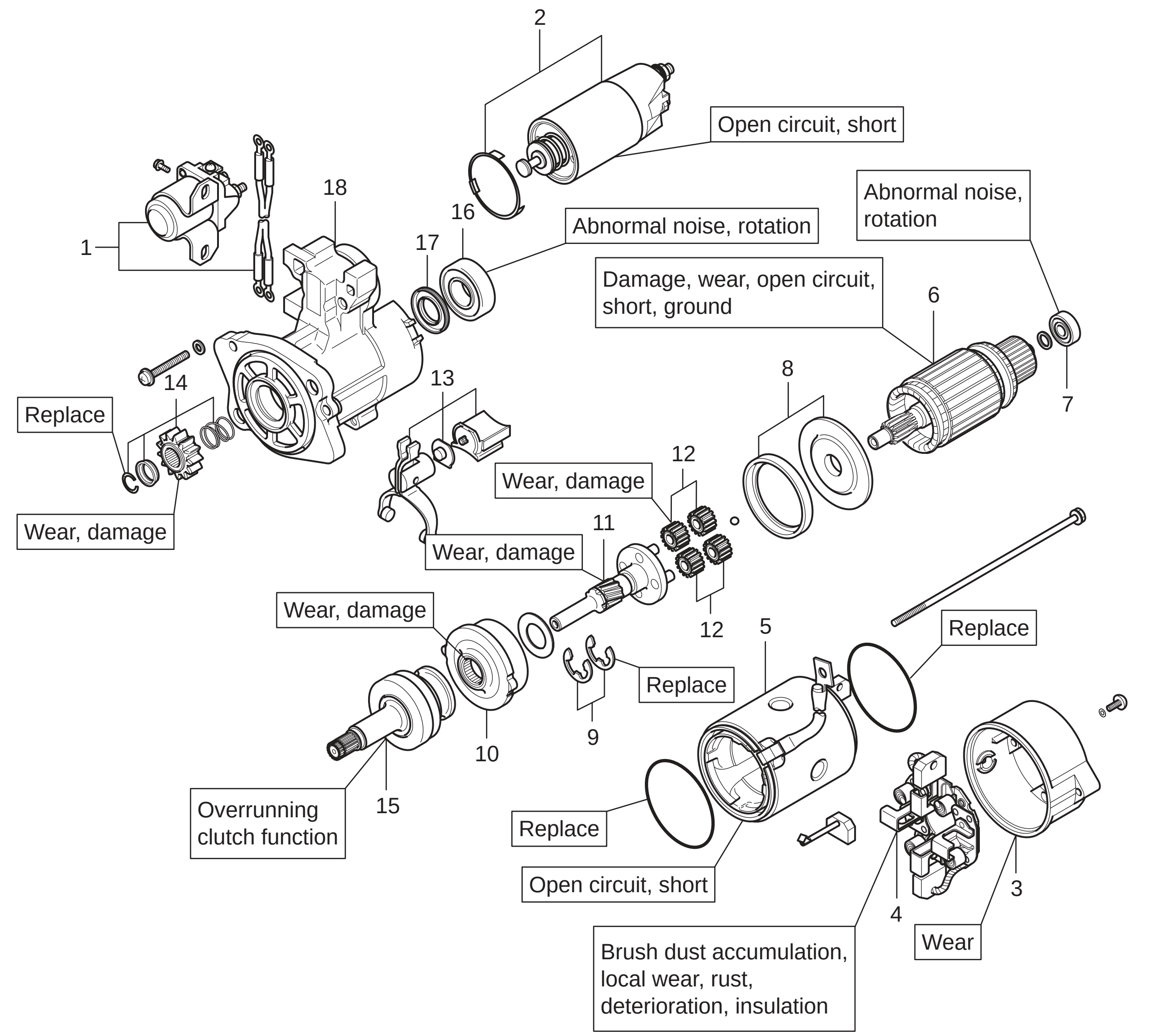
(2) In normal condition, the pinion pops out when the switch is turned ON, and the starter rotates at more than the specified rotation speed.
If the terminal voltage, current or rotation speed does not meet the standard, disassemble, inspect and repair the starter.

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



Test at no load

2.2 Disassembling and inspecting starter



Disassembling and inspecting starter

Disassembling sequence

1 Auxiliary switch
2 Magnetic switch assembly
3 Rear bracket
4 Brush holder
5 Yoke assembly
6 Armature
7 Ball bearing
8 Packing set
9 Washer set
10 Internal gear
11 Gear shaft
12 Gear
13 Lever assembly
14 Pinion set
15 Overrunning clutch
16 Ball bearing
17 Oil seal
18 Front bracket

2.2.1 Removing pinion set

CAUTION

The starter generates heat when current is being applied. Remove the pinion within 10 seconds.

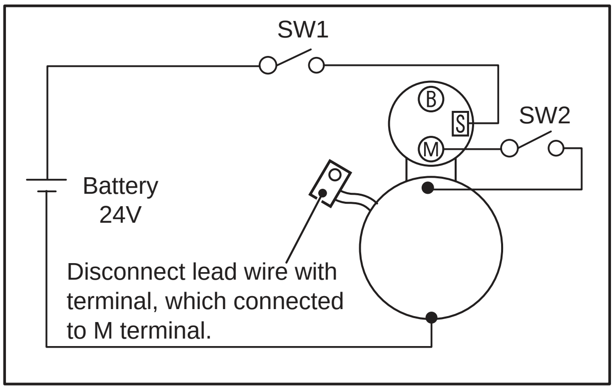
(1) Connect the starter to the circuit as shown in the illustration.

(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.

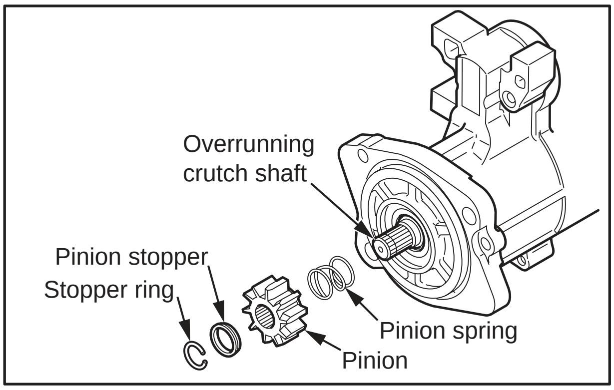
(3) Place an appropriate tube on the pinion stopper.
Tap the tube with a hammer to drop the pinion stopper to the clutch side. This will expose the stopper ring.

(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

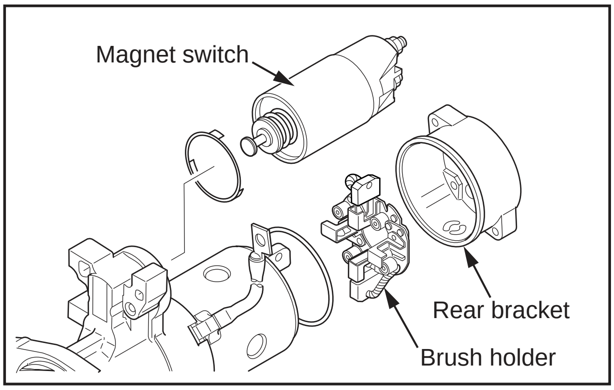
Disconnect the leads, and remove the magnetic switch.

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

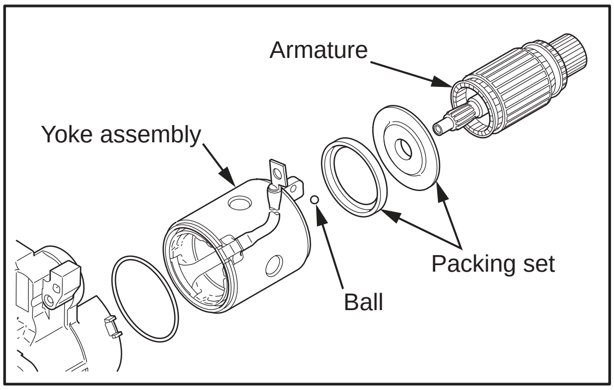
Apply a socket (of the same diameter as the commutator) to the commutator of the armature. Remove the brush holder and brush assembly by sliding on the socket.



Disassembling starter (1)

2.2.5 Removing armature and yoke

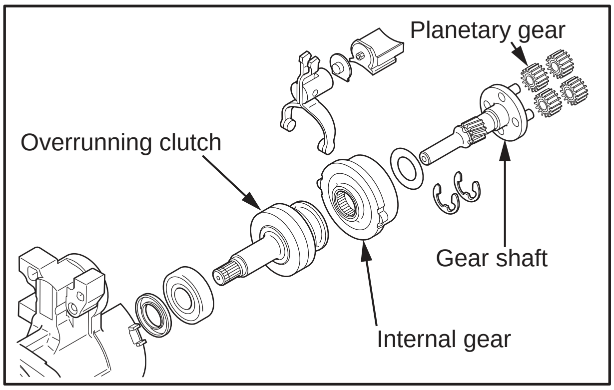
(1) Remove the armature and the yoke.
(2) Remove the packing from the internal gear.
(3) Remove the packing and plate on the lever support.
(4) Remove the ball from the internal gear.
(5) Remove the planetary gears.



Disassembling starter (2)

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.



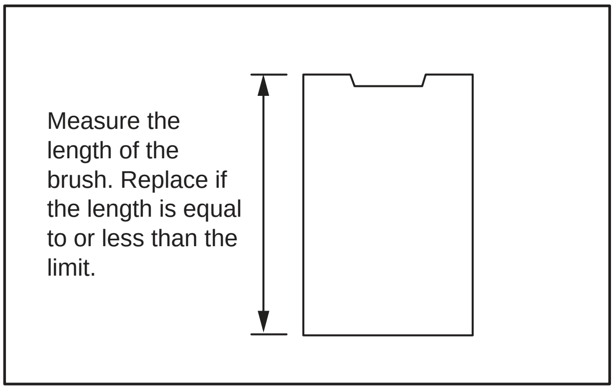
Disassembling starter (3)

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.]

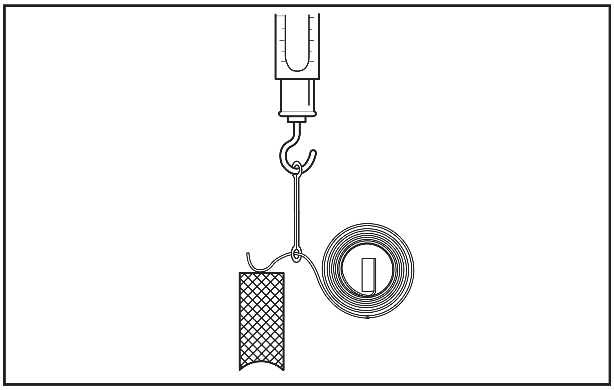


Inspecting brushes for wear

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.

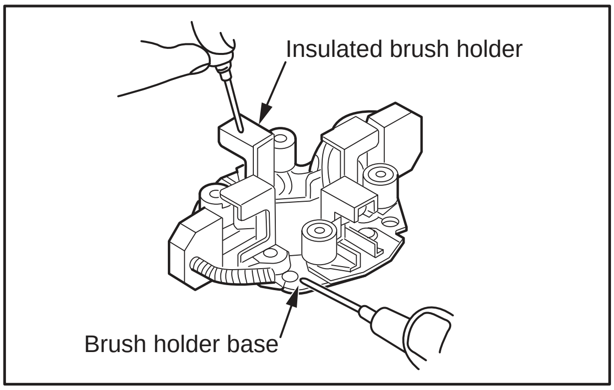
Item	Standard	Limit
Brush spring load	29.4 to 39.4 N {3.0 to 4.0 kgf} [6.6 to 8.8 lbf]	13.7 N {1.4 kgf} [3.1 lbf]



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.

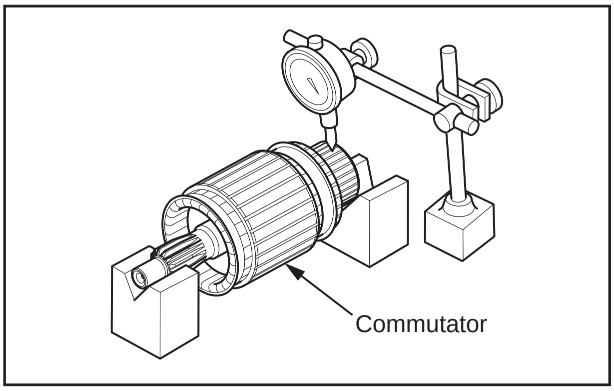


Checking brush holder for grounding

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.]



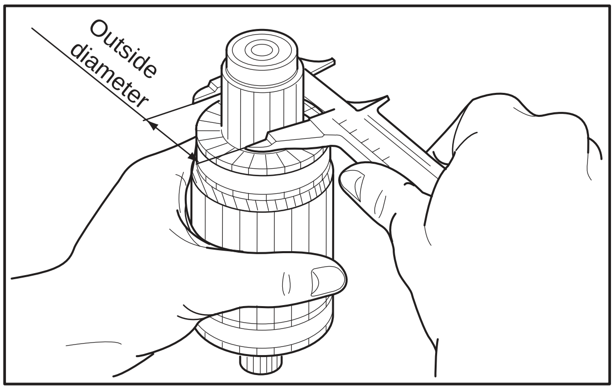
Measuring commutator radial runout

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.]



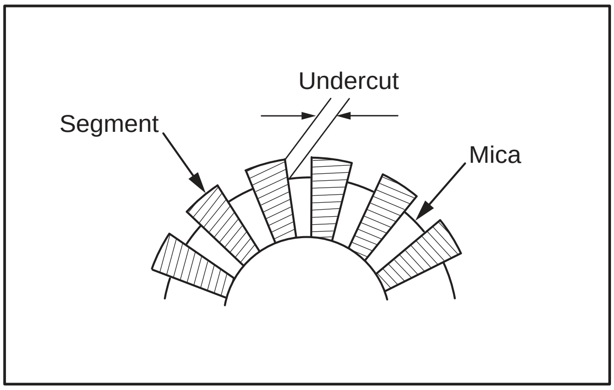
Measuring commutator outside diameter

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.

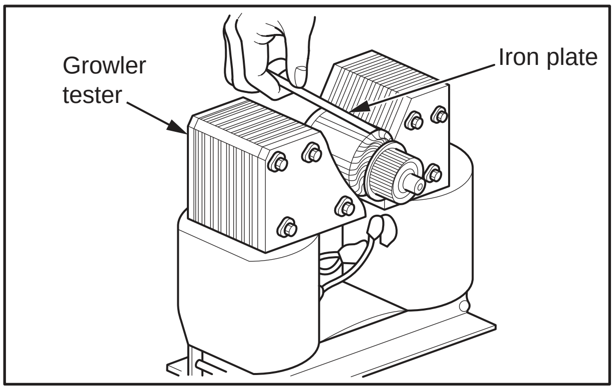
Item	Standard	Limit
Undercut depth	0.4 to 0.6 mm [0.016 to 0.024 in.]	0.2 mm [0.008 in.]



Measuring commutator undercut depth

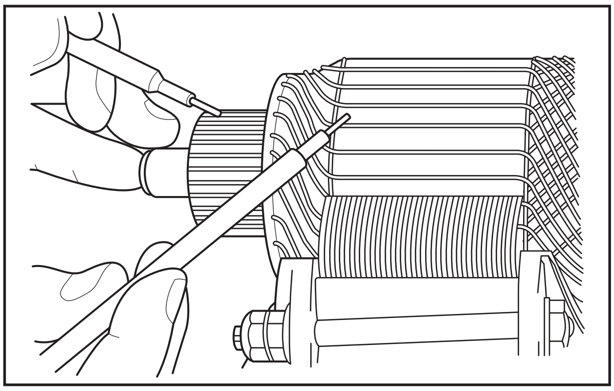
2.3.7 Checking armature coil

(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.



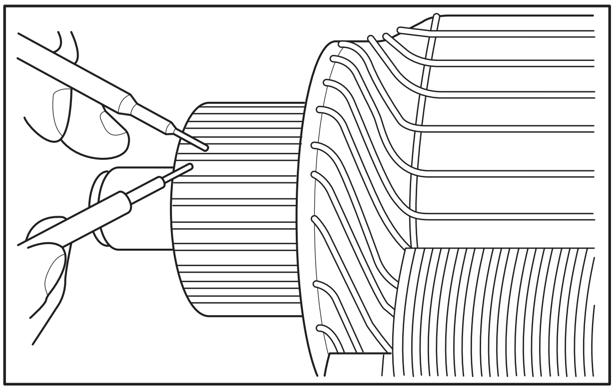
Inspecting armature coil for short circuit

(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

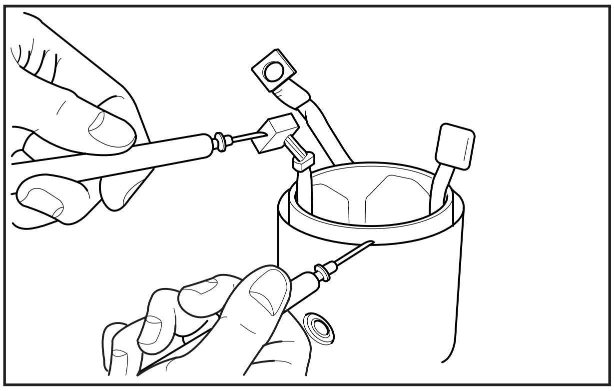
(3) Check continuity between segments in various combinations.
If poor or no continuity is found, replace the armature with a new one.



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

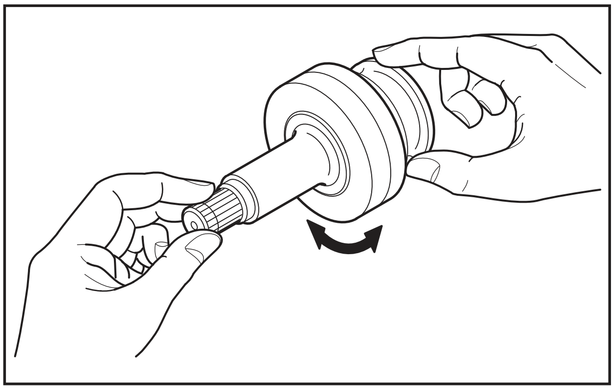
Replace the rear bracket if the bearing is worn.

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

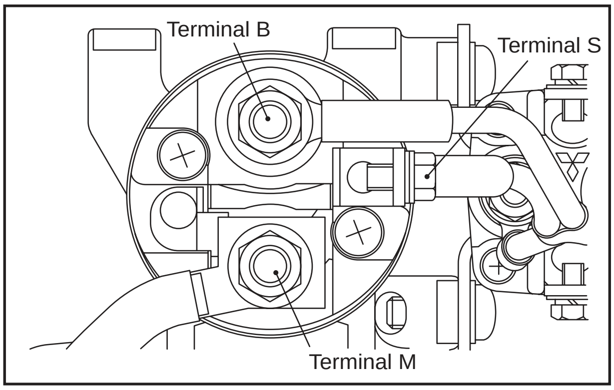
Check gears of the starter for wear or damage. If faulty, replace the gears.

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.

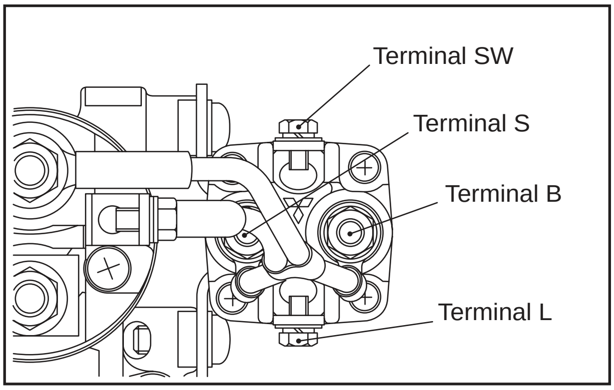


Inspecting magnetic switch

2.3.14 Inspecting starter relay

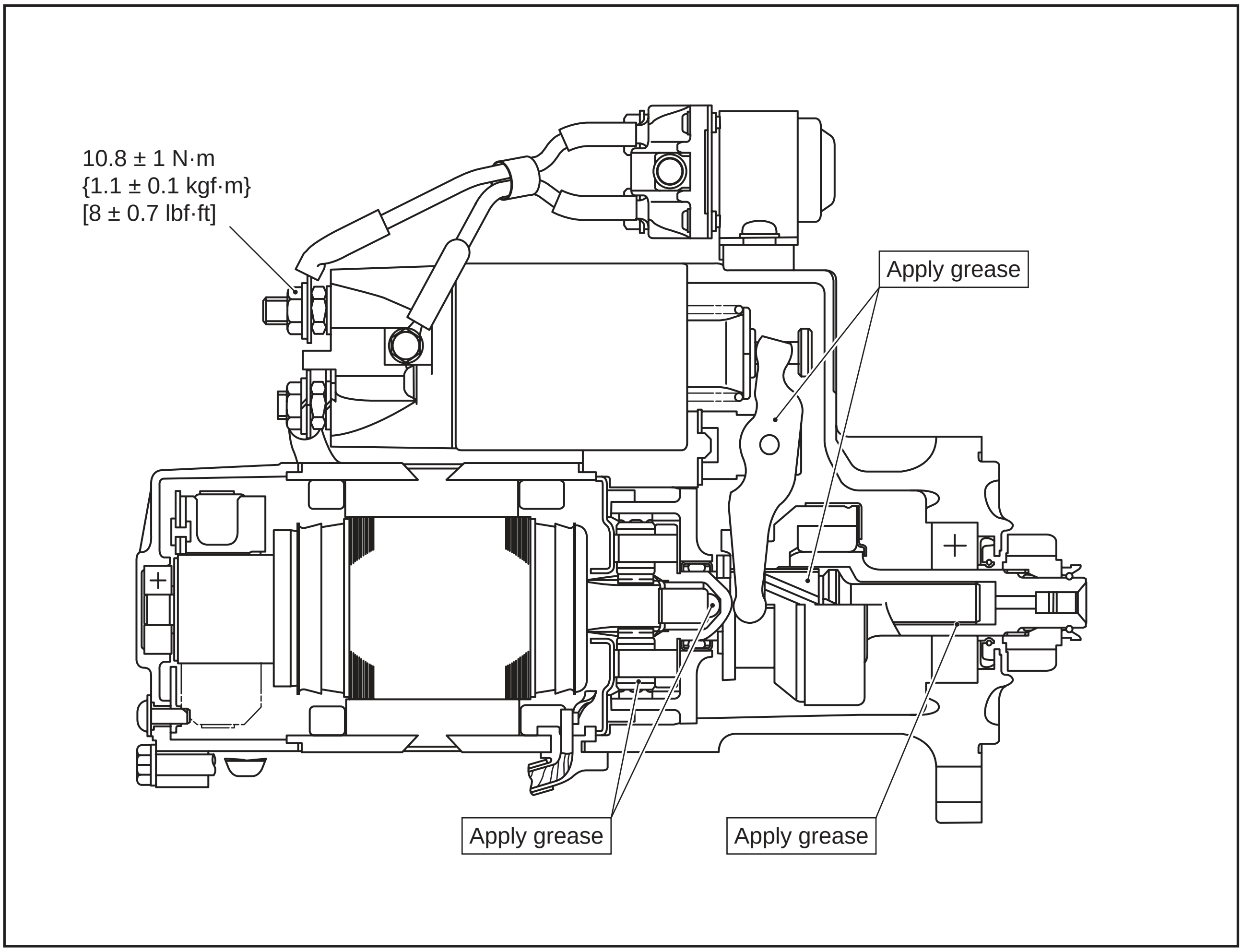
(1) Open circuit of coil
Check continuity between terminal SW and terminal L.
If continuity is not found, replace the starter relay.

(2) Adhension 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

2.4 Reassembling starter



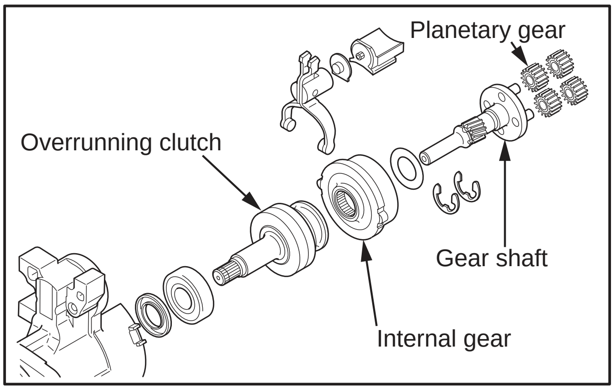
Reassembling starter

2.4.1 Installing gear shaft

(1) Install the lever to the overrunning clutch.

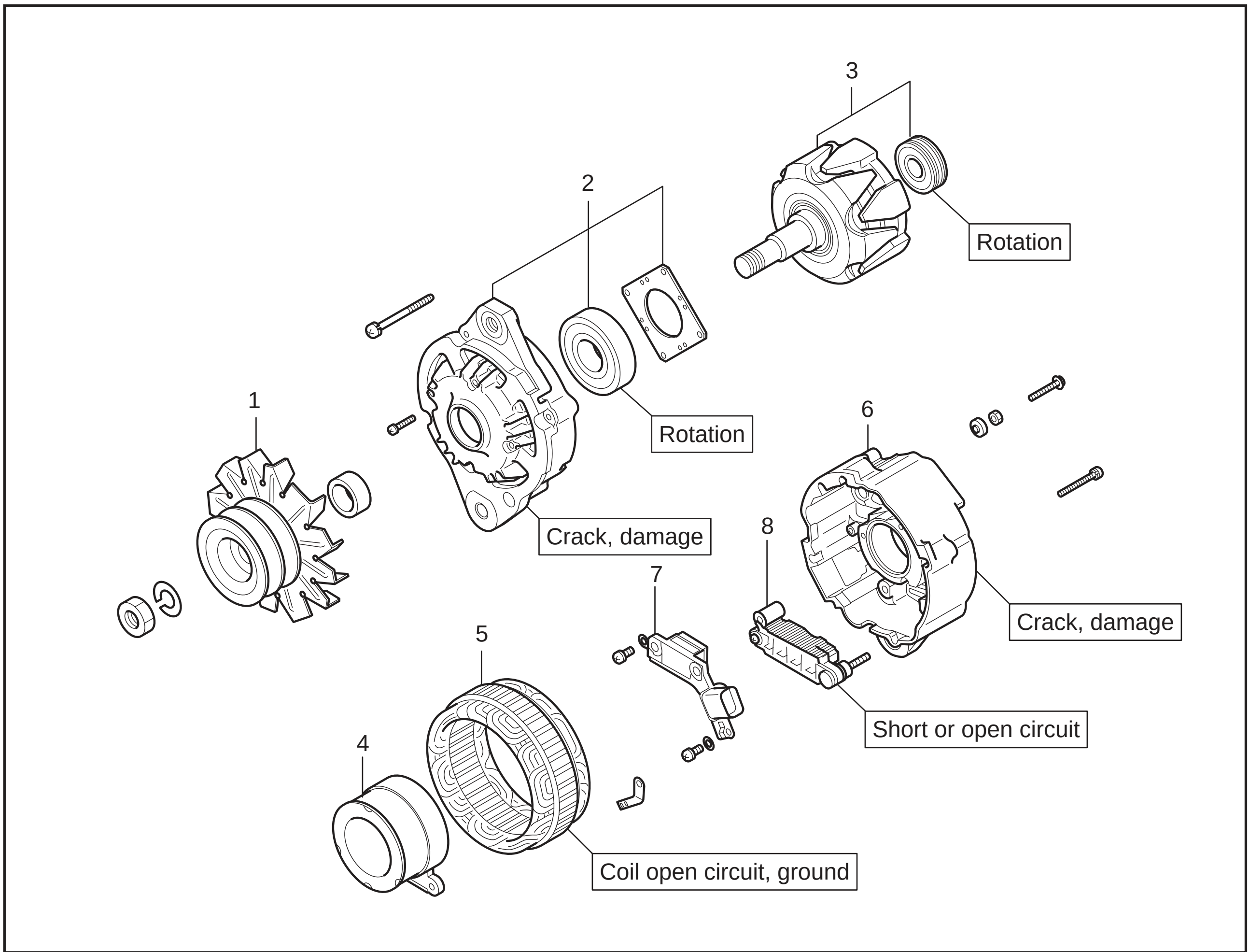
(2) Fit the internal gear into the gear shaft.

(3) Put the gear shaft into the overrunning clutch.



Installing gear shaft

2.5 Disassembling and inspecting alternator



Disassembling and inspecting alternator

Disassembling sequence

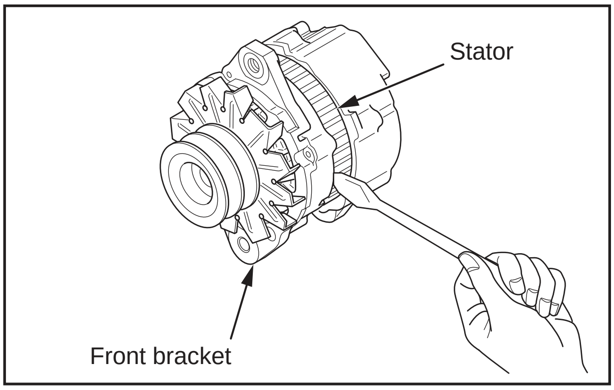
1	Pulley (with fan)	4	Coil	7	Regulator assembly
2	Front bracket assembly	5	Stator coil	8	Rectifier assembly
3	Rotor assembly	6	Rear bracket		

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.



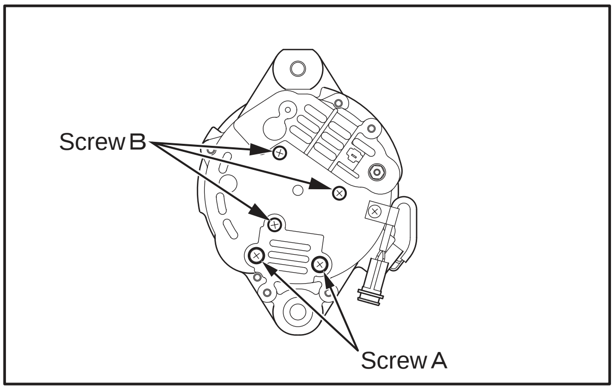
Separating front bracket from stator

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.



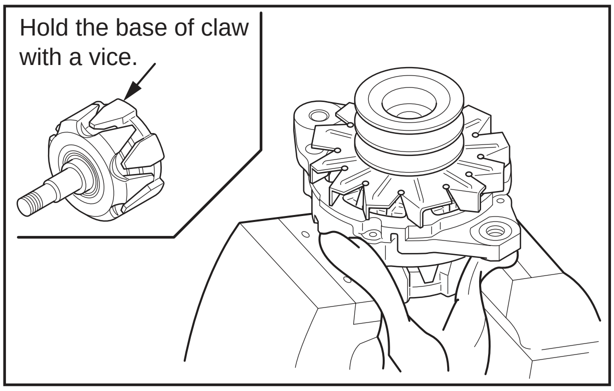
Removing field coil

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.

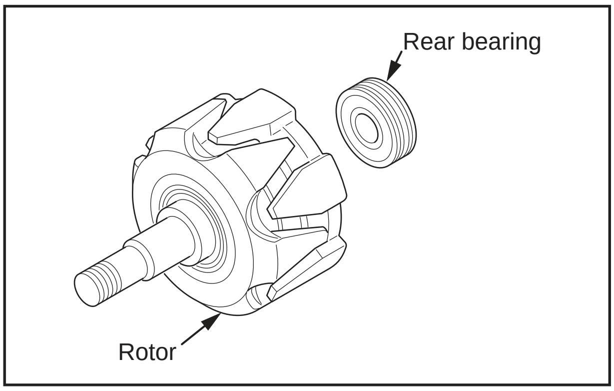
(1) Apply a cloth to the rotor and set it in a vise.
(2) Remove the pulley nut and then pull out the pulley.



Removing pulley

2.5.4 Removing rear bearing

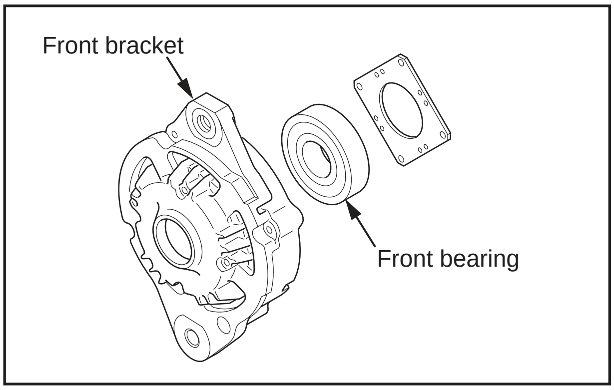
Remove the rear bearing from the rotor using a bearing puller.



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.



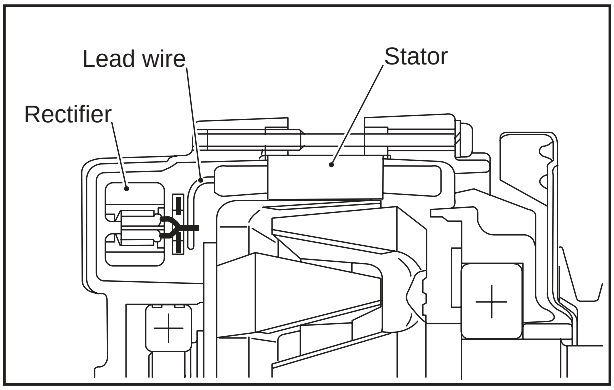
Removing front bearing

2.5.6 Removing stator

CAUTION

Unsoldering must be finished as quickly as possible. Extended heating will damage the diodes.

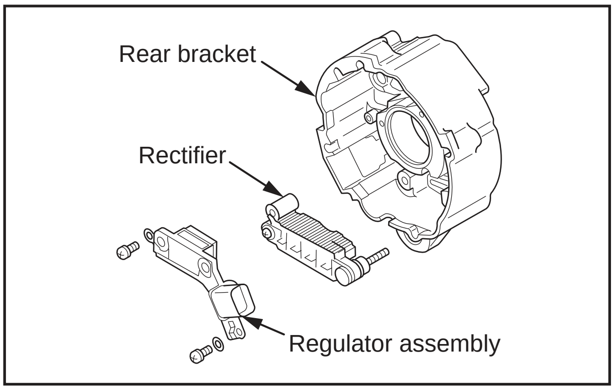
Unsolder the joint of the stator and remove the stator from the rectifier.



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

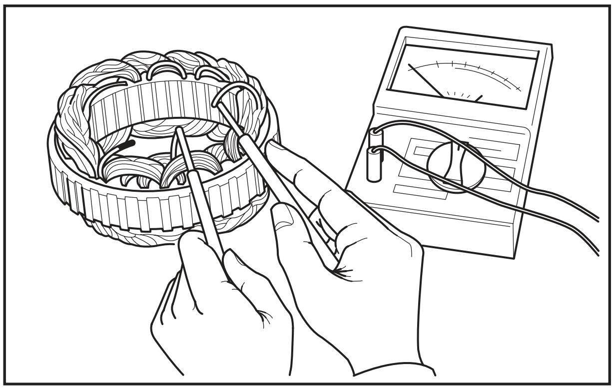
(1) Remove the screw and nut from the rectifier.

(2) Remove the rectifier assembly.

2.6 Inspecting and repairing alternator

2.6.1 Inspecting stator

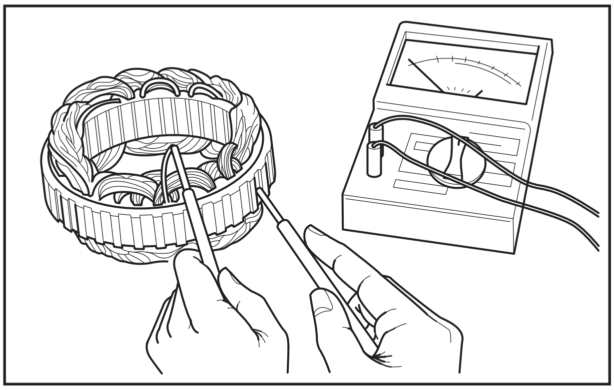
(1) Checking continuity between lead wires.
Check continuity between a pair of lead wires.
Also check for no continuity between a pair of lead wires and other pairs of lead wires.
If defective, replace the stator.



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.

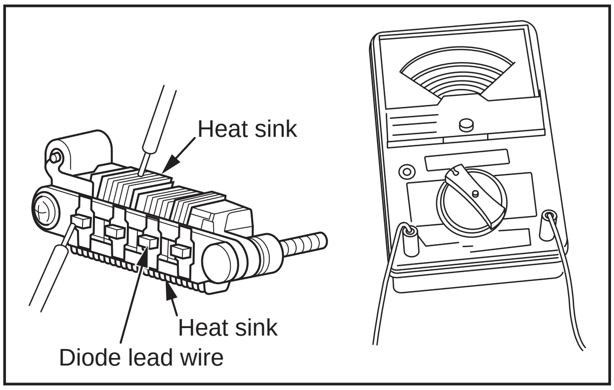


Inspecting continuity between lead wires and core

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 Ω, 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.

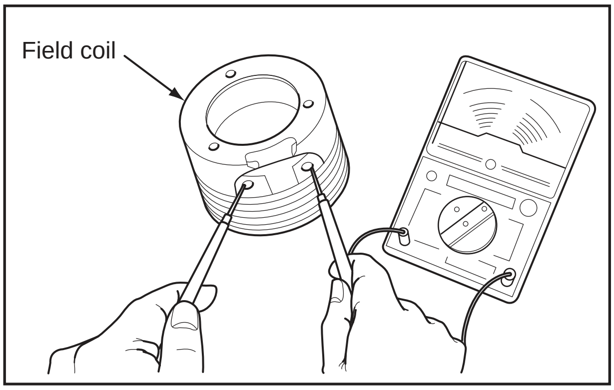


Inspecting rectifier

2.6.3 Measuring field coil

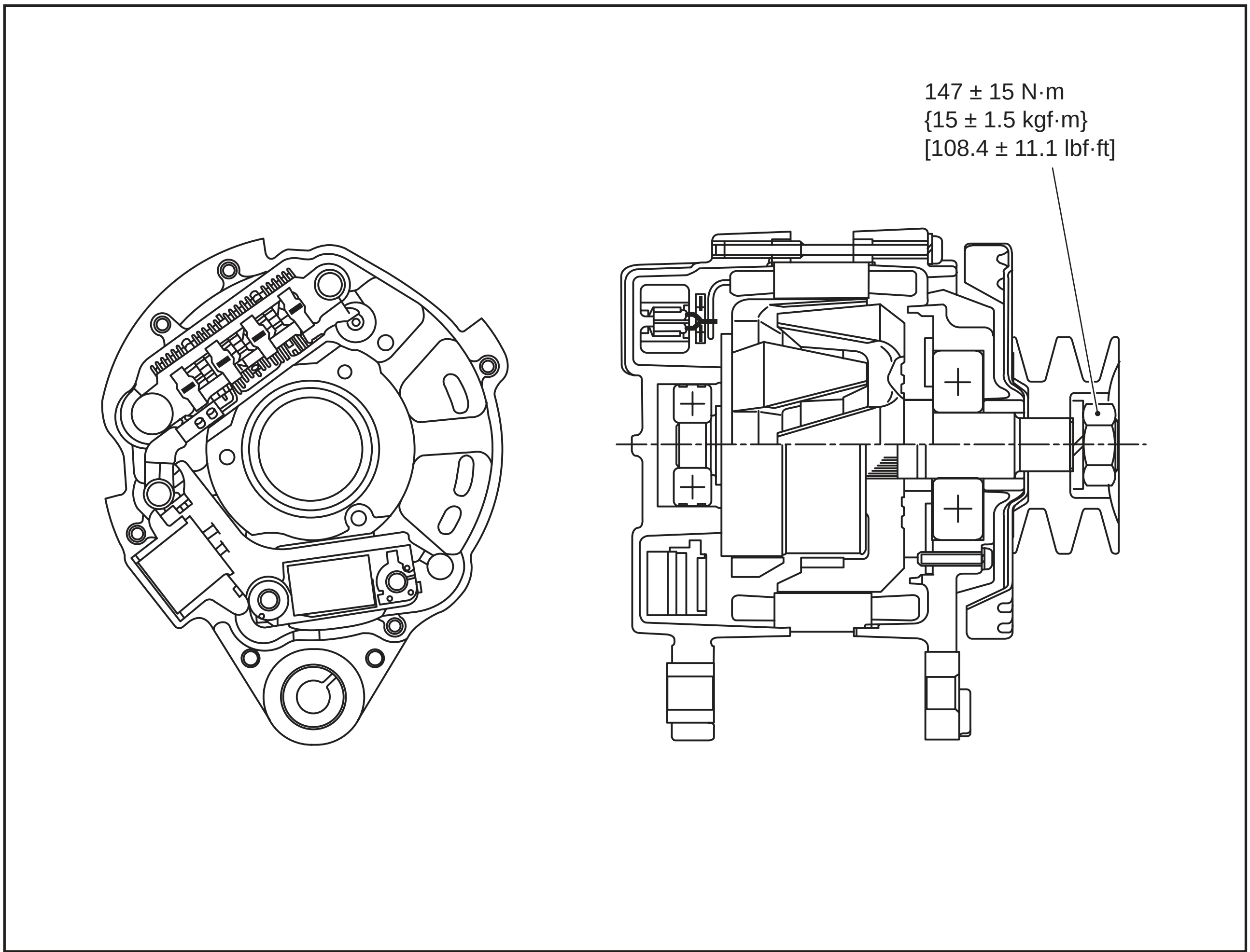
Measure resistance between the terminals of the field coil.

If the measured value deviates from the standard value, replace the field coil with a new one.



Measuring field coil

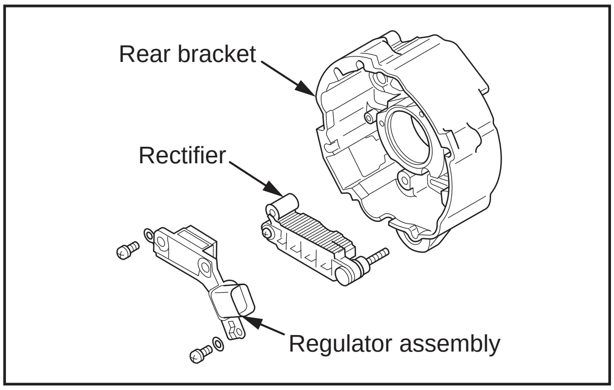
2.7 Reassembling alternator



Reassembling alternator

2.7.1 Installing rectifier assembly and regulator assembly

Install the rectifier assembly and regulator assembly on the rear bracket.



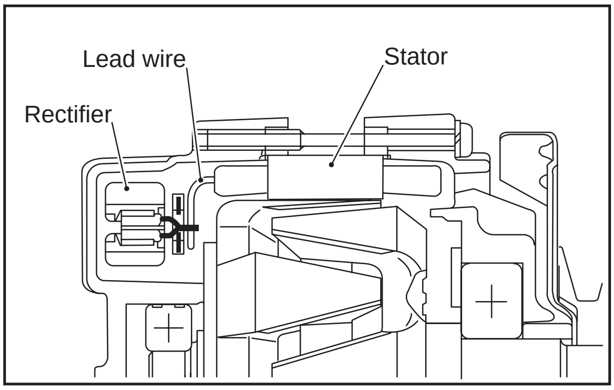
Installing rectifier assembly and regulator assembly

2.7.2 Installing stator

CAUTION

Soldering must be finished as quickly as possible.
Extended heating will damage the diodes.

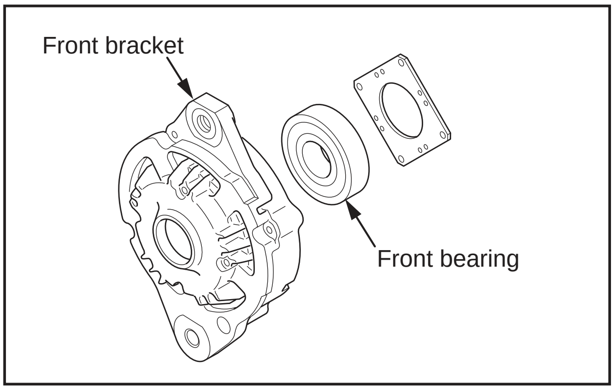
Install the stator and solder the leads of the stator to the rectifier.



Installing stator

2.7.3 Installing front bearing

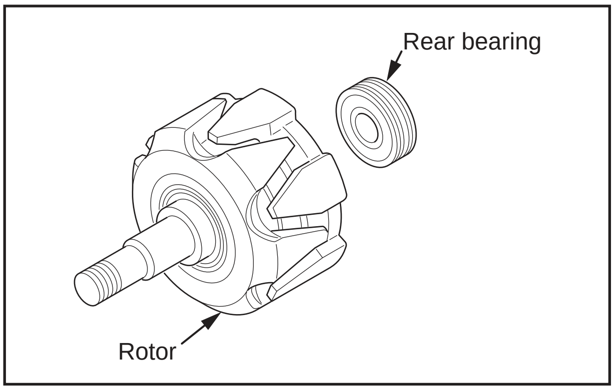
Drive the front bearing into the front bracket and secure the bearing retainer with a screw.



Installing front bearing

2.7.4 Installing rear bearing

Press-fit the rear bearing to the rotor.

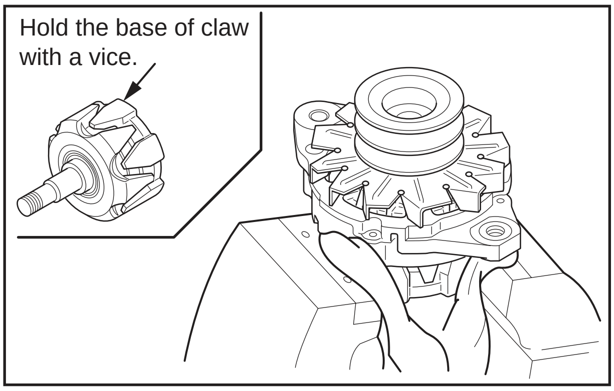


Installing rear bearing

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.

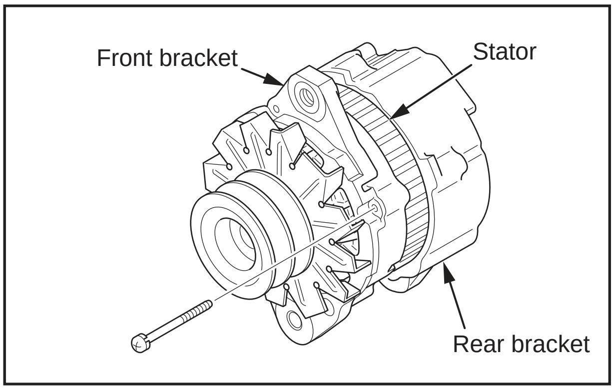
(2) Install the spacer and pulley, and secure the pulley with a nut.



Installing pulley

2.7.6 Assembling stator and front bracket

Assemble the front bracket, stator and rear bracket, and secure them with through bolts.

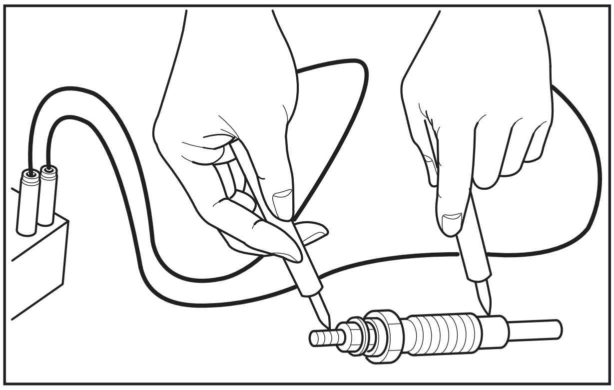


Installing stator and front bracket

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.



Continuity test of 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.

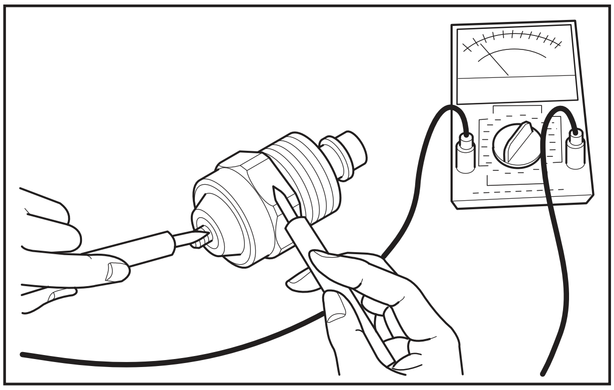
Item	Standard	
Rated voltage - Armature current	22 V - 4.4 $^{+0.3}_{-0.7}$ A	When applying the rated voltage for 15 seconds.

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.

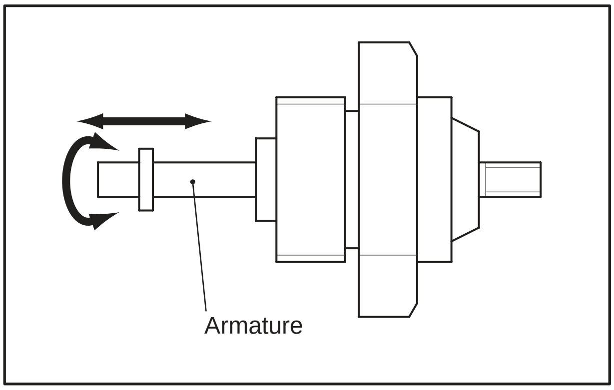
Item	Standard
Resistance value	37 to 41 Ω (Ambient temperature: 23 ± 5°C [73.4 ± 9°F])



Continuity test of magnetic valve

2.9.2 Inspecting magnetic valve (stop solenoid) operation

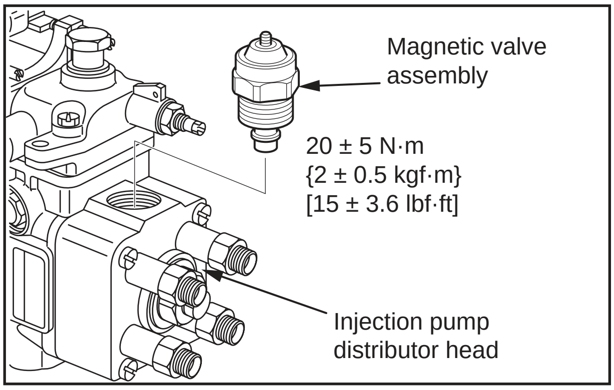
Check visually for rubber strips of the tip of the armature and damages. Also check the armature moves smoothly by rotating with a hand.



Inspecting magnetic valve operation

2.10 Installing magnetic valve (stop solenoid)

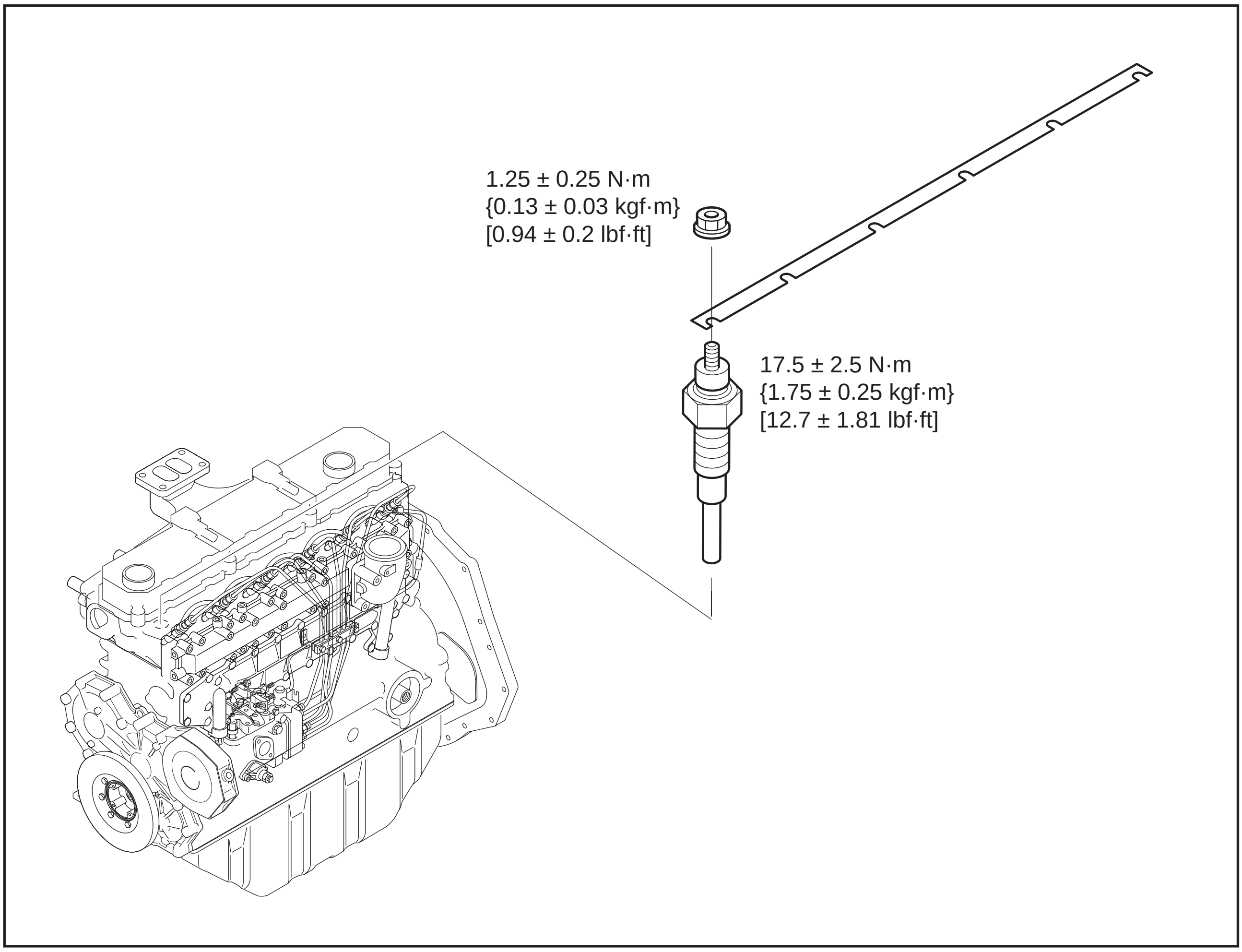
Install the magnetic valve assembly to the distributor with the specified torque.



Installing magnetic valve

3. Installing electrical system

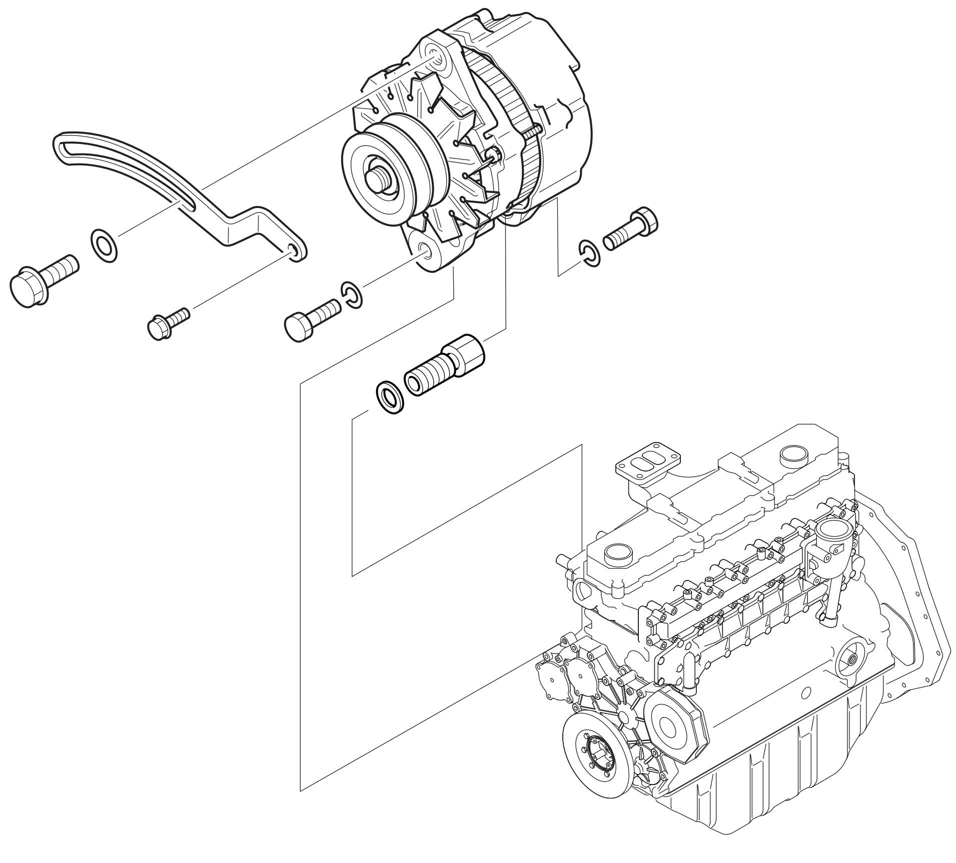
3.1 Installing glow plug



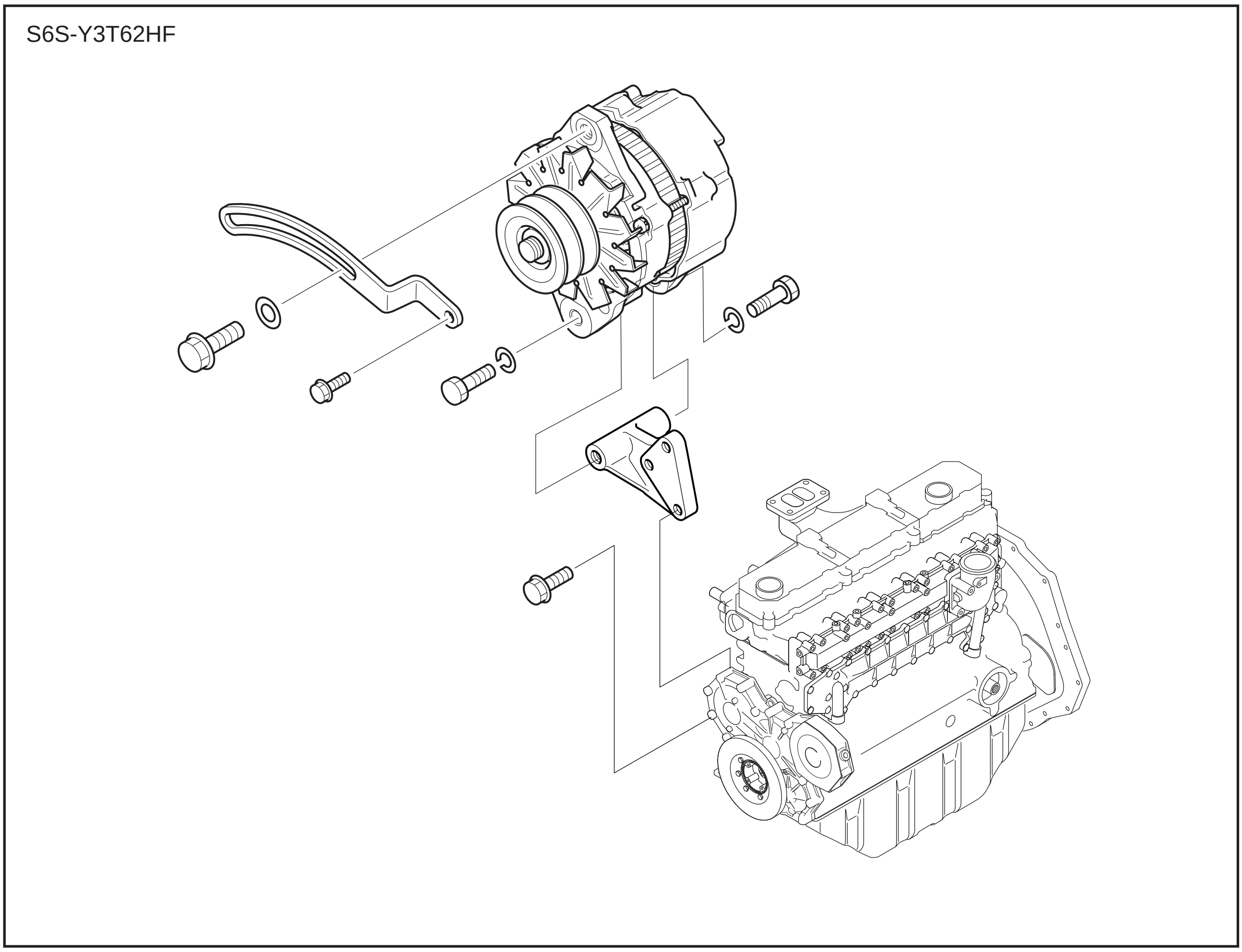
Installing glow plug

3.2 Installing alternator

S6S-Y3T61HF

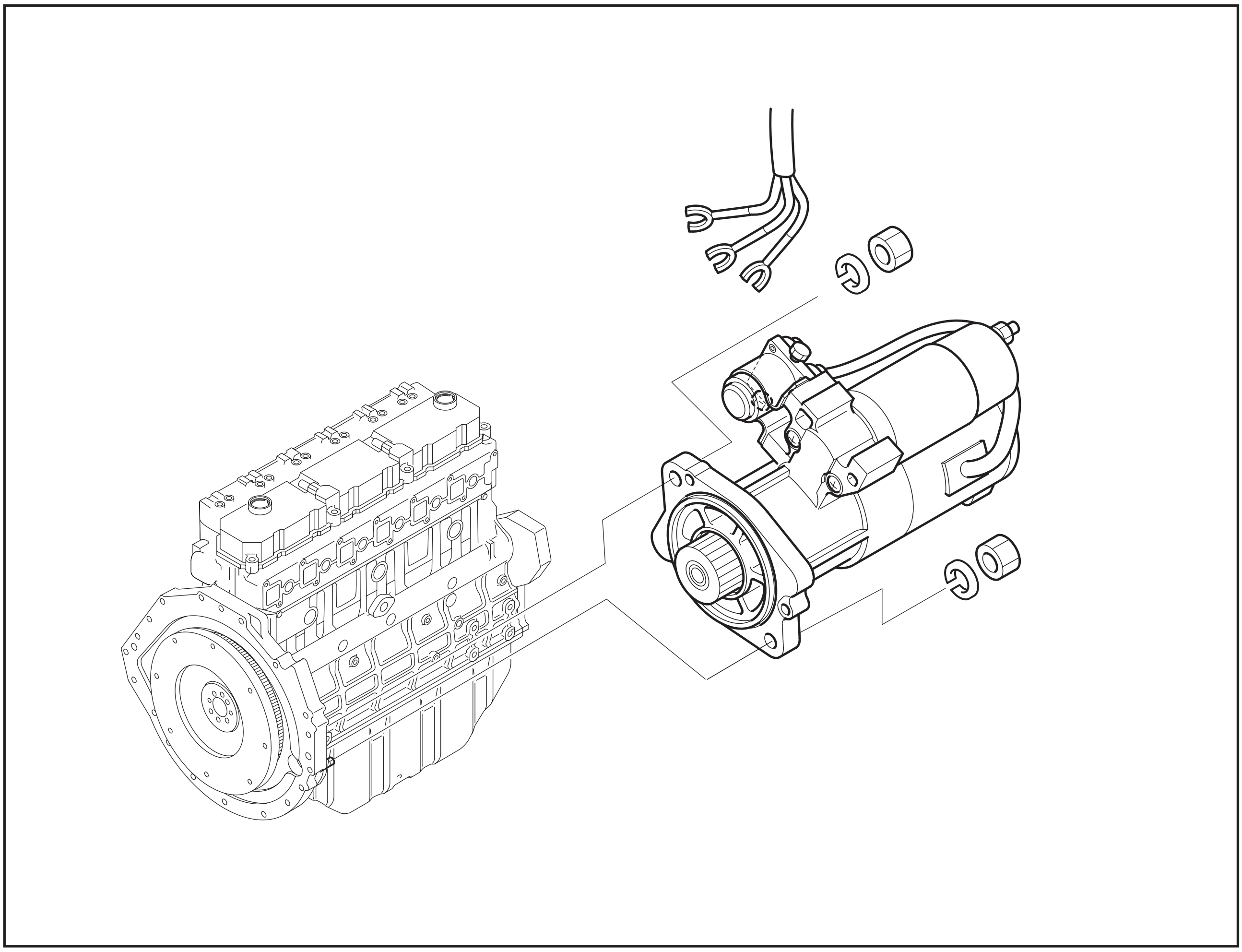


Installing alternator



Installing alternator

3.3 Installing starter



Installing starter

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	

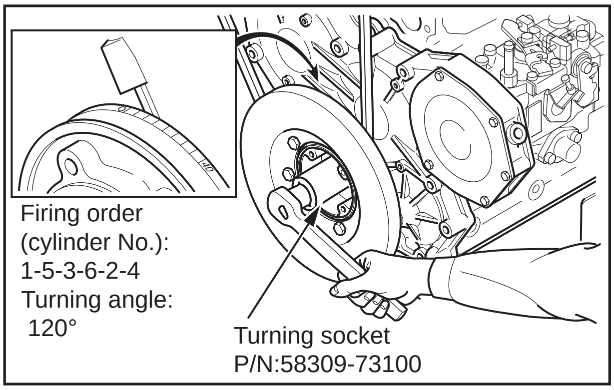
1.1.1 Inspecting valve clearance

(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.

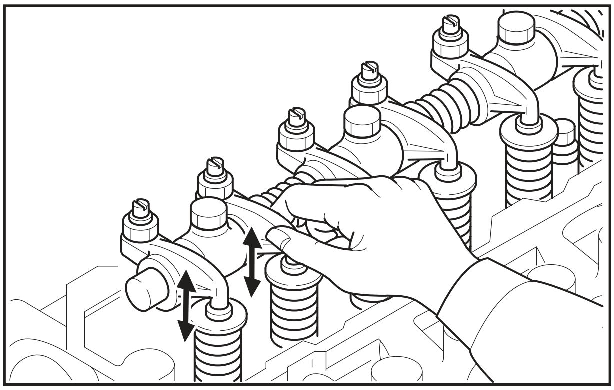
Note: To turn the crankshaft, fit a socket and ratchet handle on the crankshaft pulley nut.

(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

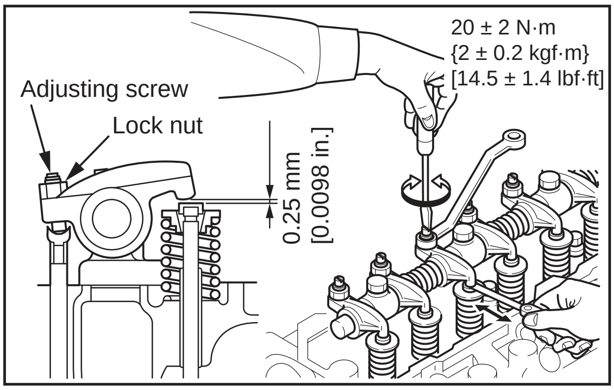


Determining top dead center of No. 1 cylinder compression stroke

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.

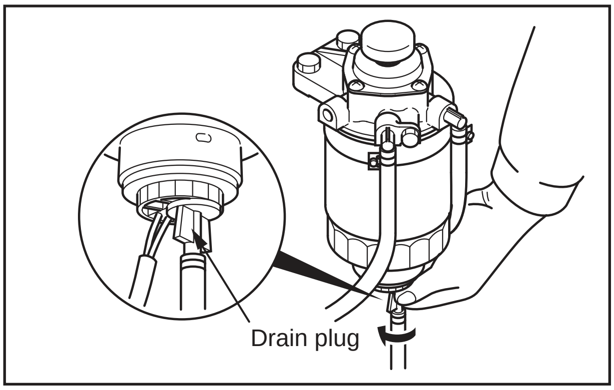
1.2.1 Draining fuel filter

(1) Loosen the drain plug on the bottom of the fuel filter.

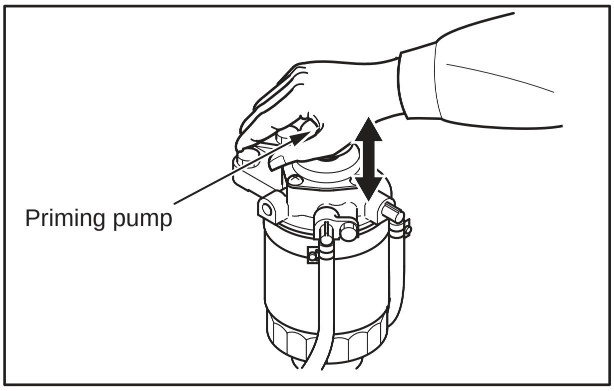
(2) Water is easily drained by pressing the manual feed pump repeatedly (approx. 7 times) to feed the fuel.

(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

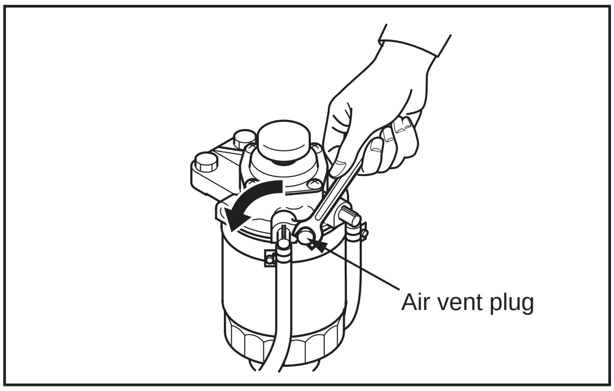
Completely wipe off any spilled fuel from the air vent plug with a cloth, and be sure to tighten the air vent plug after air bleeding. Failure to do so could cause a fire.

1.3.1 Bleeding fuel filter

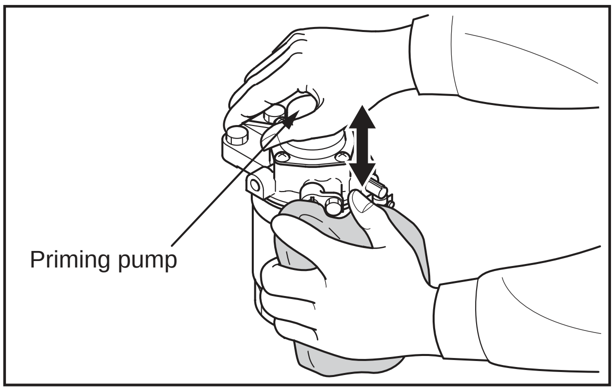
(1) Loosen the air vent plug of the fuel filter with a wrench.

(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)

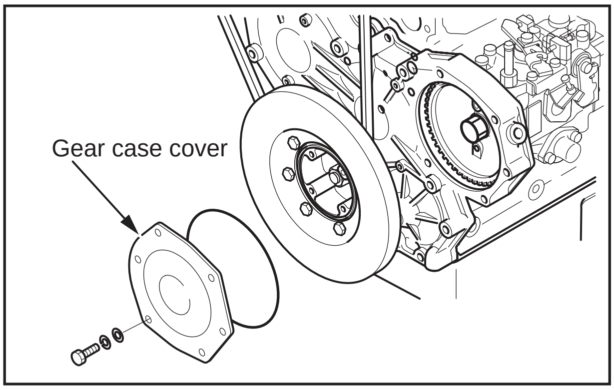
1.4 Inspecting and adjusting fuel injection timing

1.4.1 Adjusting fuel injection timing

When the fuel injection pump is replaced, adjust the fuel injection timing after the replacement.

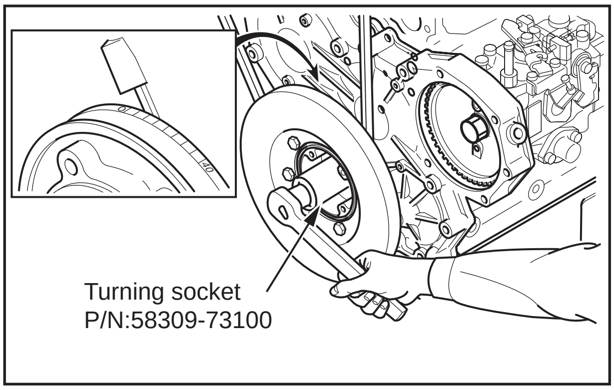
To adjust it, bring No. 1 cylinder piston to top dead center on compression stroke. Make sure that the marks on the flange plate and the fuel injection pump body are aligned.

(1) Remove the gear case cover.



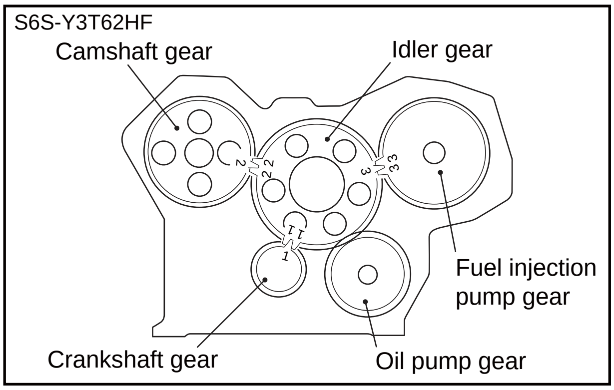
Removing gear case cover

(2) Attach the turning socket to the pulley nut and turn the crankshaft in the normal direction (clockwise as viewed from the front end).

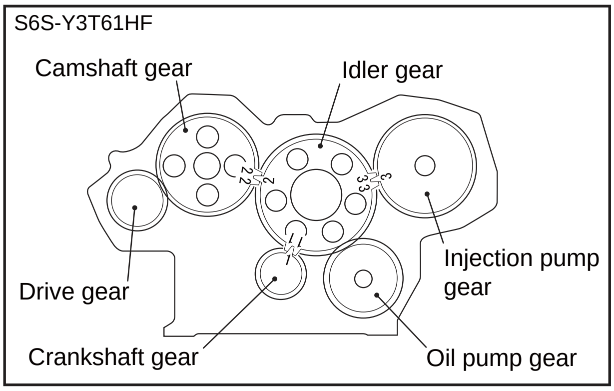


Turning engine

(3) Stop turning the crankshaft when the marks of the fuel injection pump gear and idler gear are aligned.

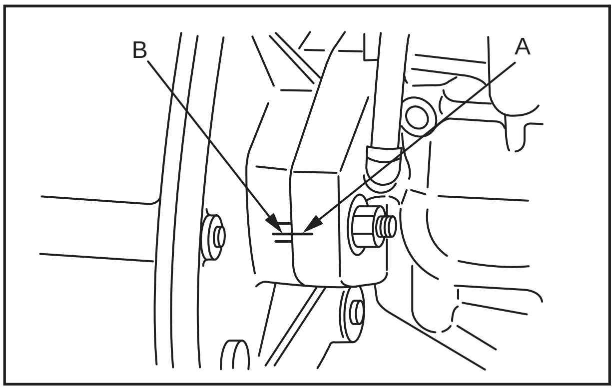


Match mark of gears



Match mark of gears

(4) Put a mark B on the flange plate where aligned with the mark A of the fuel injection pump.



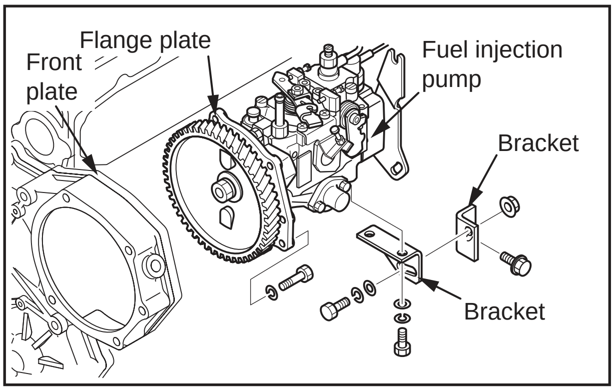
Alignment mark of fuel injection pump

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.



Removing fuel injection pump

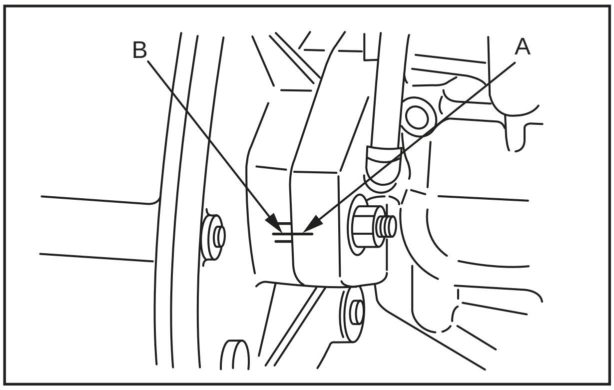
CAUTION

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.

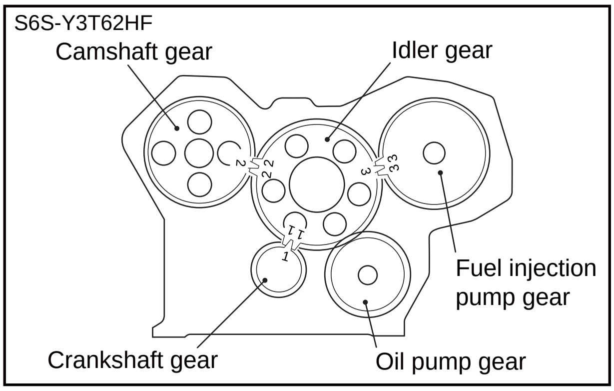
(8) Install the flange plate and the fuel injection pump gear to the fuel injection pump.

(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.

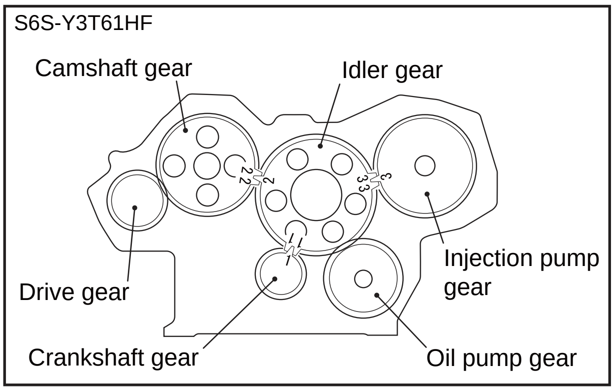


Alignment mark of fuel injection pump

(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.

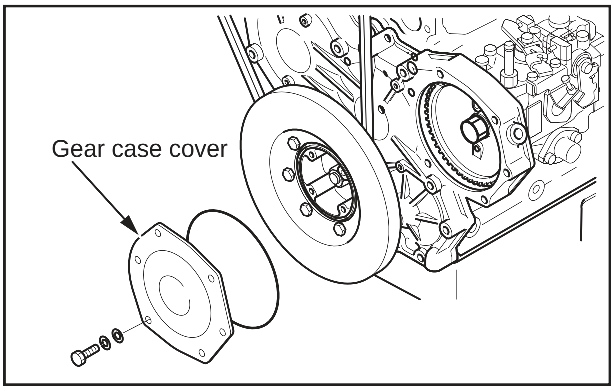


Match mark of gears



Match mark of gears

(11) Install the gear case cover.



Installing gear case cover

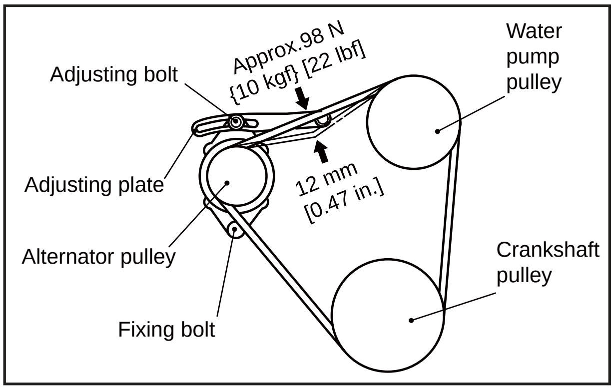
1.5 Inspecting V-belt and adjusting V-belt tension

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.

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)

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.

Colculation output = Correction factor(α_c) × Measured brake power

- Atmospheric conditions during test

  Temperature(T):283K(10°C)[50°F]≦ T≦ 313K(40°C)[104°F]

  Dry atmospheric pressure(P_d):80kPa(600mmHg)≦P_d≦110kPa(825mmHg)

$\alpha_c=(f_a)^{fm}$ 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≦ α_c≦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≦q_c≦65mg/(l-cycle)

- q_c≦ 37.2mg/(l -cycle):f_m =0.2(constant)
- 65mg/(l -cycle)≦q_c :f_m =1.2(constant)