CONTENTS

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

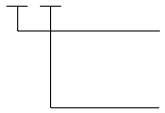
Distribution and updating

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



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
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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/cm² to lbf/in²

1kgf / cm² = 14.2233lbf / in²

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

TEMPERATURE

Fahrenheit-Centigrade Conversion.

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

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

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

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

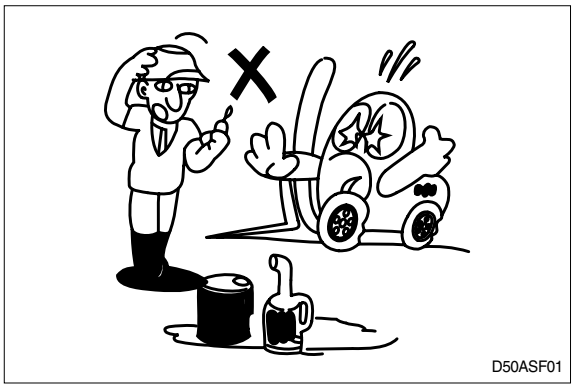
°C		°F	°C		°F	°C		°F	°C		°F
-40.4	-40	-40.0	-11.7	11	51.8	7.8	46	114.8	27.2	81	117.8
-37.2	-35	-31.0	-11.1	12	53.6	8.3	47	116.6	27.8	82	179.6
-34.4	-30	-22.0	-10.6	13	55.4	8.9	48	118.4	28.3	83	181.4
-31.7	-25	-13.0	-10.0	14	57.2	9.4	49	120.2	28.9	84	183.2
-28.9	-20	-4.0	-9.4	15	59.0	10.0	50	122.0	29.4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

SECTION 1 GENERAL

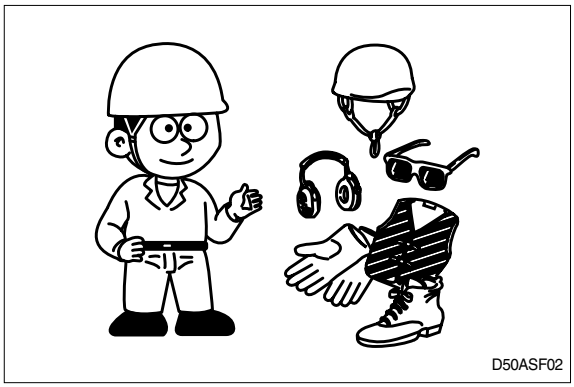
GROUP 1 SAFETY HINTS

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

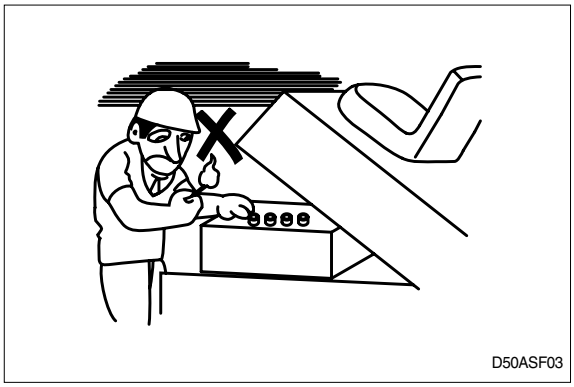
- Oil is a dangerous substance. Never handle oil, grease or oily clothes in places where there is any fire of flame.
  As preparation in case of fire, always know the location and directions for use of fire extinguishers and other fire fighting equipment.


D50ASF01

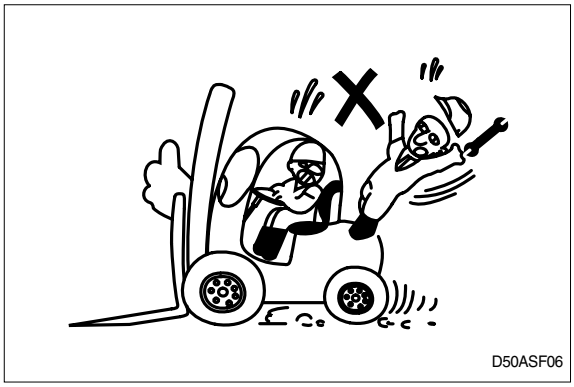
- Wear well-fitting helmet, safety shoes and working clothes. When drilling, grinding or hammering, always wear protective goggles.
  Always do up safety clothes properly so that they do not catch on protruding parts of machines. Do not wear oily clothes.
  When checking, always release battery plug.


D50ASF02

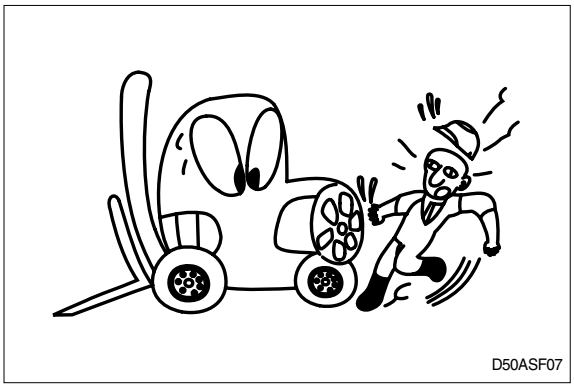
- Flames should never be used instead of lamps. Never use a naked flame to check leaks or the level of oil or electrolyte.


D50ASF03

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

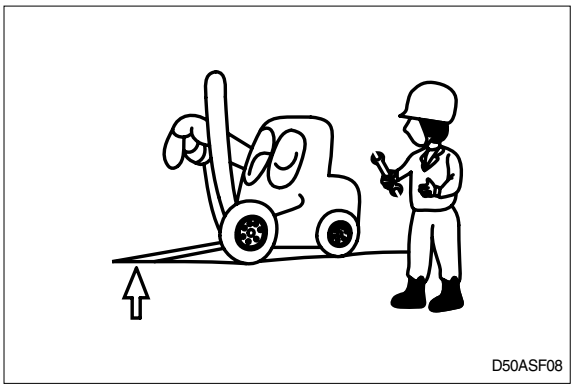

D50ASF06

- 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.

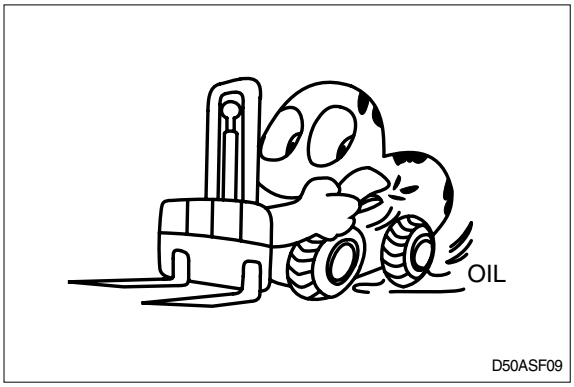

D50ASF07

When inspecting running parts or near such parts, always stop the machine 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.

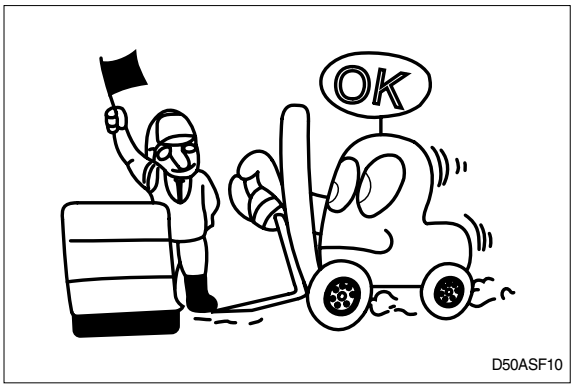

D50ASF08

- 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

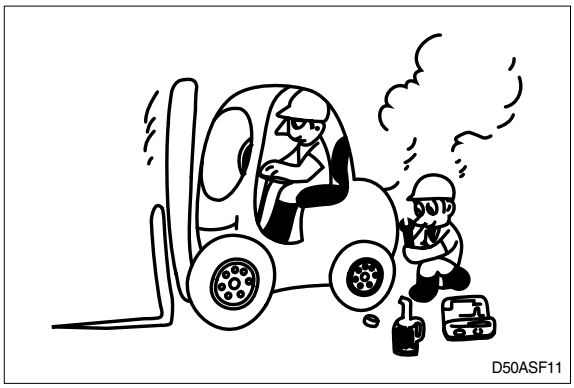
- When working with others, choose a group leader and work according to his instructions. Do not perform any maintenance beyond the agreed work.



D50ASF10

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

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

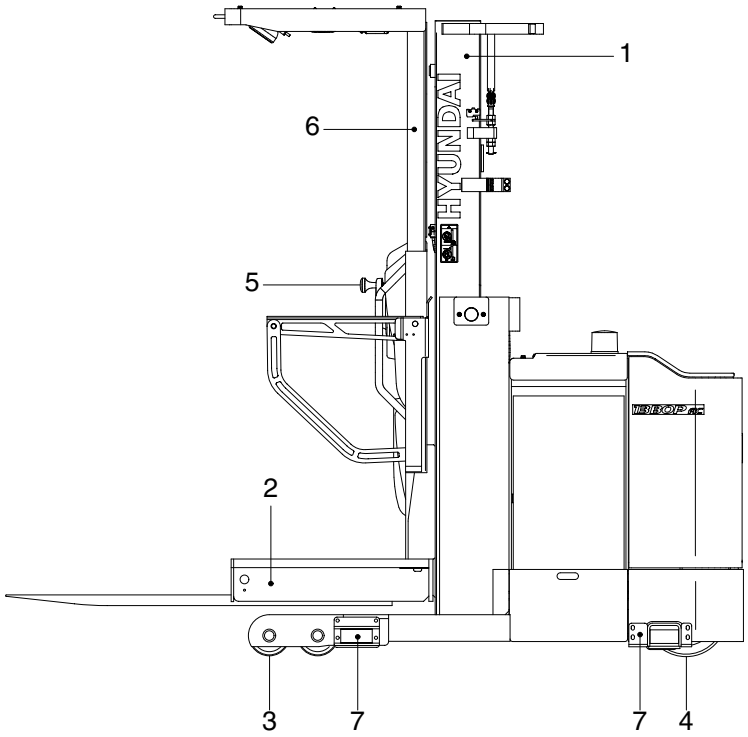


- Thoroughly clean the machine. In particular, be careful to clean the filler caps, grease fittings and the area around the dipsticks. Be careful not to let any dirt or dust into the system.
- Always use HYUNDAI Forklift genuine parts for replacement.
- Always use the grades of grease and oil recommended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

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

GROUP 2 SPECIFICATIONS

1. GENERAL LOCATIONS

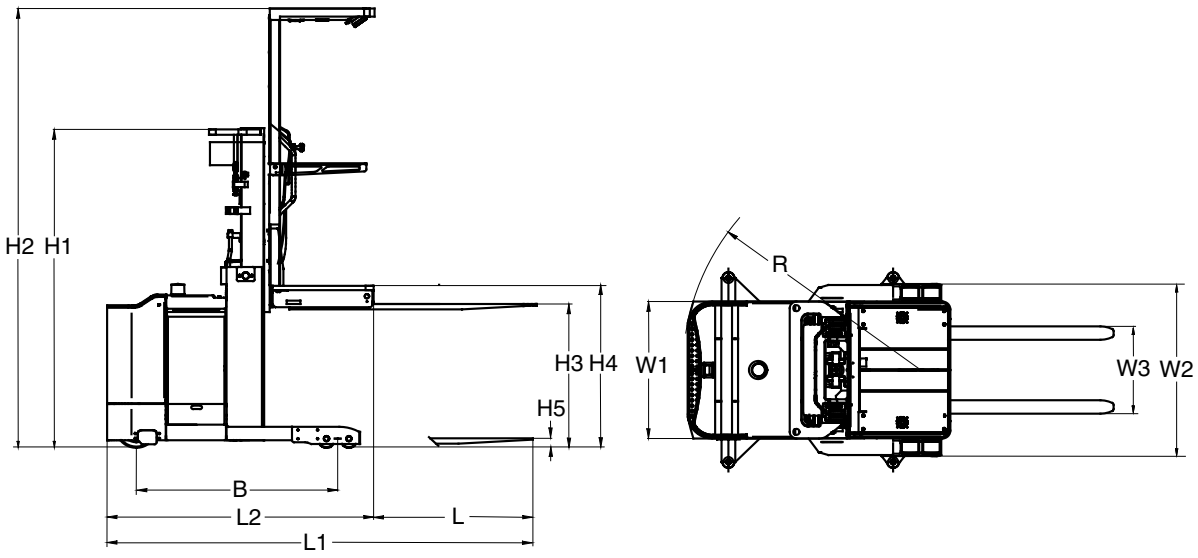


10BOP7OM51

1 Mast
2 Fork and platform
3 Load tire
4 Drive unit and tire
5 Steering wheel
6 Overhead guard
7 Guide roller

2. SPECIFICATIONS

1) 10/13BOP-7



10BOP7SP01

Model			Unit	10BOP-7	13BOP-7
Capacity			kg	1000	1360
Load center			mm	600	←
Weight			kg	2691	2831
Fork	Max lifting height	H3	mm	3275	←
	Min lifting height	H5	mm	65	←
	Max spread width	W3	mm	650	←
	Dimensions (T × W × L)		mm	40 × 100 × 1200	←
Platform	Max lifting height	H4	mm	3410	3440
Mast	Max height	H2	mm	5470	←
	Closed mast height	H1	mm	2220	←
Picking height			mm	5010	←
Overall width of chassis		W1/W2	mm	1020/1050	←
Overall length (without load)		L1	mm	3080	3130
Travel speed (Load/unload)			mm	9.5/10	←
Lifting speed (Load/unload)			mm/sec	0.25/0.35	0.24/0.35
Lowering speed (Load/unload)			mm/sec	0.38/0.38	←
Length to fork face		L2	mm	1880	1930
Wheel base		B	mm	1430	1480
Min turning radius		R	mm	1769	1818

3. SPECIFICATION FOR MAJOR COMPONENTS

1) CONTROLLER

Item	Unit	Traction motor	Pump motor	Eps motor
Nominal battery voltage	V	48	←	←
Maximum output current	A	180/2	350/3	45/2
Output frequency range	Hz	0~200	←	←
Dimensions (L×W×H)	mm	200×150×105	200×150×120	144×180×64.8
Weight	kg	2	2.5	0.72

2) MOTOR

Item	Unit	Traction	Pump	EPS	Steering
Power	W	10600	5200	400	9.6
Voltage	V	30	32	31	12
Current	A	296	138	16	0.4
Weight	kg	36.5	41.9	12	0.47

3) HYDRAULIC PUMP

Item	Unit	Specification
Type	-	Fixed displacement gear pump
Displacement	cc/rev	19.6
Rated pressure	bar	210
Speed (max/min)	rpm	3000/500

4) MANIFOLD ASSY

Item	Unit	Specification	
		Standard	Option
Rated flow	lpm	57	←
Maximum pressure	bar	240	←
Main relief valve pressure	bar	150	←
Voltage	V	48	36
Nominal ampere	mA	470±50	620±50

5) DRIVE UNIT

Item	Unit	Specification
Gear ratio	-	14.5
Oil Quantity	ℓ	2.2

6) WHEELS

Item	Unit	Specification		
		Drive tire	Load tire	Guide roller
Material	-	Urethan	←	←
Dimension	Outside diameter	305	127	100
	Width	140	100	50

7) BRAKES

Item	Unit	Specification
Type	-	Electromagnetic brake

8) BATTERY

Model	Voltage	Capacity	Dimensions						Weight
			Length (L)		Width (W)		Height (H)		
	V	Ah	mm	in	mm	in	mm	in	kg
10BOP-7	48	300	972	38.3	365	14.4	790	31.1	600±30
	48	400	972	38.3	365	14.4	790	31.1	725±35
13BOP-7	48	400	972	38.3	415	16.3	790	31.1	730±35
	48	500	972	38.3	415	16.3	790	31.1	830±40

4. TIGHTENING TORQUE FOR MAJOR COMPONENTS

1) 10/13BOP-7

NO	Items		Size	kgf · m	lbf · ft
1	Electric system	Hyd pump motor mounting bolt	M10×1.5	6.5	47
2		Traction motor mounting bolt	M 8×1.25	4.1±0.4	29.7±2.9
3	Hydraulic system	Hydraulic pump mounting bolt	M10×1.5	6.5	47
4		MCV mounting bolt, nut	M10×1.5	6.9±1.4	50±10
5		Hydraulic oil tank mounting bolt	M10×1.5	6.5	47
6	Power train system	Drive unit mounting bolt	M12×1.75	14.7±1.5	106±10
7		Drive wheel mounting nut	M14×1.5	14.5±1.0	105±7
8	Others	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)	Ambient temperature ℃(°F)
			-35 (-31) / -20 (-4) / -10 (14) / 0 (32) / 10 (50) / 20 (68) / 30 (86) / 40 (104)
Drive unit	Gear oil	2.2 (0.58)	SAE 80W/90
Hydraulic oil tank	Hydraulic oil	27 (7.1)	ISO VG 22 / ISO VG 46 / ISO VG 68
Fitting (Grease nipple)	Grease	0.1 (0.03)	NLGI No.1 / NLGI No.2

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.

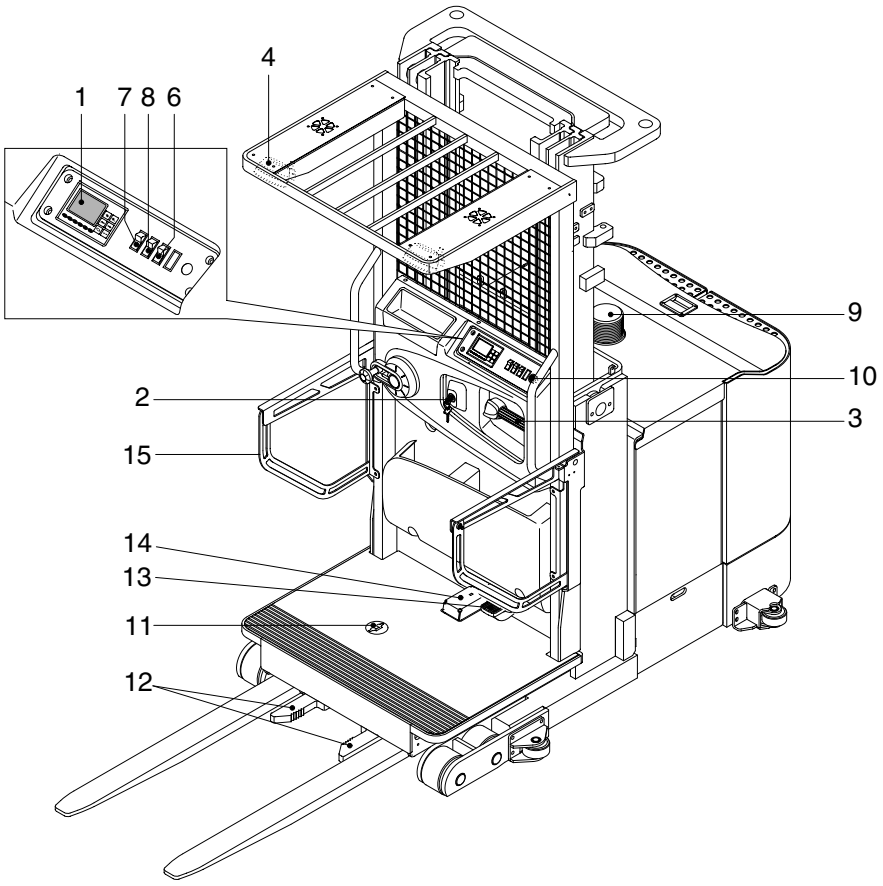
※ **Replacement of consumable service parts is not covered under warranty.**

No.	Description	Period of replacement
1	Hydraulic oil	Every 1 year
2	Gear oil	Every 1 year
3	Power steering hose	Every 1 year
4	Rubber parts of the power steering inside	Every 2 year
5	Cups and dust seals etc. of cylinder	Every 2 year
6	Lift chain	Every 2 year
7	Hydraulic equipment hose	Every 2 year

SECTION 2 REMOVAL AND INSTALLATION OF UNIT

SECTION 2 REMOVAL & INSTALLATION OF UNIT

GROUP 1 MAJOR COMPONENTS



10BOP7OM61

1	Display	9	Beacon lamp
2	Start switch	10	Emergency switch
3	Multifunction lever	11	Dead man switch
4	Head lamp	12	Pallet clamp
6	Fan switch	13	Pallet clamp pedal
7	Work lamp switch	14	Pallet clamp release pedal
8	Beacon switch	15	Safety lever

※ **The multifunction lever, steering wheel, display, lamps and all switches, (key : emergency stop, light etc) are located on the console.**
Familiarize yourself with the controls and follow safe operating procedures.

GROUP 2 REMOVAL AND INSTALLATION OF UNIT

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

1. MAST

1) REMOVAL

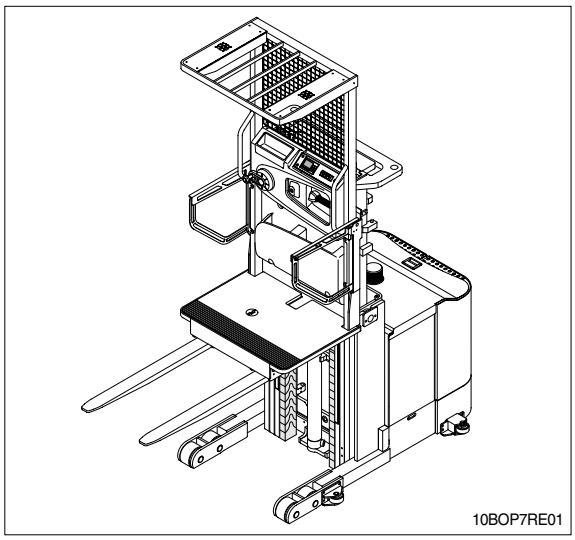
Fork → Mast → Platform & overhead guard → Piping

(1) PREPARATION

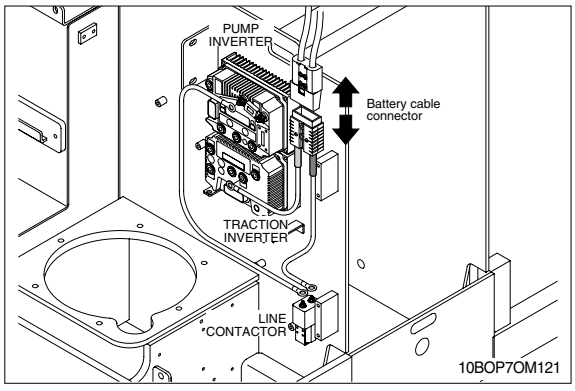
① Lift up the platform from the floor to easy removal of the forks.

② Prop up blocks under the platform in order that it can avoid from unintentional lowering of the platform.

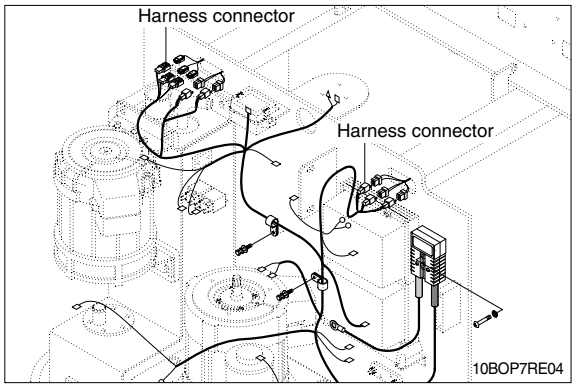
⚠ When propping up the block under the platform, pay careful attention to support it properly so that they can prevent the platform from dropping on the floor.
It can cause to happen unexpected accident such as personal injury or death.



③ Turn the start switch off and then disconnect the battery connector from the order picker truck.



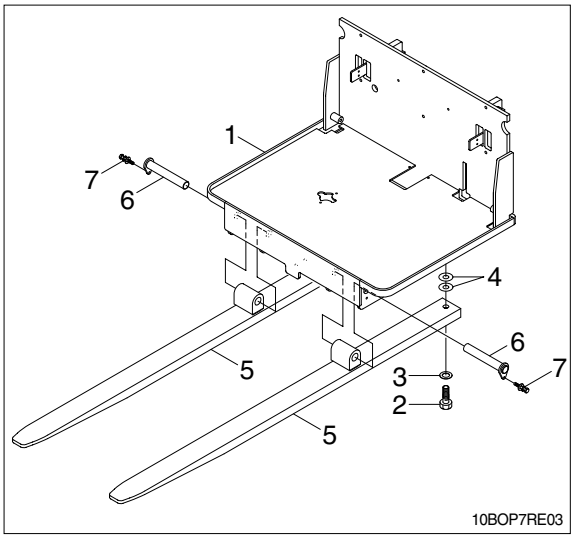
④ Disconnect harnesses.



(2) FORKS

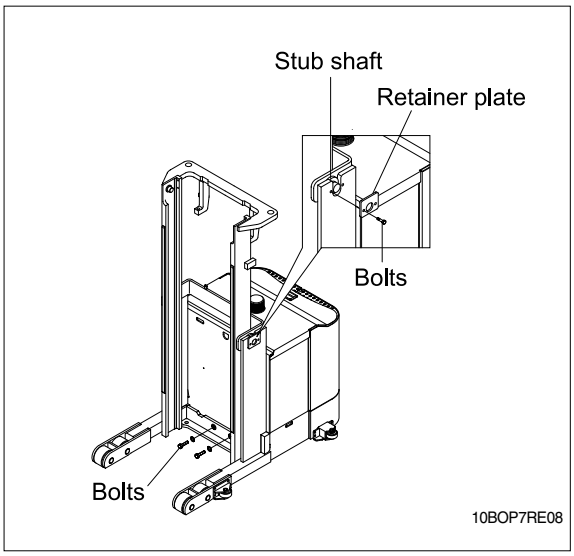
① Loosen and remove bolts(2), washers(3) and shims(4) which are used for fixing the forks(5) under the platform(1).

② Loosen bolts(7), and then remove pins(6) which are used for fixing the forks(8) to the platform(1).



(3) MAST & PLATFORM REMOVAL

① Remove bolts and retainer plates from the left and right sides of truck frame.

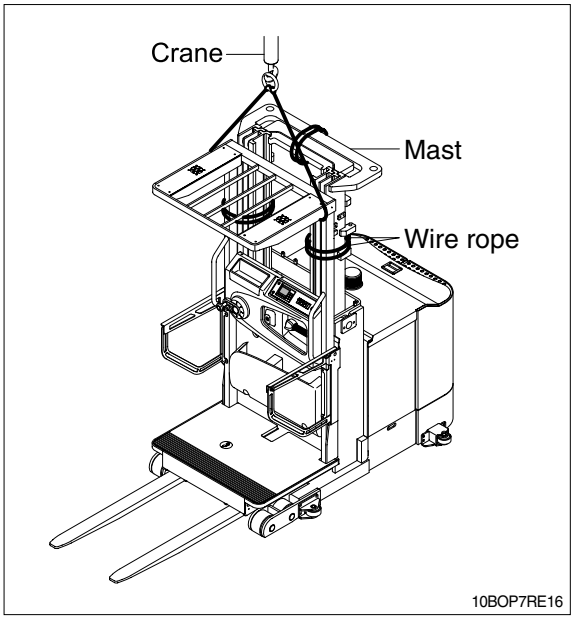


② Raise mast until the stub shafts on the sides of the outer mast rail clear the saddles of the truck frame.

※ Make sure the mast lifts straight up.

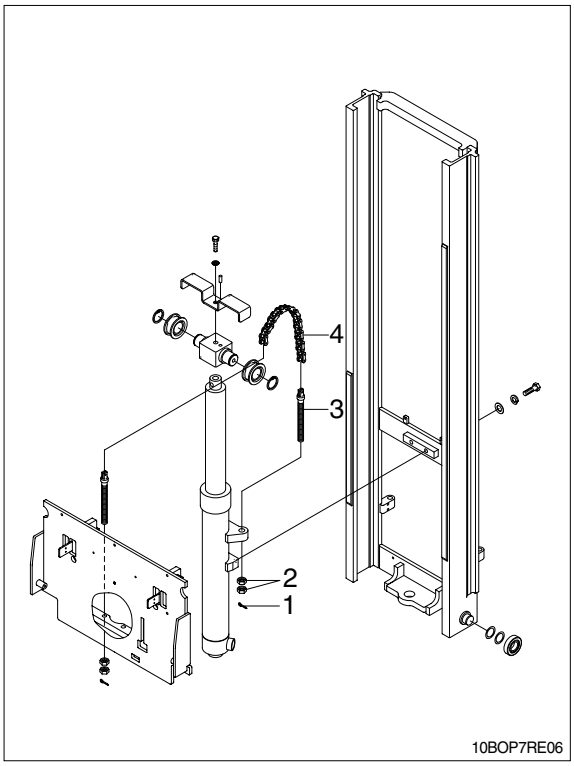
※ **Take care to draw out the platform in order that it can not happen damage due to bump between the platform and the inner mast.**

③ Inspect all parts of the platform for wear or damage.
Replace the defected parts if necessary.

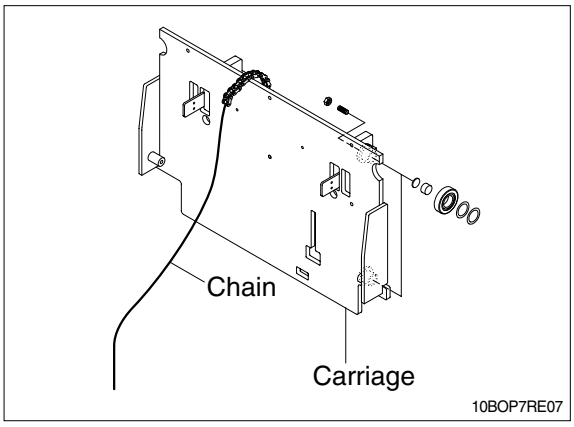


(4) PLATFORM

① While slacking the lift chains(4), loosen and remove split pin(1), nuts(2) from anchor bolt(3) of the chains(4).

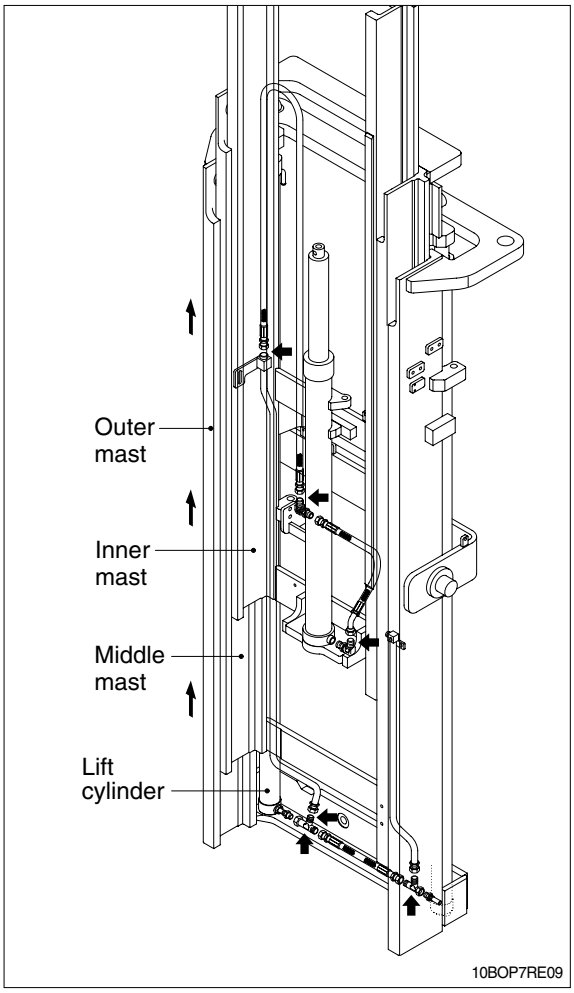


② Pull the chains out of the sheaves and drape them over the front of carriage.



(5) PIPING

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

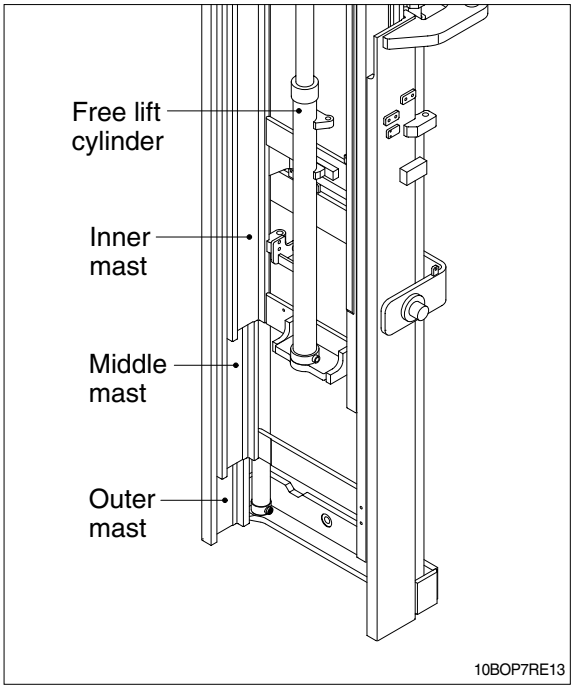


(6) LIFT CYLINDER

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

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

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

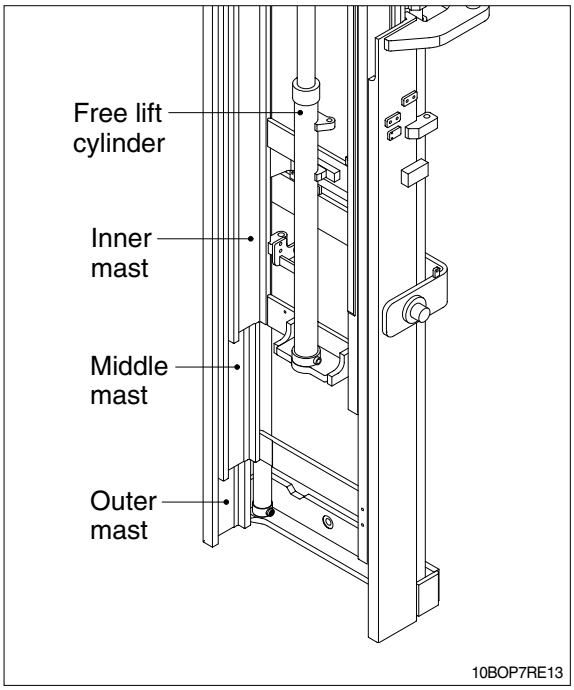


(7) INNER MAST

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.

② Using an universal puller, remove the load rollers.



2) INSTALLATION

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

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

(1) LIFT CYLINDER INSTALLATION AND ADJUSTMENT

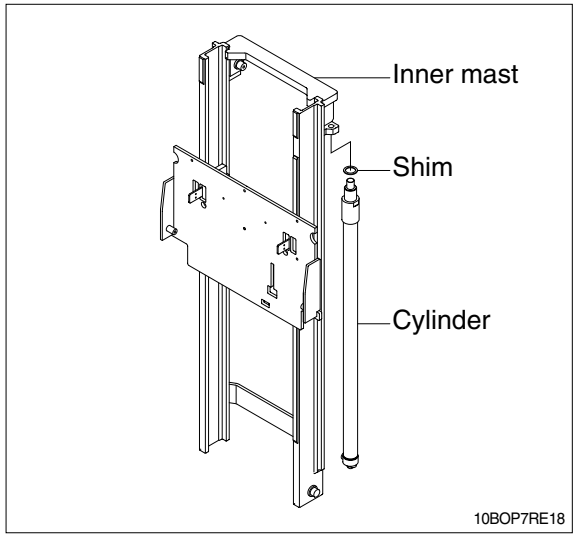
① Assemble the lift cylinder inside the outer mast, then tighten the stopper bolt. If the cylinder assembly has been replaced, adjust as follows so that the left and right cylinders are synchronized at the maximum lifting height.

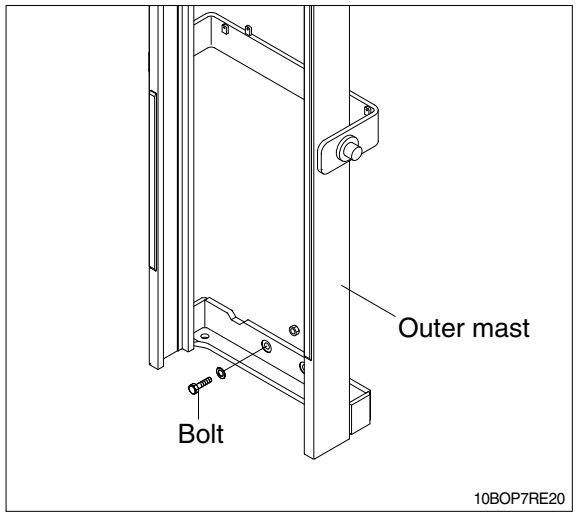
② Assemble the cylinder rod to the inner mast, and check the left-to-right play of the mast at the maximum lifting height.

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

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

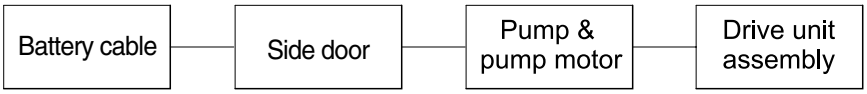
· Shim thickness : 1.0mm(0.04in)





2. POWER TRAIN ASSEMBLY

1) REMOVAL



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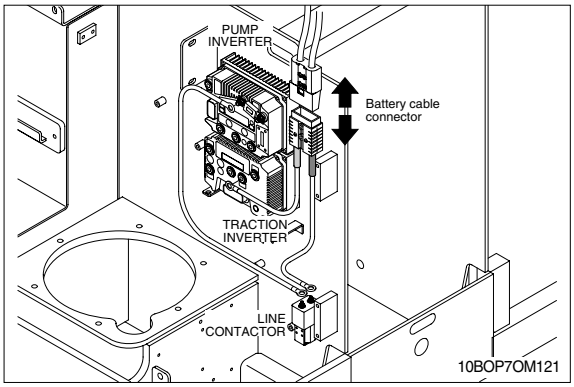
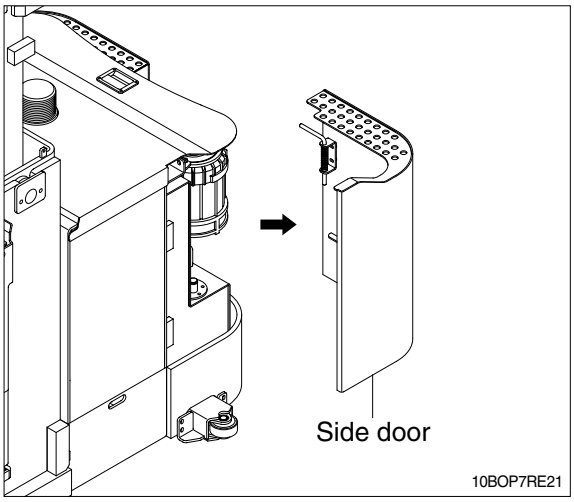
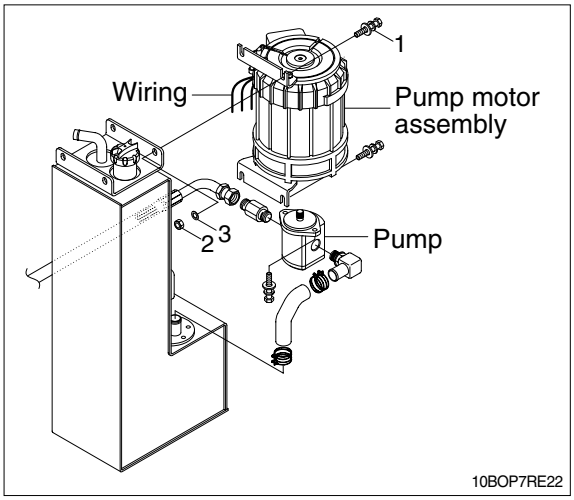
(1) Disconnect the battery cable.



(2) After loosening the bolts of the hinges, remove the side door.

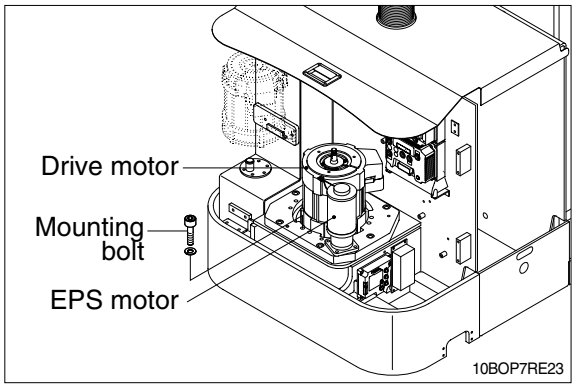


(3) Disconnect the hose, pipe and wiring from pump & motor assembly.
Loosen mounting bolts(1), nuts(2), and washers(3) from frame and then take out the pump & motor assembly.

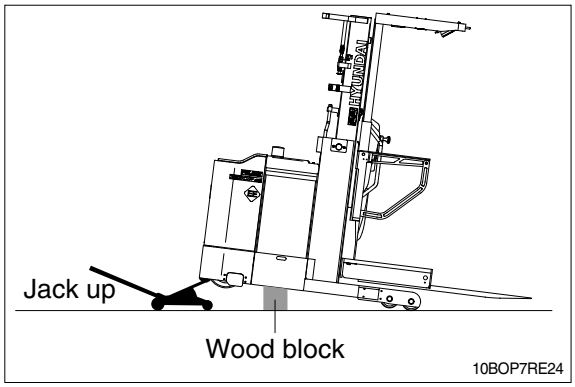


(4) Disconnect the wiring .
① Drive motor wiring
② EPS motor wiring

(5) Loosen mounting bolts for the drive unit assembly.

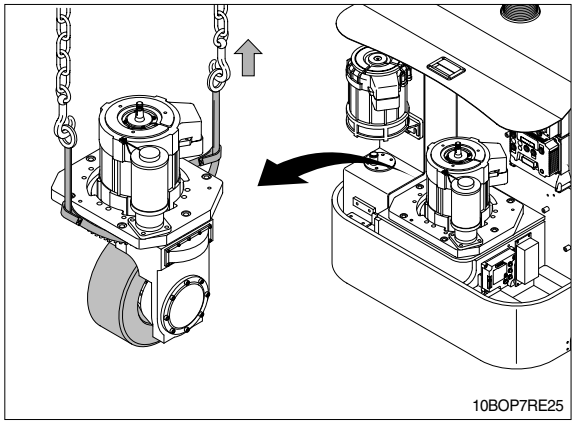


(6) Lift up the frame and support both side of frame with wood block.



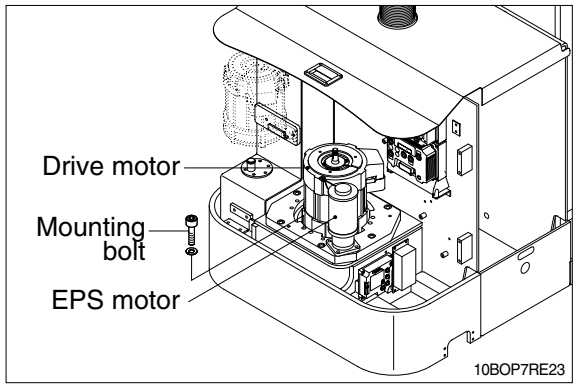
(7) Hang up the drive unit assembly using overhead hoist or overhead crane.

※ **When hanging up the drive unit assembly, it should be maintained weight balance so that it can prevent the drive unit assembly from wobble or swing.**



2) INSTALLATION

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

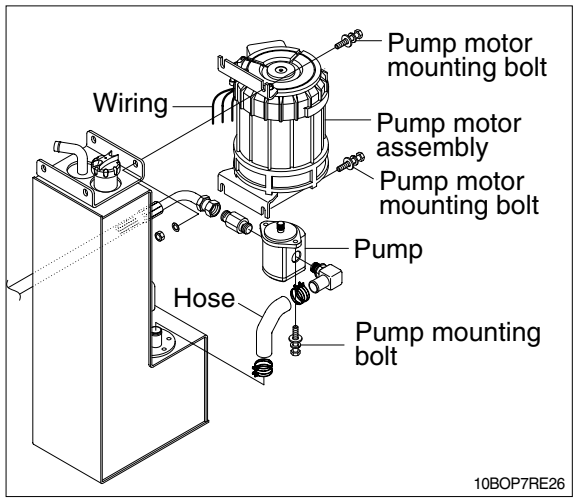


(1) Drive unit mounting bolts : 6EA
- Tightening torque : 13.2~16.2kgf · m (95.5~117.1lbf · ft)

(2) Drive unit bracket mounting bolt : 6EA
- Tightening torque : 13.2~16.2kgf · m (95.5~117.1lbf · ft)

(3) Drive motor mounting bolts : 6EA
- Tightening torque : 3.7~4.5kgf · m (26.8~32.5lbf · ft)

(4) EPS motor mounting bolts : 4EA
- Tightening torque : 7.5~9.1kgf · m (54.2~65.8lbf · ft)



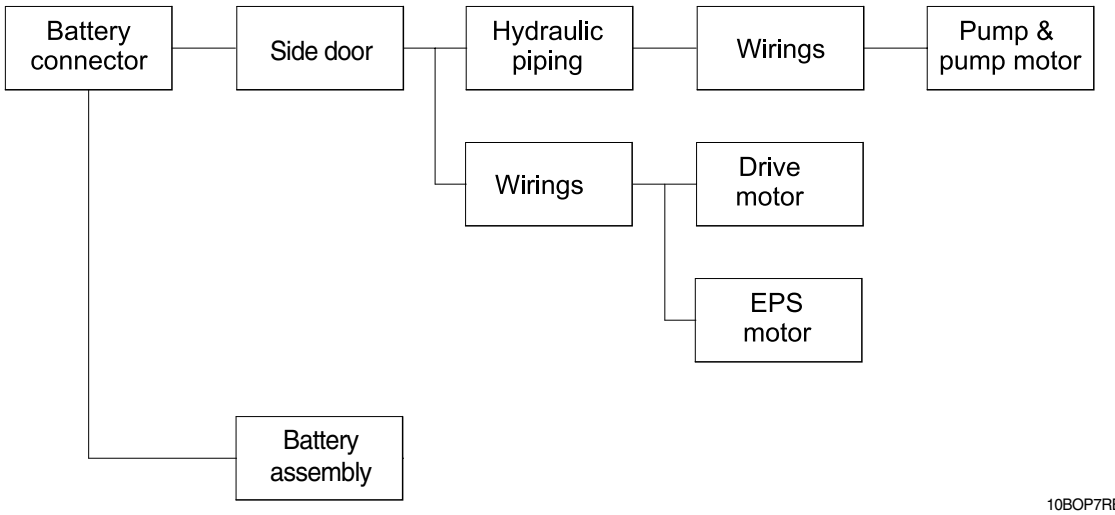
(5) Pump motor mounting bolts : 4EA
- Tightening torque : 6.5kgf · m (47lbf · ft)

(6) Pump mounting bolts : 2EA
- Tightening torque : 5kgf · m (63.2lbf · ft)

3. ELECTRICAL COMPONENTS

Before removing each component, disconnect cables and earth lines attached to the component.

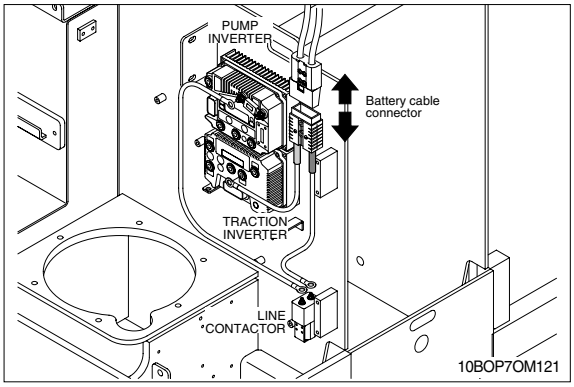
1) REMOVAL



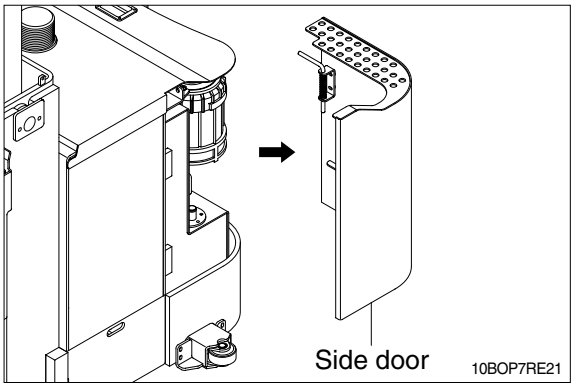
10BOP7RE002

(1) PUMP MOTOR

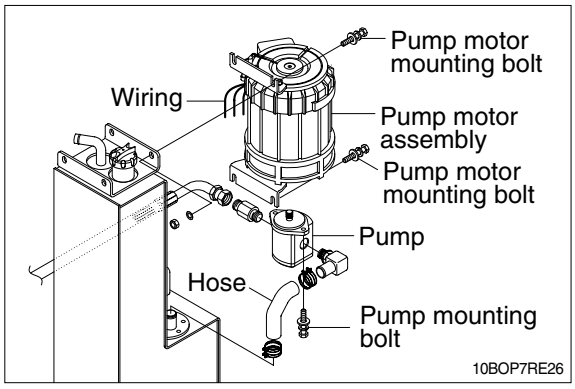
① Disconnect the battery cable.



② After loosening the bolts of the hinges, remove the side door.

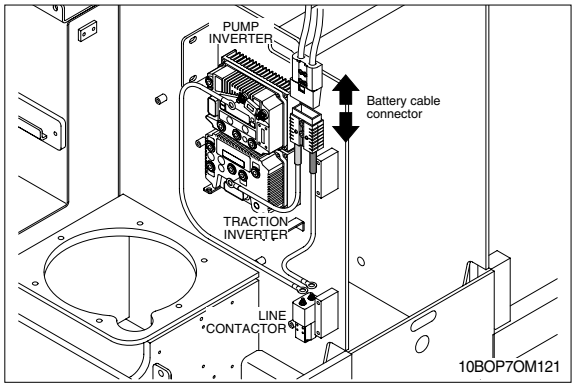


③ Disconnect the hoses, pipes and wiring from pump & motor assembly.
Loosen mounting bolts from frame and then take out the pump & motor assembly.

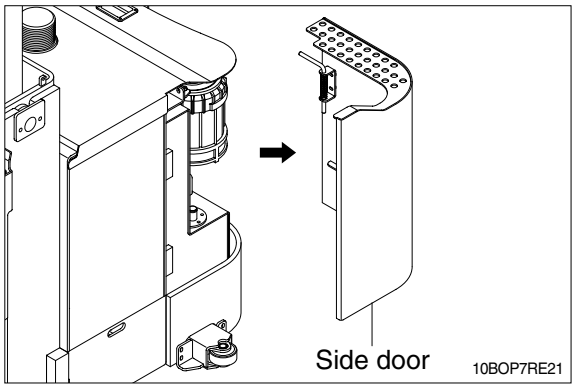


(2) DRIVE MOTOR

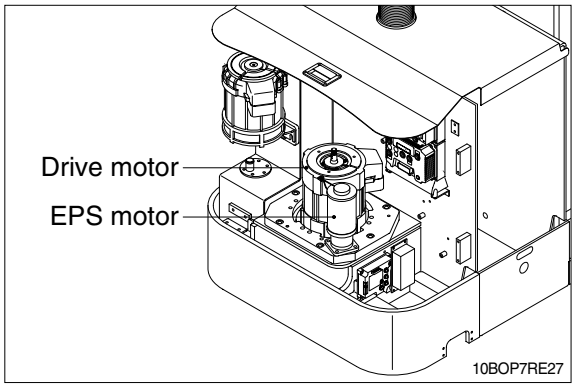
① Disconnect the battery cable.



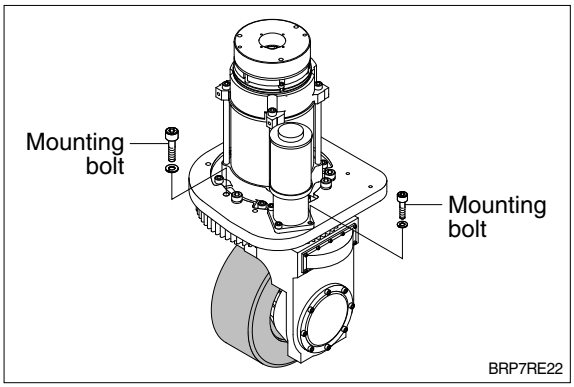
② After loosening the bolts of the hinges, remove the side door.



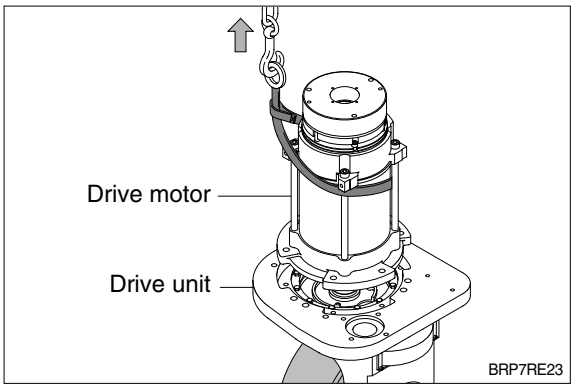
③ Disconnect wirings from the following motors.
a. Drive motor
b. EPS motor



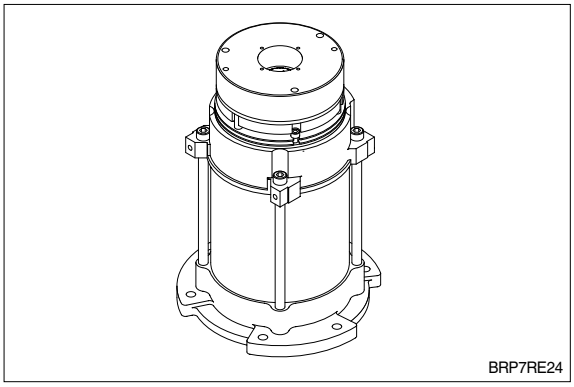
④ Remove bolts to fix the motor and drive unit.



⑤ Tie wire rope around the drive motor and lift up slowly.

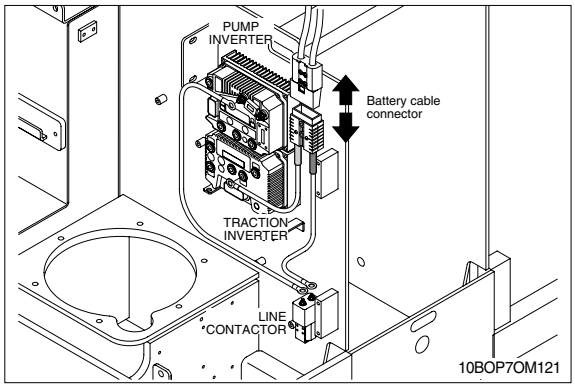


⑥ Put the motor on the clean work bench.

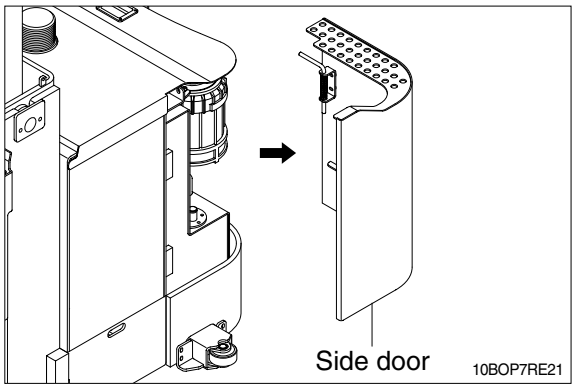


(3) EPS MOTOR

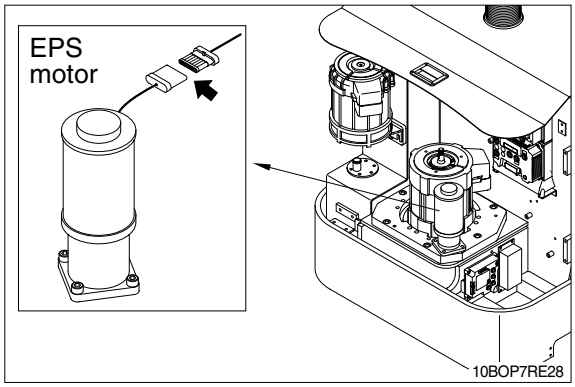
① Disconnect the battery cable.



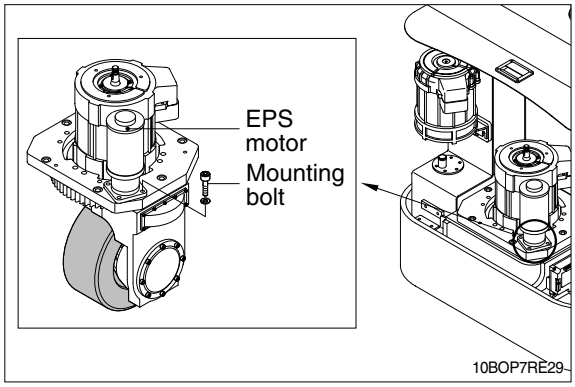
② After loosening the bolts of the hinges, remove the side door.



③ Disconnect wirings.



④ Loosen bolts and remove EPS motor assembly.



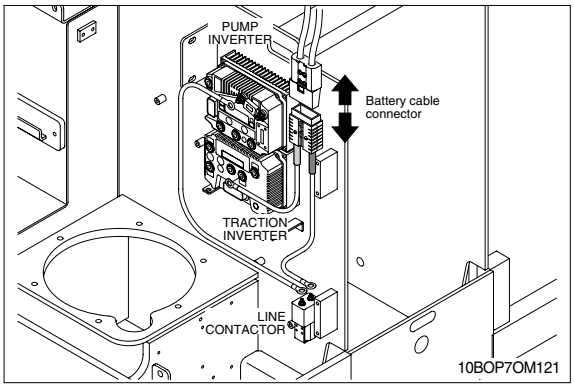
(4) BATTERY REMOVAL

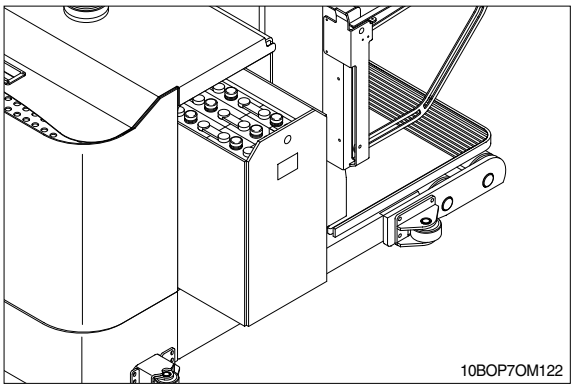
① Turn off the key.

② Release the lock screw of side support in frame.

③ Disconnect the battery connector.

④ Pull out the battery and using a battery hanger, carefully raise the battery assembly.





2) INSTALLATION

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

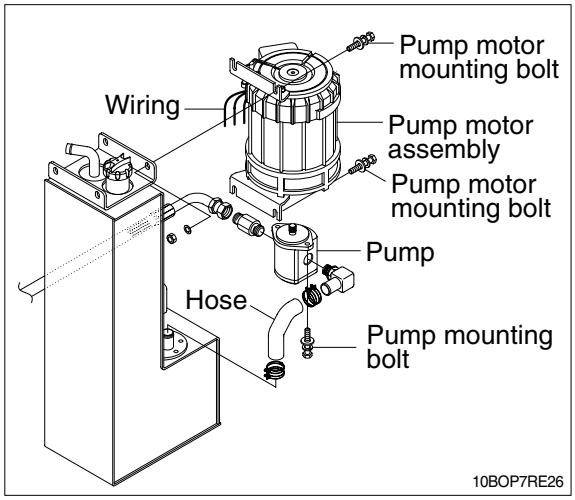
(1) PUMP MOTOR

① Pump motor mounting bolts : 4EA

· Tightening torque : 6.5kgf · m
(47lbf · ft)

② Hydraulic pump mounting bolts : 2EA

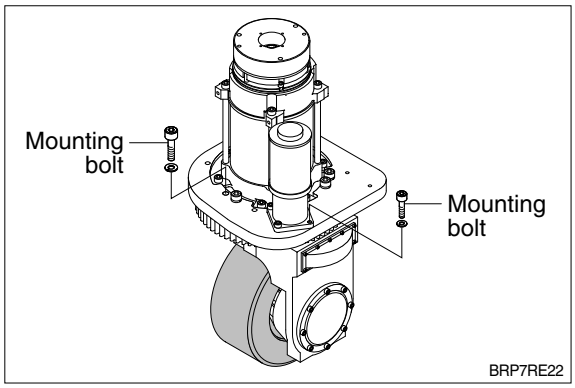
· Tightening torque : 5kgf · m
(36.2lbf · ft)



(2) DRIVE MOTOR

① Mounting bolts between drive motor and drive unit.

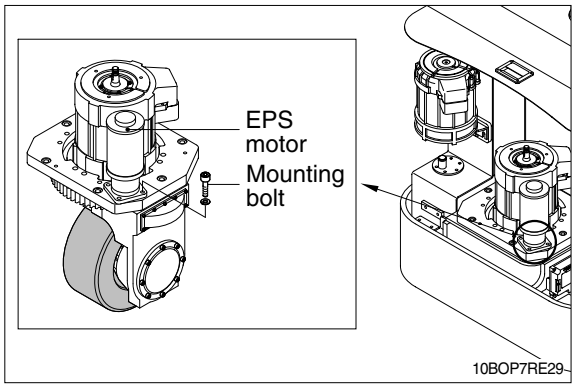
· Tightening torque : 3.7~4.5kgf · m
(26.8~32.5lbf · ft)



(3) EPS MOTOR

① EPS motor mounting bolts.

· Tightening torque : 7.5~9.1kgf · m
(54.2~65.8lbf · ft)

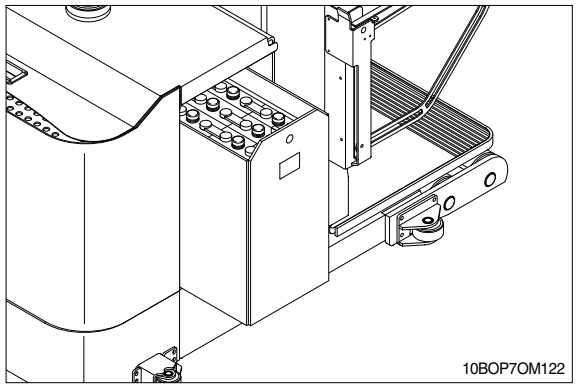


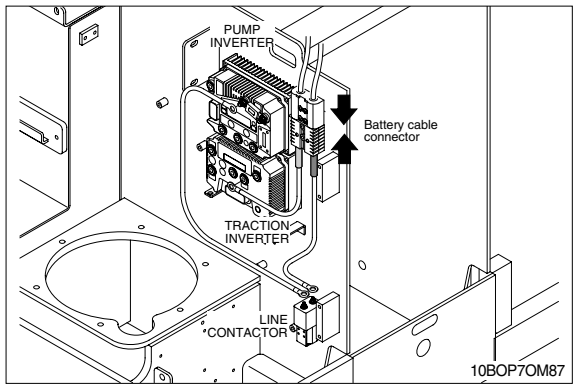
(4) BATTERY INSTALLATION

① Using a battery hanger, carefully push in the battery assembly in the battery assembly compartment.

② Adjust the lock screw of side support in frame.

③ Connect the battery connector.





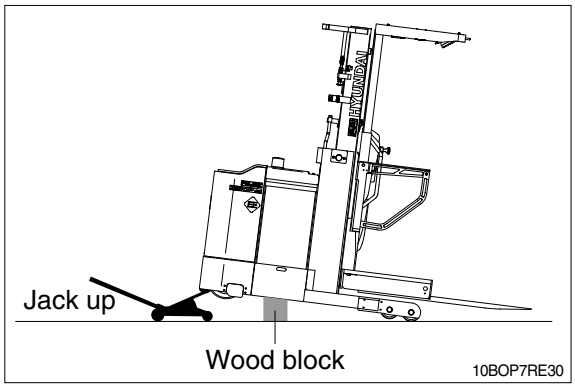
4. TIRE & WHEEL ASSEMBLY

1) REMOVAL

(1) DRIVE TIRE & WHEEL ASSEMBLY

① Lift up lower side of the frame and put on the wooden blocks under the both side of the frame.

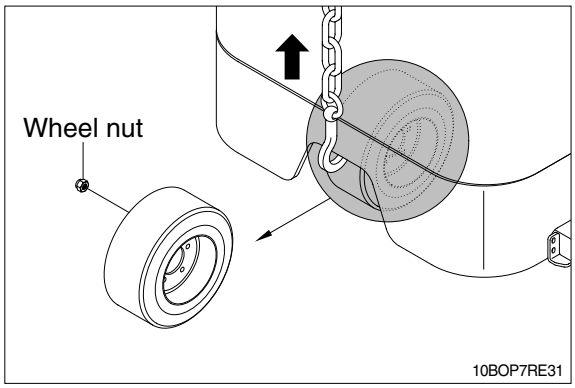
※ **Lift up until the tire clear off the ground.**



② Remove wheel nuts attaching the drive wheel and take off the drive wheel assembly.

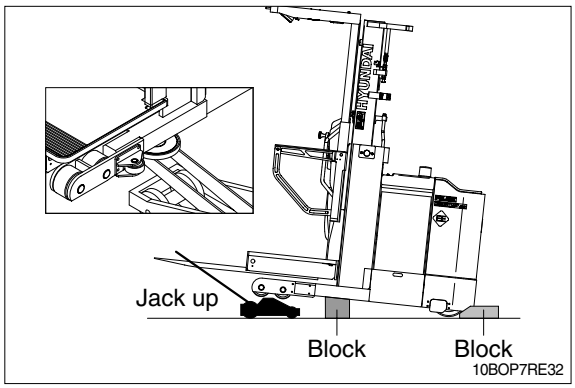
· Wheel nuts : 5EA

※ **The condition of the tire affects the stability and performance of the machine.**
It should be checked that the tire is happened defects or damage.
When replacing the tire which has defects or homage, it should be replaced with genuine part.

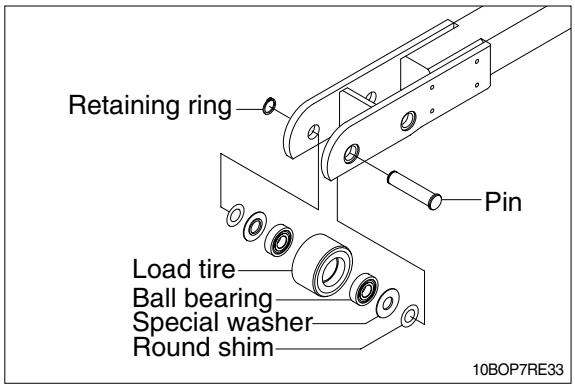


(2) LOAD WHEEL ASSEMBLY

① Lift up leg weld assy and fix the machine with blocks.



② Disassemble load tire assy
- After removing retaining ring, pin, washers and shims, take out load tire assy.
- Remove ball bearings from load tire assy if necessary and replace with new bearings.

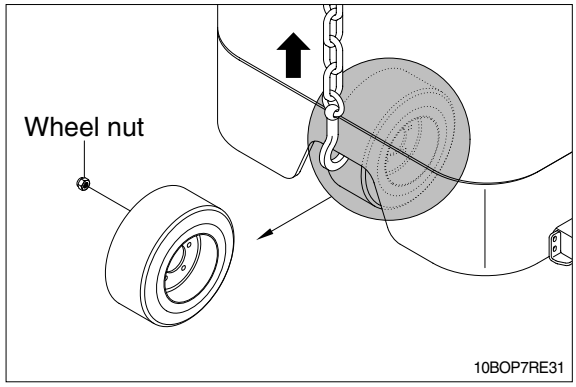


2) INSTALLATION

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

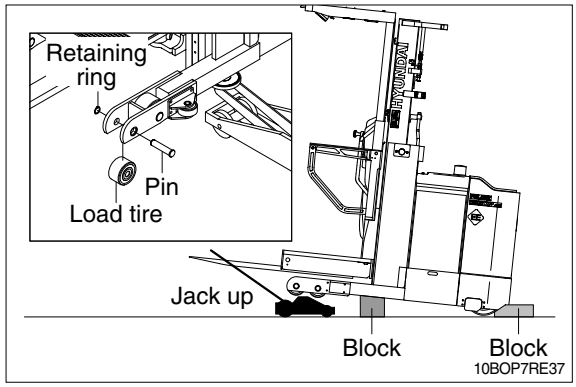
(1) Drive wheel nuts

· Tightening torque : 13.5~15.5kgf · m
(98~112lbf · ft)



(2) When assembling bearings in the leg assembly, it should be cleaned on the pin and in the bore of the load tire assy in order to prevent it from scratch or damage.

(3) When inserting shims between wheel box assy and special washer, it should be kept clearance within 0.5 mm.



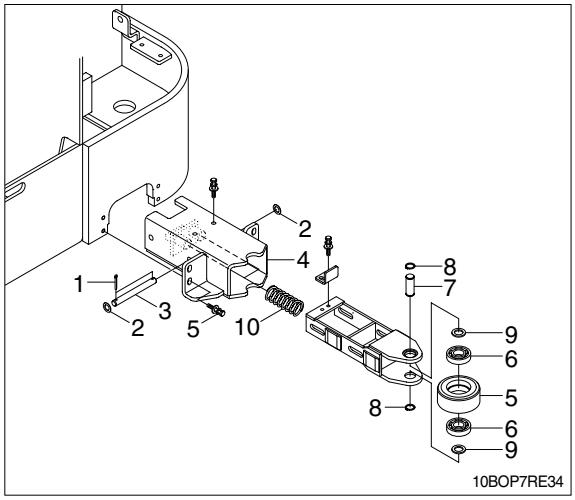
3) FRONT GUIDE ROLLER

(1) Lift up and prop up with wooden block under guide roller bracket.

(2) Remove split pin(1), washers(2) and clevis pin(3) from front bracket assy(4).

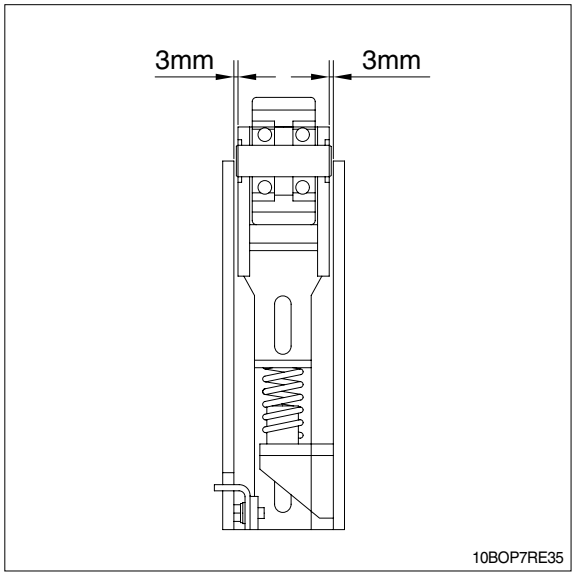
(3) Take out front roller assy which are assembled with guide wheel(5), ball bearings(6) shaft (7), washers(9) and retaining rings(8) pior to disassembling, and then remove the spring (10) from the bracket assy (4).

(4) To disassemble the front roller assy, remove the retaining rings (8), shafts (7), washers (9), and guide wheels (5) including ball bearings (6).



※ **After checking condition of the guide wheels and the ball bearings, replace it if necessary.**

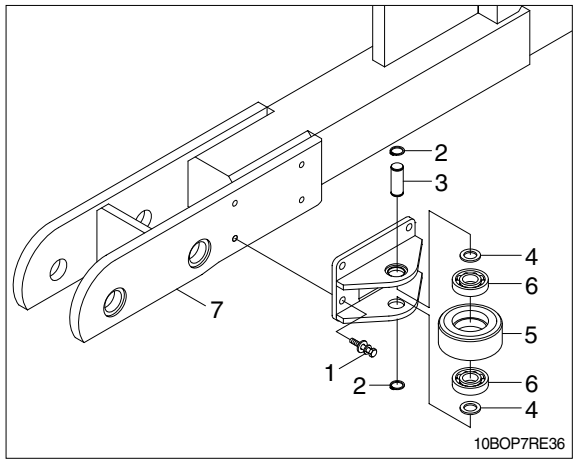
※ **It should be maintained within 3㎜ gap between front roller weld assy and front bracket assy.**



4) REAR GUIDE ROLLER

(1) Loosen and remove bolts(1) from leg assy(7) of the frame.
After taking out rear guide roller assy, remove retaining rings(2) shafts(3), washers(4) and guide rollers(5) including ball bearing(6).

※ **After checking condition of the guide wheels and ball bearings, replace it if necessary.**



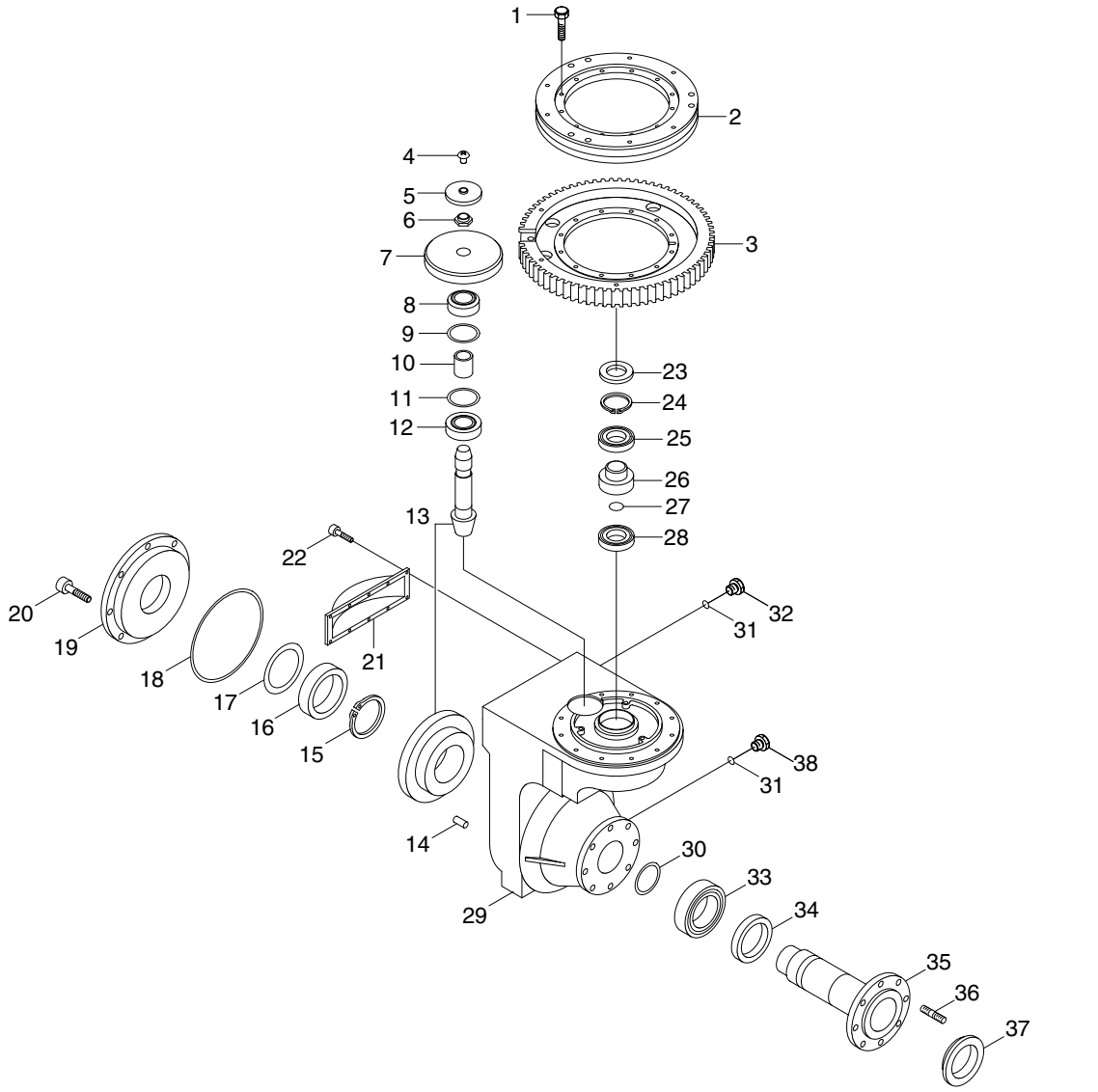
SECTION 3 POWER TRAIN SYSTEM

GROUP 1 STRUCTURE AND OPERATION

1. DRIVE UNIT

1) STRUCTURE

(1) 10/13BOP-7



1	Hexagon screw	14	Slotted pin	27	Protection cap
2	Turntable bearing	15	Retaining ring	28	Bearing ball
3	Steering gear	16	Taper roller bearing	29	Housing
4	Breather valve	17	Shim	30	Shim
5	Protection cap	18	O-ring	31	Seal ring
6	Hexagon nut	19	Bearing cover	32	Plug
7	Spur gear	20	Cap screw	33	Taper roller bearing
8	Taper roller bearing	21	Cover	34	Taper roller bearing
9	Shim	22	Hex screw	35	Wheel shaft
10	Spacer	23	Shaft sealing ring	36	Wheel bolt
11	Shim	24	Retaining ring	37	Wheel shaft protection
12	Taper roller bearing	25	Bearing ball	38	Plug
13	Bevel gear set	26	Input pinion		

2. SPECIFICATION

Item		Unit	Specification
Gear ratio	Total	-	14.5
Oil Quantity		ℓ	2.2

GROUP 2 TROUBLESHOOTING

Problem	Cause	Remedy
1. Noise		
1) Loud, beating noise	· Gearing of helical gear stage damaged, indentations.	- Check tooth flanks of the drive pinion and the helical gear for damage. In case of damage always replace both components.
	· Fault on grooved ball bearing input.	- Remove and replace drive pinion bearing.
	· Contaminations.	- Remove and replace drive pinion bearing.
2) Loud, steady noise	· Motor/transmission connection not ok.	- Check motor installation.
	· Motor bearing defective.	- Check motor bearing.
3) Dull, grinding noise	· Wrong bearing preload or incorrect backlash.	- Check bearing preload and backlash and readjust it, if necessary.
2. Leakage		
1) Breather	· Excessive oil level.	- Check oil level.
2) Housing cover	· Screws not tightened with the specified tightening torque.	- Tighten screws with the specified tightening torque.
	· O-Ring sealing defective.	- Replace O-Ring.
3) Oil filler or oil drain plug	· Screws not tightened with the specified tightening torque.	- Tighten screws with the specified tightening torque.
	· Dirt between sealing ring and housing.	- Clean.
	· Sealing ring worn.	- Install new sealing ring.
4) Input shaft / wheel shaft	· Radial sealing ring damaged or worn.	- Install new radial sealing ring.
	· Damaged race on input- and/or wheel shaft.	- Replace input shaft and wheel shaft respectively.
5) Side cover	· Screws not tightened according to sequence of tightening and the tightening torque.	- Tighten screws according to correct sequence of tightening and with the tightening torque specified.
	· No uniform adhesive application of LOCTITE 5910.	- Apply LOCTITE 5910 evenly and continuously.
	· Joining time not observed.	- Observe LOCTITE specification and replace the sealing.
6) Sealing disc on drive pinion	· No uniform adhesive application of LOCTITE 5910.	- Apply LOCTITE 5910 evenly and continuously.
	· Joining time not observed.	- Observe LOCTITE specification and replace the sealing.
3. Other fault possibilities		
1) Only sluggish rotation of the pivoted bogie bearing is possible or bearing clearance is sensible	· Cover disc has loosened and dirt got into the bearing.	- Replace pivoted bogie bearing.
	· Cage segments are damaged.	- Replace pivoted bogie bearing.
	· Plastic deformation of the balls or the ball race.	- Replace pivoted bogie bearing.

Fault	Probable cause	Remedy
Oil leakage on oil filler or oil drain plug	· Dirt between sealing ring and housing. · Old sealing ring was used. · Bolts not tightened according to the specified tightening torque.	· Cleaning required. · Use new sealing ring · Tighten bolts with the specified tightening torque.
Oil leakage between housing and top section	· Seal faces not sealed or uneven. · Burrs on cylinder pin. · Bolts not tightened according to the specified tightening torque.	· Apply LOCTITE 574 onto seal faces. · Touch up seal faces with oil rubber. · Use a new cylinder pin. · Tighten bolts with the specified tightening torque.
Oil leakage on top section within helical gear stage / input	· Too much oil in transmission. · O-ring on cover defective. · Breather valve defective.	· Check oil level. · Install new O-ring. · Replace breather valve.
Beating noise at helical gear stage	· Teeth on input pinion and/or helical gear damaged by false installation.	· Check tooth flanks for damage and touch up damaged spots with oil rubber.
Ringing noise	· Helical gear stage running without oil.	· Check oil level. Refill oil.
Grinding noise	· Bearing preload or backlash not correctly adjusted.	· Checking and new adjustment.
Bearing damage on input pinion	· No axial play.	· Install new bearing and adjust axial play.
Pivoting bearing is difficult to rotate or backlash recognizable	· Cover disc loosened and dirt entered into the bearing. · Cage segments are damaged. · Plastic deformation of balls or ball race. · Bearing not relubricated. · Grease not distributed.	· Replace pivoting bearing. · Replace pivoting bearing. · Replace pivoting bearing. · Relubricate pivoting bearing. · Rotate pivoting bearing several times by hand.

GROUP 3 DISASSEMBLY AND ASSEMBLY

1. INSTRUCTION

1) Pay attention to cleanliness and expert like manner for all work to be carried out. Transmission removed from the vehicle has therefore to be cleaned prior to opening. Both utmost care and cleanliness are essential conditions for a correct disassembly and reassembly of the transmission as well as for the installation of each spare part. A fault during installation can result in an early wear and chips or other foreign particles in the transmission can cause fatal damages.

2) Prior to assembly all parts must be cleaned and inspected for wear and other defects.

3) If it is found that removed parts are damaged or worn, do not reinstall but replace them by new ones.

4) If not separately indicated, the housing and cover faces forming an oil tight connection are to be provided with the corresponding sealing compound during assembly.

5) Special devices and special tools are necessary besides the standard tools. Their use is unavoidable for a technically adequate dis- and reassembly. The application of devices, special tools and other fixtures are to be adapted to circumstances of the respective users.

6) Commercial tools and fixtures belonging to the basic equipment are assumed to be available.

7) If not otherwise indicated all pressing operations are made by means of the hand lever press.

8) All screws and threads in this transmission have metric dimensions. Only spanners and socket spanners with metric sizes are allowed to be used.

9) For reassembly all of the indicated setting values, test data and tightening torques must be observed.

10) Observe the described sequence of the working steps.

11) All pictures serve the illustration and are not obliging for this execution.

2. NECESSARY SPECIAL TOOLS FOR DISASSEMBLY AND REASSEMBLY

Reference number	Description	Is necessary for :
225296	Extracting fixture	Removal of drive pinion
62519	Holding fixture	Loosening of taper press fit
62507-1	Counter holder	Determination of shim thickness
62523	Assembly fixture	Installation of drive pinion
62478	Striking mandrel	Roller bearing drive pinion
62507	Locating fixture	Transmission locating jack
62529	Striking mandrel-Insert	Bearing outer ring pinion shaft bottom
62625	Striking mandrel	Roller bearing housing
63428	Press-in/out fixture	Wheel shaft and crown gear
62521	Striking mandrel	Shaft seal drive pinion
62522	Striking mandrel	Breather cover
63290	Press-in sleeve	Grooved ball bearing drive pinion
63293	Striking mandrel without handle	Thread protective shield
63291	Striking mandrel without handle	Shaft seal wheel shaft
62542	Striking mandrel without handle	Bearing outer ring crown gear
63294	Striking mandrel without handle	Bearing inner ring wheel shaft
62748	Striking mandrel	Bearing outer ring cover
63296	Handle	Striking mandrels
62819	Measuring stop	Torsional backlash
62228	Gear lock	Helical gear lock
62222	Pressure oil device	Loosen press fit
223705, 22	Pressure-in sleeve	Bearing inner ring pinion shaft
62747	Striking mandrel	Bearing outer ring pinion shaft top
62846	Striking mandrel	Helical gear on pinion shaft
62825	Measuring fixture	Housing dimension wheel shaft
62827	Measuring fixture	Housing dimension crown shaft
222863.2	Extracting fixture	Pulling-off taper roller bearing outer ring
62532	Measuring fixture	Bearing friction torque wheel shaft

3. SAFETY INSTRUCTIONS

1) The use as directed requires the strict observance with the specification for installation, dis-and reassembly, initial operation and maintenance.

2) Every person concerned with installation, disassembly and reassembly, initial operation and maintenance of the transmission in the user plant must have read and understood the whole instruction and in particular the safety instructions.

3) Any working method which endangers the safety of the transmission is prohibited.

4) Modifications and changes without the proper permission are affecting the safety of the transmission and are not allowed.

5) Only original spare parts from Hyundai are allowed to be used. It is explicitly pointed out to the fact that spare parts and accessories, which were not supplied by Hyundai are not checked and approved by us either. We do not accept any liability or admit any original parts from Hyundai.

6) The described work is only allowed to be made by authorized, skilled and instructed staff.

7) The proper repair of this products requires adequately trained specialists. The repairer is responsible for the training.

8) Keep away aggressive cleaners from your skin, do not drink it or inhale its vapours. Always wear safety gloves and goggles. If by mistake cleaner was swallowed, call medical aid immediately. Strictly observe manufacturer instruction.

9) Do not drain cleaner or transmission oil into the sewerage system or into the soil.

10) Prior to start working on the installed or mounted transmission, the wheels must be blocked.

11) Prior to any work on the installed transmission(e.g. oil change) or its mounted-on parts the voltage source feeding the motor must always be disconnected resp. switched off.

12) The local regulations for safety and prevention of accidents must be observed.

4. COMPLETE DISASSEMBLY

1) GENERAL INSTRUCTIONS DISASSEMBLY

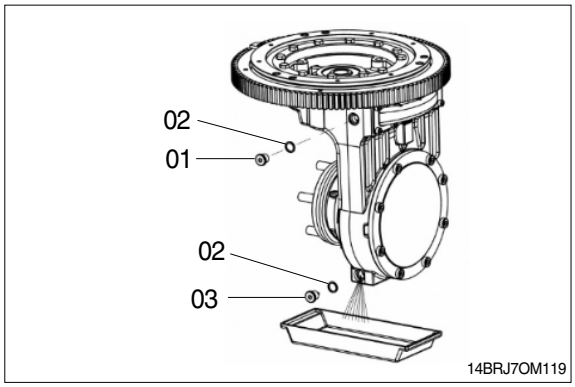
(1) Prior to dismantling the transmission is to be cleaned carefully.
Parts which are only available as assemblies will not be dismantled further.
It is recommendable to install a locating fixture as shown in Figure 44. It serves to rotate the unit and offers easy working for disassembly and reassembly.
(S) Locating fixture 62507

2) DRAIN OFF TRANSMISSION OIL

(1) Place a suitable big oil collecting vessel under the oil drain plug.
(2) Loosen the oil filler plug(item 01) with a 6㎜ allen wrench. Remove the oil filler plug and the sealing ring(item 02).
(3) Loosen the oil drain plug(item 03) with a 6㎜ allen wrench. Remove the oil drain plug and the sealing ring(item 02).
(4) Have the transmission oil drained into the vessel completely.

※ Do not drain transmission oil into the soil or the sewerage system. Pay attention to the type and quantity of debris.

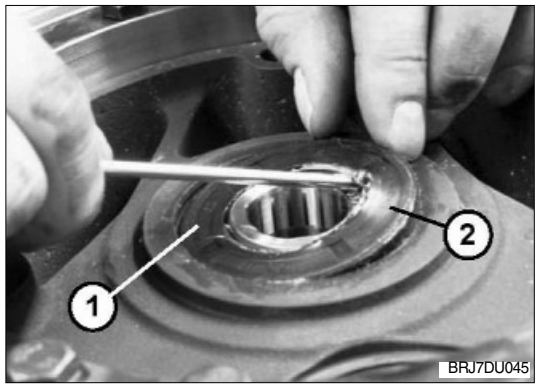
⚠ High oil temperatures are to be expected after continuous operation of the transmission. Wear temperature-resistant gloves.



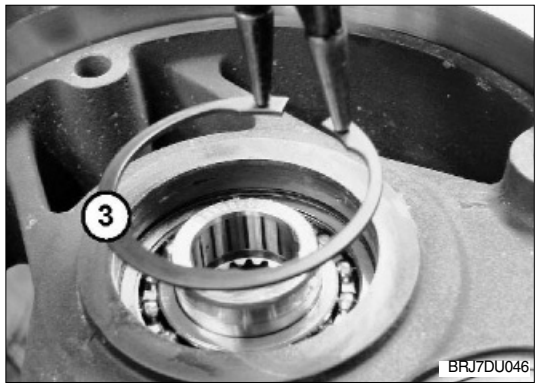
3) REMOVAL OF DRIVE PINION

(1) With a screwdriver press the radial sealing ring (item 2) upwards from the bore seat of the housing and remove it.

Dispose of the radial sealing ring according to chapter 6.

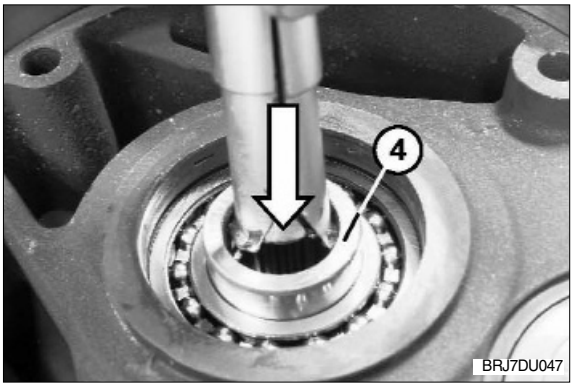


(2) Unsnap and remove the retaining ring (item 3) from the housing bore by means of flat-head pliers.



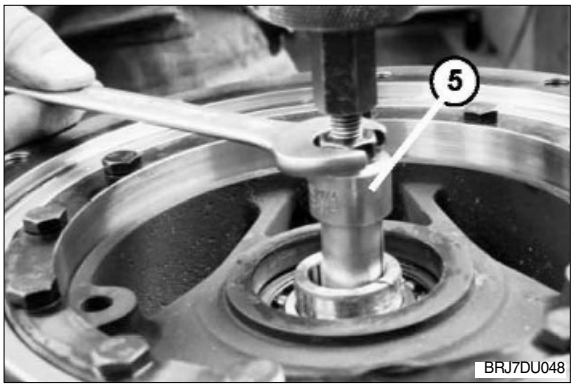
(3) Extracting fixture 225296 is necessary to remove the drive pinion (item 4) from the bore.

Insert the extracting fixture into the bore of the drive pinion.



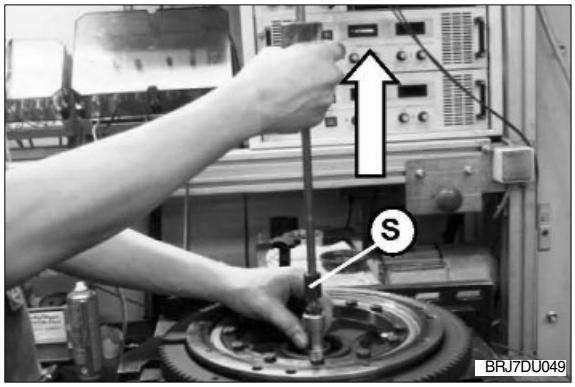
(4) Fasten the hexagon screw of the bearing puller hand-tight so that a sufficient preload of the clamping jaws is given.

By tightening the hexagon screw expand the clamping jaws of the bearing puller (item 5) in the bore of the drive pinion.

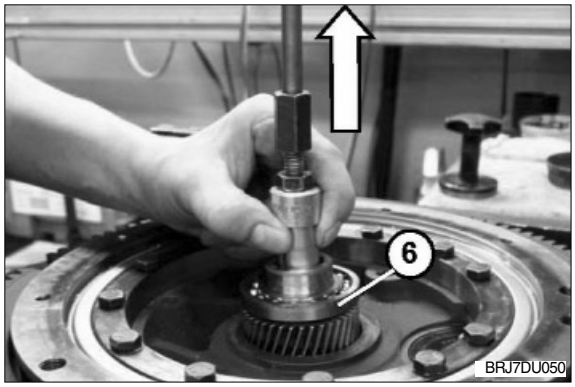


(5) Handle the extracting fixture "S" as shown on the right. Move the handle on the bar upwards strongly several times until the drive pinion is loosened from the bearing seat completely.

⚠ Do not damage the gearing of the drive pinion at the next work step! Damages might cause louder running noises and consequential damages!

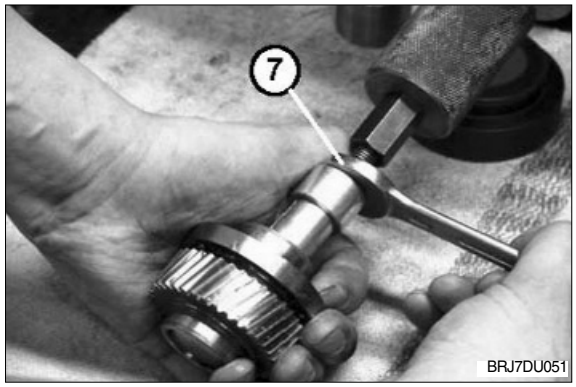


(6) By means of the extracting fixture pull the drive pinion (item 6) out of the housing bore and remove it.

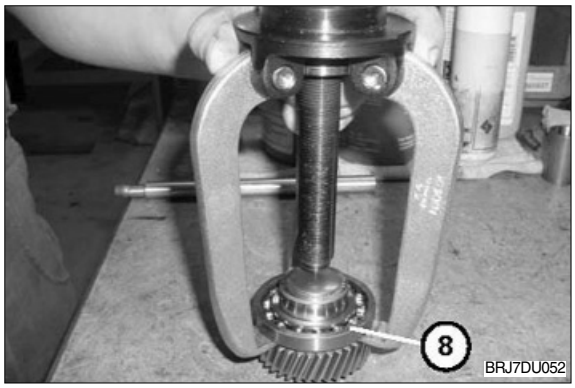


(7) Loosen the hexagon bolt (item 7) and remove the extracting fixture from the drive pinion.

⚠ Do not damage the gearing of the drive pinion! Damages might cause louder running noises and consequential damages!

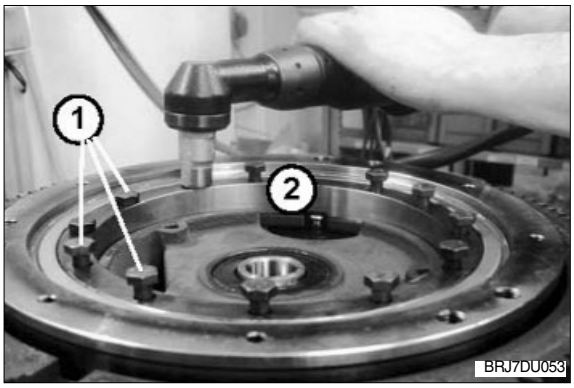


(8) Pull of the grooved ball bearing (item 8) by means of a puller or a parting tool over the bearing seat of the drive pinion and dispose it of according to chapter 6.

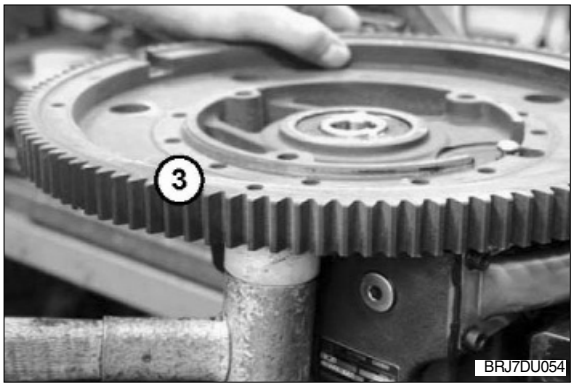


4) REMOVAL OF GEAR RING AND PIVOTED BOGIE BEARING

(1) Loosen the 12 hexagon screws (item 1) on the pivoted bogie bearing (item 2), remove and dispose them of acc. to chapter 6.

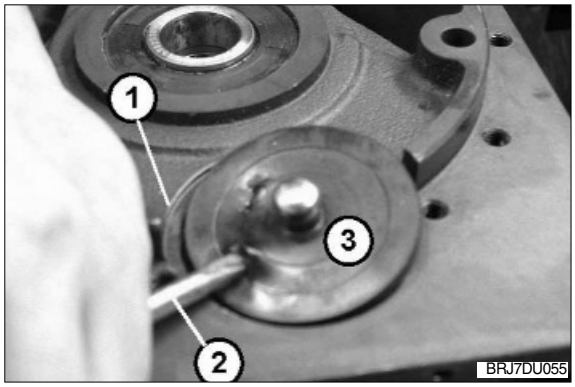


(2) With a dead-blow soft-face hammer slightly beat against the gear ring (item 3) from the bottom to loosen it from the connecting construction. Take off and remove the pivoted bogie bearing and the gear ring.



5) DISASSEMBLY OF TRANSMISSION HOUSING WITH TRANSMISSION COMPONENTS

(1) Removal of sealing cap

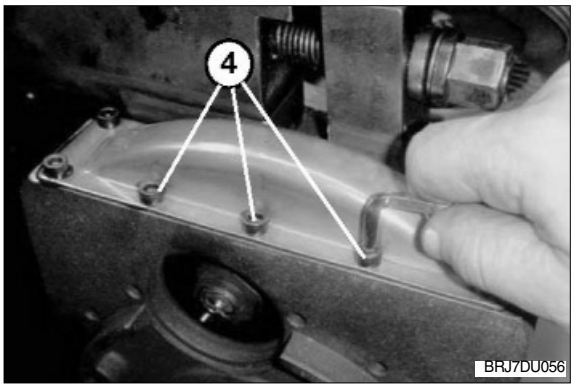


⚠ The surface (item 1) where the sealing cap is located must not be damaged. The sealing cap itself is destroyed and cannot be reused.

① Insert a screwdriver (item 2) into the sealing cap (item 3) beating cautiously and press it off or by using the lever effect upwards and scrap it.

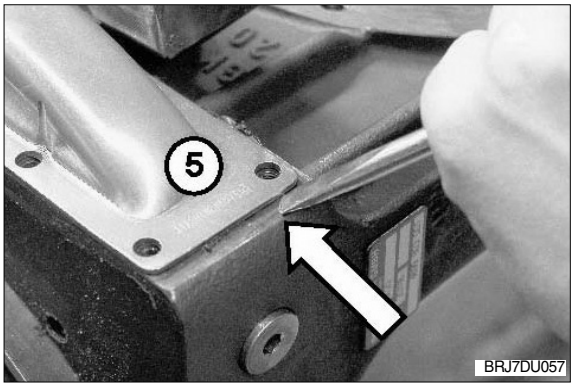
② The breather valve is not to be scrapped.

(2) Removal of side cover



① Loosen and remove the 10 cap screws (item 4) on the side cover.

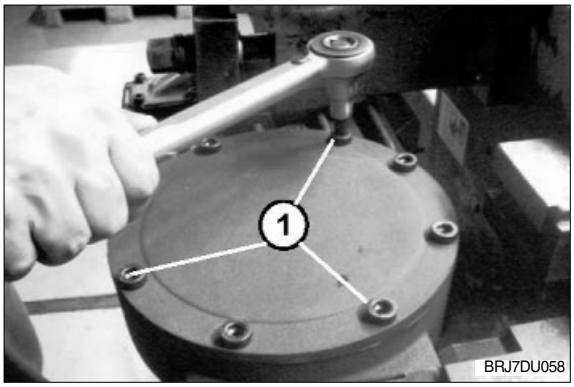
⚠ Do not damage the housing surface at the next working step! Burrs and other damages on the sealing surface which are caused during the removal have to be eliminated. Touch up damaged sealing surface on the housing with an oil stone!



② Separate the side cover (item 5) from the sealing compound with a suitable screwdriver. Place the tool between housing and cover and press it off slightly from the housing.

③ Loosen the side cover from the housing by tapping onto the outer contour and dispose it of acc. to chapter 6.

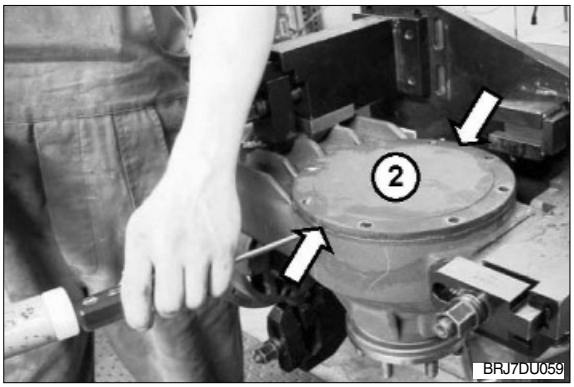
(3) Removal of wheel shaft and crown gear



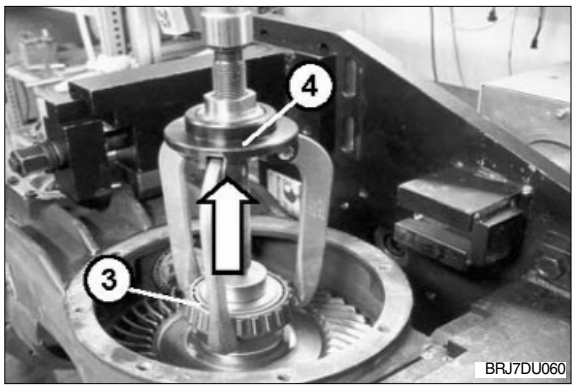
① Loosen and remove the 8 cap screws (item 1) in the housing cover.

⚠ Do not damage the housing and cover surface! Burrs and other damages on the sealing surface which are caused during the removal have to be eliminated. Touch up damaged sealing surface on the housing with an oil stone!

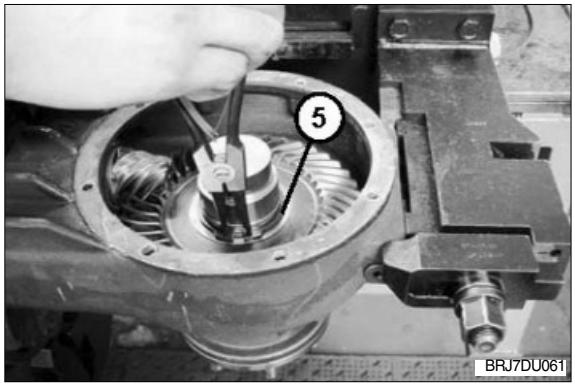
② Loosen the housing cover (item 2) by tapping against the outer edges and remove it. Use the two recesses in the housing.



③ With a three-armed puller (item 4) pull the taper roller bearing inner ring (item 3) over the bearing seat of the wheel shaft and remove it.



④ Unsnap and remove the retaining ring (item 5) by means of flat-head pliers.

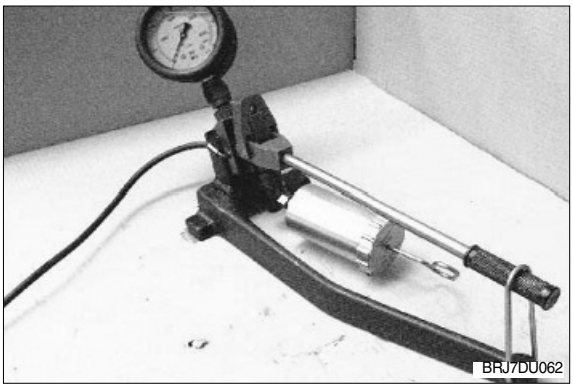


(4) Loosening of taper press fit

※ For work at high oil pressures to loosen the taper press fit there is the danger of eye and skin injuries, if oil would come out under high pressure. Always wear goggles and safety gloves! Observe and follow the instructions of the pressure oil device manufacturer.

① A pressure oil device with a maximum pressure of up to 300 MPa is necessary for widening of the taper press fit. There are two possibilities to press out the shaft wheel from the crown gear which are described in the following:

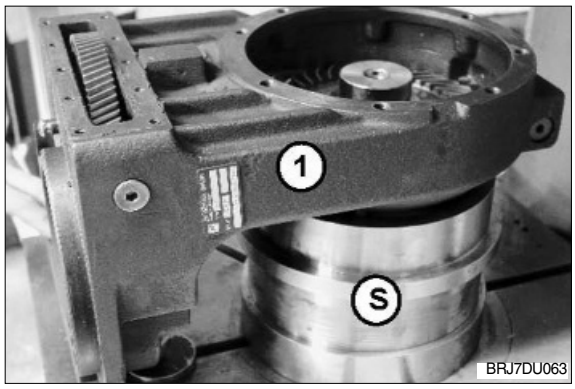
(S) Pressure oil device 62222



② Pressing-off by means of press

Locate the housing (item 1) in the press-out fixture "S" on the press as shown in the picture.

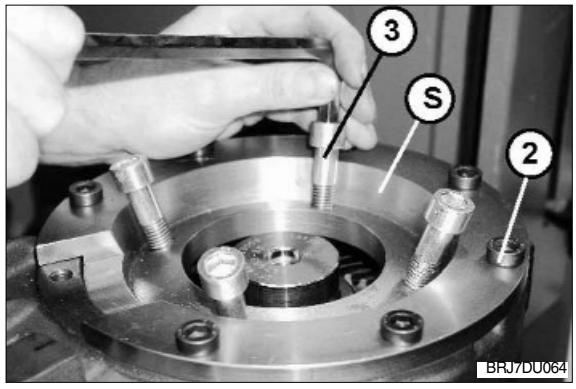
(S) Press-out fixture 63428



③ The holding fixture "S" which is used as stop for the gliding off wheel shaft is to be connected to the cover surface with the appropriate cap screws (item 2).

Fasten the 4 supporting bolts (item 3) hand-tight until contact with the crown gear.

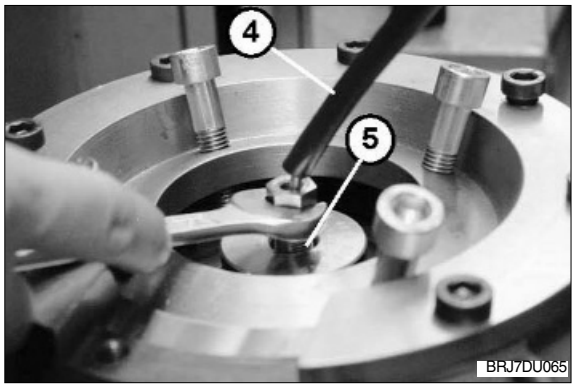
(S) Holding fixture 62519



④ Connect the flexible high-pressure pipe (item 4) from the pressure oil device into the connecting bore provided in the wheel shaft (item 5).

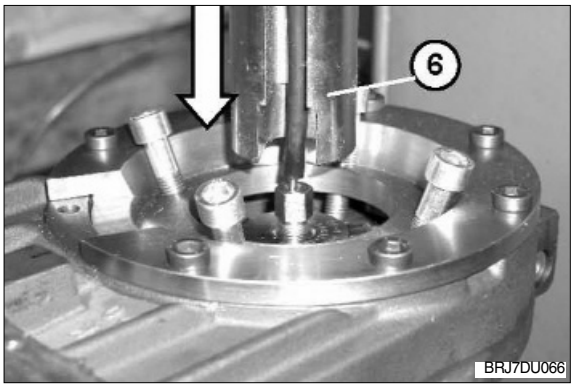
Fixedly tighten the connecting nipple with an openjaw spanner.

⚠ Pay attention for pressing-off that there is sufficient clearance in pressing-off direction avoiding that the wheel shaft is bottoming. Do not jam the wheel shaft at the pressing-off procedure.



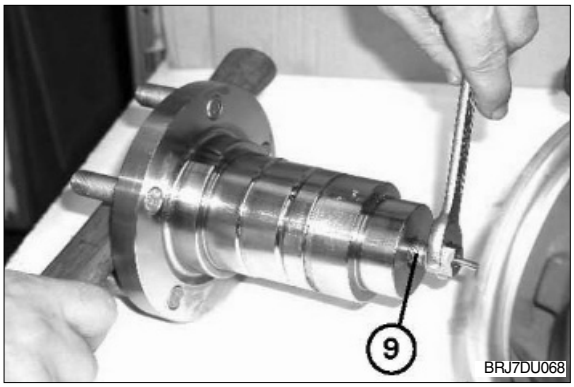
⑤ Mount the stamp (item 6) from the holding fixture (see Figure 64) into the press.

Adjust a pressing-off force from approx. 80 ... max. 120 KN on the press.

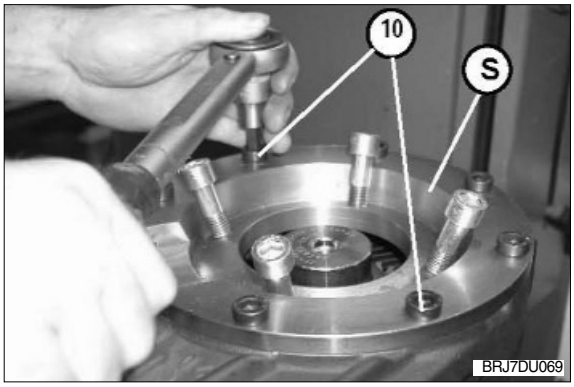


⑥ At the same time also use fixture 62222 to produce the necessary pressure until the wheel shaft is pressed out from the crown gear.

⑦ Remove and handle the wheel shaft in such a way that the flexible high-pressure pipe can be unscrewed from the connecting bore of the wheel shaft (item 9), removed and put aside.



⑧ Loosen the cap screws (item 10), take off and remove the holding fixture "S" from the housing.

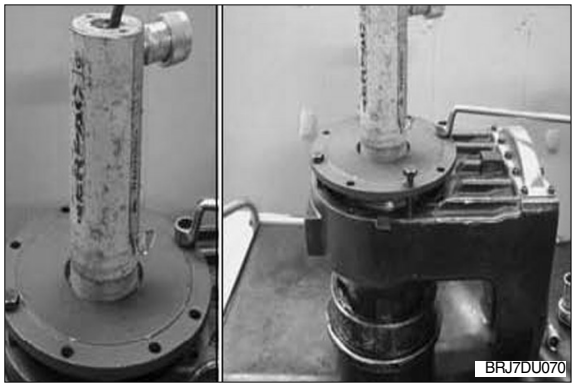


⑨ Pressing-off by means of 2nd hand pump

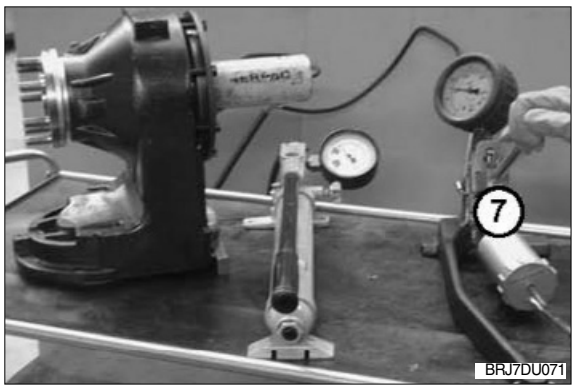
Alternatively the wheel shaft can be pressed off with a second press-out cylinder, e.g. in the mobile area. It is to be proceeded as follows:

Connect the dis- and assembly fixture with the press-out cylinder for the wheel shaft and bolt it with the transmission completely.

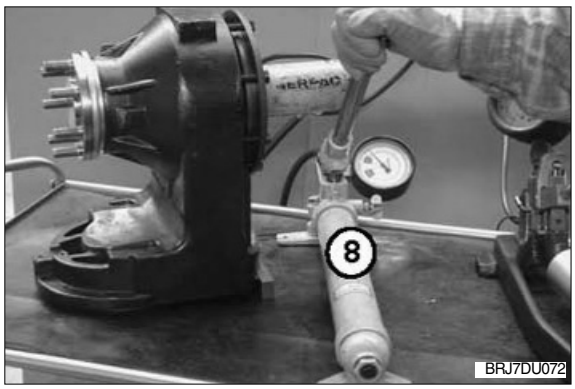
(S) Press-out cylinder 63428



⑩ Actuate the pressure oil device (item 7) until approx. 30MPa/4300psi is reached. Under this pressure the bevel gear is expanded sufficiently.
This pressure is to be kept constant by pumping subsequently until the wheel shaft has been loosened completely.



⑪ Actuate the second oil pressure device (item 8) until the pressure oil cylinder has loosened the wheel shaft from the bevel gear completely.

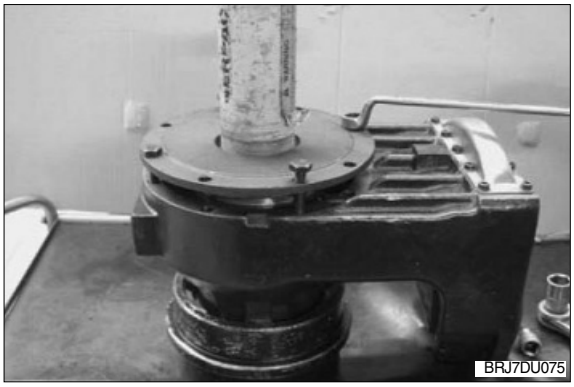


⑫ Take the wheel shaft out of the transmission.

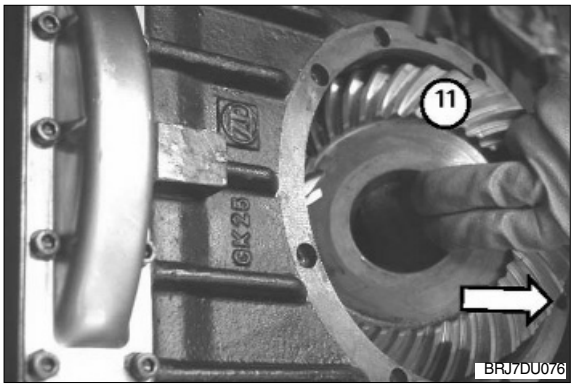
⑬ Unscrew the hydraulic hose from cylinder 1 of the wheel shaft. Wipe off excessive oil.

⑭ Unscrew the dis- and assembly fixture from the transmission

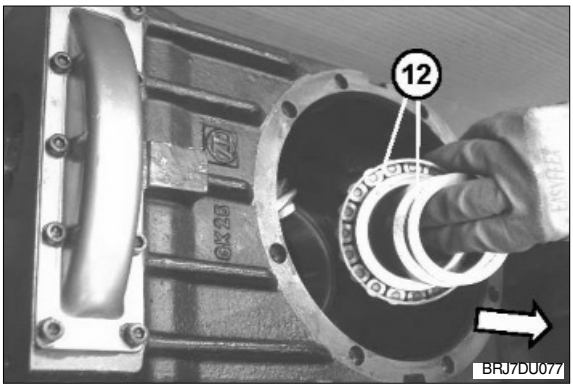
⚠ When the gearing is damaged, running noises and consequential damages might occur, so that the bevel gear set has to be replaced.



⑮ Take the crown gear (item 11) cautiously out of the housing as shown.



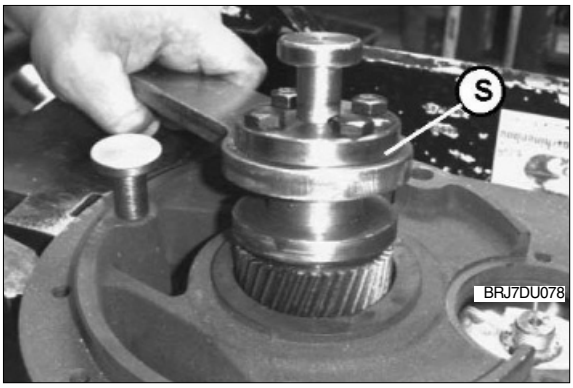
⑯ Then remove the following parts from the housing (item 12) : Shims and taper roller bearing



(5) Removal of bevel pinion shaft

① Put the gear lock "S" into the housing bearing bore of the drive pinion and block the helical gear with it.

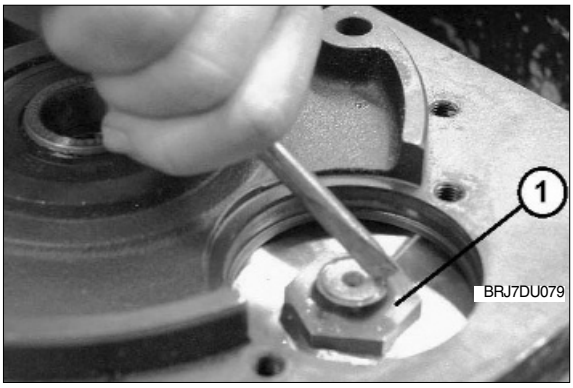
(S) Gear lock 62228



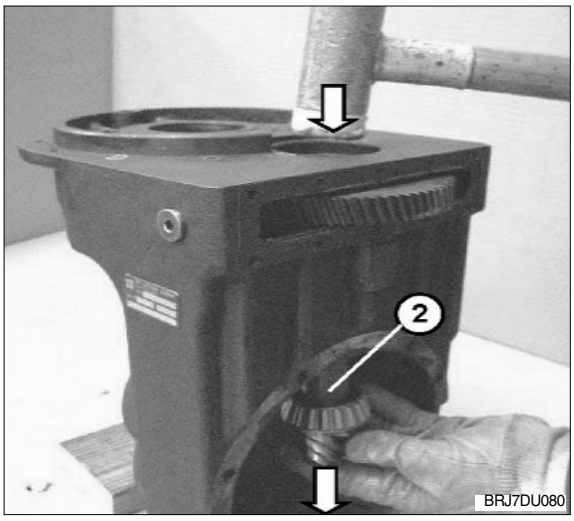
② Unlock the hexagon nut (item 1). Loosen, take off and remove the hexagon nut.

③ Take out and remove the gear lock.

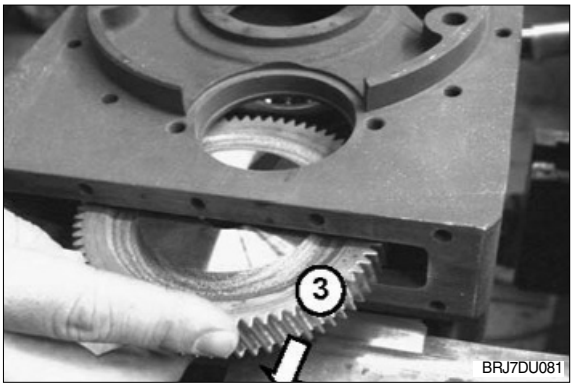
⚠ Pay attention not to damage the bevel pinion shaft when it is expelled in the following procedure.



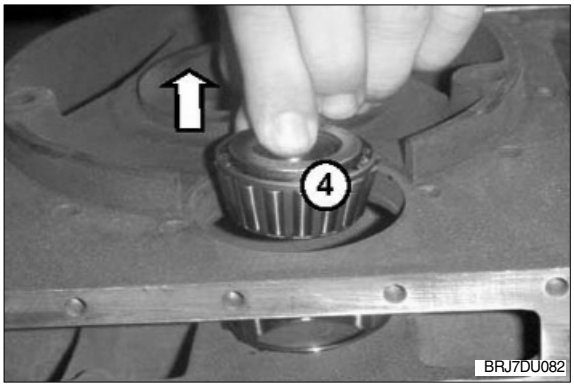
④ By means of a dead-blow soft face hammer expel the bevel pinion shaft (item 2) from the internal gearing and the bearings.



⑤ Pull out, remove and keep the helical gear (item 3) from the cover opening of the housing.



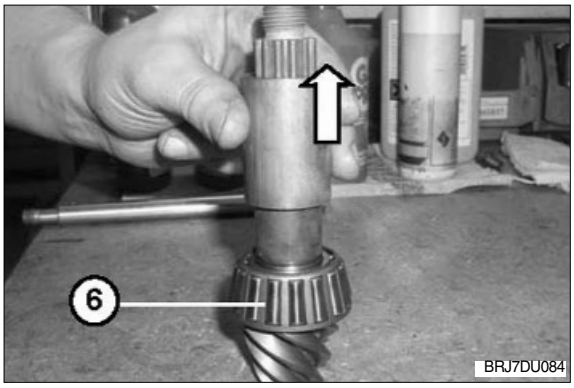
⑥ Take out and remove the taper roller bearing inner ring (item 4) upwards from the bearing bore:



⑦ Take off and remove the spacer bush (item 5) from the bevel pinion shaft.

⚠ If disassembly of the bearing inner ring is not possible with a special tool or puller, the bearing cage must be destroyed and the inner ring must be removed by heating.

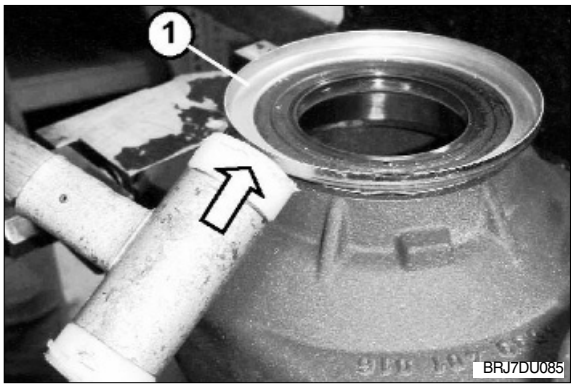
⚠ When the gearing of the bevel pinion shaft is damaged, running noises and consequential damages might occur, so that the bevel gear set has to be replaced.



(6) Removal of thread protective shield and radial sealing ring

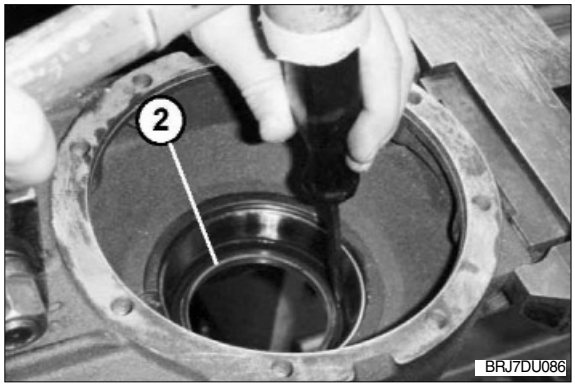
① By means of a hammer remove the thread protective shield (item 1) from the glued joint on the housing.

⚠ Do not damage the housing and supporting face!



② With a screwdriver and a hammer expel and remove the radial sealing ring (item 2) cautiously from the housing seat.

⚠ Do not damage the surface where the radial sealing ring is seated! At this working step the radial sealing ring is destroyed completely.



(7) Disassembly of bearings

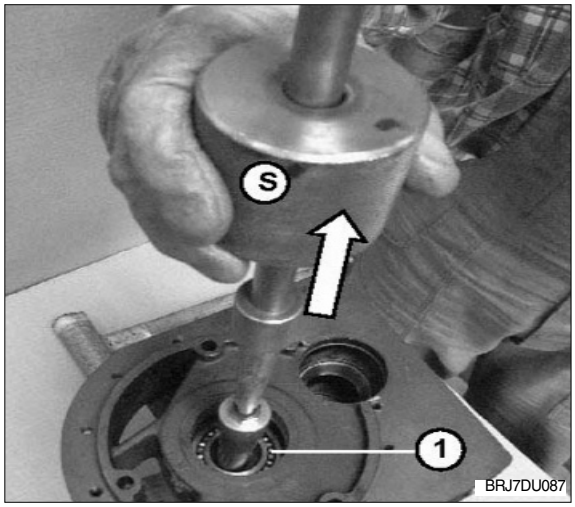
Disassembly bearings drive pinion

① With an extracting fixture (S) pull out the grooved ball bearing (item 1) from the bore of the housing seat and dispose it of acc. to chapter 6.

② The service of the extracting fixture (S) is analogous like in the figures 47 to 51 shown.

(S) Extracting fixture 225296

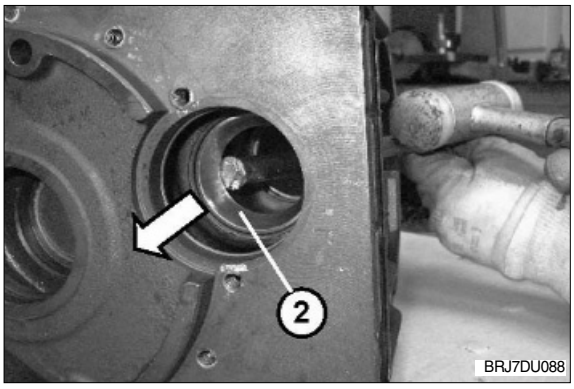
⚠ Upon removal of the bearing outer rings put them to the respective bearing inner ring.



Disassembly bearings bevel pinion shaft

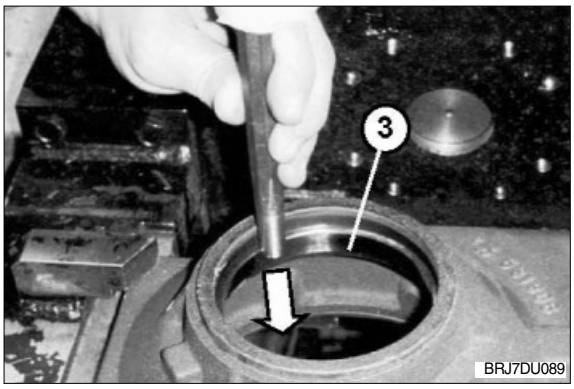
① Expel the outer rings of the taper roller bearings (item 2) on both sides from the housing seat cautiously.

② Shims which were damaged have to be replaced by new shims of the same size.



Disassembly bearings wheel shaft

① Expel the outer ring of the taper roller bearing (item 3) by means of a copper mandrel and a hammer from the housing cautiously.



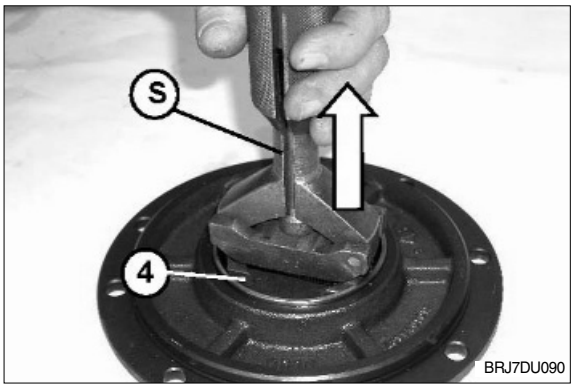
② Pull out and remove the outer ring of the 2nd taper bevel bearing (item 4) with the bearing extracting fixture "S" from the bore of the housing cover.

③ The service of the extracting fixture (S) is analogous like in the figures 49 to 50 shown.

④ Shims which were damaged have to be replaced by new shims of the same size.

(S) Extracting fixture 222863.2

Thus the disassembly is ended.



5. COMPLETE REASSEMBLY

1) GENERAL INSTRUCTIONS FOR REASSEMBLY

(1) Clean components by means of cleaning agent if necessary and remove the loctite residues.

(2) Check all components for wear, damage and cracks, if necessary components have to be replaced.

(3) All connection faces and plan face clean and steadily smoothing.

2) CONSUMABLES

Suitable cold cleaners, e.g. LOCTITE.

Only use suitable agents, which are non toxic, non-combustible and permissible on the market. Never use benzens, solvents or other combustible agents for cleaning purposes.

Description	To be used for
Loctite No. 243	Screw lock up to size M10 and bigger
Loctite No. 270	Screw lock for studs
Loctite No. 574	To glue the shaft seals into the housing & sealing of housing and cover
Loctite No. 5910	Surface sealing for side cover on the housing
Grease "Shell Alvania R3"	To grease or wet the sealing lip of the shaft seal
Siilicone grease 704 or transmission oil acc. to API GL-5 or MIL-L-2105C/D	To grease or wet the O-rings

3) USED DESCRIPTIONS AND SYMBOLS

You will find again all descriptions used in the following sections and their calculations.

Description	Symbol
Bearing width taper roller bearing	Dimension "B"
Housing dimension	Dimension "G"
Housing bearing bore 1	L1
Housing bearing bore 2	L2
Housing bearing bore 3	L3
Zero position at measuring fixture I(Part I) with dial gauge	Dimension "1"
Difference dimension bevel pinion shaft calculation of L3	Dimension "2"
Zero position at measuring fixture II(Part I) with dial gauge	Dimension "3"
Difference dimension crown gear calculation of L3	Dimension "4"
Installation dimension bevel pinion shaft	Dimension "E"
Bearing difference dimension	Dimension "D"
Constant	K1
Constant	K2
Free constant	a
Shim dimension	Dimension "P"
Bush width	Dimension "H"
Shim thickness	Dimension "X"

4) USE OF REMOVED SHIMS AS BASIS FOR REASSEMBLY

The bevel gear set, consisting of bevel pinion shaft and crown gear, has fixed installation dimensions. However the transmission housing and the taper roller bearings have to be measured.

(1) If the removed shims are used as basis it is not necessary to measure the transmission housing.

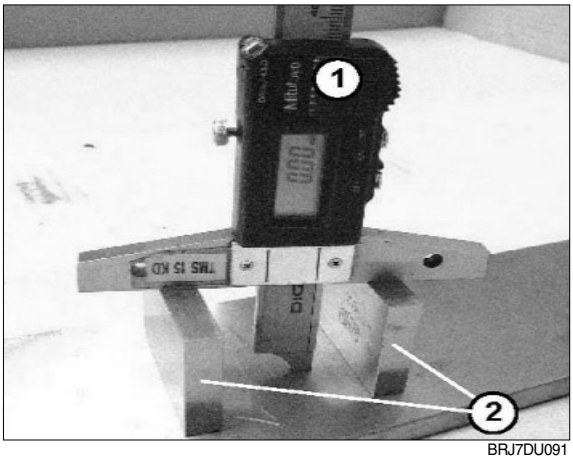
(2) If all of the removed components are to be reused, the original shim thickness has also to be used again.

(3) If the taper roller bearings with the bevel gear set replaced, only the taper roller bearings have to be measured.

5) DETERMINATION OF BEARING WIDTH DIFFERENCE OF A TAPER ROLLER BEARING

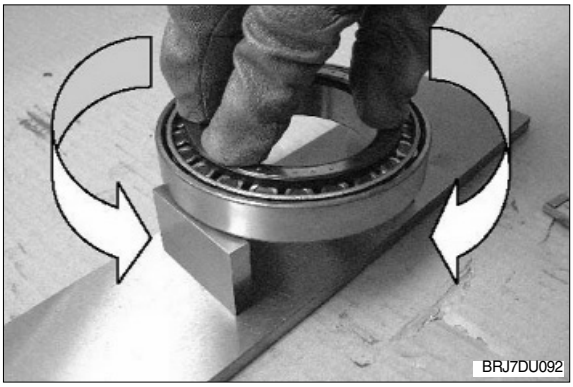
(1) Determination of bearing width general

① Zeroize depth gauge (item 1) by means of gauge blocks (item 2).



BRJ7DU091

② Put the new bearing on both gauge blocks and roll it as shown.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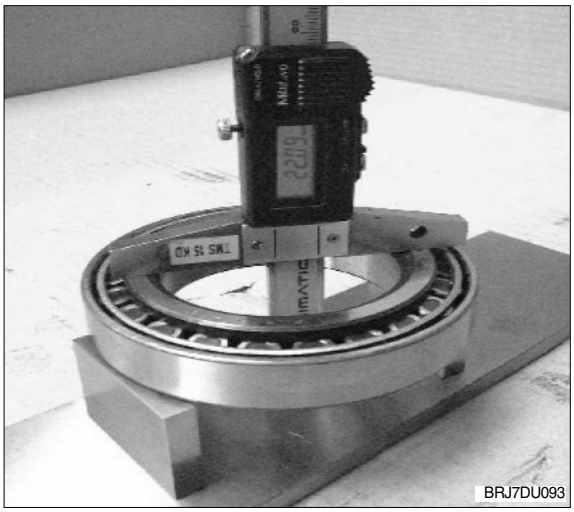
③ Determine dimension "B".
Example : Dimension "B" = 22.09 mm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(2) Determination of bearing difference for the installation of removal shims

① The difference dimension "D" of the new bearings to the bearings to be replaced is compensated with the shim dimension.

Example :

New bearing dimension	"B" 22.09 mm
Difference "D"	0.10 mm
Original bearing	-21.99 mm

The height of the existing shim set must by reduced by 0.1 mm.

6) DETERMINATION OF BASIC INSTALLATION DIMENSIONS

(1) Determination of the necessary shim thickness for the exact installation dimension setting of the bevel pinion shaft

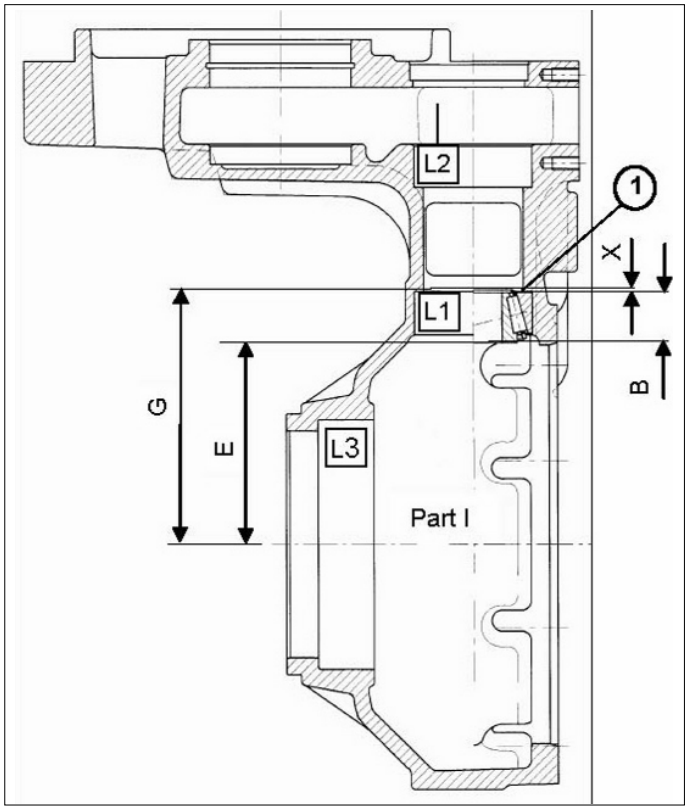
The correct position of the bevel pinion shaft is required for an optimum service life of the transmission.

Thickness of the shim (Item 1) and the correct setting of the bevel pinion shaft respectively will be determined according to the following method:

① Put measuring fixture I Part Ⅰ (see figure 95) into the housing bearing bore L1 until contact is obtained.

② Put measuring fixture I Part Ⅱ (see figure 96) into the housing bearing bore L2 until contact is obtained and fasten it hand-tight with measuring fixture I Part Ⅰ.

③ Put measuring fixture part Ⅰ to zero.
(S) Measuring fixture I 62231



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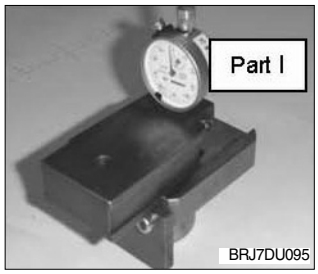
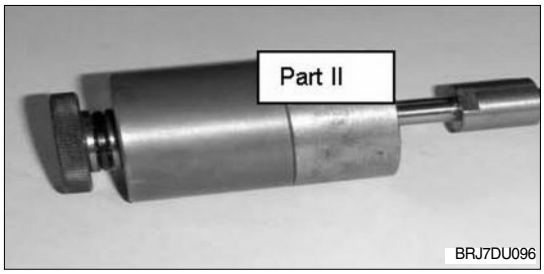
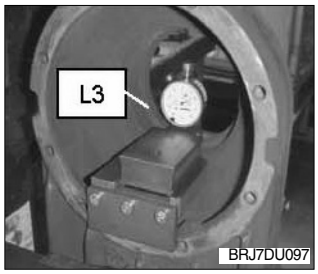






At zero position of the dial gauge the following can be taken as basis:
Dimension "1" = 111.50 mm

Determine Dimension "2" in housing bearing bore L3 (see figure 94) and add it to the respective Dimension "1".

Example :

Dimension "1"	111.50 mm
Dimension "2"	0.05 mm
Housing dimension "G"	**111.55 mm**

By means of the equation
X = G - E - B

The required thickness of the shim (Item 1, Figure 94) can be calculated. "E" means the installation dimension of the bevel pinion shaft

Dimension "E" : 89.00 mm

Calculation example

Dimension "**G**"	- 111.55 mm
Dimension "**B**"	- 22.09 mm
Dimension "**E**"	- 89.00 mm

X = G - E - B
X = 111.55 - 89.00 - 22.09 = **0.46 mm**

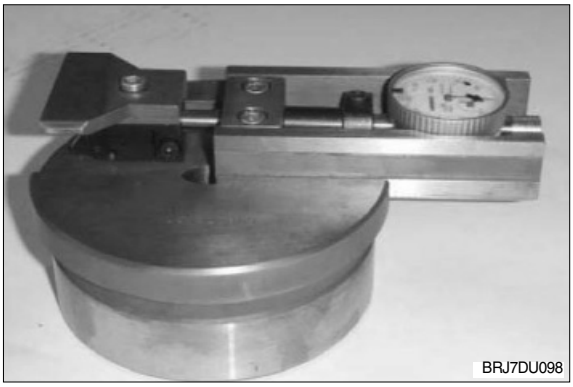
Add shims according to thickness X = **0.46 mm**

(2) Determination of necessary shim thickness for optimum setting of torsional backlash of the crown gear

Correct setting of the crown gear is necessary to obtain an optimum torsional backlash of the bevel gearing.

Bearing width "B" for the taper roller bearing on the crown gear can be measured according to chapter 5) at page 3-24 "Determination of bearing width and difference of a taper roller bearing".

Thickness of the shim and the correct setting of the crown gear respectively will be determined according to the following method :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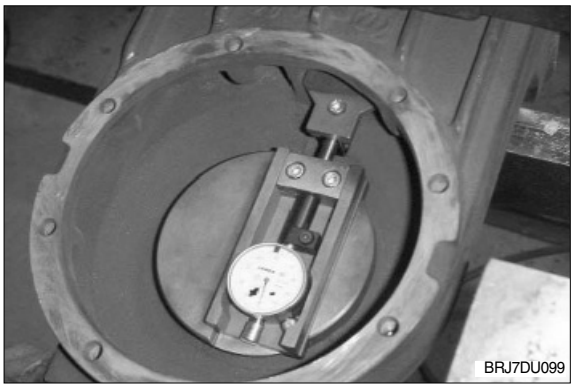
① Put the measuring fixture into the housing bearing bore L3 until contact is obtained (see Figure 100 or 101).
(S) Measuring fixture 62827


BRJ7DU099

② Put measuring fixture dial gauge to zero position.
At zero position of the dial gauge the following can be taken as basis :
Dimension "3" = 68.50 mm

Determine Dimension "4" in housing bearing bore L3 and add it to the respective Dimension "3".

Example:

Dimension "3"	68.50 mm
Dimension "4"	0.03 mm
Housing dimension "G"	68.53 mm

By means of the equation

X = G - E - B - K1

the required thickness of the shim (Item 3) can be calculated, i.e. with

Dimension "E" = 46.00 mm

Example :

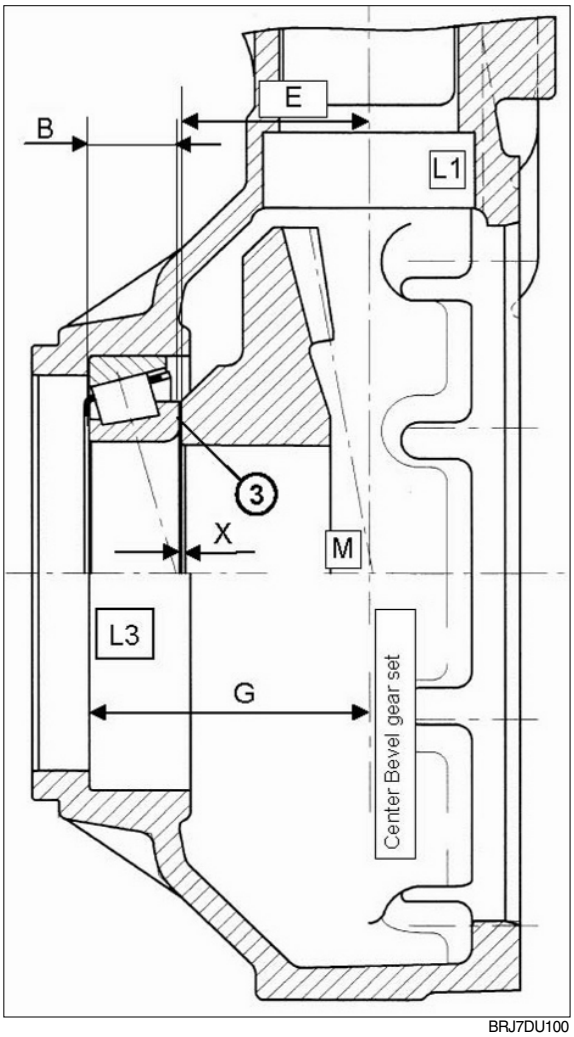
Dimension "G"	68.53 mm
Dimension "B"	22.09 mm
Dimension "E"	46.00 mm
Dimension "K1"	0.11 mm

X = G - E - B - K1

X = 68.53 - 46.00 - 22.09 - 0.11 =

0.37 mm

Schematic sketch



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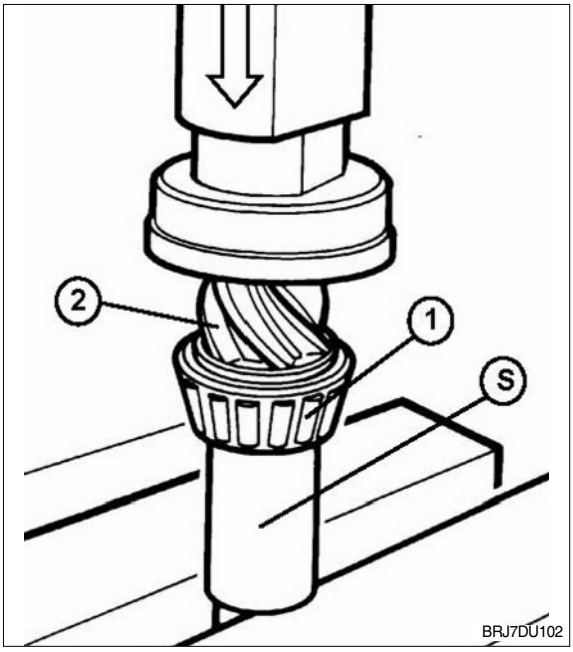
7) INSTALLATION OF BEARING FOR BEVEL PINION SHAFT AND EXACT SETTING OF THE BEARING PRELOAD

(1) Preassembly of bevel pinion shaft with bearing

① Use a hand-lever press for pressing the taper roller bearing inner ring (item 1) with the press-in sleeve "S" cautiously on the bevel pinion shaft (item 2) until contact is obtained.

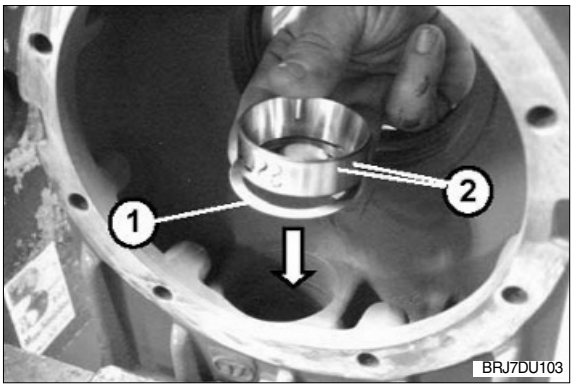
⚠ Pay attention to the gearing when the bearing of the bevel pinion shaft is installed. In case of damage, noise problems can be caused later.
(S) Press-in sleeve 223705.22



(2) Installation of bearing outer ring into the housing

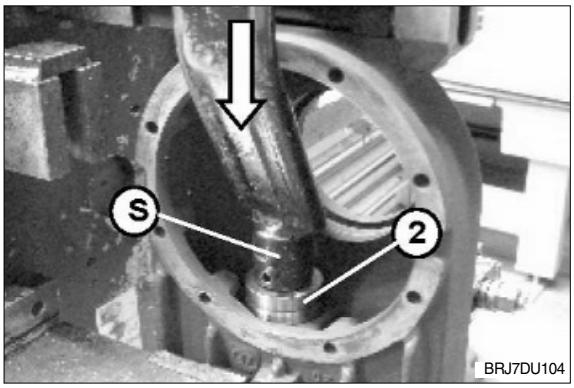
① Prepare the shim thickness determined according to chapter (1) at page 3-26 "Determination of the necessary shim thickness for the exact installation dimension setting of the bevel pinion shaft" by means of the differently thick shims.

② Put the shim(s) (item 1) and the bearing outer ring (item 2) into the bearing seat.



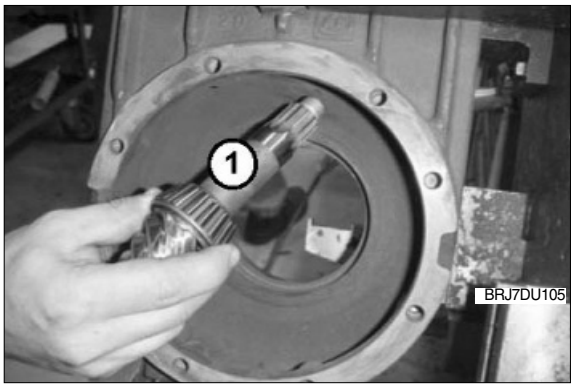
③ By means of striking mandrel "S" install the shim (s) and the bearing outer ring into the bearing seat of the housing until contact is obtained.

⚠ A repeated measurement of the bearing height is only allowed to result in a deviation of max. ±0.05 mm. Otherwise the process of the shim calculation has to be repeated.
(S) Striking mandrel 62529

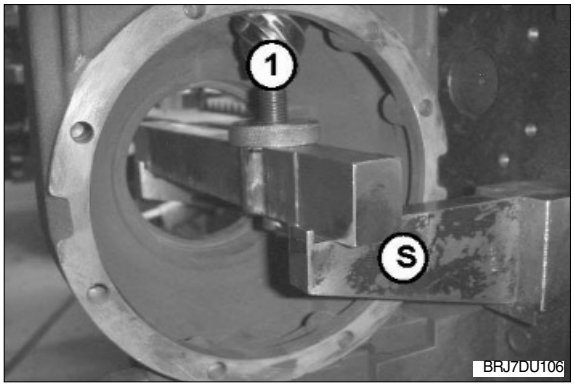


(3) Calculation of distance dimension between collar bevel pinion shaft and housing

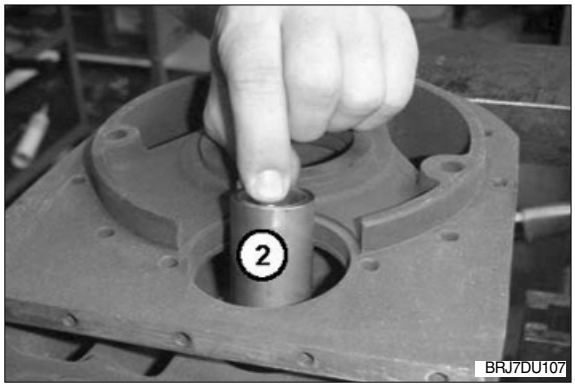
① Install the preassembled bevel pinion shaft (item 1) from the bottom into the housing.



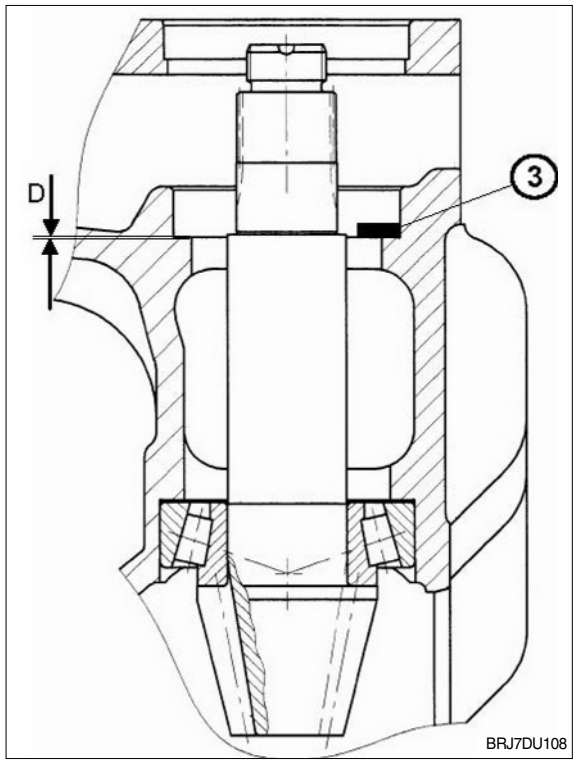
② By means of the counter holder "S" preload the bearing outer ring in the housing hand-tight.
(S) Counter holder 62507-1



③ Put the spacer bush (item 2) onto the bevel pinion shaft.

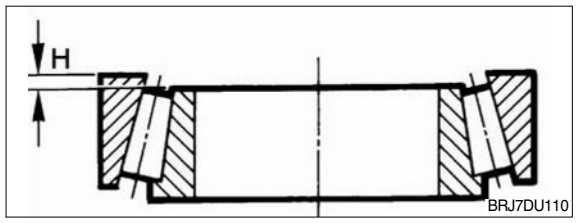


Determine distance dimension "D" from the spacer bush (item 2) to contact of the bearing outer ring in the housing.
(item 3 is the required shim thickness)



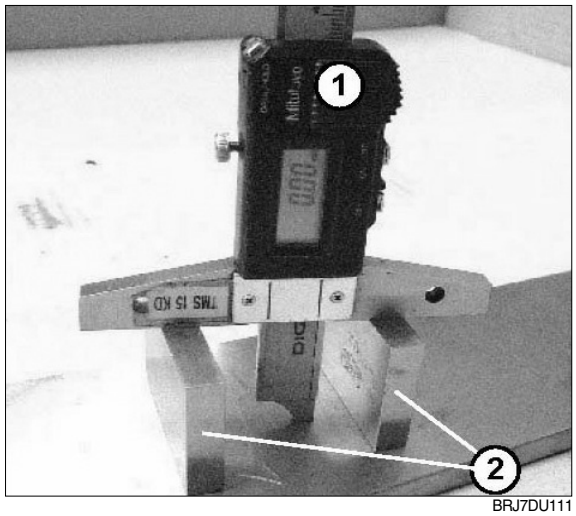
(4) Determination of bearing slack of the taper roller bearing

① Arrow gap = Bearing slack H



Measure the bearing slack "H" with a measuring fixture and gauge blocks/measuring ledge in the following steps :

① Zeroizing of depth gauge (item 1) by means of gauge blocks (item 2).



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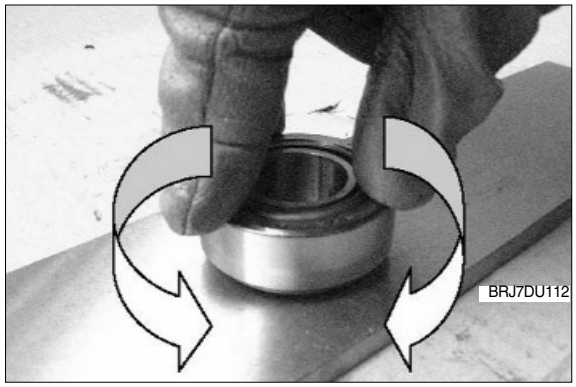
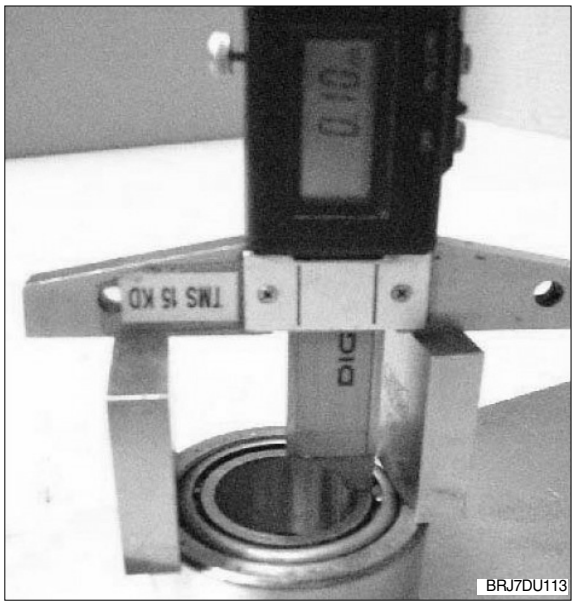
② Rolling-in of bearing.


BRJ7DU112

③ Measuring of bearing slack H.

Example : Dimension "H" = 0.10 mm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(5) Calculation of shims required for upper bevel pinion shaft bearing

By means of the equation

X = D - H

the required thickness of the shim (Item 3 figure 108 or 109) can be calculated, i.e. with

Dimension "D" Distance from spacer bush

Dimension "H" Bearing slack of taper roller bearing

Dimension "a" Constant = 0.04 mm

Example :

Distance dimension : Dimension **D** measured on the housing - 0.7 mm

Bearing slack : Dimension **H** measured on the bearing - 0.10 mm

X = D - H - a

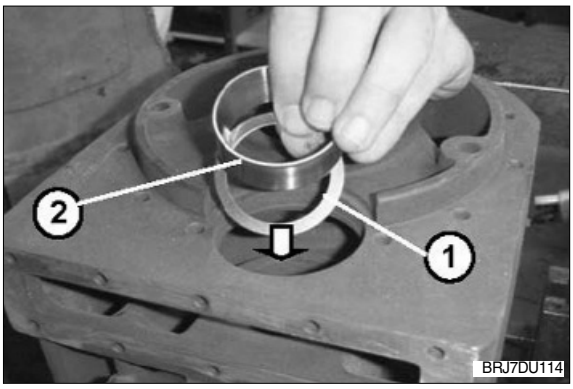
X = 0.7 - 0.10 - 0.04 = 0.56 mm

Add shims corresponding to thickness X = 0.56 mm.

8) INSTALLATION OF UPPER TAPER ROLLER BEARING OF THE BEVEL PINION SHAFT

Prepare the shim thickness determined according to chapter (5) above "Calculation of shims required for upper bevel pinion shaft bearing" by means of the differently thick shims and continue the installation as follows:

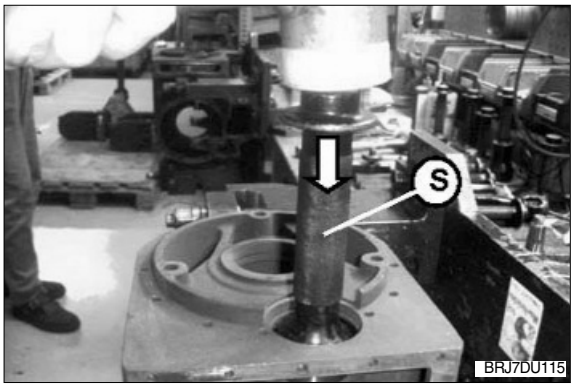
① Put shim(s) (item 1) and bearing outer ring (item 2) into the bearing seat.



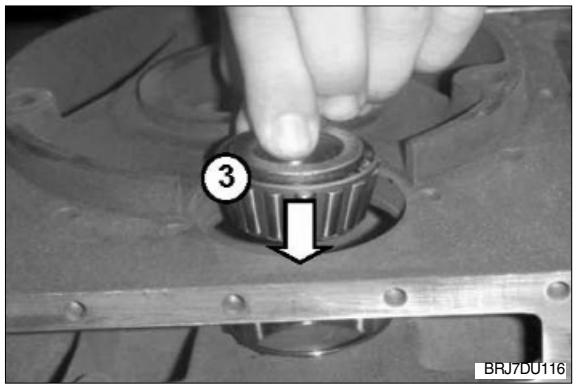
② By means of striking mandrel "S" install the shim(s) and the bearing outer ring into the bearing seat of the housing until contact is obtained.

⚠ A repeated measurement of the bearing height is only allowed to result in a deviation of max. ¡ 0.05 mm. Otherwise the process of the shim calculation has to be repeated.

(S) Striking mandrel 62747



③ Put the bearing inner ring (item 3) into the outer ring of the taper roller bearing.

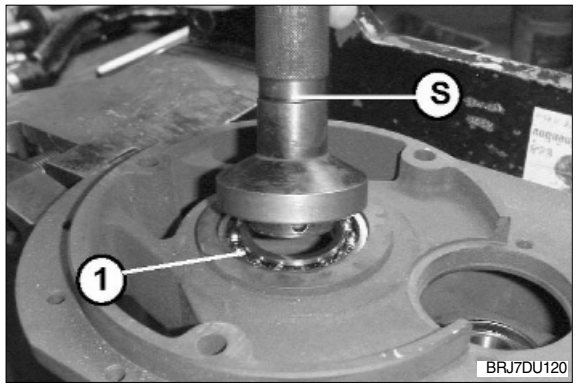


(1) Installation of grooved ball bearing for drive pinion

① Install the grooved ball bearing (item 1) with the striking mandrel "S" into the bearing seat of the housing until contact is obtained.

(S) Striking mandrel 62625

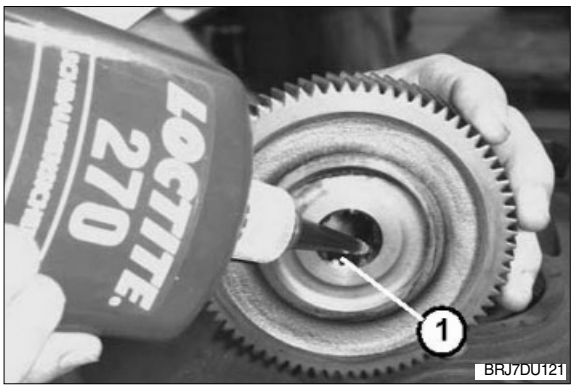
⚠ Prior to installation of the helical gear the lower grooved ball bearing has to be installed into the housing bearing bore.



(2) Installation of helical gear with bevel pinion shaft

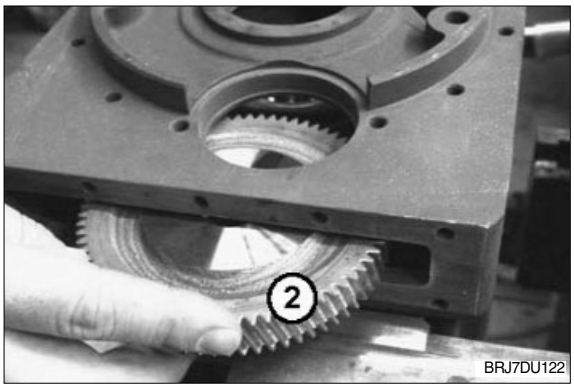
① Apply a thin and even layer of LOCTITE 270 onto the internal gearing of the helical gear (item 1).

⚠ Wear safety gloves for working with adhesives and observe the LOCTITE instructions.

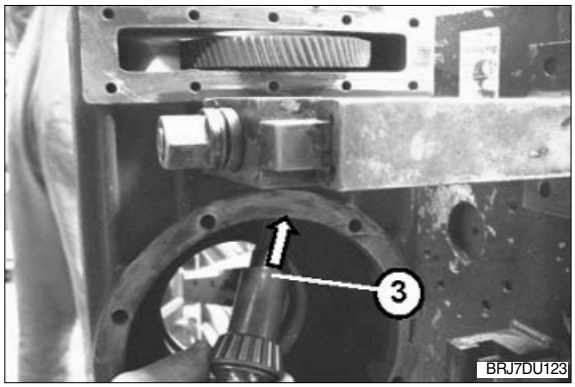


② Insert the helical gear (item 2) by the lateral opening of the housing, align it centrally and put it onto the taper roller bearing.

⚠ When inserting the helical gear pay attention that the helical gear is not damaged. In case of damage noise problems can occur later.

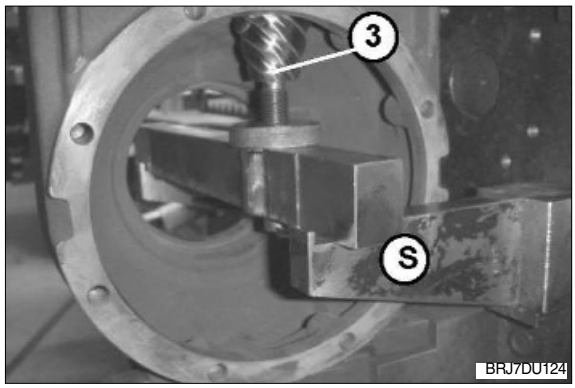


③ Install the bevel pinion with space bush (item3) from the bottom into the housing and assemble is through the profiled seat of the helical gear bore.



④ Preload the bevel pinion shaft (item 3) with the counter holder "S" hand-tight against the bearing outer rings in the housing.

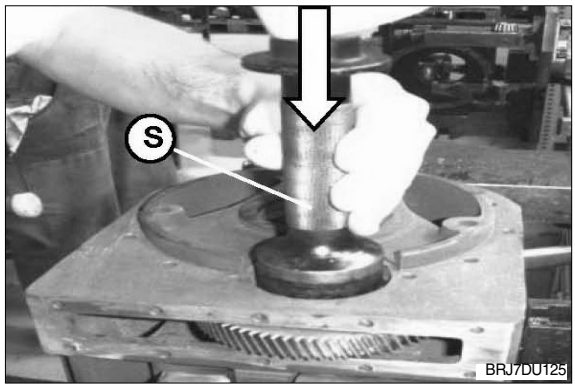
(S) Counter holder 62507-1



⑤ By means of striking mandrel "S" install the helical gear until contact is obtained. Hand-tighten the adjusting screw on the counter holder repeatedly, so that all components like taper roller bearing, spacer bush and shims are located exactly.

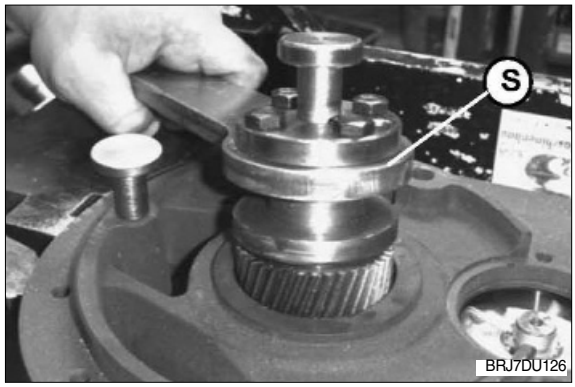
⑥ When all components are located tightly the counter holder can be removed again.

(S) Striking mandrel 62846



⑦ Insert gear lock "S" into the housing bearing bore of the drive pinion and block the helical gear.

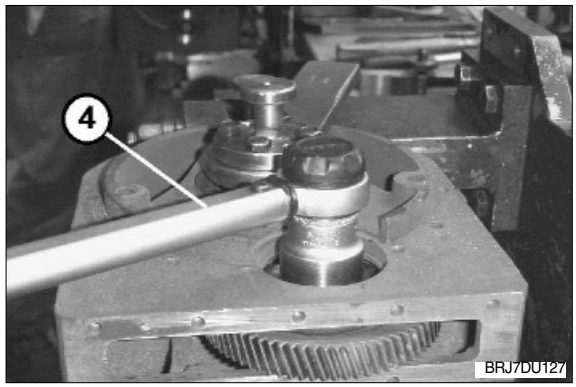
(S) Gear lock 62228



⑧ Place the hexagon nut (M16 × 1.5) onto the bevel pinion shaft and tighten it with a torque spanner (item 4).

Tightening torque : 100 Nm

⚠ Do not yet peen the hexagon nut with the bevel pinion shaft! The hexagon nut must only be peened after setting and checking of the bearing preload. Use the hexagon nut only once.



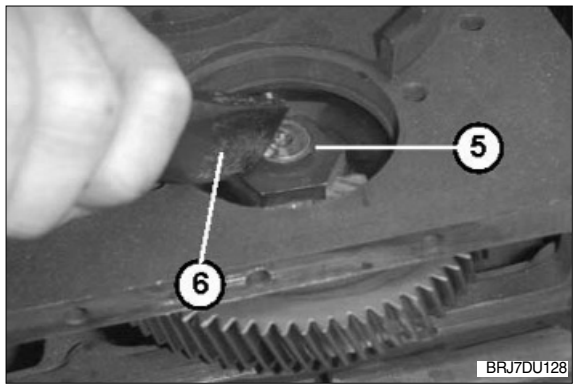
⑨ Turn the bevel pinion shaft and the helical gear respectively by hand several times, that the taper rollers can align in the bearing rings.

⑩ Check the bearing preload by means of a drag torque spanner with dial gauge.
The bearing preload is adjusted correctly, when a bearing friction torque of

0.5 ... 1.0 Nm

is reached on the bevel pinion shaft.
If this value deviates the procedure must be repeated.

⑪ Drive the collar of the hexagon nut (item 5) by means of a chisel (item 6, edge of the chisel must be a radius of approx. 2.0 mm) into the recesses of the bevel pinion shaft. Lock the hexagon nut by peening!

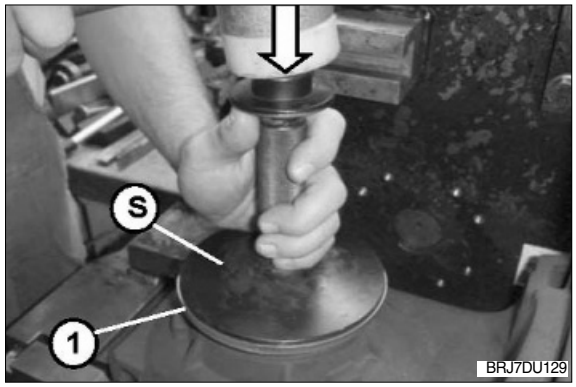


9) INSTALLATION OF CROWN GEAR AND WHEEL SHAFT INTO THE HOUSING

(1) Installation of thread protective shield and radial sealing ring

① Wet the thread protective shield (item1) on the bore seat evenly with LOCTITE 270 and install it until contact by means of the striking mandrel "S".

(S) Striking mandrel 63293



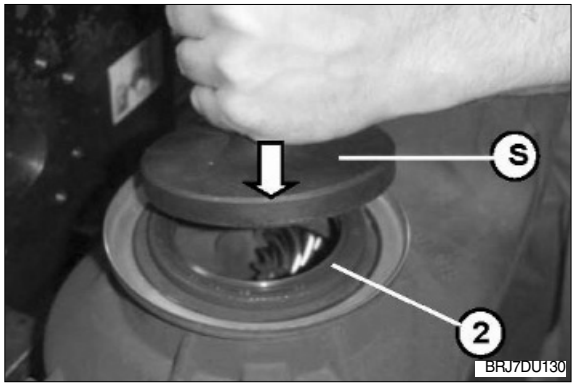
② Apply a thin and even layer of LOCTITE 574 onto the outer diameter of the radial sealing ring.

③ By means of the striking mandrel "S" drive the radial sealing ring (item 2) into the housing seat until contact is obtained at the mandrel.

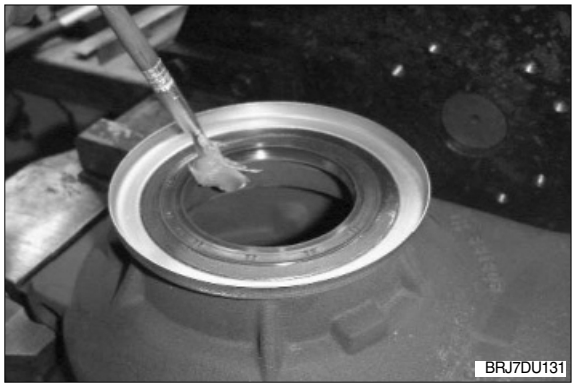
(S) Striking mandrel 63291

⚠ Pay attention that the radial sealing ring is not jammed during installation. Jamming will cause leakage.

⚠ Do not damage the sealing lip of the radial sealing ring.



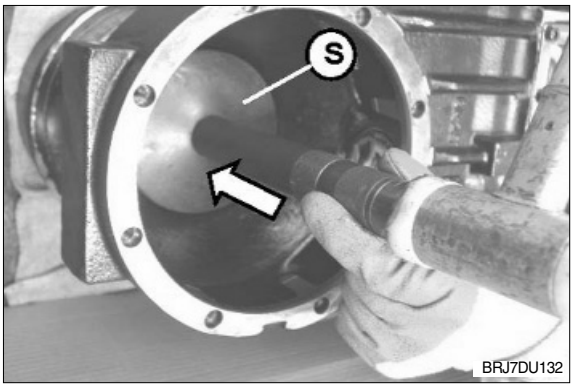
③ Wet the sealing lip of the radial sealing ring with grease (e.g. Shell Alvania R3) slightly.



(2) Installation of taper roller bearing into the housing

① By means of striking mandrel "S" drive the bearing outer ring into the bearing seat of the housing until contact is obtained.

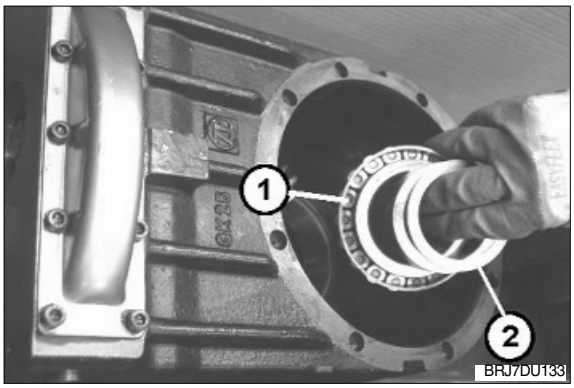
(S) Striking mandrel 62542



② Insert the bearing inner ring (item 1) into the outer ring of the taper roller bearing.

③ Prepare the shim thickness (thickness X) with the differently thick shims as determined in Chapter 7) (5) at page 3-33 "Calculation of shims required for upper bevel pinion shaft bearing".

④ Insert shim(s) (item 2).



(3) Determination of control dimension for seat

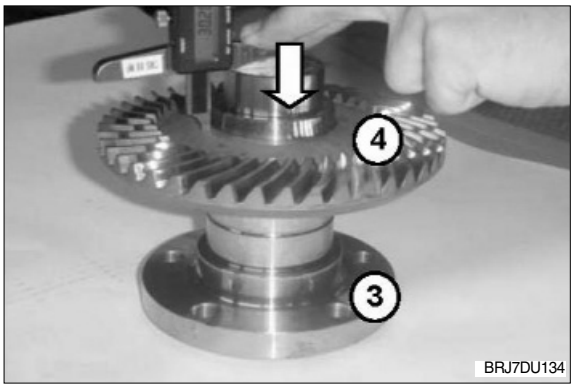
① Place the wheel shaft (item 3) onto a plane and solid support. Mount the crown gear (item 4) onto the taper seat of the wheel shaft by hand cautiously and press it on slightly.

Determine distance "A" from plane face P of the wheel shaft to face S of the crown gear as shown in Figure135.

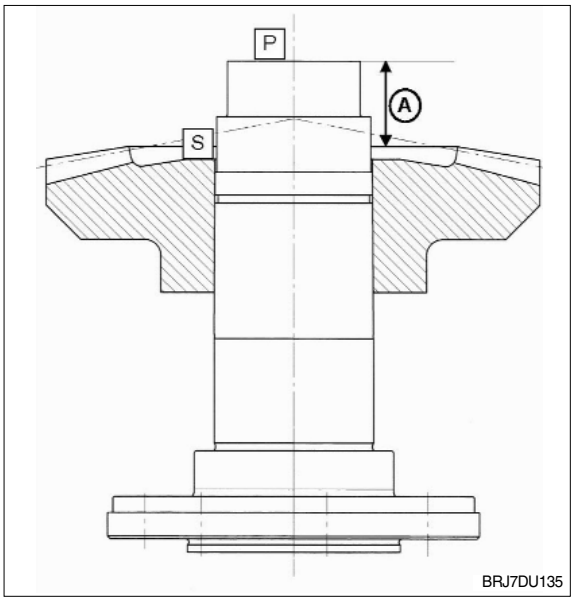
Dimension "A" e.g. 30.85 mm

⚠ Carry out this measuring procedure to 1/100mm exactly.

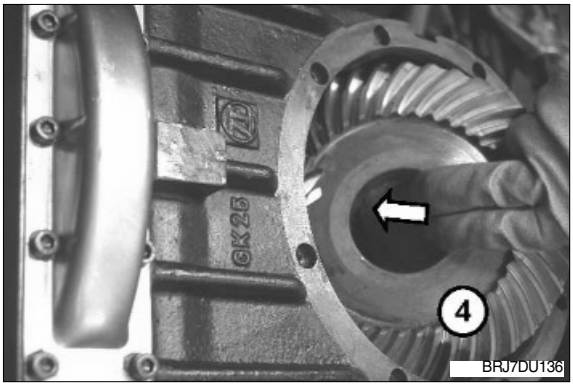
⚠ Pay attention not to damage the gearing of the crown gear, when the crown gear is mounted onto the wheel shaft. In case of damage, noise problems can occur later.



⚠ Pay attention not to damage the gearing, when the crown gear is assembled.



① Assemble the crown gear (item 4) into the housing carefully and insert it into the gearing of the bevel pinion shaft at the same time. Pay attention that the crown gear is aligned centrally to the shim and the bush.

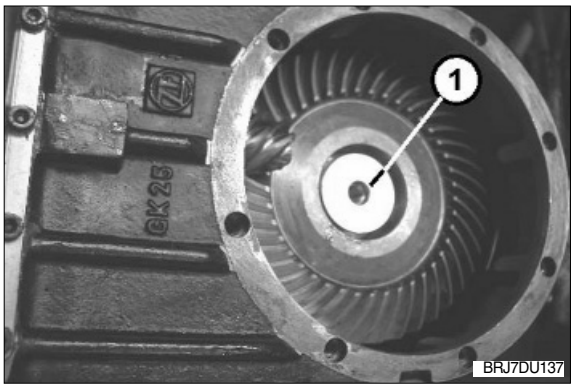


(4) Pressing-on wheel shaft

⚠ Taper press fit must be grease- and oilfree. Pay attention to an impeccable surface of the press fit. In case of damage use a new wheel shaft.
All components must be aligned and centered for the press-on procedure.
For this installation procedure a press with a controllable press-on force is required.

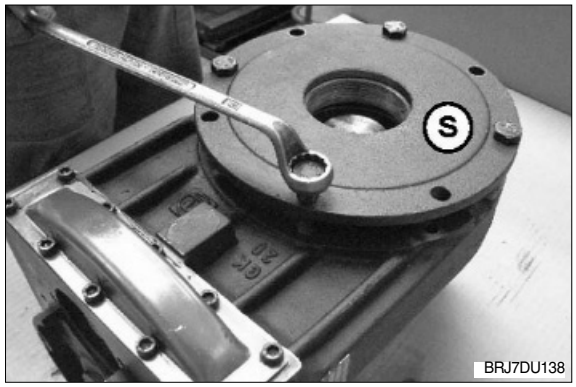
Press-on force: 250 kN up to max. 300 kN.

① Assemble the wheel shaft (item 1) cautiously and install it until contact is obtained.



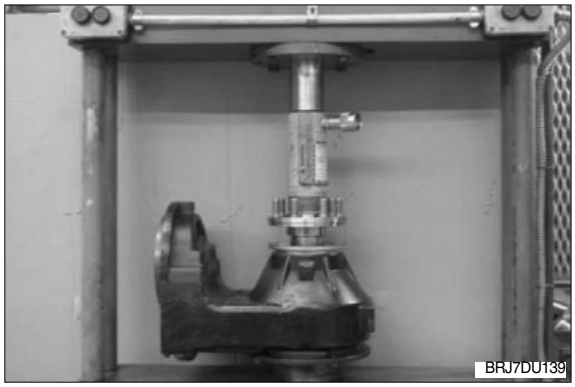
② Screw on the press-on fixture (S).

(S) Press-on fixture 63428



③ Press the wheel shaft onto the crown gear.
During this procedure the shim(s) and the taper roller bearing inner ring are pressed on until contact is obtained.

⚠ For pressing on the wheel shaft, only apply the press-on force to the wheel shaft.



(5) Determination of seat

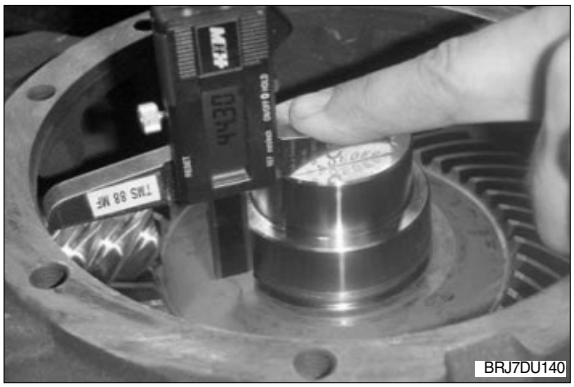
⚠ The seat must be 10 to 15 mm.

① Measure Dimension A from plane face/wheel shaft to face/crown gear once again (see chapter 9) (3) at page 3-38 "Determination of control dimension for seat“).

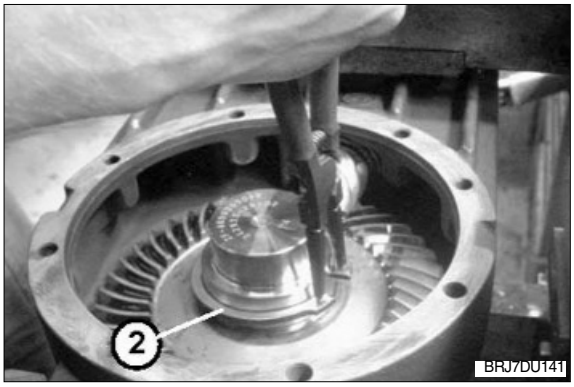
Dimension "A" e.g. 44.34 mm

Example:
Dimension "A" after pressing-on 44.43 mm
Dimension "A" after pressing-on 30.85 mm
Resulting difference = Seat 13.49 mm

⚠ If the seat determined is not between 10 and 15 mm a new wheel shaft and a new crown gear have to be installed.



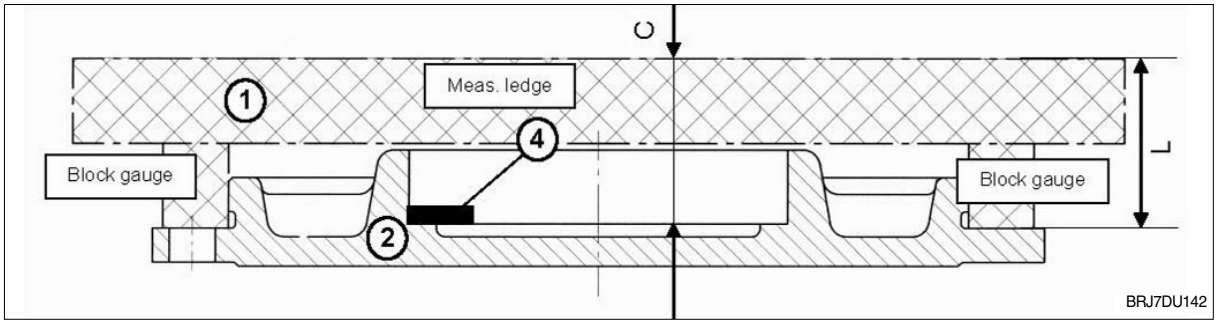
② Install the retaining ring (item 2).



10) INSTALLATION OF BEARING FOR WHEEL SHAFT

(1) Determination of required shim thickness for exact bearing preload of the wheel shaft

Thickness of the shim (item 4) to be added can be determined with the following method:



1 Measuring ledge
2 Housing cover

Dim. "L" Distance from mounting face/housing cover equal to zero position on measuring instrument
Dim. "C" Measure distance from contact shim/housing cover.
Dim. "L" e.g. Zero position on measuring instrument = 0
Dim. "C" e.g. 0.85 mm

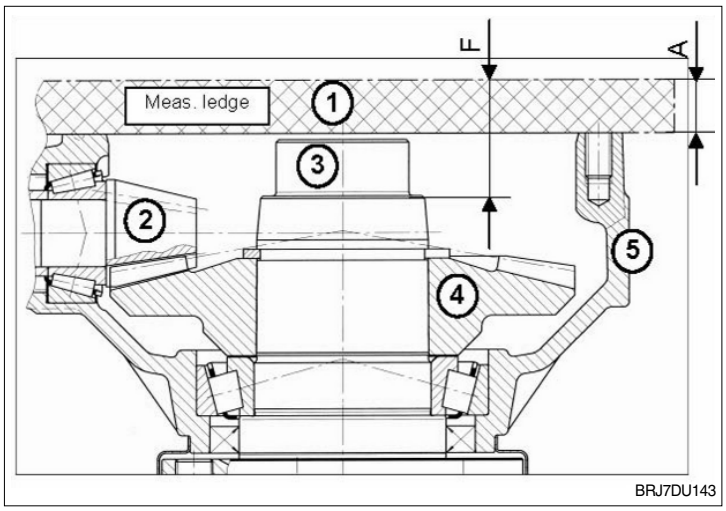
1 Measuring ledge
2 Bevel pinion shaft
3 Wheel shaft
4 Crown gear
5 Housing

Dim. "A"
Distance from mounting face / housing equal to zero position on measuring instrument

Dim. "F"
Measure distance from contact bearing inner ring / wheel shaft.

Dim. "A"
e.g. zero position on measuring instrument = 0

Dim. "F"
e.g. 23.01 mm



(2) Calculation of shim required

Thickness of shim can be calculated with the dimensions determined.

Example :

Cover dimension :	Dim. C measured on housing cover	0.85 mm
Housing dimension :	Dim. F measured on housing	23.01 mm
Bearing dimension :	Dim. B measured on bearing under preloading force	21.85 mm

$$X1 = F - (C + B)$$

$$X1 = 23.01 - (0.85 + 21.85) = 0.31 \text{ mm}$$

Constant : a = 0.20 at $X1 \geq 0.31$

a = 0.25 at $X1 \leq 0.30$

$$X = X1 + a$$

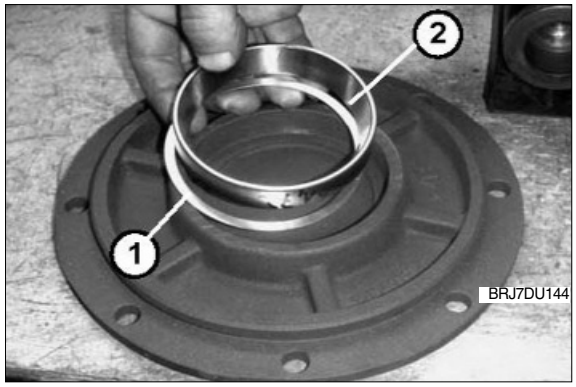
$$X = 0.31 + 0.20 \text{ mm} = 0.51$$

Add shims according to thickness X.

(3) Installation of bearing into housing cover and wheel shaft

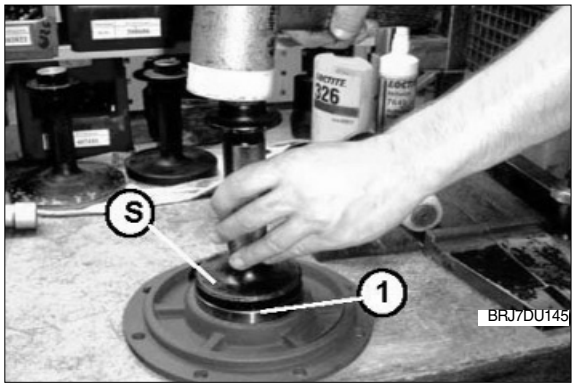
① Prepare the shim thickness determined under chapter (2) above "Calculation of shim required" by means of the differently thick shims.

② Put shim(s) (item 1) and bearing outer ring (item 2) into the bearing seat.



③ By means of striking mandrel "S" drive shim(s) and bearing outer ring (item 1) into the bearing seat of the housing cover until contact is obtained.

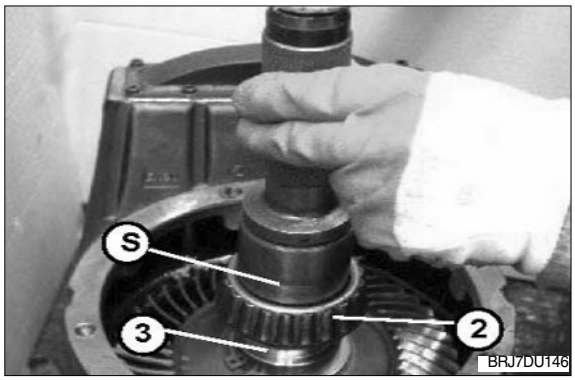
(S) Striking mandrel 62748



④ Place counter holder "N" into the assembly fixture and preload it hand-tight against the wheel shaft (cf. figure 124).
(N) Counter holder 62507-1

⑤ Mount the taper roller bearing inner ring (item 2) by means of striking mandrel "S" onto the bearing seat of the wheel shaft (item 3) until contact is obtained.

(S) Striking mandrel 63294



(4) Installation of housing cover

⚠ Use a new O-ring for the installation. Wet the O-ring with transmission oil or grease slightly. Clean plane face of the housing cover carefully and do not damage it.

① Put the o-ring (item 4) into the groove of the housing cover.

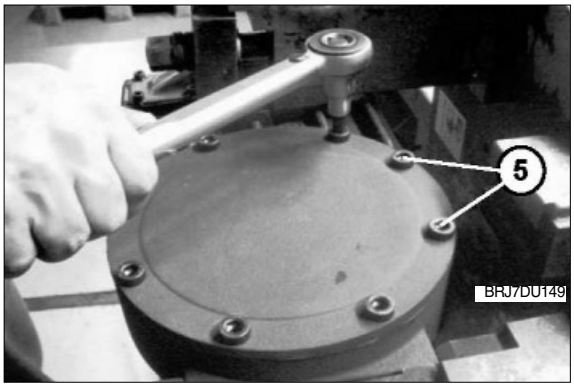
② Plane face for housing cover on the housing is to be cleaned carefully and must be grease-free.

③ Apply a thin and even layer of LOCTITE 574 onto the plane face.

④ Place the housing cover cautiously and install it slightly tapping with a dead-blow soft face hammer until contact is obtained.

By means of cap screws M10×25 (item 5) bolt the cover to the housing. Tighten the cap screws crosswise evenly!

Tightening torque of the cap screws : 46 Nm.



(5) Checking of bearing friction torque on wheel shaft

Rolling

For measuring of the bearing friction torque place tool "S" on the wheel shaft congruent with the wheel bolts and by means of the torque spanner turn the wheel shaft several times.

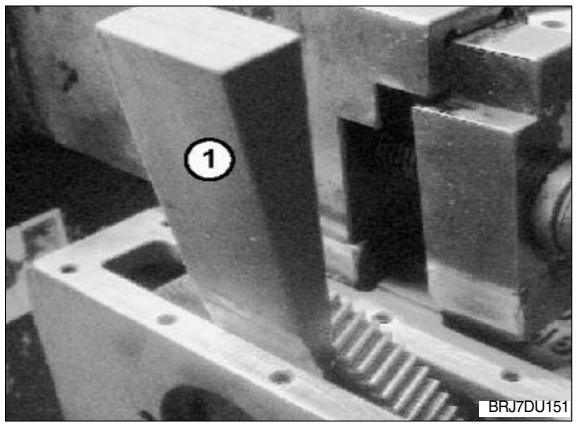
(S) : Measuring fixture 62532

Bearing preload is adjusted correctly when a bearing friction torque of is obtained at the wheel shaft.

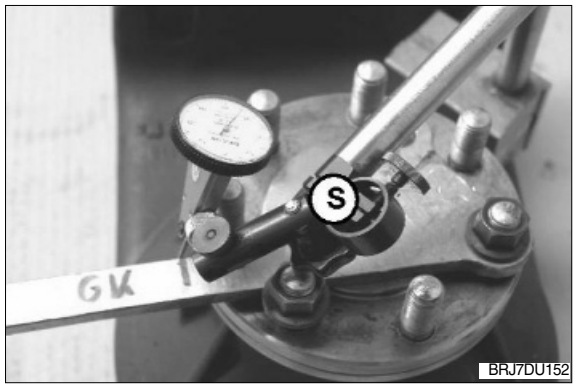
If this value is not reached the working steps from Chapter 10) (2) have to be repeated. The cover has to be removed again.
If the measured value is greater than the above mentioned value, the shim thickness of value "X" in "Chapter 10) (2) calculation of shim required" has to be reduced.

If the measured value is smaller than the above mentioned, the shim thickness of value "X" in "Chapter 10) (2) at page 3-43 calculation of shim required" has to be increased.

(6) Measuring of torsional backlash on wheel shaft



① For measuring of the torsional backlash lock the bevel pinion shaft against distortion, e.g. with a wooden wedge (item 1).



② Measure the torsional backlash with measuring stop "S".

(S) Measuring stop 62819

Admissible torsional backlash :

0.10 ~ 0.15 ㎜

The torsional backlash can be adjusted by adding or removing of the shim(s) (see chapter 6) (2) at page 3-27 "determination of the necessary shim thickness for optimum setting of the torsional backlash of crown gear"). The wheel shaft has to be removed again.

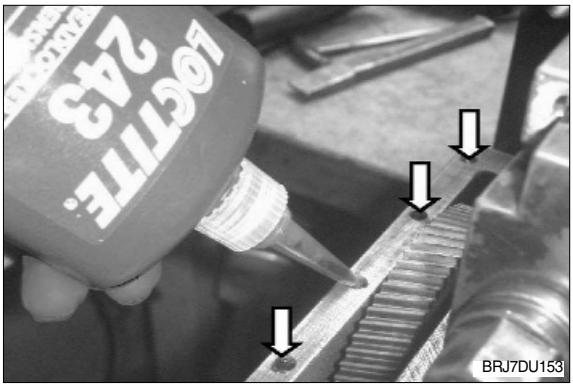
(7) Installation of side cover

Prior to the installation of the side cover clean the sealing surface on the housing and remove the oil residues. The sealing surface must not be damaged.

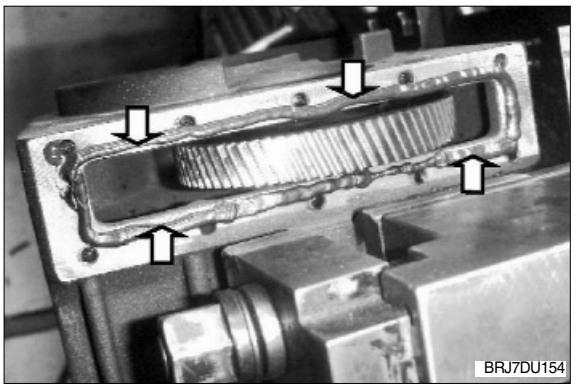
⚠ Wear safety gloves for working with adhesives and observe the LOCTITE instructions.

⚠ The following step must be carried out within 10 minutes since the LOCTITE hardens.

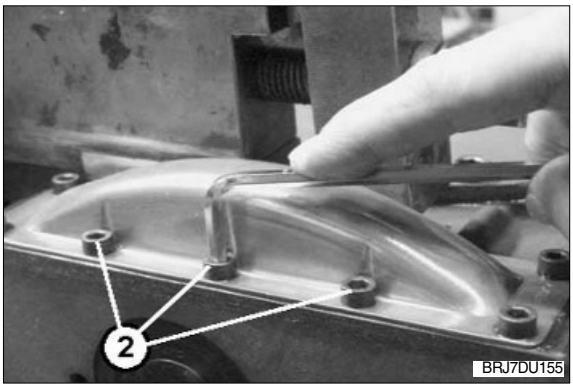
① For sealing of the through holes as well as of the area around the screw the following sealing application is required:
LOCTITE 243 : Product application into the threaded blind holes M6 as sealing function by excess product.



② Sealing of the cover:
LOCTITE 5910: Product application as uniform adhesive application onto the sealing surface at the housing as sealing function.



③ Put on the side cover (sheet cover) and fasten it hand-tight with 10 cap screws M6 × 10 (item 2) onto the housing.

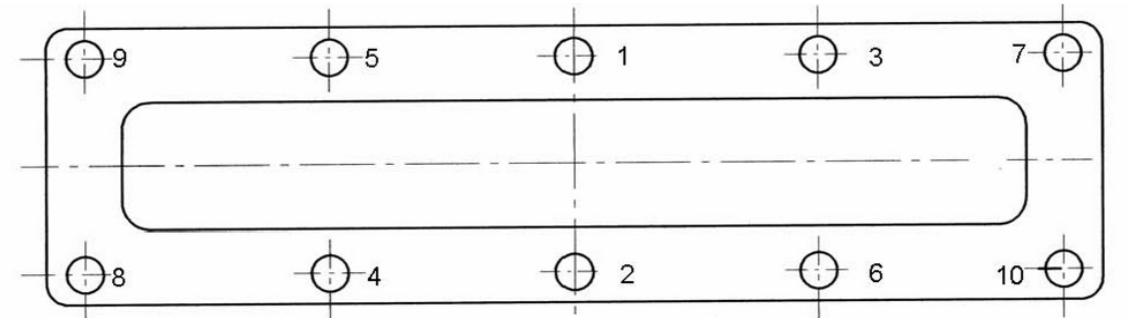


⚠ Do not yet tighten the cap screws with the corresponding tightening torque.

Tighten the 10 cap screws evenly only in the tightening sequence shown in Figure 156.
Sequence of tightening :

Number 1 beginning ..... Number 10 end

Tightening torque of the cap screws : 9.5 Nm



BRJ7DU156

11) PREASSEMBLY AND INSTALLATION OF DRIVE PINION

(1) Installation of ball bearing

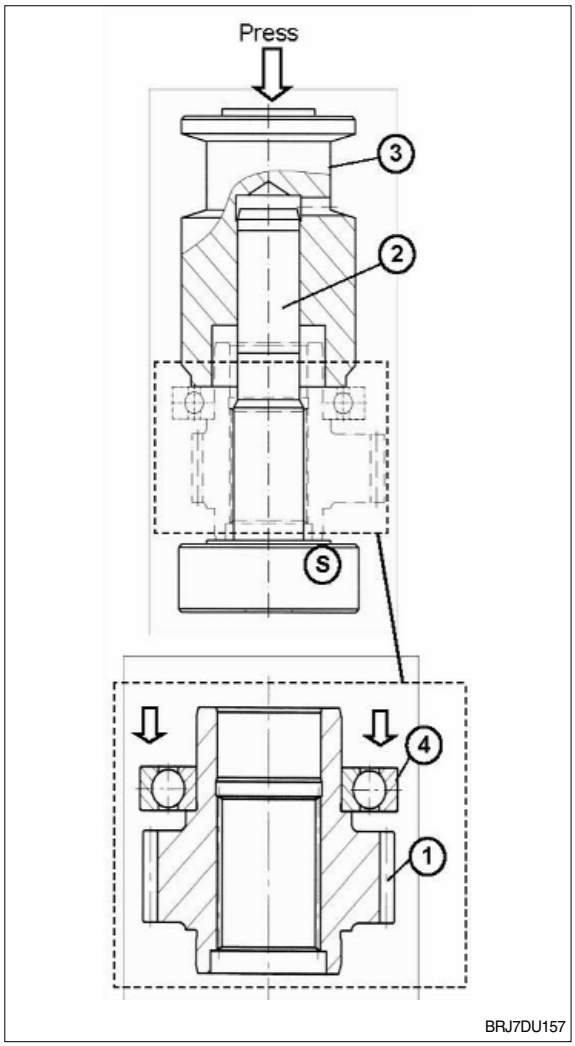
① For mounting of the bearing onto the drive pinion use assembly fixture "S", as shown.

(S) Assembly fixture 62523

② Put the drive pinion (item 1) onto the guide mandrel (item 2) of the assembly fixture and install it until contact is obtained.

③ Put on the ball bearing (item 4) and the pressing sleeve (item 3). By means of a hand lever press, press on the ball bearing with the pressing sleeve onto the drive pinion (item 1) until contact is obtained.

(item 3) Pressing sleeve 63290



BRJ7DU157

④ If there is no hand press available, the bearing can be installed as follows:

⚠ Danger of burnings! Wear safety gloves.

⑤ Heat the ball bearing to max. 90°C and install it onto the drive pinion until contact is obtained.

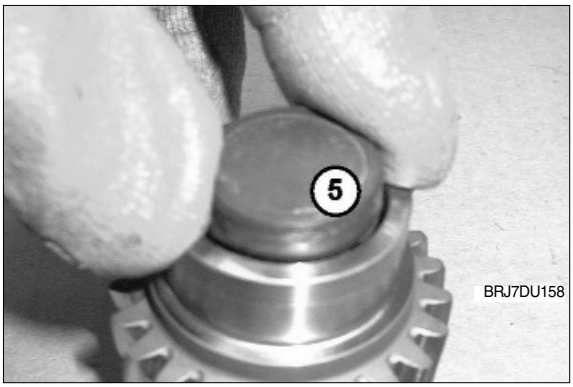
⑥ After cooling down install the bearing subsequently.

(2) Mounting of sealing cap

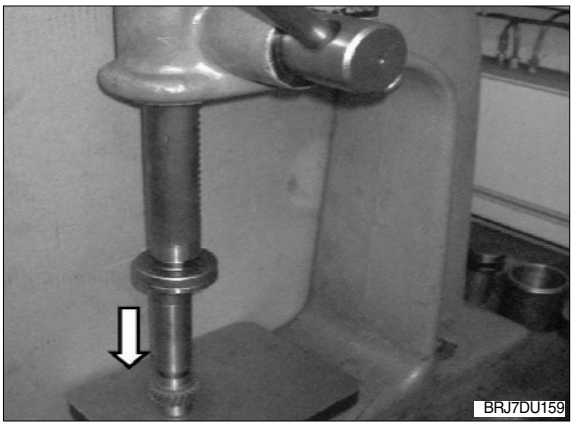
For sealing of the bore in the drive pinion a sealing cap (item 5) must be mounted. This requires the following sealing application:

① LOCTITE 5910 : Product application as adhesive application onto the supporting face and around the bore in the drive pinion as sealing function by excessive product.

② Insert the sealing cap.



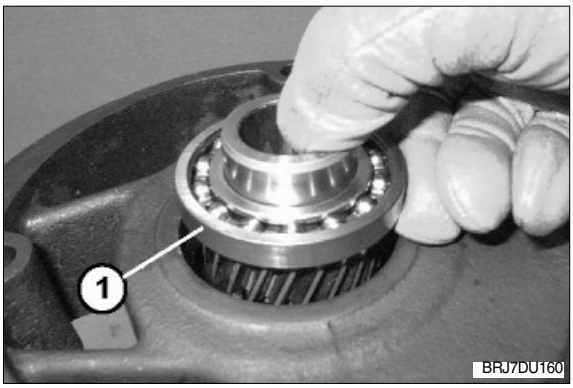
③ Press in the sealing cap with a press until contact is obtained.



(3) Installation of drive pinion

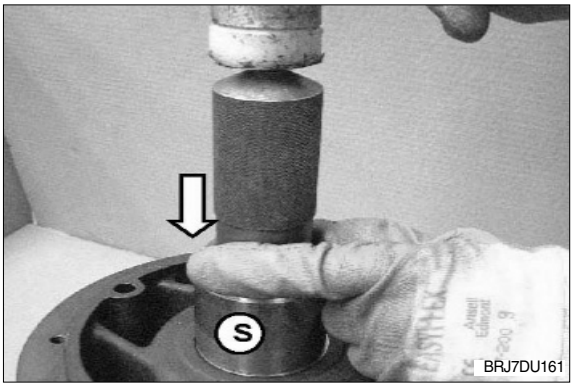
⚠ Pay attention when inserting the drive pinion not to damage the gearing of drive pinion and helical gear. Damages might cause louder running noises and consequential damages!

① Install the preassembled drive pinion (item 1) into the housing bearing bore cautiously. For joining turn the wheel shaft of the transmission cautiously until the drive pinion engages into the gearing of the helical gear.

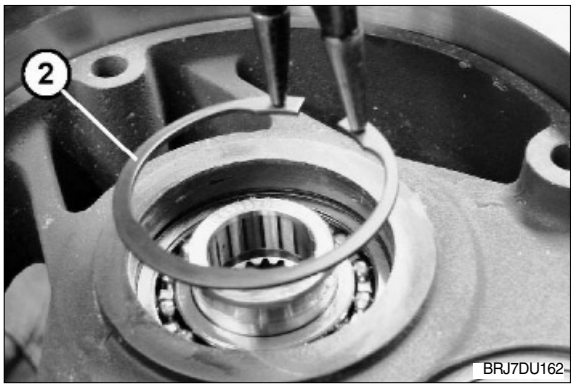


② By means of the striking mandrel "S" install the drive pinion into the bearing seat until contact is obtained.

(S) Striking mandrel 62478



③ Snap the retaining ring (item 2) by means of flat-head pliers into the groove of the housing bore and install it until contact is obtained.

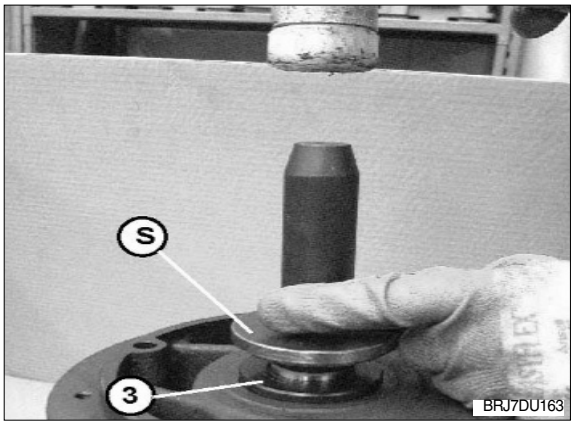


④ Wet the sealing lip of the radial sealing ring with grease (e.g. Shell Alvania R3) slightly.

⑤ Apply a thin and even layer of LOCTITE 574 onto the outer diameter of the radial sealing ring.

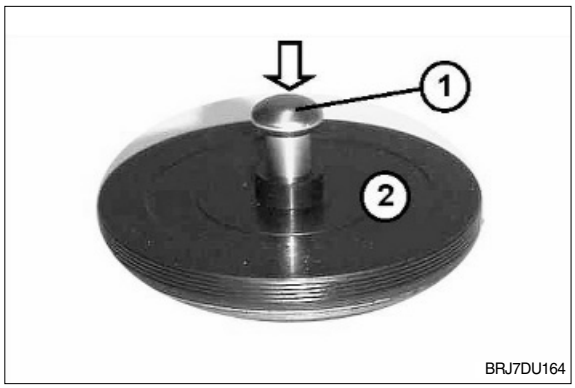
⑥ By means of striking mandrel "S" drive the radial sealing ring with the closed surface upwards into the housing seat until contact at the mandrel is obtained.

(S) Striking mandrel 62521



(4) Installation of sealing cap

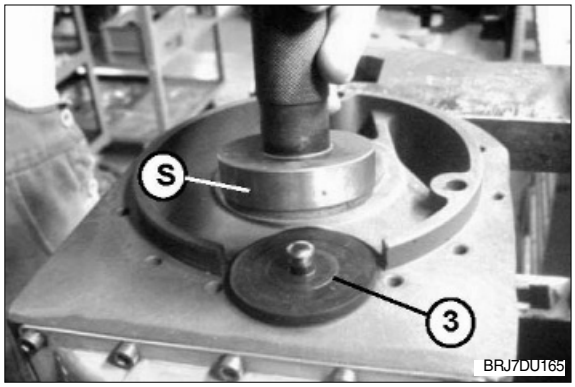
① Press the breather valve (item 1) slightly by hand into the central bore of the sealing cap (item 2) (Reference depth approx. 5mm).



③ Insert the sealing cap with breather valve (item 3) into the boring seat of the housing bore in the bevel pinion shaft.

④ By means of the striking mandrel "S" install the sealing cap subsequently until contact is obtained.

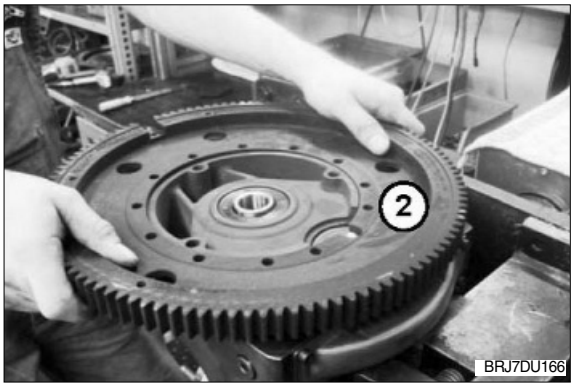
(S) Striking mandrel 62522



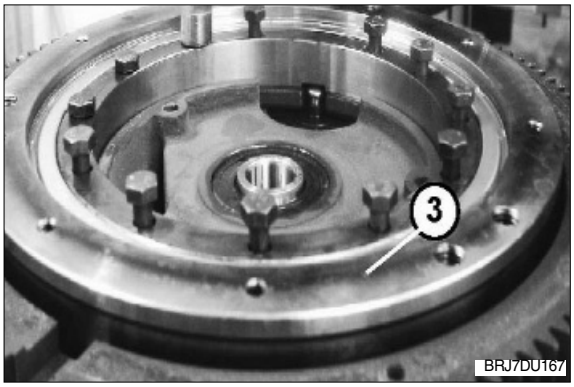
(5) Attachment of pivoted connection geared steering

① Place the gear ring (item 2) and turn it so that the bolt holes match the threaded holes of the connecting construction.

② Install the gear ring with a dead-blow soft face hammer until contact is obtained.



③ Put on the pivoted bogie bearing (item 3) with the peripheral recess upwards and turn it that the bolt holes in the pivoted bogie bearing match with the gear ring and housing hole pattern.



④ Wet screws M8x40-10.9 with LOCTITE 243.

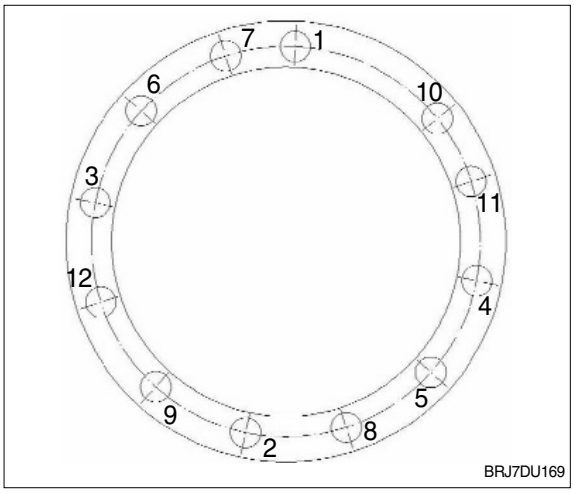
⑤ By means of the screws fasten the pivoted bogie bearing and the gear ring onto the connecting constructions.

⑥ Tighten the screws evenly in the tightening sequence shown in figure 169.

Sequence of tightening:
Number 1 beginning Number 12 end

Tightening torque of cap screws : 34 Nm

⚠ Pay attention for installing of the drive pinion that the gearing of drive pinion and helical gear are not damaged. Damages might cause louder running noises and consequential damages!



Thus the reassembly is ended.

12) GENERAL INSTRUCTIONS AFTER REASSEMBLY

(1) For reinstallation of the power train into the vehicle observe the installation instructions at page 2-7.

(2) Fill in oil according to the operating instructions.

(3) Transmission and vehicle respectively may be used or operated at the earliest 24 hours after the reassembly again.

6. DISPOSAL

Disposal of the replaced components, materials and substances adequately, environmentally friendly and in accordance with the legal regulations for disposal for the respective material :

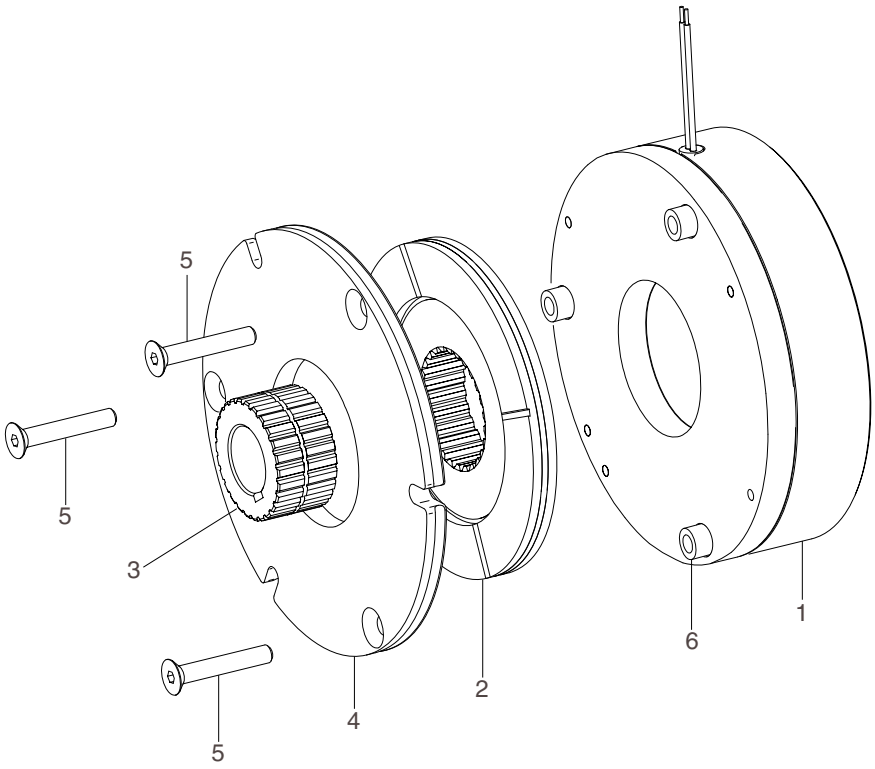
Component	Consisting of	Disposal acc. to the regulations :
Transmission oil		Waste oil
Side cover	Sheet	Scrap metal
Radial sealing ring	Sheet	
Shims	Sheet	
Wheel bolts	Steel	
Grooved ball bearing	Steel	
Screw	Steel	
O-ring	PE	PE plastic materials
Shaft seal	PE	
Sealing cap	PE	

SECTION 4 BRAKE SYSTEM

SECTION 4 BRAKE SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. STRUCTURE



10BOP7EB01

1	Inductor	4	Flange
2	Friction disc	5	Screw
3	Hub	6	Adjusting spacer

2. SPECIFICATION

Description	Unit	Specification
Nominal torque(Standard version)	N.m	70
Nominal airgap(S+0.1/-0.5)	mm	0.35
Nominal torque	N.m	9.1(M6 on Ø 132mm)
		22(M8 on Ø 145mm)
		9.1(M6 on Ø 168mm)

3. PRE-INSTALLATION CHECKS

Check that in the process of unpacking and subsequent handling prior to assembly, the mounting features and parts of the brake are undamaged. Prior to fitting, remove and clean off any foreign matter which may have found its way into the assembly during transit, also ensure that the interfaces to which the brake is mounted are clean and free from burrs or swellings.

4. PRECAUTIONS AND RESTRICTIONS ON USE

1) RESTRICTIONS ON USE

(1) The equipment is designed for dry running. Friction faces must be kept completely clean of any oil, grease or abrasive dust.

(2) Exceeding the maximum rotation speeds stated in the specification invalidates the warranty.

(3) The equipment can be fitted either horizontally.

(4) This equipment is designed for an ambient temperature of 40° F maximum (155° C insulation class).

2) PRECAUTIONS AND SAFETY MEASURES

⚠ During maintenance, ensure that the mechanism to be braked by the equipment is at rest and that there is no risk of accident start-up. All interventions have to be made by qualified personnel owning this manual.

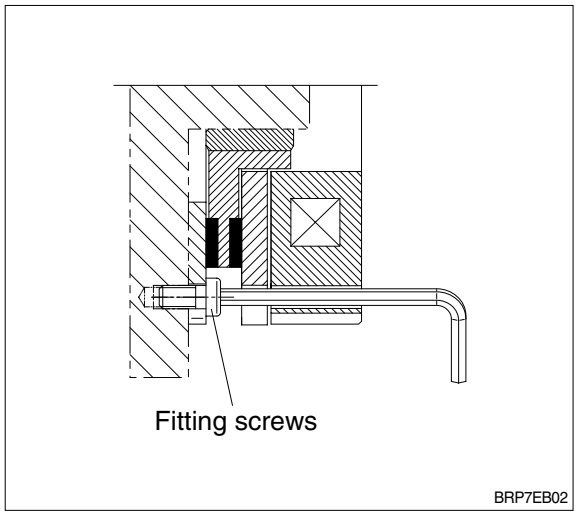
⚠ Any modification made to the brake without the express authorization of representative of Hyundai, in the same way than any use out of the contractual specifications accepted by Hyundai, will result in the warranty being invalidated and Hyundai will no longer be liable in any way with regard to conformity.

5. REASSEMBLY AND INSTALLATION

1) PK brakes are delivered completely assembled.
2) Put the key into the shaft then slide the hub (#3) onto the shaft and secure it axially by suitable means.
3) Slide the brake onto the hub (#3), taking care not to damage the splines of the disc (#2). Make sure that the disk locates properly on the splines of the hub.
4) Secure the brake in position using suitable screws, (see fig. EB02 and Spec). Secure the fitting screws using a loctite 270 type thermoplastic liquid.
5) Switch the equipment on and confirm that the friction disc rotates freely.

⚠ Do not grease the guiding splines (friction disc / hub). It will change the brake's performances.

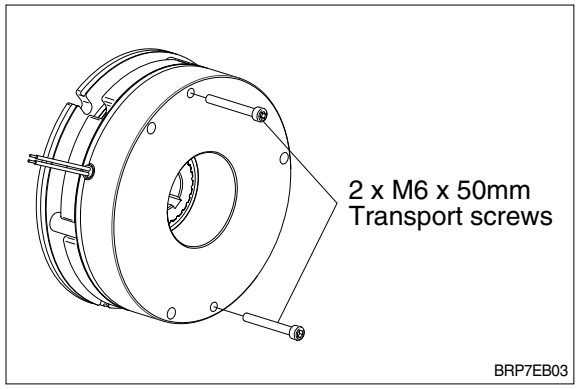
⚠ Respect obligatory the direction of the hub when mounting (see the brake drawing).



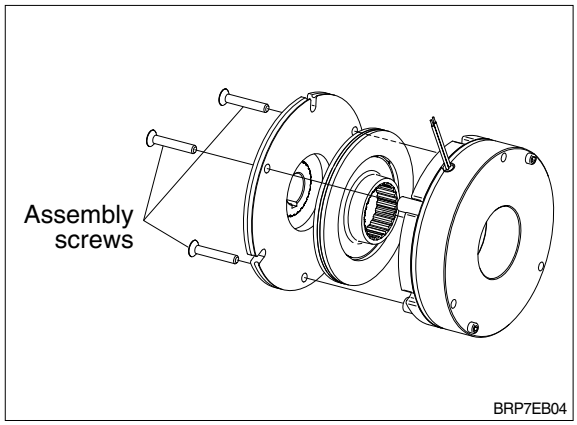
6. DISC REPLACEMENT

⚠ When the maximum airgap is reached, the brake will not release correctly. It is then necessary to replace the friction disc.

1) To replace the friction disc (#2), fit transport screws on the brake (fig. EB03), then remove the brake from the motor.
2) Undo the assembly screws (#5) then take out the flange (#4) and the friction disc (#2), fig. EB04.



3) Put the new friction disc into position, fit the flange (#4) and the assembly screw (#5) secured with loctite 221 or similar.



7. ELECTRICAL CONNECTION

1) IMPORTANT RECOMMENDATIONS

⚠ All works on the electrical connections have to be made with power off.

⚠ Ensure compliance with the nominal supply voltage (inadequate supply causes a reduction in the starting distance).

The connecting wires should be of sufficient diameter to prevent voltage drops between the source and equipment supplied.

I (A) / L (m)	0 to 10 m	From 10 to 20 m
0 to 3 (A)	1.5 mm^2	1.5 mm^2
3 to 6 (A)	1.5 mm^2	2.5 mm^2

Tolerance for the supply voltage to the brake terminals +5% / -10% (NF C 79-300).

8. MAINTENANCE

The brake is required to be kept in good working order and must be included in the planned maintenance program. This must include regular examination for wear and removal of friction dust caused by friction facing wear. The frequency of inspection depends on the duty demanded of the brake.

9. TROUBLESHOOTING AND FAULT ELIMINATION

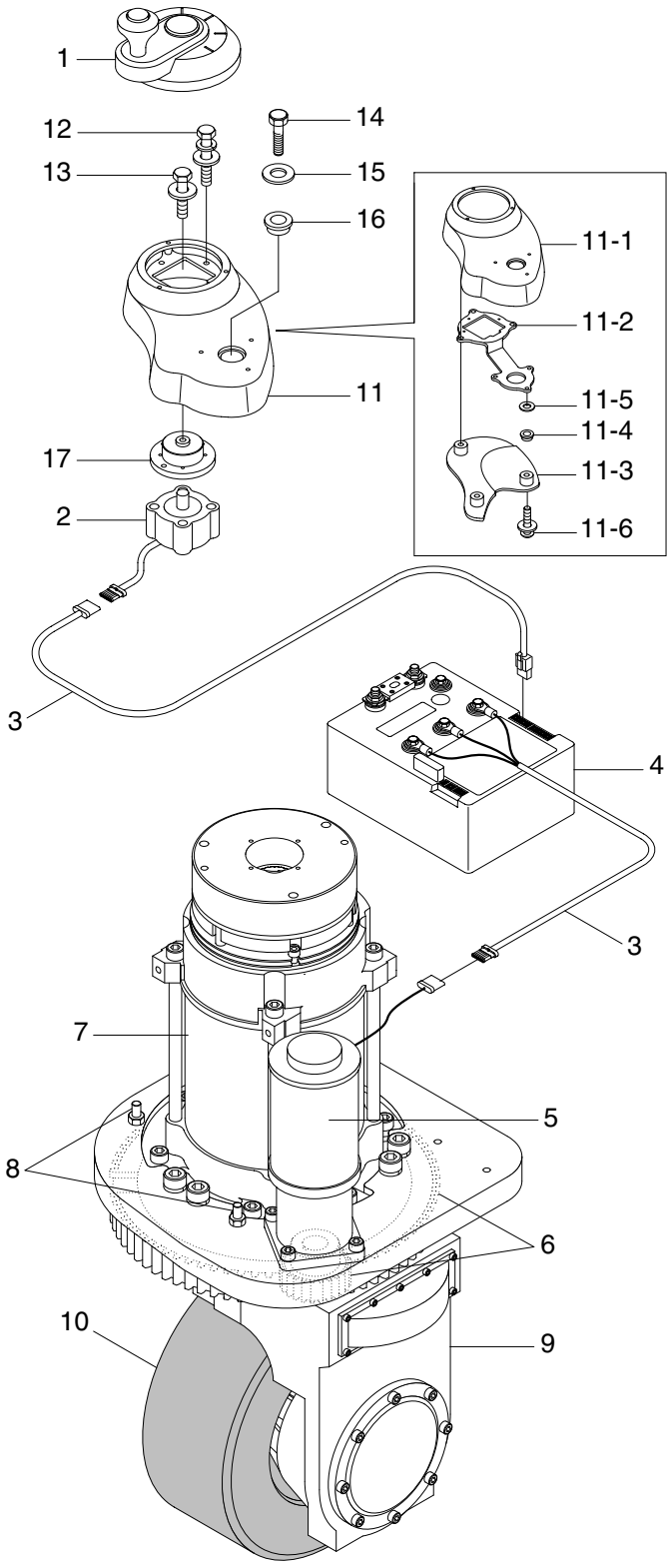
Fault	Cause	Remedy
Brake does not release.	· Power supply is too low. · Power supply is interrupted. · Airgap too large. · Worn disc · Coil is damaged. · Voltage present at switch off position.	· Adjust power supply. · Reconnect power supply. · Replace the disc. · Replace the disc. · Replace the brake. · Check the customer's power supply.
Brake does not brake.	· Grease on friction faces.	· Replace the disc.
Nuisance braking.	· Power supply is too low.	· Adjust power supply.

SECTION 5 STEERING SYSTEM

SECTION 5 STEERING SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

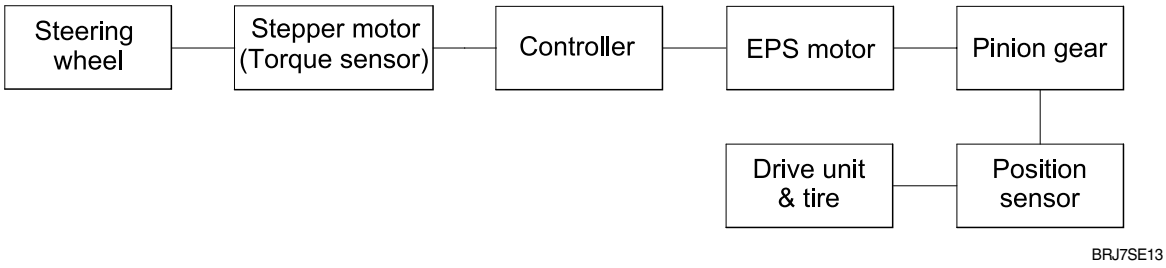
1. STRUCTURE



1	Steering wheel
2	Stepping motor
3	Main harness
4	Controller sub assy
5	EPS motor
6	Pinion & steering gear
7	Traction motor
8	Position sensor assy
9	Drive unit
10	Drive tire
11	Steering panel assy
11-1	Steering panel
11-2	Panel bracket
11-3	Panel cover
11-4	Hex nut
11-5	Washer
11-6	Screw
12	With washer bolt
13	With washer bolt
14	Hex bolt
15	Washer
16	Rotation
17	Boss sub assy

BRP7SE02

2. FUNCTION



BRJ7SE13

1) Steering wheel

(1) It decides the direction of rotation of the truck.
(2) It transmits the handling of operator.

2) Stepper motor

(1) It is sensing the operation of steering wheel.
(2) It is transmits the output signal to controller.

3) Controller

(1) It decides the torque and the direction of rotation of motor.
(2) It supplied power to motor.

4) EPS motor

(1) It transmits torque to pinion gear.

5) Pinion gear

(1) It increases torque to drive unit steering gear.

6) Position sensor

(1) It is sensing angle of steering.
(2) It transmits resistance to controller.

7) Tire

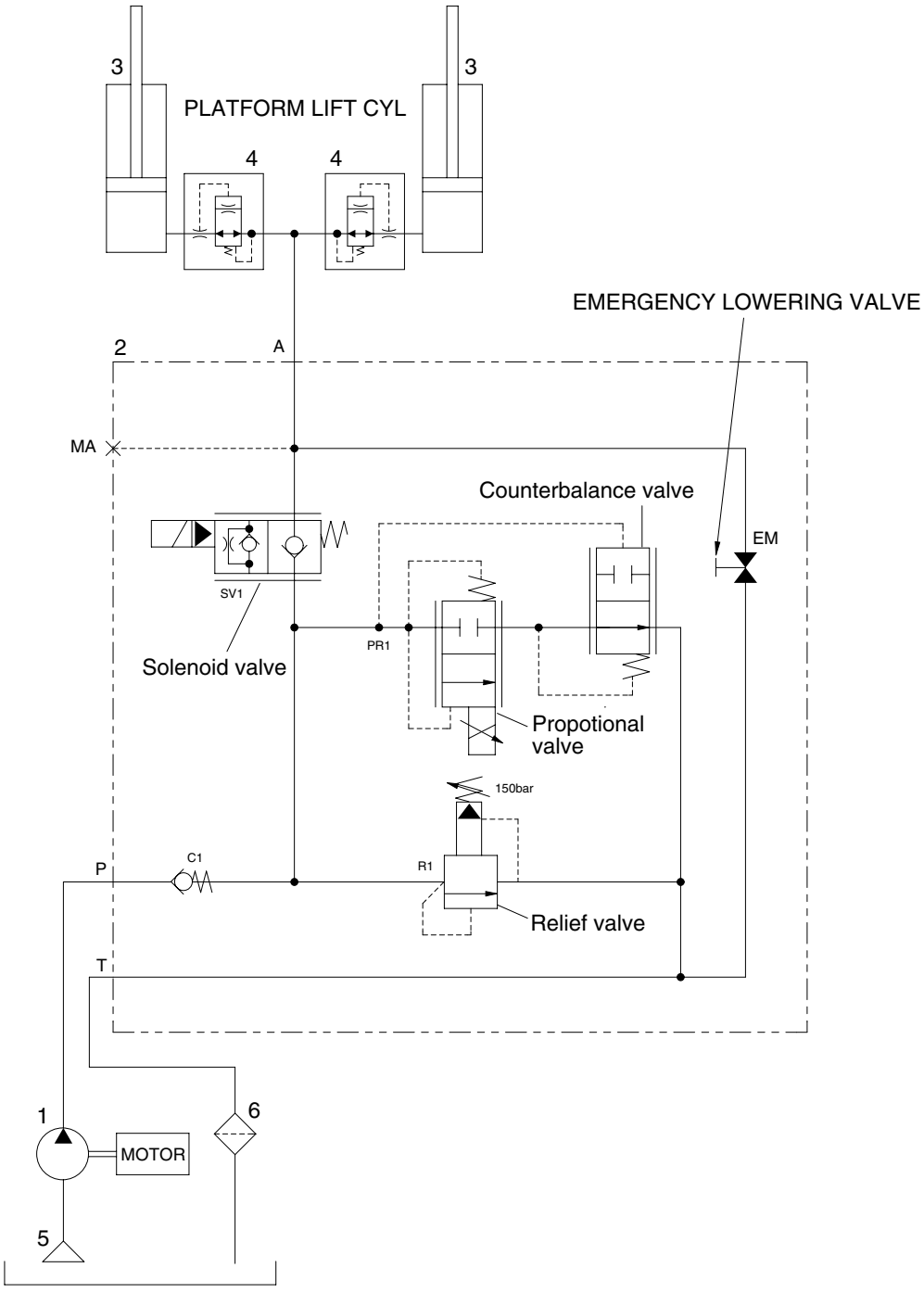
(1) It is rotated by the transmitted torque.

SECTION 6 HYDRAULIC SYSTEM

SECTION 6 HYDRAULIC SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

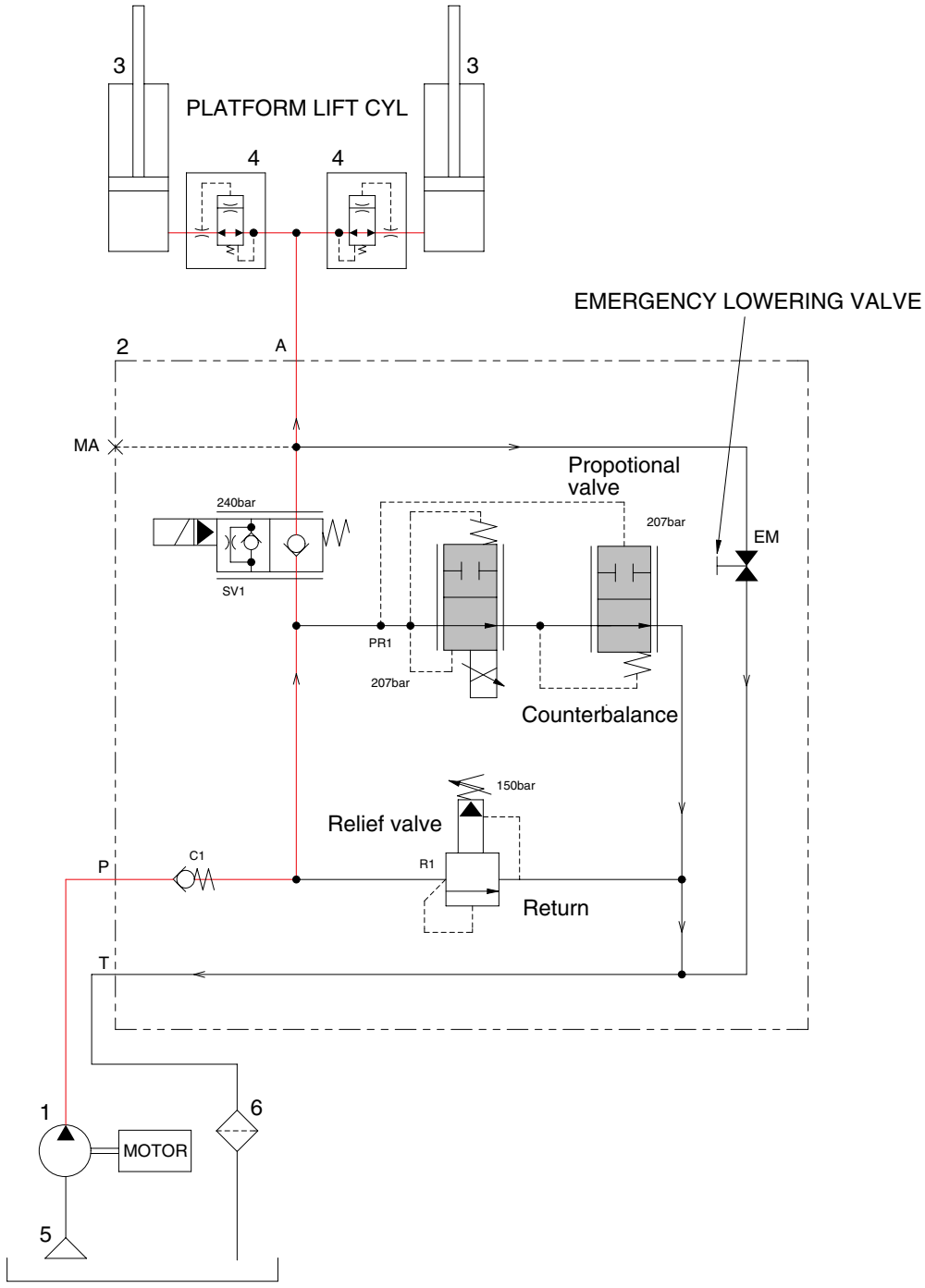
1. HYDRAULIC CIRCUIT



10BOP7HS01

1	Hydraulic pump	4	Safety valve
2	Manifold assy	5	Strainer
3	Platform lift cylinder	6	Return filter

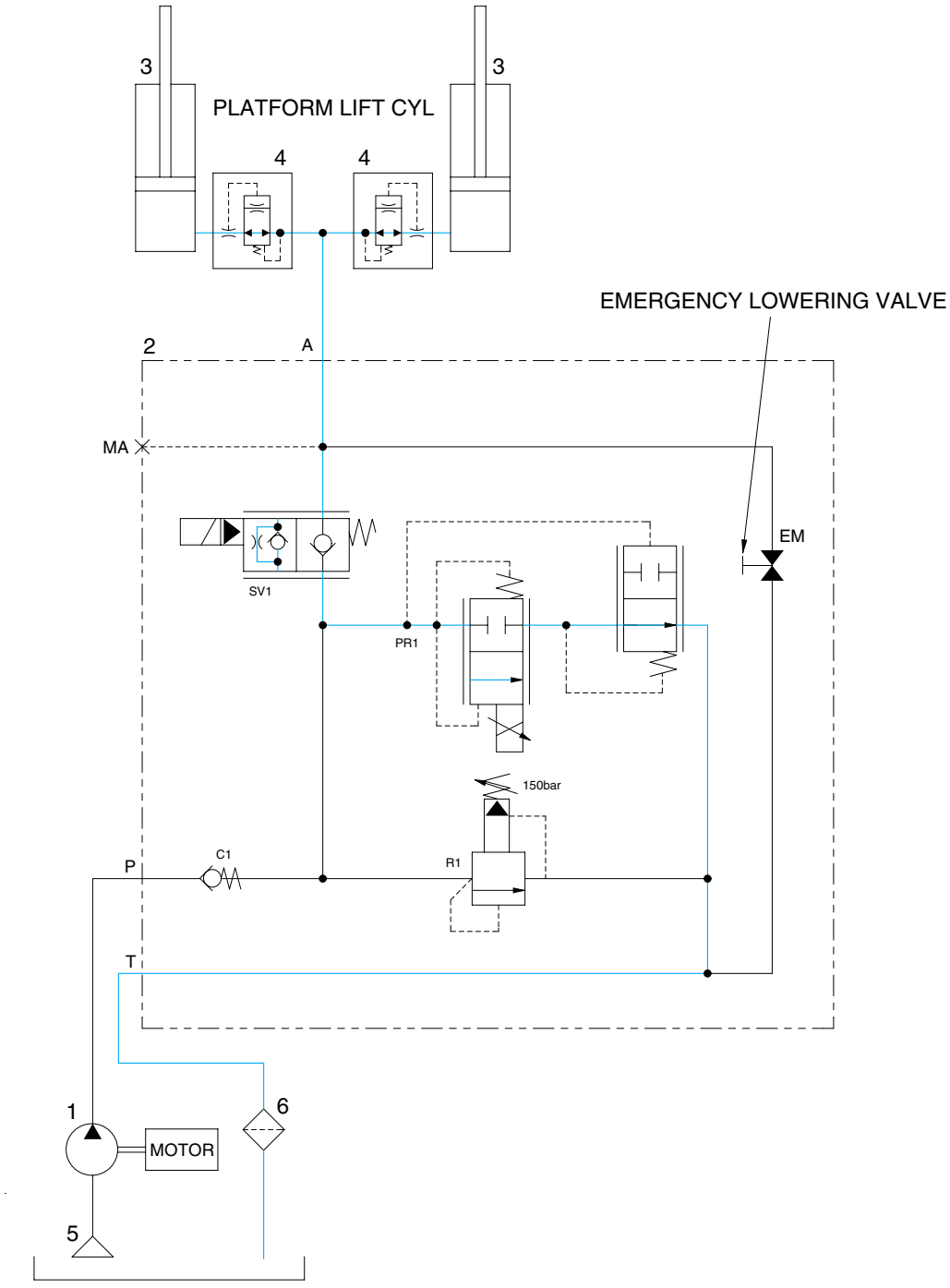
1) WHEN THE MULTIFUNCTION LEVER IS IN THE LIFT POSITION



10BOP7HS02

When turning the lift grip of the multifunction lever clockwise the oil from the hydraulic pump(1) flows into the manifold assy(2) and then get into the large chamber of the platform lift cylinder(3).
The air of the small chamber of the platform lift cylinder(3) is compressed at the same time.
When this happens, the forks go up.

2) WHEN THE MULTIFUNCTION LEVER IS IN THE LOWER POSITION

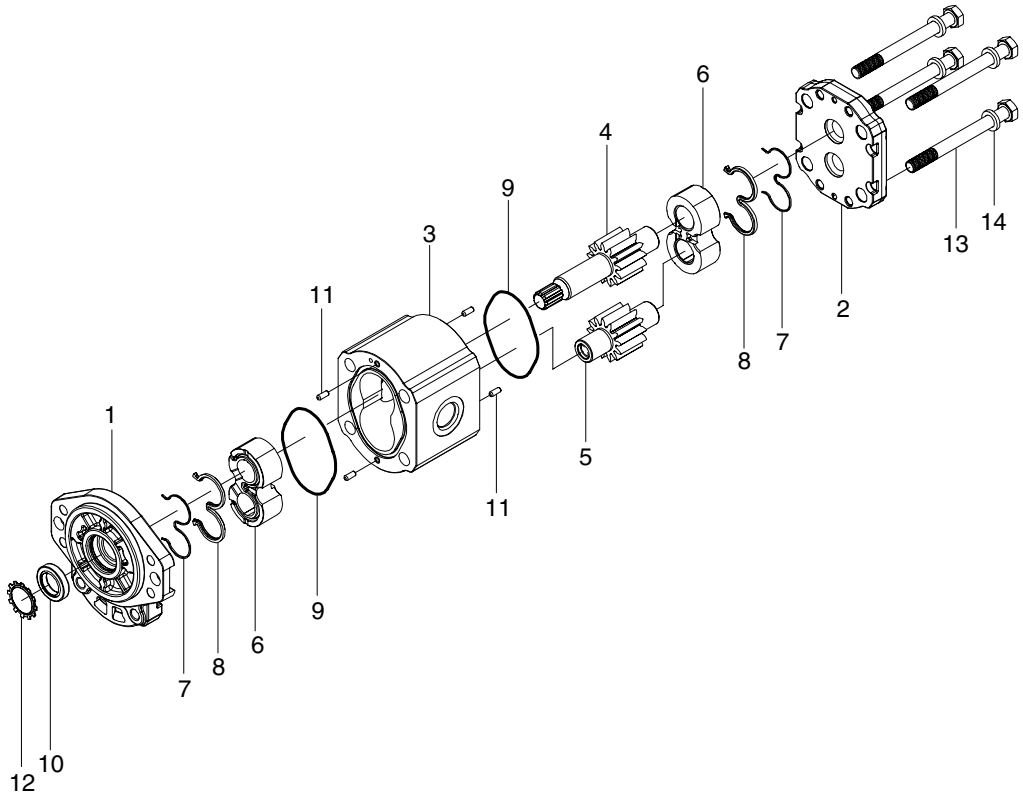


10BOP7HS03

When turning the lift grip of the multifunction lever to counterclockwise, the solenoid valve is energized and then the work port(A) and the large chamber are connected to the return passage, so the fork will be lowered due to its own weight.

2. HYDRAULIC GEAR PUMP

1) STRUCTURE



BRJ7HS19

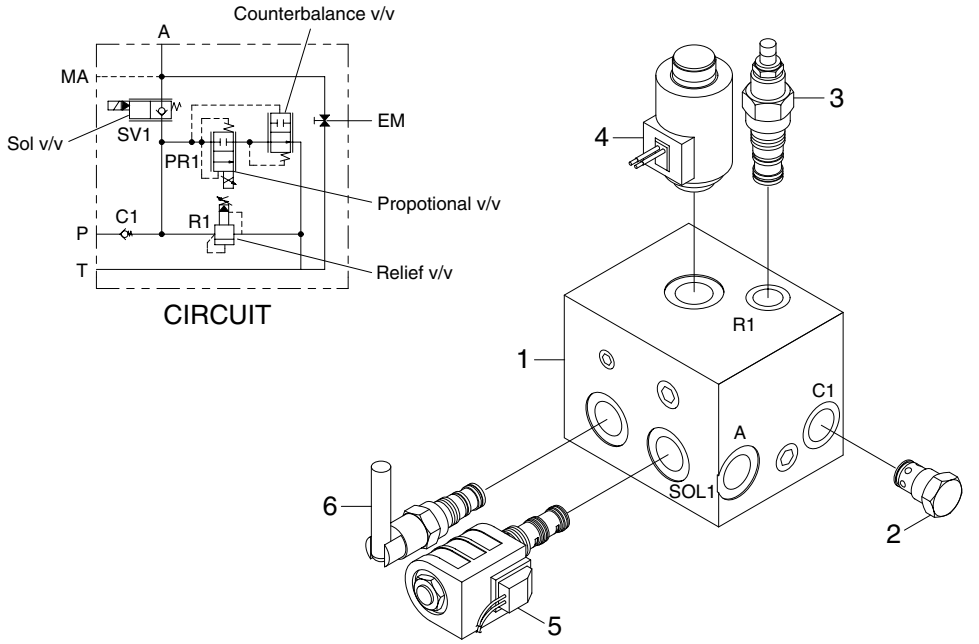
1	Mounting flange	6	Bearing block	11	Dowel pin
2	End cover	7	Backup ring	12	Start ring
3	Gear housing	8	Seal	13	Socket head bolt
4	Drive gear	9	O-ring	14	Spring washer
5	Idler shaft	10	Shaft seal		

2) OPERATION

This pump comprises of an rear cover, a body, bushings and a housing bolted together with bolts. The gear journals are supported in side plate within pressure balanced bushings to give high volumetric and mechanical efficiencies.

3. MANIFOLD VALVE

1) STRUCTURE



Port name	Size	Port
Inlet port	7/8-14UNF	P
Outlet port	7/8-14UNF	T
Work port	7/8-14UNF	A
Gauge port	9/16-18 UNF	MA

10BOP7HS12

1	Block	3	Relief valve	5	Solenoid valve
2	Check valve	4	Proportional valve	6	Emergency lever

2) EMERGENCY LOWERING

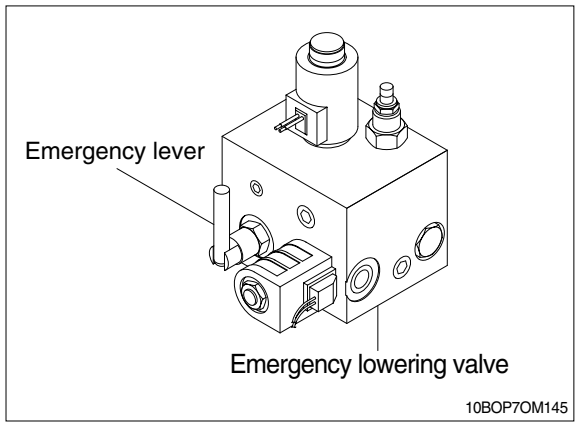
In case that the mast cannot be lowered due to a problem in the controller, activate the emergency lowering valve on the manifold assy by pulling the emergency lever.

(1) Turn off the electric emergency switch.

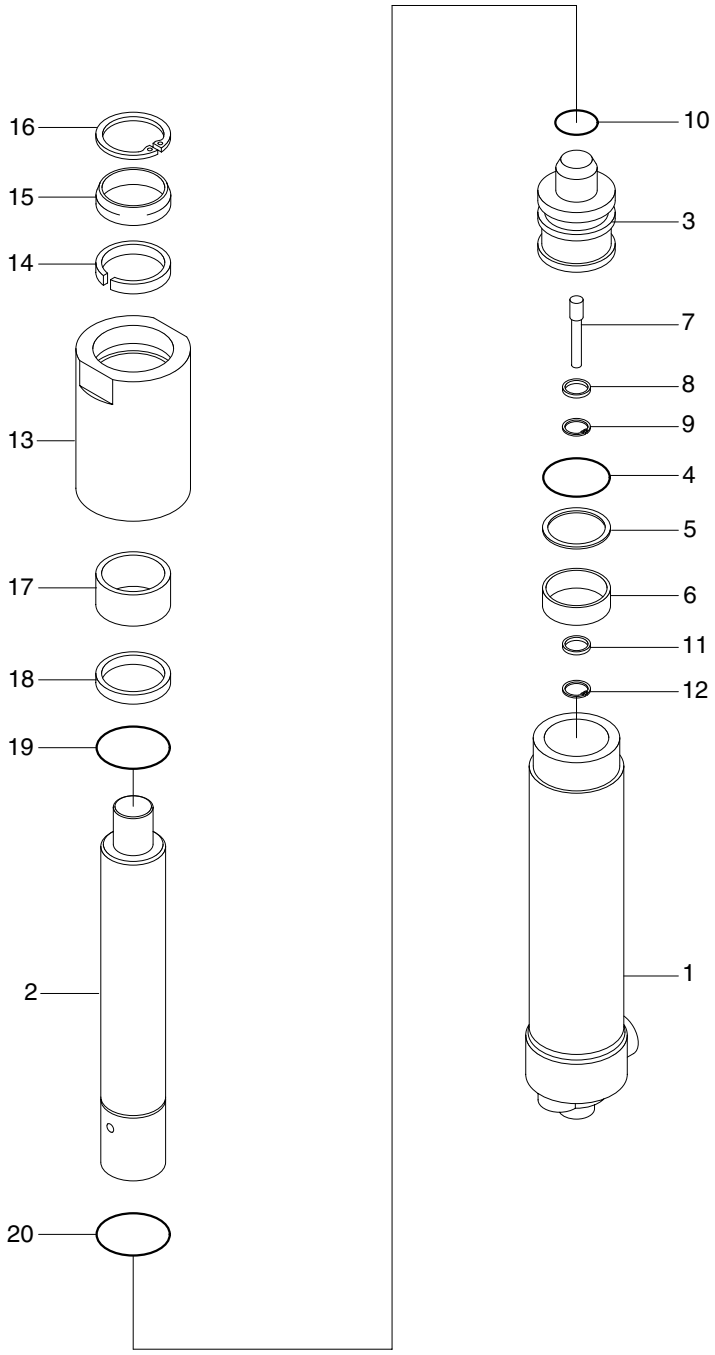
(2) In order to activate the emergency lowering valve, pull the emergency lever which is mounted on the manifold assy.
The lowering speed is increased according as the pulling angle of the emergency lever is getting bigger.

(3) After lowering, close the emergency lowering valve.

⚠ When operating the emergency lowering valve in order to lower the mast inevitably, always make certain that any person should not stand or pass under the mast, the forks and platform so as to avoid from unexpected accident such as severe personal injury or death.



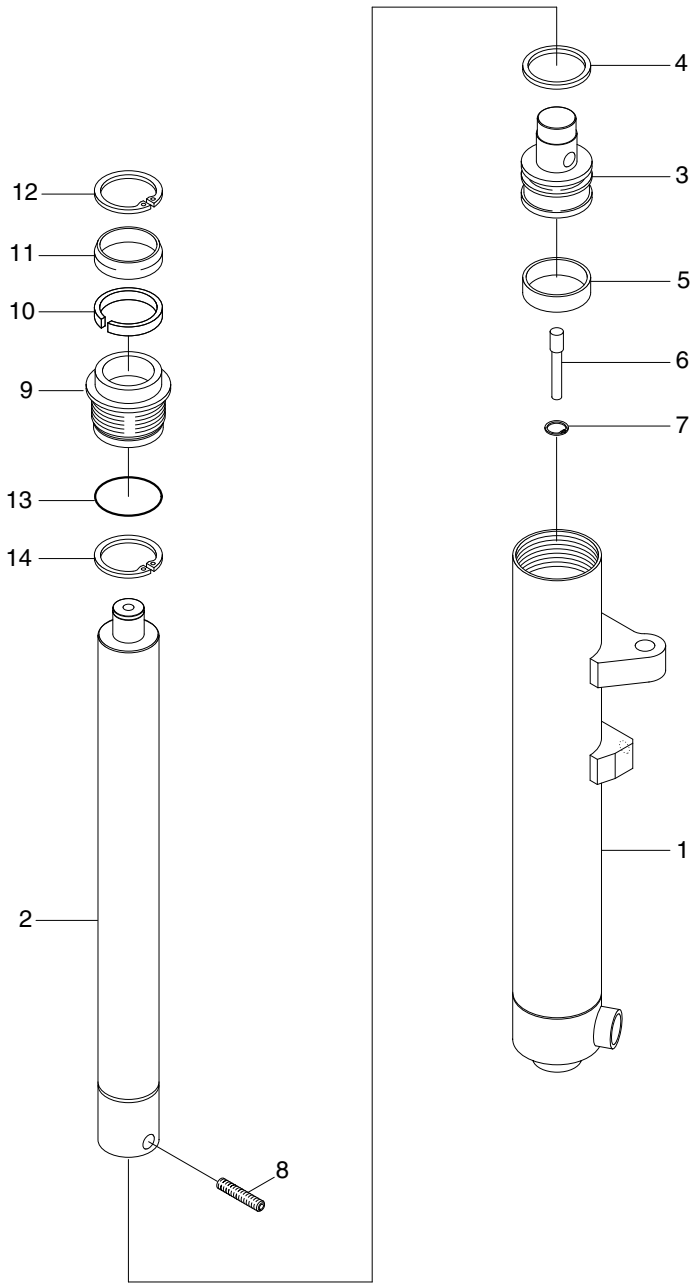
4. LIFT CYLINDER



BRP7HS21

1	Tube assy	8	Spacer	15	Dust wiper
2	Rod	9	Retaining ring	16	Retaining ring
3	Piston	10	Stop ring	17	Wear ring
4	U-packing	11	Cushion seal	18	Dust ring
5	Back up ring	12	Retaining ring	19	O-ring
6	Wear ring	13	Rod cover	20	Stop ring
7	Check valve	14	U-packing		

5. FREE LIFT CYLINDER

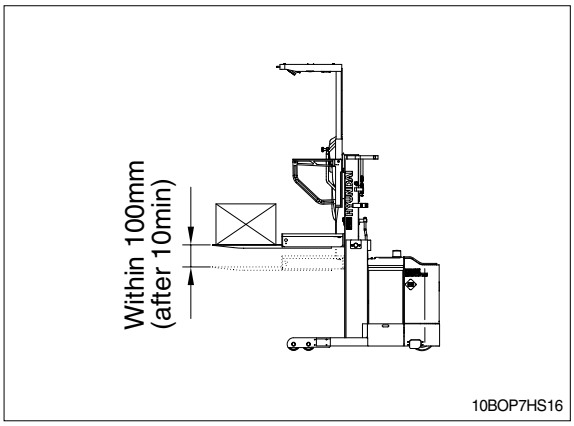


10BOP7HS23

1	Tube assy	6	Check valve	11	Dust wiper
2	Rod	7	Retaining ring	12	Retaining ring
3	Piston	8	Set screw	13	O-ring
4	Piston seal	9	Rod cover	14	Back up ring
5	Wear ring	10	U-packing		

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS



1) CHECK ITEM

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

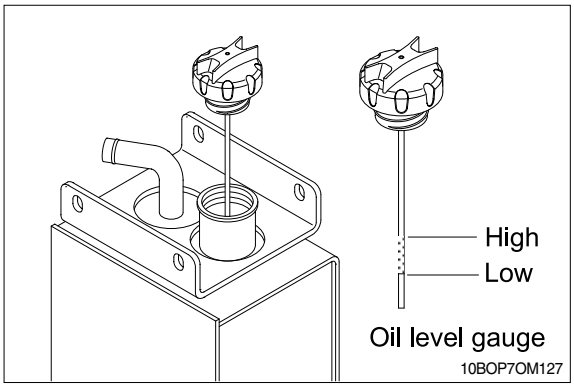
(2) Load maximum load, set mast vertical and raise 1m from ground. Wait for 10 minutes and measure hydraulic drift(amount forks move down and amount mast tilts forward).

· **Hydraulic drift**

- Down(Downward movement of forks)
  : Within 100mm(3.9in)

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

2) HYDRAULIC OIL



(1) Measure oil level using dipstick, and refill oil if necessary.

(2) Before changing hydraulic oil, take out and clean strainer which is assembled with flange after loosening the bolts and replace the element of the return filter if necessary. (Change interval of the return filter : 2000 hours)

3) MANIFOLD ASSY

(1) Raise forks to maximum height and measure oil pressure.
Check that oil pressure is 150kgf/cm^2.
(2130psi)

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.
Slow fork lifting	· 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 ISO VG 46. · 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.
High oil temperature	· Lack of hydraulic oil. · High oil viscosity. · Oil filter clogged.	· Add oil. · Change to SAE80W-90LSD, class API GL-5 gear 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) LIFT CYLINDER

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

GROUP 3 DISASSEMBLY AND ASSEMBLY

1. HYDRAULIC GEAR PUMP

※ **Tools required**

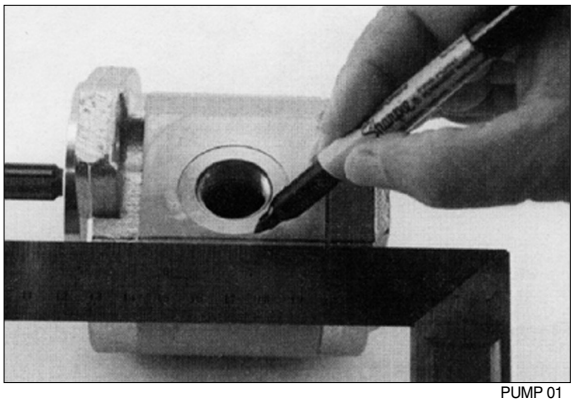
- Metric socket set
- Internal snap ring pliers
- Shaft seal sleeve
- Torque wrench

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

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

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

(4) Remove key from drive shaft if applicable.

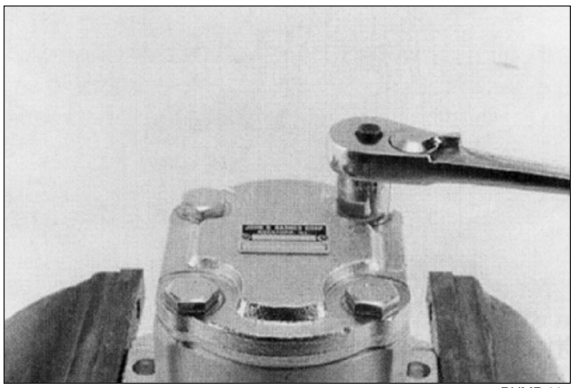


PUMP 01

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

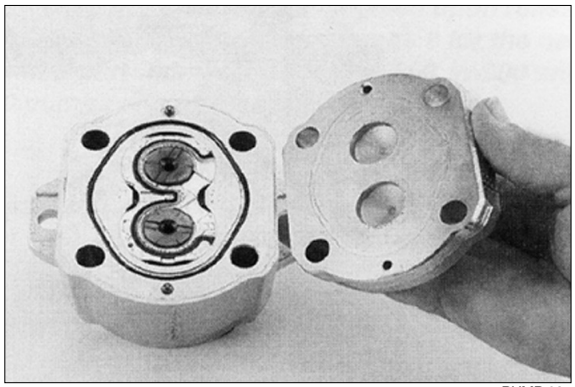
(6) Loosen the four metric hexagon head bolts.

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



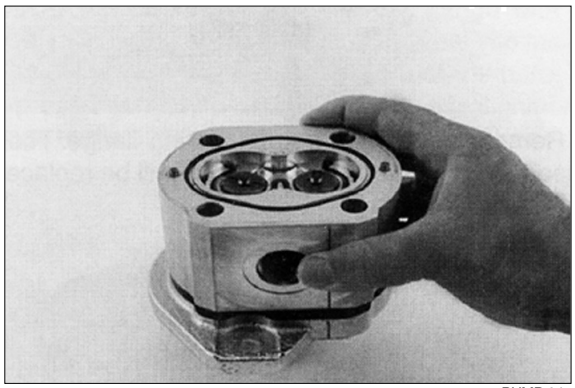
PUMP 02

(8) Lift and remove end cover.



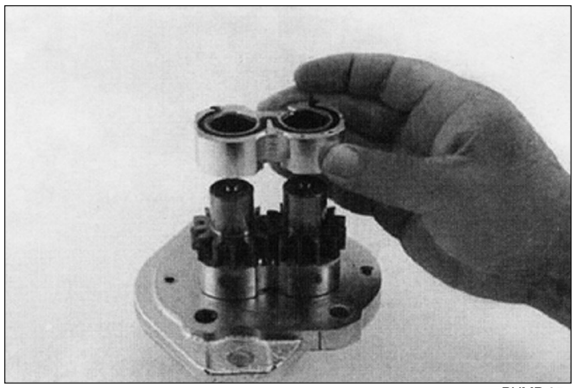
PUMP 03

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



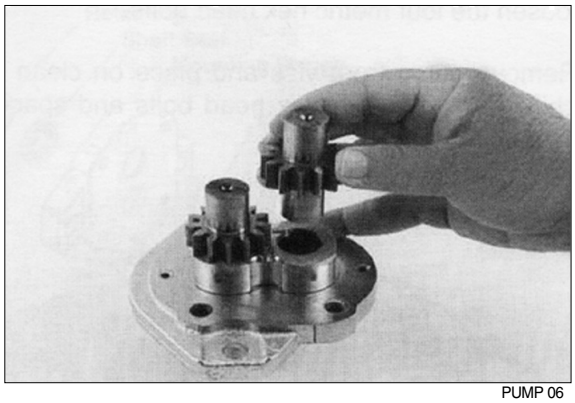
PUMP 04

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



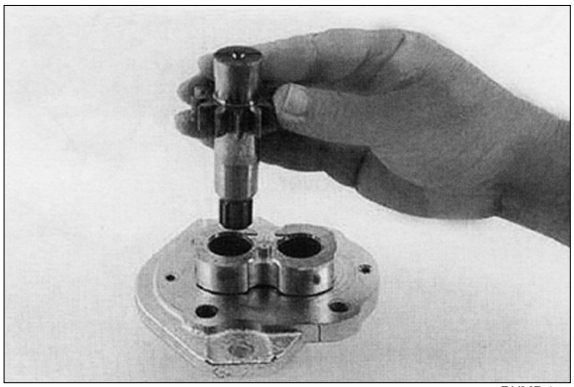
PUMP 05

(11) Remove idler shaft from bearing block.



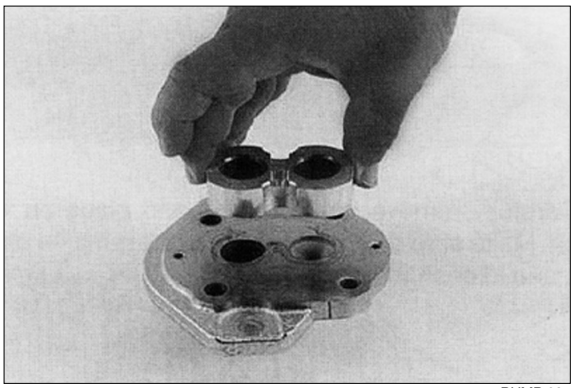
PUMP 06

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



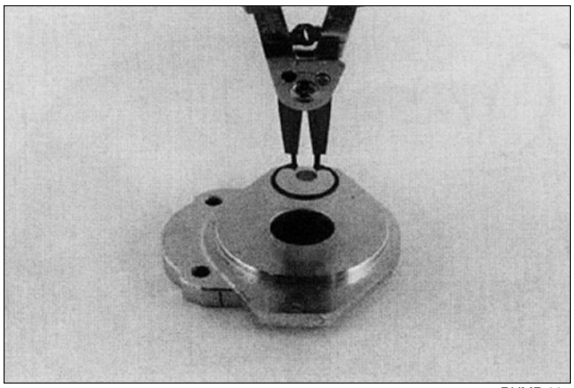
PUMP 07

(13) Remove the front bearing block.



PUMP 08

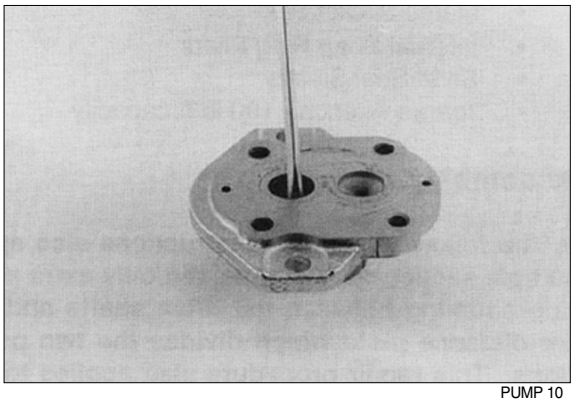
(14) Turn mounting flange over, with shaft seal up, and remove the retaining ring with proper snap ring pliers.



PUMP 09

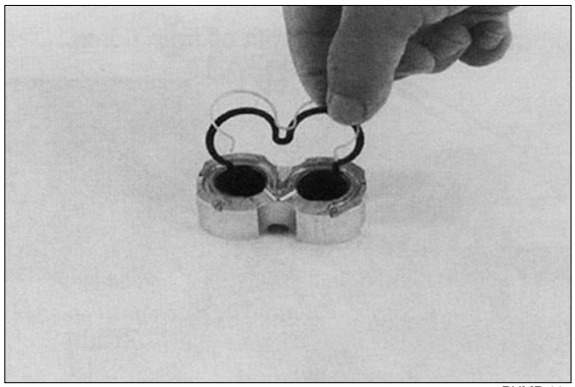
(15) Remove the oil seal from mounting flange, be careful not to mar or scratch the seal bore.

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



PUMP 10

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



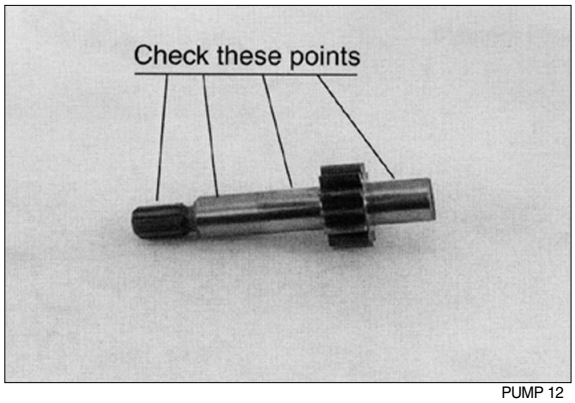
PUMP 11

2) INSPECT PARTS FOR WEAR

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

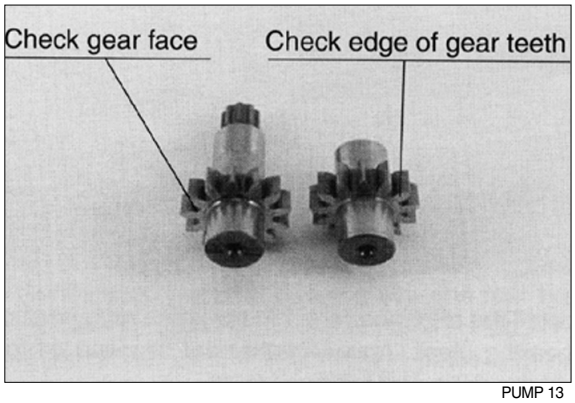
(2) Check drive shaft spline for twisted or broken teeth, check keyed drive shaft for broken or chipped keyway. No marks or grooves on shaft in seal area, some discoloration of shaft is allowable.

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



PUMP 12

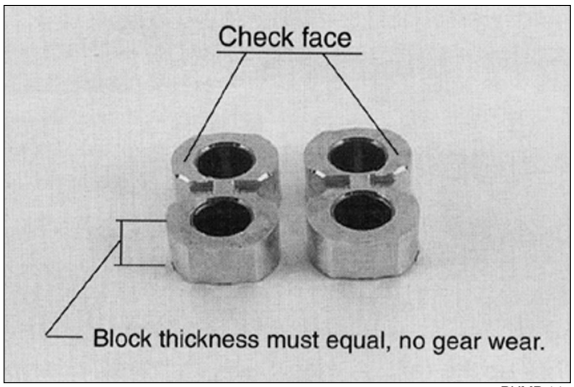
(4) Inspect gear face for scoring or excessive wear. If the face edge of gear teeth are sharp, they will mill into the bearing blocks. If wear has occurred, the parts are unusable.



PUMP 13

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

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



PUMP 14

※ **General information**

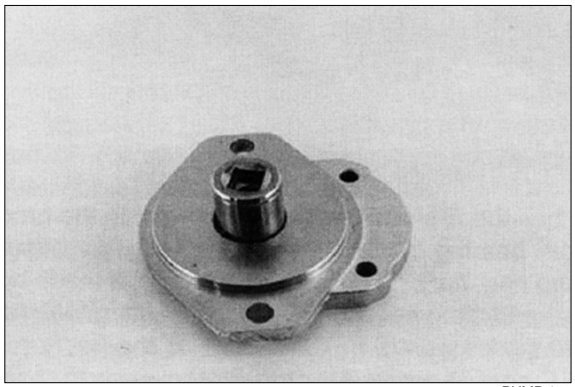
It is important that the relationship of the mounting flange, bearing blocks and gear housing is correct. Failure to properly assemble this pump will result with little or no flow at rated pressure.

※ **This pump is not bi-rotational.**

3) ASSEMBLY

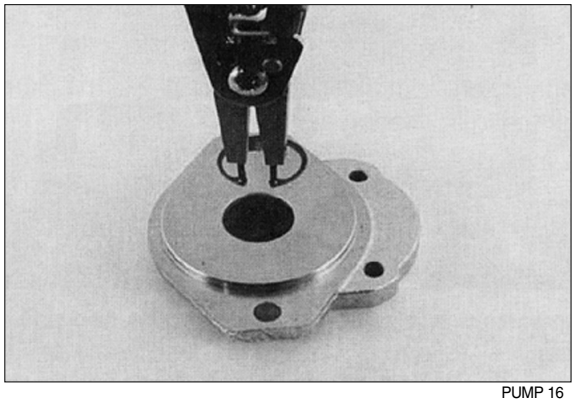
※ **New seals should be installed upon reassembly of pump.**

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



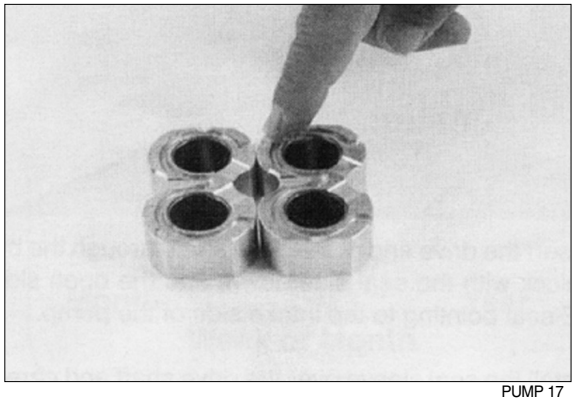
PUMP 15

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



PUMP 16

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

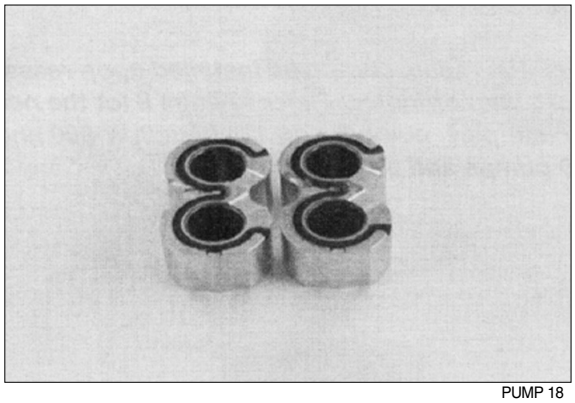


PUMP 17

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

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

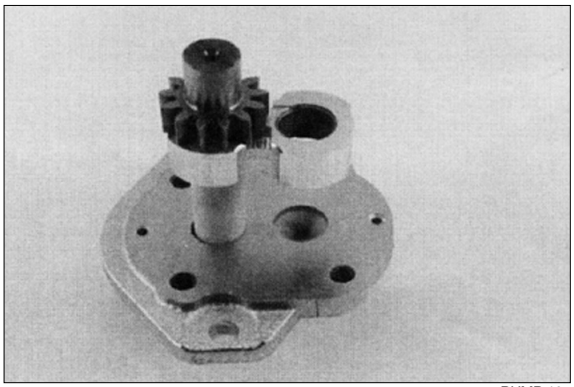
(6) Apply a light coating of petroleum jelly to the exposed face of the front bearing block.



PUMP 18

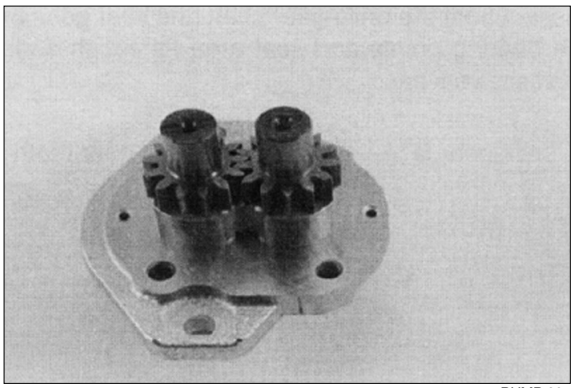
(7) Insert the drive end of the drive shaft through the bearing block with the seal side down, and the open side of the E-seal pointing to the intake side of the pump.

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



PUMP 19

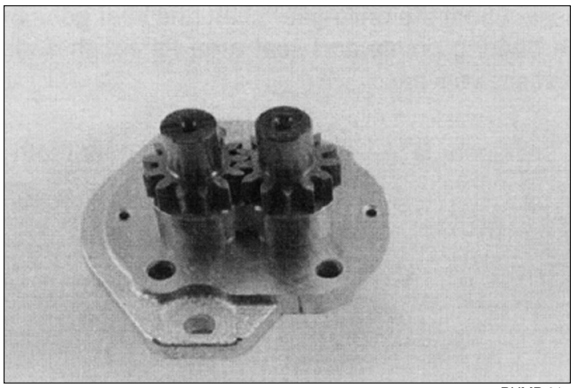
(9) Install the idler gear shaft in the remaining position in the bearing block. Apply a light coat of clean oil to the face of the drive and idler gears.



PUMP 20

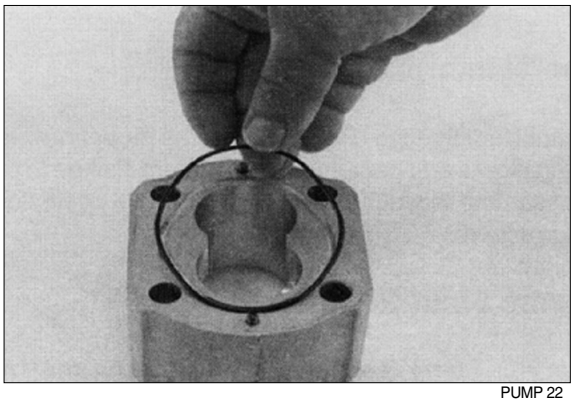
(10) Pick up the rear bearing block, with seal side up and with open end of the E-seal facing the intake side of the pump, place over the drive and idler gear shafts.

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



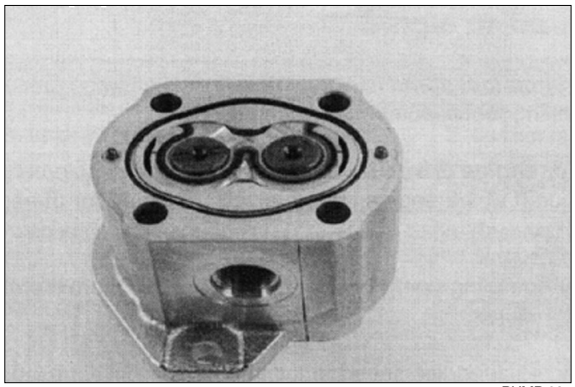
PUMP 21

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



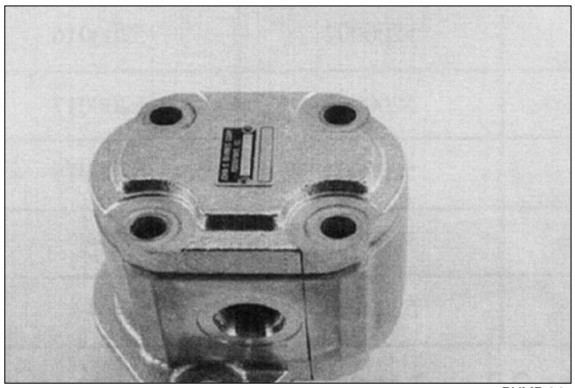
PUMP 22

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

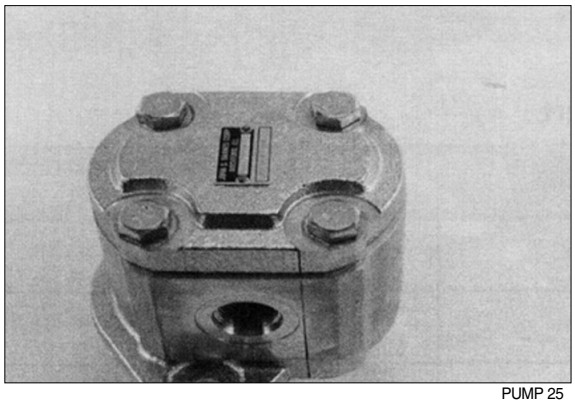

PUMP 23

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

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


PUMP 24

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

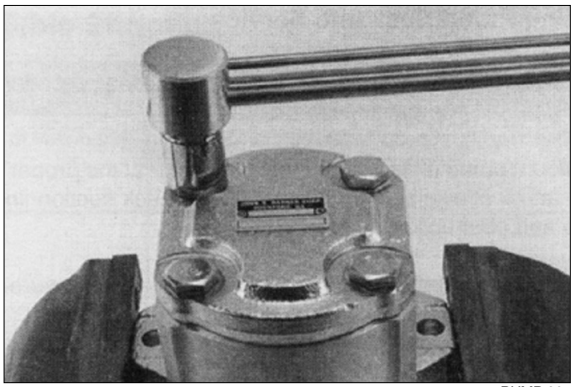

PUMP 25

(17) Place mounting flange of the pump back in the protected jawed vise and alternately torque the bolts.

· Tighten torque : 6~7kgf · m
(43.4~50.6lbf · ft)

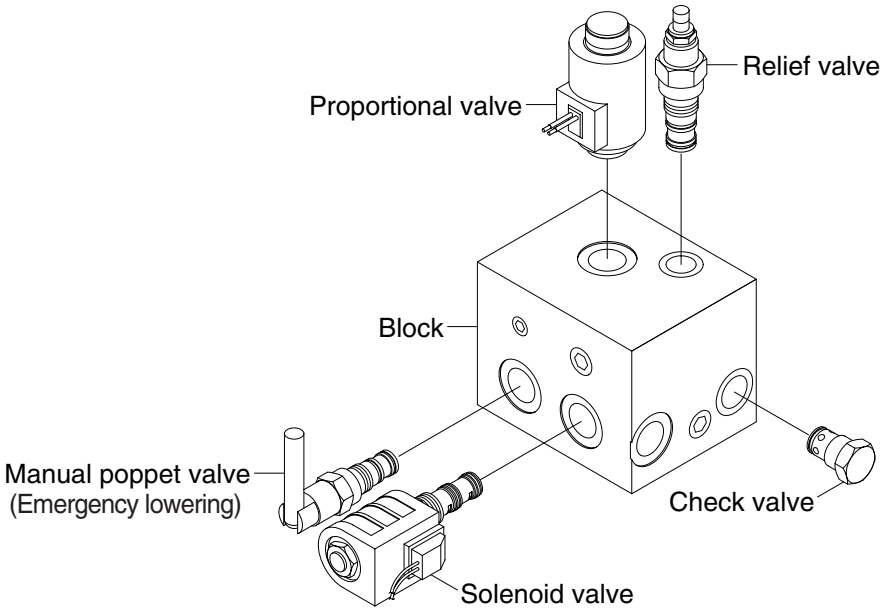
(18) Remove pump from vise.

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



PUMP 26

2. MANIFOLD VALVE



10BOP7HS13

1) ASSEMBLY INSTRUCTION

(1) General

① Ensure that the assembly area will be clean and free of contamination.
Use a flat (within 0.5㎜) work surface when bolting the valve sections together.
Use calibrated torque wrenches and instrumentation.

(2) Propotional valve assembly

① The proportional valve is installed on the top side of the block.
② The tightening torques of the propotional valve is 47.4 N · m(max).
③ When it is necessary to tighten the nut of the proportional valve, it should be tightened the nut with 15±1 N · m torque(max).

(3) Solenoid valve assembly

① The solenoid valve is installed on the front left side of the block.
② The tightening torques of the solenoid valve is 33.9 N · m(max).
③ When it is necessary to tighten the nut of the solenoid valve, it should be tightened the nut with 6.8 N · m torque(max).

2) DISASSEMBLY INSTRUCTION

(1) General

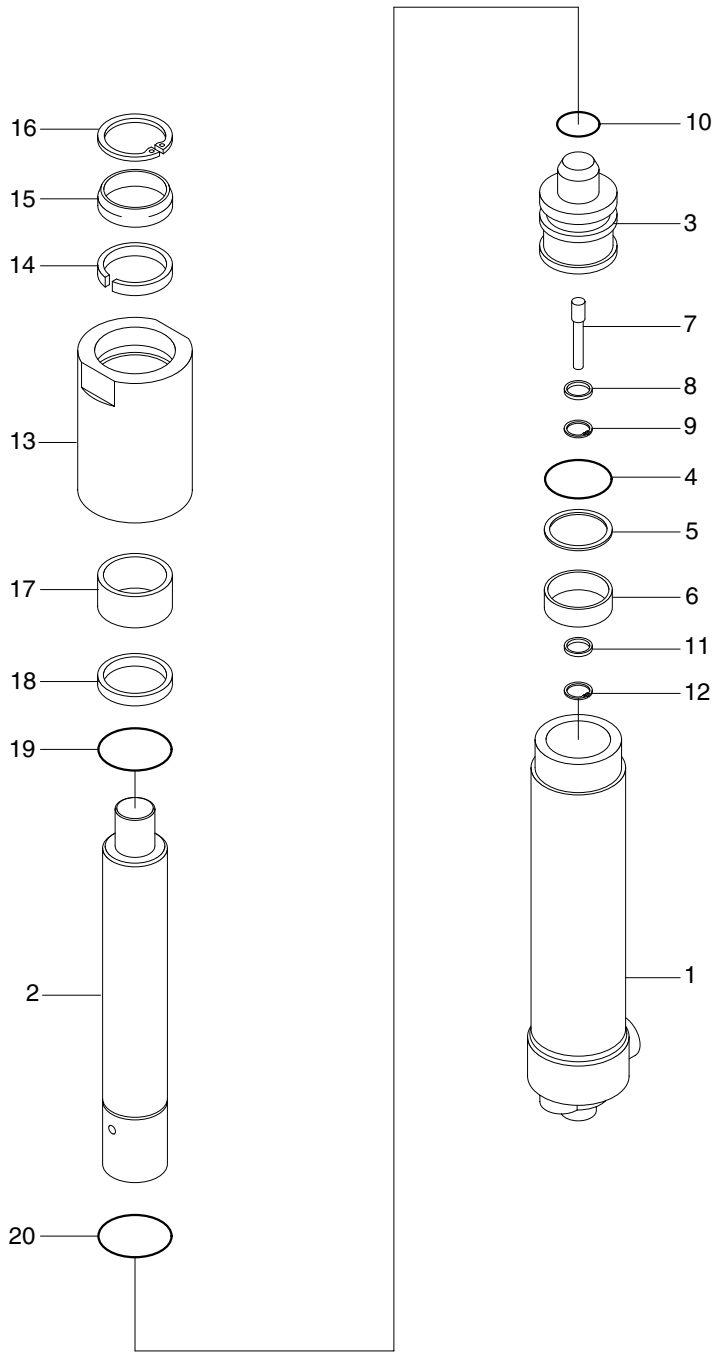
① Disassemble the valve components on the flat working surface.
② Ensure that the disassembly area will be clean and free of contamination.
③ Keep the disassembly area neat to avoid loss or damage of parts.

(2) Perform the assembly in reverse order

① Remove the solenoid valves and the propotional valve from the block.
② Valve components are precision items, and care must be taken when handling them to avoid damage or the introduction of contamination that could adversely affect performance.

3. LIFT CYLINDER

1) STRUCTURE

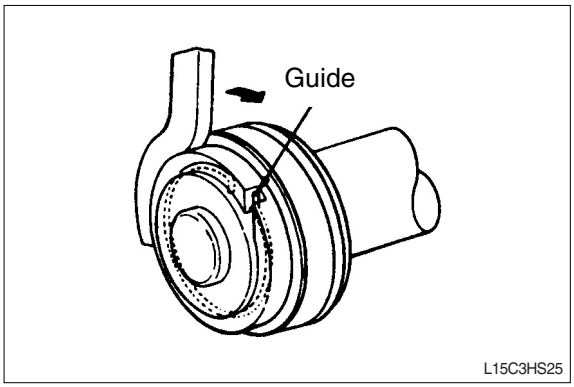


BRP7HS21

1	Tube assy	7	Stop ring	13	Rod bush
2	Rod	8	Cushion seal	14	Rod cover
3	Piston	9	Retaining ring	15	U-packing
4	U-packing	10	Spacer	16	Dust wiper
5	Back up ring	11	O-ring	17	O-ring
6	Wear ring	12	Stopper		

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.



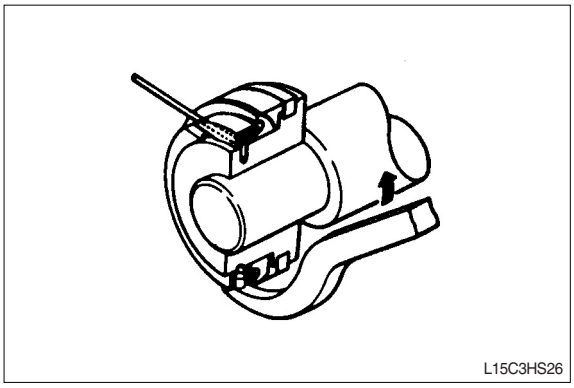
3) CHECK AND INSPECTION

mm(in)

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

4) ASSEMBLY

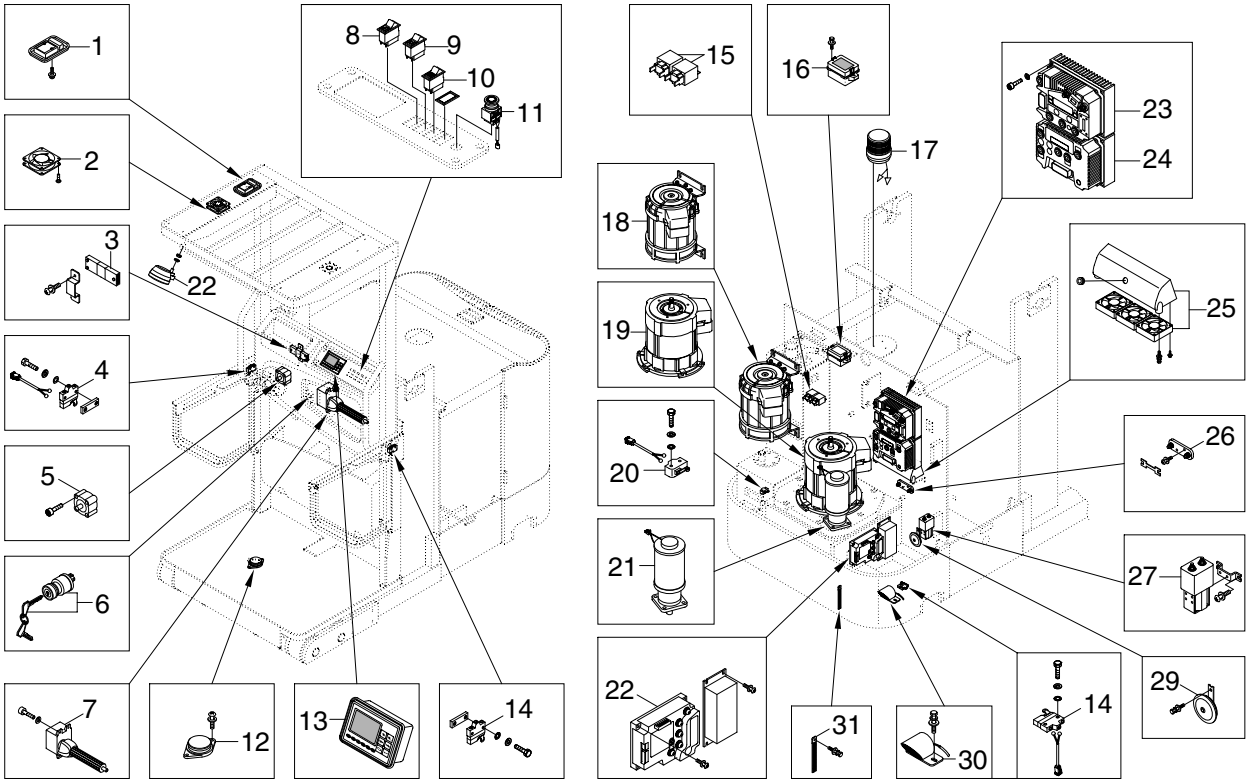
(1) Soak the piston ring in hydraulic oil at a temperature of 40 to 50°C, expand the inside diameter and assemble on the piston. Install a piston seal.
Bend the edge of the guide and rotate it to install the guide completely.



SECTION 7 ELECTRICAL SYSTEM

SECTION 7 ELECTRICAL SYSTEM

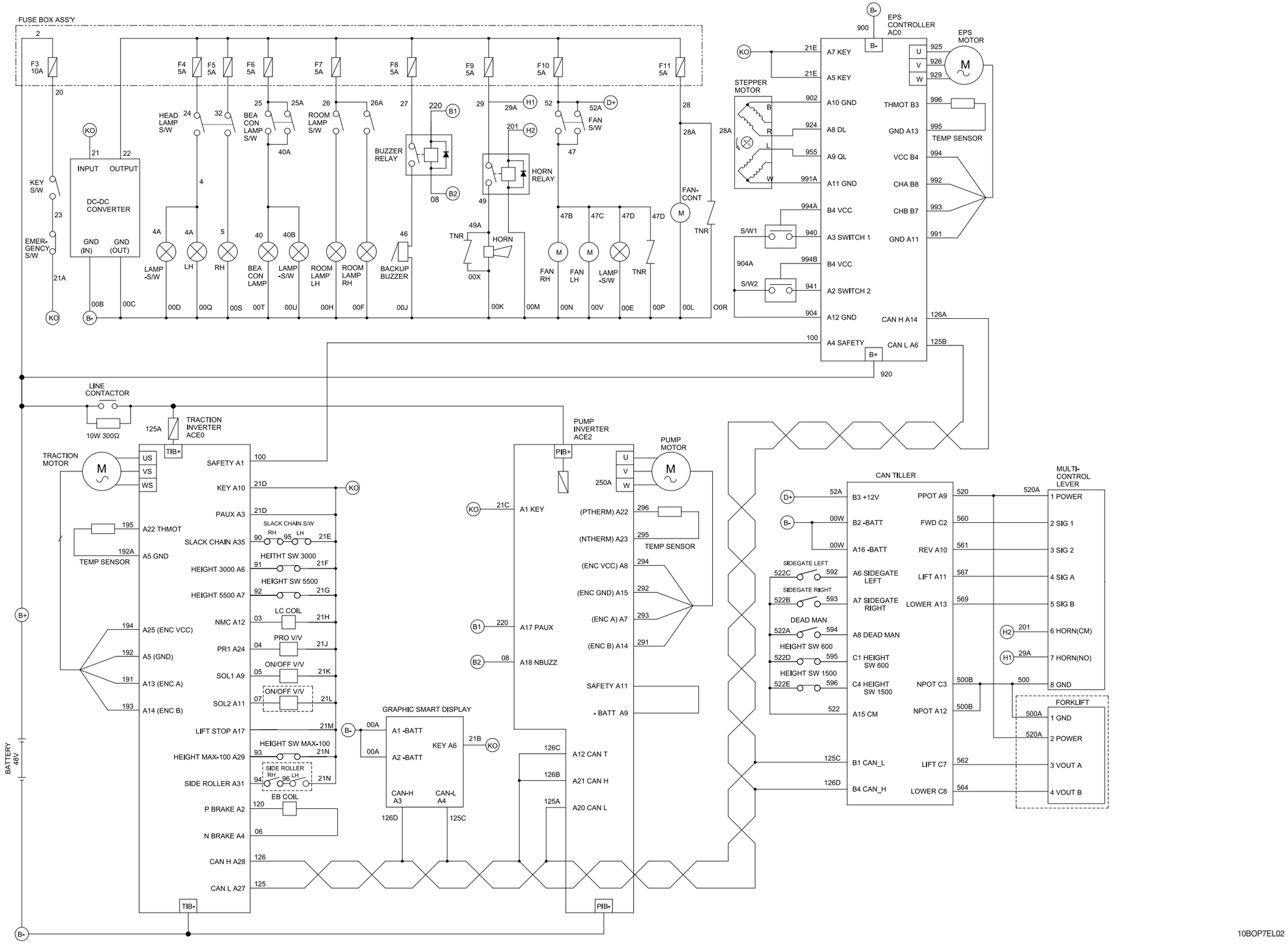
GROUP 1 COMPONENT LOCATION



10BOP7EL01

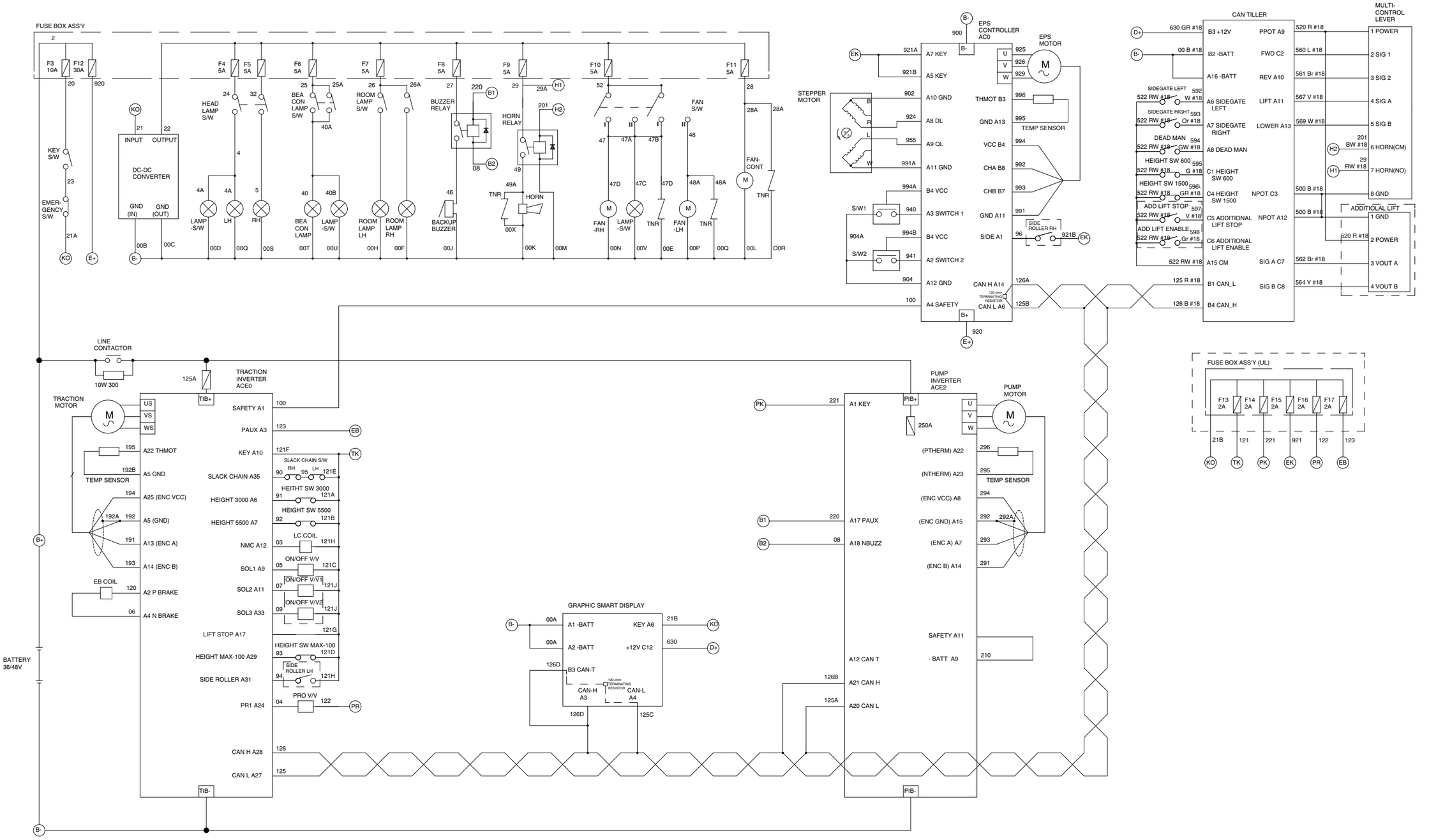
1	Room lamp	12	Deadman switch	23	Controller(ACE2)
2	Fan	13	Display	24	Controller(ACE0)
3	Can tiller card	14	Micro switch	25	Duct
4	Micro switch	15	Relay	26	Fuse
5	Stepping & gear motor	16	Fuse box	27	Contactor
6	Key switch	17	Beacon lamp	28	Horn
7	Multifunction lever	18	Pump motor	29	Side roller switch
8	Work light switch	19	Traction motor	30	Back buzzer
9	Beacon switch	20	Side roller switch	31	Strap
10	Heater switch	21	EPS motor		
11	Emergency switch	22	EPS controller		

GROUP 2 ELECTRICAL CIRCUIT



10BOP7EL02

GROUP 2 ELECTRICAL CIRCUIT



21HW-70023-00

GROUP 3 ELECTRIC COMPONENTS

1. FUNCTIONS OF BATTERY FORKLIFT TRUCK AND ELECTRIC COMPONENTS.

The major functions of the battery order picker truck can be divided into DRIVING FUNCTION and LOADING & UNLOADING FUNCTION.

All the components that work DRIVING and LOADING & UNLOADING functions are driven by AC MOTORS. And as the BATTERY works as power source of these motors, a charging device is needed.

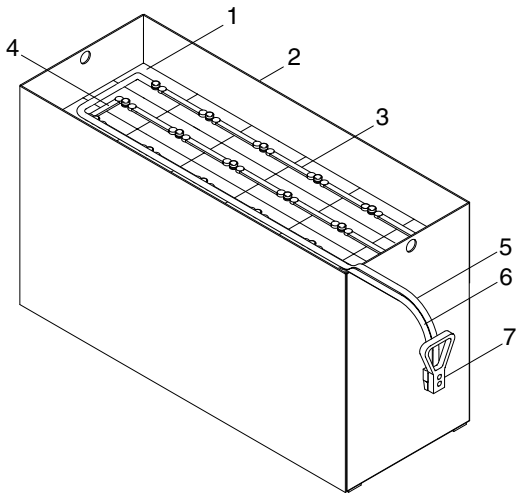
To drive the fork lift truck, a DRIVING CONTROL SYSTEM and a multifunction lever is required to select the driving direction and to control the speed of driving motor.

The CONTROL SYSTEM includes some protective circuits that protect the equipment and components from malfunctioning.

A MONITORING SYSTEM is installed in the monitor panel, which monitors the equipment and working condition, and let the operator take proper action. For the monitoring system, there are many sensors such as current sensors, hydraulic pressure sensors, and temperature sensors. The HYUNDAI battery order picker trucks are equipped with the most advanced DRIVING CONTROL SYSTEM currently available world-widely. The operator friendliness features enable him to set the truck conditions properly according to each working circumstance easily on the platform, and the SELF-DIAGNOSTIC function displays current status of truck in working.

2. BATTERY

1) STRUCTURE



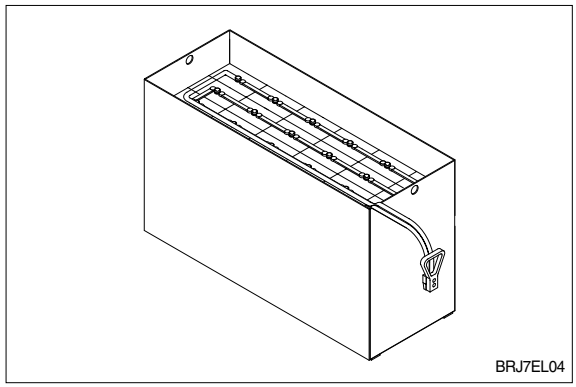
BRJ7EL03

1	Cells	7	Plug
2	Steel box	8	Spacer
3	Cell connector	9	Handle (Red)
4	Row connector	10	Screw
5	Positive leading cable	11	Spring washer
6	Negative leading cable		

2) GENERAL

As in the battery order picker trucks, the battery is an energy source, the handling of the battery is very important. The life and performan-ce of the battery greatly depend on the ordinary handling and maintenance.

Therefore, be sure to check and maintain the battery so that it may be kept best.



3) SPECIFICATION AND SERVICE DATA

Fully charged specific gravity	1.280(25° C)
End of discharge specific gravity	1.130(25° C)
Discharge end voltage	48V
Electrolyte	Refined dilute sulfuric
Replenishment fluid	Refined water(pure water)
Insulation resistance	More than 1MΩ

4) SAFETY PRECAUTIONS

(1) When a sulfuric acid contact with skin

For acid contact with skin, eye or clothing, flush with water immediately. If swallowed, drink a large amount of water or milk. Seek medical attention immediately. When handling acid, always wear eye goggles or a face shield and rubber gloves.

(2) Strict prohibition of fire and ventilation

Since batteries generate explosive hydrogen gas, no fire should be drawn near. Before the battery charging, keep the battery cover open and check the ventilation status. Charging in an enclosed space can cause a explosion.

(3) Never place metallic articles on the batteries

If done so, it may cause “short circuit” accidents(dangerous especially while charging).
Sparks will be generated which is equally dangerous as open fires.

(4) Handling of charger

When connecting or disconnecting a battery from a charger or attempting maintenance, make sure switches are all off. Ensure that the charger and the battery are matched. If a 300Ah battery is used with a charger designed to charge a 500Ah battery, it will severely overcharge the battery.

5) OPERATION PRECAUTIONS

(1) Avoid over-discharge

If over-discharged, it will be difficult to restore the batteries to the original state by recharge. In order to maintain the batteries in use for long period of time, it is recommended to use the batteries with discharge amount not exceeding 80% of the rated capacity. Further care should be taken for preventing the unit cell voltage from falling below 1.5V.

(2) Avoid over-charge

If overcharged, the rise in battery temperature will become excessive, resulting in deterioration of plates and other parts and markedly shortening of battery life.

(3) Avoid excessive elevation of temperature

Be sure to open the cover of battery housing tray before charging. If there is a possibility of temperature to exceed 55°C, discontinue the charge operation temporarily, or reduce the charge current.

6) INSTRUCTION

(1) Unpacking

Electric traction storage batteries(herein after refer to as “batteries”) are delivered to customers in dry-charged condition. At unpacking, check whether the batteries and accessories have been damaged. If there are observed defects, you should notify the condition to our branch office or agent. Never remove the sealing plug until the battery is put into service.

(2) Performance and maintenance of batteries

① Initial charge

Wet-charged battery gradually decrease its capacity during storage. In order to provide sufficient discharge capacity in the first discharge, the good initial charge is required. The conditions of initial charging are seen as below at room temperature.

a. By modified constant voltage charger

Connect the battery to the charger and turn on the equalizing charge "ON". The battery will be fully charged and terminated automatically.

b. By constant voltage constant current charger

Connect the battery to the charger and turn on the equalizing charge "ON". The battery will be fully charged and terminated automatically.

c. By constant current charger

Connect the charger to the battery and charge the battery by 0.1C×5 hour rate nominal capacity current for 24 hours or more. The charge shall be terminated when one of the following condition is identified.

- When a constant value is indicated for more than 1 hour after the battery voltage has reached the maximum value.
- When more than 1 hour of charge is continued after the electrolyte specific gravity has risen fully and becomes constant.

② Discharge and capacity

The capacity of batteries is indicated at 5 hour rate capacity which means the battery can be discharged for 5 hours with the discharge current calculated by dividing the capacity value by 5 until the unit cell mean voltage reaches down to 1.7V at the electrolyte temperature of 30° C.

That is, the capacity is indicated by AH(ampere hour) being calculated as the product of ampere(A) and time(H). However, even in the same type of batteries, the capacity varies with the discharge conditions(discharge current, battery temperature and specific gravity of electrolyte) Even if the batteries discharged its full capacity, if immediately charged to full, there will be no harmful effects remained. Ideal charging amount(AH) is 110-125% of the amount of previous discharge.

③ Specific gravity of electrolyte

Specific gravity of electrolyte drops at discharge and rises at charge. When the batteries are fully charged, it becomes almost constant and shows no further rise. The specific gravity value varies with the change in temperature. Therefore specific gravity measurement should be made with temperature of electrolyte at the same so the measured specific gravity value could be corrected to that at the standard temperature of 25℃ by the following formula.

$$S_{25} = S_t + 0.0007(t-25)$$

Where, S_{25} : Specific gravity at 25℃
S_t : Actually measured specific gravity at t ℃
t : Electrolyte temperature (℃)

The standard specific gravity for this type of battery is 1.280±0.01(25℃) at full charge condition.
If the electrolyte is decreased naturally while using, distilled water shall be replenished up to the specified level. (Never refill sulfuric acid)
Only when large quantity of electrolyte is lost due to spillage, etc., dilute sulfuric acid specified in gravity shall be added.

④ **Normal charge**

Charge the discharged batteries as quickly as possible. The temperature of electrolyte before starting the charging operation shall preferably be below 45℃, and the temperature during the charge should be maintained at no higher than 55℃. (Under any unavoidable situations, it should never be above 55℃). Methods of charging varies in precise meaning with the types of chargers used. A standard charging method is described hereunder. (If a special method is mentioned to be adopted, follow that instruction).

a. Charging by modified constant voltage automatic charger

There is almost automatic charger today which complete the charging just only connecting the plug between battery and charger without outer operating timer but if your charger has it, after setting the timer for 3-4 hours and turn on the charger and the charger is left as it is, then the charge will be made automatically. In principle, regardless of the amount of previous discharge, it is not required to alter the setting of timer time. The recommendable current value of this type of charger is "5 hour rate current ×1.0~1.5" at the start of charging, and at the final stage it is "5 hour rate current ×0.15~0.25". Normally the charge is terminated within 8~12 hours automatically.

b. Charging by constant current constant voltage automatic charger

After a lapse of specified charging time after the switch is turned on, the charge will be completed by turning off the switch. The charging time can be calculated by the following formula.

$$\text{Charging time} = \frac{\text{Amount of previous discharge(AH)}}{\text{Capacity of charger(A)}} + 2\sim3\text{(H)}$$

When the amount of previous discharge is not known, use the 5 hour rate rated capacity of the batteries. At immediately after charging, the charge current is allowed up to 3 times 5 hour rate current. For charger provided with a timer, the charge will terminate automatically if the timer is set at the specified time according to the operation manual.

⑤ **Equalizing charge**

When large number of cells are used in a set of battery, the voltage and specific gravity of respective cells tend to become unequal, resulting in necessity of charging all the cells at an appropriate time in order to equalize them. This is called equalizing charge. Normally the equalizing charge should be carried out once every month. The methods are in normal type charger, extend the charge for 5 more hours after full charge at the final stage current, and in automatic charger which are in most cases provided with timer, extend the time setting for 3-6 more hours.

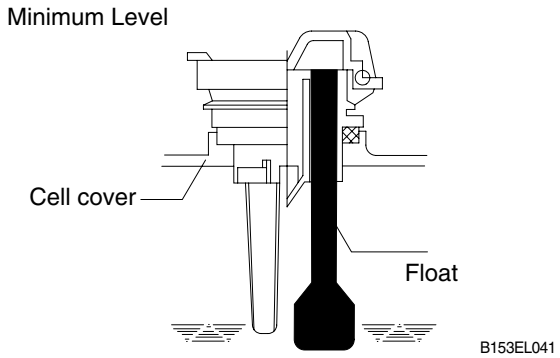
⑥ **Water replenishment**

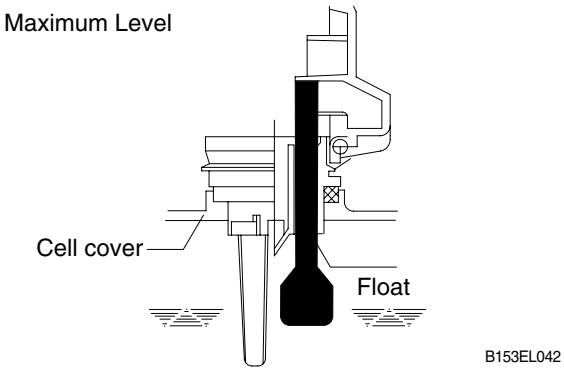
Only the water content of electrolyte is decreased due to electrolysis of water during charge and natural evaporation. If a battery used with the electrolyte decreased excessively, plates will deteriorate resulting in markedly shortening of battery life. Be sure to check the electrolyte level once every week. If the electrolyte level is lowered, replenish distilled water up to the specified level. In this case, never attempt to replenish sulfuric acid or tap water. Use only distilled water for battery replenishment. If the amount of water required for weekly addition to a unit cell for 100AH of battery capacity is in excess of 45cc, it is assumed that the cell is receiving overcharge. Accordingly, be sure to reduce slightly the daily charge amount. Under the normal conditions, the addition of water per week is 45cc or less. Incidentally, water replenishment should be made before charging to the contend of minimum level.

(for the purpose of uniform stirring of electrolyte by charging). If the electrolyte level is improper after completion of charging, you may topping up the electrolyte level to the maximum level .

a. Determination of replenishment time and methods(cell with ONE TOUCH CAP)

Confirm the electrolyte level by looking at the float in the ONE TOUCH CAP. If too low as shown in figure, replenish water. Replenishment shall be performed after opening the cover of the plug using syringe and jug. When refilling is completed, close each cover completely until “click” sound is heard.





⑦ Cleaning

If electrolyte spills or the cells are polluted with dust or stains, it will cause generation of leak current. Wipe off dust and stains with moist cloth and clean in such a manner that the cells are kept in dry condition. In the case of plastic containers or covers, never use such organic solvents as paint thinner and gasoline. If used, the plastic containers or covers may suffer cracking. If you are forced to use them, be sure to use white kerosene.

⑧ Notice on charging

The charging area must be well ventilated to facilitate exhaust of gas generated from the battery during charging. Charge the battery in an area free from iron working, welding, etc. Further the battery generates hydrogen, oxygen, acid mist and on rare occasions, hydrogen sulfide during charging depending on the case. Special care may be required in the case of equipment and objects near the battery that may contaminated or damaged. Do not pull out the charging plug during charging, as it will cause sparks. Since hydrogen gas generated during charging may remain in the area surrounding the battery after charging, never bring fire or flame close to this area. In case of counter-balance type vehicles, open the battery cover before charging.

⑨ Repair of failure cell

a. To remove a cell from the circuit or battery from steel tray, it is first necessary that the intercell connector be removed.

b. Before performing any repairs, you must open one-touch caps for gas purging of all cells. After you have finished that, must remove connector covers and on-touch caps from failure cell including surrounding cells. All vent holes of cells removed of one-touch caps must cover by four layers of water dampened cloth and then proceed with repairs. Using an acid syringe withdraw sufficient electrolyte from failure cell to reduce the liquid levels until minimum level indicating of one touch caps.

c. The safe and most efficient method of removing a connector is with hand or electric drill(ø 25㎜) from failure cell as well as all surrounding cells.

⚠ You must make sure to clear of explosive hydrogen gas in the cells before repairs. Be careful not to drill to far into the cell and damage the unit. During drilling operation make sure lead curls produced do not contact opposite cell poles and cause a spark.

d. Upon completion of drilling the intercell connectors, can be lifted off.
e. Lifted off the failure cell from circuit after removing of intercell connector.
f. Installing new cell and connector.
g. With surfaces properly cleaned and neutralized, position the connectors.
h. Place damp rags around each lead head. Hold tip of the welder in center of post move welder completely around top of post and out to the area where the post meets the connector. Move welder back to center of post and add molten lead until area is filled to top of connector. Again, move welder completely around area, with tip on molten lead. If you have jig for welding connector, have easier and better welding work.
i. When replacing electrolyte in a repaired cell, use sulphuric acid of the same specific gravity that is found in the balance of the battery.
j. Finally, rejoin connector covers and one-touch caps to the cells.

⑩ **Summary of daily maintenance**

a. Avoid overcharge. After discharge, charge the batteries immediately. The standard frequency of equalizing charge is more than once every month.
b. Check the electrolyte level once a week. If found decreased, replenish distilled water up to the specified level.
c. The top surface of battery cells should be kept clean and dry.
d. Be sure to keep open the cover of battery housing tray during charge.
e. Never draw near open fires such as lighted cigarettes or burning matches during charge.

(3) Others

① **Storage of batteries**

When batteries are stored, keep them distant from room heaters or other heat generating sources. Clean, cool and dry place where no direct sunlight is directed is suited for battery storage. Before putting into storage, it is important to charge the batteries and keep the electrolyte level at the specified level. When the temperature in storage location is higher than 20°C, check the specific gravity once a month, and when lower than 20°C, check it once every two months. If the measurements show values lower than 1.230(20°C), it is required to charge the battery in accordance with the method described in NORMAL CHARGE.

② **Maintenance record**

It is recommended to keep maintenance record in order to know the operational conditions of batteries. Daily charge and discharge, equalizing charge requirements, and water replenishment requirements can be clarified at a glance. Measurements of specific gravity and temperatures once every two to four months after equalizing charge and maintenance thereof will serve for battery health diagnosis.

③ **Electrolyte temperature**

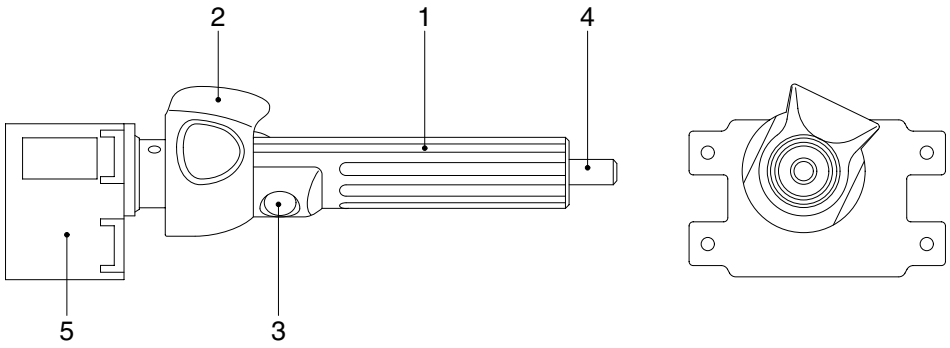
The operating temperature range of batteries is -10~45°C(temperature of electrolyte). If the batteries are exposed to cold atmosphere in discharged condition, the electrolyte may freeze, and in extreme cases, the capacity will be decreased, but, if not frozen, no adverse effects will be exerted over the life. Contrarily if the temperature is high, especially if used at above 55°C, the battery life will be considerably shortened. Care must be taken so that the temperature during charge will be maintained at 55°C or lower. Even under unavoidable circumstances it should not exceed 55°C.

7) TROUBLESHOOTING

Nature of trouble	Symptoms	Causes	Repair
Deformation	· Deformation of container, lid or one touch cap	· Excessive temperature rising or external impact	· Replace
Breakage	· Electrolyte leakage according to breakage of container, lid or one touch cap	· External impact, improper handling, excessive vibration	· Replace or install a new one
	· Termination of connector or pole post etc.	· Excessive temperature rising or vibration/external impact	· Replace
Sulfate	· Specific gravity drops and capacity is decreased.	· When left in state of discharge or left long without equalizing charge.	· Need equalizing charge
	· Charge voltage rises rapidly with immature gassing in earlier stage but specific gravity does not rise and charge can't be carried out.	· Insufficient charge.	· Need equalizing charge
		· When electrolyte is so decreased that plate is deposed.	· Need equalizing charge
		· When concentration of electrolyte rises.	· Adjust specific gravity
		· When impurities are mixed in electrolyte.	· Replace electrolyte
Decrease and falling of specific gravity	· May be easily detected by measurement of the specific gravity.	· Rise of temperature due to such trouble.	· Replace
		· When left long period without refilling of water.	· Refill water in regular period
		· Short circuit.	· Replace
Rise of specific gravity	· May be easily detected by measurement of the specific gravity.	· Diluted sulfuric acid is used in refilling.	· Adjust specific gravity after full charge.
		· When the electrolyte level excessively drops.	· Refill distilled water.
Mixing of impurities	· Decrease of capacity.	· Metals such as iron, copper, nickel and manganese.	· Under a fully discharged condition, pour out the electrolyte. Then pour in an acid of the specific gravity higher by 0.03~0.05 than that of the drained acid. Charge fully and adjust the specific gravity to the specified value.
	· Drop of charge and discharge voltage.	· Impurities such as sea water, chloric acid, nitric acid etc.	
	· Odor of generated gas and coloring of the electrolyte.	· Filling of impure water.	

3. MULTIFUNCTION LEVER

1) STRUCTURE



10BOP7ML01

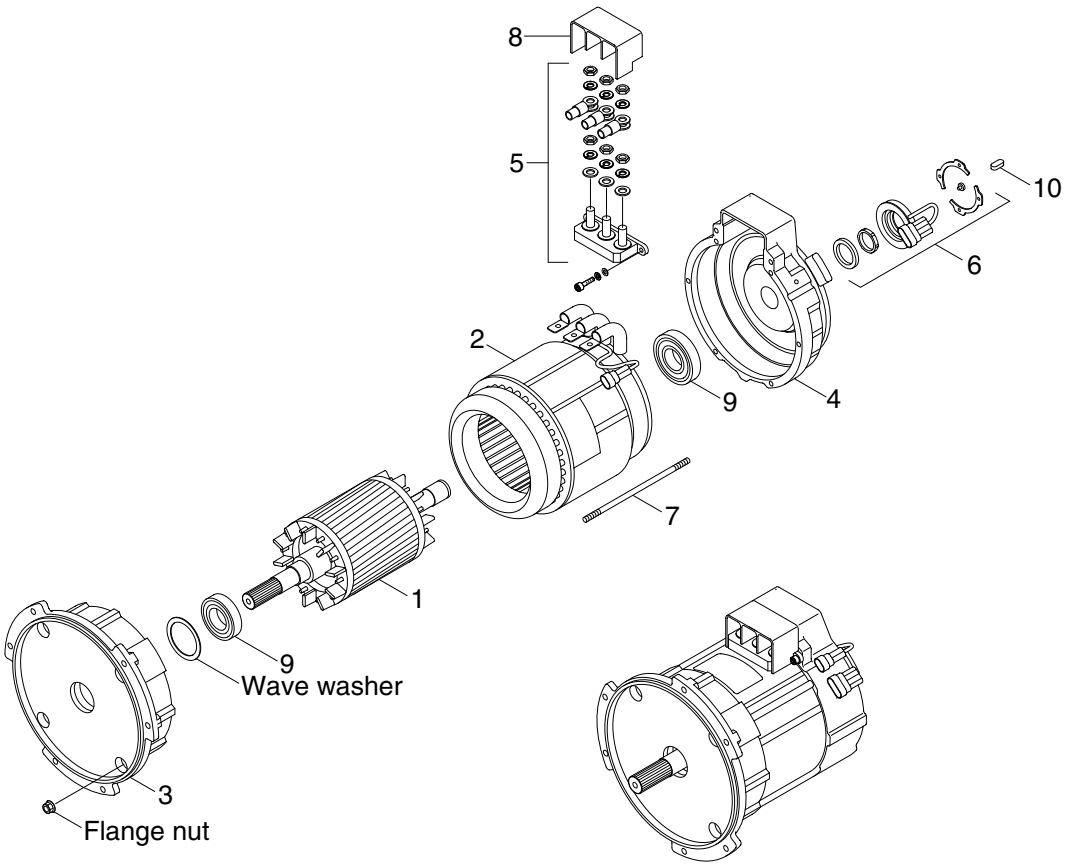
1 Center pin
2 FR grip
3 Horn switch
4 Lift grip
5 Body

2) SPECIFICATION

Description		Unit	Specification
Electrical	Rated voltage	Vdc	5±0.1
	Operating voltage	Vdc	4.75 to 5.25
	Testing voltage	Vdc	5±0.1
	Operating current	mA	30 (normal), 40(max)
Mechanical	Mechanical angle	deg	Lift : 35, Lower 35
Environmental characteristics	Operating temperature	°C	-30 to 70
	Storage temperature	°C	-40 to 80

3. DRIVE MOTOR

1) STRUCTURE



10BOP7EL06

1	Rotor assy	6	Speed sensor kit
2	Stator assy	7	Stud bolt
3	Endbell de	8	Terminal protector
4	Endbell	9	Bearing
5	Terminal-A block	10	Key

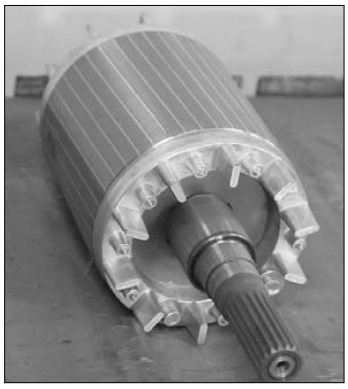
2) SPECIFICATION

Item	Unit	Specification
Type	-	AMDF6008
Rated voltage	V	32
Power	kW	5.2
Current	A	138
Speed	rpm	2270

3) INSPECTION

(1) Rotor Assembly

- Rotor should always be cleaned with compressed air.
  If the dirt will not come off lightly wipe off with piece of cotton or soft cloth wetted with gasoline.
- Rotor out diameter : ø 123.1±0.05
- Tool : Vernier calipers and standard tool

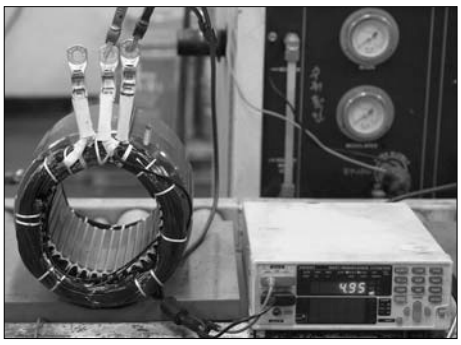


10BOP7TM01

(2) Stator Assembly

Stator should always be cleaned with compressed air.
If the dirt will not come off lightly wipe off with piece of cotton or soft cloth wetted with gasoline, using care not to damage the coil insulation.

- Use mmΩ tester and check for two power line of stator repeatedly (U-V, V-W, W-U)
  At that time resistance is around 6.85mmΩ



10BOP7TM02

- Insulation test
  Use insulation tester (1000Vac, Min. 10MΩ) and measure as a picture.
  If the insulation is defective, replace with new parts.

10BOP7TM03

4) DISASSEMBLY FOR AC MOTOR

- Before disassembling motor, remove terminal protector from the motor and separate thermistor and speed sensor connectors from hanger.

10BOP7TM04

10BOP7TM05

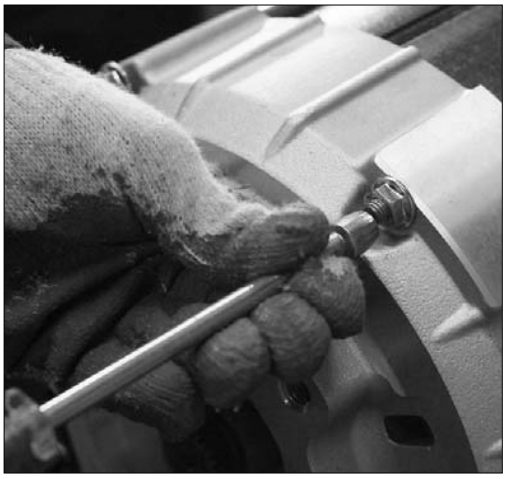
- Remove 3 nuts from terminal block of the motor to disassemble terminal block from the motor.

10BOP7TM06

- Remove 4 screw fixing speed sensor on the enbell side and then disassemble speed sensor, fixed nut and toothed wheel of the motor.

10BOP7TM07

- Remove 4 flange nuts with available general tool on the endbell drive side.

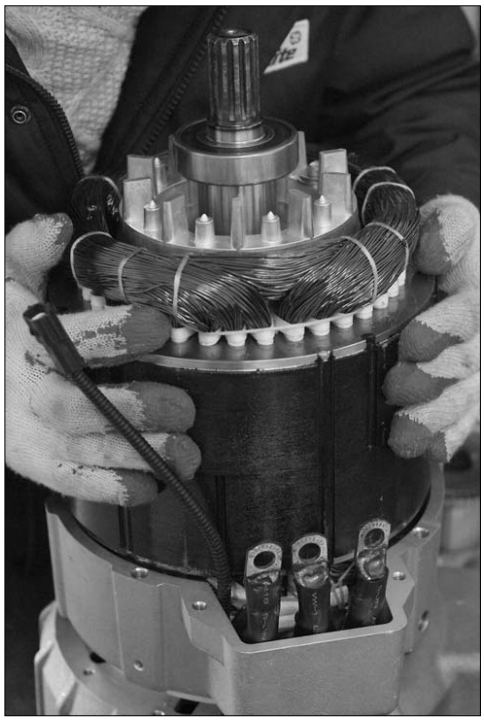


10BOP7TM08

- Remove endbell de and wave washer.

10BOP7TM09

- Remove stator assembly by hand or suitable tool.



(Removing stator)

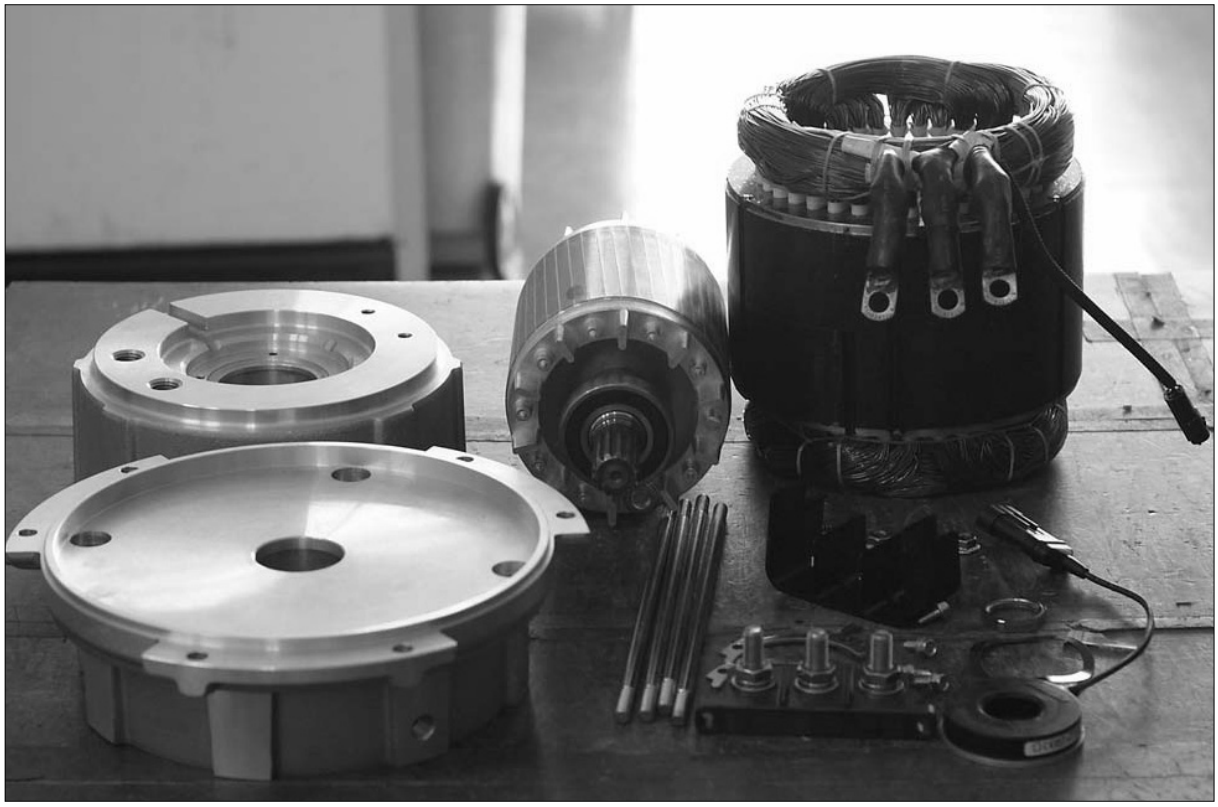
10BOP7TM10

(Removing endbell)

10BOP7TM11

- Remove endbell from rotor assembly by hand-puller as a above picture.

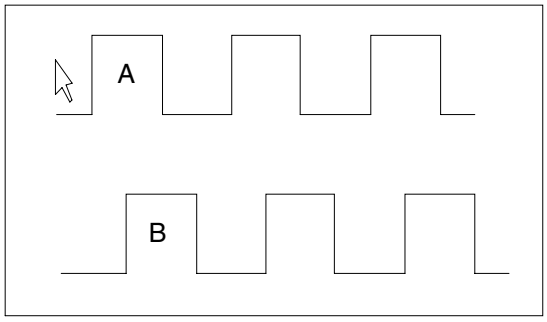
- The motor are composed of 5-parts.
  (Rotor assembly, stator assembly, enbell de, endbell, etc)



10BOP7TM12

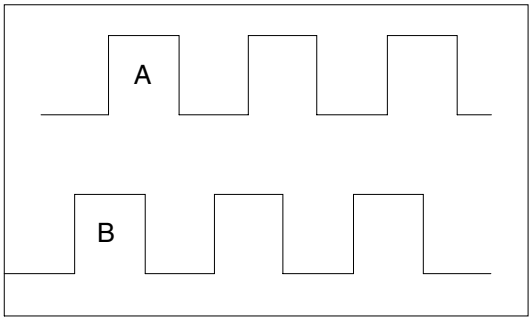
5) ASSEMBLY AND INSTALLATION

- Perform assembly in the reverse order of disassembling.
- After assembling, check for speed sensor. Normal signal is as below.



CLOCKWISE ROTATION

10BOP7TM13

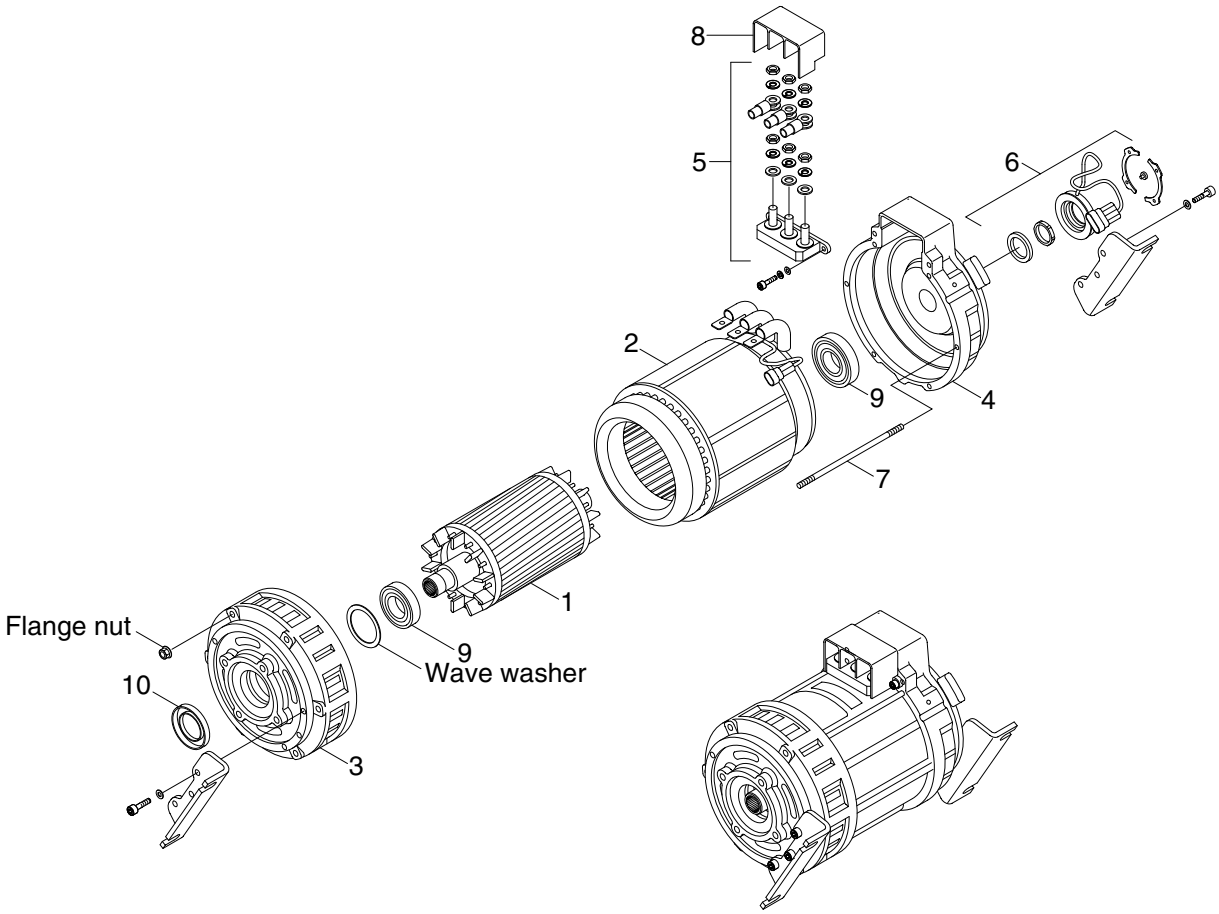


COUNTER CLOCKWISE ROTATION

10BOP7TM14

4. PUMP MOTOR

1) STRUCTURE



10BOP7EL07

1	Rotor assy	6	Speed sensor kit
2	Stator assy	7	Stud bolt
3	Endbell de	8	Terminal protector
4	Endbell	9	Bearing
5	Terminal-A block	10	Oil seal

2) SPECIFICATION

Item	Unit	Specification
Type	-	AMDG6007
Rated voltage	V	30
Power	kW	10.6
Current	A	296
Speed	rpm	1688

3) INSPECTION

(1) Rotor assembly inspection

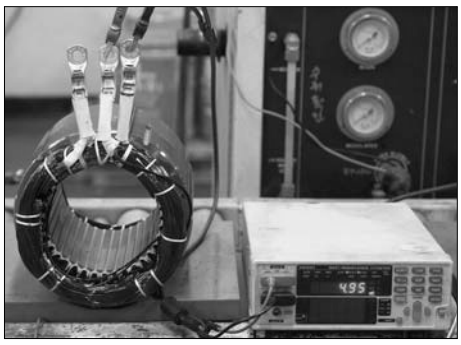
- Rotor should always be cleaned with compressed air.
  If the dirt will not come off lightly wipe off with piece of cotton or soft cloth wetted with gasoline.
- Rotor out diameter : ø 123.1 ± 0.05
- Tool : Vernier calipers and standard tool

10BOP7PM01

(2) Stator assembly inspection

Stator should always be cleaned with compressed air.
If the dirt will not come off lightly wipe off with piece of cotton or soft cloth wetted with gasoline, using care not to damage the coil insulation.

- Use mmΩ tester and check for two power line of stator repeatedly (U-V, V-W, W-U).
  At that time resistance is around 5.3mmΩ.



10BOP7PM02

- Insulation test
  Use insulation tester (1000Vac, Min. 10MΩ) and measure as a picture.
  If the insulation is defective, replace with new parts

10BOP7PM03

4) DISASSEMBLY FOR AC MOTOR

- Before disassembling motor, remove terminal protector from the motor and separate thermistor and speed sensor connectors from hanger.

10BOP7PM04

10BOP7PM05

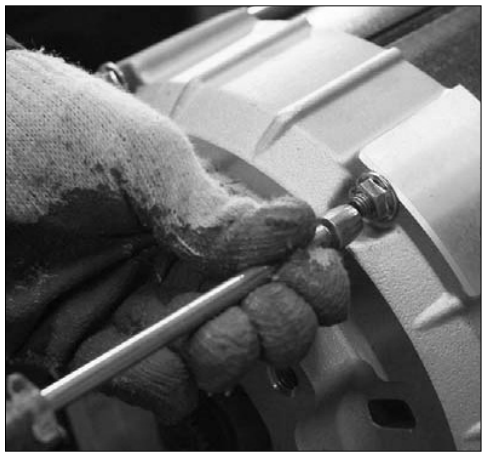
- Remove 3 nuts from terminal block of the motor to disassemble terminal block from the motor.

10BOP7PM06

- Remove 4 screws fixing speed sensor on the enbell side and then disassemble speed sensor, fixed nut and toothed wheel of the motor.

10BOP7PM07

- Remove 6 flange nuts with available general tool on the endbell drive side.

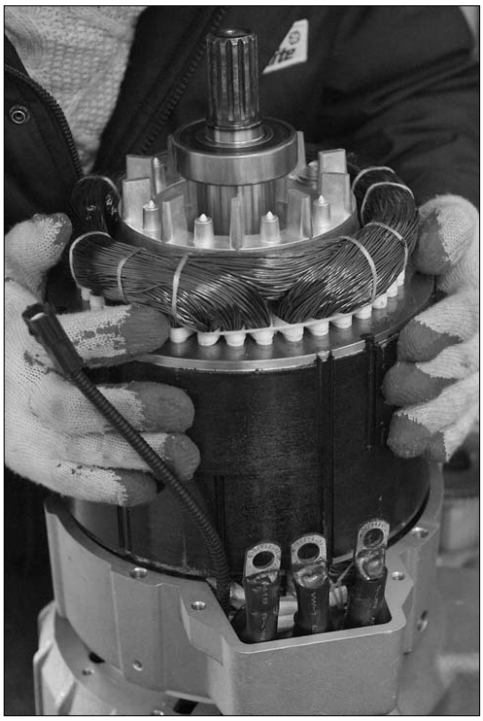


10BOP7PM08

- Remove endbell de and wave washer.

10BOP7PM09

- Remove stator assembly by hand or suitable tool.



10BOP7PM10

(Removing stator)

10BOP7PM11

(Removing endbell)

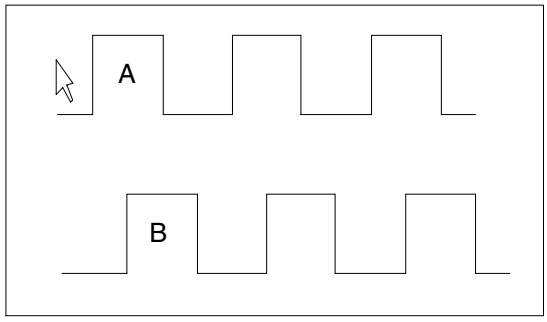
- Remove endbell from rotor assembly by hand-puller as a above picture.

- The motor are composed of 5-parts.
  (Rotor assembly, stator assembly, enbell de, endbell, etc)

10BOP7PM12

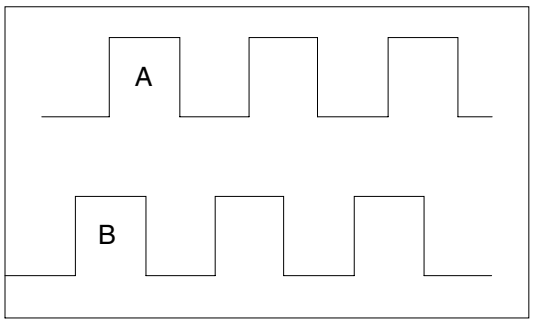
5) ASSEMBLY AND INSTALLATION

- Perform assembly in the reverse order of disassembling.
- After assembling, check for speed sensor. Normal signal is as below.



CLOCKWISE ROTATION

10BOP7TM13

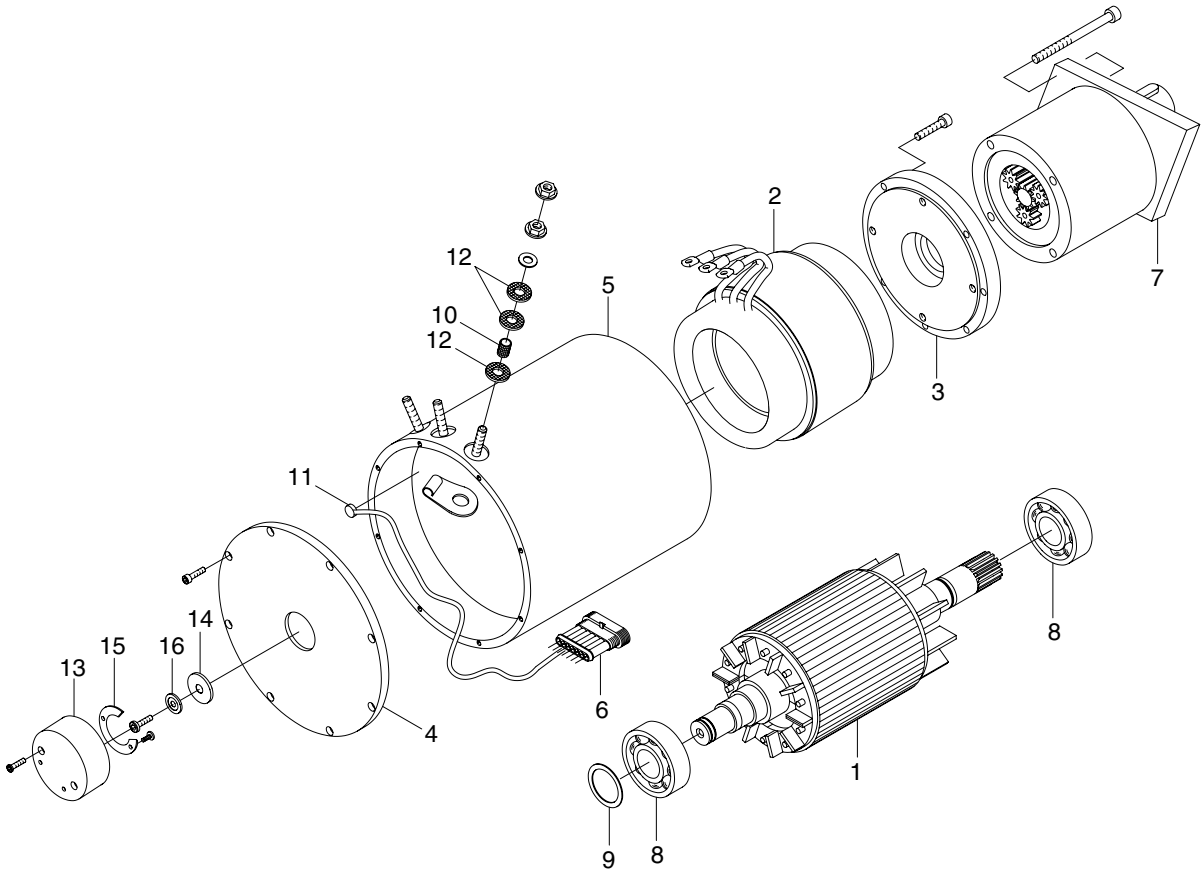


COUNTER CLOCKWISE ROTATION

10BOP7TM14

5. EPS MOTOR

1) STRUCTURE



BRJ7EL08

1	Rotor	9	Screw	17	Screw
2	Stator	10	Screw	18	Washer
3	Flange	11	Thickness ring	19	Bakelite washer
4	Flange	12	Flange nut	20	Sensor support
5	Casing	13	Bakelite pipe	21	Magnet
6	Super seal	14	Thermal	22	Screw
7	Gear	15	Screw	23	Sensor card
8	Bearing	16	Grower	24	Magnet support

2) SPECIFICATION

Item	Unit	Specification
Type	-	G104087A
Rated voltage	Vac	23
Rated output	W	400
Insulation	-	Class H

3) MAINTENANCE INSTRUCTION

※ Before starting the maintenance please disconnect the power supply.

(1) Ball bearing

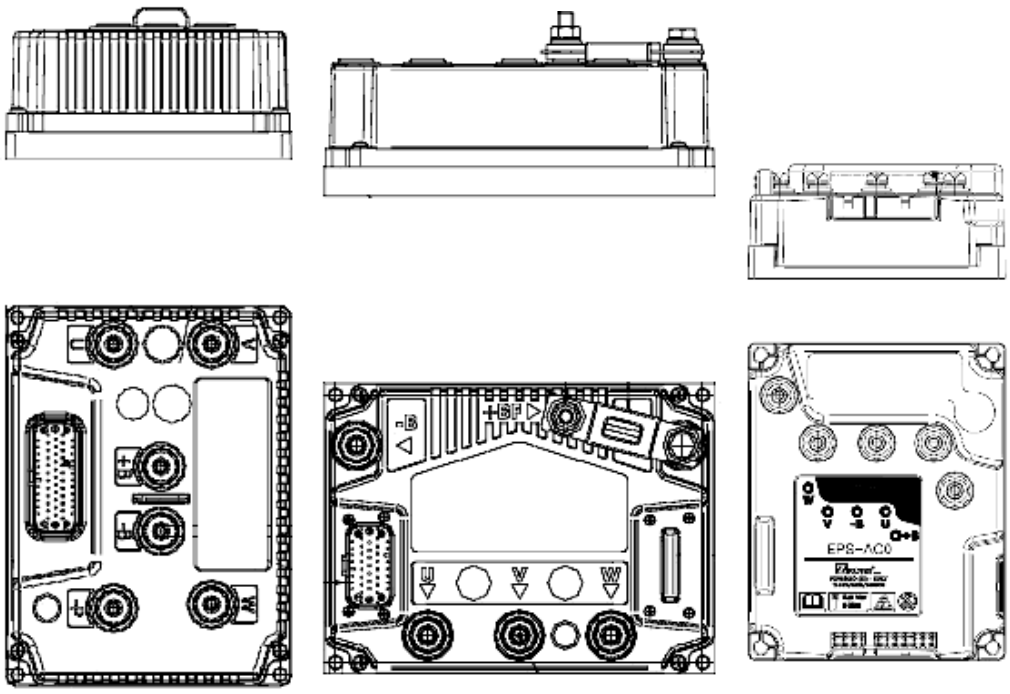
Both ball bearing are maintenance free. Should it be necessary to remove the bearings in case of repair, they should be replaced. In any case the sealing parts (shaft sealing ring etc.) have to be replaced.

If a bearing which is to be replaced has only one sealing lip, this should be greased with quality bearing grease.

After approximately 10,000 operating hours the bearings have to be replaced.

6. CONTROLLER SYSTEM

1) STRUCTURE



ACE0 ACE2 AC0 10BOP7EL11

2) SPECIFICATIONS

Model	Inverter	Application	Power	Current limit
10/13BOP-7	ACE0	Traction	36-48V, 250A	180A, 2min
	ACE2	Pump	36-48V, 350A	350A, 3min
	AC0	Steering	36-48V, 45A	45A, 2min

3) PIN MAP DESCRIPTION

(1) Traction inverter (ACE0)

No. of Pin	Function	Description
A1	SAFETY	Connect to EPS inverter safety port
A2	P BRAKE	Positive of the electromechanical brake coil
A3	P AUX	Positive supply for electrovalves. This input has to be supplied with positive taken after main contactor
A4	N BRAKE	Electro mechanic brake coil driver output; PWM controlled
A5	GND	Negative of encoder & temp sensor
A6	HEIGHT3000	Input of height 3000 mm switch
A7	HEIGHT5500	Input of height 5500 mm switch
A8	NA	-
A9	SOL1	Output of the ON/OFF electrovalve EV1
A10	KEY	Input of the key switch signal
A11	SOL2	Output of the ON/OFF electrovalve EV2(Optional)
A12	NMC	Main contactor coil driver output
A13	ENC A	Traction motor encoder phase A
A14	ENC B	Traction motor encoder phase B
A15	NA	-
A16	NA	-
A17	LIFT STOP	Input of lift stop switch
A18	NA	-
A19	NA	-
A20	NA	-
A21	NA	-
A22	TMOT	Traction motor thermal sensor input
A23	NA	-
A24	PR1	Negative of the lower proportional electrovalve driver
A25	ENC VCC	Encoder positive supply
A26	NA	-
A27	CAN L	Low level CAN-BUS voltage I/O.
A28	CAN H	High level CAN-BUS voltage I/O.
A29	HEIGHT MAX-100	Input of height MAX-100㎜ switch
A30	NA	-
A31	SIDE ROLLER	Input of the side roller switch(Optional)
A32	NA	-
A33	NA	-
A34	NA	-
A35	SLACK CHAIN	Input of the slack chain switch

(2) Pump inverter (ACE2)

No. of Pin	Function	Description
A1	KEY	Input of the key switch signal
A2	NA	-
A3	NA	-
A4	NA	-
A5	NA	-
A6	NA	-
A7	ENC A	Pump motor encoder phase A
A8	ENC VCC	Encoder positive supply
A9	- BATT	Negative power supply
A10	NA	-
A11	SAFETY	Connect to -BATT
A12	CANT	If it is connected with A21. It introduces the120 Ohm termination resistance between CAN-L and CAN-H
A13	NA	-
A14	ENC B	Pump motor encoder phase B
A15	ENC GND	Negative of encoder
A16	NA	-
A17	PAUX	Positive of the horn relay coil
A18	NBUZZ	Horn relay coil driver output.
A19	NA	-
A20	CAN L	Low level CAN-BUS voltage I/O.
A21	CAN H	High level CAN-BUS voltage I/O.
A22	PTHERM	Input for motor temperature sensor
A23	NTHERM	Negative of temperature sensor

(3) EPS inverter (AC0)

No. of Pin	Function	Description
A1	NA	-
A2	SW 2	2nd toggle switch (90 degrees)
A3	SW 1	1st toggle switch (0 degrees)
A4	-BATT.	Safety switch lower voltage point
A5	SAFETY	Safety switch higher voltage point
A6	CAN L	Can bus low
A7	KEY	Key in
A8	QL	Stepper motor Q line
A9	DL	Stepper motor D line
A10	GND	GND. encoder D line negative supply
A11	GND	GND. encoder Q line negative supply and EPS motor encoder negative
A12	GND	GND. SW 1 & SW 2 negative
A13	GND	GND. motor thermal sensor negative
A14	CANH	Can bus high
B1	NA	-
B2	NA	-
B3	THMOT	Motor thermal sensor (KTY84-130) input
B4	VDC	Encoder positive supply
B5	NA	-
B6	NA	-
B7	CHB	Encoder channel B
B8	CHA	Encoder channel A

4) MENU DESCRIPTION

(1) Traction inverter

Parameter change	Description
ACCELER. DELAY	Seconds. It determines the acceleration ramp. The parameter sets the time needed to speed up the traction motor from 0Hz to 100Hz
RELEASE BRAKING	Seconds. It controls the deceleration ramp when the travel request is released. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz.
DEADMAN BRAKING	Seconds. It controls the deceleration ramp when the deadman switch is in braking position (released). The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz
INVERS. BRAKING	Seconds. It controls the deceleration ramp when the direction switch is inverted during travel. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz.
DECEL. BRAKING	Seconds. It controls the deceleration ramp when the accelerator has turned down but not completely released. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz.
PEDAL BRAKING	Seconds. This parameter determines the deceleration ramp when the travel request is released and the brake pedal switch is closed. It sets the time needed to decelerate the traction motor from 100Hz to 0Hz.
SPEED LIMIT BRK.	Seconds. It controls the deceleration ramp when a speed reduction has been activated. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz.
CURVE BRAKING	Seconds. It controls the deceleration ramp when a curve speed reduction has been activated. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz.
MAX SPEED FORW	Hz. It determines the maximum speed in forward direction. When truck steer angle is in 10 degrees and lift height is 0 to 600mm.
MAX SPEED BACK	Hz. It determines the maximum speed in backward direction. When truck steer angle is in 10 degrees and lift height is 0 to 600mm.
AUX SPEED #1	Hz. This parameter is related to the EMBRAKE management and define the speed at which open EM Brake (default 2Hz).
CURVE CUTBACK	Hz. It determines the maximum speed when truck steer angle is over MAX ANGLE SP CTB and lift height is 0 to 600mm.
CUTBACK SPEED 1	Hz. It determines the maximum speed when truck steer angle is in 10 degrees and lift height is 600 to 1500mm.
AUX FUNCTION 1	Hz. It determines the maximum speed when truck steer angle is over MAX ANGLE SP CTB and lift height is 600 to 1500mm.
CUTBACK SPEED 2	Hz. It determines the maximum speed when truck steer angle is in 10 degrees and lift height is 1500 to 3000mm.
AUX FUNCTION 2	Hz. It determines the maximum speed when truck steer angle is over MAX ANGLE SP CTB and lift height is 1500 to 3000mm.
CUTBACK SPEED 3	Hz. It determines the maximum speed when truck steer angle is in 10 degrees and lift height is 3000 to 5500mm.

Parameter change	Description
AUX FUNCTION 3	Hz. It determines the maximum speed when truck steer angle is over MAX ANGLE SP CTB and lift height is 1500 to 3000mm.
CUTBACK SPEED 4	Hz. It determines the maximum speed when truck steer angle is in 10 degrees and lift height is 5500 to END mm.
AUX FUNCTION 4	Hz. It determines the maximum speed when truck steer angle is over MAX ANGLE SP CTB and lift height is 5500 to END mm.
TURTLE SPEED	Hz. It determines the maximum speed when turtle mode is activated.
MAX ANGLE SP CTB	Degrees. It determines the angle for speed reduction.
FREQUENCY CREEP	Hz value. This is the minimum speed applied when the forward or reverse switch is closed, but the accelerator is at its minimum
MAXIMUM CURRENT	Maximum level of the current (percentage of the maximum current of the controller).
ACC SMOOTH	It gives a parabolic form to the acceleration ramp.
INV SMOOTH	It gives a parabolic form to the acceleration ramp after a direction inversion
STOP SMOOTH	Hz. It sets the level of frequency where the smooth effect of the acceleration parabolic form ends.
BRK SMOOTH	It gives a parabolic form to the deceleration ramp.
STOP BRK SMOOTH	Hz. It sets the level of frequency where the smooth effect of the deceleration parabolic form ends.
AUXILIARY TIME	Time units value (seconds). For the encoder version, it determines the time duration the truck is hold on the ramp if the STOP ON RAMP option is ON.
MIN EVP	0 to 100. This parameter determines the minimum voltage applied on the EVP1 when the position of the lowering lever is at the minimum. This parameter is not effective if the EVP1 is programmed like a On/Off valve
MAX EVP	0 to 100. This parameter determines the maximum voltage applied on the EVP1 when the position of the lowering lever is at the maximum. If the EVP1 is programmed like a On/Off valve this parameter determines the fixed voltage applied on the electro valve coil.
MAX EVP RED	0 to 100. This parameter determines the maximum voltage applied on the EVP1 when the position of the lowering lever is at the maximum and lift height is 0 to 600mm. If the EVP1 is programmed like a On/Off valve this parameter determines the fixed voltage applied on the electro valve coil.
EVP OPEN DELAY	In seconds. It defines the opening ramp of the EVP1 electro valve when related output is set as Analog (refer to Set Option menu).
EVP CLOSE DELAY	In seconds. It defines the closing ramp of the EVP1 electro valve when related output is set as Analog (refer to Set Option menu).
CHAT TIME DELAY	In seconds. When truck is key on, if the operator doesn't use the truck for the time(CHAT TIME DELAY), main contactor is open to save energy.
DEADMAN DELAY	In seconds. Even though the operator step on the deadman switch, It is sometimes open because of vibration or other things. "DEAD MAN DELAY" is the time dead man switch signal is being kept "ON" status for set time, even though it is open.

Set option	Description
HOUR COUNTER	This option specifies the hour counter mode. It can be set one of two : - RUNNING : The counter registers travel time only - KEY ON : The counter registers when the ""key"" switch is closed
EVP TYPE	Analog/digital : defines the type of the EVP1 electro valve, current controlled : Analog : the related output manages a proportional valve, current controlled Digital : the related output manages an on/off valve
BATTERY CHECK	This option specifies the handling of the low battery charge detection. There are three levels : - Level 0 : Nothing happens, the battery charge level is calculated but is ignored, it means no action is taken when the battery is discharged. - Level 1 : BATTERY LOW alarm is raised when the battery level is calculated being less than or equal to 10% of the full charge. The BATTERY LOW alarm inhibits the Lifting function. - Level 2 : BATTERY LOW alarm is raised when the battery level is calculated being less than or equal to 10% of the full charge. The BATTERY LOW alarm reduces the maximum truck speed down to 24% of the full truck speed and it inhibits the Lifting function.
STOP ON RAMP	Only when the encoder is present, it is possible to electrically hold the truck on a slope when the accelerator is released but the tiller is not released. - ON : The stop on ramp feature (truck electrically hold on a ramp) is managed for a time established by AUXILIARY TIME parameter. - OFF : The stop on ramp feature is not performed. That means the truck comes down slowly during the AUXILIARY TIME.
SET MOT.TEMPERAT	It can be set : - ANALOG : An analogue sensor for the control of the motor temperature is connected to CNA#22. Typically the temperature sensor is a PTC (positive thermal coefficient resistance), providing the sensor characteristic to Zapi the correct table can be loaded in the controller software. 1. DIGITAL : A digital (on/off) sensor for the motor temperature monitoring is connected to CNA#22 input. 2. NONE : No temperature sensor is connected.
AUX OUTPUT #1	PRESENT/ABSENT : When is set PRESENT the ON/OFF valve #1 is used for platform lift. If is set ABSENT the ON/OFF valve #1 isn't used.
AUX OUTPUT #2	PRESENT/ABSENT : When is set PRESENT the ON/OFF valve #2 is used for auxility lift. If is set ABSENT the ON/OFF valve #2 isn't used. (Not applicable)

Adjustments	Description
SET BATTERY TYPE	Selects the nominal battery voltage.
ADJUST BATTERY	Fine adjustment of the battery voltage measured by the controller.
THROTTLE 0 ZONE	Establishes a deadband in the accelerator input curve.
THROTTLE X POINT	This parameter, together with the THROTTLE Y POINT, changes the characteristic of the accelerator input curve : when the accelerator is de-pressed to X point per cent, the corresponding truck speed is Y point percent of the Maximum truck speed. The relationship between the accelerator position and the truck speed is linear between the THROTTLE 0 ZONE and the X point and also between the X point and the maximum accelerator position but with two different slopes.
THROTTLE Y POINT	This parameter, together with the THROTTLE X POINT, changes the characteristic of the accelerator input curve : when the accelerator is de-pressed to X point per cent, the corresponding truck speed is Y point per cent of the Maximum truck speed. The relationship between the accelerator position and the truck speed is linear between the THROTTLE 0 ZONE and the X point and also between the X point and the maximum accelerator position but with two different slope.
BAT. MIN ADJ.	Adjust the lower level of the battery charge table (Level 0 to 9).
BAT. MAX ADJ.	Adjust the upper level of the battery charge table (Level 0 to 9).
ADJUSTMENT #03	Set an increment of battery charge above actual value. If battery voltage exceed this total value the software recognize charging, and battery charge percentage increase to correct value also if battery isn't fully charged.
MC EB VOLT	%. This parameter stores the PWM value applied to MC coil and AUX COIL for the first second of the output activation. It is expressed in percentage of battery voltage.
MC EB V RID	%. This parameter stores the PWM value applied to MC coil and AUX COIL after the first second of the output activation. It is expressed in percentage of MC EB VOLT.
PWM ON MAIN CONT	- OFF : The inverter applies the battery voltage to the loads on the main contactor coil connected to CNA#12. - ON : The PWM reduces the voltage on the main contactor coil down to the value programmed with "MC EB VOLT" and "MC EB V RID" parameters.
PWM ON AUX OUT	- OFF : The inverter applies the battery voltage to the loads on the auxiliary output coil connected to CAN#4. - ON : The PWM reduces the voltage on the main contactor coil down to the value programmed with "MC EB VOLT" and "MC EB V RID" parameters.
ADJUSTMENT #04	This parameter determines the motor temperature level at which the "Motor temperature" alarm is signalled. This parameter must be adjusted only if the "Set temperature" (menu "Set option") parameter is programmed "Analog".
DISP SPD FACTOR	It adjusts the speed coefficient to have the correct speed indication on the display. This coefficient has to be regulated depending on truck mechanic characteristics. It results from the following formula : Speed factor = 88 * rr * p / ø where : rr = total gearbox ratio ø = traction wheel diameter (cm) P = number of pair poles of the motor
VACC MAX	It is the voltage level, when accelerator lever is operated in forward direction.
VACC NEUTRAL	It is the voltage level, when accelerator lever is not in operation.
VACC MIN	It is the voltage level, when accelerator lever is operated in backward direction.

(2) Pump inverter

Parameter change	Description
ACCELER. DELAY	Level 0 ~ 9 ; It determines the acceleration ramp.
DECELER. DELAY	Level 0 ~ 9 ; It determines the deceleration ramp.
DEC DEL LIFT LIM	Level 0 ~ 9 ; It determines the deceleration ramp. When lift limit function is activated.
MAX SPEED UP	It determines the maximum lifting speed with a potentiometer control
MAX SP. UP FORK	It determines the maximum auxility lifting speed with a potentiometer control
MIN SPEED UP	It determines the minimum lifting speed with a potentiometer control when the lifting enable switch is closed.
CUTBACK SPEED	Hz. It determines the maximum lift speed when lift height is END-100 to END mm.
LIFT SPEED #1	Hz. It determines the maximum lift speed when lift height is 0 to 1500 mm.
LIFT SPEED #2	Hz. It determines the maximum lift speed when lift height is 1500 to 3000 mm.
LIFT SPEED #3	Hz. It determines the maximum lift speed when lift height is 3000 to 5500 mm.
LIFT SPEED #4	Hz. It determines the maximum lift speed when lift height is 5500 to END-100 mm.
MAXIMUM CURRENT	This parameter changes the maximum current of the inverter

Set option	Description
HOUR COUNTER	This option specifies the hour counter mode. It can be set one of two : - RUNNING : The counter registers travel time only - KEY ON : The counter registers when the "key" switch is closed
SET TEMPERATURE	- ANALOG : An analogue motor thermal sensor is connected between A22 and A23 inputs (the curve can be customized on a customer request). - DIGITAL : A digital (ON/OFF) motor thermal sensor is connected between A22 and A23 inputs. - NONE : No motor thermal sensor switch is connected.
HOUR METER TRUCK	With this parameter set to ON alarms are saved into logbook with truck hourmeter timestamp instead of pump inverter hourmeter
FORK	- OFF : Auxility lift function is not used. - ON : Auxility lift function is used.
D.M. PUMP	- OFF : Lift and lowering function is available after putting on dead man switch. - ON : Lift and lowering function is available without regard to put on dead man switch.

Adjustments	Description
SET BATTERY TYPE	Selects the nominal battery voltage.
ADJUST BATTERY	Fine adjustment of the battery voltage measured by the controller.
THROTTLE 0 ZONE	It establishes a dead band in the lift potentiometer input curve.
THROTTLE X POINT	This parameter, together with the THROTTLE Y POINT, changes the characteristic of the lift potentiometer input curve : when the potentiometer is depressed to X point per cent, the corresponding pump speed is Y point percent of the Maximum pump speed. The relationship between the lift potentiometer position and the pump speed is linear between the THROTTLE 0 ZONE and the X point and also between the X point and the maximum potentiometer position but with two different slopes.
THROTTLE Y POINT	This parameter, together with the THROTTLE X POINT, changes the characteristic of the lift potentiometer input curve : when the potentiometer is de-pressed to X point per cent, the corresponding pump speed is Y point per cent of the Maximum pump speed. The relationship between the potentiometer position and the pump speed is linear between the THROTTLE 0 ZONE and the X point and also between the X point and the maximum accelerator position but with two different slope.
AUX OUTPUT VOLT	It specifies the percentage of battery voltage supplied to back buzzer relay coil to apply the back buzzer.
AUX OUTPUT V RID	It specifies the percentage of AUX OUT VOLT parameter, supplied to back buzzer relay coil to keep back buzzer applied.
ADJUSTMENT #04	This parameter determines the motor temperature level at which the "Motor temperature" alarm is signalled. The range is from 70°C to 160°C with 10°C steps. This parameter must be adjusted only if the "Set temperature" (menu "Set option") parameter is programmed "Analog".
MOTOR SHUTDOWN	This parameter determines the motor temperature level at which the motor is shutdown. The range is from 70°C to 160°C with 10°C steps. This parameter must be adjusted only if the "Set temperature" (menu "Set option") parameter is programmed "Analog".
IMAX PROTECTION	%, The maximum current of the inverter.
VACC MAX	It is the voltage level, when lift lever is activated in upward direction.
VACC NEUTRAL	It is the voltage level, when lift lever is not in activation
VACC MIN	It is the voltage level, when lift lever is activated in downward direction.
VACC MAX FORK	It is the voltage level, when auxility lift lever is activated in upward direction.
VACC NEUTRAL FRK	It is the voltage level, when auxility lift lever is not in activation
VACC MIN FORK	It is the voltage level, when auxility lift lever is activated in downward direction.

(3) EPS inverter

Parameter change	Description
SPEED LIMIT	Level 0 to 9. It determines the scaling factor between the speed of the steering wheel and the speed of the steering motor but only when the steering wheel is fast turning. By increasing the SPEED LIMIT value, the steering motor speed increases too. In practice, it sets the maximum motor speed when the steering wheel is fast turning.
AUX FUNCTION #3	Level 0 to 9. This setting performs the dynamic numbness compensation : it consists of a reduction in the steer sensitivity when the truck is driving at high speed. To get this goal, it is necessary to attenuate the scaling factor between the speed of the steering wheel and the speed of the steering motor. AUX FUNCTI ON #3 does that but only when the steering wheel is fast turning. This attenuation must be proportional to the drive speed. At full drive speed the attenuation of the scaling factor is maximum. AUX FUNCTION #3 to Level 0 means no attenuation of the scaling factor with the truck speed. AUX FUNCTION #3 to Level 9 means maximum attenuation of the scaling factor with the truck speed. Obviously, to perform the dynamic numbness compensation, it is necessary to know the drive speed and so the eps-ac0 must be CAN Bus connected"
SENSITIVITY	Level 0 to 9. It determines the scaling factor between the speed of the steering wheel and the speed of the steering motor but only when the steering wheel is slow turning. By increasing the SENSITIVITY value, the steering motor speed increases too. In practice, it changes the sensitivity of the steering wheel when it is slow turning.
AUX FUNCTION #2	Level 0 to 9. This setting performs the dynamic numbness compensation: it consists of a reduction in the steer sensitivity when the truck is driving at high speed. To get this goal, it is necessary to attenuate the scaling factor between the speed of the steering wheel and the speed of the steering motor. AUX FUNCTI ON #2 does that but only when the steering wheel is slow turning. This attenuation must be proportional to the drive speed. At full drive speed the attenuation of the scaling factor is maximum. AUX FUNCTION #2 to Level 0 means no attenuation of the scaling factor with the truck speed. AUX FUNCTION #2 to Level 9 means maximum attenuation of the scaling factor with the truck speed. Obviously, to perform the dynamic numbness compensation, it is necessary to know the drive speed and so the eps-ac0 must be CAN Bus connected.
CREEP SPEED	Level 0 to 9. It sets a minimum amount of motor torque when the steering motor is slow turning. It is useful (together with the ANTIROLLBACK parameter) to neutralize the recall torque generated by the elastic tyre on the steered wheel.
KP	Level 0 to 9. It is used to set the proportional contribution to a PID algorithm for AUTC functions. The proportional contribution is applied to the difference between the commanded position and the real position (steered wheel angle). The accuracy of the pursuing between commanded and real position increases if KP increases. It is used in closed loop applications.

Parameter change	Description
POS. ACCURACY	Level 0 to 9. It is used to set the proportional contribution to a PID algorithm for AUTC functions. The proportional contribution is applied to the difference between the commanded position and the real position (steered wheel angle). The accuracy of the pursuing between commanded and real position increases if POS. ACCURACY increases. POS. ACCURACY is used only for closed loop applications. KP and POS. ACCURACY are a coarse and a fine contribution to the same setting.
DYNAM NUMB SPEED	Level 0 to 9. This parameter handles the dynamic numbness vs. the steering error for AUTC functions. This functions applies a linear correspondence between the steering motor speed and the angle error between the actual commanded position and the latest steady state position of the steered wheel. This parameter sets the percentage of the full steering motor speed is applied when in the full dynamic numbness. The full steering motor speed is the sum of the SET SAT FREQ and OVERSAT FREQ settings. When the angle between the actual commanded position and the latest steady state position is less than 40% of the DINAM NUMB ANG setting, the full dynamic numbness vs. the steering error is applied and the steering speed is clamped to the DYNAM NUMB SPEED percentage below. - LEVEL 0 : At full dynamic numbness, the steering motor frequency is clamped to 40% (maximum numbness) - LEVEL 1 : At full dynamic numbness, the steering motor frequency is clamped to 46%. - LEVEL 2 : At full dynamic numbness, the steering motor frequency is clamped to 53%. - LEVEL 9 : At full dynamic numbness, the steering motor frequency is clamped to 100% (no numbness). Each step more has a weight of 6.6 %.
DYNAM NUMB ANG	Level 0 to 9. This parameter handles the dynamic numbness vs. the steering error for AUTC functions. This functions applies a linear correspondence between the steering motor speed and the angle error between the actual commanded position and the latest steady state position of the steered wheel: when this angle error is wider than the angle specified with this setting, there will be no clamp on the steering motor speed (full speed steering motor is SET SAT FREQ plus OVERSAT FREQ); when this angle error is smaller than 40% of the angle specified with this setting, the maximum numbness will be applied. This parameter sets the angle, between the commanded position and the latest steady state position, at which the steering motor speed get sits maximum value (SET SAT FREQ plus OVERSAT FREQ). - LEVEL 0 : No numbness if the angle between tiller and latest steady state is higher than 5°. - LEVEL 1 : No numbness if the angle between tiller and latest steady state is higher than 11°. - LEVEL 2 : No numbness if the angle between tiller and latest steady state is higher than 17°. - LEVEL 9 : No numbness if the angle between tiller and latest steady state is higher than 60°. Each step has a weight of 6 degrees.

Parameter change	Description
COMPENSATION	Level 0 to 2. This parameter applies a compensation for the drops in the motor connections to have a real Emf/f control law. - LEVEL 0 : No compensation. - LEVEL 1 : Compensate the drop on power mosfets and cables. - LEVEL 2 : Compensate the drop on power mosfet, cables and motor resistance. COMPENSATION to LEVEL 2 is strongly suggested (the correct setting of the motor resistance is required when COMPENSATION is set to LEVEL 2)
1ST ANGLE COARSE	This parameter regulates in coarse steps the maximum steered wheel angle in the direction where FEEDBACK ENC is higher than 2.5 V. Parameters 1st and 2nd ANGLE COARSE both to level 9 get the steered wheel angle unlimited. If parameter change level 2 to level 9, it means that 180 angle system is changed to 360 angle system.
2ND ANGLE COARSE	This parameter regulates in coarse steps the maximum steered wheel angle in the direction where FEEDBACK ENC is lower than 2.5 V. Parameters 1st and 2nd ANGLE COARSE both to level 9 get the steered wheel angle unlimited. If parameter change level 2 to level 9, it means that 180 angle system is changed to 360 angle system.
AUXILIARY TIME	This parameter defines the time, after the steer handle is released and the travel demand deactivated, for which the stand still torque is applied. - LEVEL 0 : No stand still torque. - LEVEL 1 : Brief application of the stand still torque (about 6 secs). - LEVEL 9 : Long application of the stand still torque (about 90 secs). Intermediate levels are for proportionally increasing auxiliary time. The stand still torque reduces with a ramp from the ANTIROLLBACK value down to zero with a delay specified with this setting.
ANTIROLLBACK	This parameter adjusts the stand still torque after the steer handle is released and the travel demand deactivated. It is in percentage of the maximum current. Injecting a continuous current in the motor generates the stand still torque. It is useful (together with the CREEP SPEED parameter) to neutralize the recall torque generated by the elastic tyre on the steered wheel.
LAG FB REGULAT	Level 0 to 9. It is used to set the integral (lag) contribution to a PID algorithm for AUTC functions. The integral contribution is applied to the FEEDBACK ENC value only. It works like a low pass filter to get smooth the pursuing next to the commanded position. The derivative (lead) contribution generates dither that is possible to reduce by increasing this adjustment. Obviously lag and lead regulations influence the stability of the closed loop and so different setting must be empirically tried to avoid oscillations. - LEVEL 0 : Lowest lag contribution (high cut off frequency low pass filter). - LEVEL 9 : Highest lag contribution (low cut off frequency low pass filter).

Parameter change	Description
LEAD FB REGULAT	Level 0 to 9. It is used to set the derivative (lead) contribution to a PID algorithm for AUTC functions. The derivative contribution is applied to the FEEDBACK ENC value only. High LEAD FB REGULAT value brakes the steering motor in advance respect to the commanded position so avoiding the overshooting of the commanded position. On the other side generates damping and dither, close to the commanded position. Obviously lag and lead regulations influence the stability of the closed loop and so different setting must be empirically tried to avoid oscillations. - LEVEL 0 : Lowest lead contribution (overshooting is favorite). - LEVEL 9 : Highest lead contribution (damping is favorite).

Set option	Description
HOUR COUNTER	This option specifies the hour counter mode. It can be set one of two : - RUNNING : The counter registers travel time only - KEY ON : The counter registers when the "key" switch is closed
MICRO CHECK	This option is useful to support debug and troubleshooting. It makes possible to inhibit the supervisor (slave uC) operations and allows the system to run with just the main uC. When entering this operating mode the safety contacts stay open. Therefore, traction shall be disabled. It can be set one of two : -PRESENT: Default setting : enable the operations of the supervisor (slave uC). -ABSENT: Disable the operations of the supervisor (slave uC). The safety contacts stay opened.
ENCODER CONTROL	This option specifies if the motor is controlled via encoder or completely sensorless. Normally it is set OFF. When glitches are heard from the motor, it is necessary to turn to a sensored control. In this case set ENCODER CONTROL to on. Then, take care the encoder resolution used in the software is matched with the actual encoder resolution.
FEEDBACK DEVICE	This option specifies which kind of feedback sensor is adopted. Here is the feedback sensor list : - Option #4 : FB ENC & ONE (or TWO) toggle switches This is only admitted setting. It specifies the feedback sensors consists of one or two toggle switches (in the straight and 90 degrees positions of the steered wheel) together with an encoder in the motor.
AUTOCENTERING	This option makes the automatic centering (AUTC) operation available. When it is set on, an automatic alignment of the steered wheel on the straight ahead toggle switch is always performed at key-on. When it is set off, the AUTC at key-on is still performed for any configuration but for the open loop (stepper motor at the steering wheel) without angle limitation. In this latest case, the centering must be manually executed. Besides, this option enables the AUTC on demand. A centering request is required in this case to get the AUTC on-demand really performed.

Set option	Description
RECOVERY AT REST	(Stepper motor version only).This option enables the function "alignment at the rest position" It consists of the following steps : - When releasing the stepper motor, the SW records the steered wheel angle. - Then it is expected the steered wheel angle does not change meanwhile travelling with a released stepper motor. - If the steered wheel angle changes more than 8 degrees, the system automatically turns back to the recorded position If the driver moves the stepper motor meanwhile an alignment at the rest position is in progress, the alignment will be aborted.
AUX FUNCTION 1	This option sets the steering mode after the feedback sensor has reached the commanded position (it is used only in closed loop configurations (i.e. automatic centering). It can be set one of three : - LEVEL 0 : The steering control is always active when a travel demand is active. The steer control is turned off when the travel demands are deactivated (after a 3 sec delay). - LEVEL 1 : The steering control is alternatively turned off (15 secs long plus the AUXILIARY TIME) and on (3 secs long). - LEVEL 2 : The steering control is alternatively turned off (15 secs long plus the AUXILIARY TIME) and on (3 secs long) but only when a travel demand is active.AUXILIARY TIME is the delay (in secs) the DC standing current takes to arrive to 0.
DIAG MOTOR TEMP	This option enables the diagnosis of the motor temperature. When it is set on and the motor temperature overtakes 150°, a MOTOR TEMPERAT alarm occurs. The KTY84-130 motor thermal sensor must be connected between CNB#3 and a minus battery (CNA#13).
COMBI CAN PORT.(N/A)	This option isn't used BOP truck. It's always set to absent.

Adjustments	Description
ADJUSTMENT #01	This setting is used to acquire the motor resistance.
SET CURRENT	This setting is factory adjusted to calibrate the ADJUSTMENT #03 and #04 below.
ADJUSTMENT #02	Motor resistance in milliohms. This is the resistance of the motor measured between two motor terminals. The motor resistance may be either self-acquired or may be set by rolling up or down this adjustment.
ADJUSTMENT #03	(Factory adjusted). Parameter to compensate for the gain of the current amplifier in phase W.
ADJUSTMENT #04	(Factory adjusted). Parameter to compensate for the gain of the current amplifier in phase V.
SET BATTERY TYPE	Set this adjustment to the nominal battery voltage. Pay attention, never set SET BATTERY TYPE higher than 36 V for a 24/36 V controller. Never set SET BATTERY TYPE lower than 36V for a 36/48V controller.
SET SAT. FREQ.	Set this adjustment to the corner frequency of the motor. SET SAT FREQ is to be meant as the maximum frequency at which the motor supplies the maximum torque (it is the superior limit of the constant torque characteristic). Frequency higher than SET SAT FREQUENCY gets the motor weakened.
OVERSAT FREQ	The maximum motor frequency is set with the sum between SET SAT FREQ and OVERSAT FREQ. OVERSAT FREQ is the increment, over the SET SAT FREQUENCY, in which the steering motor works with degraded flux (weakening area). Default choice is 1 Hz (i.e. the steering motor never works in the weakening region).
MAXIMUM SLIP	(Factory adjusted). MAXIMUM SLIP modifies the acceleration and deceleration ramp for the frequency in the motor. Higher MAXIMUM SLIP gets faster acceleration and deceleration ramp. If the encoder is used for the motor control (ENCODER CONTROL is On), MAXIMUM SLIP has another meaning: it is the slip to be applied when the control is sourcing the maximum current.
AUX VOLTAGE #1	(Factory adjusted). This is the self-acquired offset value of the stepper motor line connected to CNA#9. The default value is 2.500 mV and can be re-acquired by rolling the DEBUG OUTPUT to 0.
AUX VOLTAGE #2	(Factory adjusted). This is the self-acquired offset value of the stepper motor line connected to CNA#8. The default value is 2.500 mV and can be re-acquired by rolling the DEBUG OUTPUT to 0.
NO LOAD CURRENT	In order it shall be possible to weaken the steering motor when lightened (reducing power loss in the motor), it is necessary to specify the current the motor drains when working full flux and without load (NO LOAD CURRENT). To find this value it is necessary to set the DEBUG OUTPUT to level 10 and to measure the current in the motor when running without load and a frequency close to SET SAT FREQ/2.
ZERO SP POT	(Twin Pot version only). This adjustment is used to self-acquire the voltages on the twin potentiometers when the steer handle is released in its straight ahead position. Just push the enter button with a released steer handle to record the new ZERO SP POT value.

Set option	Description
SET STEER 0-POS	It must be set to the FEEDBACK ENC value corresponding to a perfectly straight-ahead steered wheel inside the first and fourth quadrant (i.e. it must be set to the value of FEEDBACK ENC for a steered wheel that is straight ahead around the null WHEEL ANGLE position). The steered wheel will be positioned to SET STEER 0-POS either when an AUTC is demanded (in case the steered wheel angle is electrically limited or in case the steered wheel is the first and fourth quadrant). SET STEER 0-POS may be rolled up or down in 5 mV steps. 2492mV is the default value.
SET STEER 180	It must be set to the FEEDBACK ENC value corresponding to a perfectly straight-ahead steered wheel inside the second and third quadrant (i.e. it must be set to the value of FEEDBACK ENC for a steered wheel that is straight ahead around the 180 degrees WHEEL ANGLE position). The steered wheel will be positioned to SET STEER 180 when an AUTC is demanded (in the second and third quadrant and for any application without electrical angle limitation). SET STEER 180 may be rolled up or down in 5 mV steps. 0mV is the default value.
SET ENC AT 180	This adjustment is used to acquire the encoder counting corresponding to a partial steered wheel revolution (about a half) occurring between two falling edges of the straight ahead sensor : the first falling edge occurs on incidence of the first iron plate limit; the second falling edge occurs on incidence of the second iron plate limit .It is an important setting for applications without steered wheel angle limitation. Procedure for SET ENC AT 180 consists of collecting the encoder counting corresponding to that half steered wheel revolution on the tester reading ENC COUNT AT 180. To do that two ways are available: autoteaching and manual teaching. Autoteaching procedure automatically saves the new ENC COUNT AT 180 on SET ENC AT 180; manual teaching procedures asks the ENC COUNT AT 180 being manually saved on SET ENC AT 180.
SET ENC AT 360	This adjustment is used to acquire the encoder counting corresponding to a full steered wheel revolution. It is an important setting especially for applications without steered wheel angle limitation. Procedure for SET ENC AT 360 consists of collecting the encoder counting corresponding to a full steered wheel revolution on the tester reading ENC COUNT AT 360. To do that three ways are available: autoteaching, manual teaching and SET ENC AT 360 manual setting. Autoteaching procedure automatically saves the new ENC COUNT AT 360 on SET ENC AT 360; manual teaching asks the ENC COUNT AT 360 being manually saved on SET ENC AT 360; SET ENC AT 360 manual setting consists of writing directly the SET ENC AT 360 value in EEPROM .

Set option	Description
AUTOTEACHING	This option (on/off) is used to launch the autoteaching procedure. Take care there is not mechanical angle limitation before to turn it on. Then recycle the key and the steering motor starts an automatic sequence to collect the ENC COUNT AT 360 and ENC COUNT AT 180. If the collected couple is consistent (ENC COUNT AT 180 stays inside the window from 3/8 to 6/8 of ENC COUNT AT 360) they are automatically saved on the settings SET ENC AT 360 and SET ENC AT 180. If the autoteaching procedure successful ends, the display switches from the DATA ACQUISITION alarm to the collected values (in the range 0 to 5Vdc. Left side shows the ENC COUNT AT 360 value; the right side shows the ENC COUNT AT 180 value). If the couple of values is not consistent they were not saved and the display switches cyclically from the collected data to the DATA ACQUISITION inscription.

5) TESTER

Traction inverter	Description
HOUR METER TRUCK	This parameter displays the working hour of traction controller.
BATTERY VOLTAGE	Voltage value with 1 decimal digit. Battery voltage value measured at the key on.
MOTOR VOLTAGE	Percentage value. It is the voltage generated by the inverter expressed in percent of the actual battery voltage. 100% means the sine wave width is close to the actual battery voltage; 0% means the sine wave width is null.
VOLTAGE BOOSTER	Percentage value. It is the booster contribute to the voltage really supplied to the motor expressed in per cent of the actual battery voltage.
FREQUENCY	Hz value. This is the frequency of the sine waves the inverter is supplying.
ENCODER	Hz value. This is the speed of the motor measured with the encoder and expressed in the same unit of the FREQUENCY reading.
SLIP VALUE	Hz value. This is the slip between the frequency and the speed of the motor (SLIP VALUE = FREQUENCY-ENCODER).
CURRENT RMS	Ampere value. Root mean square value of the line current in the motor.
BATTERY CHARGE	Percentage value. It supplies the residual charge of the battery as a percentage of the full charge level.
TEMPERATURE	°C value. This is the temperature of the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm detection.
MOTOR TEMPERAT.	°C value. This is the temperature of the motor windings picked up with an analog sensor inside the motor. Normally this sensor is a PTC Philips KTY84-130. This temperature is used only to raise a warning. when the motor temperature overtakes the MOTOR OVERTEMP setting.
ACCELERATOR	From 0.0V to 5.0V. ACCELERATOR reading is in the range 0.0 to 5.0Vdc.
LIFTING CONTROL	From 0.0V to 5.0V. LIFTING reading is in the range 0.0 to 5.0Vdc.
STEER ANGLE	° Value. This is the angle of steering wheel.
DEADMAN SWITCH	ON/OFF. This is the status of deadman switch.
FORWARD REQUEST	ON/OFF. This is the status of forward signal.
BACKWARD REQUEST	ON/OFF. This is the status of backward signal.
LIFT STOP SWITCH	ON/OFF. This is the status of lift stop switch. (N/A)
MAST 1 SWITCH	ON/OFF. This is the status of MAST 1 SWITCH (600mm switch)
MAST 2 SWITCH	ON/OFF. This is the status of MAST 2 SWITCH (1500mm switch)
MAST 3 SWITCH	ON/OFF. This is the status of MAST 3 SWITCH (3000mm switch)
MAST 4 SWITCH	ON/OFF. This is the status of MAST 4 SWITCH (5500mm switch)
RIGHT SIDEGATE	ON/OFF. This is the status of right side gate switch.
LEFT SIDEGATE	ON/OFF. This is the status of left side gate switch.
CABIN LOWER SWITCH	ON/OFF. This is the status of cabin lower switch. (N/A)
MAINTEN ENABLE	ON/OFF. This is the status of maintenance switch. (N/A)
LIFT LIMIT SW	ON/OFF. This is the status of lift switch (MAX - 100 mm switch)
CHAIN LOOSER SW	ON/OFF. This is the status of slack chain switch.
SIDE ROLLER SW	ON/OFF. This is the status of side roller guide switch. When it is on, steering wheel is locked to the center position.
SETP. EVP LIFT	This parameter shows the setpoint of EVP valve.

Traction inverter	Description
OUTPUT EV1	ON/OFF: determines if the valve EV1 is open or closed.
OUTPUT EV2	ON/OFF: determines if the valve EV2 is open or closed.
MAIN CONT.VOLT	% value. This is the percentage of battery voltage into the main contactor coil.
ELEC BRAKE VOLT	% value. This is the percentage of battery voltage into the electrical brake coil.

Pump inverter	Description
HOUR METER TRUCK	This parameter displays the working hour of pump controller.
BATTERY VOLTAGE	Voltage value with 1 decimal digit. Battery voltage value measured at the key on.
MOTOR VOLTAGE	Percentage value. It is the voltage generated by the inverter expressed in percent of the actual battery voltage. 100% means the sine wave width is close to the actual battery voltage; 0% means the sine wave width is null.
VOLTAGE BOOSTER	Percentage value. It is the booster contribute to the voltage really supplied to the motor expressed in per cent of the actual battery voltage.
FREQUENCY	Hz value. This is the frequency of the sine waves the inverter is supplying.
ENCODER	Hz value. This is the speed of the motor measured with the encoder and expressed in the same unit of the FREQUENCY reading.
SLIP VALUE	Hz value. This is the slip between the frequency and the speed of the motor (SLIP VALUE = FREQUENCY-ENCODER).
CURRENT RMS	Ampere value. Root mean square value of the line current in the motor.
TEMPERATURE	°C value. This is the temperature of the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm detection.
MOTOR TEMPERAT.	°C value. This is the temperature of the motor windings picked up with an analog sensor inside the motor. Normally this sensor is a PTC Philips KTY84-130. This temperature is used only to raise a warning. when the motor temperature overtakes the MOTOR OVERTEMP setting.
LIFTING CONTROL	From 0.0V to 5.0V. LIFTING reading is in the range 0.0 to 5.0Vdc.
FRK LIFT CONTROL	From 0.0V to 5.0V. FORK LIFTING reading is in the range 0.0 to 5.0Vdc. (N/A)
LIFT REQUEST	ON/OFF. This is the status of the lifting signal.
LOWER REQUEST	ON/OFF. This is the status of the lowering signal.
LIFT FORK REQ	ON/OFF. This is the status of the auxiliary fork lifting signal.
LOWER FORK REQ	ON/OFF. This is the status of the auxiliary fork lowering signal.
BUZZER VOLT	% value. This is the percentage of battery voltage into the back up alarm relay coil.

EPS Inverter	Description
STEPPER MOTOR	Voltage value with 2 decimal digit. Measurement of the stepper motor speed with sign in the range 0 to 5 Vdc.
Feedback sector	Voltage value with 2 decimal digit. Measurement (scaled in the range 0 to 5 Vdc) of the actual state of the toggle switches. The steered wheel revolution is divided into 4 quadrants (sectors) corresponding to two toggle switches configurations : The steered wheel is in the 1ST sector (FEEDBACK SECTOR to 3.13V) when the configuration of the toggle switches is the one expected for a steered wheel angle in the range 0 to 90 degrees. The steered wheel is in the 2ST sector (FEEDBACK SECTOR to 4.39V) when the configuration of the toggle switches is the one expected for a steered wheel angle in the range 90 to 180 degrees. The steered wheel is in the 3RD sector (FEEDBACK SECTOR to 0.62V) when the configuration of the toggle switches is the one expected for a steered wheel angle in the range -180 to -90 degrees. The steered wheel is in the 4TH sector (FEEDBACK SECTOR to 1.88V) when the configuration of the toggle switches is the one expected for a steered wheel angle in the range -90 to 0 degrees.
Feedback ENC	Voltage value with 2 decimal digit. Measurement (scaled in the range 0 to 5 Vdc) of the position of the feedback encoder connected to CNB#7 and CNB#8.
Temperature	Degrees. Temperature of the controller base plate.
Motor temperature	Degrees. Temperature of the motor windings measured with the thermal sensor inside the motor and connected to CNB#3.
Frequency	Hertz value with 2 decimal digit. This is the frequency applied to the steering motor.
SAT. FREQ HZ	Hertz value with 2 decimal digit. This is a real time magnetic flux measurement : Vbattery/ SAT.FREQ HZ provides real time the linked flux in the motor. The flux in the motor is modulated from 75% to 100% of the maximum flux.The maximum flux is Vbattery/SET SAT FREQ. The minimum flux is Vbattery/(1.33*SET SAT FREQ). When the motor is loaded, SAT. FREQ HZ is equal to SET SAT FREQ; when the motor is lightened the flux reduces and SAT. FREQ HZ increases up to 1.33*SET SAT FREQ.
Motor voltage	It is a percentage. 100% means the sine waves in the motor have the maximum PWM amplitude.
Motor current	Ampere value. Root Mean Square value of the line current in the motor.
ENC speed	Hertz value with 2 decimal digit. This is the speed of the motor measured with the encoder on the motor shaft
Endstroke CW	Provides real time the active state (ON) or not of the CW toggle switch (connected to CNA#3). It is On when CNA#3 is low.
Endstroke ACW	Provides real time the active state (ON) or not of the CCW toggle switch (connected to CNA#2). It is On when CNA#2 is low.
CW limit level	When the maximum angle limitation via feedback sensors is enabled (option LIMIT DEVICE to ON) and the FEEDBACK ENC overtakes the superior limit for the steered wheel angle limitation, the steered wheel angle will be limited and CW LIMIT LEVEL turns ON (active).

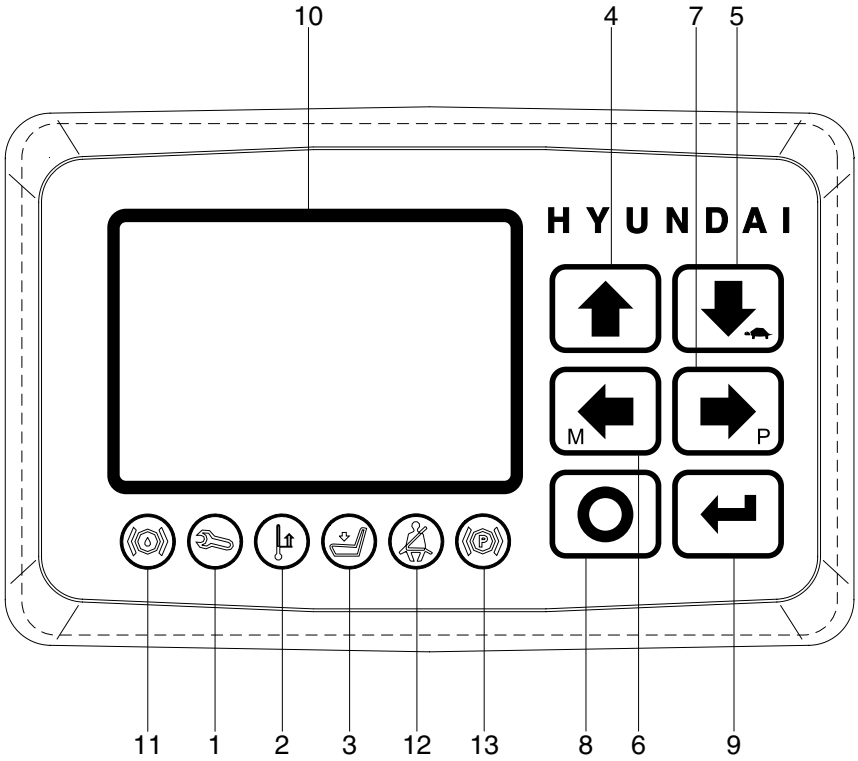
EPS Inverter	Description
ACW limit level	When the maximum angle limitation via feedback sensors is enabled (option LIMIT DEVICE to ON) and the FEEDBACK ENC is lower than the inferior limit for the steered wheel angle limitation, the steered wheel angle will be limited and ACW LIMIT LEVEL turns ON (active).
Auto in progress	Provides real time the information the eps-ac0 follows the manual command (AUTO INPROGRESS is OFF) or is executing an automatic centering (AUTO IN PROGRESS is ON).
MM alarm switch	It is On when the safety contact belonging to the main uC is closed.
SM alarm switch	It is On when the safety contact belonging to the slave uC (supervisor) is closed.
Truck moving	It provides the state of the travel demand for driving the truck. This information is obtained either with the travel demands directly connected to CNA#1 or via CAN Bus (depending by the state of the CAN BUS setting).
High resol AD	It turns ON when the set point potentiometer is processed with a high resolution AD (it occurs when the set pot potentiometer is close to the straight ahead position and SET HI RESOL AD is Level 1).
Wheel angle	It provides the current angle of the drive wheel by the degree.
Slope peak	This reading is just for debugging the maximum slope of the potentiometers connected to the epsac0. Especially for not redundant sensor equipments (just a single command potentiometer or just a single feedback potentiometer without encoder) a concern regarding the safety raises: if a single potentiometer fails a sudden movement of the steered wheel may occur with danger. To avoid this problem it is necessary to detect any failure in a single potentiometer. This is hard to do because the failure mode can be quite different. Anyway, the best countermeasure we can take is to seek for the wiper voltage changes faster than its physical limit. In fact, for the limited speed of the steering motor(or of the steering wheel), the slope in the wiper voltage must be limited under a certain threshold. When this slope threshold is overtook, the potentiometer may be assumed broken. So, it is useful to measure the maximum slope occurring in your application when right working, in order a right slope threshold can be chosen to avoid an alarm occurs when the potentiometer is not failed. The SLOPE PEAK reading in the tester menu is a real time measurement of the slope peak of the potentiometers. In particular:When the special adjustments DEBUG OUTPUT is other than Level 12 or 13, SLOPE PEAK supplies the slope peak of the CPOC1 set point potentiometer (CNA#9).When the special adjustments DEBUG OUTPUT is Level 13, SLOPE PEAK supplies the slope peak of the CPOT feedback potentiometer (CNB#6). When the special adjustments DEBUG OUTPUT is Level 12, SLOPE PEAK supplies the slope peak of the CPOC2 set point potentiometer (CNA#8).The SLOPE PEAK measurement is the difference between two AD conversions of the selected potentiometer picked up with 16 msec long interval. The SLOPE PEAK reading can be converted in a Voltage change (V in volts) of the wiper voltage in an interval 16 msec long, with the formula : V = SLOPE PEAK*5/1024 = Voltage change in Volts in 16 msec (e.g. When SLOPE PEAK is 61 it means the selected potentiometer, in the worst case, changes61*5/1024 =0.3 V in 16 msec.). Obviously the SLOPE PEAK reading must be compared with the threshold for the STEERSENSOR KO alarmThe STEER SENSOR KO alarm may be adjusted.

Pump inverter	Description
TRUCK SPEED	Percentage value. It represents the truck speed represented in percentage of the full drive speed. It is used for the dynamic numbness (i.e. the steering sensitivity reduces when the truck speed increases).
ENC COUNT AT 360	Voltage value with two digits in the range 0 to +/-5Vdc value. This reading supplies the encoder counting corresponding to a complete steered wheel revolution in the range 0 to +/- 5.00Vdc. At rest it assumes a 5Vdc value, after a first valid falling edge on the straight ahead sensor it switches from 5Vdc to 0Vdc. After a second valid falling edge on the straight ahead sensor it switches to an intermediate value (between 0Vdc and +/-5Vdc) corresponding to the encoder counting for a full steered wheel revolution.
ENC COUNT AT 180	Voltage value with two digits in the range 0 to +/-5Vdc value. This reading supplies the encoder counting corresponding to a quasi-half steered wheel revolution in the range 0 to +/- 5.00Vdc. At rest it assumes a 5Vdc value, after a first valid falling edge on the straight ahead sensor it switches from 5Vdc to 0Vdc. After a second valid falling edge on the straight ahead sensor it switches to an intermediate value (between 0Vdc and +/-5Vdc) corresponding to the encoder counting for a side to side iron plate rotation. ENC COUNT AT 180 is expected being about a half of the ENC COUNT AT 360.

7. DISPLAY

1) STRUCTURE

The instrument panel has six built-in red LED, which provide the operator with an easy information about the status of some truck devices.



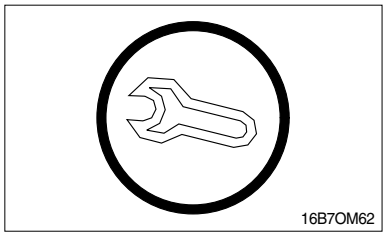
10BOP7OM65

1 Wrench warning lamp
2 Thermometer warning lamp
3 Dead man warning lamp
4 Key 1 button
5 Key 2 button
6 Key 3 button
7 Key 4 button
8 Key 5 button
9 Key 6 button
10 LCD function
11 Brake fail warning lamp
12 Seat belt warning lamp
13 Parking brake signal lamp

2) WARNING LAMP

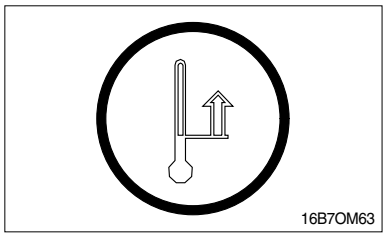
When the key switch is OFF, the display makes a general test lighting and switching OFF all the LED in sequence.

(1) Wrench warning lamp



This LED blinks when truck is in alarm condition.

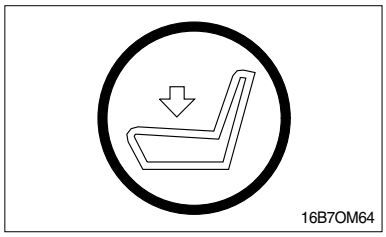
(2) Thermometer warning lamp



This LED blinks when one truck's controller is in alarm due IMS high temperature.

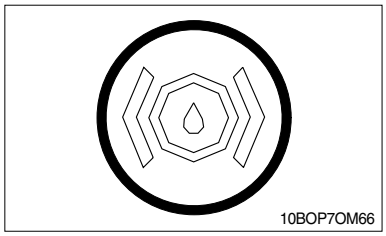
※ IMS : Input motor switch

(3) Dead man warning lamp



This LED lights when the operator doesn't on the dead man switch.

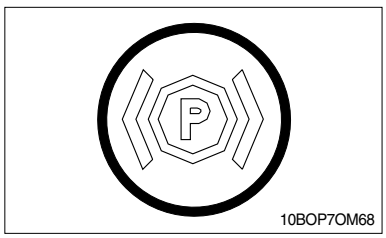
(4) Brake fail warning lamp



This lamp lights on when the oil pressure of service brake drops below the normal range.
When the lamp is on, stop the engine and check for its reason.

※ Do not operate until any problems are corrected.

(5) Parking brake signal lamp



This lamp shows whether the parking brake is applied or not.

① Parking brake applied : Signal lamp lights on

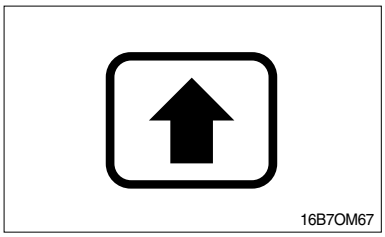
② Parking brake released : Signal lamp goes out

Make sure that the signal lamp goes out before operating the machine.

3) TESTER MENU

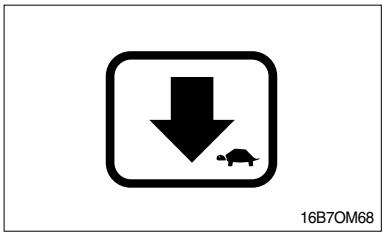
Status of keyboard buttons can be monitored in real time in the TESTER menu.

(1) Key 1 button



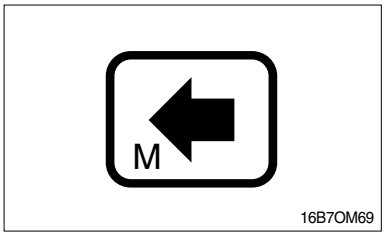
Status of ↑ keyboard button:
ON = Input active, button pushed
OFF = Input not active, button released

(2) Key 2 button



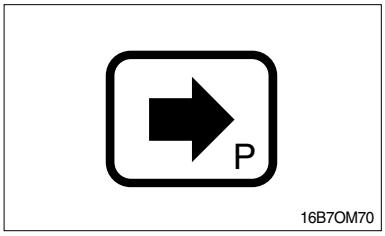
Status of ↓ TURTLE keyboard button:
ON = Input active, button pushed
OFF = Input not active, button released

(3) Key 3 button



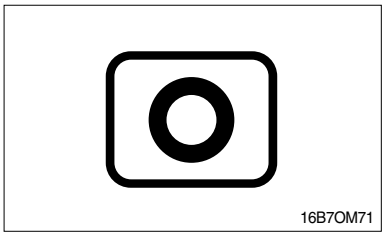
Status of ← M (Menu) keyboard button:
ON = Input active, button pushed
OFF = Input not active, button released

(4) Key 4 button



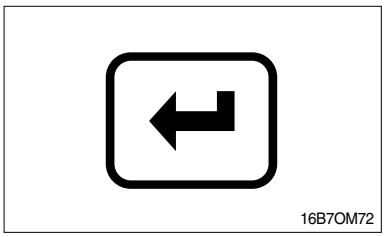
Status of → P (Performance) keyboard button:
ON = Input active, button pushed
OFF = Input not active, button released

(5) Key 5 button



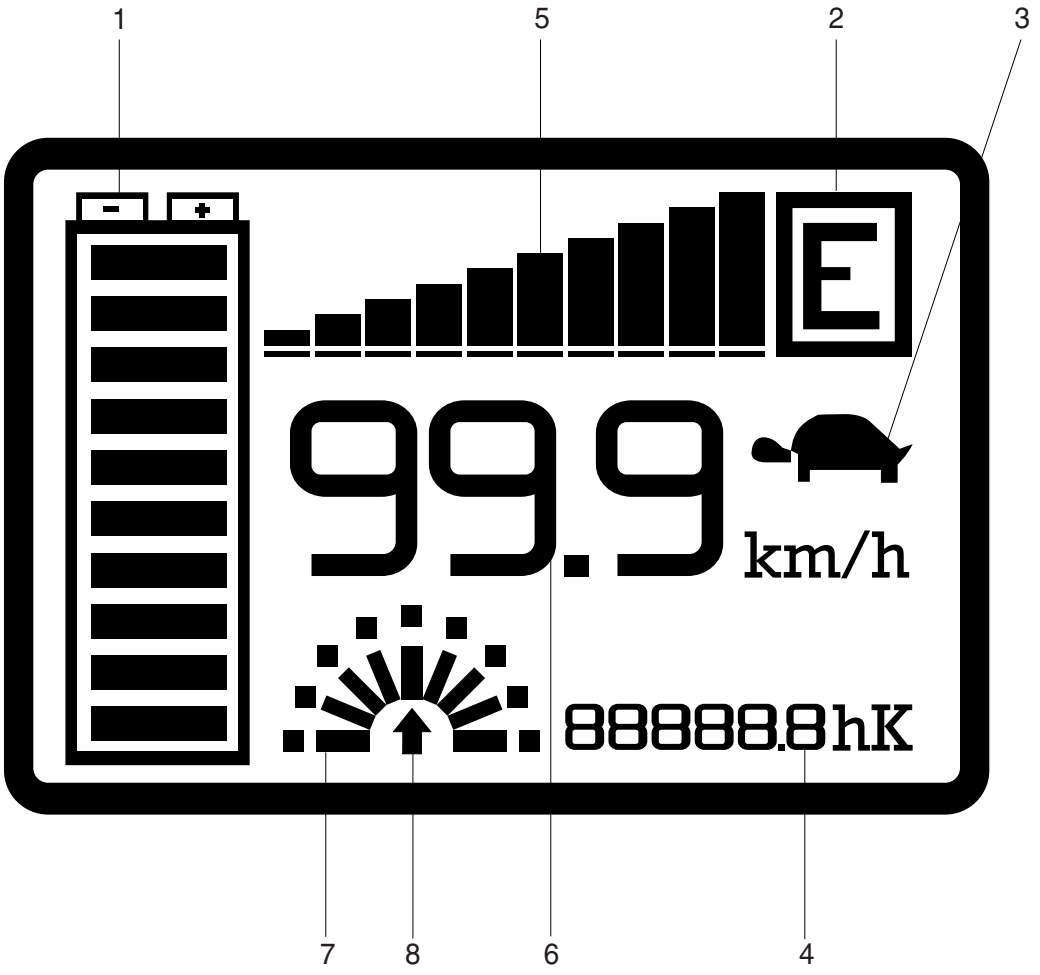
Status of ○ (Esc) keyboard button:
ON = Input active, button pushed
OFF = Input not active, button released

(6) Key 6 button



Status of ↵ (Enter) keyboard button:
ON = Input active, button pushed
OFF = Input not active, button release

4) LCD FUNCTION



(1) Battery's state of charge

The battery's state of charge indication is displayed on the left side of the unit (1); it is shown by ten notches. Each notch represents the 10% of the battery charge. As the battery becomes discharged, the notches turn off progressively, one after the other, in proportion to the value of the residual battery charge. When the residual battery charge is $\leq$ 20 % the notches displayed start to blink.

(2) Performance

The letter which appears in the rectangle displayed in the top right side of the unit (2) shows the performance mode which is being used in the controller.

Performances can be scrolled pressing button . When one performance is selected, the related information will be sent via can-bus to traction and pump controllers that will manage this data. The standard functioning reduces truck performance passing from the high to economic performance.

The real meaning, in terms of parameters level of these performances, depends on software present on pump and traction controllers:

- "H" corresponds to highest performance;
- "N" corresponds to normal performance;
- "E" corresponds to economic performance;

(3) Turtle

The turtle symbol (3) is normally off; when it appears (fixed) it shows activation of the "soft" mode of the truck, in which maximum speed and acceleration are reduced. The "soft" mode can be activated pressing button [⬇].

(4) Hour meter

The number displayed on the bottom right side of the unit (4) shows the Hours Worked.
The letter present near the hour meter shows which hour meter is displayed:
- K : the key hour meter is displayed;
- T : the traction hour meter is displayed;
- P : the pump hour meter is displayed; it increases if pump control is working.

(5) Accelerator

The accelerator level indication is displayed on the central top side of the unit (5); it is shown by ten notches. When the accelerator level is minimum only a notch is displayed, when the accelerator level is maximum all the ten notches are displayed. Each notch represents 1/10 of the difference between maximum and minimum accelerator level.

(6) Speed

The number displayed under the accelerator notches on the center of the unit (6) shows the truck speed. The unit can be km/h or mph depending on the SPEED UNIT parameter setting.

(7) Wheel position

The notch displayed on the left of the hour meter (7) represents the wheel (only one of the nine notches is displayed) and shows the steering angle (it corresponds to the relative truck direction if the truck is running).

(8) Running direction

① Angle 180° (Default setting)

The arrow (8) shows the set truck rulling direction. The arrow point is up to when the truck is forward running; the arrow point is down when the truck is reverse running. If the truck doesn't run a dot is displayed instead of the arrow.

② Angle 360° (Selectable setting at parameter change menu of EPS controller)

If you select this function(please see the 7-51), you can steer to every direction.
When the wheel position is over 180°, the direction and wheel position display is reversed like below.

5) DESCRIPTION OF PROGRAMMABLE FUNCTIONS

(1) Menu set model

① Connect to

Using CANBUS link, every module connected to can net can act as the "access node" to the canbus net for the external world.

For example the ZAPI hand console (or the PC-Win console) can be physically connected to one module and, by the canbus, virtually connected to any other module of the net.

This parameter is used to select the module to which the user wishes to be connected.

Following the numbers associated to each module in Zapi canbus system are showed.

Number associated in canbus net	Module
02	TRACTION
06	EPS
05	PUMP
09	MHYRIO
16	GRAPHIC SMART DISPLAY

(2) Menu set options

① Power selector

It sets the truck performances.

OPTION #1 : H (High performance)

OPTION #2 : N (Normal performance)

OPTION #3 : E (Economic performance)

② Hour counter

It sets the hour counter displayed.

OPTION #1 : The key hour meter is displayed

OPTION #2 : The traction hour meter is displayed

OPTION #3 : The pump hour meter is displayed

③ Auxiliary output #1

The options are :

PRESENT : An external load is connected between PAUX and NAUX.
The related diagnosis are enabled.

ABSENT : No external load is connected between PAUX and NAUX.
The related diagnosis are disabled.

④ Auxiliary voltage #1

It specifies the percentage of battery voltage supplied to AUX coil to close the AUXILIARY electro valve. This parameter can be changed in the range 0% to 100%.

⑤ Speed unit

It sets the speed unit.

OPTION #1 : The speed unit is km/h

OPTION #2 : The speed unit is mph

⑥ User password

The options are :

ON : After key-on a user password is asked to utilize the Graphic Smart Display

OFF : No user password needed

⑦ **Maintenance**

The options are :

PRESENT : A maintenance hour-counter is incremented with key ON.

When the hours elapsed reach the programmed value with the display the warning "SERVICE REQUIRED" is shown.

ABSENT : No "SERVICE REQUIRED" warning

⑧ **Maintenance done**

It can be ON/OFF. This parameter is normally off. Setting the "MAINT. DONE" on at next key-on the maintenance hours are updated with the display' s hour meter contents. This operation erases the "MAINTENANCE NEEDED" warning if it is present.

⑨ **Seat belt status**

It sets the "Seat belt" diagnostic LED indication in the following way:

OPTION #1 : No "Seat belt" indication. The diagnostic LED is not used.

OPTION #2 : If the seat belt are not fastened at Key-ON the diagnostic LED blinks for three times than it turns off.

OPTION #3 : The diagnostic LED blinks until the seat belt is fastened than it turns off.

(3) Submenu "ADJUSTMENTS"

① **Delay display OFF**

This parameter sets the display ON "Service time". If the CNB#4 is connected to +batt after key-off the display is still supplied for a programmable time, follow the table below to choose your temporization :

Delay display off level	0	1	2	3	4	5	6	7	8	9
Service time [sec]	1	3	5	7	9	11	13	15	17	20

6) DESCRIPTION OF CONSOLE USING

(1) Access to SET MODEL menu.

The only parameter present in SET MODEL function is CONNECTED TO.

By setting this parameter, operator can connect ZAPI console to every ZAPI product connected to CAN-BUS line. This functionality allows completely control of every ZAPI product without changing the position of the console connector.

① Opening Zapi menu.

② Press ROLL UP & SET UP buttons to enter CONFIG MENU.

③ The display will show: SET MODEL. If another menu is displayed, press ROLL UP or ROLL DOWN until SET MODEL appears.

④ Press ENTER to go into the SET MODEL.

⑤ The display will shows the first option, only CONNECTED TO option is present in this menu.

⑥ Press SET UP or SET DOWN buttons in order to select the desired value for selected option.

⑦ New desired value appears.

⑧ Press OUT to exit the menu.

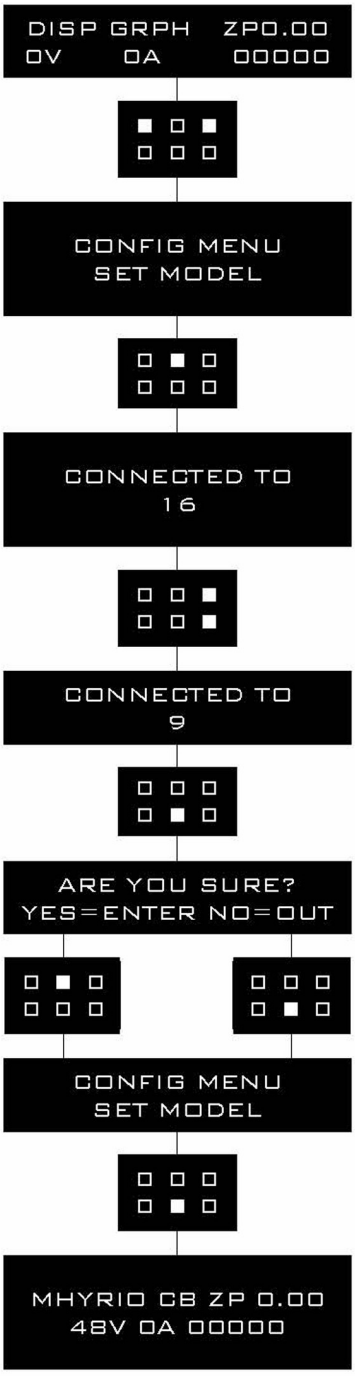
⑨ The display will ask "ARE YOU SURE?"

⑩ Press ENTER for YES, or OUT if you do not accept the changes.

⑪ SET MODEL menu appears.

⑫ Press OUT again. Console now disconnects and reconnects.

⑬ Display now shows the opening Zapi Menu of the ZAPI product corresponding to option selected at point 7.



20B7EL28

(2) Flow chart showing how to make changes to option menu:

① Opening Zapi menu.

② Press ROLL UP & SET UP Buttons to enter CONFIG MENU.

③ The display will show: SET MODEL.

④ Press ROLL UP or ROLL DOWN until SET OPTIONS appears.

⑤ SET OPTIONS menu appears.

⑥ Press ENTER to go into the SET OPTIONS menu.

⑦ The display will show the first option.

⑧ Press ROLL UP or ROLL DOWN buttons until desired option appears.

⑨ Desired option appears.

⑩ Press SET UP or SET DOWN buttons in order to modify the value for selected option.

⑪ New value for selected option appears.

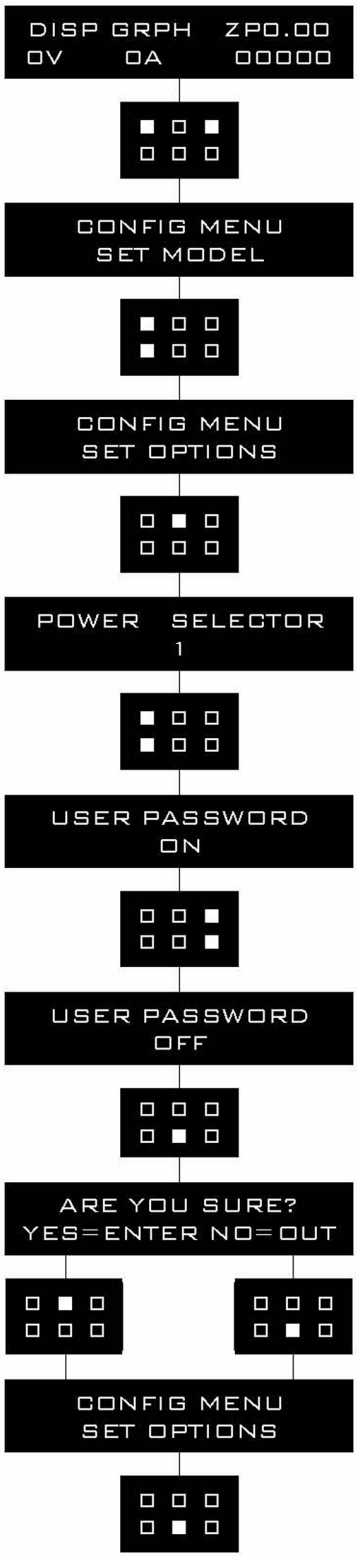
⑫ Press OUT to exit the menu.

⑬ Confirmation request appears.

⑭ Press ENTER to accept the changes, or press OUT if you do not accept the changes.

⑮ SET OPTIONS menu appears.

⑯ Press OUT again. Display now shows the opening Zapi menu.



20B7EL29

(3) Flow chart showing how to use the TESTER function of the digital console:

① Opening Zapi menu.

② Press ENTER to go into the MAIN MENU.

③ The display will show: PARAMETER CHANGE.

④ Press ROLL UP or ROLL DOWN until TESTER menu appears on the display.

⑤ The display will show: TESTER.

⑥ Press ENTER to go into the TESTER function.

⑦ The first variable to be tested is shown on the display.

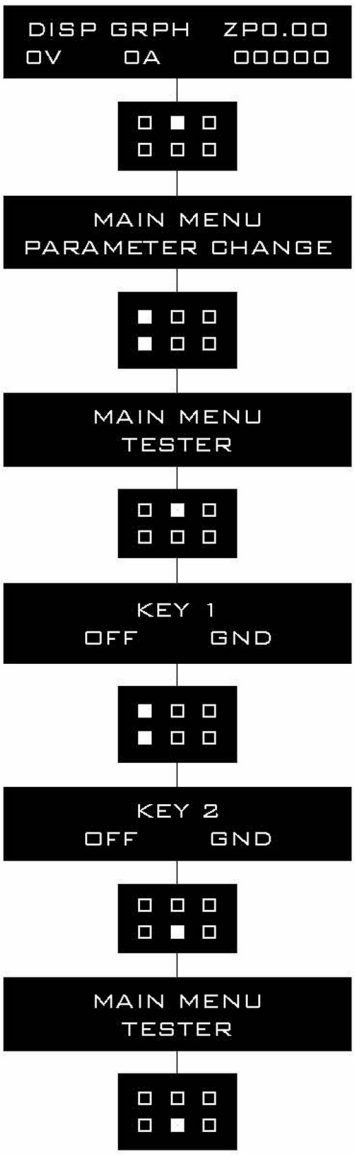
⑧ Press either ROLL UP or ROLL DOWN buttons.

⑨ Next variable for measurement appears.

⑩ When you have finished press OUT.

⑪ The Display will show: TESTER.

⑫ Press OUT again and return to opening Zapi menu.



20B7EL30

Remember it is not possible to make any changes using TESTER.
All you can do is measure as if you were using a pre-connected multimeter.

7) DESCRIPTION OF ALARM MENU

The microprocessor in the controller records the last five alarms that have occurred. Items remembered relative to each alarm are: the code of the alarm, the number of times the particular alarm occurred and the hour meter count. This function permits deeper diagnosis of problems as the recent history can now be accessed.

Flow chart showing how to use the ALARMS function via the digital console:

① Opening Zapi menu.

② Press ENTER to go into the MAIN MENU.

③ The display will show:

④ Press ROLL UP or ROLL DOWN until ALARMS menu appears on the display.

⑤ The display will show:

⑥ Press ENTER to go into the ALARMS menu.

⑦ The display will show the most recent alarm.

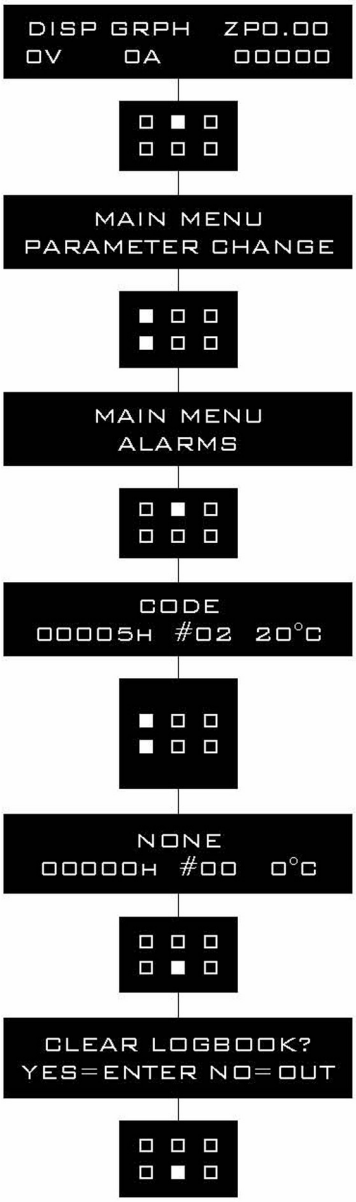
⑧ Each press of ROLL UP button brings up following alarms. Pressing ROLL DOWN returns to the most recent.

⑨ If an alarm has not occurred, the display will show: NONE.

⑩ When you have finished looking at the alarms, press OUT to exit the ALARMS menu.

⑪ The display will ask: "CLEAR LOGBOOK?" Press ENTER for Yes, or OUT for No.

⑫ Press OUT again and return to opening Zapi menu.



20B7EL31

8) STRUCTURE OF DISPLAY MENU

Graphic Smart Display present a software structure made by menus and submenus. It is possible to have access to Graphic Smart Display menu structure by the six operator buttons integrated in a membrane keyboard.

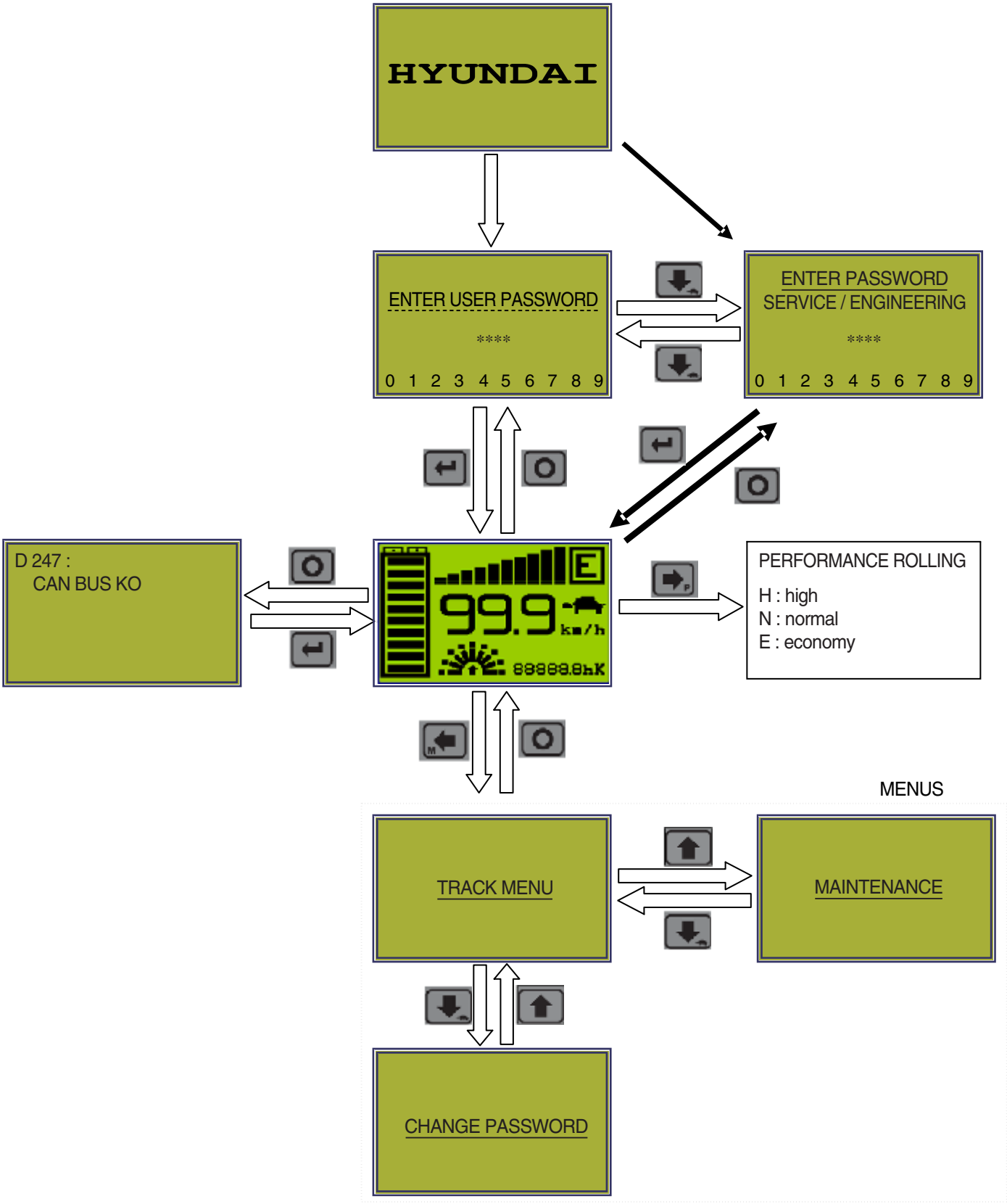
At turn on the display shows the HYUNDAI logo for some seconds, then asks the starting password to have access to the main page (if "USER PASSWORD" option is ON), otherwise it shows directly the main page (if "USER PASSWORD" option is OFF).

The main page, if there aren't alarms, shows battery charge, truck speed (in km/h or mph, it depends on "SPEED UNIT" parameter) and key/traction/pump hour meter (see "HOUR COUNTER" option); if alarms are present, it will show alarm code, node initials in which alarm has occurred and alarm description.

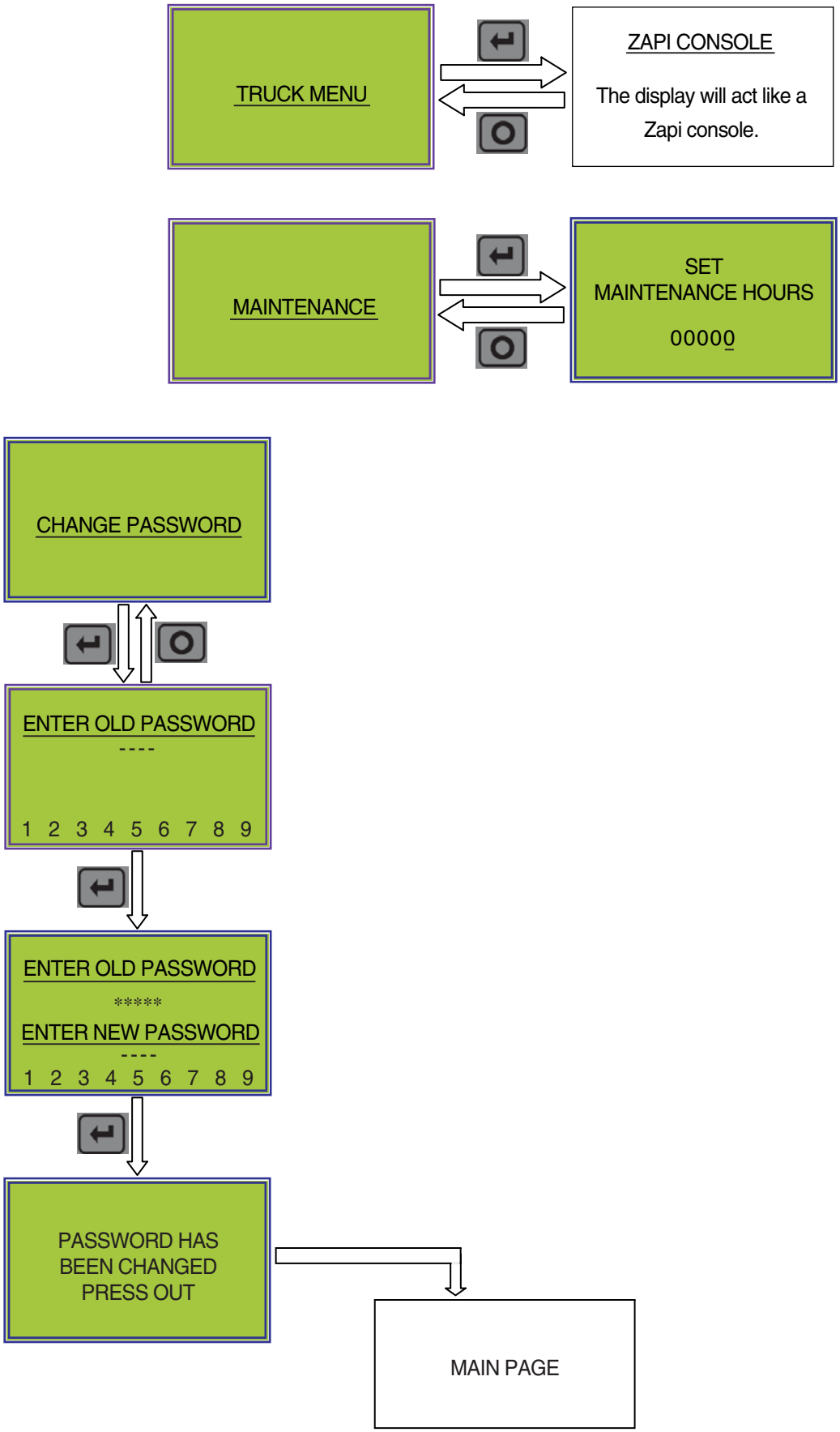
From the main page it is possible to have access to the ALARM page (if alarms occur) and to MENUS page. The CHANGE PASSWORD MENU is always accessible and visible, while the others ones are accessible and showed, by entering service password. To enter this password is necessary to push the out button (button #5) of membrane keyboard; this will show a entering password page.

By using service password it's possible to enter in all menus (TRUCK, CHANGE PASSWORD, MAINTENANCE).

It follows flow chart diagram of menu structure.


HYUNDAI
ENTER USER PASSWORD
****
0 1 2 3 4 5 6 7 8 9
ENTER PASSWORD
SERVICE / ENGINEERING
****
0 1 2 3 4 5 6 7 8 9
D 247 :
CAN BUS KO
99.9
km/h
PERFORMANCE ROLLING
H : high
N : normal
E : economy
MENUS
TRACK MENU
MAINTENANCE
CHANGE PASSWORD

16B7SM23


TRUCK MENU
ZAPI CONSOLE
The display will act like a Zapi console.
MAINTENANCE
SET MAINTENANCE HOURS
00000
CHANGE PASSWORD
ENTER OLD PASSWORD
----
1 2 3 4 5 6 7 8 9
ENTER OLD PASSWORD
*****
ENTER NEW PASSWORD
----
1 2 3 4 5 6 7 8 9
PASSWORD HAS BEEN CHANGED PRESS OUT
MAIN PAGE

20B7EL41

(1) Performance rolling

From MAIN PAGE using membrane keyboard numbers, it is possible to select the performance mode which must be used in traction and pump controllers.
Performance can be chosen with button 4, and it is displayed in the top right side of the unit.
When one performance is selected, the related information will be sent via canbus to traction and pump controllers that will manage this data. The standard functioning reduces truck performance passing from high performance mode (H) to economy performance mode (E).
The real meaning, in terms of parameters level of these performances, depends on software present on pump and traction controllers.

Button 4 Selects in sequence the truck performance (H → N → E).

(2) Using dashboard like console

By entering the service or engineering password, from MAIN PAGE it's possible to have access to TRUCK MENU, which allows user to use dashboard as a real Zapi digital console connected to one module of canbus net.
Here with roll buttons (button 1 and 2 of membrane keyboard) and enter button (button 6), it is possible to choose which module of canbus net has to be connected to the display.
When the display has been connected, it works exactly like a Zapi digital console.
Buttons of membrane keyboard do the same functions of Zapi console keys.

Button 1 Performs function of the ROLL UP console key
Button 2 Performs function of the ROLL DOWN console key
Button 3 Performs function of the SET DOWN console key
Button 4 Performs function of the SET UP console key
Button 5 Performs function of the OUT console key
Button 6 Performs function of the ENTER console key

(3) Using of password menu (option)

From MAIN PAGE it's always possible to have access to CHANGE PASSWORD MENU. Here with ENTER button (button 6 of membrane keyboard) the operator can change user Graphic Smart Display password.
To edit password use these buttons:

SET UP / SET DOWN	Shifts cursor through 10 digits on the bottom side of unit
ENTER	Inputs digit selected or saves all changing
OUT	Cancels one digit or exits (if there is no digit input yet)

(4) Set maintenance hours (option)

By entering the service or engineering password from MAIN PAGE it's possible to access to MAINTENANCE MENU. Here the service can change the programmed work hours between two maintenances.
Buttons of membrane keyboard have the same functions in the RESET HOURMETERS MENU:

Button 1 Increases digit marked by cursor
Button 2 Decreases digit marked by cursor
Button 3 Shifts cursor on previous digit
Button 4 Shifts cursor on following digit
Button 5 Cancels all changing and out from hour meter submenu
Button 6 Saves all changing

9) ANALYSIS OF GRAPHIC SMART DISPLAY RELATED ALARMS

(1) Graphic Smart Display alarms

① WATCHDOG

Cause:

At start-up the watch dog signal is already active before the software has generated it. At standby or running condition the watch dog signal is not active (in alarm status).

Troubleshooting:

The WD hardware circuit or microcontroller output port are damaged. In both cases no external component are involved. Replace the logic board.

② COIL SHORTED

Cause:

This alarm occurs when there is a short circuit of the AUXILIARY coil connected to CNB#1 output. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand.

Troubleshooting:

A) The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between dashboard outputs and loads.

B) In case no failures/problems have been found externally, the problem is in the logic card, which has to be replaced.

③ DRIVER SHORTED

Cause:

The driver of the auxiliary electro valve coil is shorted.

Troubleshooting:

A) Check if there is a short or a low impedance pull-down between NAUX (CNB#1) and -BATT.

B) The driver circuit is damaged in the logic board, which has to be replaced.

④ AUX DRIVER OPEN

Cause:

The AUX coil driver is not able to drive the load. The device itself or its driving circuit is damaged.

Troubleshooting:

This type of fault is not related to external components; replace the logic board.

⑤ HARDWARE FAULT

Cause:

At key-on the dashboard checks if the AUX driver is turned off by a not active (alarm status) watch-dog signal. If it is not turned off then the alarm is generated.

Troubleshooting:

The problem is inside the logic, no external component are involved, replace the logic board.

⑥ **CAN BUS KO**

Cause:

Graphic Smart Display doesn't receive messages from canbus line or the hour meter synchronization at key-on fails.

Troubleshooting:

A) If this fault code is displayed together with other alarm messages, the fault is probably to be looked for in the Graphic Smart Display can interface, since the display seems to be unable to receive any can message. So it is suggested to check Graphic Smart Display canbus wiring and connection.

B) Otherwise, the fault is in the can interface of other modules present on canbus network.

(2) Graphic Smart Display warnings

① **EEPROM KO**

Cause:

It's due to an HW or SW defect of the non-volatile embedded memory supporting the dashboard parameters. This alarm does not inhibit the machine operations, but the truck will work with the Graphic Display parameters default values.

Troubleshooting:

Try to execute a CLEAR EEPROM operation (refer to console manual).

Switch the key off and on to check the result. If the alarm occurs permanently, it is necessary to replace the logic. If the alarm disappears, the previously stored parameters will have been replaced by the default parameters.

② **MAINTENANCE NEEDED**

Cause:

This is just a warning to call for the time programmed maintenance.

Troubleshooting:

It is just enough to turn the MAINTENANCE DONE option to level ON after the maintenance is executed.

(3) Alarms visualization

When an alarm condition occurs, Graphic Smart Display gives the information showing the initial of module in which the alarm occurred, the alarm code and description.

For example, the information:

```
M 245:
    WRONG SET BAT
```

means that the alarm 245 - "WRONG SET BATTERY" occurred in the master traction controller (M).

Here the table with the alarm codes and the respective meaning is shown.

8. DIAGNOSTIC FAULT CODES

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
6	SERIAL ERR#1			○	Main uC and Slave uC communicate via a local serial interface. This alarm occurs when the slave uC does not receive the communication from the main uC through this serial interface. It is necessary to replace the controller.
8	WATCHDOG	○			Cause : This is a safety related test. It is a self diagnosis test within the logic. The watch dog circuit is composed by two monostable multivibrators so there is a double check of software execution. Troubleshooting : This alarm could be caused by an hardware failure in one of two (or both) multivibrator or due to a software execution problem. For both cases it is an internal fault of the controller which must be replaced.
13	EEPROM KO	○	○		Cause : It's due to a HW or SW defect of the non-volatile embedded memory supporting the controller parameters. This alarm does not inhibit the machine operations, but the truck will work with the default values. Troubleshooting : Try to execute a CLEAR EEPROM operation (refer to console manual). Switch the key off and on to check the result. If the alarm occurs permanently, it is necessary to replace the controller. If the alarm disappears, the previously stored parameters will have been replaced by the default parameters.
				○	Fault in the area of memory in which the adjustment parameters are stored; this alarm inhibits machine operation. If the defect persists when the key is switched OFF and ON again, replace the logic. If the alarm disappears, remember that the parameters stored previously have been cancelled and replaced by the default values.
16	LOGIC FAILURE #4			○	This alarm occurs in the rest state if the output of the voltage amplifier of the phase Vw-Vv have a drift larger than ±0.25 V. It is necessary to replace the controller.
17	LOGIC FAILURE #3	○			Cause : Hardware problem in the logic card circuit for high current (overload) protection. Troubleshooting : This type of fault is not related to external components, so, when it is present it is necessary to replace the controller.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
17	LOGIC FAILURE #3		○		Cause : Hardware problem in the logic card circuit for high current (overload) protection. Troubleshooting : This type of fault is not related to external components, so, when it is present it is necessary to replace the ACE logic board.
				○	This alarm occurs in the rest state if the output of the voltage amplifier of the phase Vu-Vw have a drift larger than ±0.25 V. It is necessary to replace the controller.
18	LOGIC FAILURE #2	○			Cause : Fault in the hardware section of the logic board which manages the phase's voltage feedback. Troubleshooting : This type of fault is not related to external components, so when it happens it is necessary to replace the controller.
			○		Cause : Fault in the hardware section of the logic board which manages the phase's voltage feedback. Troubleshooting : This type of fault is not related to external components, so when it happens it is necessary to replace the ACE2 logic board.
				○	This alarm occurs when the real voltage between phases W and V of the motor is different from the desired. It is necessary to replace the controller.
19	LOGIC FAILURE #1	○			This fault is displayed when the controller detects an overvoltage or undervoltage condition. Overvoltage threshold is 35V, undervoltage threshold is 9,5V in the 24V controller. In 48V controller overvoltage threshold is 65V, undervoltage threshold is 9,5V. Troubleshooting of fault displayed at startup or in standby; in these cases it is very likely the fault is due to an undervoltage, so it is suggested to check : A) Key input signal down-going pulses (below undervoltage threshold) due to external loads, like DC/DC converters starting-up, Relays or contactor switching, solenoids energizing / deenergizing. B) If no voltage transient is detected on the supply line and the alarm is present every time the key is switched ON, the failure is probably in the controller hardware, so it is necessary to replace the controller. Troubleshooting of fault displayed during motor driving; in this case it can be an undervoltage or a overvoltage condition. A) If the alarm happens during traction acceleration or driving hydraulic functions, it is very likely it is an undervoltage condition; check battery charge condition, power cable connection. B) If the alarm happens during release braking, it is very likely it is due to overvoltage condition; check line contactor contact, battery power cable connection.

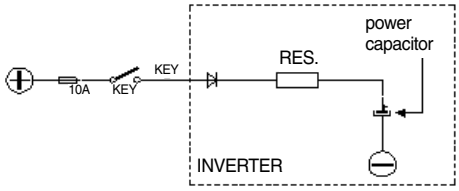
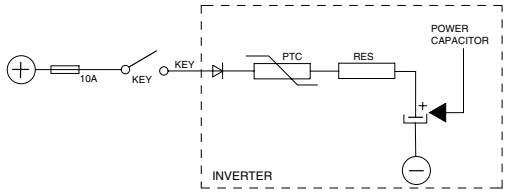
Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
19	LOGIC FAILURE #1		○		Cause : This fault is displayed when the controller detects an over voltage or under voltage condition. Over voltage threshold is 45V, under voltage threshold is 9V in the 24V controller. In 48V controller over voltage threshold is 65V, under voltage threshold is 11V. Troubleshooting : Troubleshooting of fault displayed at start-up or in standby; in these cases it is very likely the fault is due to an under voltage, so it is suggested to check : A) Key input signal down-going pulses (below under voltage threshold) due to external loads, like DC/DC converters starting-up, relays or contactor switching, solenoids energizing / de-energizing. B) Check the connection of power cables to the battery terminal, positive and negative, to MC and to controller +Batt and .Batt, which must be screwed with a torque comprised in the range 13Nm÷15Nm. C) If no voltage transient is detected on the supply line and the alarm is present every time the key is switched ON, the failure is probably in the controller hardware, so it is necessary to replace the logic board. Troubleshooting of fault displayed during motor driving; in this case it can be an under voltage or an over voltage condition. D) If the alarm happens during traction acceleration or driving hydraulic functions, it is very likely it is an under voltage condition; check battery charge condition, power cable connection. E) If the alarm happens during release braking, it is very likely it is due to over voltage condition; check line contactor contact, battery power cable connection.
				○	This alarm occurs when the real voltage between phases W and U of the motor is different from the desired. It is necessary to replace the controller.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
30	VMN LOW	○			Cause 1 : start-up test. Before switching the LC on, the software checks the power bridge: it turns on alternatingly the High side Power Mosfets and expects the phases voltage to increase toward the rail capacitor value. If the phases voltage does not increase, this alarm occurs. Cause 2 : Motor running test. When the motor is running, power bridge is ON, the motor voltage feedback is tested; if it is lower than commanded value, fault status is entered. Troubleshooting : A) If the problem occurs at start up (the LC does not close at all), check : - Motor internal connections (ohmic continuity) - Motor power cables connections - Motor leakage to truck frame - If the motor connections are OK, the problem is inside the controller B) If the alarm occurs during motor running, check : - Motor connections - If motor phases windings/cables have leakages towards truck frame - That the LC power contact closer properly, with a good contact - If no problem are found on the motors, the problem is inside the controller.
			○		Cause 1: Start-up test. Before switching the LC on, the software checks the power bridge: it turns on alternatingly the High side Power Mosfets and expects the phases voltage to increase toward the rail capacitor value. If the phases voltage is less than 66% of the rail capacitor voltage, this alarm occurs. Cause 2 : Motor running test. When the motor is running, power bridge is ON, the motor voltage feedback is tested; if it is lower than commanded value (a window of values are considered) fault status is entered. Troubleshooting : A) If the problem occurs at start up (the LC does not close at all), check : - Motor internal connections (ohmic continuity) - Motor power cables connections - Motor leakage to truck frame - If the motor connections are OK, the problem is inside the controller, replace it. B) If the alarm occurs during motor running, check : - Motor connections - If motor phases windings/cables have leakages towards truck frame - That the LC power contact closer properly, with a good contact - If no problem are found on the motors, the problem is inside the controller, replace it.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
31	VMN HIGH	○			Cause 1 : Before switching the LC on, the software checks the power bridge: it turns on alternatingly the Low side Power Mosfets and expects the phases voltage to decrease down to -BATT. If the phases voltage do not decrease, this alarm occurs. Cause 2 : This alarm may occur also when the start up diagnosis is overcome, and so the LC is closed. In this condition, the phases' voltages are expected to be lower than 1/2 Vbatt. If it is higher than that value, fault status is entered. Troubleshooting : A) If the problem occurs at start up (the LC does not close at all), check : - Motor internal connections (ohmic continuity) - Motor power cables connections - If the motor connection are OK, the problem is inside the controller B) If the problem occurs after closing the LC (the LC closed and then opens back again), check : - Motor connections - If motor phases windings/cables have leakages towards truck frame - If no problem are found on the motors, the problem is inside the controller
			○		Cause 1 : Before switching the LC on, the software checks the power bridge : it turns on alternatingly the Low side Power Mosfets and expects the phases voltage to decrease down to -BATT. If the phases voltage is higher than 10% of nominal battery voltage, this alarm occurs. Cause 2 : This alarm may occur also when the start up diagnosis is overcome, and so the LC is closed. In this condition, the phases' voltages are expected to be lower than 1/2 Vbatt. If it is higher than that value, fault status is entered. Troubleshooting : A) If the problem occurs at start up (the LC does not close at all), check : - Motor internal connections (ohmic continuity) - Motor power cables connections - If the motor connection are OK, the problem is inside the controller, replace it. B) If the problem occurs after closing the LC (the LC closed and then opens back again), check : - Motor connections - If motor phases windings/cables have leakages towards truck frame - If no problem are found on the motors, the problem is inside the controller, replace it.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
32	VMN NOT OK			○	This alarm occurs in the initial rest state after key on if the outputs of the motor voltage amplifiers are not in the window from 2.2 to 2.8 Vdc. It is necessary to replace the controller.
37	CONTACTOR CLOSED	○			Cause : Before driving the LC coil, the controller checks if the contactor is stuck. The controller drives the bridge for some tens milliseconds, trying to discharge the capacitors bank. If they don't discharge the fault condition is entered. Troubleshooting : It is suggested to verify the power contacts of LC; to replace the LC is necessary.
			○		Cause : Before driving the MC coil, the controller checks if the contactor is stuck. The controller drives the bridge for some tens milliseconds, trying to discharge the capacitors bank. If the capacitor voltage does decrease by 20% of the key voltage the alarm is generated. Troubleshooting : It is suggested to verify the power contacts of LC; to replace the LC is necessary.
38	CONTACTOR OPEN	○			Cause : The main contactor coil has been driven by the controller, but the contactor does not close. Troubleshooting : It could be also a problem of the contact in the LC that is not working (does not pull-in), try replacing the LC.
			○		Cause : The main contactor coil has been driven by the controller, but the contactor does not close. Troubleshooting : A) It could be a problem of the contacts in the MC that are not working (does not pull-in), try replacing the MC. B) If the contactors of MC are working correctly than the problem is in the controller, replace it.
48	MAIN CONT.OPEN			○	This alarm occurs only when the setting CAN BUS is PRESENT. Then the EPS-AC0 waits for a via CAN information that the traction controller has closed the main contactor. If this information lacks more than about 1.5 secs, this alarm occurs. Find, on the traction controller, the reason for keeping the main contactor open.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
53	STBY I HIGH	○			Cause : The current transducer or the current feedback circuit is damaged in the controller. Troubleshooting : This type of fault is not related to external components so, when it is present, it is necessary to replace the controller.
			○		Cause : The current transducer or the current feedback circuit is damaged in the controller. Troubleshooting : This type of fault is not related to external components so, when it is present, it is necessary to replace the controller.
				○	This alarm occurs two ways : A) In the initial rest state after key on, if the outputs of the current amplifiers are not comprised in the window 2.2 to 2.8 Vdc. B) After the initial diagnosis this alarm occurs when the outputs of the current amplifiers at rest have a drift larger than ±0.15 V. It is necessary to replace the controller.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
60	CAPACITOR CHARGE	○			Follows the charging capacitor system :  When the key is switched ON, the inverter tries to charge the power capacitors through a power resistance, and check if the capacitor are charged within a timeout. If they do not charge, an alarm is signalled; the main contactor is not closed. Troubleshooting : A) There is an external load in parallel to capacitor bank, which sinks current from the controller capacitors precharging circuit, thus preventing the caps from charging. Check if a lamp or a dc/dc converter or a auxiliary load is placed in // to capacitor bank. B) The charging resistance is opened; insert a power resistance across line contactor power terminals; if the alarm disappears, it means the controller internal charging resistance is damaged. C) The charging circuit has a failure, inside the controller. D) There is a problem in the controller power section.
			○		Follows the charging capacitor system :  Cause : When the key is switched ON, the inverter tries to charge the power capacitors through a series of a PTC and a power resistance, and check if the capacitor are charged within a timeout. If the capacitor voltage measured is less than 20% of the nominal battery voltage, an alarm is signalled; the main contactor is not closed. Troubleshooting : A) There is an external load in parallel to capacitor bank, which sinks current from the controller capacitors pre-charging circuit, thus preventing the caps from charging. Check if a lamp or a dc/dc converter or an auxiliary load is placed in parallel to capacitor bank. B) The charging resistance or PTC is opened; insert a power resistance across line contactor power terminals; if the alarm disappears, it means the controller internal charging resistance is damaged. C) The charging circuit has a failure, inside the controller. D) There is a problem in the controller power section.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
61	HIGH TEMPERATURE			○	Inverter temperature is greater than 75°C. The maximum current is reduced proportionally to the temperature increase. The inverter stops at 100°C. If the alarm is signalled when the inverter is cold: A) Check the wiring of the thermal sensor; B) Thermal sensor failure; C) Logic failure.
62	TH. PROTECTION	○			Cause : The controller detected a high temperature, and the performance of the motor is limited. Troubleshooting : It is suggested to check the cause of the high temperature. Usually the controller is not correctly installed or the fan doesn't work.
	TEMPERATURE		○		Cause : This alarm occurs when the temperature of the base plate is higher than 85°C. Then the maximum current decreases proportionally with the temperature increases from 85°C up to 105°C. At 105°C the current is limited to 0 Amps. Troubleshooting : It is necessary to improve the controller cooling. For realise an adequately cooling in case of finned heat sink are important factor the flux [m3/h] and temperature [°C] of cooling air. In case of thermal dissipation realised with the controller base plate installed on truck frame it is important the thickness of frame and the planarity and roughness of its surface. If the alarm is signalled when the controller is cold, the possible reasons are a thermal sensor failure or a failure in the logic card. In this case, it is necessary to replace the controller.
65	MOTOR TEMPERATURE	○	○		Cause : This warning occurs when the temperature sensor is opened (if digital) or has overtaken the threshold of 150°C (if analog). Troubleshooting : Check the thermal sensor inside the motor (use the MOTOR TEMPERATURE reading in the TESTER menu); check the sensor ohmic value and the sensor wiring. If the sensor is OK, improve the air cooling of the motor. If the warning is present when the motor is cool, then the problem is inside the controller.
				○	This warning is signalled if the motor temperature switch opens (digital sensor) or if the analog signal overtakes the cut off level. If it happens when the motor is cold, check the wiring. If all is ok, replace the logic board.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
66	BATTERY LOW	○			Cause : It occurs when the battery charge is calculated being less than or equal to 10% of the full charge and the BATTERY CHECK setting is other than 0 (refer to SET OPTION menu). Troubleshooting : Get the battery charged. If it doesn't work, measure with a voltmeter the battery voltage and compare it with the value in the BATTERY VOLTAGE parameter. If they are different adjust the value of the ADJUST BATTERY function.
			○		"If the" "battery check" "option is ON, a battery discharge algorithm is carried out. When the charge level is 10%, this alarm is signalled and the current is reduced to the half of the programmed level.Troubleshooting: recharge the battery."
70	HIGH CURRENT			○	This alarm occurs if the circuit to limit via hardware the current in the motor is either always active at key-on or repeatedly active when the motor is turning. Check the motor is suited to work with the eps-ac 0 (not oversized). Otherwise it is necessary to replace the controller.
71	POWER FAILURE #3			○	This alarm occurs when the current in the phase V of the motor is zero and the motor is commanded for moving. Check the power fuse is OK. Check the battery positive arrives to the controller. Check the continuity of the wire in the phase V of the motor. Otherwise it is necessary to replace the controller.
72	POWER FAILURE #2			○	This alarm occurs when the current in the phase U of the motor is zero and the motor is commanded for moving. Check the power fuse is OK. Check the battery positive arrives to the controller. Check the continuity of the wire in the phase U of the motor. Otherwise it is necessary to replace the controller.
73	POWER FAILURE #1			○	This alarm occurs when the current in the phase W of the motor is zero and the motor is commanded for moving. Check the power fuse is OK. Check the battery positive arrives to the controller. Check the continuity of the wire in the phase W of the motor. Otherwise it is necessary to replace the controller.
74	DRIVER SHORTED	○			Cause : The driver of the main contactor coil is shorted or the coil is disconnected. Troubleshooting : A) Check if there is a short or a low impedance pull-down between NMCC (CAN#12) and -BATT. B) The driver circuit is damaged in the controller, which has to be replaced. C) The wires to the LC coil are interrupted or not connected, so check the coil related harness.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
74	DRIVER SHORTED		○		Cause : The driver of the main contactor coil is shorted. Troubleshooting : A) Check if there is a short or a low impedance pull-down between NMC (CNA#16) and -BATT. B) The driver circuit is damaged in the logic board, which has to be replaced.
75	CONTACTOR DRIVER	○			Cause : The LC coil driver is not able to drive the load. The device itself or its driving circuit is damaged. Troubleshooting : This type of fault is not related to external components; replace the controller.
			○		Cause: The MC coil driver is not able to drive the load. The device itself or its driving circuit is damaged. Troubleshooting: This type of fault is not related to external components; replace the ACE2 logic board.
78	VACC NOT OK	○			Cause : The test is made at key-on and after 20sec that both the travel demands have been turned off. This alarm occurs if the ACCELERATOR reading in the TESTER menu' is 1.0V higher than PROGRAM VACC min acquisition when the accelerator is released. Troubleshooting : Check the mechanical calibration and the functionality of the potentiometer.
			○		Cause : The test is made at key-on and immediately after that both the travel demands have been turned off. This alarm occurs if the ACCELERATOR reading in the TESTER menu' is 1.0V higher than PROGRAM VACC min acquisition when the accelerator is released. Troubleshooting : Acquire the maximum and minimum potentiometer value through the PROGRAM VACC function. If the alarm is still present, check the mechanical calibration and the functionality of the potentiometer. If the alarm is not disappeared the failure is in the ACE logic board, replace it.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
79	INCORRECT START	○			Cause: This is a warning for an incorrect starting sequence. Troubleshooting : The possible reasons for this alarm are (use the readings in the TESTER to facilitate the troubleshooting) : A) A travel demand active at key on B) Presence man sensor active at key on Check the wirings. Check the micro-switches. It could be also an error sequence made by the operator. A failure in the logic is possible too; so when all of the above conditions were checked and nothing was found, replace the controller.
			○		Cause : This is a warning for an incorrect starting sequence. Troubleshooting : The possible reasons for this alarm are (use the readings in the TESTER to facilitate the troubleshooting) : A) A travel demand active at key on B) Presence man sensor active at key on Check the wirings. Check the micro switches. It could be also an error sequence made by the operator. A failure in the logic is possible too; so when all of the above conditions were checked and nothing was found, replace the ACE logic board.
80	FORW+BACK	○			Cause : This alarm occurs when both the travel demands (Fwd and Bwd) are active at the same time. Troubleshooting : Check the wiring of the Fwd and Rev travel demand inputs (use the readings in the TESTER to facilitate the troubleshooting). Check the microswitches for failures. A failure in the logic is possible too. So, when you have verified the travel demand switches are fine working and the wiring is right, it is necessary to replace the controller.
			○		Cause : This alarm occurs when both the travel demands (Fwd and Bwd) are active at the same time. Troubleshooting : Check the wiring of the Fwd and Rev travel demand inputs (use the readings in the TESTER to facilitate the troubleshooting). Check the microswitches for failures. A failure in the logic is possible too. So, when you have verified the travel demand switches are fine working and the wiring is right, it is necessary to replace the ACE-2 logic board.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
82	ENCODER ERROR	○	○		Cause : This fault is signalled in following conditions: the frequency supplied to the motor is higher than 40 Hz and the signal feedback from the encoder has a jump higher than 40 Hz in few tens mSec. This condition is related to a malfunctioning of the encoder. Troubleshooting : A) Check both the electric and the mechanical encoder functionality, the wires crimping. B) Check the encoder mechanical installation, if the encoder slips inside its compartment raising this alarm condition. C) Also the electromagnetic noise on the sensor bearing can be a cause for the alarm. In these cases try to replace the encoder. D) If the problem is still present after replacing the encoder, the failure is in the controller.
83	BAD ENCODER SIGN			○	It occurs when the ENC SPEED in the tester menu has opposite sign than FREQUENCY in the tester menu. Swap the channels of the encoder (CNB#8 with CNB#7).
84	STEER SENSOR KO			○	This alarm occurs if the command potentiometer (CPOC1 on CNA#9 or CPOC2 on CNA#8) changes with a jerk larger than MAX SP SLOPE . This alarm is used to catch a discontinuity in the voltages of the command potentiometer.
85	STEER HAZARD			○	This is just a warning to inform that the steering controller is limiting the angle in the steering direction. No speed reduction occurs on the traction.
86	PEDAL WIRE KO	○			Cause : The SW continuously checks for the connection of the two supply ends of the potentiometer in the accelerator. The test consists of reading the voltage drop on a sense diode, connected between NPOT (CNA#30) and GND and cascaded with the potentiometer: if the potentiometer gets disconnected on PPOT (CNA#25) or NPOT, no current flows in this sense diode and the voltage on the NPOT connection collapses down. When the NPOT voltage is less than 0.3V this alarm occurs. This alarm occurs also when the NPOT voltage is higher than 2Vdc (to detect also the condition of a broken sense diode). Troubleshooting : Check the voltage on NPOT and the potentiometer connections.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
99	LIFT+LOWER		○		"This alarm occurs when both a Lifting request and a Lowering request are active at the same time. Pump motor is stopped. Troubleshooting : Check the wiring of the Lifting/Lowering pair. A failure in the logic is possible too. When you have checked the Lifting/Lowering switches are fine working and the wiring is right, it is necessary to replace the controller."
	INPUT ERROR #1			○	It occurs when the voltage on CNA#4 (NK1: Lower potential terminal of the safety contacts is higher than 12 V before to turn the safety contacts closed. When the safety contacts are open, the voltage on CNA#4 is expected to be close to 0 Vdc and this is independent from whether the safety contacts are connected to a plus battery or to a minus battery. In the first case (safety contacts connected to a plus battery), when the safety contacts are open, CNA#4 is connected to a minus battery through a load. Only a harness mistake may connect NK1 to a higher than 12 V voltage.
201	MAST SWITCH MISM	○			"There are 4 switches that give information about the position of the forks; two of these switches are read by the ACE0 and two of these are read by the CAN Tiller and their status are sent via CAN to the ACE0. This alarm occurs if there is any inconsistency between the status of these switches. These switches are normally closed (when the forks are in the lower position) and if, for instance, switch 4 is released (because the forks are in the higher position) but either switch 1 or switch 2 or switch 3 is closed, then this allarm occurs (switch 1 is the lower one, while switch 4 is the higher one). This alarm causes the truck to stop. Troubleshooting : Check the harness related to the 4 switches (CNA-7 and CNA-6 of the ACE0 and CNC-1 and CNC-4 of the CAN Tiller). If the state of these inputs is right, then it could be a problem inside the controller, which has to be changed."
202	DISPLAY ENABLE	○			"This alarm occurs when the ACE0 doesn't receive the enable signal from the display; this enable signal is sent by the display after the password is entered. Troubleshooting : This fault could be determined by a problem in the truck Canbus line or by an internal problem in the display logic card. It is suggested to preliminary check Canbus connection. The alarm does not occur if the display is set to off in the Set options menu."

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
203	D.MAN OR SIDE ON	○			"This alarm occurs if a traction movement is requested and if the inputs DEAD MAN, SIDE GATE LEFT and SIDE GATE RIGHT read by the CAN tiller are released. Moreover, this alarm occurs also if a pump movement is requested and DEAD MAN, SIDE GATE LEFT and SIDE GATE RIGHT read by the CAN tiller are released. Troubleshooting : Do again the traction/pump movement request with the switches reported above closed."
204	MAINTENANCE	○			"This alarm occurs when the switch input ENABLE MAINTENANCE is closed. Troubleshooting : Release the switch input ENABLE MAINTENANCE."
205	NO CAN MSG. DISP	○			"This alarm occurs when the ACE0 doesn't receive a display CAN message for more than 1 minute. Troubleshooting : Check the CAN network harness and if the other modules connected to the CAN network are fully functioning."
206	EPS RELE CLOSED	○			"This alarm occurs if the safety contact managed by the EPS (whose state is sent via CAN from the EPS to the ACE0) is already closed during the initialization phase where the diagnosis is done. Troubleshooting : Check the harness and if the alarm still remains then it could be a problem inside the controller, which has to be changed."
207	EPS RELE OPEN	○			"This alarm occurs if the safety contact managed by the EPS (whose state is sent via CAN from the EPS to the ACE0) remains opened after the initialization phase. Troubleshooting : Check the harness and if the alarm still remains then it could be a problem inside the controller, which has to be changed."
208	POT MISMATCH	○			CAN Tiller has to read 6 potentiometers signals : 2 signals for the fork lift & lower, 2 signal for the accelerator and 2 signals for the cabin lift & lower. All these information are sent to the ACE0 via CAN, and the ACE0 checks the coherence between the signal couple. If one of these 3 couples show an incoherence between the 2 signals, this alarm is set. Troubleshooting : Check the harness related to the 3 potentiometers and if the alarm still remains then it could be a problem inside the controller, which has to be changed.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
209	MOTOR STALL	○			After 15 seconds with the motor stalled with the maximum current, the inverter reduce maximum current to 50%. Troubleshooting : Release the accelerator.
210	MOTOR SHUTDOWN	○			Not managed by this software
211	EPS REDUCTION	○			This alarm occurs when the EPS has detected a steering angle whereby a reduction on speed truck is requested. Troubleshooting : Reduce the acceleration or reduce the steering angle.
212	WRONG RAM	○			The algorithm implemented to check the main RAM registers finds a wrong contents : the register is "dirty". This alarm inhibit the machine operations. Troubleshooting : Try to switch the key off and then on, if the alarm is still present replace the logic board.
				○	It occurs when the encoder counting of the main uC is not matched with the encoder counting of the slave uC. It is necessary to replace the controller.
213	AUX BATT. SHORT	○			Cause : A) The coil on the aux output is not correctly connected. B) The smartdriver inside the controller is damaged. Troubleshooting : - It is suggested to check that the coil is correctly connected between A2 and A4. - If no problem is found on the coil. the problem is inside the controller.
	VACC OUT OF RANGE		○		Cause : The CPOT input red by the microcontroller is not comprised in the range Vacc_min ÷ Vacc_max, programmed through the "PROGRAMM VACC" function. Troubleshooting : Acquire the maximum and minimum potentiometer value through the PROGRAM VACC function. If the alarm is still present, check the mechanical calibration and the functionality of the potentiometer. If the alarm is not disappeared the failure is in the ACE logic board, replace it.
	SL CENTERING			○	This alarm occurs when an automatic centering is requested from steady state condition. Then the slave uC expects the angle measured on the steered wheel goes into a window from -20 to +20 degrees before the traction turns moving. In case the traction turns moving with a steered wheel outside that window, this alarm occurs. It is necessary to replace the controller.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
214	EVP1 COIL OPEN	○			Cause : This fault appears when the LOWER EVP1 output is used (parameter "EVP TYPE" in "SET OPTION" menu is set ANALOG or DIGITAL) but no load is connected between the output and PAUX positive. Troubleshooting : A) It is suggested to check the harness, in order to verify if EVP1 coil is connected to the right connector pin and if it is not interrupted. B) If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic board, replace it.
	ACQUIRE JOY2		○		Not managed by this software.
	SL EPS NOT ALL			○	This alarm occurs at key on : A) When the initial automatic centering is expected. B) The slave uC detects the encoder is at rest longer than two secs C) Within this two secs delay, the main uC does not communicate that the automatic centering was successfully ended. It is necessary to replace the controller.
215	EVP2 COIL OPEN	○			Cause : This fault appears when the EVP2 output is used (parameter "EVP2 TYPE" in "SET OPTION" menu is set ANALOG or DIGITAL) but no load is connected between the output and PAUX positive. Troubleshooting : A) It is suggested to check the harness, in order to verify if EVP2 coil is connected to the right connector pin and if it is not interrupted. B) If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic board, replace it.
	INCOR START PUMP		○		This alarm occurs when an incorrect sequence of pump activation is performed, resulting in a pump stop. Troubleshooting : Retry the pump activation sequence.
	CAN BUS KO SL			○	This alarm occurs when the slave uC does not receive any CAN BUS frame from the main uC. It is necessary to replace the controller.
216	AUX OUT OF RANGE		○		Not managed by this software.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
217	PUMP I NO ZERO	○			Cause: In standby condition (pump motor not driven), the feedback coming from the current sensor in the pump chopper gives a value out of a permitted range, because the pump current is not zero. Troubleshooting : This type of fault is not related to external components; replace the controller.
	CHAIN LOOSER		○		This alarm occurs when the chain looser switch, read by the traction and sent via CAN to the pump, is opened.
218	SENS. MOT. TEMP.	○			Cause : A) The motor temperature sensor is not correctly connected to A22. B) The motor temperature sensor is damaged. Troubleshooting : A) Check the correct connection of the motor temperature sensor. B) If the current sensor is correctly connected, replace it. C) If the problem persist, it is due to the controller.
	TILT OUT OF RNG.		○		Not managed by this software.
	CLOCK PAL NOT OK			○	The main uC sends an analog signal towards the slave uC to reset the slave uC on demand. When the slave uC detects this analog signal external to a window from 2.2 to 2.8 and not in the range to generate the reset on demand, the slave uC raises this alarm. It is necessary to replace the controller.
219	DEAD MAN ABSENT	○			Cause : This warning (presents only in trucks with "Dead Man" switch) appears when the "Dead Man" switch is open. Troubleshooting : At the next travel request with dead man switch close the warning disappears.
	LIFT OUT OF RNG.		○		Not managed by this software.
	STEPPER MOTOR MISM			○	This alarm occurs if the frequency and the amplitude of the voltages from the stepper motor lines are mismatched in between (i.e. the voltage from the D and Q line of the stepper motor have high amplitude but with very low frequency). In normal condition when the amplitude of the stepper motor lines increases, the frequency of the stepper motor lines must increase too. This alarm occurs also if a stepper motor line (D or Q) is short circuited to minus battery. Check if a stepper motor line is short circuited to minus battery. Otherwise it is necessary to replace the controller.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
220	KEY OFF SHORTED	○			Cause : This fault is displayed when the controller detects a low logic level of Key-Off signal during Start-Up diagnosis. Troubleshooting : It is very likely the fault is due to an under voltage, so it is suggested to check : A) Key input signal down-going pulses (below under voltage threshold) due to external loads, like DC/DC converters starting-up, relays or contactor switching, solenoids energizing / de-energizing. B) Check the connection of power cables to the battery terminal, positive and negative, to MC and to controller +Batt and .Batt, which must be screwed with a torque comprised in the range 5,6Nm ÷ 8,4Nm. C) If no voltage transient is detected on the supply line and the alarm is present every time the key is switched ON, the failure is probably in the controller hardware, so it is necessary to replace the logic board.
	ACQUIRE JOY1		○		Not managed by this software.
	MOTOR LOCKED			○	This alarm occurs if the current in the steering motor stays higher than 90% of the maximum current longer than 1 sec. Search for a mechanical problem locking the motor. To make easier the fault catching, set DEBUG OUTPUT to level 11.
221	FLASH CHECKSUM	○			Cause : The software was not correctly written into the flash memory or the flash memory is damaged. Troubleshooting : This type of fault is not related to external components, replace the controller.
	MICRO SLAVE #4			○	It occurs in one of the following conditions : If the slave uC detects the stator voltage phasor rotates in the opposite direction respect to the sign of the stepper motor speed, this alarm occurs. (i.e. slave uC detects the actual sign of the frequency in the motor opposes the sign that the frequency should have according the command). It is necessary to replace the controller.
222	SMART DRIVER KO	○			Cause : The built in smart driver is open, not able to provide the electro mechanic brake positive. Troubleshooting : A) It is suggested to check the harness, in order to verify if the Smart driver output CNA#2 is shorted to -Batt. B) If, even disconnecting the wire from the connector pin, the output stays at low value, the problem is inside the controller and the Smart Driver is probably damaged.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
222	WAITING FOR NODE		○		"The controller receives from the CAN the message that another controller in the net is in fault condition; as a consequence the controller itself cannot enter an operative status, but has to WAIT for the other controller coming out from the fault status.Troubleshooting: check the CAN network connection and verify the CAN communication of the other modules connected to the CAN network."
	FBSENS LOCKED			○	This alarm occurs only when option ENCODER CONTROL is off. Then, if the encoder is frozen and the steering motor is demanded for moving at higher than 40% of the maximum motor speed, this alarm occurs. Check the encoder is right working. This alarm may be masked (for the trouble shooting activity only) by setting special adjustment DEBUG OUTPUT to level 11 and recycling the key . Then it is possible to verify the reading ENC SPEED is frozen or not meanwhile the steering motor is turning.
223	COIL SHORTED	○			Cause : This alarm occurs when there is a short circuit of one of the coils connected to outputs of the Combiac1 (LC coil or EB coil). After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting : A) The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads. B) In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.
	WATCHDOG#1		○		Cause : At start-up the watch dog signal is already active before the software has generated it. At standby or running condition the watch dog signal is not active (in alarm status). Troubleshooting : The WD hardware circuit or microcontroller output port are damaged. In both cases no external component are involved. Replace the logic board.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
224	WAITING FOR NODE	○			Cause : The controller receives from the CAN the message that another controller in the net is in fault condition; as a consequence the ACE0/COMBIAC0 controller itself cannot enter an operative status, but has to WAIT for the other controller coming out from the fault status.
	COIL SHORTED EF		○		Cause : This alarm occurs when there is a short circuit of the EB/AUX coils connected to CNA#18 output. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting : A) The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads. B) In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.
225	CURRENT SENS. KO	○			Cause : One of the current sensor, used to measure the value of the current on the motor phases, is damaged. Troubleshooting : This type of fault is not related to external components, replace the controller.
	CURRENT GAIN			○	This alarm occurs when the parameters to compensate for the gain of the current amplifiers (ADJUSTMENT #03 and ADJUSTMENT #04) have the default values (i.e. the maximum current was not regulated). It is necessary to send the controller to Zapi to perform the maximum current regulation.
226	VACC OUT RANGE	○			The voltage on the Vacc potentiometer (A15) is outside of the range that was set with the "Program Vacc" function. Troubleshooting : Repeat the "Program Vacc" procedure.
	CHAT TIME		○		After no travel request is active for the chat time, the line contactor is automatically opened. Troubleshooting : To restart, the operator needs to press the accelerator pedal.
	NO SYNC			○	Every 16msec, inside the code cycle, the main uC rises and then lowers an input for the slave uC (SYNC). When the slave uC detects no edge for more than 100 msec on this input, this alarm occurs. This is just a watch dog function: when the main uC does not execute the code cycle it does not update the SYNC signal and the slave uC cuts off the steer and traction. It is necessary to replace the controller.

<table>
<tr><th>Code</th><th>Alarm</th><th>Traction (T)</th><th>Pump (P)</th><th>EPS (E)</th><th>Description</th></tr>
<tr><td rowspan="3">227</td><td>WATCHDOG#2</td><td></td><td>○</td><td></td><td>Cause :
At start-up the watch dog signal is already active before the software has generated it. At stby or running condition the watch dog signal is not active (in alarm status).

Troubleshooting :
The WD hardware circuit or microcontroller output port are damaged. In both cases no external component are involved. Replace the logic board.</td></tr>
<tr><td>SLAVE COM.ERROR</td><td></td><td></td><td>○</td><td>Main uC and Slave uC communicate via a local serial interface. This alarm occurs when the main uC does not receive the communication from the slave uC through this serial interface. It is necessary to replace the controller.</td></tr>
<tr><td rowspan="3">228</td><td>TILLER OPEN</td><td>○</td><td></td><td></td><td>Cause :
Warning : When the tiller is released, after a fixed period of time of standby (30 seconds) the main contactor open.

Troubleshooting :
At the next travel request the warning disappear.</td></tr>
<tr><td>TILLER OPEN</td><td></td><td>○</td><td></td><td>Not managed by this software.</td></tr>
<tr><td>POSITION ERROR</td><td></td><td></td><td>○</td><td>This alarm occurs for an error in the redundant test of the feedback sensors. Here we have an encoder and two toggle switches. This alarm occurs whether the sector (toggle switches configuration) and the encoder counting are not matched. The sector is provided with the FEEDBACK SECTOR reading in the tester menu ; the encoder counting is provided with the WHEEL ANGLE reading in the tester menu.
<table>
<tr><th>WHEEL ANGLE (degrees)</th><th>Admitted SECTOR</th><th>Admitted PEEDBACK SECTOR</th></tr>
<tr><td>-22 to +22</td><td>1st or 4th</td><td>3.13V or 1.88V</td></tr>
<tr><td>+23 to +67</td><td>1ST</td><td>3.13V</td></tr>
<tr><td>+68 to +112</td><td>1st or 2nd</td><td>3.13V to 4.39V</td></tr>
<tr><td>+113 to +157</td><td>2nd</td><td>4.39V</td></tr>
</table>
<table>
<tr><th>WHEEL ANGLE (degrees)</th><th>Admitted SECTOR</th><th>Admitted PEEDBACK SECTOR</th></tr>
<tr><td>+158 to -158</td><td>2nd or 3rd</td><td>4.39V or 0.62V</td></tr>
<tr><td>-157 to -113</td><td>3rd</td><td>0.62V</td></tr>
<tr><td>-112 to -68</td><td>3rd or 4th</td><td>0.62V to 1.88V</td></tr>
<tr><td>-67 to -23</td><td>4th</td><td>1.88V</td></tr>
</table>
When the FEEDBACK SECTOR and WHEEL ANGLE don't meet the above correspondence, an alarm POSITION ERROR occurs in less than 100msec. If the alarm occurs when installing a new controller, be sure the AUX FUNCTION 11 corresponds to the toggle switches arrangement you have and SET ENC AT 360 was correctly set .</td></tr>
</table>

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
229	POS. EB SHORTED	○			Cause : The output of the built in smart driver, which supplies the positive to the electromechanical brake coil is high when the Tiller and the H&S switch are open. Troubleshooting : A) It is suggested to check the harness, in order to verify if a positive is connected to the Smart driver output CNA#2. B) If, even disconnecting the wire from the connector pin, the output stays at high value, the problem is inside the controller and the smart driver is probably shorted.
	SAFETY IN		○		Cause : The safety input is opened and accordingly the MC is opened an EB/AUX OUT coil is driven. Troubleshooting : Check the CAN#11 input, if it is connected to -Batt and the alarm is generated then there is a fault in the SAFETY IN hardware circuit. Replace the logic board.
230	EMERGENCY	○			Cause : The voltage on A3 is different than +Vbatt. Troubleshooting : A) If A3 is correctly connected to +Vbatt. B) If the fuse on A3 is not damaged.
	COIL SHORTED MC		○		Cause : This alarm occurs when there is a short circuit of the MC coils connected to CNA#16 output. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting : A) The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads. B) In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.
231	WATCHDOG#2	○			The watchdog circuit is composed by two monostable multivibrators: a self diagnosis test is carried out to verify the correct operation of both circuits. This alarm is raised if the second watchdog circuit has a malfunction. Troubleshooting : This alarm could be caused by an hardware failure or by a software execution problem. For both cases it is an internal fault of the controller which must be replaced.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
231	COIL SHORTED		○		Cause : This alarm occurs when there is a short circuit of one of the coils connected to outputs of the ace 2 (back buzzer relay coil). After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: A) The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads. B) In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.
232	CONT. DRV. EV1	○			Cause : The EV1 valve driver is not able to drive the load (cannot close). Troubleshooting : The device or its driving circuit is damaged, replace the controller.
	CONT. DRV. EV2	○			Cause : The EV2 valve driver is not able to drive the load (cannot close). Troubleshooting : The device or its driving circuit is damaged, replace the controller.
	CONT. DRV. EV3	○			Cause : The EV3 valve driver is not able to drive the load (cannot close). Troubleshooting : The device or its driving circuit is damaged, replace the controller.
	CONT. DRV. EV4	○			Cause: The EV4 valve driver is not able to drive the load (cannot close). Troubleshooting : The device or its driving circuit is damaged, replace the controller.
	CONT. DRV. EV5	○			Cause: The EV5 valve driver is not able to drive the load (cannot close). Troubleshooting : The device or its driving circuit is damaged, replace the controller.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
232	KEY OFF SHORTED		○		Cause: This fault is displayed when the controller detects a low logic level of Key-Off signal during Start-Up diagnosis. Troubleshooting : It is very likely the fault is due to an under voltage, so it is suggested to check : A) Key input signal down-going pulses (below under voltage threshold) due to external loads, like DC/DC converters starting-up, relays or contactor switching, solenoids energizing/de-energizing. B) Check the connection of power cables to the battery terminal, positive and negative, to MC and to controller +Batt and .Batt, which must be screwed with a torque comprised in the range 13Nm ÷ 15Nm. C) If no voltage transient is detected on the supply line and the alarm is present every time the key is switched ON, the failure is probably in the controller hardware, so it is necessary to replace the logic board.
233	POWER MOS SHORTED	○			Cause : Before switching the LC on, the software checks the power bridge: it turns on alternatingly the Low side and High side Power Mosfets and expects the phases voltage to decrease down to -BATT (increase up to +Batt). If the phases voltage do not follow the commands, this alarm occurs. Troubleshooting : This type of fault is not related to external components; replace the controller.
			○		Cause : Before switching the MC on, the software checks the power bridge: it turns on alternatingly the Low side and High side Power Mosfets and expects the phases voltage to decrease down to -BATT (increase up to +Batt). If the phases voltage do not follow the commands, this alarm occurs. Troubleshooting : This type of fault is not related to external components; replace the controller.
234	EV1/5 DRIVER SHORTED	○			Cause : Electrovalve EV1 or EV2 driver is shorted. Troubleshooting : Check if there is a short or a low impedence between the negative of one of those coils and -BATT. Otherwise the driver circuit is damaged and the controller must be replaced.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
234	EV2 DRIVER SHORTED	○			Cause : Electrovalve EV2 driver is shorted. Troubleshooting : Check if there is a short or a low impedance between the negative of this coil and -BATT. This warning occurs also if the external load is not present and the parameter EV2 in the "Set Options" menu is set "PRESENT", in this case the warning disappears setting the EV2 parameter "ABSENT". Otherwise the driver circuit is damaged and the controller must be replaced.
	EV3 DRIVER SHORTED	○			Cause : Electrovalve EV3 driver is shorted. Troubleshooting : Check if there is a short or a low impedance between the negative of this coil and -BATT. This warning occurs also if the external load is not present and the parameter EV3 in the "Set Options" menu is set "PRESENT", in this case the warning disappears setting the EV3 parameter "ABSENT". Otherwise the driver circuit is damaged and the controller must be replaced.
	EV4 DRIVER SHORTED	○			Cause : Electrovalve EV4 driver is shorted. Troubleshooting : Check if there is a short or a low impedance between the negative of this coil and -BATT. This warning occurs also if the external load is not present and the parameter EV4 in the "Set Options" menu is set "PRESENT", in this case the warning disappears setting the EV4 parameter "ABSENT". Otherwise the driver circuit is damaged and the controller must be replaced.
	BRAKE RUN OUT		○		Cause : The CPOTBRAKE input red by the microcontroller is at the maximum value without the hand brake request. Troubleshooting : Check the mechanical calibration and the functionality of the brake potentiometer. If the alarm is not disappeared the failure is in the ACE logic board, replace it.
235	COIL SHORTED EV	○			Cause : This alarm occurs when there is a short circuit of one of the coils connected to outputs of the ac0(electronic valve coil). After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: A) The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads. B) In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
235	MOTOR TC START		○		This alarm occurs if the pump motor temperature read by analog sensor, overtakesthe MOTOR SHUTDOWN value setted in submenu ADJUSTMENT. If this warning occurs the motor rpm begin to decrease and motor current and speed decrease linearly with the temperature increasing. Troubleshooting : If "MOTOR TC START" warning occurs when pump motor is cold, check the wiring. If all is ok, replace logic board.
236	CURRENT GAIN	○	○		Cause : The maximum current gain parameters are at the default values, which means the maximum current adjustment procedure has not been carried out yet. Troubleshooting : Ask the assistance of a Hyundai technician to do the correct adjustment procedure of the current gain parameters.
237	ANALOG INPUT	○			Cause : This alarm occurs when the A/D conversion of the analog inputs gives frozen value, on all of the converted signals, for more than 400msec. The goal of this diagnosis is to detect a failure of the A/D converter or a problem in the code flow that omits the refreshing of the analog signal conversion. Troubleshooting : If the problem occurs permanently it is necessary to substitute the controller.
			○		Cause : This alarm occurs when the A/D conversion of the analog inputs gives frozen value, on all of the converted signals, for more than 400msec. The goal of this diagnosis is to detect a failure of the A/D converter or a problem in the code flow that omits the refreshing of the analog signal conversion. Troubleshooting : If the problem occurs permanently it is necessary to substitute ACE logic board.
	WAITING DATA			○	This warning occurs only if CAN BUS is PRESENT. At key-on the eps-ac0 asks to the traction controller to send a list of parameters via CAN BUS. From the request until the parameters are correctly relieved, this warning occurs. The steer is not activated yet, and the safety relays remain open when this warning is present.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
238	TILLER ERROR	○			Cause : Mismatch between the H&S input and the tiller input. Troubleshooting : Check the harness related to CNA#1 and CNA#29 with a voltmeter. If the state of these inputs is right, then it could be a problem inside the controller, which has to be changed.
	WRONG 0 VOLTAGE		○		Cause : At start-up the high resolution VMN feedback is not comprised in a permitted window of values centred around 2.5V. The circuit is damaged in the controller. Troubleshooting : It is suggested to check : - Motor internal connections (ohmic continuity) - Motor power cables connections - Motor leakage to truck frame - If the motor connections are OK, the problem is inside the controller, replace the logic board
	EPS NOT ALIGNED			○	This is a real alarm that cut off the traction. It occurs when the system tries to perform an automatic centering at key on but no straight ahead edge is detected within 6 secs. Check the straight ahead switch (SW1 to CNA#3) is right working.
239	EVP2 NOT OK	○			Cause : A) The EVP2 driver is shorted. B) The microcontroller detects a mismatch between the valve set-point and the diver voltage measured on the EVP2 output. Troubleshooting : Check if there is a short or a low impedance between the negative of the coil and -BATT. Otherwise the driver circuit is damaged and the controller must be replaced.
	SAFETY OUT		○		Cause : The safety out driver is shorted. Troubleshooting : A) Check if there is a short or a low impedance pull-down between SAFETY OUT (CNA#19) and -BATT. B) The driver circuit is damaged in the logic board, which has to be replaced.
	WAITING FOR TRAC			○	This warning occurs only if CAN BUS is PRESENT. At key-on the eps-ac0 needs an assent from the traction controller to close the safety contacts and to turn onto operational mode. Until this assent is not relieved, this warning occurs. The steer is not activated yet and the safety relays remain open when this warning is present.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
240	EVP1 NOT OK	○			Cause : A) The EVP driver is shorted. B) The microcontroller detects a mismatch between the valve set-point and the diver voltage measured on the LOWER EVP1 output. Troubleshooting : Check if there is a short or a low impedance between the negative of the coil and -BATT. Otherwise the driver circuit is damaged and the controller must be replaced.
	HARDWARE FAULT 20 FAULT 21 FAULT A1		○		Cause : Before driving the MC coil, the controller checks if the Mosfets drivers are turned of by a not active (alarm status) Watch-dog signal. If they are not turned of then the alarm is generated. Before driving the MC coil, the controller checks if the EB/AUX drivers are turned of by a not active (alarm status) Watch-dog signal. If they are not turned of then the alarm is generated. Before driving the MC coil, the controller checks if the MC/AUX drivers are turned of by a not active (alarm status) Watch-dog signal. If they are not turned of then the alarm is generated. Troubleshooting : The problem is inside the controller, no external component are involved, replace the logic board.
241	LIFT+LOWER	○			Cause : This alarm occurs when both forks movement requests (Lift + Lower) are active at the same time. Troubleshooting : Check the wiring of the Lift and lower inputs (use the readings in the TESTER to facilitate the troubleshooting). Check the microswitches for failures. A failure in the logic is possible too. So, when you have verified the travel demand switches are fine working and the wiring is right, it is necessary to replace the controller.
	FLASH CHECKSUM		○		Cause : After key-on the software verifies the integrity of program stored in the flash memory, if the verify has a negative result this alarm is generated. Troubleshooting : The problem is in the microcontroller flash memory, which could be damaged, or in the program stored inside, which could be corrupted. Try to program the logic again, if the alarms is still signalled the problem is in the microcontroller. Replace the ACE logic board.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
241	ENCODER ERROR			○	It occurs when ENCODER CONTROL is set ON and the real frequency does not pursuit the commanded frequency. This condition is several times due to either, a mismatching between the Encoder resolution used in the SW and the real encoder resolution, or a wrong connection between the two encoder channels. In this latest case swap the channels of the encoder (CNB#8 with CNB#7).
242	ENCODER LOCKED		○		"If target speed is larger than 10Hz and the frequency applied to the motor is larger than 1.5Hz, the controller checks if the frequency read by the encoder increases above a certain threshold. If this does not happen, this alarm is raised. Troubleshooting: check both the electric and the mechanical encoder functionality. Check the wires crimping.If the problem is still present after replacing the encoder, the failure is in the controller."
	Q LINE SENSOR KO			○	This alarm occurs when the mean voltage on the quadrature line of the stepper motor (connection CNA#8) is not null: the voltage on every stepper motor line is a sine wave with null mean voltage. Check the continuity of the stepper motor connections. In particular the resistance between CNA#8 and the minus battery (with the stepper motor at rest) is expected being very low (close to 30 ohms).
243	SENS MOT TEMP KO		○		This alarm occurs when the output of the motor thermal sensor is out of range. The cause could be either if the motor temperature sensor is not correctly connected or if the motor temperature sensor is damaged. Troubleshooting : Check the correct connection of the motor temperature sensor. If the current sensor is correctly connected, replace it. If the problem persists, it is due to the controller. Replace it.
	D LINE SENSOR KO			○	This alarm occurs when the mean voltage on the direct line of the stepper motor (connection CNA#9) is not null: the voltage on every stepper motor line is a sine wave with null mean voltage. Check the continuity of the stepper motor connections. In particular the resistance between CNA#9 and the minus battery (with the stepper motor at rest) is expected being very low (close to 30 ohms).
244	PHASE KO	○			Cause : One of the traction motor phases is open. Troubleshooting : A) Check the cable U, V, W from the ac0 to the traction motor. B) If cables are OK, the problem is in the traction motor. Replace the traction motor.
	SOFTWARE ERROR		○		Several are the causes that generate this alarm and are related to the checks done by the SW : for instance CAN bus off, bad EEPROM read/write,...

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
244	GAIN EEPROM KO			○	The parameters to compensate for the gain of the current amplifiers (ADJUSTMENT #03 and ADJUSTMENT #04) are recorded in a not volatile memory (EEPROM) with a redundant handling. In fact every adjustment is recorded in three EEPROM locations. If the values in these three locations are different in between this alarm occurs. It is necessary to send the controller to service man to perform the maximum current regulation.
245	PUMP VACC NOT OK	○			Cause : The minimum of the lift potentiometer is not correctly set. Troubleshooting : It is suggested to repeat a "PROGRAM VACC" procedure.
	WRONG RAM MEMORY		○		Cause : The algorithm implemented to check the main RAM registers finds a wrong contents : the register is "dirty". This alarm inhibit the machine operations. Troubleshooting : Try to switch the key off and then on, if the alarm is still present replace the ACE2 logic board.
	DATA ACQUISITION			○	This alarm occurs two ways : 1) When hardware setting AUTOTEACHING is turned On and the key recycled. Then during the consequent autoteaching procedure, a DATA ACQUITION alarm occurs. 2) When acquiring the motor resistance or when adjusting the parameters to compensate for the gain of the current amplifiers(maximum current factory adjusted). Recycle the key.
246	AUX DRIVER OPEN	○			Cause : The driver of the electromechanical brake coil is not able to drive the load. Troubleshooting : Replace the controller.
			○		Cause : The EB/AUX coil driver is not able to drive the load. The device itself or its driving circuit is damaged. Troubleshooting : This type of fault is not related to external components; replace the ACE2 logic board.
	MICRO SLAVE KO			○	In stepper motor application, this alarm occurs if the main uC is detecting a direction of the stepper motor not matched with the one that the slave uC is detecting. In closed loop application, this alarm occurs if the main uC is detecting a direction of the steering error not matched with the one that the slave uC is detecting. Furthermore, this alarm occurs also if the main uC is detecting no steering limitation meanwhile the slave uC is detecting steering limitation. It is necessary to replace the controller.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
247	DATA ACQUISITION	○			Cause : Acquisition of the current gains. Troubleshooting : The alarm ends when the acquisition is done.
			○		"This alarm is signalled in the current gain acquisition phase.Troubleshooting: wait for the end of the acquisition activity."
	CAN BUS KO			○	The diagnosis of the CAN-BUS line is present only if the inverter uses this link (depends on the software version). It is signalled if the inverter does not receive any message from the CAN-BUS line. First of all, check the wiring. If it is ok, the problem is on the logic board, which must be replaced.
248	NO CAN MSG.	○	○		This is a generic CAN error and it occurs when one of the other modules connected to the CAN network doesn't send its CAN messages or the timing of the CAN transmission is wrong. Troubleshooting : Check the CAN connections between the different modules, check the ohmic value between CANL and CANH.
	S.P OUT OF RANGE			○	This alarm occurs for a fault on the command potentiometer (CPOC1 on CNA#9, CPOC2 on CNA#8). When a single command pot is chosen, the alarm occurs if its wiper (CPOC1) exits the range from 0.8 Vdc to 4.2 Vdc. When the twin pot is chosen, the alarm occurs if the sum of the two wiper voltages (CPOC1+CPOC2) exits the range from 4.5 Vdc to 5.5 Vdc. Check the connections of the potentiometer. This alarm occurs when one connection of the command potentiometer is broken.
249	CHECK UP NEEDED	○			Cause : This is just a warning to call for the time programmed maintenance. Troubleshooting : It is just enough to turn the CHECK UP DONE option to level ON after the maintenance is executed.
	MANTAINANCE		○		This alarm occurs when the switch input ENABLE MAINTENANCE, read by the ACE0 and sent via CAN to the ACE2, is closed. Troubleshooting : Release the switch input ENABLE MAINTENANCE.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
250	THERMIC SENS KO	○	○		Cause : The output of the controller thermal sensor is out of range. Troubleshooting : This type of fault is not related to external components; replace the controller.
	MICRO SLAVE			○	It occurs two ways: A) In steady state condition, when the main uC finds the safety contact controlled by the slave uC has been opened, but no alarm information has been communicated from the slave uC to justify the opening of the safety contact. B) at key on,when the main uC has closed its own safety contact, it grants the local status bus to the slave uC that is expected to change properly the status bus configuration within 300msec. In case it doesn't, this alarm occurs. It is necessary to replace the controller.
251	WRONG SET BATTERY	○	○		Cause : At start-up, the controller checks the battery voltage and verify it is within a window around the nominal value. Troubleshooting : A) Check that the controller SET BATTERY parameter value matches the battery nominal voltage. B) Check that the TESTER MENU/BATTERY VOLTAGE parameter shows same value as the battery voltage measured with a voltmeter. If it is does not match, then do a "ADJUST BATTERY" function. C) Replace the battery.
	KM OPEN			○	This alarm occurs if the slave uC detects the safety contact, of the main uC, open when expected being closed. It is necessary to replace the controller.
252	WRONG ZERO	○			Cause : The outputs of the amplifiers (used to measure the traction motor voltage) are checked to be included into a range. This alarm occurs when the voltage signals >3V or <2V at the initial. Troubleshooting : This type of fault is not related to external components; replace the controller.
	KS OPEN			○	This alarm occurs if the main uC detects the safety contact, of the slave uC, open when expected being closed. It is necessary to replace the controller.

Code	Alarm	Traction (T)	Pump (P)	EPS (E)	Description
253	SLIP PROFILE	○	○		Cause: There is an error on the choice of the parameters of the slip profile. Troubleshooting: Check in the hardware setting menu the value of those parameters.
	KM CLOSED			○	This alarm occurs at key on if the slave uC detects the safety contact, of the main uC, closed prior to be commanded. This alarm occurs if the connection CNA#5 (K1) is around a voltage of 12 Vdc when switching on the key. In fact, when the safety contacts are open, K1 is expected being connected to a battery voltage (not 12 V). Search for a harness problem or replace the controller.
254	AUX DRIVER SHORTED	○			Cause : The driver of the electro mechanical brake coil is shorted. Troubleshooting : A) Check if there is a short or a low impedance pull-down between NEB CNA#4 and -BATT. B) The driver circuit is damaged in the controller, which has to be replaced.
			○		Cause : The driver of the electro mechanic brake/auxiliary electro valve coil is shorted. Troubleshooting : A) Check if there is a short or a low impedance pull-down between NEB/NAUX (CNA#18) and -BATT. B) The driver circuit is damaged in the logic board, which has to be replaced.
	KS CLOSED			○	This alarm occurs if the main uC detects the safety contact, of the slave uC, closed prior to be commanded. This alarm occurs if the connection CNA#4 (NK1) is around a voltage of 12 Vdc when switching on the key. In fact, when the safety contacts are open, NK1 is expected being connected to a minus battery voltage (not 12 V). Search for a harness problem or replace the controller.

9. BATTERY CHARGER

This explains basic information related to charger to help you easily understand and use it. This includes the contents from the way to install a charger to tips for emergency situations. This is focused on practices aiming to be usefully utilized in the field.

1) BASIC INFORMATION

(1) What is charger

Charger is a device which makes a battery accept D.C electricity under optimal condition as it transforms A.C provided from external source of electricity.

The charger is a constant-current and constant-voltage way, SCR type charger that it has advantages as follows

① Even though A.C input voltage fluctuates within 10% of rated voltage (220/380/410/440V), the current and voltage provided to the battery are stable.

② As minimizing the increase of temperature while charging a battery, it minimizes the stress on the battery.

③ The noisy of charger is minimal but the charging efficiency is very high.

④ It prevents from under charging and overcharging.

Therefore, it helps the battery to maintain its performance for longer time and to prolong the life of the battery.

(2) Notice on caring chargers

① If any abnormal status is found while using a charger, immediately stop using and check the charger. If it is impossible to take an appropriate measure for yourself, please apply for A/S.

② While charging, hydrogen and oxygen gas is produced. Use or approach of fire should be strictly prohibited.

③ Keep clean to prevent from sneak current and attack on the interface and surroundings of the battery.

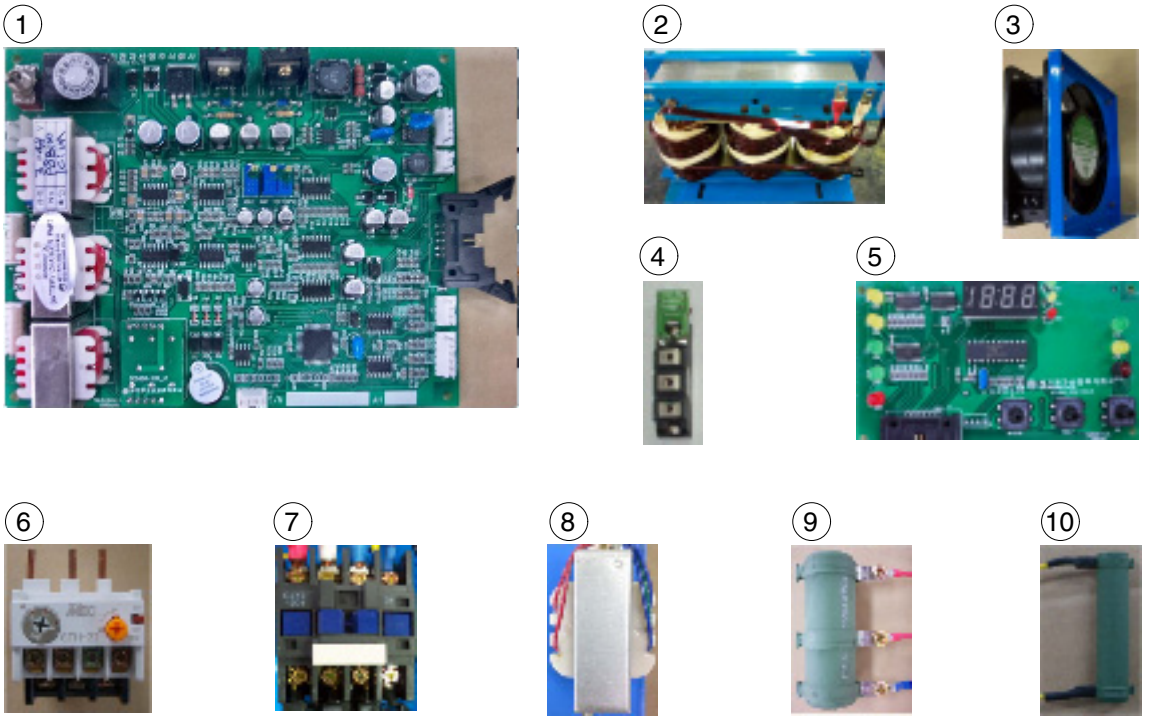
④ Check the electrolyte of the battery every week and provide distilled water immediately if it is required. (Electrolyte has to be provided between 10~12㎜ level on the positive plate inside storage battery)

⑤ If battery liquid temperature becomes over 55° C, charging should be stopped.
If it is continued,
- the appearance is transformed
- and metal area can be attacked as electrolyte overflows

⑥ Electric forklift truck using battery should be charged as soon as the charging lamp is on while driving. As batteries are internally discharged naturally if they are deposed for a long time, charge them once or twice a month to prevent from reducing the lives of batteries.

⑦ When a green sign is on among charging status indication lamps, please notify that it is not converted as equalized charge for stabilization of charging status.

(3) Names of each part (independent items)



BOP7BAT30

1	Main PCB board	5	Monitor PCB	9	Resistance (RD)
2	Main trans (Class H)	6	Overload	10	Resistance (DR)
3	Cooling fan	7	MG S/W		
4	SCR module	8	Assistant trans		

2) CHARGER INSTALLATION METHOD

(1) Location for charger installation

① Dry and well ventilated place.
② No inflammable and B7 fire are near by.
③ Safe place where no collision possibility with people or equipment is.

(2) Check points before installing charger

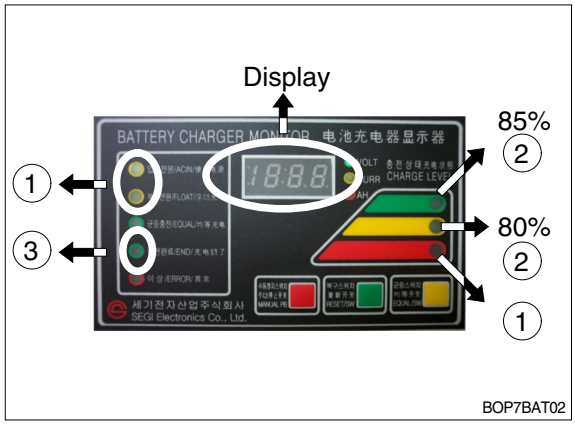
① Enough capacity of AC input power source to operate charger.
② Standard electric wire for power source by capacity.


BOP7BAT01

3) HOW TO USE A CHARGER

(1) General charging method (Floating charging)

① Charging by this method supplies electric power to the charger as operating external AC power switch of the charger.
② Connect battery connecter and charger connecter.



BOP7BAT02

· According to charging condition

① If there is no abnormality found when the charger checks itself for 3-4 seconds after inputting AC input power source, the charger slowly increases the electric flow for charging and the charging condition lamp in the lower part of the front panel for floating charging of "input" is on.
② When charging is processed about 80%, yellow lamp in the middle of the front panel, which shows that the charging condition is in the middle, is on and then green lamp is on when charging is processed over 85% until charging is completed.
③ When charging is completed, "charging is completed" lamp is on in the monitor and other lamps of all monitors become off.

(2) Equalized charging

① Equalized charging is

Equalized charging is to correct the battery when it does not normally perform its functions as the voltage differences are too big between cells of a battery.

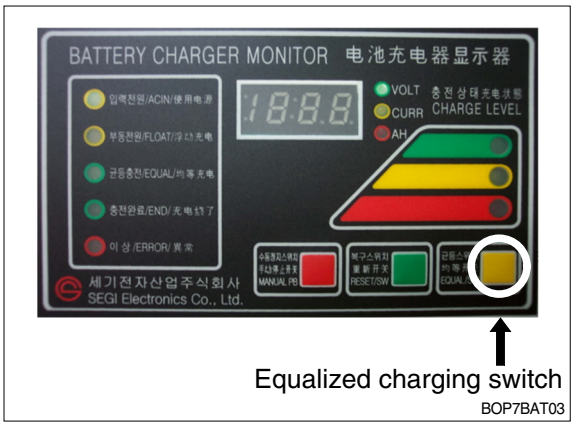
When equalized charging is required?

- When re-operates the battery after having left the battery for a long time.
- When a battery is over-discharged.
- When there is large deviation of voltage and specific gravity between battery cells.
- When change or supply electrolyte of battery.

② Tips for equalized charging

If once push the equalized charging button on the monitor in the beginning of charging, the equalized charging lamp becomes on and starts charging.

※ **When the green charging condition lamp is on (over 85% charged), the equalized charging switch is locked that it does not operate even pushing the button.**



4) HOW TO CHECK THE CHARGER'S NORMAL OPERATION

After changing SCR module or PCB (SE-5000SN), the charger's normal operation should be checked.

· Checking order

(1) Separate the charger and battery connector.

(2) Separate lower cover in the front of the charger.

(3) Check the AV input voltage used from the input switch terminal in the lower left side of the inside of the charger.

Checking method between terminals.
Input voltage setting value → 220V 380V
- Between terminals No. 2 - No. 4 220V 380V
- Between terminals No. 2 - No. 6 220V 380V
- Between terminals No. 4 - No. 6 220V 380V

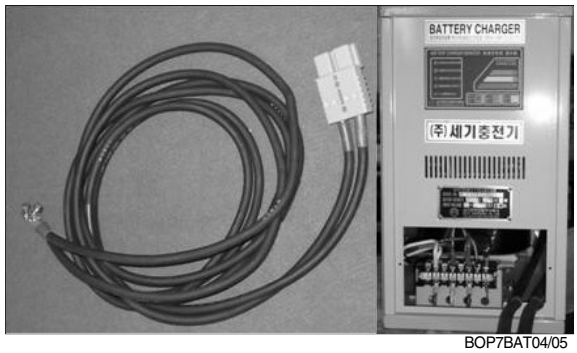
※ **Above cases are under normal operations.**

※ **When installing charger for the first time or moving its location, check and make it sure if the voltage is appropriately connected.**

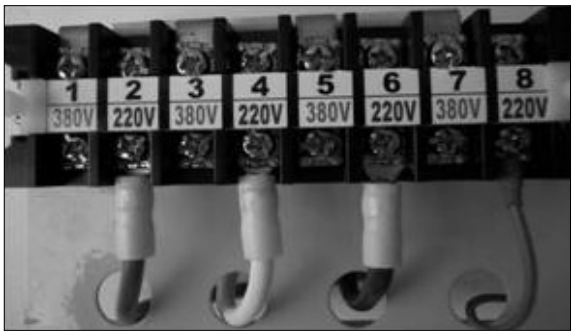
Refer to No. 2 of the charger installation method for the terminal connection method.

- In case of 220V : (2), (4), (6), (8)
- In case of 380V : (1), (3), (5), (7)

It should be connected to the terminal.



BOP7BAT04/05



220V BOP7BAT06

380V BOP7BAT06-1

(4) Convert the automatic / manual switch to manual.
The automatic/manual switch is located in the lower left part of the PCB
Be sure to check if battery connector is separated in advance.

(5) MG/SW operation (Refer to error sheet)

(6) Check the charging voltage soft start function (refer to the monitor)

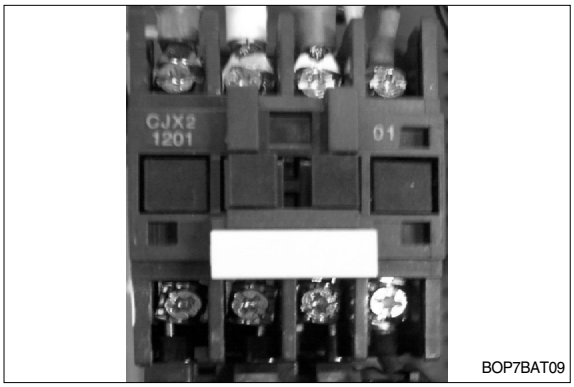
① After 5 seconds next to turn the manual switch on.
Input, floating charge and red charging condition lamp is on.

② After 15 seconds next to turn the manual switch on.
Yellow charging condition lamp is on while charging.

③ After green lamp becomes on, measure the output voltage of the battery connector by multi measure. If measured voltage is between 62.5V ~ 63.5V, it is normal. (Rated voltage : 63V)

④ After 30 seconds next to turn on the manual switch, if buzzer rings for 10 seconds and END lamp is on, it is a normal condition.

※ **When yellow lamp under charging condition is on after 1~2 times repetition, convey the automatic/ manual switch to the automatic and check if the charger trips automatically.**



(7) If charger's out voltage is under 60V, it is abnormal.
Please refer to the error sheet.

(8) When the charging voltage is indicated as normal condition (64V), convert automatic / manual switch to automatic and start charging.

※ **Display error code on the front cover as following table.**

BOP7BAT11

No	Code	Description of error
1	E.F	EPROM fail
2	O.V	Over voltage - Refer to page 7-112
3	O.C	Over current - Refer to page 7-111, 7-113.
4	F.B	Battery error (After starting charging, the voltage doesn't go over 52V for 2 hours.) Check the battery.
5	O.T	Transformer over heat (Stop charging when it is over 160°C). - If input voltage is high, output current is over normal value and there is heat in the trans because of SCR control part fault. - Check the output current and PCB control board
6	O.H	Heatsink over heat (Stop charging when it is over 100°C). - Check the cooling fan, SCR connection cable contact point and control part.
7	A.O	Power supply error (input power 220/380V wrong wiring). - Refer to page 7-110.
8	A.F	Power supply error (absent phase) - Check if input cable is open.
9	A.C	AC fail (black out) - Check if input voltage is right.
10	L.C	Low current (If this sign is on for setting value (60 sec), charging is over).
11	F	Manual stop.

5) CHECK POINTS BEFORE APPLYING A/S

(1) AC input power source switch is input.

(2) Check if the battery connector of the order picker truck and charger's connector are connected.

(3) Check points when "Error" lamp is on in the front monitor of the charger.

(4) Check the front cover indicator.

① A.F : Input three phase power source continuity check = Check if input three phase power source is normal with AC voltage meter.

② A.O : Error on selection of input power source of 220V or 380V - Check it appropriately with full three phases.

③ A.C : Check if the input power source (220V or 380V) is normal.

④ O.C : Check the electric current, as charging current of the battery is over-standards condition.

⑤ O.V : Check the voltage, as charging voltage of the battery is over-voltage condition (66V).
Normally it is 63V±1V.

(5) Check other abnormalities as well. Then apply for A/S when on-site measurements are not applicable.

BOP7BAT12

6) ERROR DETECTION

(1) Error list

① Only floating charge lamp is on in the monitor but it is not charged.

② ON and OFF is repeated with a few minutes intervals even after starting charging.

③ Charger TRIP is occurred after abnormality lamp is on.
In case error code is "O.V"

④ Charger TRIP is occurred after abnormality lamp is on.
In case error code is "O.C"

⑤ Charger TRIP is occurred after it started charging and charging completion lamp is on.

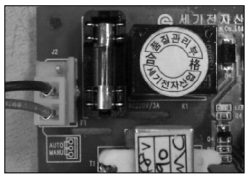
⑥ Charger has no response even the battery connector is connected.

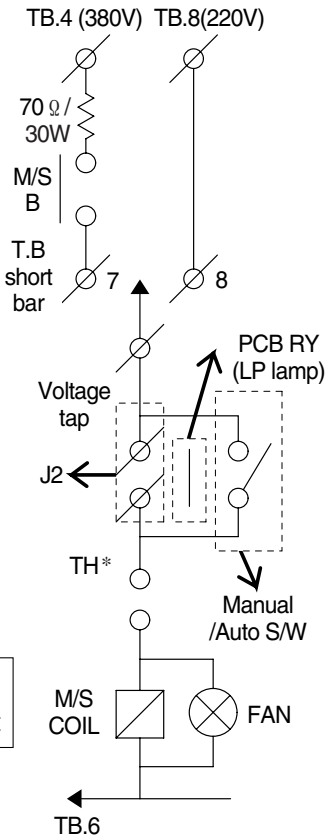
(2) Troubleshooting

① Only floating charge lamp is on after indicating "A.O", It's not charged.

· 220/380V Model : Measure the voltage between input voltage change over tabs 2-4 2-6 4-6
· 220,380,410,440V Model : Measure the voltage in front of AC INPUT MS S/W


In front of MS


Manual/Auto TAP Changer



M/S electrical circuit

Check the rated voltage — YES → After separating battery connecter, convert the automatic/manual selection switch on the lower part of PCB to manual.

AC INPUT MS switch ON — YES → PCB LP lamp ON? — YES → CN4 contact fault / PCB RY contact fault

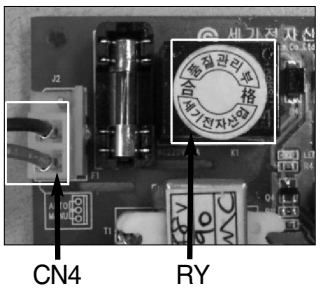
AC INPUT MS switch ON — NO → Apply multi tester for input voltage change over tab no. 6
Measure voltage between input tab no.8, PCB CN4, and contact points with red reed putting black reed on the other side
Apply multi tester for input voltage change over tab no. 6

PCB LP lamp ON? — NO → Change PCB

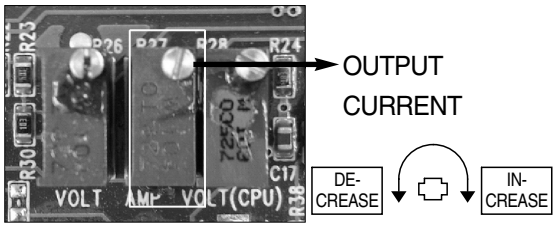
Check the rated voltage — NO → Input power source is not provided.
· Check external lead cable.
· Check the connection of external input connecter
· Check external NFB TRIP

Apply multi tester for input voltage change over tab no. 6 → Voltage 220V? — NO → TH contact fault / CN4 contact fault / PCB RELAY fault / TH manual restoration release

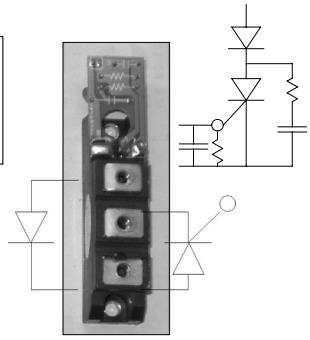
Voltage 220V? — YES → MS COIL fault



② ON and OFF is repeated with a few minutes intervals after starting charging.
Indicate "O.C" on the monitor.
- TH is operated (AC input over-current TRIP).

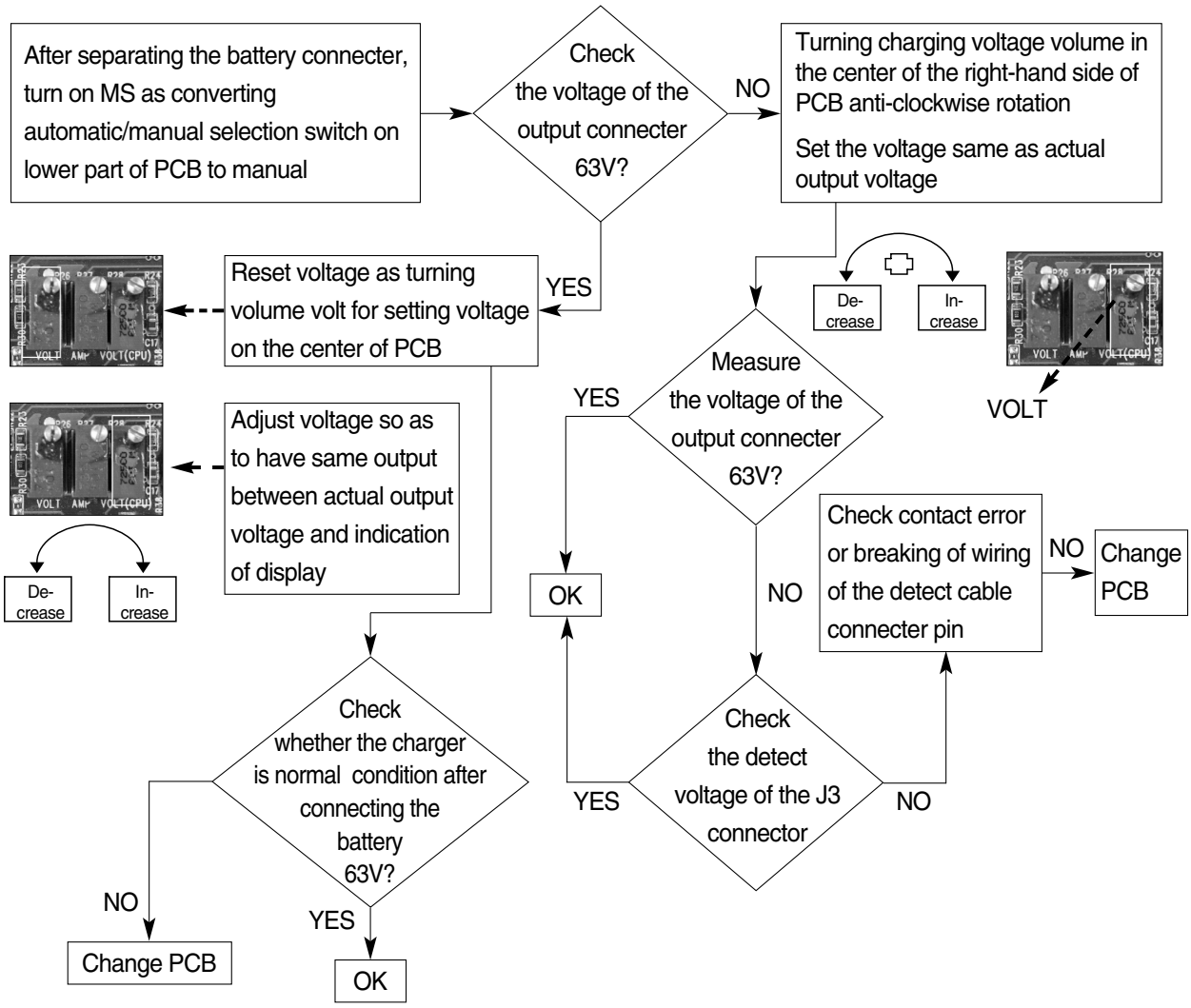


Serious trans noisy under the condition. Is MS on?
NO
Measure output current using DC current measure
Current value : 15~20A /100AH
NO
Exceed Standard current
Adjust output current AMP, VR within PCB Re-adjust to VR
YES
· TH Setting fault
· Re-adjust TH setting value
TH. TRIP
YES
Change TH
NO
Complete
Rated Current SETTING
YES
NO
Complete
Change PCB
YES
* Refer to SCR Module checking method

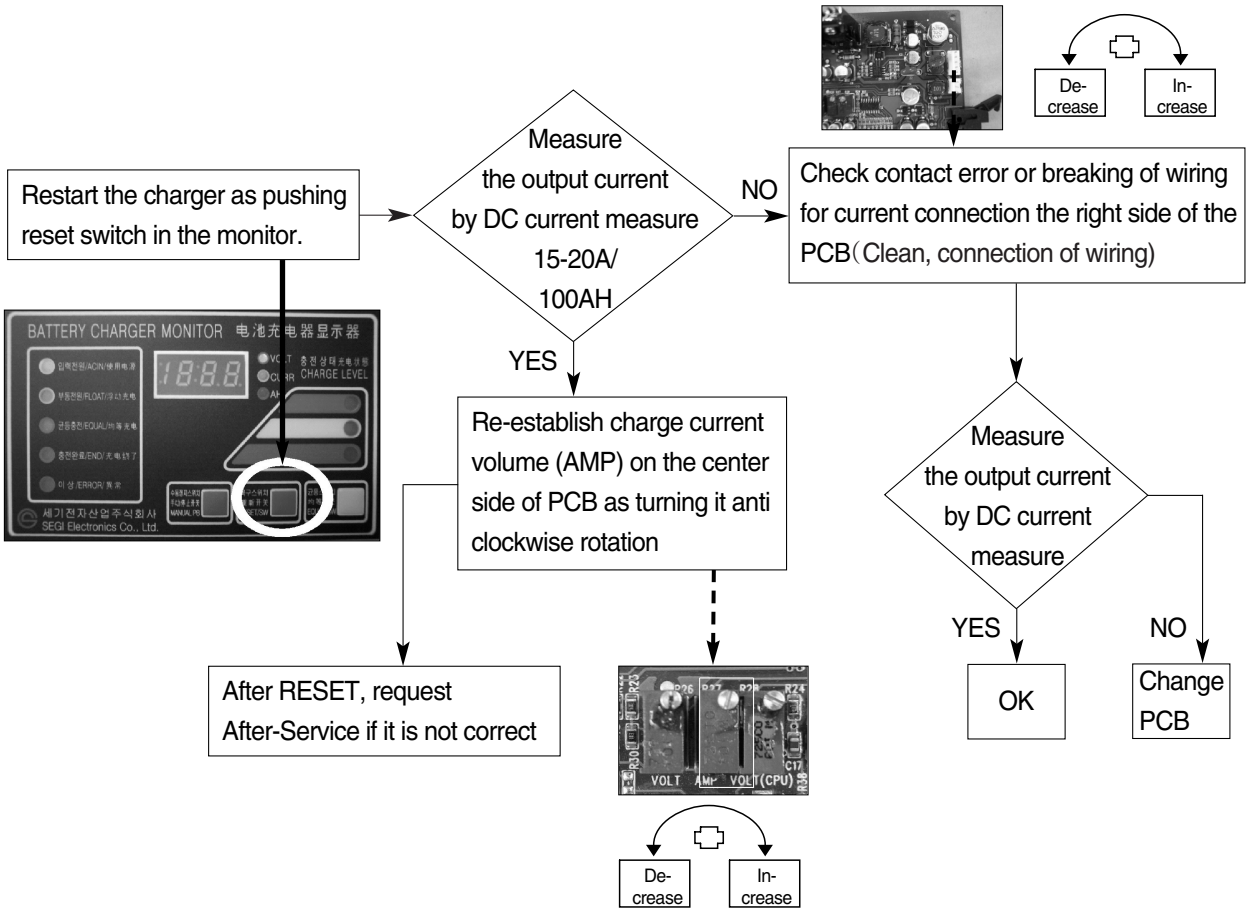


Separate the battery connector and tune the charger off
Check SCR Module
NO
Change SCR MODULE
YES
Check MAIN TRANS VOLT
NO
Change PCB
YES
Check the normal operating condition of the charger

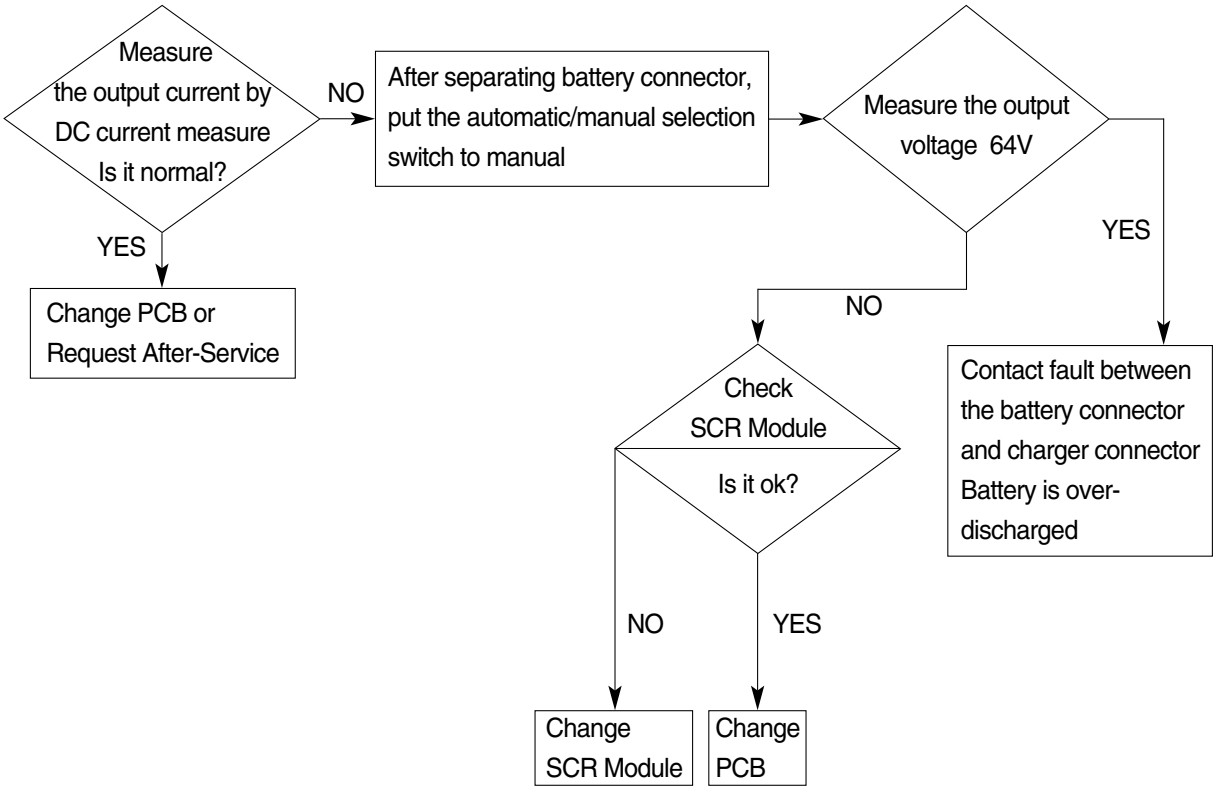
③ Charger TRIP is occurred after abnormality lamp is on.
In case error code is "O.V" → Over-voltage output / Set at 66Vdc (In case of BATT 48V)



④ Charger TRIP is occurred after abnormality lamp is on.
After opening the cover which is located on the front bottom side of the charger.
In case error code is "O.C" → Output over current, established as 110~120% of the rated current.

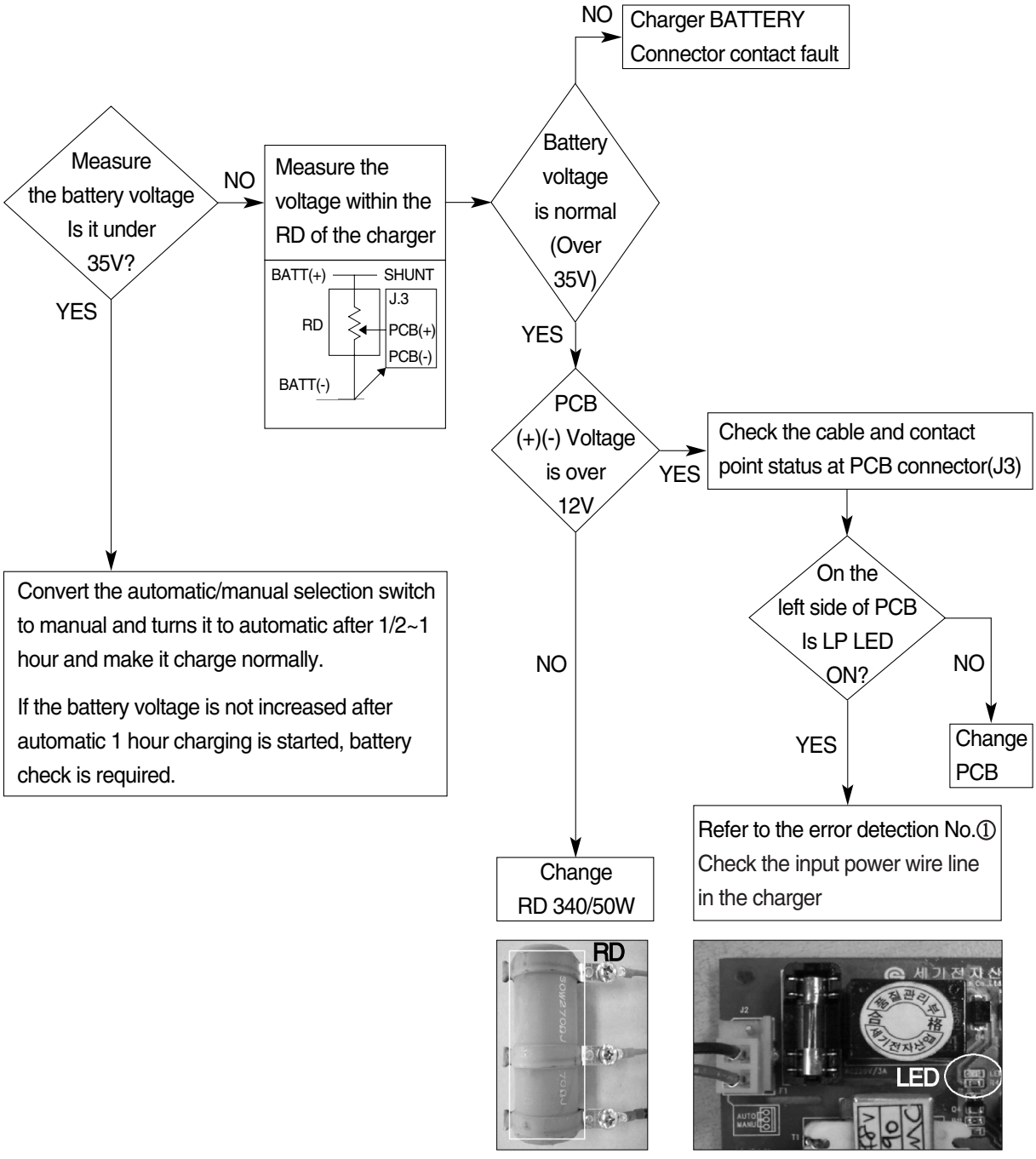


⑤ Charger TRIP is occurred after it started charging and charging completion lamp is on.
(In case input voltage is normal - Refer to the error detection No. 1)
Restore the charger as pushing reset switch.



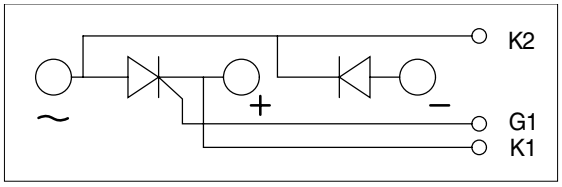
⑥ Charger has no response even if the battery connector is connected.

- In case only floating LED is on, charger input power is cut off or doesn't connect. (In case the input voltage is normal - Refer to the error detection No. ①)

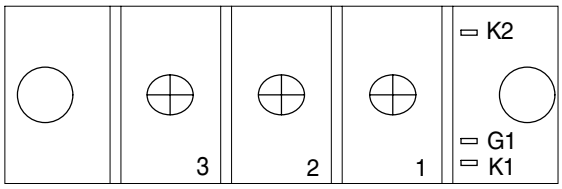


7) HOW TO CHECK THE SCR MODULE

Circuit

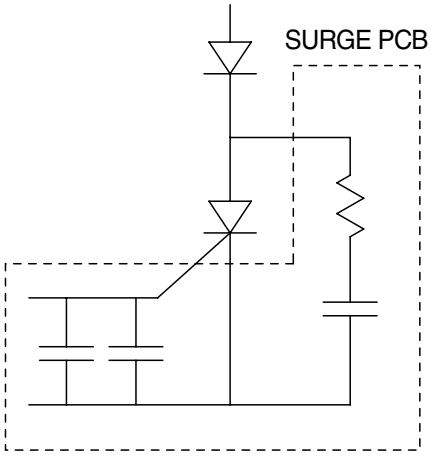


Real diagram

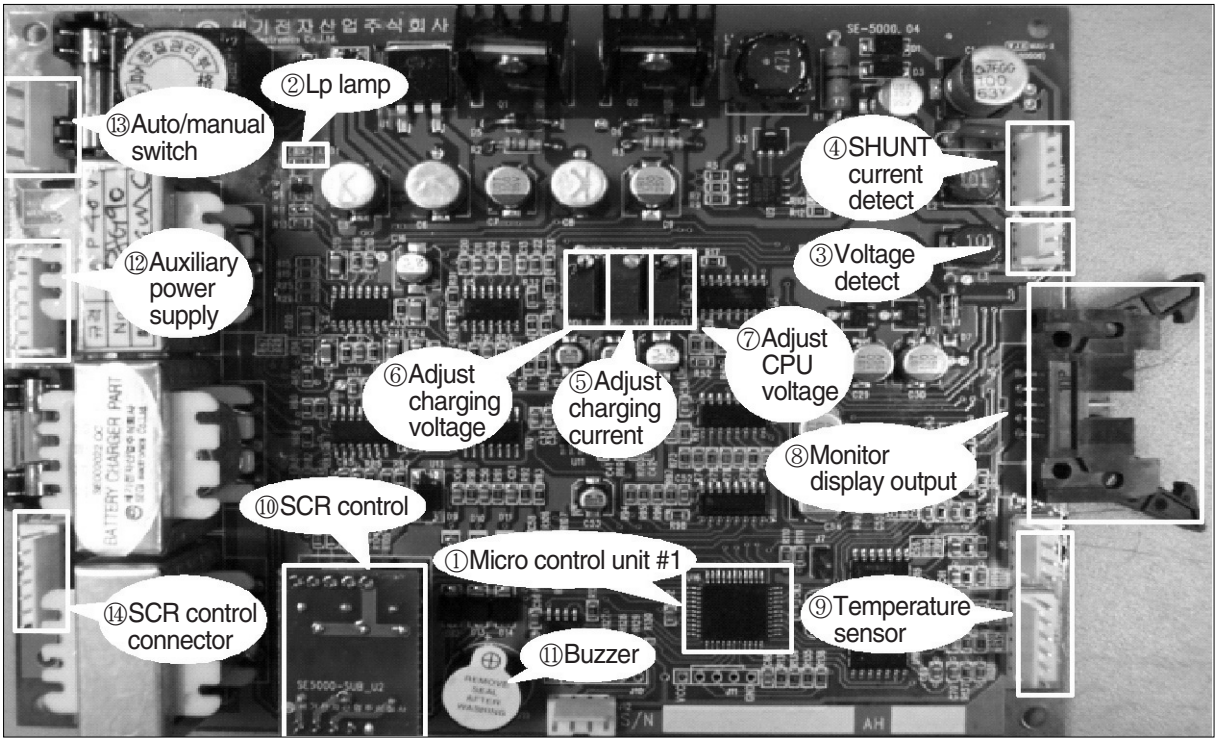


* Before checking SCR MODULE, be sure to disconnect bus bar and wire on the terminal.

No.	Measuring point (Real diagram)	Measure value (Measurement of digital tester)
1	No.1 ~ No.3	Forward : Under 100 k ohm Reverse : Infinity (∞)
2	No.2 ~ No.3	Forward : Infinity (∞) Reverse : Infinity (∞)
3	G1 ~ K1	Forward : Under 100 ohm Reverse : Under 100 ohm But It depends on the module. If it is not 0 ohm, It is Ok.
4	G1 ~ K2	Forward : Infinity (∞) Reverse : Infinity (∞)



8) PCB MAJOR PARTS (NAME AND LOCATION)



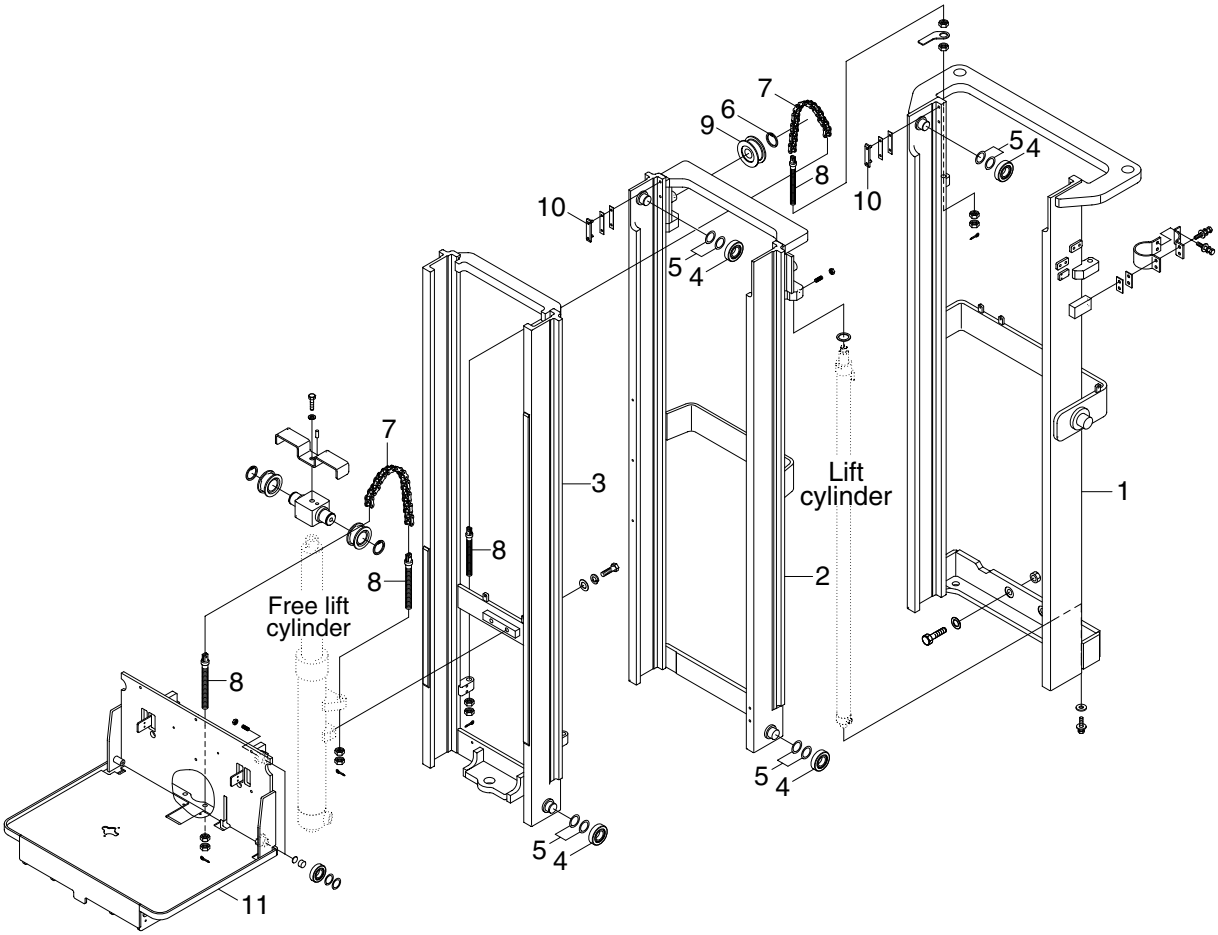
BOP7BAT26

1	Micro control unit #1	6	Adjust charging voltage	11	Buzzer
2	Lp lamp	7	Adjust CPU voltage	12	Auxiliary power supply
3	Voltage detect	8	Monitor display output	13	Auto/manual switch
4	SHUNT current detect	9	Temperature sensor	14	SCR control connector
5	Adjust charging current	10	SCR control		

SECTION 8 MAST

GROUP 1 STRUCTURE

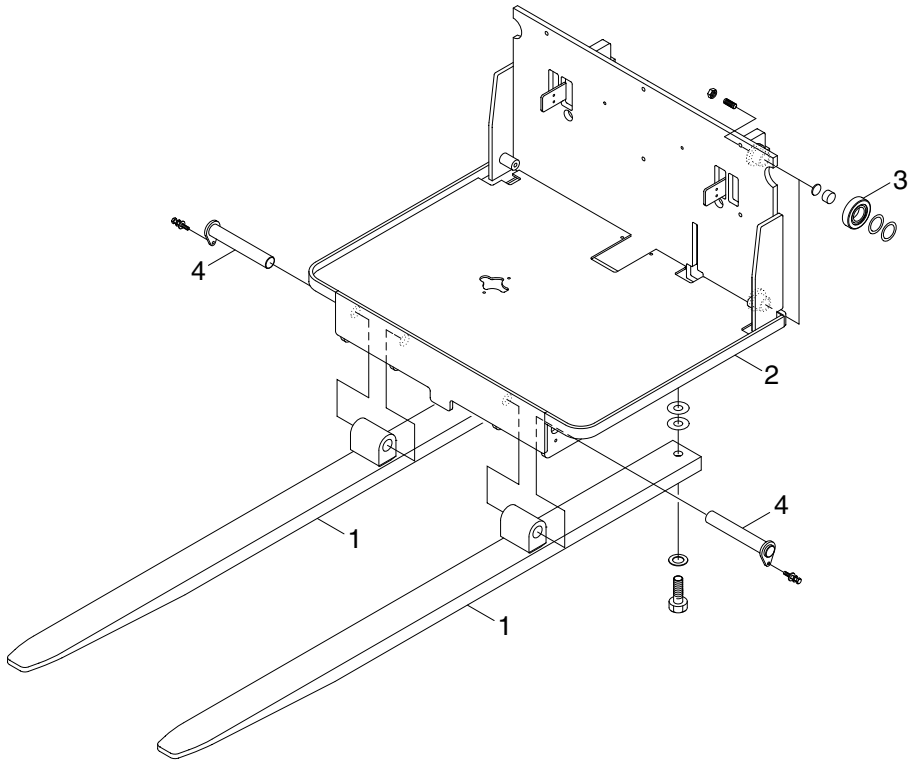
1. 3 STAGE MAST(TF MAST)



10BOP7MS03

1	Outer mast	5	Shim(0.5, 1.0t)	9	Chain sheave
2	Middle mast	6	Retaining ring	10	Back up liner
3	Inner mast	7	Lift chain	11	Platform
4	Roller	8	Anchor bolt		

2. PLATFORM AND FORK



10BOP7MS05

1	Fork assy	3	Load roller
2	Platform assy	4	Pin assy

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

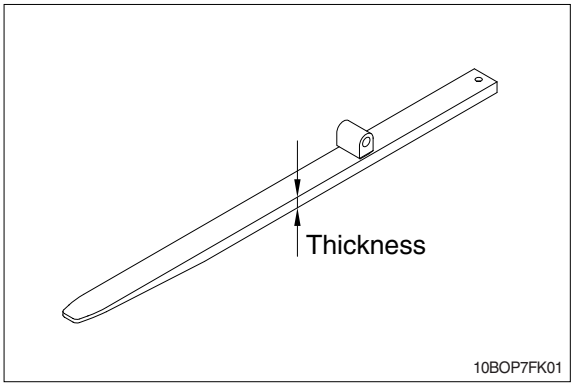
1. OPERATIONAL CHECKS

1) FORKS

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

mm(in)

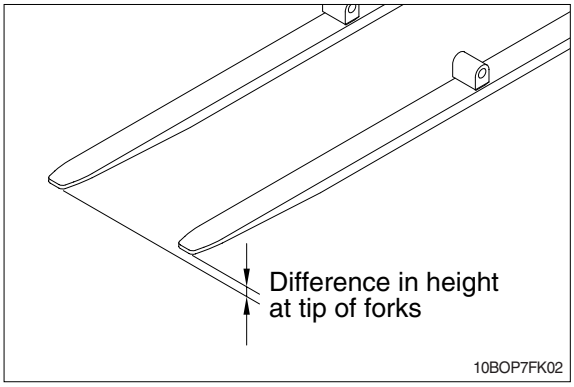
STD Fork assy	Applicable model	Standard	Limit
64HW-11030	10/13BOP-7	40(1.6)	36(1.4)



(2) Set forks in middle and measure difference in height at tip of forks.

mm

Model	Fork length	Height difference
10/13BOP-7	equal or below 1200	3
	above 1200	6



(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 welding cracks of the side arm, the chain mounting plate on the carriage assy and welding crack between carriage assy and floor assy of the platform.
   Check visually or use crack detection method. Repair any abnormality.
2) Set mast vertical, raise forks and platform about 10cm from ground and check front-to-rear clearance and left-to-right clearance between inner mast and platform, 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 and platform 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.	· See troubleshooting hydraulic pump and cylinders in section 6, hydraulic system.
	· Deformed mast assembly.	· Disassemble mast and replace damaged parts or replace complete mast assembly.
Slow lifting speed and insufficient handling capacity.	· Faulty hydraulic equipment.	· See troubleshooting hydraulic pump and cylinders in section 6, hydraulic system.
	· Deformed mast assembly.	· Disassemble mast and replace damaged parts or replace complete mast assembly.
Mast fails to lift smoothly.	· Deformed masts or carriage.	· Disassembly, repair or replace.
	· Faulty hydraulic equipment.	· See Troubleshooting Hydraulic Cylinders, pump and control valve in section 6, hydraulic system.
	· Damaged load and side rollers.	· Replace.
	· Unequal chain tension between LH & RH sides.	· Adjust chains.
	· LH & RH mast inclination angles are unequal. (Mast assembly is twisted when tilted)	· Adjust tilt cylinder rods.
Abnormal noise is produced when mast is lifted and lowered.	· Broken load roller bearings.	· Replace.
	· Broken side roller bearings.	· Replace.
	· Deformed masts.	· Disassemble, repair or replace.
	· Bent lift cylinder rod.	· Replace.
	· Deformed carriage.	· Replace.
	· Broken sheave bearing.	· Replace.
Abnormal noise is produced during tilting operation.	· Insufficient lubrication of anchor pin, or worn bushing and pin.	· Lubricate or replace.
	· Bent tilt cylinder rod.	· Replace.

2) FORKS

<table>
<tr><th>Problem</th><th>Cause</th><th>Remedy</th></tr>
<tr><td>Abrasion</td><td>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</td><td>If the measured value is below the wear limit, replace fork.</td></tr>
<tr><td>Distortion</td><td>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
<table>
<tr><th>Fork length (mm)</th><th>Height difference(mm)</th></tr>
<tr><td>equal or below 1200</td><td>3</td></tr>
<tr><td>above 1200</td><td>6</td></tr>
</table></td><td>If the measured value exceeds the allowance, replace fork.</td></tr>
<tr><td>Fatigue</td><td>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.</td><td>Repair fork by expert.
In case of excessive distortion, replace fork.</td></tr>
</table>

GROUP 3 ADJUSTMENT

1. MAST LOAD ROLLER(V MAST)

1) INNER/OUTER MAST ROLLER CLEARANCE ADJUSTMENT

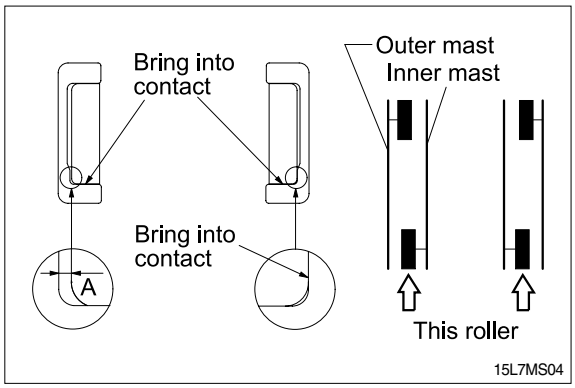
(1) Measure the clearance with the mast overlap at near 480mm.

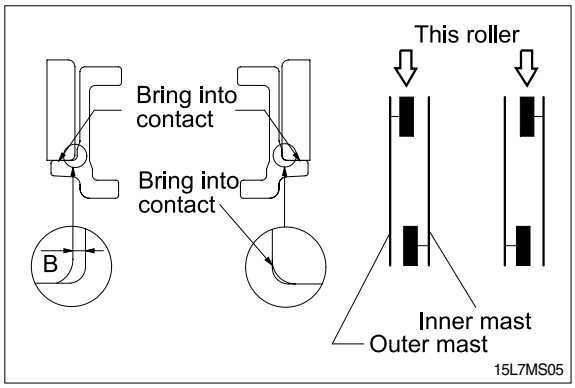
(2) Shift the inner mast to one side to bring the roller into contact with the outer mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner/outer mast roller shim.

- Standard clearance A, B = 0.3 ~ 0.6mm
- Shim thickness 0.5, 1.0mm

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

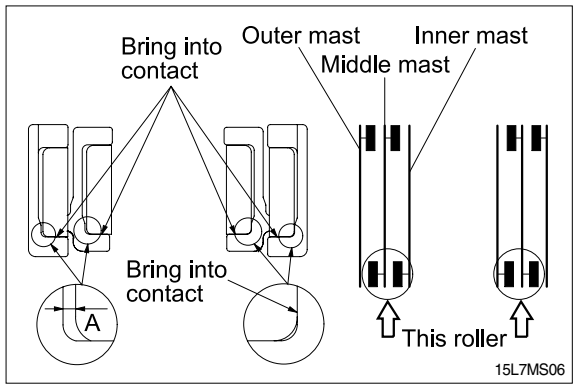
(4) After the adjustment, check that the inner mast moves smoothly in the outer mast.





2. MAST LOAD ROLLER(TF MAST)

1) INNER AND MIDDLE MAST ROLLER CLEARANCE ADJUSTMENT



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

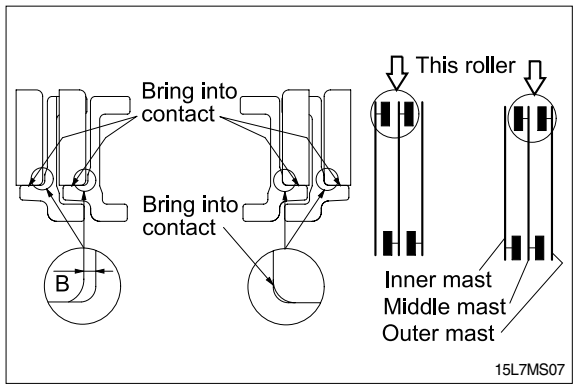
(2) Shift the inner mast to one side to bring the roller into contact with the outer mast and the middle mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner and middle mast roller shim, respectively.

- Standard clearance A = 0.3~0.6mm
- Shim thickness 0.5, 1.0mm

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

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

2) OUTER AND MIDDLE MAST UPPER ROLLER CLEARANCE ADJUSTMENT.



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

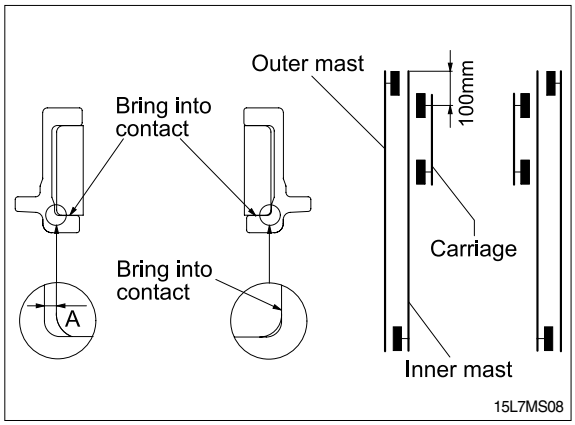
(2) Shift the inner mast to one side to bring the roller into contact with the middle mast and the inner mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the outer and middle mast roller shim, respectively.

- Standard clearance B = 0.3~0.6mm
- Shim thickness 0.5, 1.0mm

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

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

3) CARRIAGE LOAD ROLLER



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

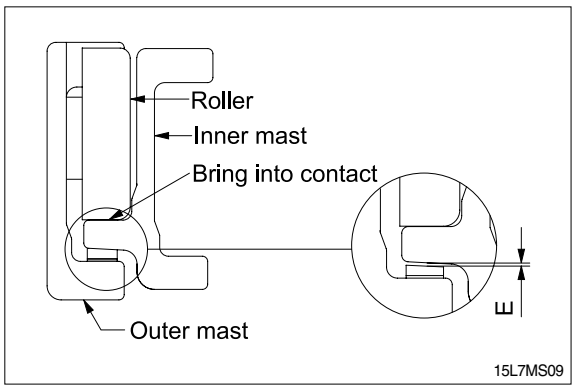
(2) Measure the clearance at upper, lower rollers after loosen the adjust screws from the side rollers. Shift the carriage to one side to bring the roller into contact with the inner mast, and measure the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the carriage roller shim.

- Standard clearance C = 0.3~0.6mm
- Shim thickness 0.5, 1.0mm

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

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

4) MAST BACK UP LINER



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

(2) With the inner mast in contact with the outer mast roller, adjust the clearance between the mast back up liner and inner mast to the following value by inserting the back up liner shim.

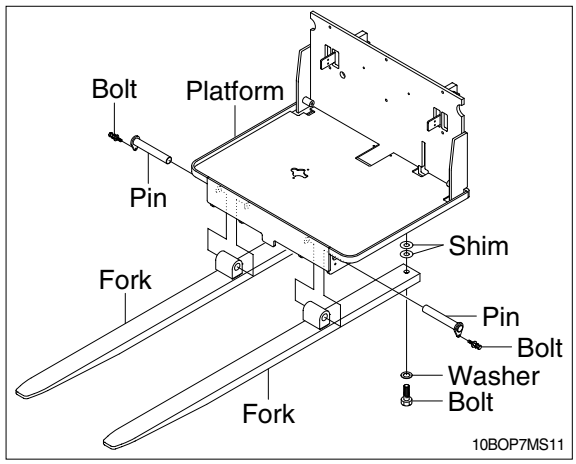
- Standard clearance E = 0.3~0.6mm
- Shim thickness 0.5, 1.0mm

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

GROUP 4 REMOVAL AND INSTALLATION

1. FORKS

1) Lower the fork and platform assy until the forks are approximately 25mm(1inch) from the floor.
2) Loosen and remove bolt washers and shims which are used for fixing the forks under the platform.
3) Loosen and remove bolts, pin weld assys which are used for fixing the forks to the platform.
4) Remove the fork one after another.
5) Assembly procedure of the forks is the reverse order of the removal procedure.

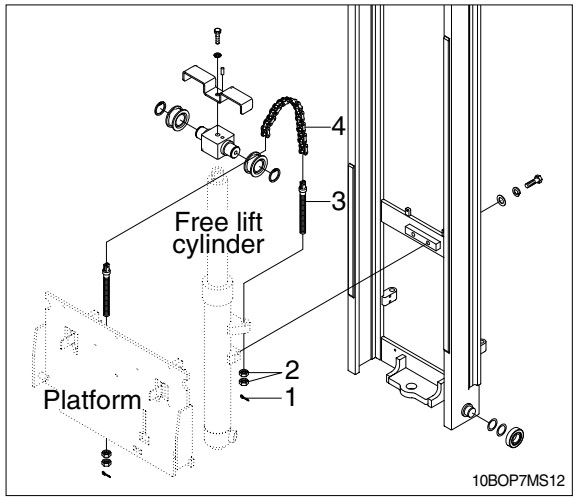


2. PLATFORM

1) Lift up the platform high enough to put up the blocks under the platform.
   While lifting up the platform, the lift chains can be slacked.
   Loosen and remove split pin, nuts from anchor bolt of the chains.
   Lift up slowly upright the platform using overhead hoist or overhead crane until it is reached to near the top of the inner mast, and them draw out carefully the platform upright

※ **Take care to draw out the platform in order that it can not happen damage due to bump between the platform and the inner mast.**

※ **Inspect all parts of the platform for wear of damage.**
Replace the defected parks if necessary.

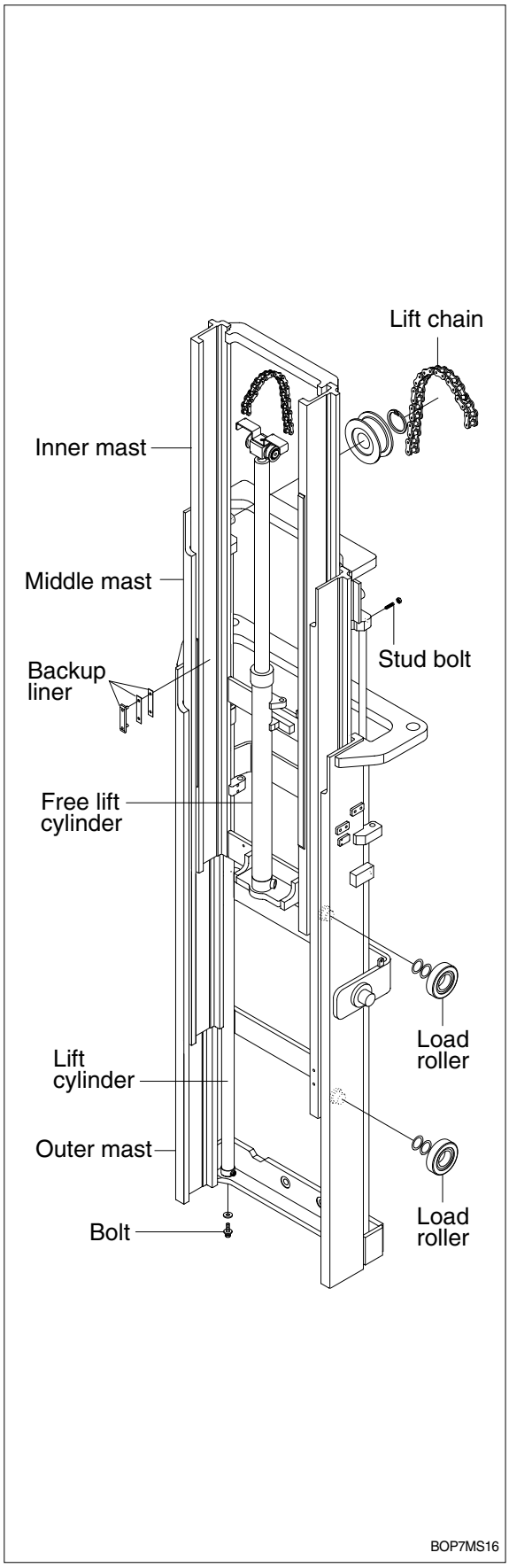


3. MASTER

1) MAST LOAD ROLLER AND BACK UP LINER

(1) 3 stage mast(TF mast)

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



2) ELEVATING MAST

(1) Inner and middle mast(TF mast)

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

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

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

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

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

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

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

3) CHAIN

(1) Rear chain sheave(TF mast)

① Raise and secure block under platform and inner mast section.

② Remove the split pin securing the chain anchor pins and discard. While supporting the chains, remove the chain anchor pins from outer mast section.

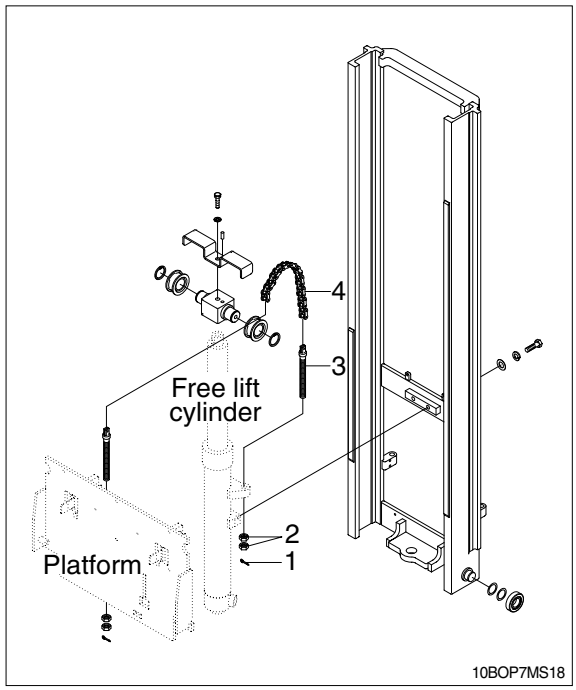
③ Remove chains.

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

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

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

⑦ Reverse the above procedure to assemble and install. Use new split pins in chain anchor pins.



(2) Chain wheel bearing support(TF mast)

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

(3) Rear chain(TF mast)

① Remove the platform and move to one side. Refer to platform 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.

(4) Lift chain

① Place a sling around platform and attach to an overhead hoist. Lift and secure high enough platform so that split and chain anchor pins on carriage can be easily be removed. Remove chain anchor pins from platform and drape chains out over carriage.
② Place a wooden block under the platform and lower the platform 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.

(5) Load chain inspection and maintenance

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

① Wear

As the chain flexes on and off the chain wheel bearings, the joints very gradually wear. The stretch a chain developes in service is due to material being worn off pin outer diameter and pitch hole inner diameter on the inside plate.
Chain wear can be measured using a wear scale or steel tape. When chains have elongated 2%, they should be discarded. When checking chain wear, be sure to measure a segment of chain that operates over a sheave. Do not repair chains by cutting of the worn section and splicing in a new piece. If part of the chain is worn, replace all the chains on the truck.

② Rust and corrosion

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

③ Cracked plate

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

④ Tight joints

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

Tight joints in lift chains can be caused by :

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

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

⑤ Protruding or turned pins

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

⑥ Chain side wear

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

⑦ Chain anchors and chain wheel bearings

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

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

⑧ **Chain wear scale**

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

- Determine pitch length of chain using 6 inch scale on one side of wear scale.
- If pitch is 1/2(12.7㎜), 3/4(19.05㎜), 1(25.4㎜), 1-1/2(38.1㎜), 2(50.8㎜), use side A of scale.
- If pitch is 5/8(15.875㎜), 1-1/4(31.75㎜) or 2(50.8㎜), 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.

(6) Load chain lubrication and adjustment

① **Lubrication**

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

- Wipe off the old oil with a clean cloth and blow out the remaining dirt with compressed air.

⚠ **Wear eye protection.**

- With a clean brush, apply EP-140 extreme pressure lubricant or heavy motor oil(40W).

② **Replacement**

Replace chains as a pair. It will be virtually impossible to maintain uniform loading between the strands if a new chain is put into service opposite an old chain. The joints in the old chain will be greater than that on the new chain, greatly complicating the problem of maintaining equal chain tension. The new chain will wear more slowly causing it to bear the major portion of the load resulting in premature wear and fatigue failure. Don't steam clean or decrease new chains.

The manufacturer's grease is effective in reducing wear and corrosion. If the original factory lube is dried out or wiped off, soak the new chain in heavy engine oil for at 1/2 hour prior to installing on truck. After the old chains have been stripped from the mast, very carefully inspect chain anchors and chain wheel bearing. Broken, cracked or worn anchor must be replaced using the new anchor pin and split pin. Do not paint newly replaced chain after it has been installed.

③ **Adjustment**

Chain adjustments are important for the following reasons :

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

④ **Adjustment procedure**

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