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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

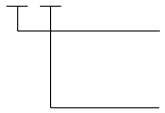
Distribution and updating

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
60	2.362	2.402	2.441	2.480	2.520	2.559	2.598	2.638	2.677	2.717
70	2.756	2.795	2.835	2.874	2.913	2.953	2.992	3.032	3.071	3.110
80	3.150	3.189	3.228	3.268	3.307	3.346	3.386	3.425	3.465	3.504
90	3.543	3.583	3.622	3.661	3.701	3.740	3.780	3.819	3.858	3.898

Kilogram to Pound

1kg = 2.2046lb

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

Liter to U.S. Gallon

1 l = 0.2642 U.S.Gal

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

Liter to U.K. Gallon

1 l = 0.21997 U.K.Gal

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

kgf · m to lbf · ft

1kgf · m = 7.233lbf · ft

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

kgf/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

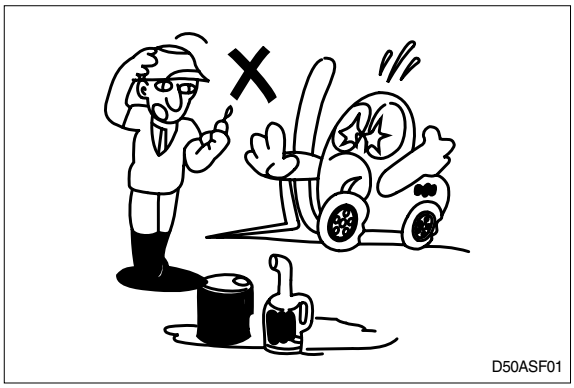
SECTION 1 GENERAL

Group 1 Safety hints 1-1
Group 2 Specifications 1-5
Group 3 Periodic replacement 1-16

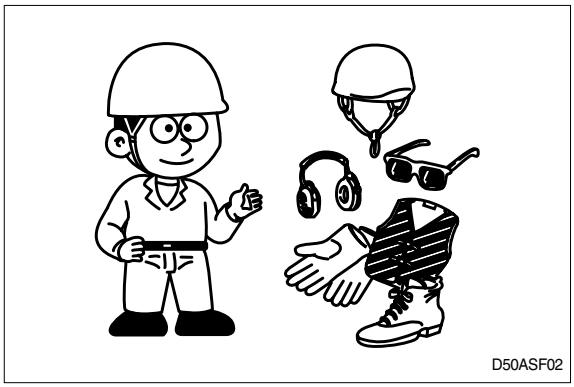
GROUP 1 SAFETY HINTS

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

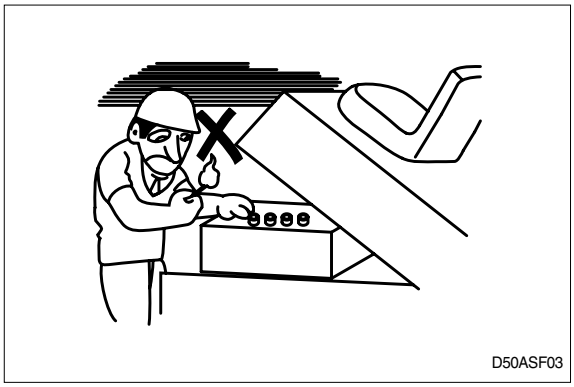
- Oil is a dangerous substance. Never handle oil, grease or oily clothes in places where there is any fire of flame.
  As preparation in case of fire, always know the location and directions for use of fire extinguishers and other fire fighting equipment.


D50ASF01

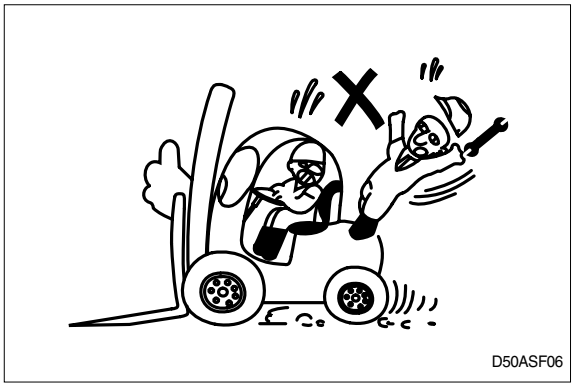
- Wear well-fitting helmet, safety shoes and working clothes. When drilling, grinding or hammering, always wear protective goggles.
  Always do up safety clothes properly so that they do not catch on protruding parts of machines. Do not wear oily clothes.
  When checking, always release battery plug.


D50ASF02

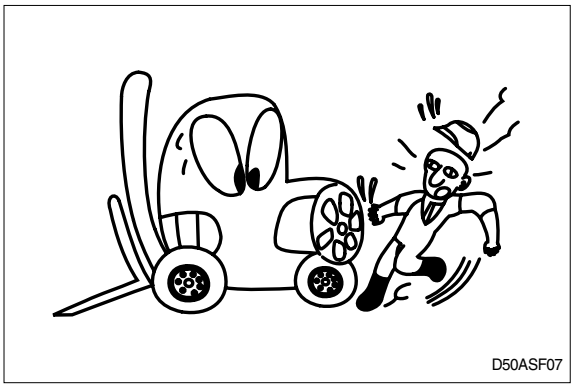
- Flames should never be used instead of lamps. Never use a naked flame to check leaks or the level of oil or electrolyte.


D50ASF03

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

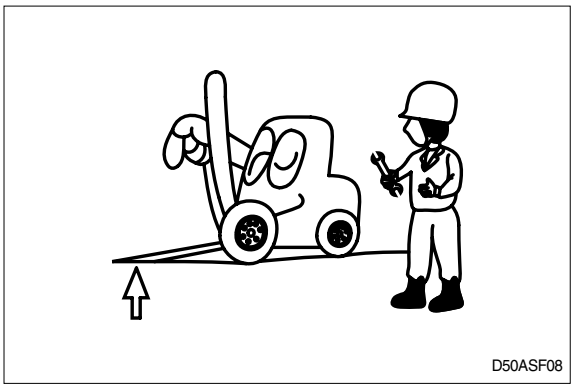

D50ASF06

- 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.

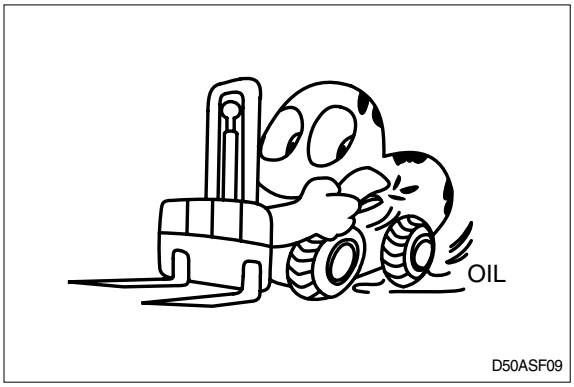

D50ASF07

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.

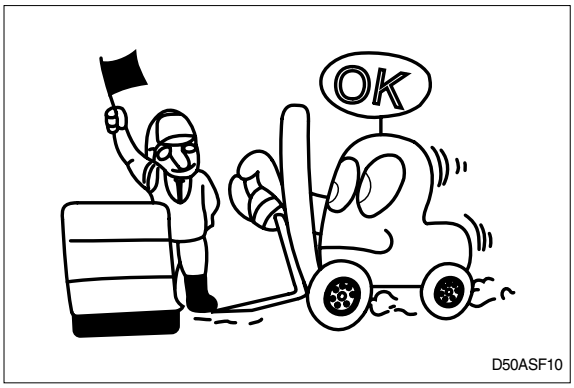

D50ASF08

- 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

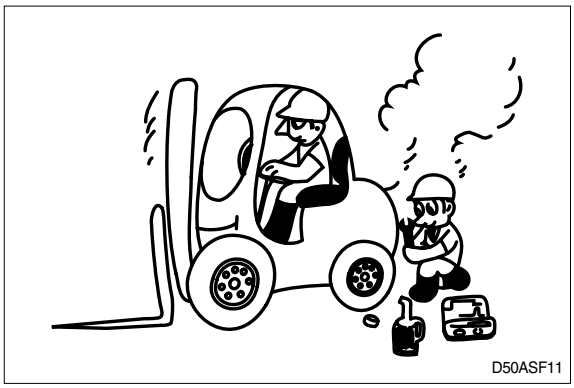
- When working with others, choose a group leader and work according to his instructions. Do not perform any maintenance beyond the agreed work.



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.

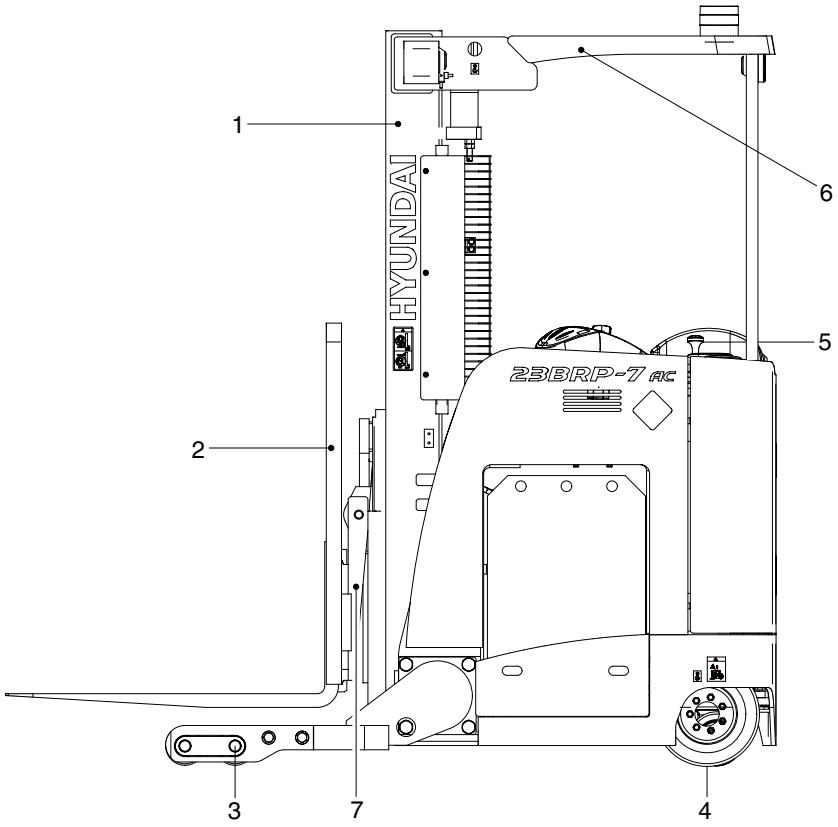


- Thoroughly clean the machine. In particular, be careful to clean the filler caps, grease fittings and the area around the dipsticks. Be careful not to let any dirt or dust into the system.
- Always use HYUNDAI Forklift genuine parts for replacement.
- Always use the grades of grease and oil recommended 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

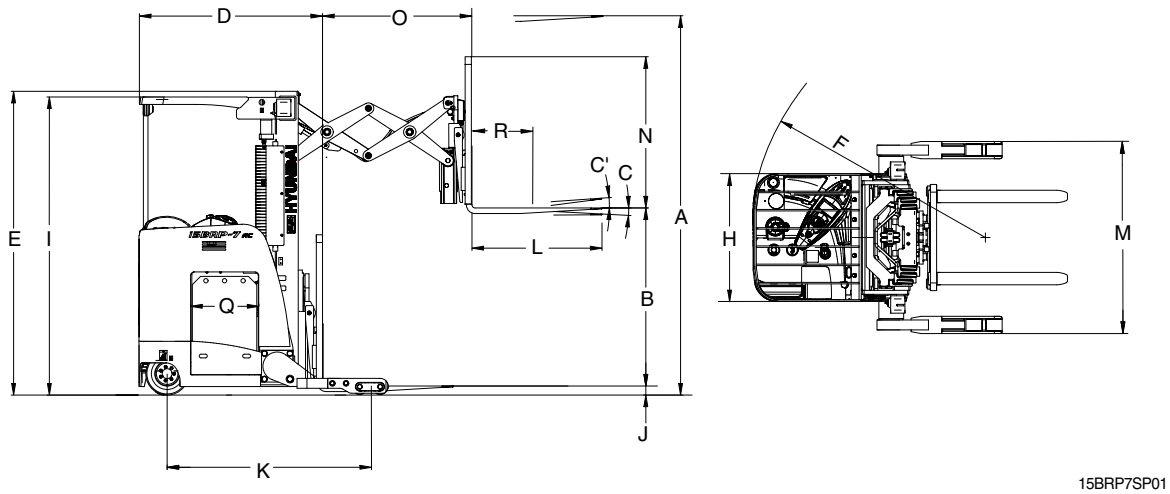


15BRP7OM54

1	Mast	5	Steering wheel
2	Carriage and backrest	6	Overhead guard
3	Load tire and brake	7	Reach
4	Drive unit and tire		

2. SPECIFICATIONS

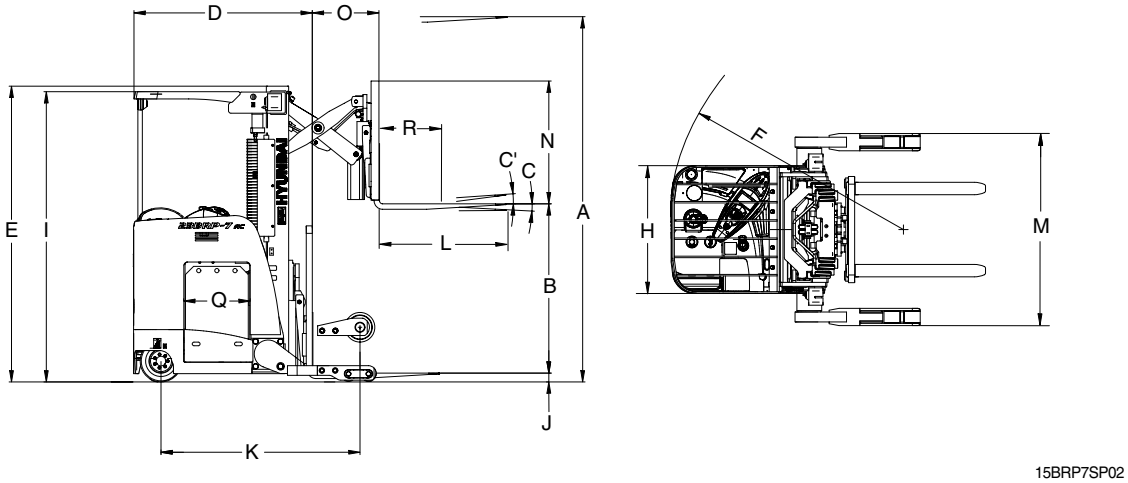
1) 15BRP-7



15BRP7SP01

Model			Unit	15BRP-7
Capacity			kg	1361
Load center		R	mm	610
Weight (With battery)			kg	4038
Fork	Lifting height	A	mm	5335
	Free lift (Without backrest)	B	mm	1196
	Lifting speed (Unload/load)		mm/sec	450/320
	Lowering speed (Unload/load)		mm/sec	450/500
	L×W×T	L,W,T	mm	1050×100×40
Mast	Tilt angle (Forward/backward)	C/C'	degree	3/4
	Max height		mm	6554
	Min height	E	mm	2415
	Backrest height	N	mm	1219
Performance	Travel speed (Unload, Forward)		km/h	11.8
	Min turning radius (STD battery)	F	mm	1856
Battery	Capacity		V-Ah	36/1085
	Weight (STD)		kg	1034
	Length	Q	mm	457
Length to fork face		D	mm	1562
Width (Frame)		H	mm	1030
Overhead guard height		I	mm	2398
Ground clearance (Load wheels)		J	mm	51
Wheel base (STD battery)		K	mm	1605
Outrigger width (Outside)		M	mm	1345
Reach stroke		O	mm	1087

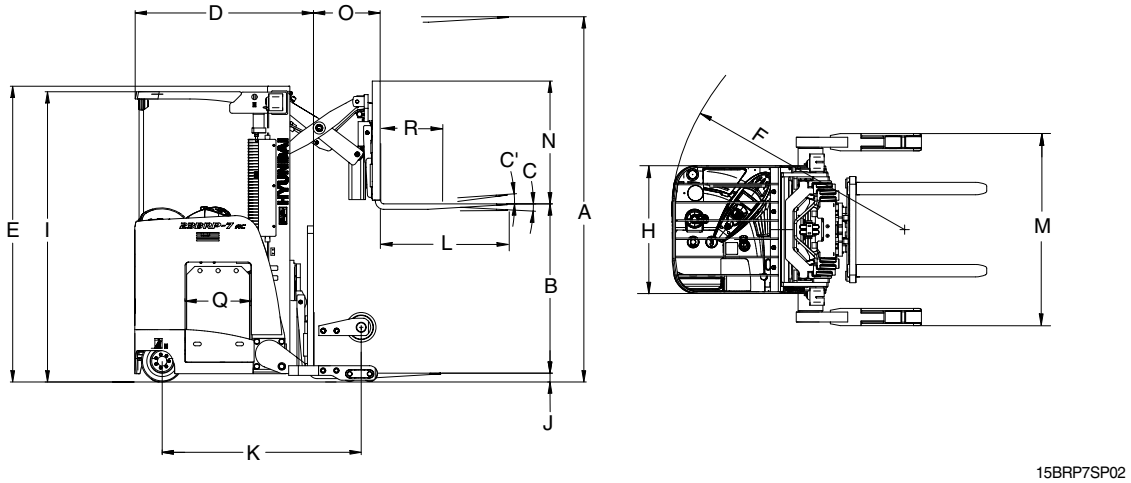
2) 18/20BRP-7



15BRP7SP02

Model			Unit	18BRP-7	20BRP-7
Capacity			kg	1588	1814
Load center		R	mm	610	←
Weight (With battery)			kg	3429	3589
Fork	Lifting height	A	mm	5335	←
	Free lift (Without backrest)	B	mm	1196	←
	Lifting speed (Unload/load)		mm/sec	450/310	460/290
	Lowering speed (Unload/load)		mm/sec	450/500	←
	L×W×T	L,W,T	mm	1050×100×40	1050×100×45
Mast	Tilt angle (Forward/backward)	C/C'	degree	3/4	←
	Max height		mm	6554	←
	Min height	E	mm	2415	←
	Backrest height	N	mm	1219	←
Performance	Travel speed (Unload, Forward)		km/h	11.8	←
	Min turning radius (STD battery)	F	mm	1665	1712
Battery	Capacity		V-Ah	36/775	36/930
	Weight (STD)		kg	725	852
	Length	Q	mm	362	413
Length to fork face		D	mm	1276	1327
Width (Frame)		H	mm	1030	←
Overhead guard height		I	mm	2398	←
Ground clearance (Load wheels)		J	mm	51	←
Wheel base (STD battery)		K	mm	1399	1450
Outrigger width (Outside)		M	mm	1345	1345
Reach stroke		O	mm	592	592

3) 23BRP-7



Model			Unit	23BRP-7
Capacity			kg	2041
Load center		R	mm	610
Weight (With battery)			kg	3936
Fork	Lifting height	A	mm	5335
	Free lift (Without backrest)	B	mm	1196
	Lifting speed (Unload/load)		mm/sec	460/270
	Lowering speed (Unload/load)		mm/sec	450/500
	L×W×T	L,W,T	mm	1050×100×45
Mast	Tilt angle (Forward/backward)	C/C'	degree	3/4
	Max height		mm	6554
	Min height	E	mm	2415
	Backrest height	N	mm	1219
Performance	Travel speed (Unload, Forward)		km/h	11.8
	Min turning radius (STD battery)	F	mm	1819
Battery	Capacity		V-Ah	36/1085
	Weight (STD)		kg	1034
	Length	Q	mm	457
Length to fork face		D	mm	1415
Width (Frame)		H	mm	1030
Overhead guard height		I	mm	2398
Ground clearance (Load wheels)		J	mm	51
Wheel base (STD battery)		K	mm	1565
Outrigger width (Outside)		M	mm	1345
Reach stroke		O	mm	592

6) WHEELS

Item	15BRP-7	18/20/23BRP-7
Type (Load/drive/caster)	Polyurethan	←
Quantity (Load/drive/caster)	4(2) / 1/2	-
Load wheel (5" STD / 10.5" Option)	ø 127×100	ø 127×100 / ø 267×100
Drive wheel	ø 345×140	←
Caster wheel	ø 178×73	←

7) BRAKES

Item	Specification
Brakes (Service)	Service : Drive motor, electromagnetic brake

8) BATTERY

Battery type	Battery compartment size (length)		Battery voltage	Capacity (6 hour rate)	Battery dimensions						Battery weight	
					Width (W)		Length (L)		Height (H)		Min. weight	
	mm	in	Volt	Ah	mm	in	mm	in	mm	in	kg	lb
Type A	362	14.3	36	775	975	38.4	355	14.0	787	31.0	725	1598
Type B	413	16.3	36	930	975	38.4	406	16.0	787	31.0	852	1878
Type C	457	18.0	36	1085	975	38.4	450	17.7	787	31.0	1034	2280
Type D	527	20.7	36	1240	975	38.4	520	20.5	787	31.0	1180	2601

※ STD : 15/18 BRP - A type, 20/23 BRP - B type

9) LOAD TIRE OPTION

Mast type	15BRP-7		18BRP-7		20BRP-7		23BRP-7	
	ø 5×4" (ø 127×101mm)	ø 10.5×4" (ø 267×101mm)	ø 5×4" (ø 127×101mm)	ø 10.5×4" (ø 267×101mm)	ø 5×4" (ø 127×101mm)	ø 10.5×4" (ø 267×101mm)	ø 5×4" (ø 127×101mm)	ø 10.5×4" (ø 267×101mm)
TF500	●	×	●	●	●	●	●	●
TF530	●	×	●	●	●	●	●	●
TF610	●	×	●	●	●	●	●	●
TF685	●	×	●	●	●	●	●	●
TF760	●	×	×	×	●	×	●	●
TF815	●	×	×	×	●	×	●	●
TF865	●	×	×	×	×	×	●	×
TF930	●	×	×	×	×	×	●	×
TF1010	●	×	×	×	×	×	●	×

3. SPECIFICATION FOR MAJOR COMPONENTS

1) CONTROLLER

Item	Unit	Drive&Pump motor controller	EPS motor controller	Fingertip controller
Model	-	AC-2	EPS-AC0	Mhyrio CB
Type	-	MOSFET	←	←
Dimension	mm	200×250×147.5	180×144×64.8	197×82×73
Current limit	A	450A	45A	2A
Communication	-	CAN	←	←

2) MOTOR

Item	Unit	Traction	Pump	EPS
Model	-	TSA 200-160-104	TSA 170-210-115	G104247A
Type	-	AC	AC	AC
Rated voltage	Vac	24	24	23
Output	kW	6.8	16	0.4
Insulation	-	Class F	Class F	Class H

3) GEAR PUMP

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

4) MAIN CONTROL VALVE

Item	Unit	Specification
Type	-	2 spool
Operating method	-	Proportional
Main relief valve pressure	bar	180

5) DRIVE UNIT

Item		Unit	Specification
Gear ratio	Total	-	20.2
Oil Quantity		l	3.3

6) WHEELS

Item	15BRP-7	18/20/23BRP-7
Type (Load/drive/caster)	Polyurethan	←
Quantity (Load/drive/caster)	4(2) / 1/2	-
Load wheel (5" STD / 10.5" Option)	ø 127 × 100	ø 127 × 100 / ø 267 × 100
Drive wheel	ø 345 × 140	←
Caster wheel	ø 178 × 73	←

7) BRAKES

Item	Specification
Brakes (Service)	Service : Drive motor, electromagnetic brake

8) BATTERY

Battery type	Battery compartment size (length)		Battery voltage	Capacity (6 hour rate)	Battery dimensions						Battery weight	
					Width (W)		Length (L)		Height (H)		Min. weight	
	mm	in	Volt	Ah	mm	in	mm	in	mm	in	kg	lb
Type A	362	14.3	36	775	975	38.4	355	14.0	787	31.0	725	1598
Type B	413	16.3	36	930	975	38.4	406	16.0	787	31.0	852	1878
Type C	457	18.0	36	1085	975	38.4	450	17.7	787	31.0	1034	2280
Type D	527	20.7	36	1240	975	38.4	520	20.5	787	31.0	1180	2601

9) LOAD TIRE OPTION

Mast type	15BRP-7		18BRP-7		20BRP-7		23BRP-7	
	ø 5 × 4" (ø 127 × 101mm)	ø 10.5 × 4" (ø 267 × 101mm)	ø 5 × 4" (ø 127 × 101mm)	ø 10.5 × 4" (ø 267 × 101mm)	ø 5 × 4" (ø 127 × 101mm)	ø 10.5 × 4" (ø 267 × 101mm)	ø 5 × 4" (ø 127 × 101mm)	ø 10.5 × 4" (ø 267 × 101mm)
TF500	●	×	●	●	●	●	●	●
TF530	●	×	●	●	●	●	●	●
TF610	●	×	●	●	●	●	●	●
TF685	●	×	●	●	●	●	●	●
TF760	●	×	×	×	●	×	●	●
TF815	●	×	×	×	●	×	●	●
TF865	●	×	×	×	×	×	●	×
TF930	●	×	×	×	×	×	●	×
TF1010	●	×	×	×	×	×	●	×

4. TIGHTENING TORQUE FOR MAJOR COMPONENTS

1) 15/18/20/23BRP-7

NO	Items		Size	kgf · m	lbf · ft
1	Electric system	Hyd pump motor mounting bolt	M10×1.5	6.9±1.4	50±10
2		Traction motor mounting bolt	M 8×1.25	2.5±0.5	18.1±3.6
3	Hydraulic system	Hydraulic pump mounting bolt	M10×1.5	5±1	36±7.2
4		MCV mounting bolt, nut	M 8×1.25	2.5±0.5	18.1±3.6
5		Hydraulic oil tank mounting bolt	M 8×1.25	2.5±0.5	18.1±3.6
6	Power train system	Drive unit mounting bolt	M12×1.75	14.0±1.0	101±7
7		Load wheels mounting bolt	M12×1.75	14.0±1.0	101±7
8		Drive wheel mounting nut	M14×1.5	14.5±1.0	105±7
9	Others	Seat mounting bolt	M 8×1.25	2.5±0.5	18.1±3.6
10		Head guard mounting bolt	M12×1.75	12.8±3.0	93±22
11			M16×2	29±4	210±29.0
12		Mast mounting bolt, nut	M20×1.5	62.8±9	455±65.2
13			M22×1.5	83.2±12.5	603±90.6
14		Outrigger mounting bolt	M27×3	120±12	868±87

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	3.3 (0.87)	SAE 80W/90
Hydraulic oil tank	Hydraulic oil	28 (7.4)	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.**

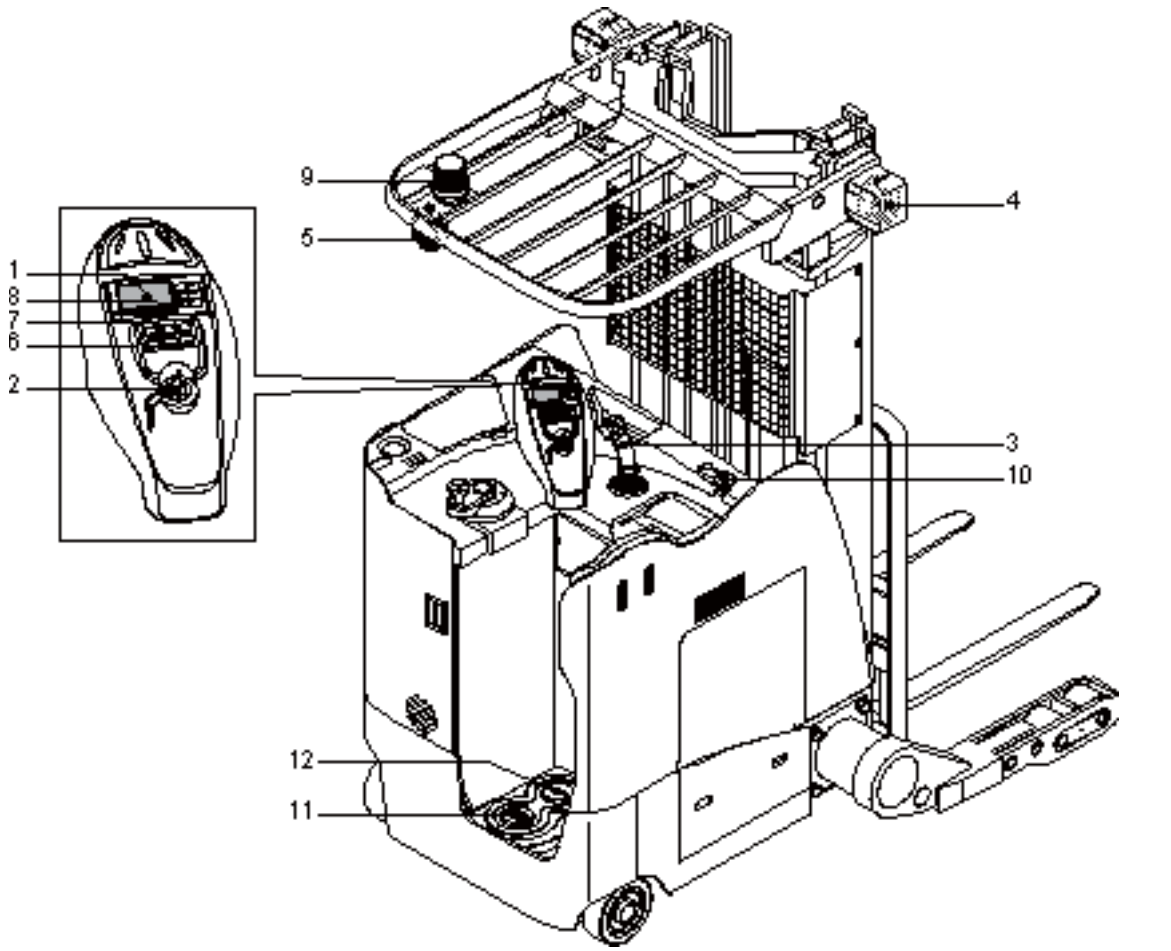
No.	Description	Period of replacement
1	Hydraulic oil	Every 1 year
2	Gear oil	Every 1 year
3	Power steering hose	Every 1 year
4	Rubber parts of the power steering inside	Every 2 year
5	Cups and dust seals etc. of cylinder	Every 2 year
6	Lift chain	Every 2 year
7	Hydraulic equipment hose	Every 2 year

SECTION 2 REMOVAL AND INSTALLATION OF UNIT

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

SECTION 2 REMOVAL AND INSTALLATION OF UNIT

GROUP 1 STRUCTURE



15BRP7OM61

1	Display	7	Work lamp switch
2	Start switch	8	Beacon switch
3	Joystick	9	Beacon lamp
4	Head lamp	10	Emergency switch
5	Rear work lamp	11	Brake switch
6	Head lamp switch	12	Dead man switch

※ 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.

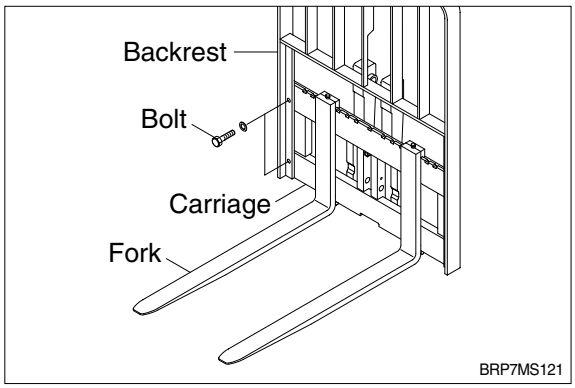
1. MAST

1) REMOVAL

Backrest & fork — Carriage — Piping — Mast

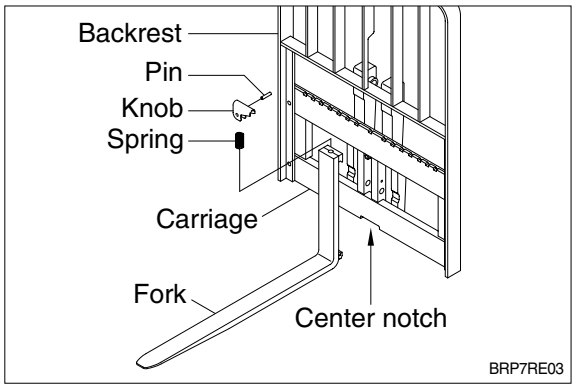
(1) Backrest

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



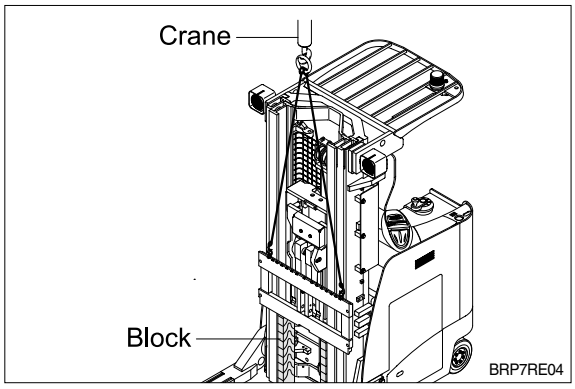
(2) Forks

① Remove shaft cover and bolt.
② Remove fork set pin and then draw out the shaft.
③ Carefully remove forks one by one.

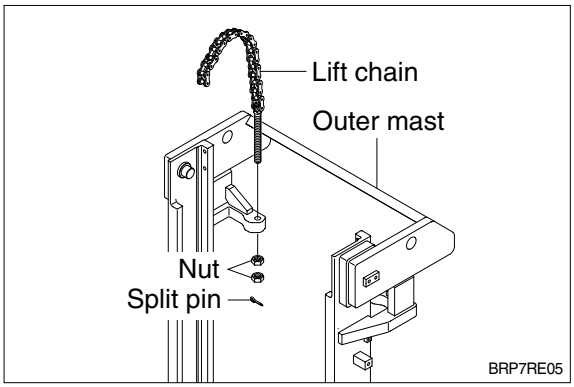


(3) Carriage

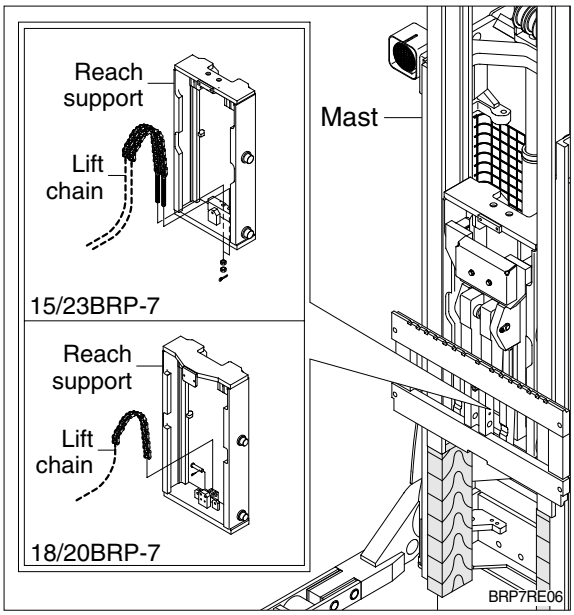
① With the mast vertical, raise the carriage high enough to place blocks under the load forks. This is done to create slack in the load chains when the carriage is lowered. Lower the carriage all the way down to the floor. Make sure the carriage is level, this will prevent any binding when the mast is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



② While supporting lift chains, remove the split pins and nuts from anchor bolts of stationary upright.



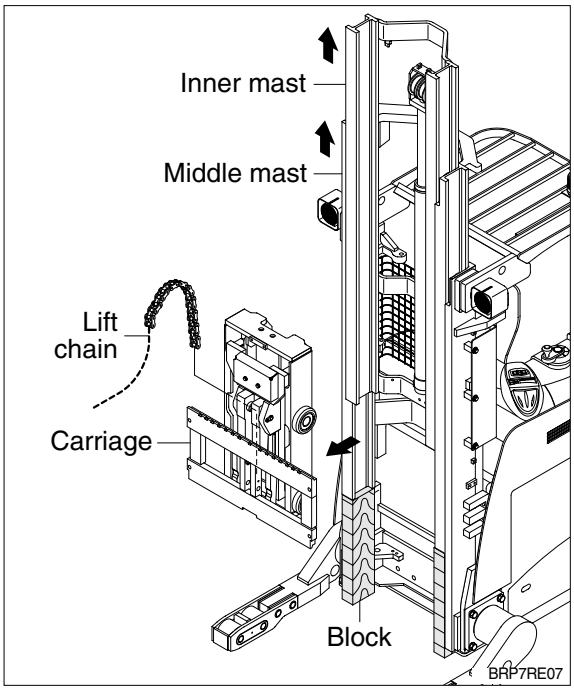
③ Pull the chains out of the sheaves and drape them over the front of the carriage.



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

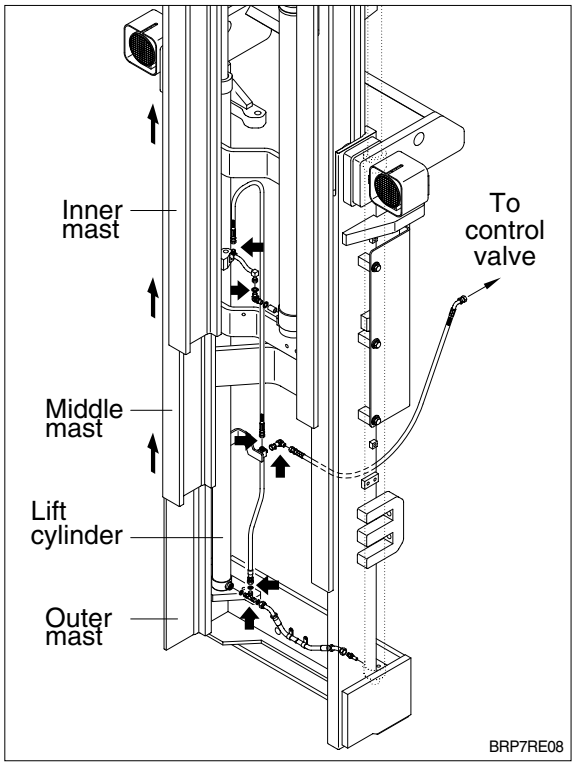
⚠ Make sure that carriage remains on floor and does not bind while mast is being raised.

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



(4) PIPING

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

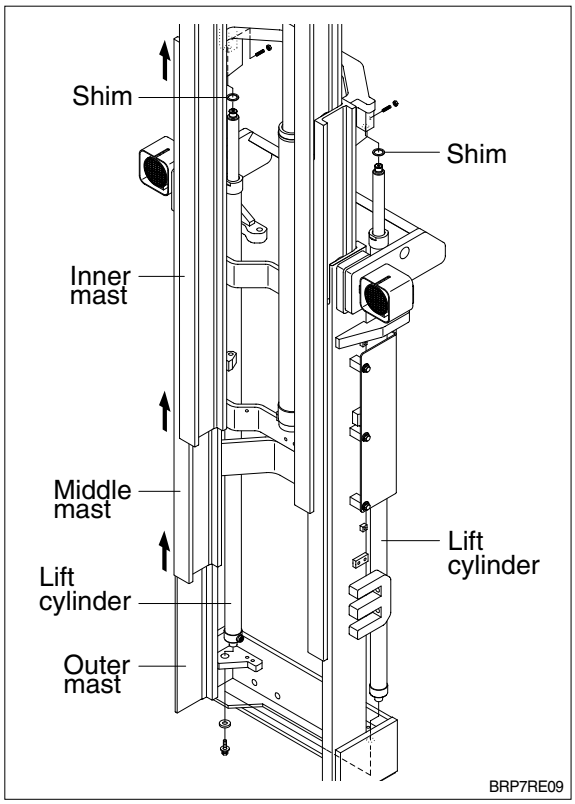


(5) LIFT CYLINDER

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

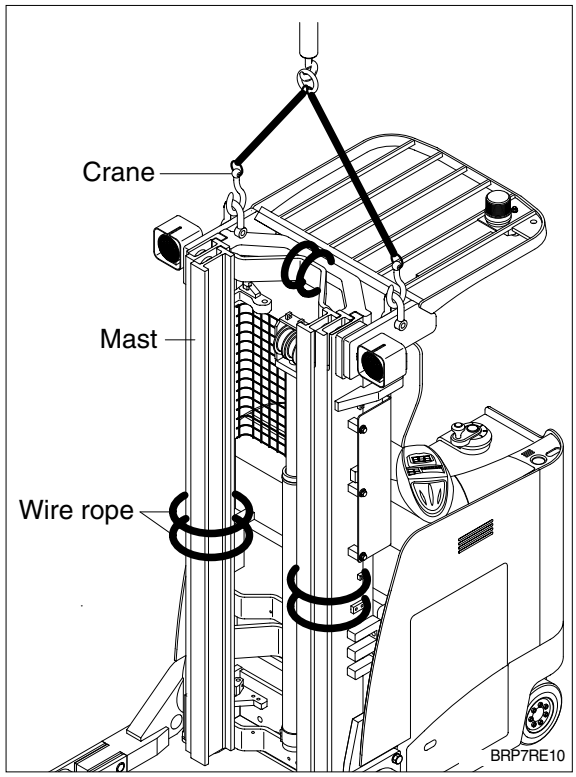
⚠ Make sure that the lift cylinder be tightened firmly for safety.

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



(6) MAST REMOVAL

① Pass wire rope around the inner and outer masts to allow lifting them out with a hoist.
② Remove the stopper pin at the end of reach cylinder and then remove the stopper bolt at the end of guide rail.
③ Draw out the mast from the guide rail with lifting up.
④ Lower the mast and place it on stand.

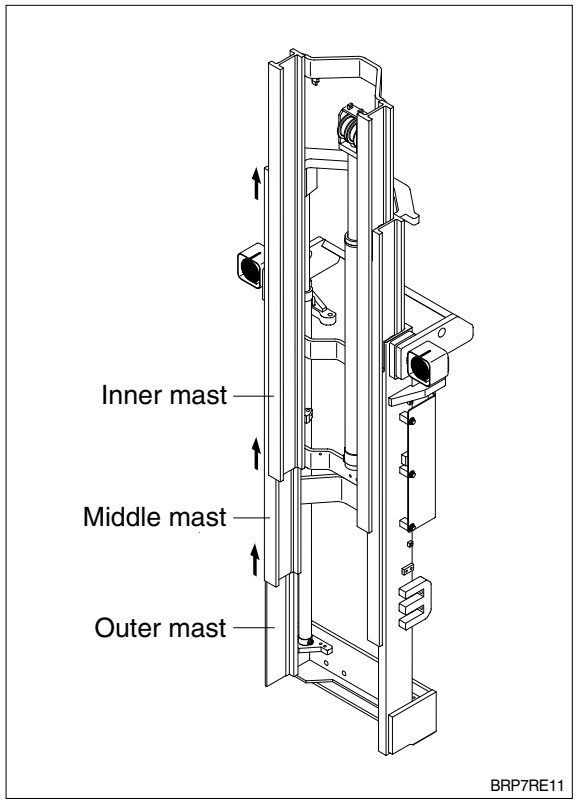


(7) INNER MAST

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

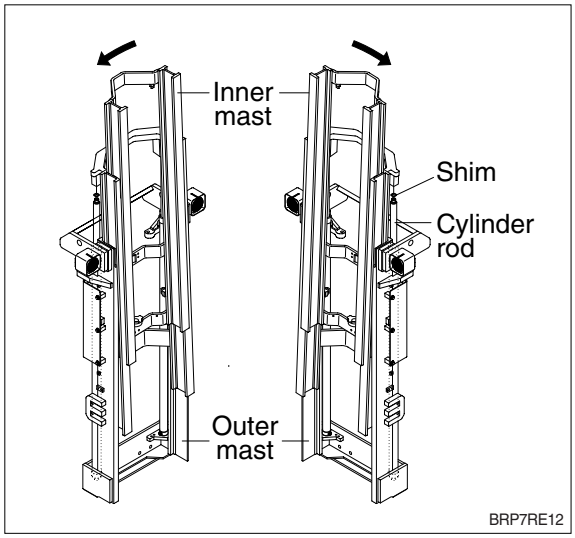
① Assemble the lift cylinder inside the outer mast, then tighten the stopper bolt. If the cylinder assembly has been replaced, adjust as follows so that the left and right cylinders are synchronized at the maximum lifting height.

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)



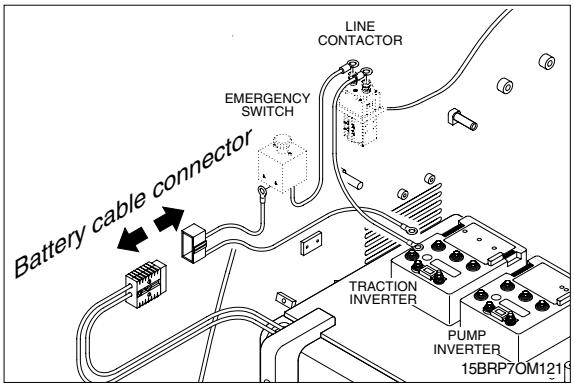
2. POWER TRAIN ASSEMBLY

1) REMOVAL

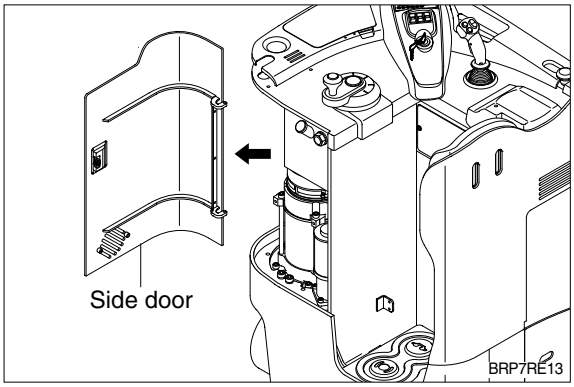
Battery disconnector — Side door — Pump & pump motor — Drive unit assembly

BRJ7RE001

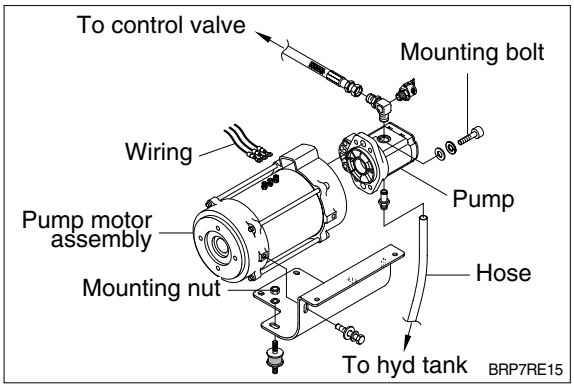
(1) Disconnect the battery cable.



(2) Remove side door.

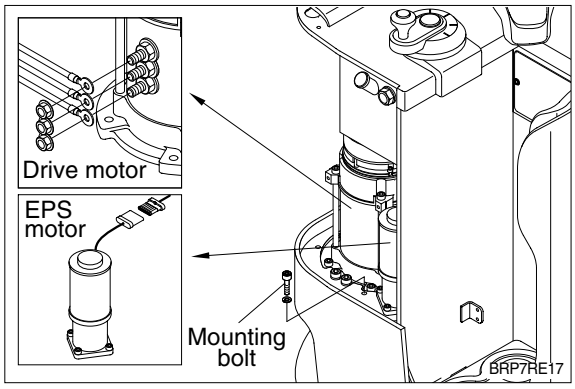


(3) Disconnect the hose, pipe and wiring from pump & motor assembly.
Loosen mounting nuts from frame and then take out the assembly.

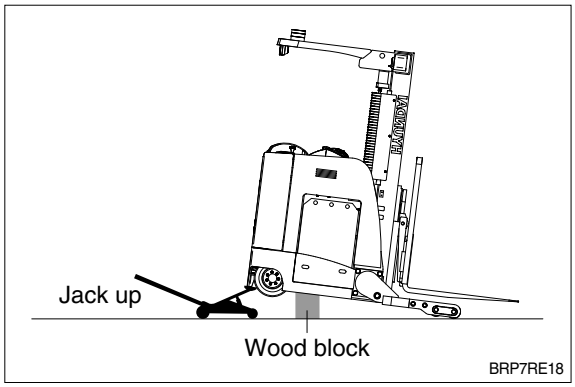


(4) Disconnect the wiring.
① Drive motor wiring
② EPS motor wiring.

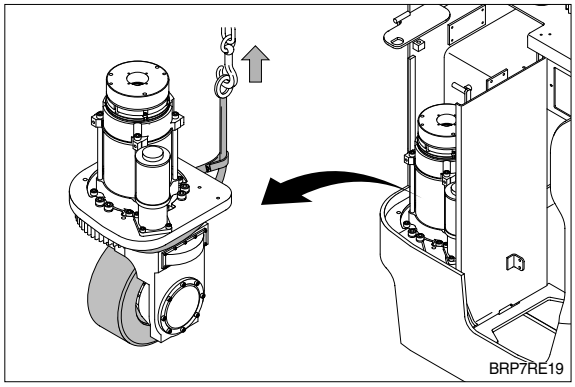
(5) Loosen mounting bolts from frame and then take out drive unit assembly.



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

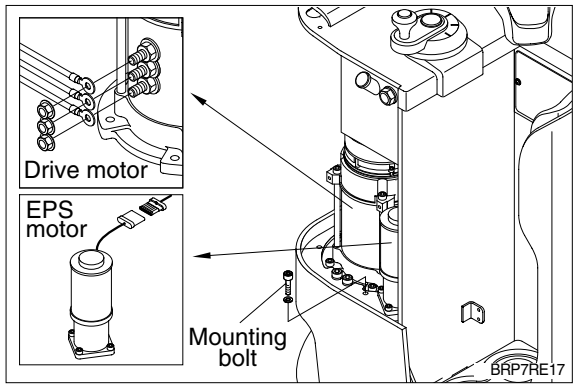


(7) Remove drive unit assembly from frame by lifting.
Sustain the drive unit assembly properly so that it may not fall down on the floor.



2) INSTALLATION

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

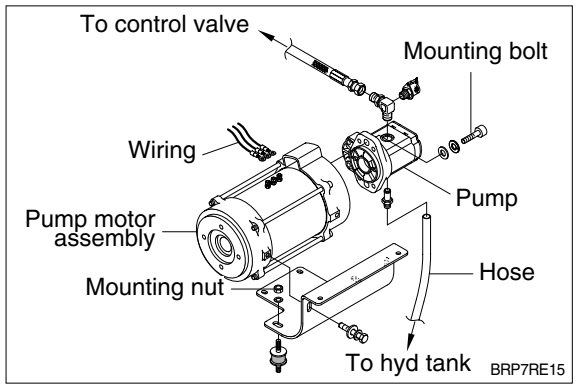


(1) Drive unit mounting bolts : 6EA
- Tightening torque : 13.3~15.3kgf · m (96.2~110.6lbf · ft)

(2) Drive unit bracket mounting bolt : 9EA
- Tightening torque : 12.8~14.0kgf · m (92.6~101.3lbf · ft)

(3) Drive motor mounting bolts : 6EA
- Tightening torque : 6.0~8.0kgf · m (43.4~57.9lbf · ft)

(4) EPS motor mounting bolts : 4EA
- Tightening torque : 3.0~4.0kgf · m (21.7~28.9lbf · ft)



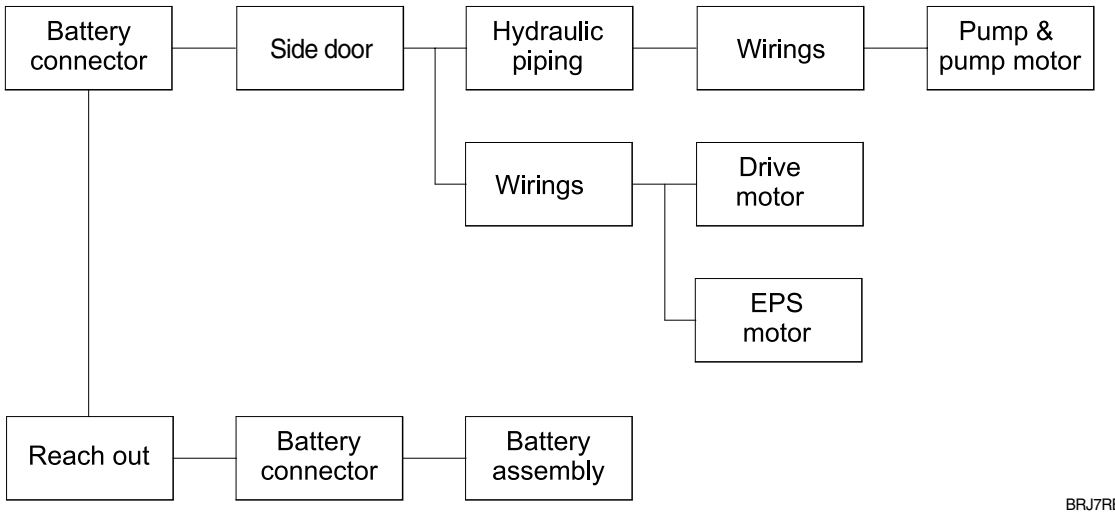
(5) Pump motor mounting nuts : 4EA
- Tightening torque : 4.0~6.0kgf · m (28.9~43.4lbf · ft)

(6) Pump motor mounting bolt : 4EA
- Tightening torque : 4.0~6.0kgf · m (28.9~43.4lbf · ft)

3. ELECTRICAL COMPONENTS

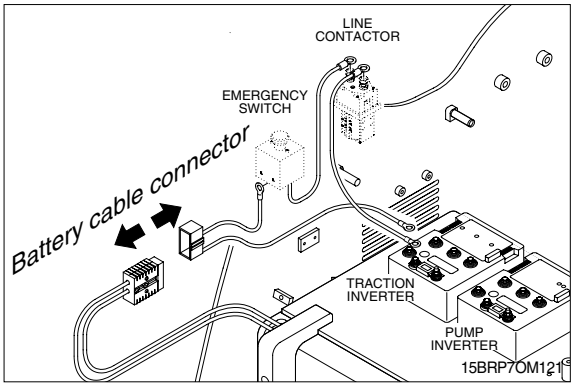
Before removing each component, disconnect cables and earth lines attached to the component.

1) REMOVAL

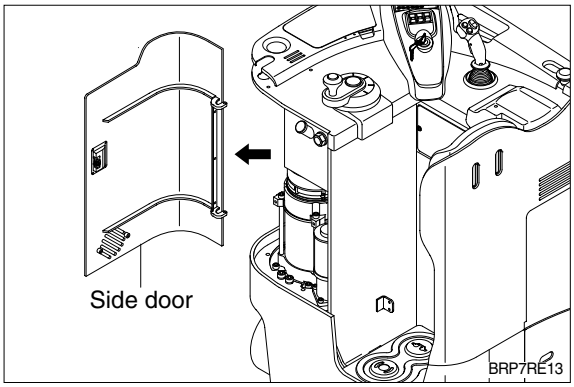


(1) PUMP MOTOR

① Disconnect the battery cable.

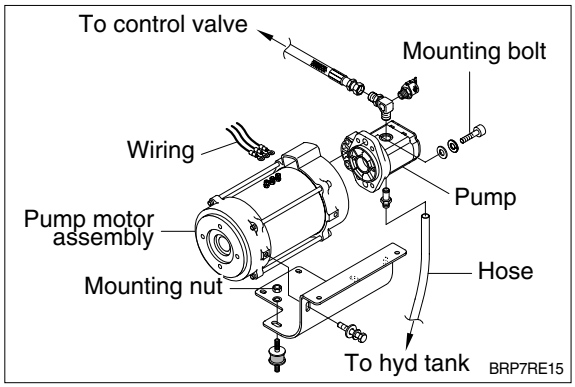


② Remove side door.



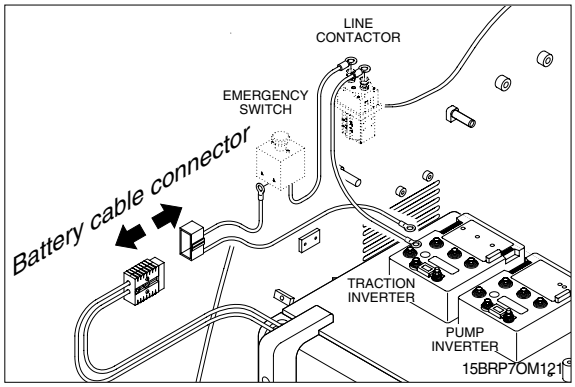
③ Disconnect the hose, pipe and wiring from pump & motor assembly.
Loosen mounting nuts from frame and then take out the assembly.

④ Remove 2 mounting bolts fastening the pump & motor and then disengage the pump from motor.

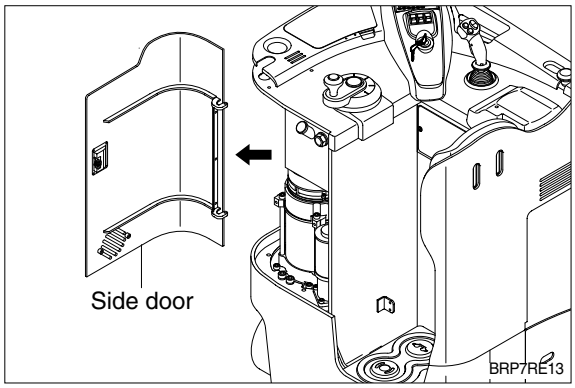


(2) DRIVE MOTOR

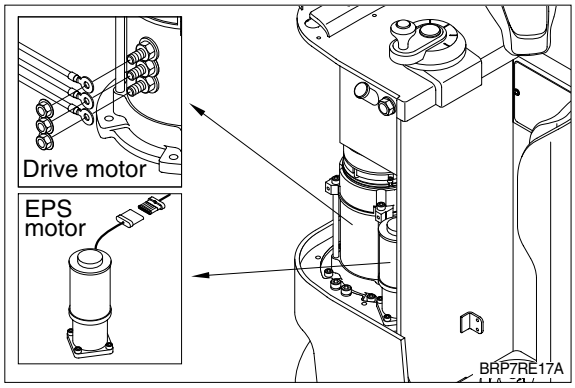
① Disconnect the battery cable.



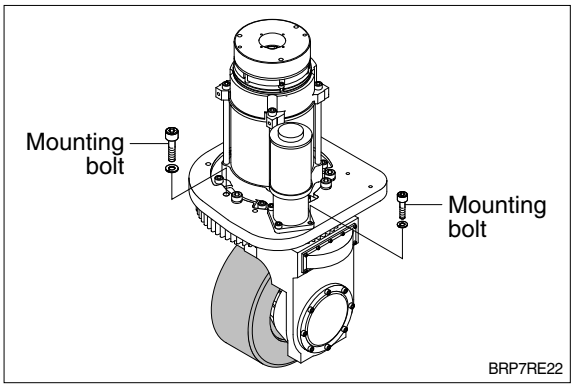
② Remove side door.



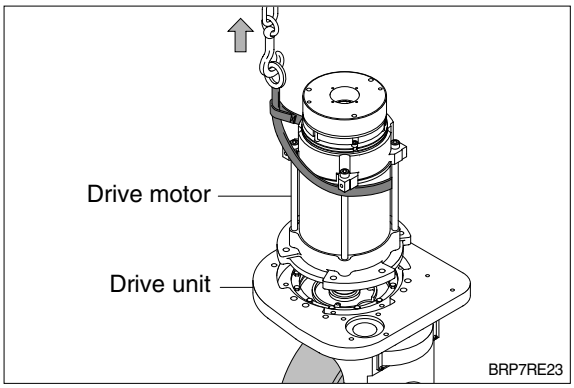
③ Disconnect wirings.
a. Drive motor wiring
b. EPS motor wiring



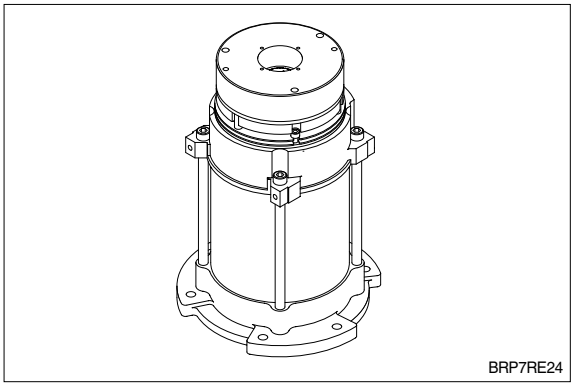
④ Remove bolts connecting the motor and drive unit.



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

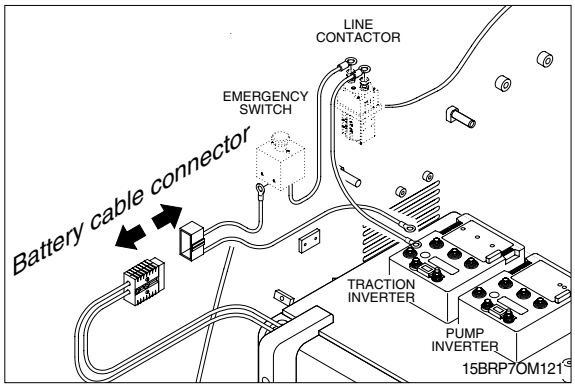


⑥ Put the motor on the clean work bench.

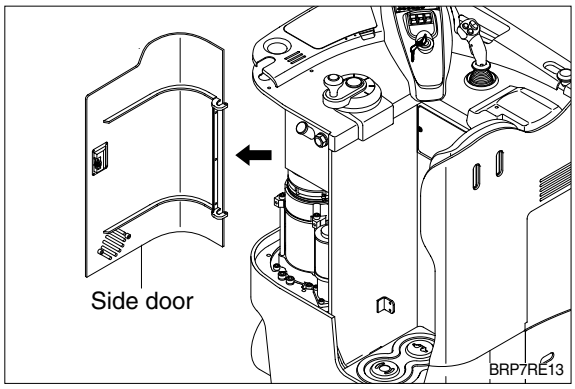


(3) EPS MOTOR

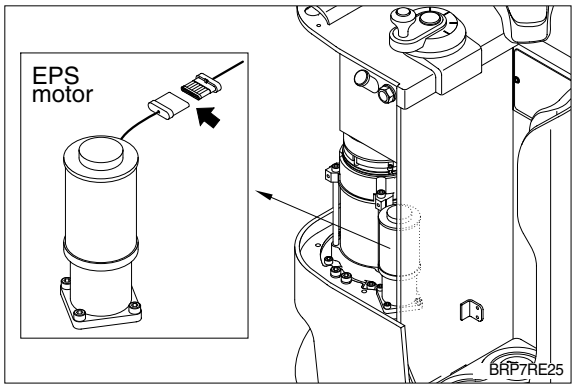
① Disconnect the battery cable.



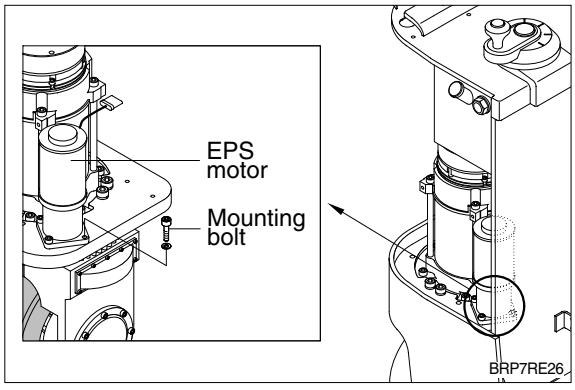
② Remove side door.



③ Disconnect wirings.



④ Loosen bolts and remove EPS motor assembly.



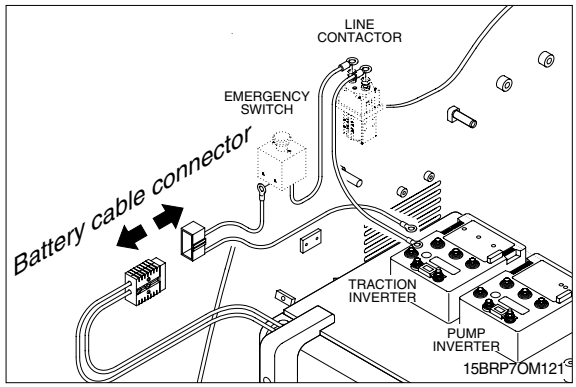
(4) BATTERY REMOVAL

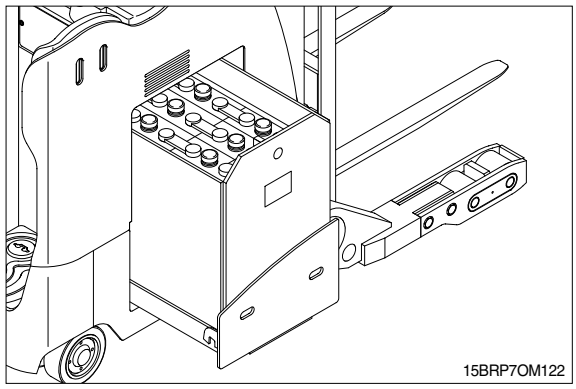
① Turn off the key.

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.

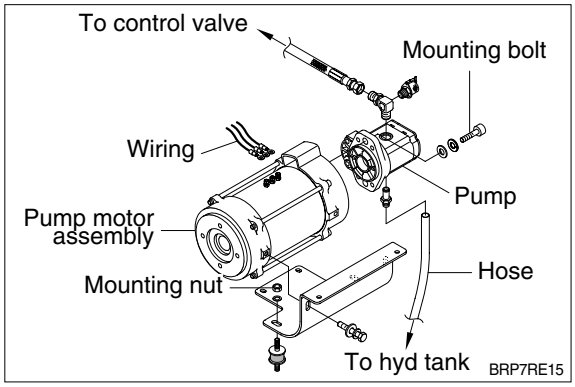
(1) PUMP MOTOR

① Pump motor mounting nut.

· Tightening torque : 2.0~3.0kgf · m
(14.5~21.7lbf · ft)

② Hydraulic pump mounting bolt

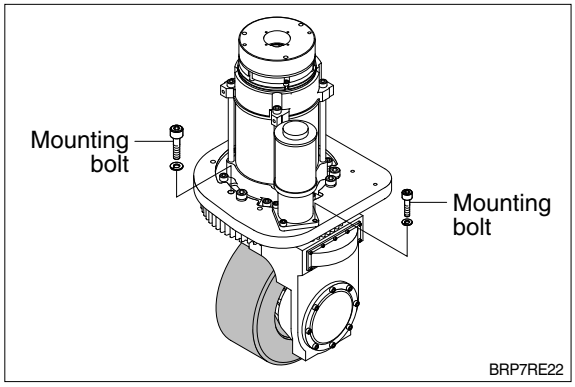
· Tightening torque : 4.0~6.0kgf · m
(28.9~43.4lbf · ft)



(2) DRIVE MOTOR

① Connection bolts between drive motor and drive unit.

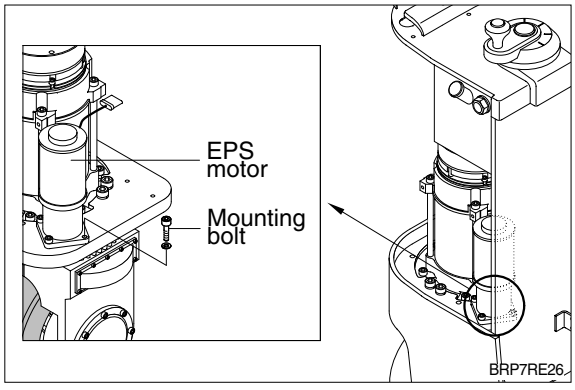
· Tightening torque : 6~8kgf · m
(43.4~57.8lbf · ft)



(3) EPS MOTOR

① EPS motor mounting bolts.

· Tightening torque : 3.0~4.0kgf · m
(21.7~28.9lbf · ft)



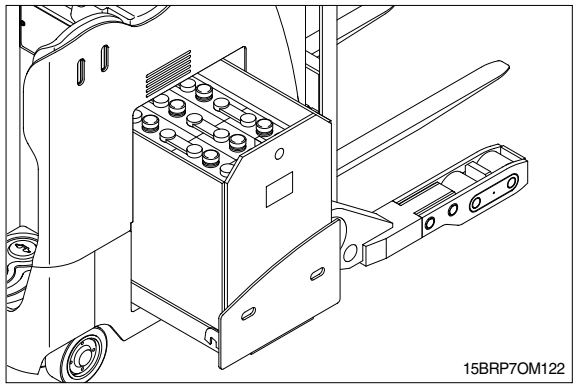
(4) BATTERY INSTALLATION

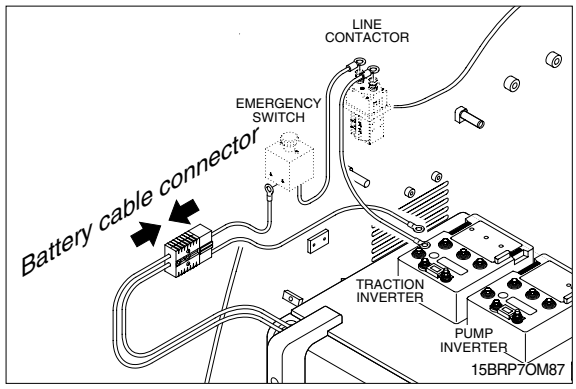
① Using a battery hanger, carefully put the battery assembly compartment push the battery assembly to the frame.

② Adjust the lock screw of side support in frame.

③ Connect the battery connector.

④ Complete installation.





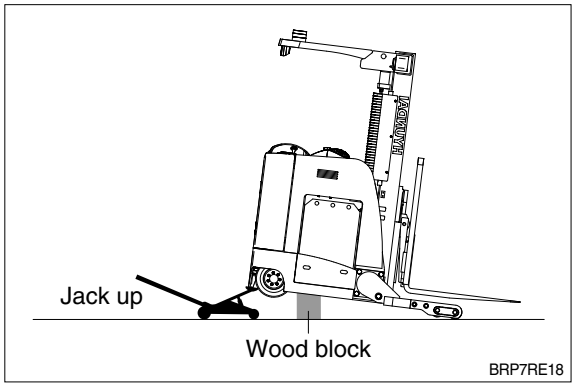
4. TIRE & WHEEL ASSEMBLY

1) REMOVAL

(1) DRIVE TIRE & WHEEL ASSEMBLY

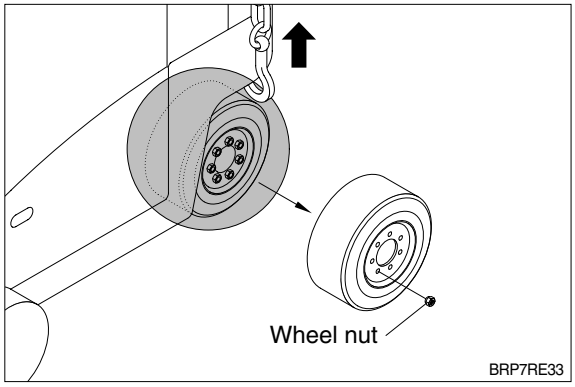
① Lift up the frame

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



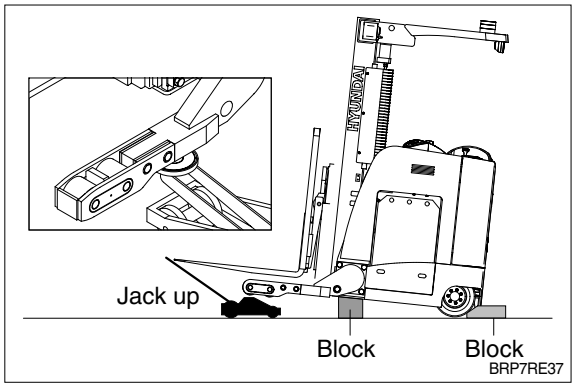
② Remove wheel nuts attaching the drive wheel and take off the drive wheel assembly.

· Wheel nuts : 7EA



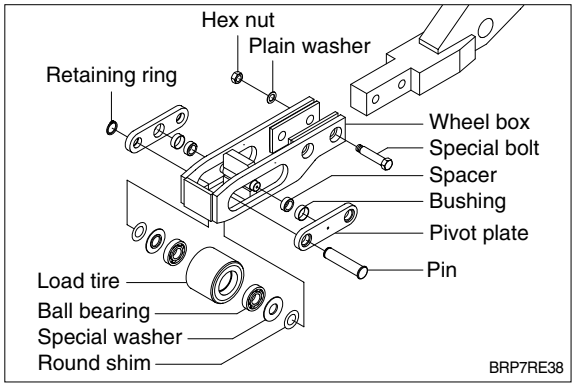
(2) LOAD WHEEL ASSEMBLY

① Lift up wheel box 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.

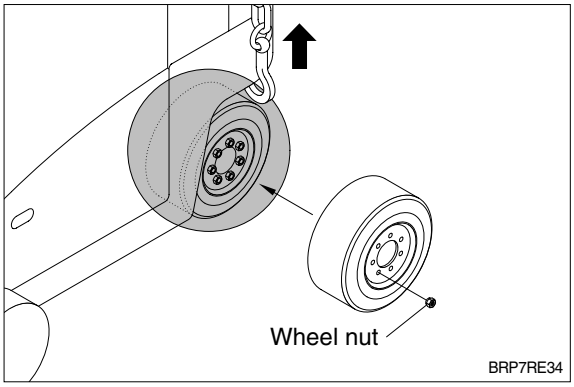


2) INSTALLATION

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

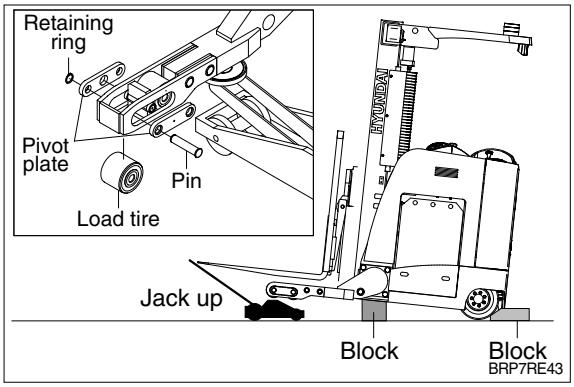
(1) Drive wheel nuts

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



(2) When assembling bearings in the wheel box 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.



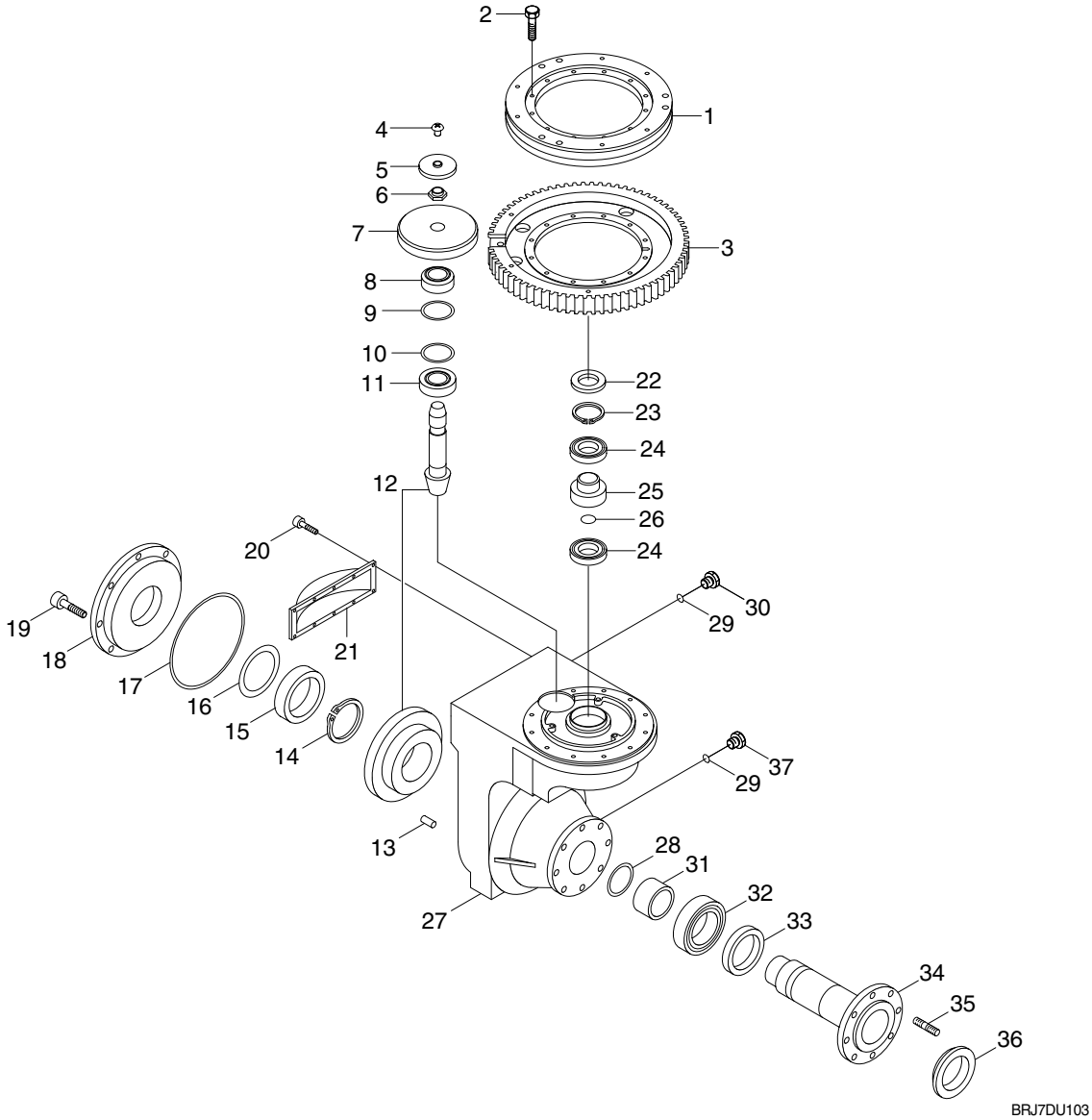
SECTION 3 POWER TRAIN SYSTEM

Group 1 Structure and operation ····· 3-1
Group 2 Troubleshooting ····· 3-3
Group 3 Disassembly and assembly ····· 3-5

GROUP 1 STRUCTURE AND OPERATION

1. DRIVE UNIT

1) STRUCTURE



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

2. SPECIFICATION

Item		Unit	Specification
Gear ratio	Total	-	20.2
Oil Quantity		l	3.3

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
62513	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
62508	Striking mandrel	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 handel	Thread protective shield
63292	Striking mandrel without handel	Shaft seal wheel shaft
62542	Striking mandrel without handel	Bearing outer ring crown gear
63294	Striking mandrel without handel	Bearing inner ring wheel shaft
62749	Striking mandrel	Bearing outer ring cover
63296	Handle	Striking mandrels
62228	Gear lock	Helical gear lock
62222	Pressure oil device	Loosen press fit
223705, 009	Pressure-in sleeve	Bearing inner ring pinion shaft
62746	Striking mandrel	Bearing outer ring pinion shaft top
62846	Striking mandrel	Helical gear on pinion shaft
62828	Measuring fixture	Housing dimension wheel shaft
62231	Measuring fixture	Housing dimension wheel shaft
62829	Measuring fixture	Housing dimension crown shaft
62232	Measuring fixture	Housing dimension crown shaft
222863.2	Extracting fixture	Pulling-off taper roller bearing outer ring
62515	Extracting 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.

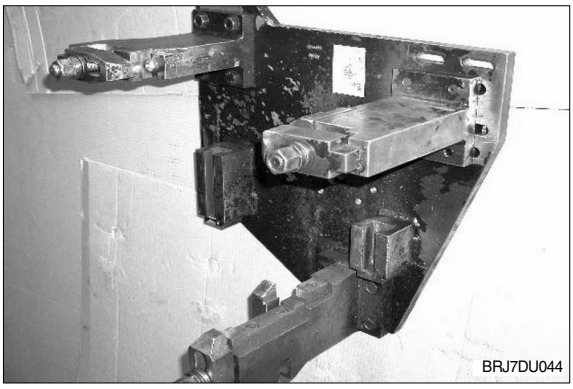
11) Prior to any work on the installed transmission(e.g. oil change) or its mounted-on parts the voltage source feeding the motor must always be disconnected resp. switched off.

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

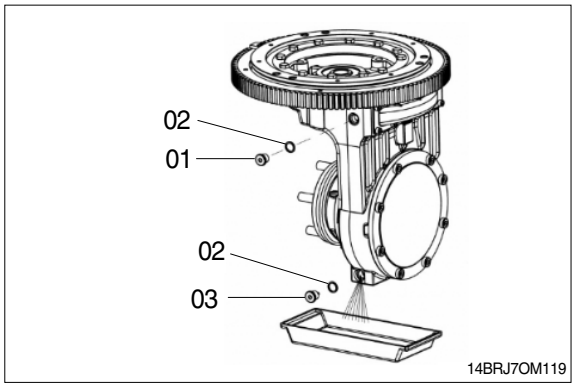


2) DRAIN OFF TRANSMISSION OIL

(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.

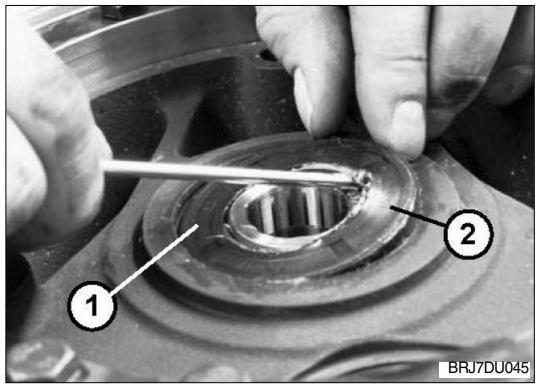
⚠ High oil temperatures are to be expected after continuous operation of the transmission. Wear temperature-resistant gloves.



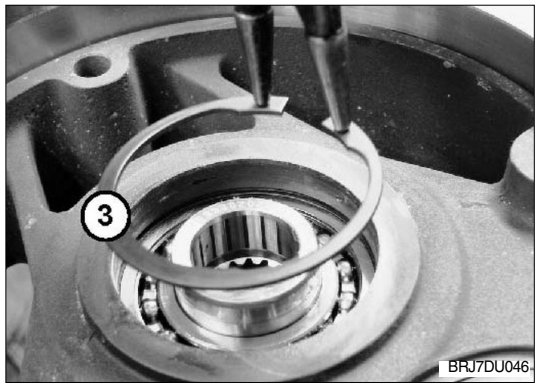
3) REMOVAL OF DRIVE PINION

(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.

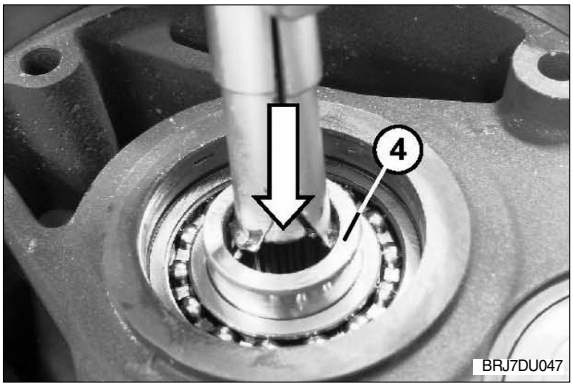


(2) Unsnap and remove the retaining ring (item 3) from the housing bore by means of flat-head pliers.



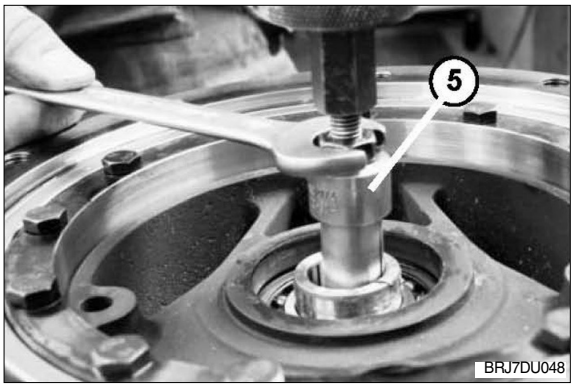
(3) Extracting fixture 225296 is necessary to remove the drive pinion (item 4) from the bore.

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



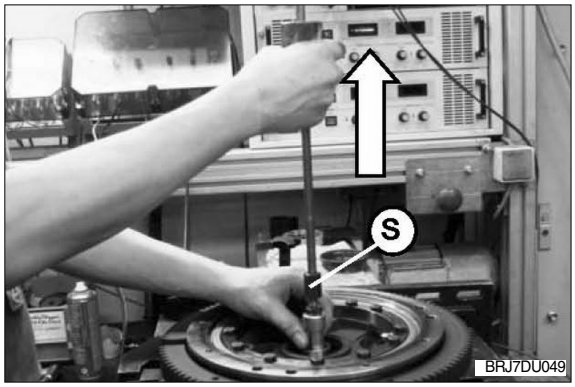
(4) Fasten the hexagon screw of the bearing puller hand-tight so that a sufficient preload of the clamping jaws is given.

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

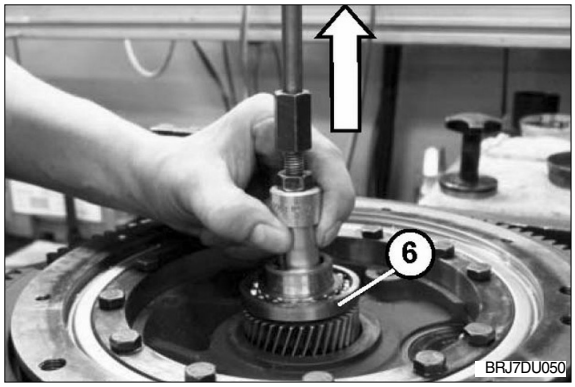


(5) Handle the extracting fixture "S" as shown on the right. Move the handle on the bar upwards strongly several times until the drive pinion is loosened from the bearing seat completely.

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

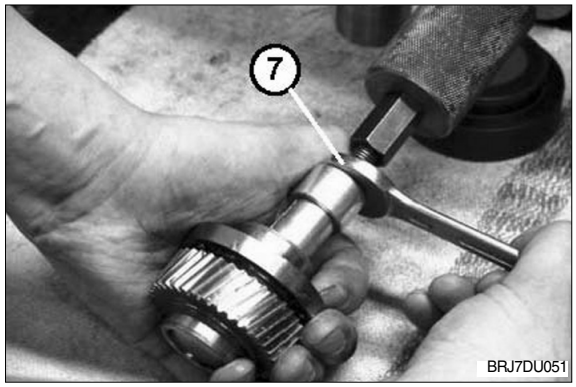


(6) By means of the extracting fixture pull the drive pinion (item 6) out of the housing bore and remove it.

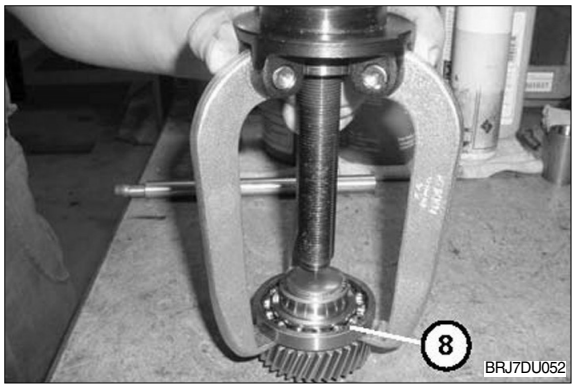


(7) Loosen the hexagon bolt (item 7) and remove the extracting fixture from the drive pinion.

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

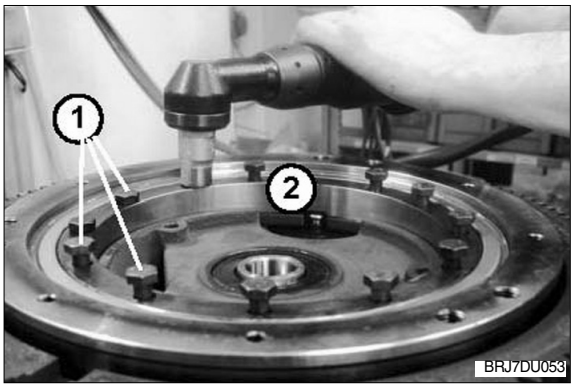


(8) Pull of the grooved ball bearing (item 8) by means of a puller or a parting tool over the bearing seat of the drive pinion and dispose it of according to chapter 6.

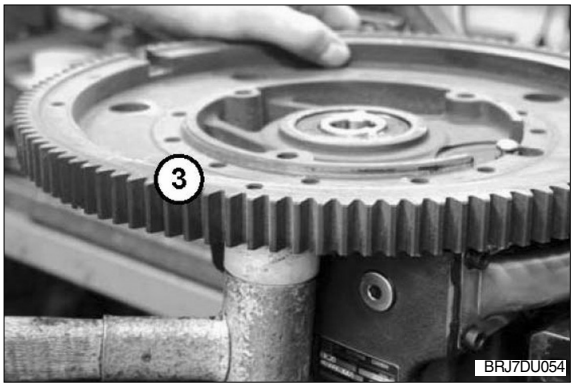


4) REMOVAL OF GEAR RING AND PIVOTED BOGIE BEARING

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

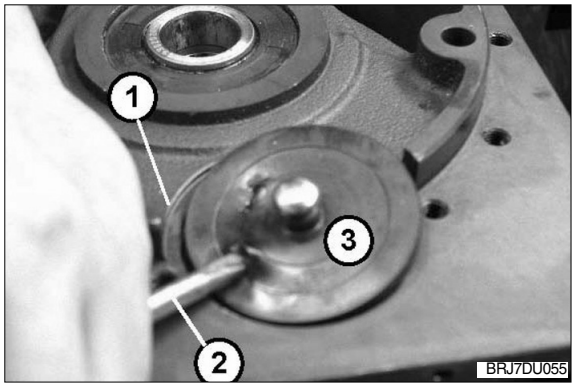


(2) With a dead-blow soft-face hammer slightly beat against the gear ring (item 3) from the bottom to loosen it from the connecting construction. Take off and remove the pivoted bogie bearing and the gear ring.



5) DISASSEMBLY OF TRANSMISSION HOUSING WITH TRANSMISSION COMPONENTS

(1) Removal of sealing cap

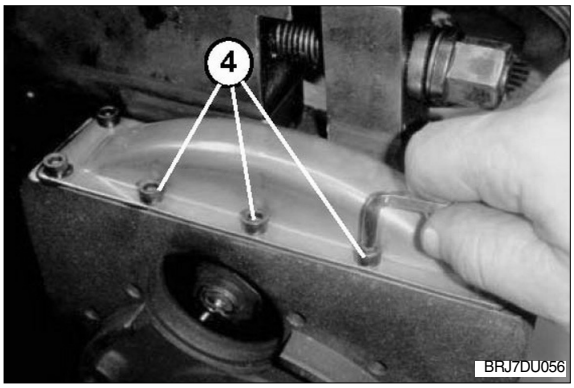


⚠ The surface (item 1) where the sealing cap is located must not be damaged. The sealing cap itself is destroyed and cannot be reused.

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.

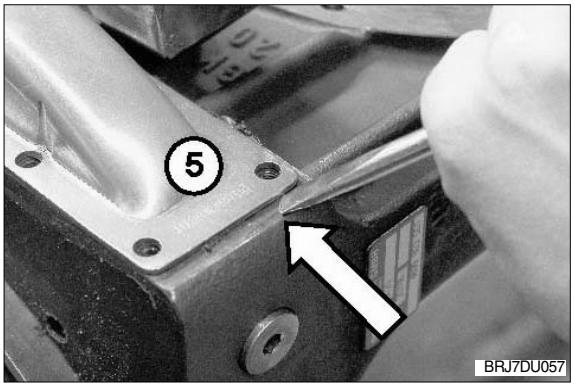
② The breather valve is not to be scrapped.

(2) Removal of side cover



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

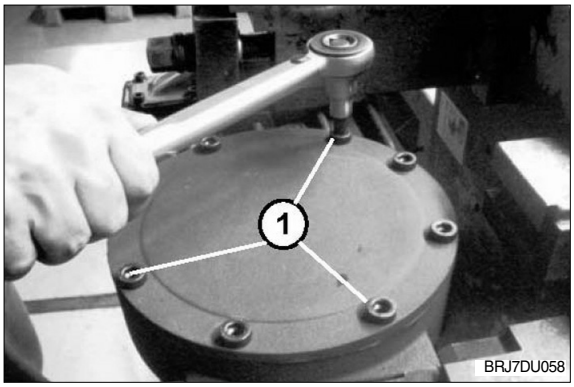
⚠ Do not damage the housing surface at the next working step! Burrs and other damages on the sealing surface which are caused during the removal have to be eliminated. Touch up damaged sealing surface on the housing with an oil stone!



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.

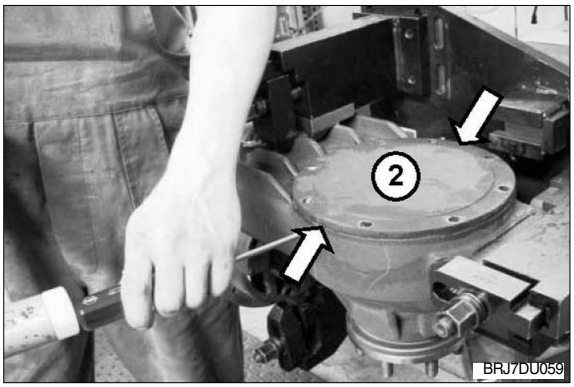
(3) Removal of wheel shaft and crown gear



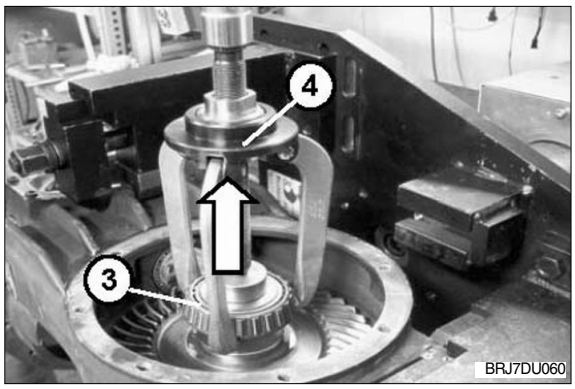
① Loosen and remove the 8 cap screws (item 1) in the housing cover.

⚠ 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!

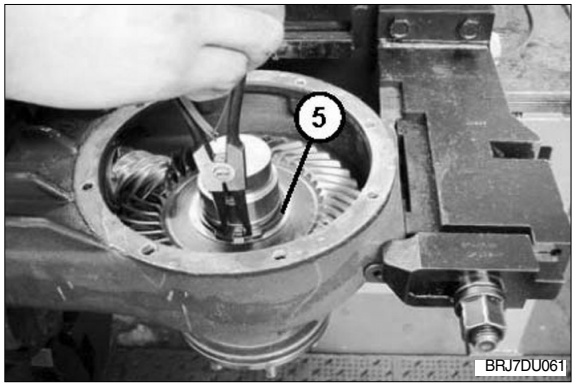
② Loosen the housing cover (item 2) by tapping against the outer edges and remove it. Use the two recesses in the housing.



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.

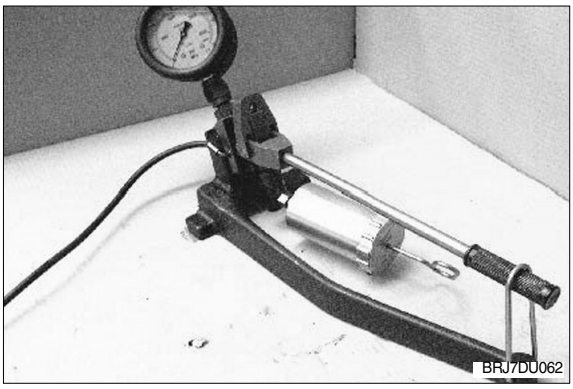


(4) Loosening of taper press fit

※ 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:

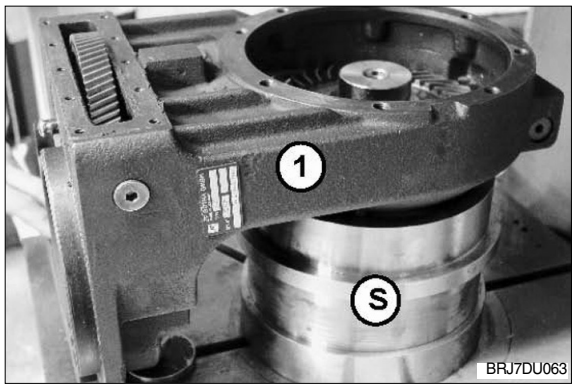
(S) Pressure oil device 62222



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.

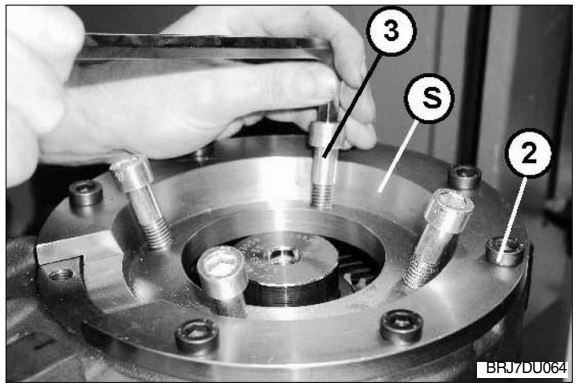
(S) Press-out fixture 63428



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.

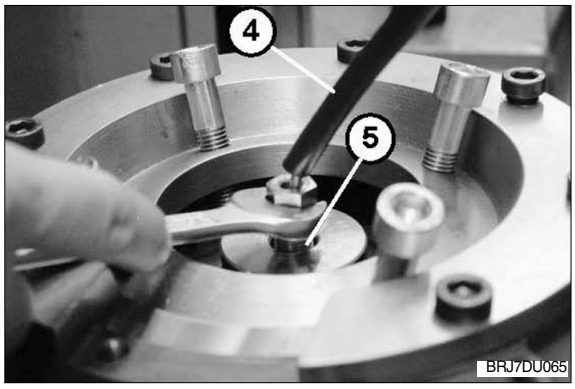
(S) Holding fixture 62513



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).

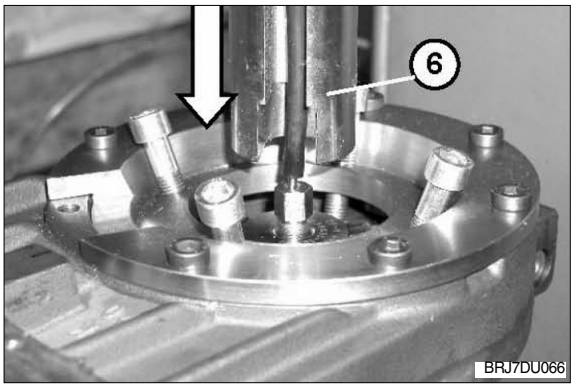
Fixedly tighten the connecting nipple with an open jaw spanner.

⚠ 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.



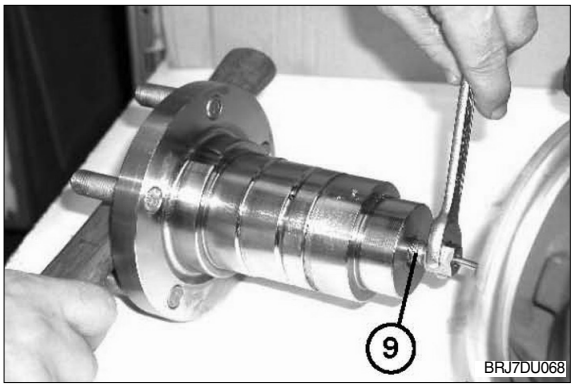
⑤ Mount the stamp (item 6) from the holding fixture (see Figure 64) into the press.

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

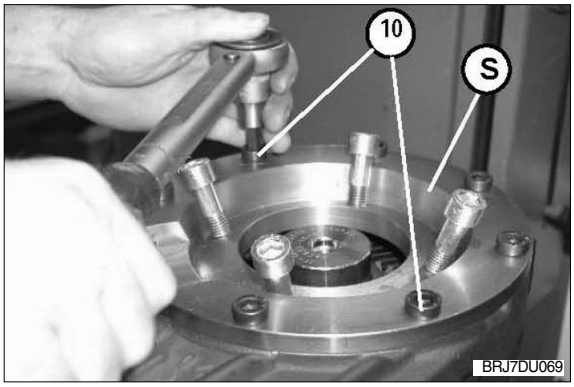


⑥ At the same time also use fixture 62222 to produce the necessary pressure until the wheel shaft is pressed out from the crown gear.

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.

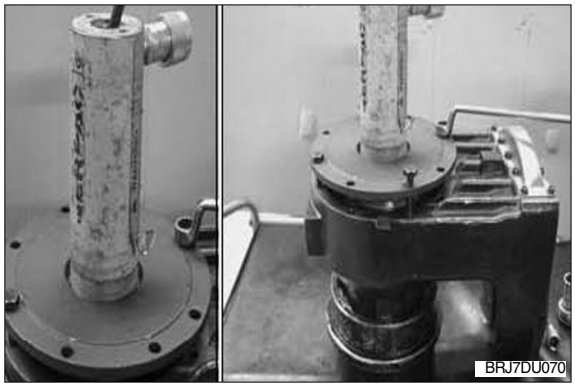


⑨ Pressing-off by means of 2nd hand pump

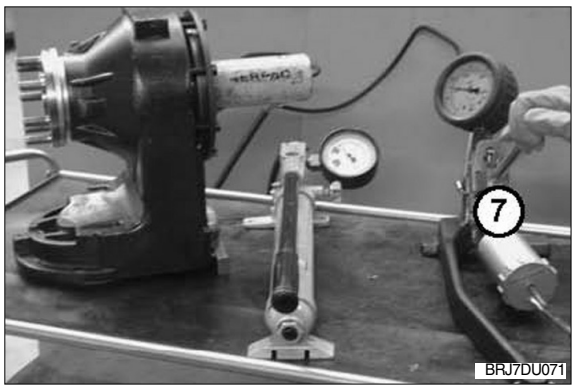
Alternatively the wheel shaft can be pressed off with a second press-out cylinder, e.g. in the mobile area. It is to be proceeded as follows:

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

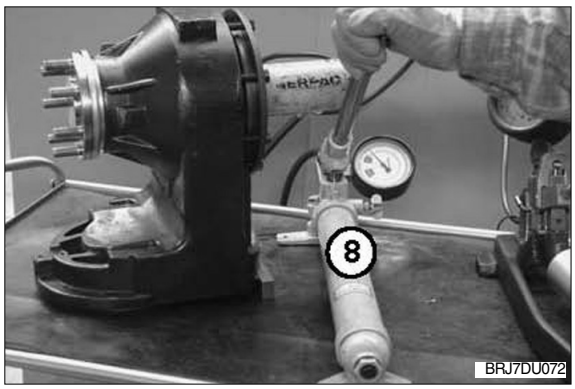
(S) Press-out cylinder 63428



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.

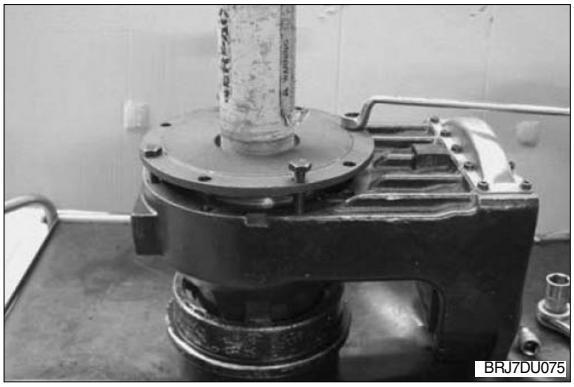


⑫ Take the wheel shaft out of the transmission.

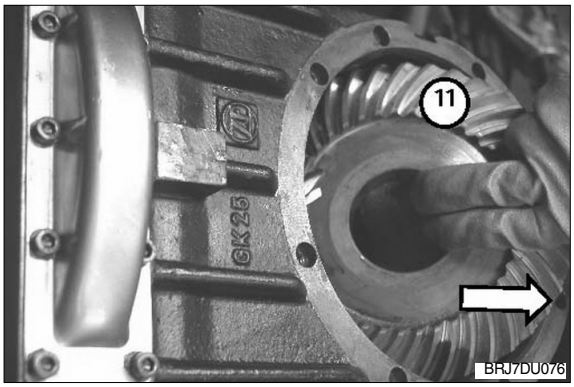
⑬ Unscrew the hydraulic hose from cylinder 1 of the wheel shaft. Wipe off excessive oil.

⑭ Unscrew the dis- and assembly fixture from the transmission

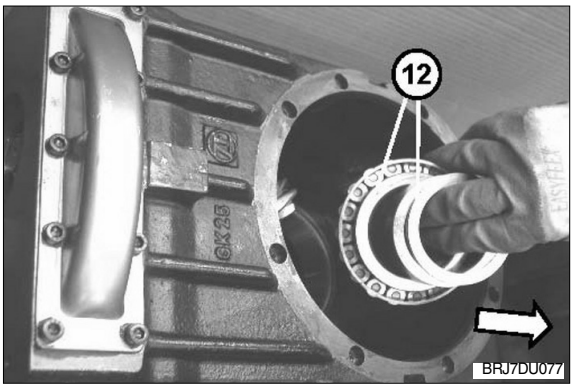
⚠ When the gearing is damaged, running noises and consequential damages might occur, so that the bevel gear set has to be replaced.



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



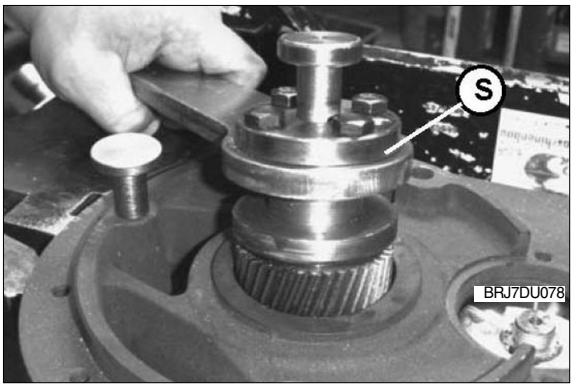
⑯ Then remove the following parts from the housing (item 12) : Shims, spacer ring and taper roller bearing



(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.

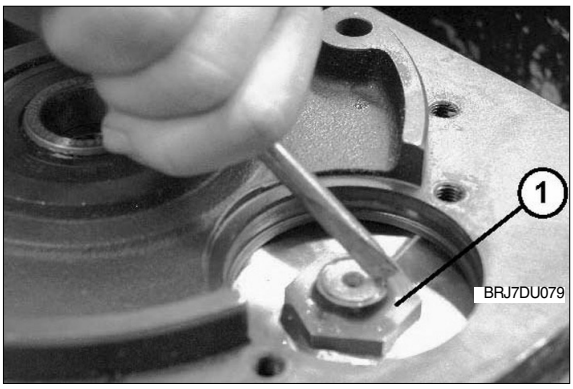
(S) Gear lock 62228



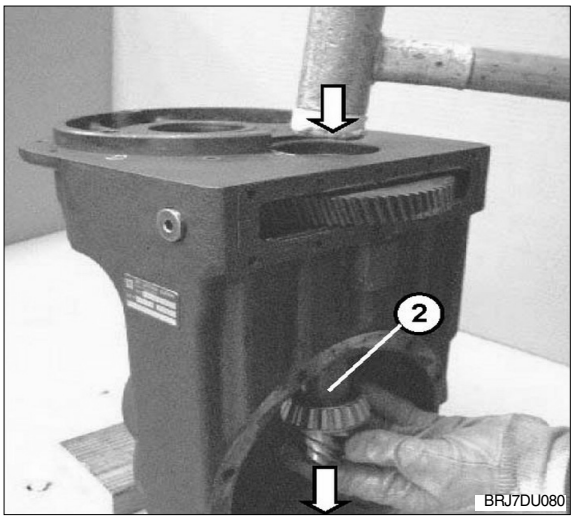
② Unlock the hexagon nut (item 1). Loosen, take off and remove the hexagon nut.

③ Take out and remove the gear lock.

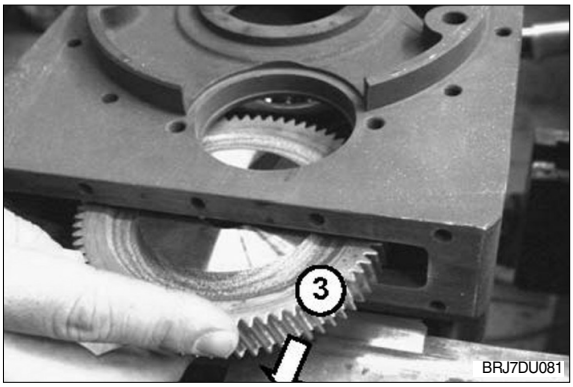
⚠ Pay attention not to damage the bevel pinion shaft when it is expelled in the following procedure.



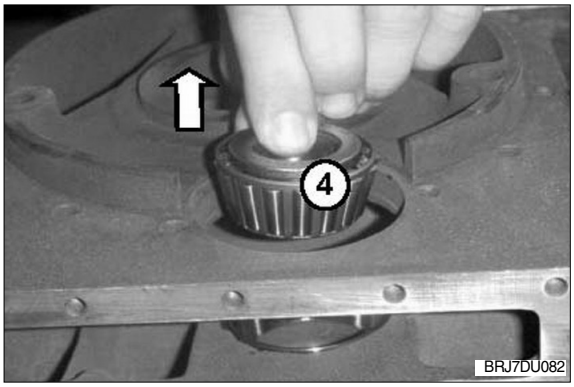
④ By means of a dead-blow soft face hammer expel the bevel pinion shaft (item 2) from the internal gearing and the bearings.



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



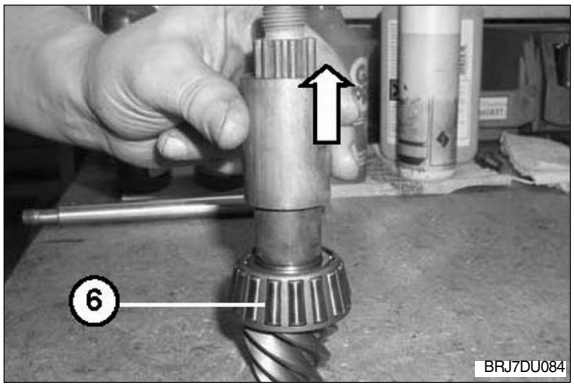
⑥ Take out and remove the taper roller bearing inner ring (item 4) upwards from the bearing bore:



⑦ Pull off and remove the taper roller bearing inner ring (item 6) 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.

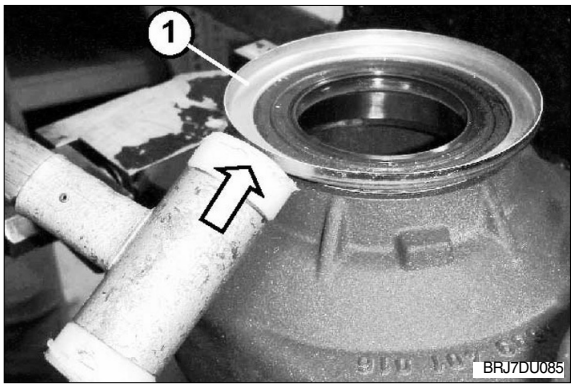
⚠ When the gearing of the bevel pinion shaft is damaged, running noises and consequential damages might occur, so that the bevel gear set has to be replaced.



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

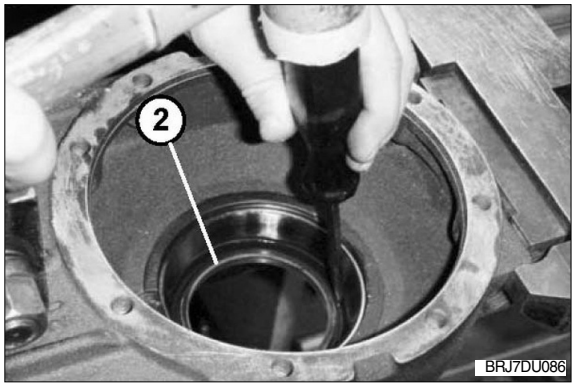
① By means of a hammer remove the thread protective shield (item 1) from the glued joint on the housing.

⚠ 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

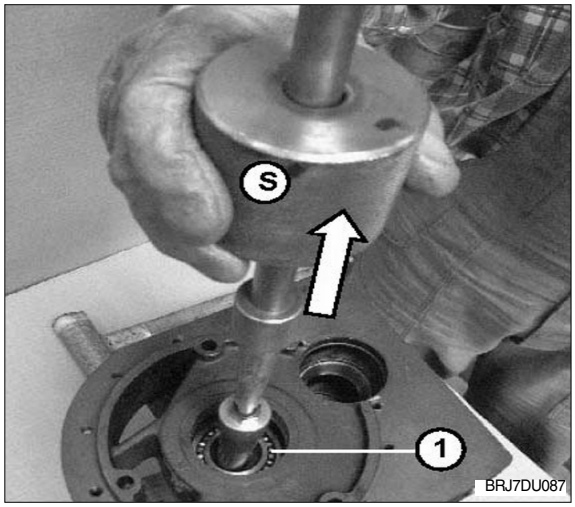
Disassembly bearings drive pinion

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

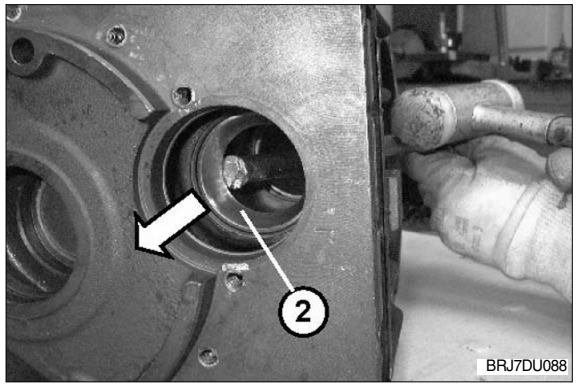
⚠ Upon removal of the bearing outer rings put them to the respective bearing inner ring.



Disassembly bearings bevel pinion shaft

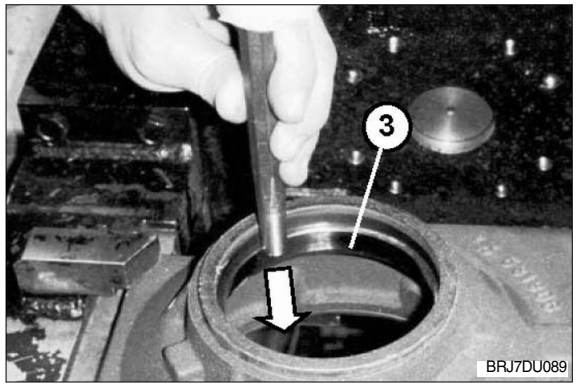
① Expel the outer rings of the taper roller bearings (item 2) on both sides from the housing seat cautiously.

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.



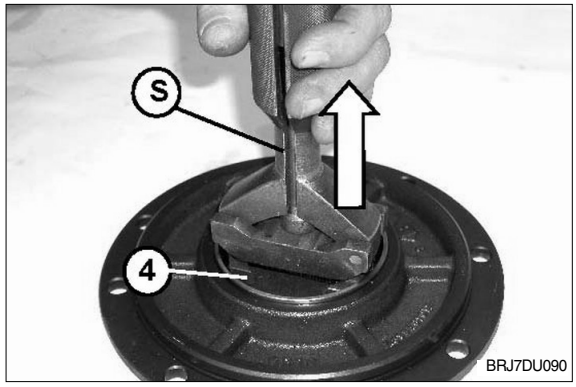
② Pull out and remove the outer ring of the 2nd taper bevel bearing (item 4) with the bearing extracting fixture "S" from the bore of the housing cover.

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
Silicone 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 on 14/16BRJ & 20/25BRJ	K1
Constant on 20/25BRJ	K2
Free constant	a
Shim dimension	Dimension "P"
Bush width on 20/25BRJ	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.

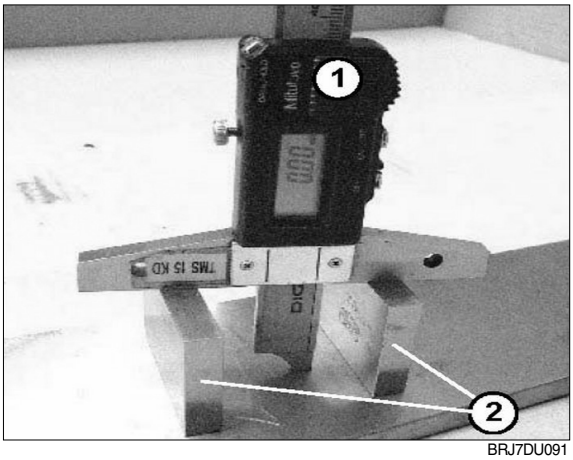
(2) If all of the removed components are to be reused, the original shim thickness has also to be used again.

(3) It 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

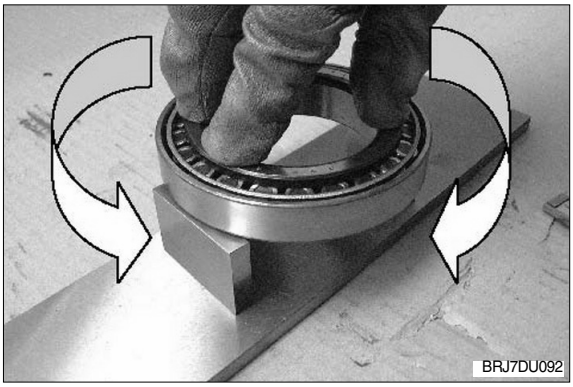
(1) Determination of bearing width general

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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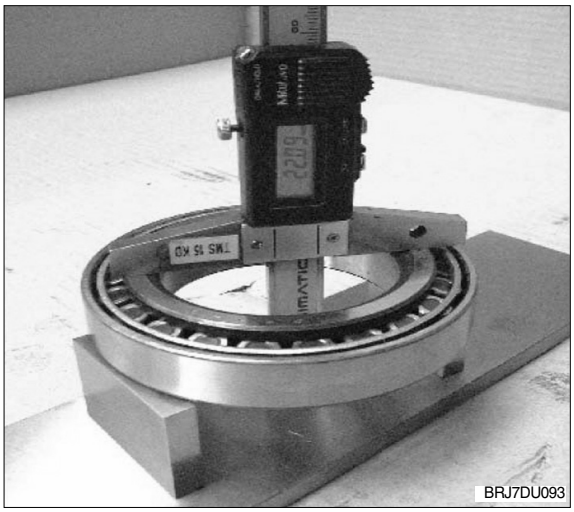
③ Determine dimension "B".
Example : Dimension "B" = 22.09 mm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(2) Determination of bearing difference for the installation of removal shims

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

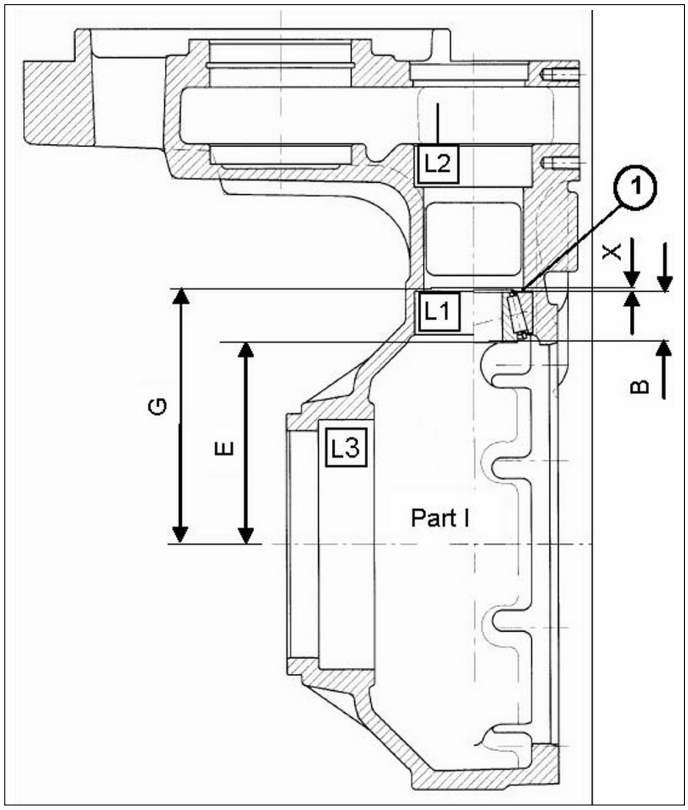
The correct position of the bevel pinion shaft is required for an optimum service life of the transmission.

Thickness of the shim (Item 1) and the correct setting of the bevel pinion shaft respectively will be determined acc. 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 62828



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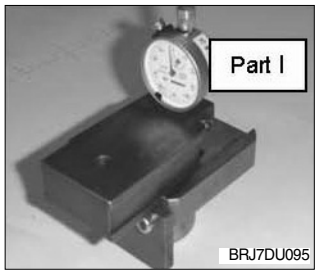
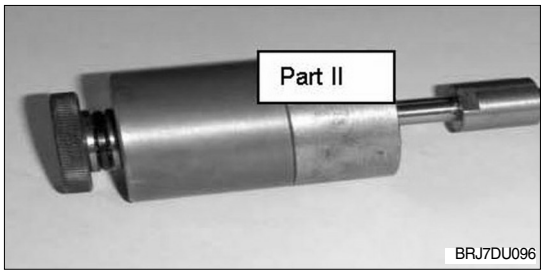
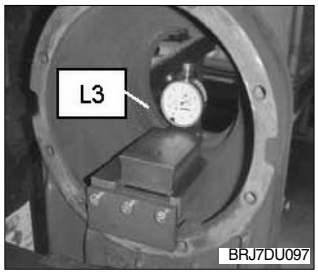






At zero position of the dial gauge the following can be taken as basis:
Dimension "1" = 117.00 mm

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

Example :

Dimension "1"	117.00 mm
Dimension "2"	0.59 mm
Housing dimension "G"	**117.59 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" : 95.00 mm

Calculation example for :

Dimension "**G**"	- 117.59 mm
Dimension "**B**"	- 22.09 mm
Dimension "**E**"	- 95.00 mm

X = G - E - B
X = 117.59 - 95.00 - 22.09 = **0.5 mm**

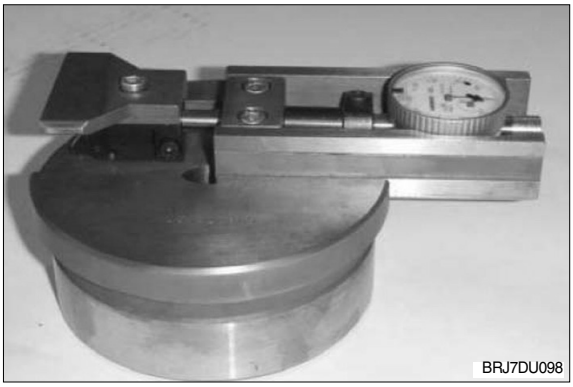
Add shims acc. to thickness X = **0.5 mm.**

(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.

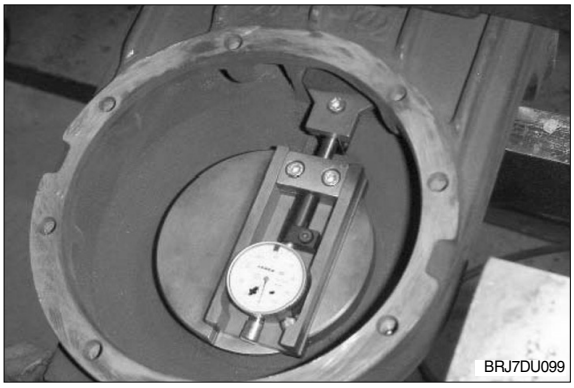
Bearing width "B" for the taper roller bearing on the crown gear can be measured according to chapter 5) at page 3-25 "Determination of bearing width and difference of a taper roller bearing".

Thickness of the shim and the correct setting of the crown gear respectively will be determined acc. to the following method :


BRJ7DU098

① Put the measuring fixture into the housing bearing bore L3 until contact is obtained (see Figure 101).
(S) Measuring fixture 62232

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" = 110.50 mm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Determine Dimension "4" in housing bearing bore L2 and add it to the respective Dimension "3".

Example:

Dimension "3"	110.50 mm
Dimension "4"	0.01 mm
Housing dimension "G"	110.51 mm

By means of the equation:

X = G – E – B – H – K2

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

Example :

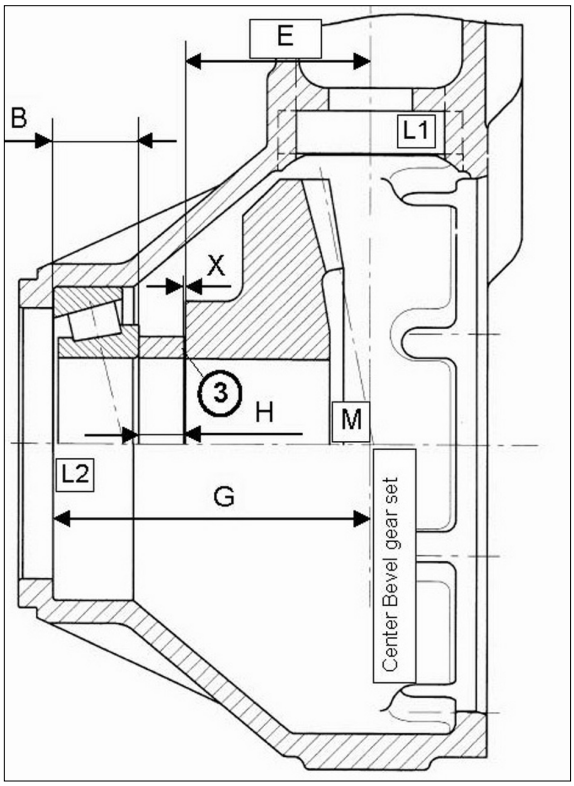
Dimension "G"	110.51 mm
Dimension "B"	29.85 mm
Dimension "H"	15.69 mm
Dimension "E"	64.50 mm
Dimension "K2"	0.13 mm

X = G – E – B – H – K2

X = 110.51–64.50–29.85–15.69–0.13

= **0.34 mm**

Schematic sketch



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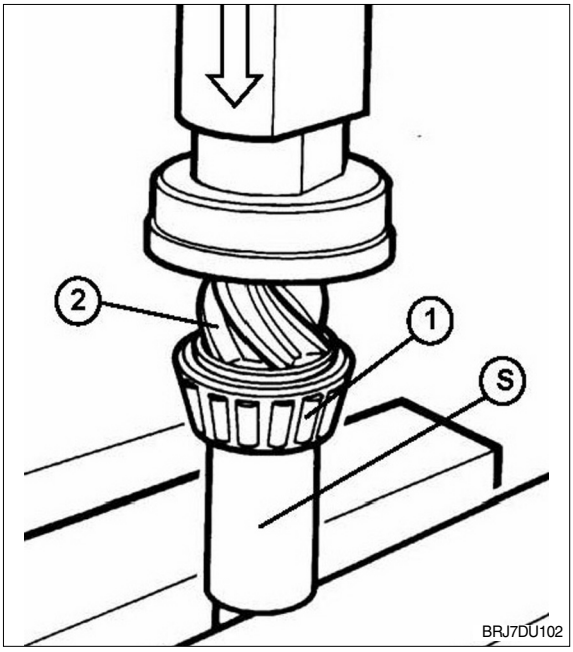
7) INSTALLATION OF BEARING FOR BEVEL PINION SHAFT AND EXACT SETTING OF THE BEARING PRELOAD

(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.

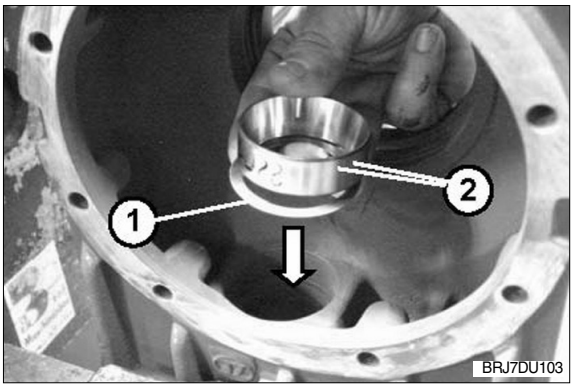
⚠ Pay attention to the gearing when the bearing of the bevel pinion shaft is installed. In case of damage, noise problems can be caused later.
(S) Press-in sleeve 223705.009



(2) Installation of bearing outer ring into the housing

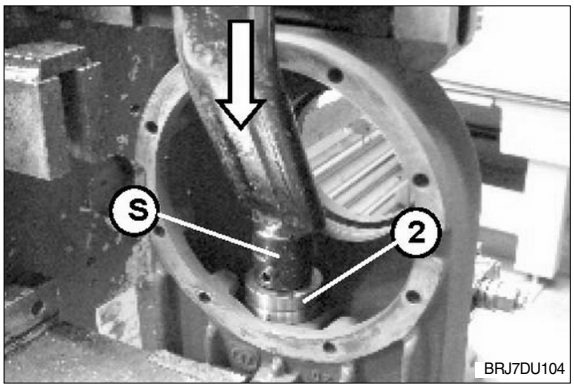
① Prepare the shim thickness determined according to chapter (1) at page 3-26 "Determination of the necessary shim thickness for the exact installation dimension setting of the bevel pinion shaft" by means of the differently thick shims.

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



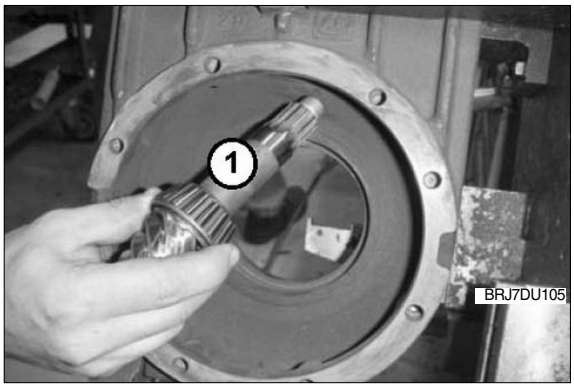
③ By means of striking mandrel "S" install the shim (s) and the bearing outer ring into the bearing seat of the housing until contact is obtained.

⚠ 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 62508

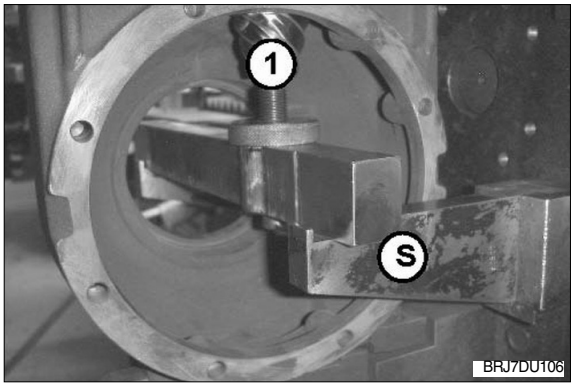


(3) Calculation of distance dimension between collar bevel pinion shaft and housing

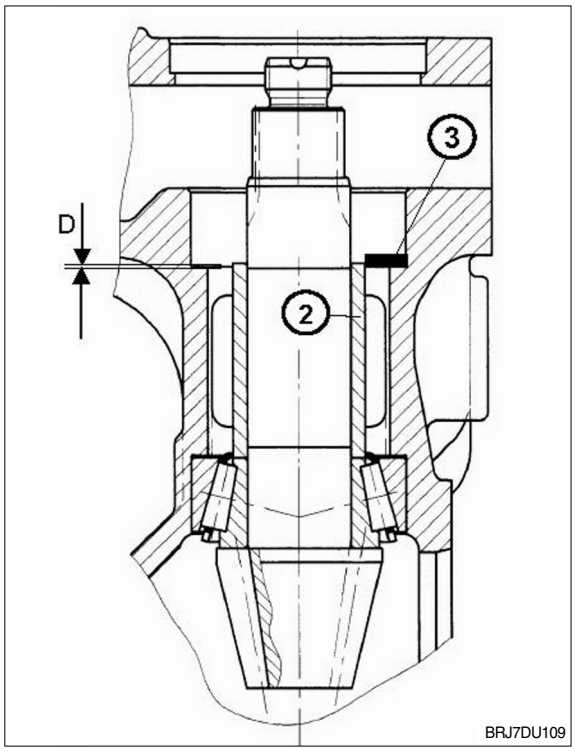
① Install the preassembled bevel pinion shaft (item 1)
from the bottom into the housing.



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

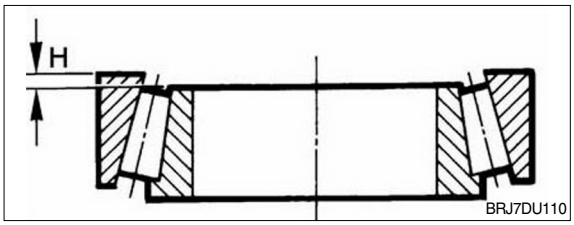


Determine distance dimension "D" by means of depth gauge from the collar of the bevel pinion shaft to contact of the bearing outer ring in the housing.
(item 3 is the required shim thickness)



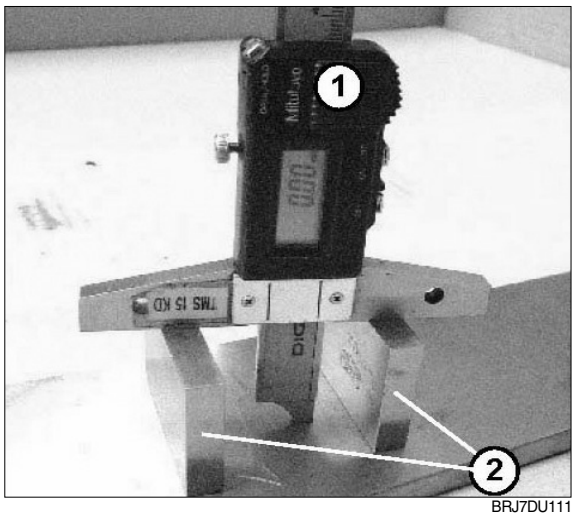
(4) Determination of bearing slack of the taper roller bearing

① Arrow gap = Bearing slack H

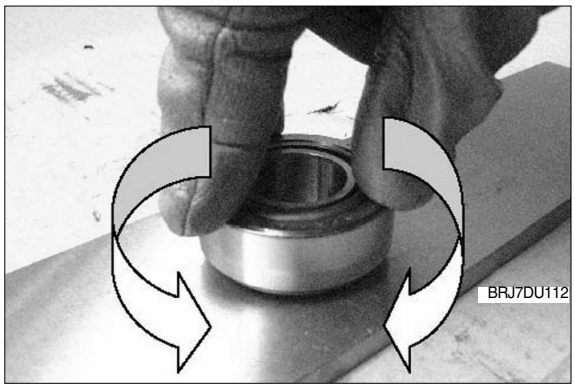


Measure the bearing slack "H" with a measuring fixture and gauge blocks/measuring ledge in the following steps :

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

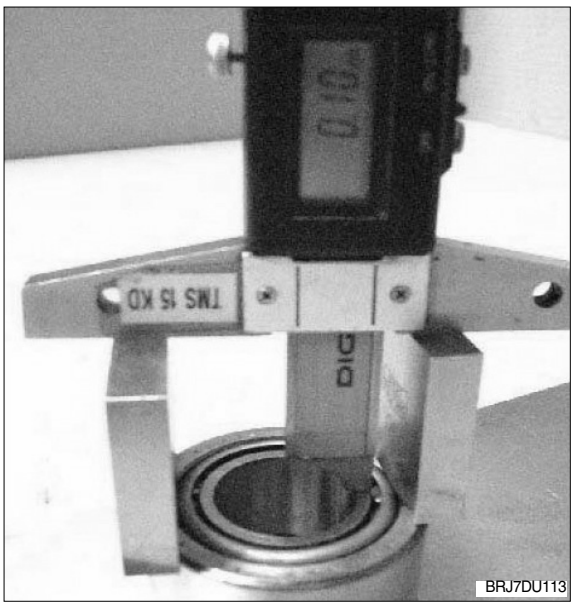


③ Rolling-in of bearing.



④ Measuring of bearing slack H.

Example : Dimension "H" = 0.10 mm



(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 109) can be calculated, i.e. with

Dimension "D" Distance from collar of bevel pinion shaft
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

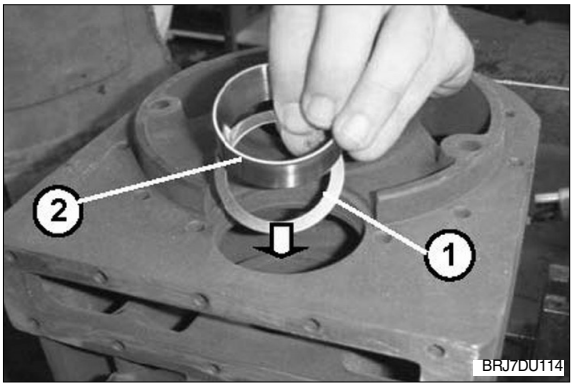
X = 0.7 – 0.10 – 0.04 = 0.56 mm

Add shims corresponding to thickness X = 0.56 mm.

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

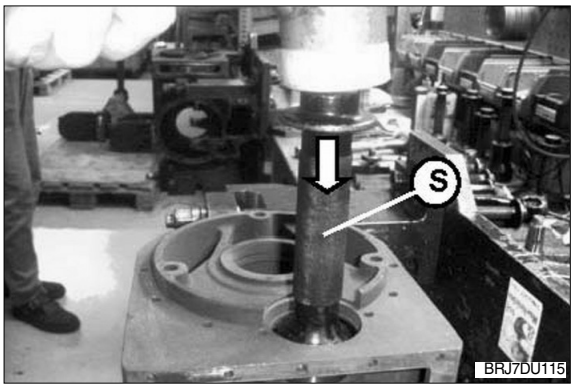
Prepare the shim thickness determined according to chapter (5) above "Calculation of shims required for upper bevel pinion shaft bearing" by means of the differently thick shims and continue the installation as follows:

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

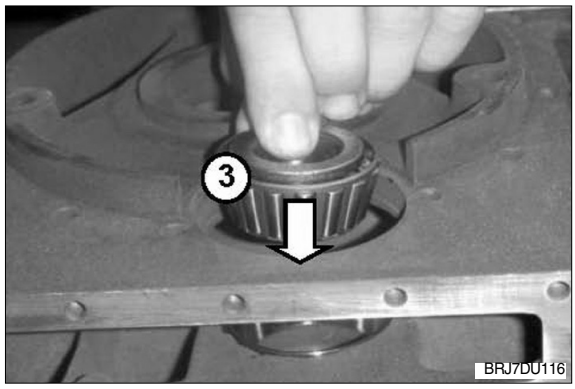


② By means of striking mandrel "S" install the shim(s) and the bearing outer ring into the bearing seat of the housing until contact is obtained.

⚠ 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 62746



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

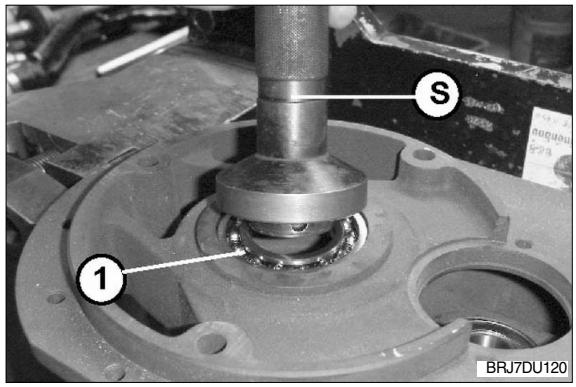


(1) Installation of grooved ball bearing for drive pinion

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

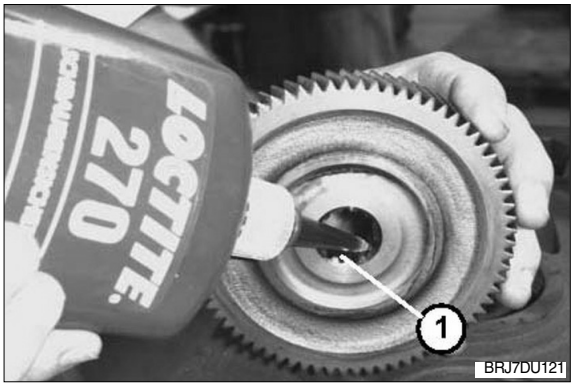
⚠ Prior to installation of the helical gear the lower grooved ball bearing has to be installed into the housing bearing bore.



(2) Installation of helical gear with bevel pinion shaft

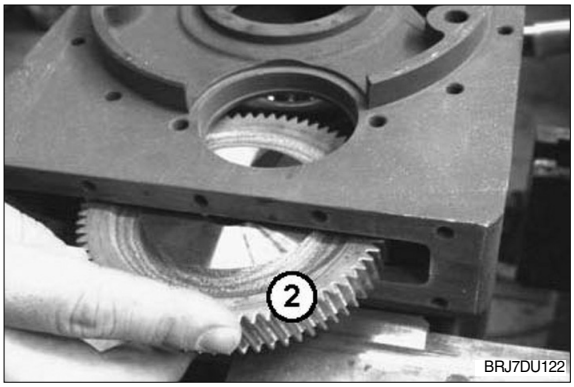
① Apply a thin and even layer of LOCTITE 270 onto the internal gearing of the helical gear (item 1).

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

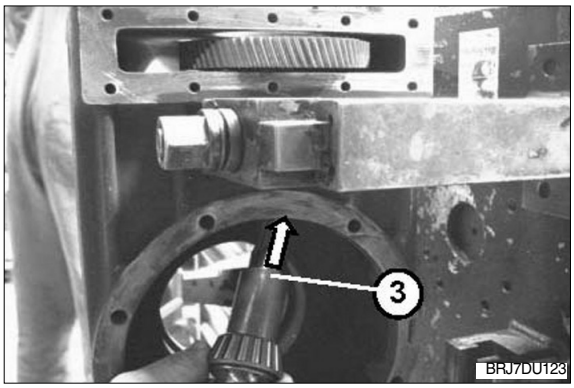


② Insert the helical gear (item 2) by the lateral opening of the housing, align it centrally and put it onto the taper roller bearing.

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

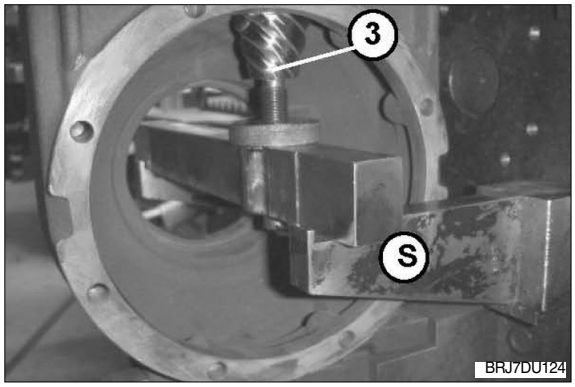


③ Install the bevel pinion shaft from the bottom into the housing and assemble is through the profiled seat of the helical gear bore.



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

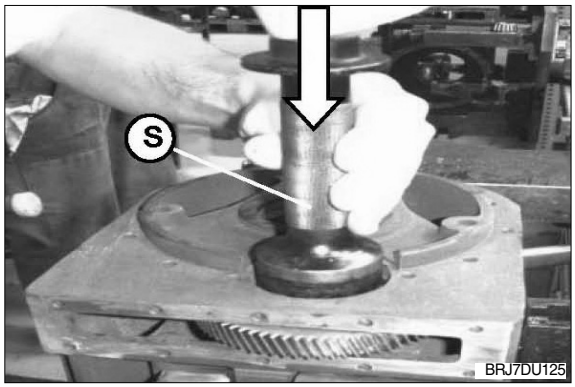
(S) Counter holder 62507-1



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 and shims are located exactly!

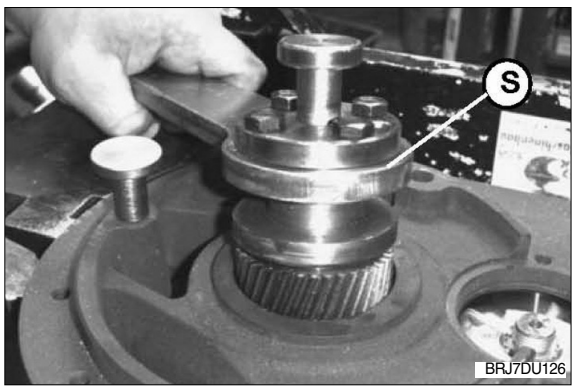
⑥ When all components are located tightly the counter holder can be removed again.

(S) Striking mandrel 62846



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

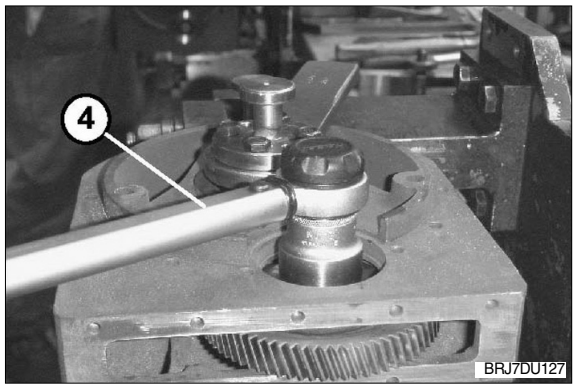
(S) Gear lock 62228



⑧ Place the hexagon nut and M20 × 1.5 onto the bevel pinion shaft and tighten it with a torque spanner (item 4).

・Tightening torque : 150 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.



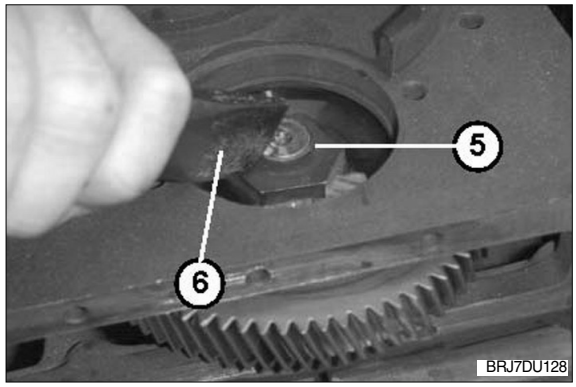
⑨ Turn the bevel pinion shaft and the helical gear respectively by hand several times, that the taper rollers can align in the bearing rings.

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!

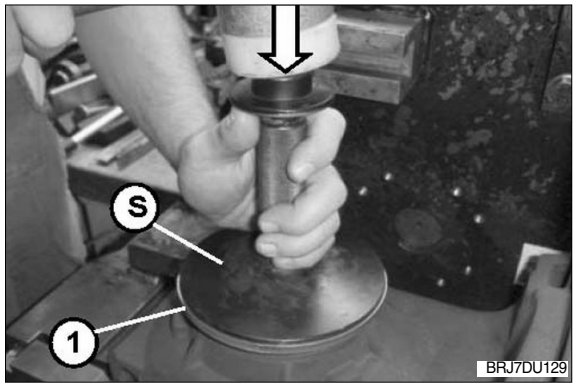


9) INSTALLATION OF CROWN GEAR AND WHEEL SHAFT INTO THE HOUSING

(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



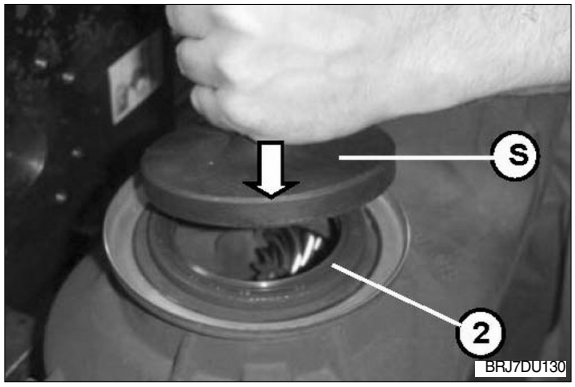
② Apply a thin and even layer of LOCTITE 574 onto the outer diameter of the radial sealing ring.

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.

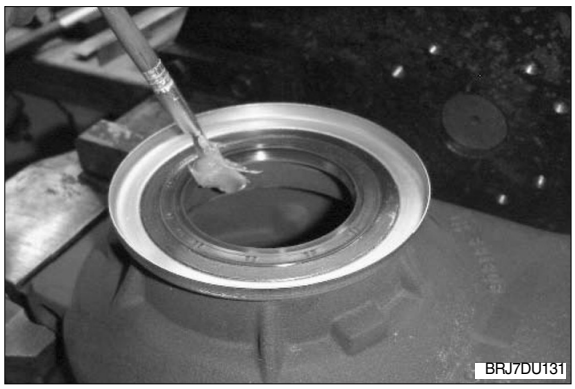
(S) Striking mandrel 63292

⚠ 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.



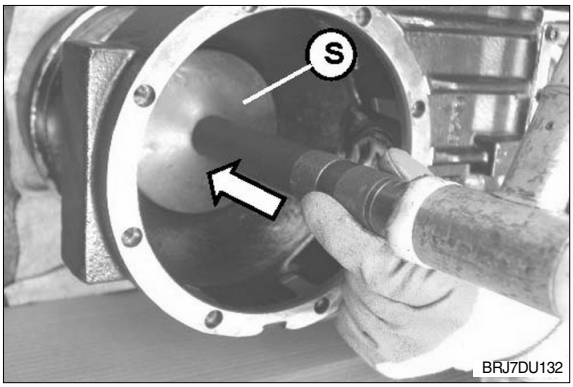
③ Wet the sealing lip of the radial sealing ring with grease (e.g. Shell Alvania R3) slightly.



(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

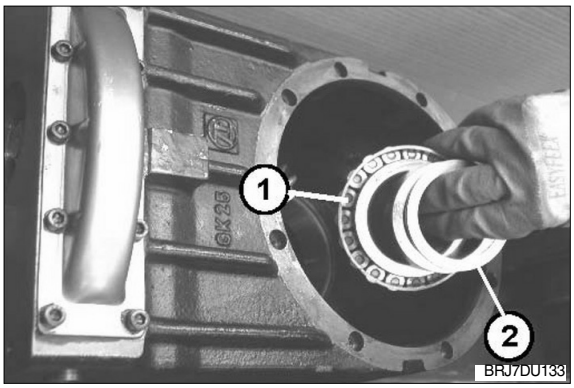


② Insert the bearing inner ring (item 1) into the outer ring of the taper roller bearing.

③ Insert the bush into the housing.

④ Prepare the shim thickness (thickness X) with the differently thick shims as determined in Chapter 7) (5) at page 3-34 "Calculation of shims required for upper bevel pinion shaft bearing".

⑤ Insert shim(s) (item 2).



(3) Determination of control dimension for seat

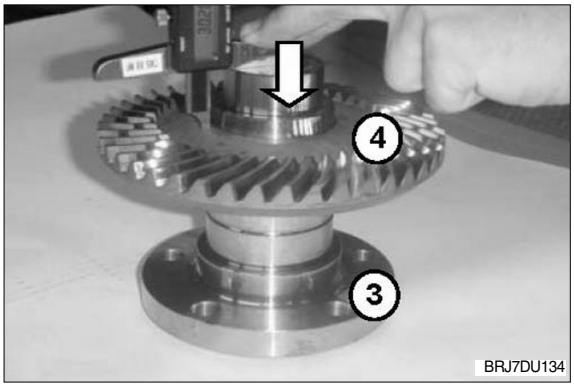
① Place the wheel shaft (item 3) onto a plane and solid support. Mount the crown gear (item 4) onto the taper seat of the wheel shaft by hand cautiously and press it on slightly.

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

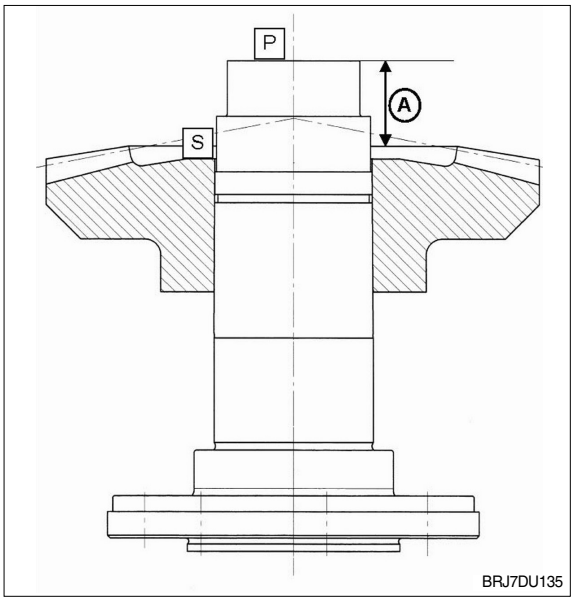
Dimension "A" e.g. 30.85 mm

⚠ 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.

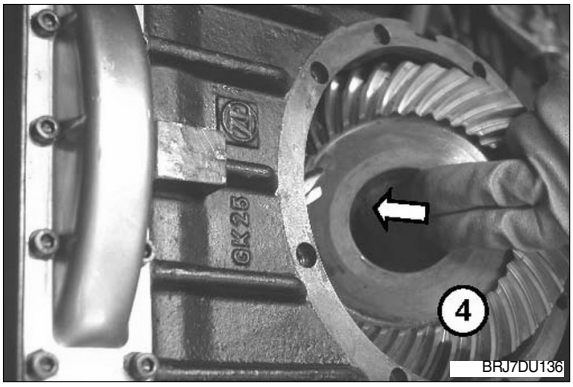


⚠ Pay attention not to damage the gearing, when the crown gear is assembled.



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 bush.

② Center the taper roller bearing inner ring, shims, crown gear.

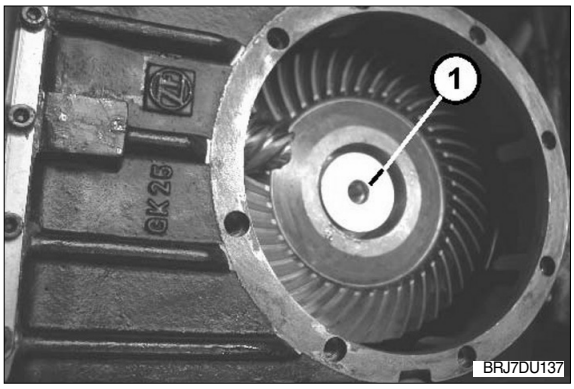


(4) Pressing-on wheel shaft

⚠ 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.

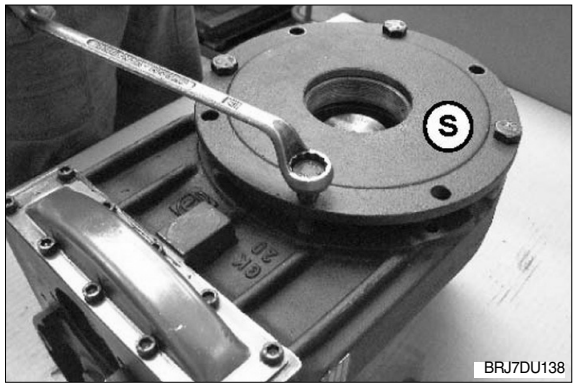
Press-on force: 250 kN up to max. 300 kN.

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



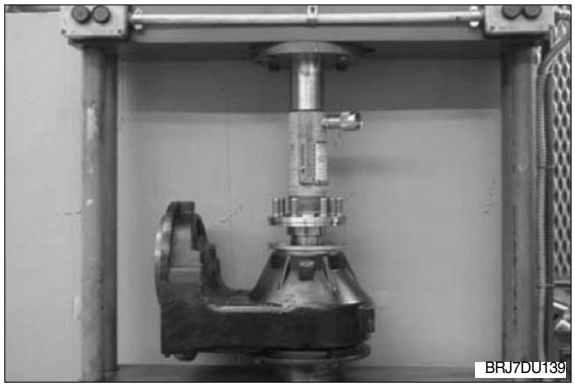
② Screw on the press-on fixture (S).

(S) Press-on fixture 63428



③ Press the wheel shaft onto the crown gear.
During this procedure the shim(s), the taper roller bearing inner ring and the bush 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.

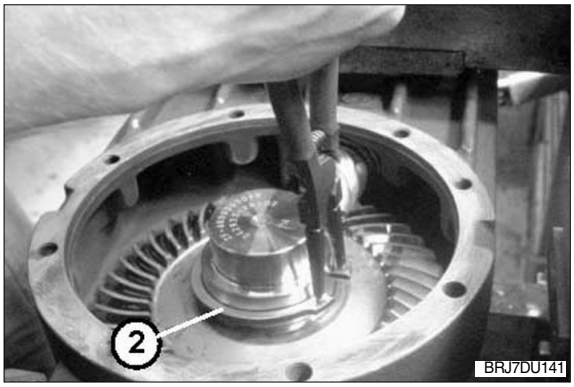
① Measure Dimension A from plane face/wheel shaft to face/crown gear once again (see chapter 9) (3) at page 3-39 “Determination of control dimension for seat“).

Dimension "A" e.g. 44.34 mm

Example:
Dimension "A" after pressing-on 44.34 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.

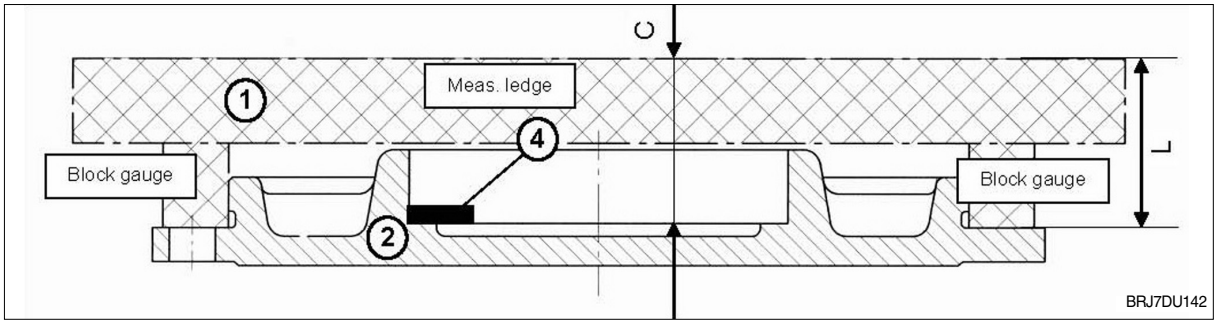
② Install the retaining ring (item 2).



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

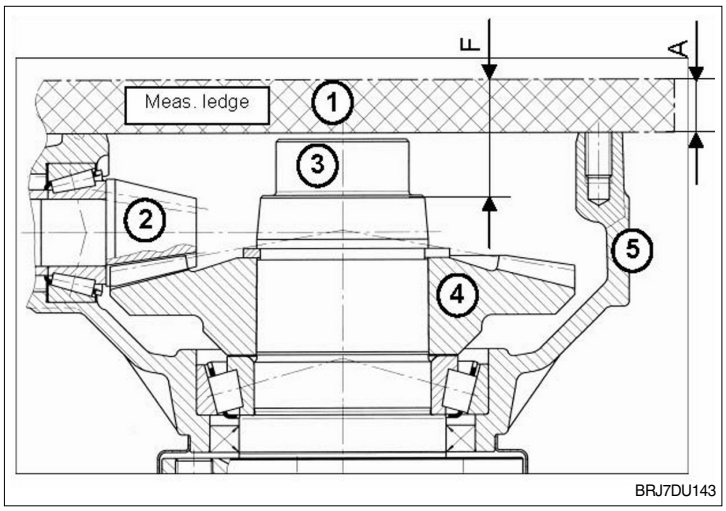
1 Measuring ledge
2 Bevel pinion shaft
3 Wheel shaft
4 Crown gear
5 Housing

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 for :

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 $X1 \leq 0.30$

$$X = X1 + a$$

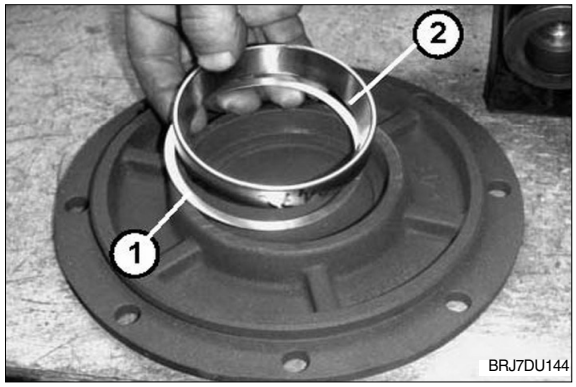
$$X = 0.31 + 0.20 \text{ mm} = 0.51$$

Add shims according to thickness X.

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

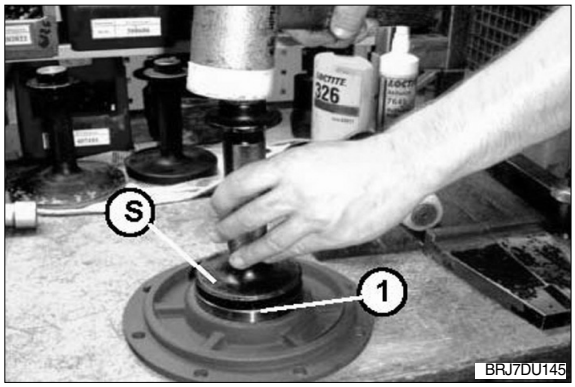
① Prepare the shim thickness determined under chapter (2) above "Calculation of shim required" by means of the differently thick shims.

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



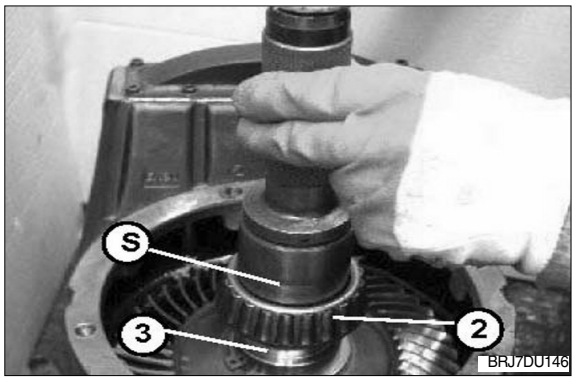
③ By means of striking mandrel "S" drive shim(s) and bearing outer ring (item 1) into the bearing seat of the housing cover until contact is obtained.

(S) Striking mandrel 62749



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.

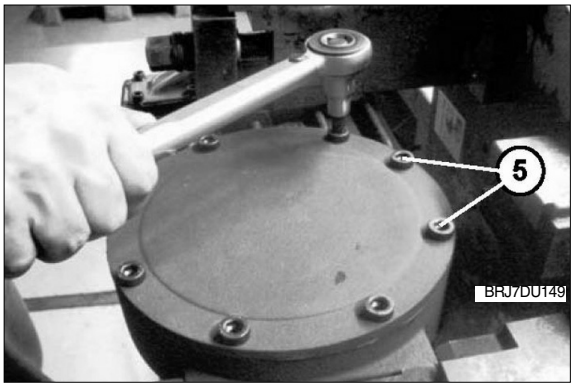
② Plane face for housing cover on the housing is to be cleaned carefully and must be grease-free.

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

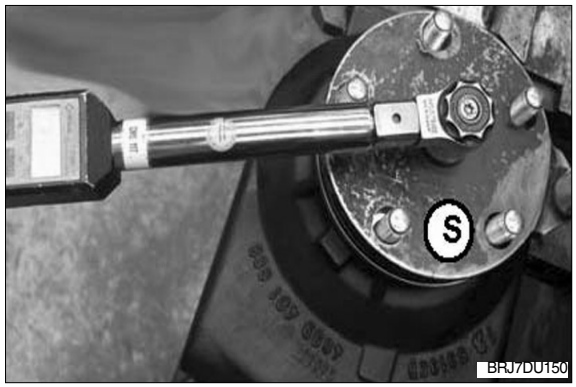
④ Place the housing cover cautiously and install it slightly tapping with a dead-blow soft face hammer until contact is obtained.

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.

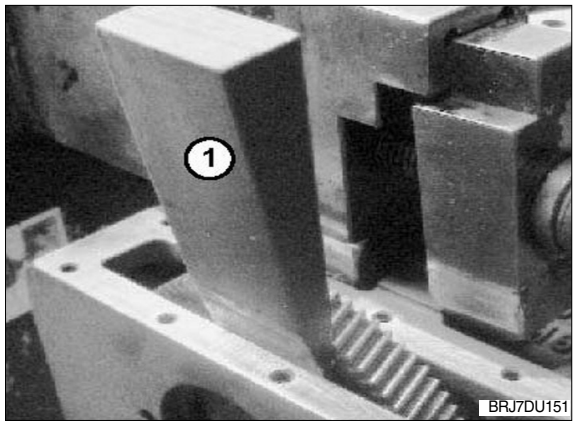
(S) : Measuring fixture 62515

Bearing preload is adjusted correctly when a bearing friction torque of 8.0 ~ 22 Nm is obtained at the wheel shaft.

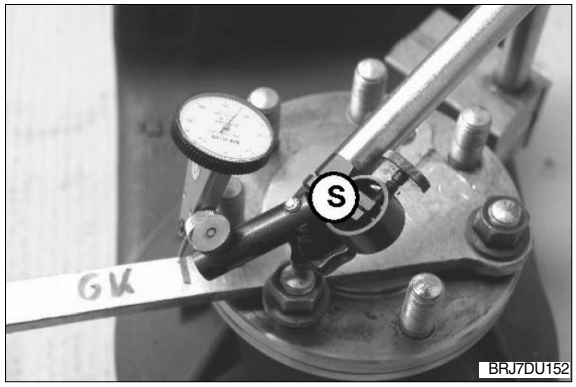
If this value is not reached the working steps from Chapter 10) (2) have to be repeated. The cover has to be removed again.
If the measured value is greater than the above mentioned value, the shim thickness of value "X" in "Chapter 10) (2) calculation of shim required" has to be reduced.

If the measured value is smaller than the above mentioned, the shim thickness of value "X" in "Chapter 10) (2) at page 3-44 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:
0.13 ~ 0.18 mm

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.

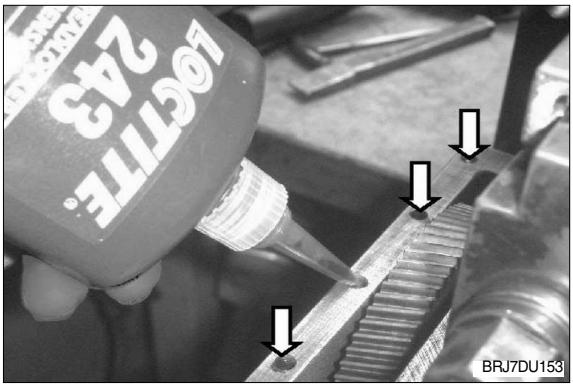
(7) Installation of side cover

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.

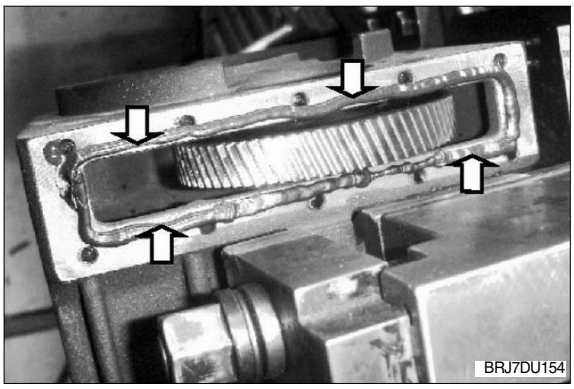
⚠ Wear safety gloves for working with adhesives and observe the LOCTITE instructions.

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

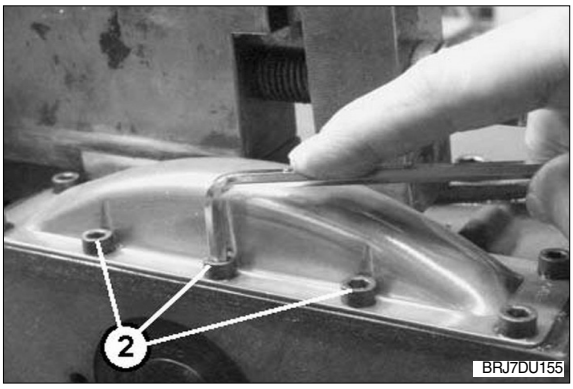
① For sealing of the through holes as well as of the area around the screw the following sealing application is required:
LOCTITE 243 : Product application into the threaded blind holes M6 as sealing function by excess product.



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.

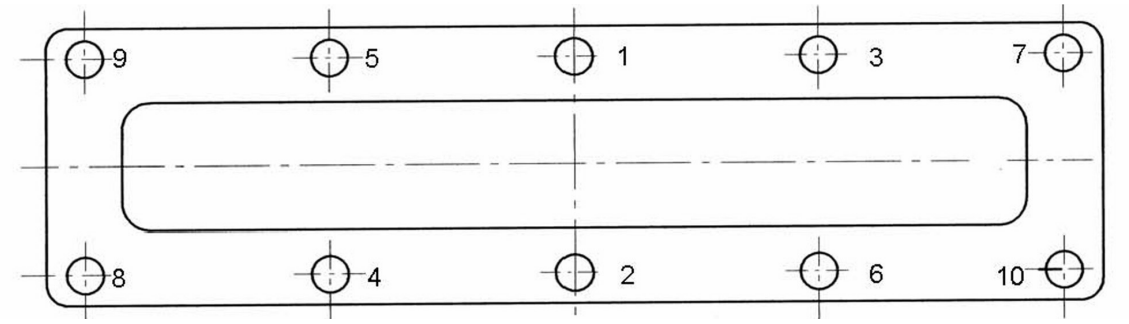


⚠ Do not yet tighten the cap screws with the corresponding tightening torque.

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

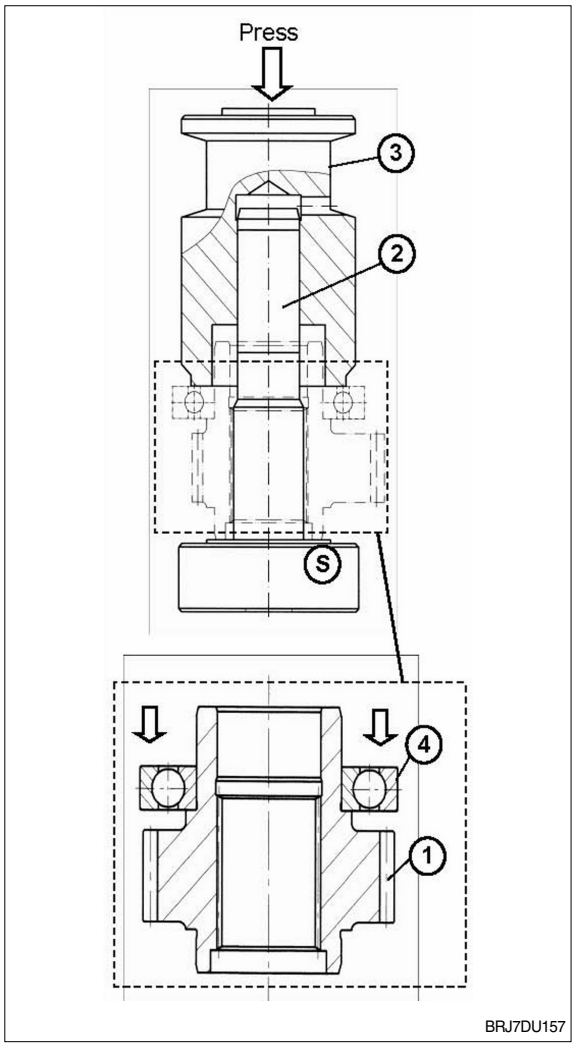
① For mounting of the bearing onto the drive pinion use assembly fixture "S", as shown.

(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.

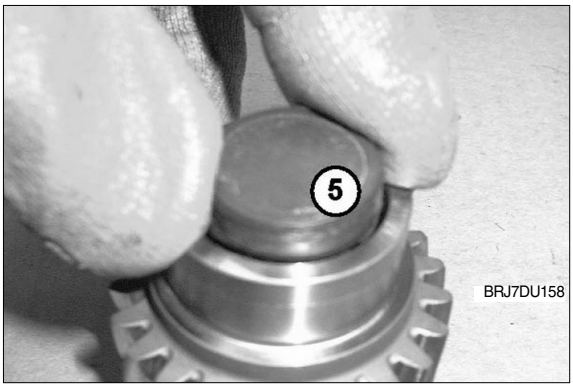
⑥ After cooling down install the bearing subsequently.

(2) Mounting of sealing cap

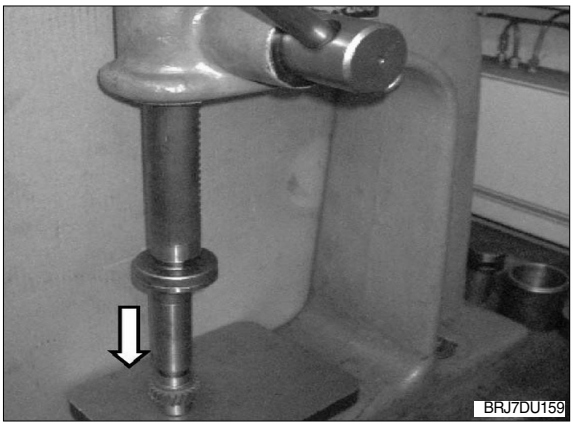
For sealing of the bore in the drive pinion a sealing cap (item 5) must be mounted. This requires the following sealing application:

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.



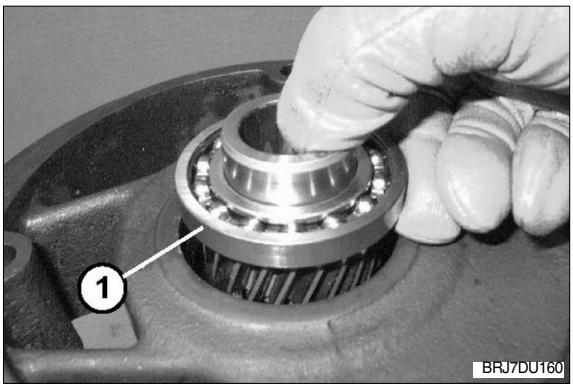
③ Press in the sealing cap with a press until contact is obtained.



(3) Installation of drive pinion

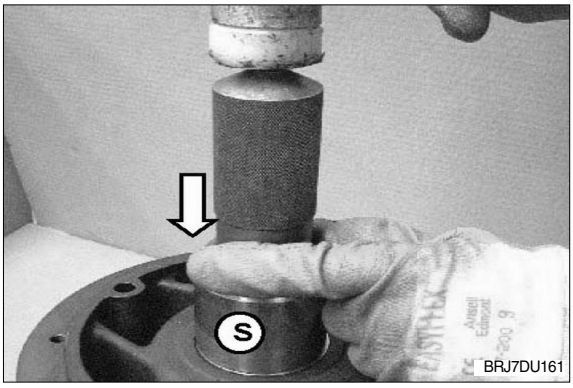
⚠ Pay attention when inserting the drive pinion not to damage the gearing of drive pinion and helical gear. Damages might cause louder running noises and consequential damages!

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.

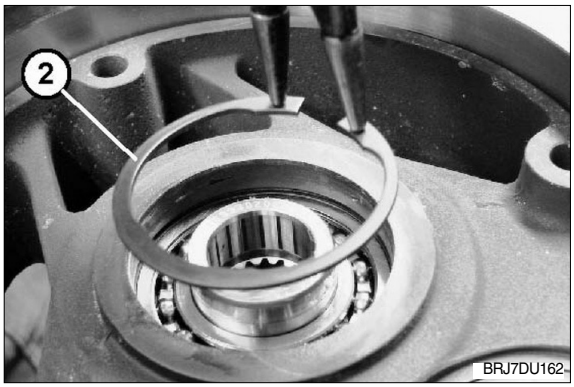


② By means of the striking mandrel "S" install the drive pinion into the bearing seat until contact is obtained.

(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.

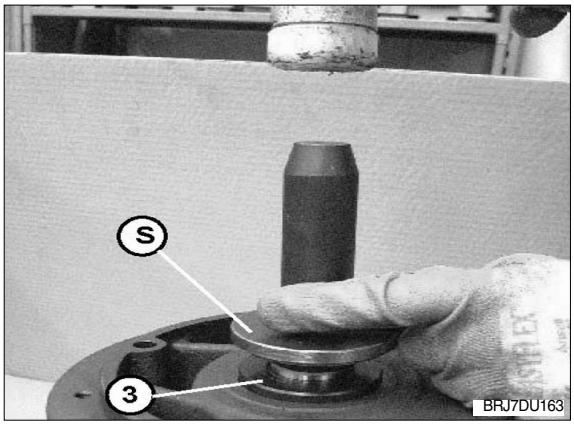


④ Wet the sealing lip of the radial sealing ring with grease (e.g. Shell Alvania R3) slightly.

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

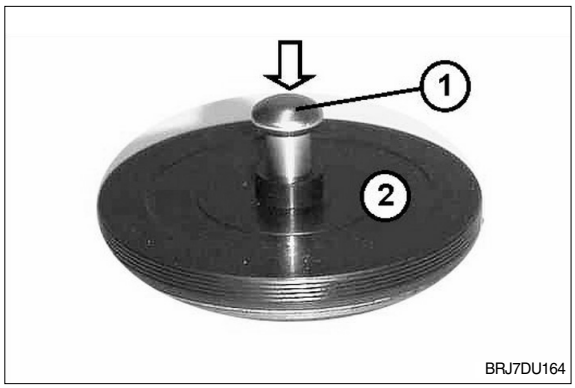
⑥ By means of striking mandrel "S" drive the radial sealing ring with the closed surface upwards into the housing seat until contact at the mandrel is obtained.

(S) Striking mandrel 62521



(4) Installation of sealing cap

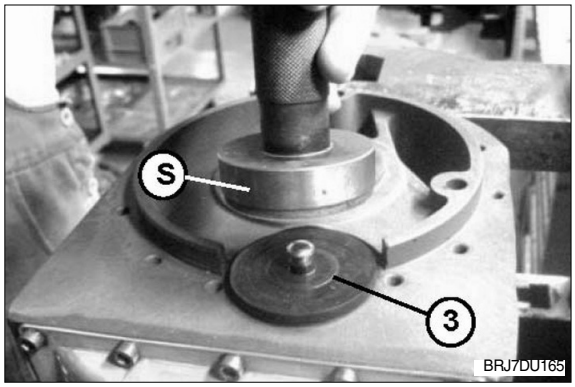
① Press the breather valve (item 1) slightly by hand into the central bore of the sealing cap (item 2) (Reference depth approx. 5mm).



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.

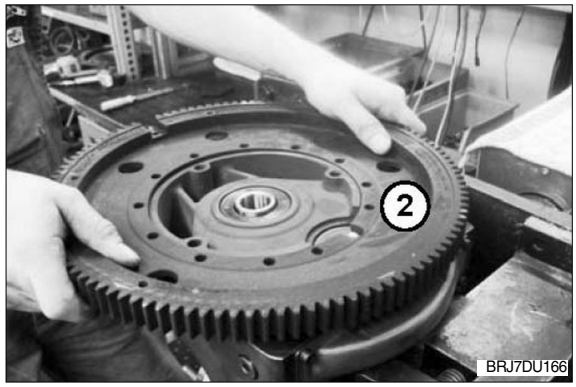
(S) Striking mandrel 62522



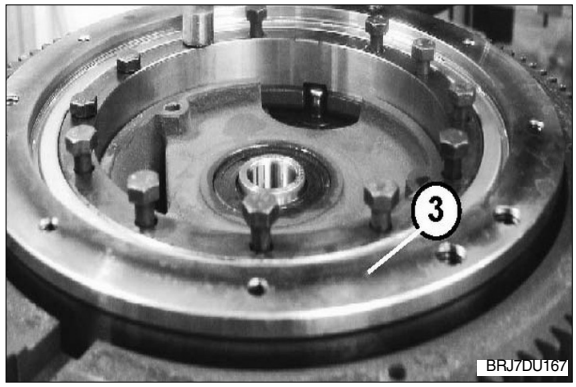
(5) Attachment of pivoted connection geared steering

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.

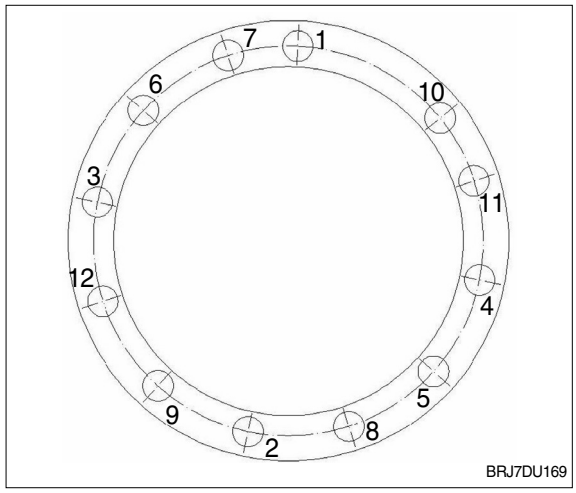
⑤ By means of the screws fasten the pivoted bogie bearing and the gear ring onto the connecting constructions.

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 transmission 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	

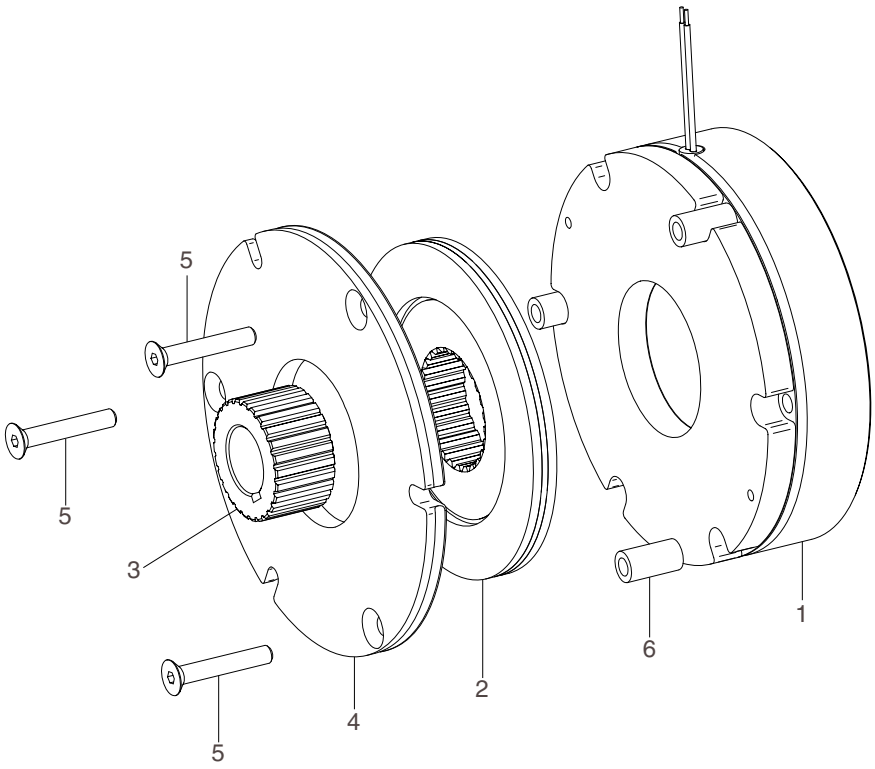
SECTION 4 BRAKE SYSTEM

Group 1 Structure and function 4-1

SECTION 4 BRAKE SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. STRUCTURE



BRP7EB01

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

2. SPECIFICATION

Description	Unit	Specification
Brakes(Service)		Load wheels, electromagnetic brake
Nominal torque	N.m	135
Nominal airgap	mm	0.30
Tightening torque	N.m	22 (3×M8 on ø170mm)
Max rotation speed	rpm	3600
Weight	kg	11

3. PRE-INSTALLATION CHECKS

1) 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 or vertically.

(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) Put the key into the shaft then slide the hub (#3) onto the shaft and secure it axially by suitable means.

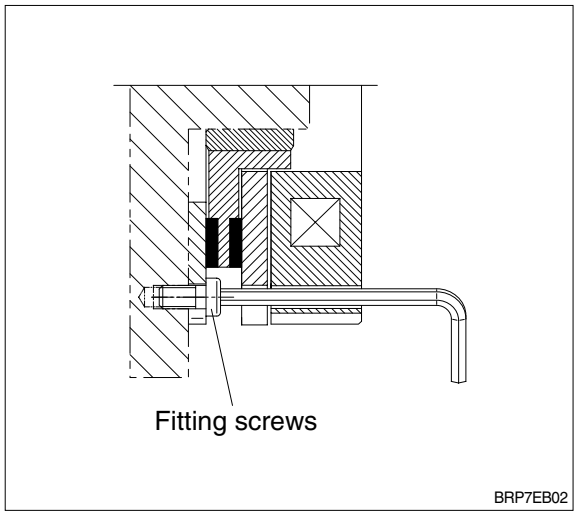
2) Slide the brake onto the hub (#3), taking care not to damage the splines of the disc (#2). Make sure that the disk locates properly on the splines of the hub.

3) Secure the brake in position using suitable screws, (see fig. EB02 and Spec). Secure the fitting screws using a loctite 270 type thermoplastic liquid.

4) 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).

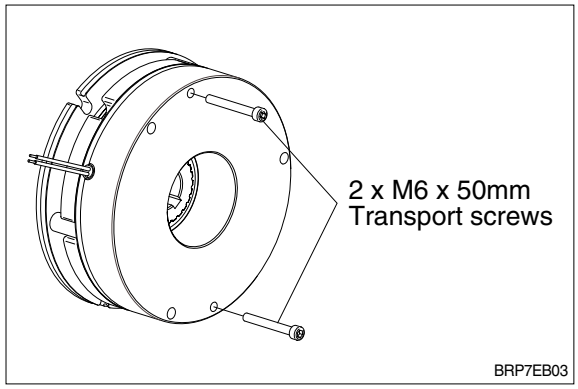


6. DISC REPLACEMENT

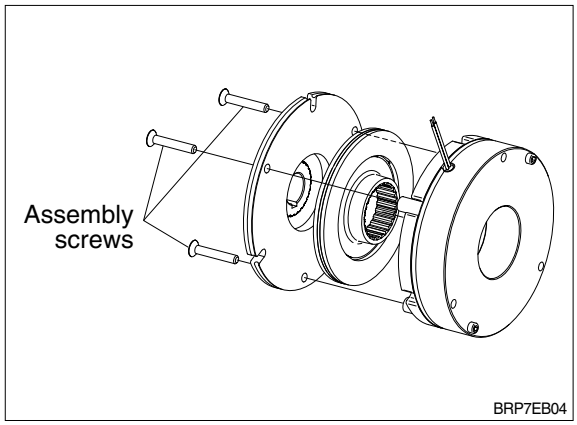
⚠ When the maximum airgap is reached, the brake will not release correctly. It is then necessary to replace the friction disc.

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.

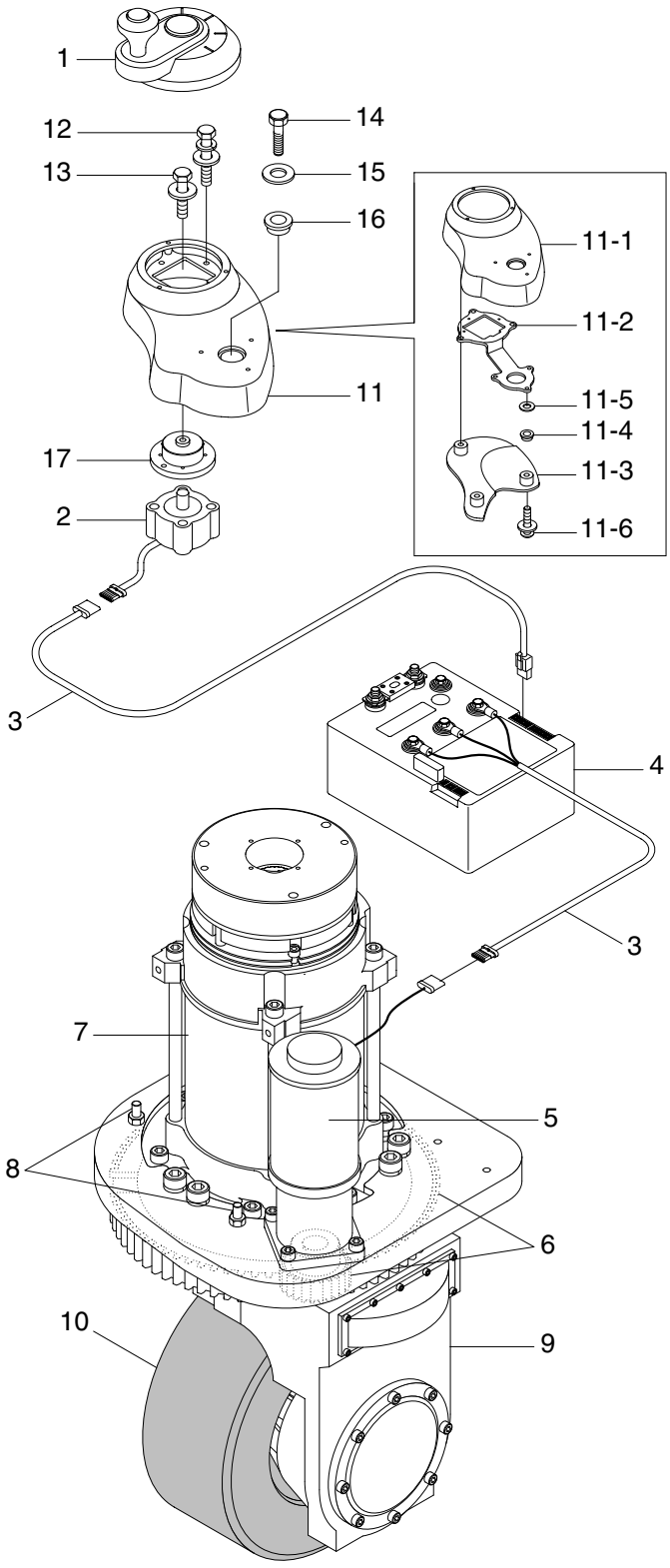
SECTION 5 STEERING SYSTEM

Group 1 Structure and function 5-1

SECTION 5 STEERING SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

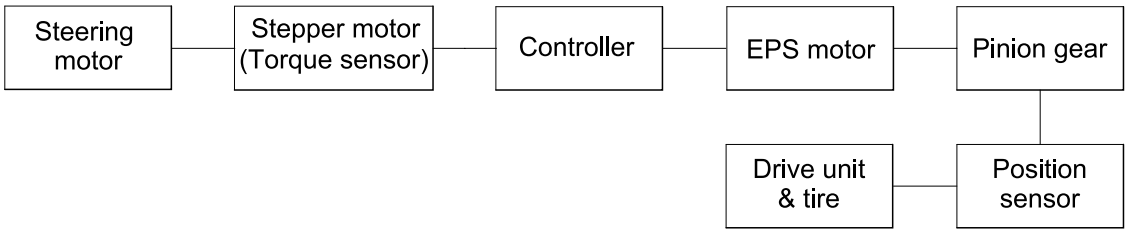
1. STRUCTURE



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.

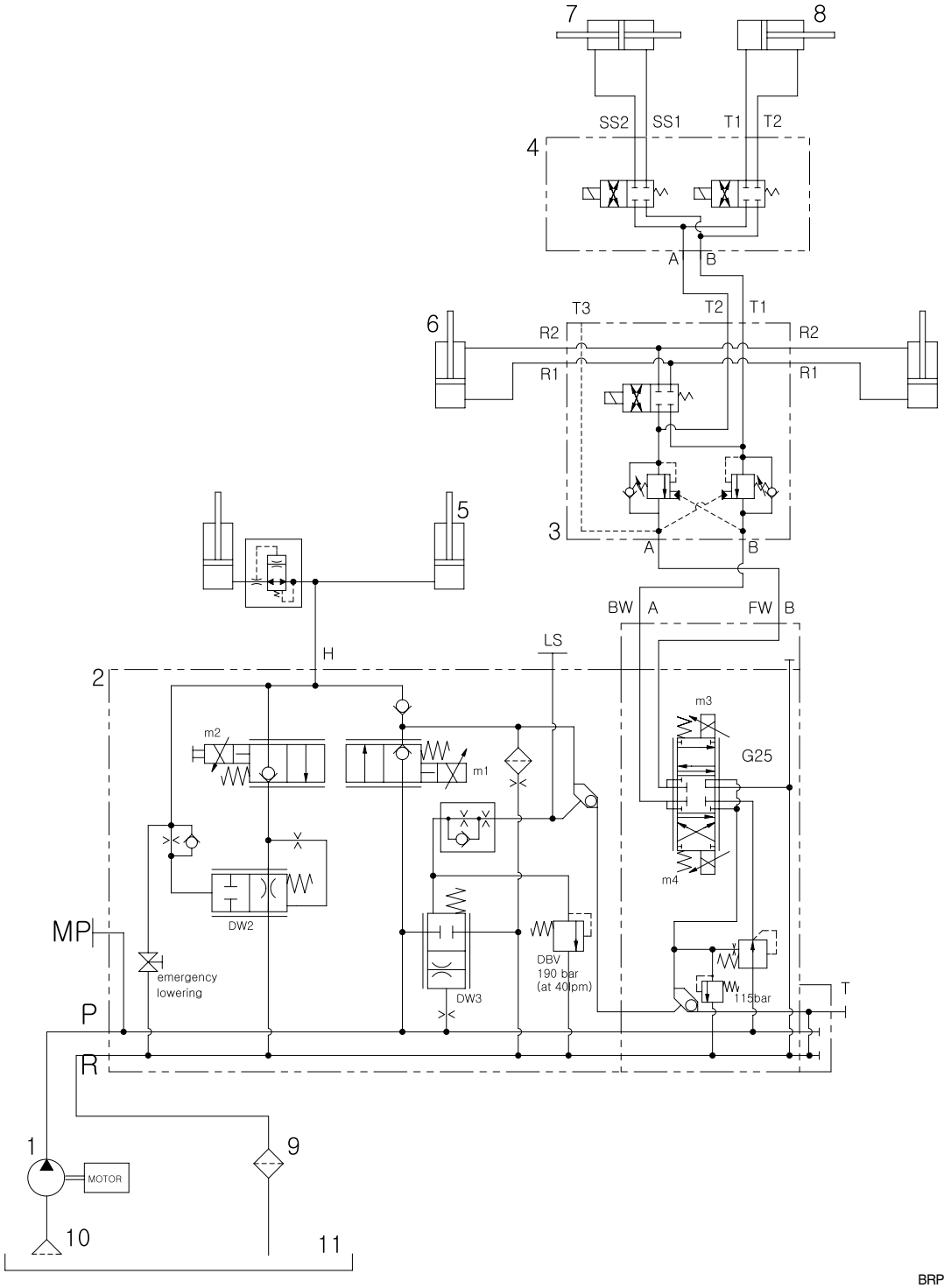
SECTION 6 HYDRAULIC SYSTEM

Group 1 Structure and function ····· 6-1
Group 2 Operational checks and troubleshooting ····· 6-17
Group 3 Disassembly and assembly ····· 6-21

SECTION 6 HYDRAULIC SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

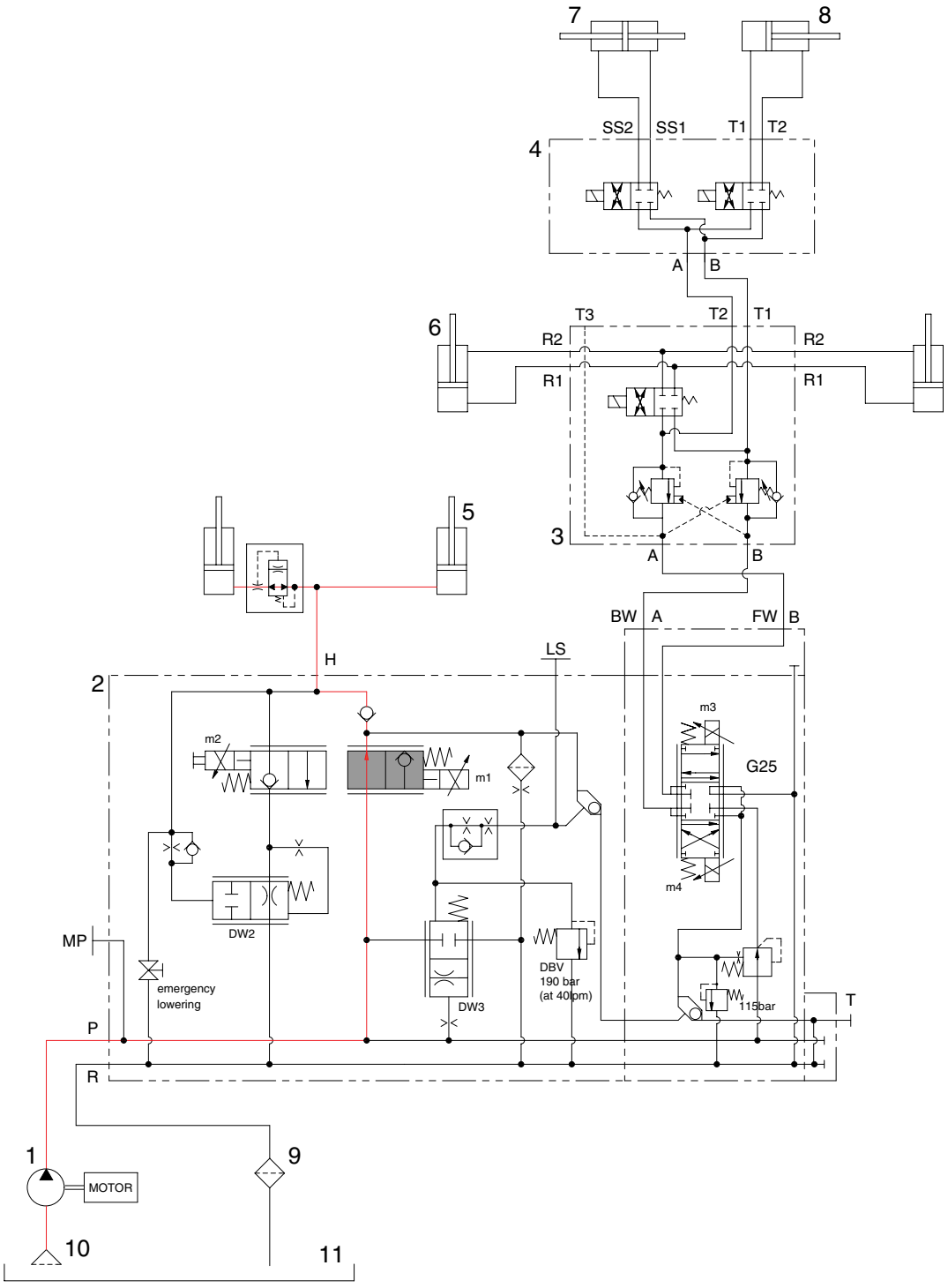
1. HYDRAULIC CIRCUIT



BRP7HS01

1 Hydraulic pump
2 Main control valve
3 Reach manifold
4 Tilt / side shift manifold
5 Lift cylinder
6 Reach cylinder
7 Side shift cylinder
8 Tilt cylinder
9 Return filter
10 Strainer
11 Tank

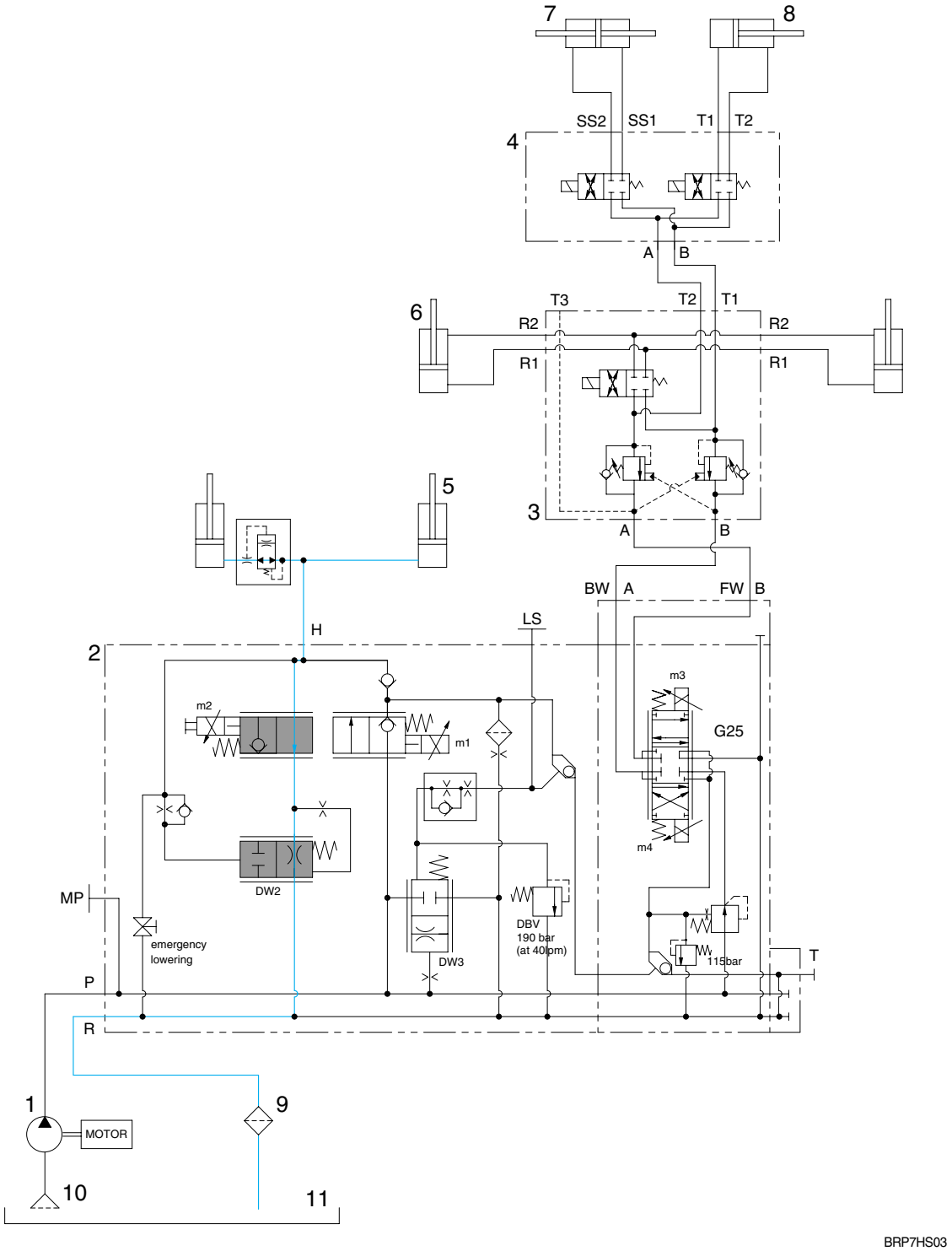
1) WHEN THE JOYSTICK IS IN THE LIFT POSITION



BRP7HS02

When the joystick is pulled backward, the m1 valve on the lift block is moves to open position.
The oil from hydraulic gear pump(1) flows into main control valve(2) and then goes to the large chamber of lift cylinder(5).
The air of the small chamber of lift cylinder(5) is compressed at the same time.
When this happens, the forks go up.

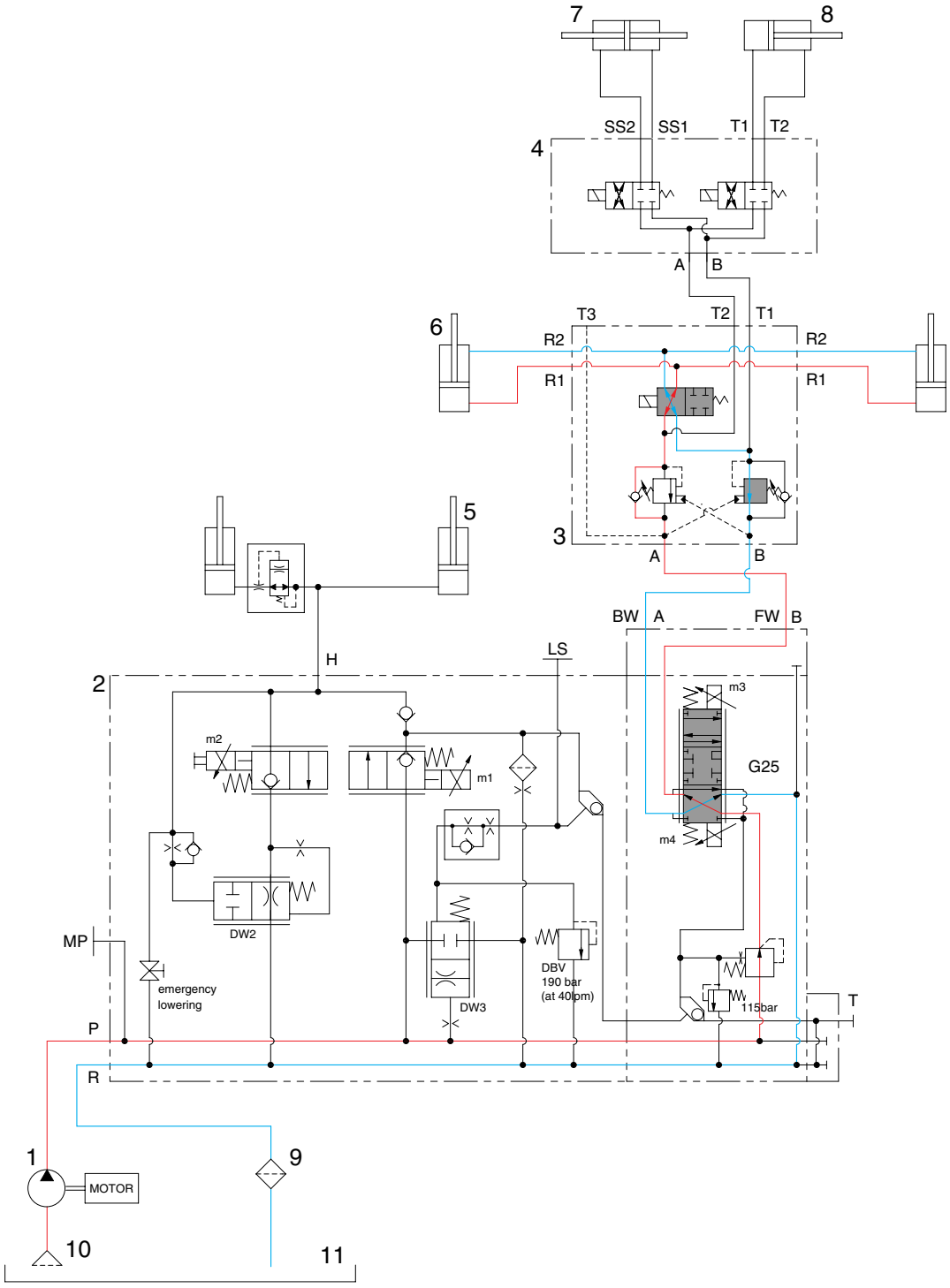
2) WHEN THE JOYSTICK IS IN THE LOWER POSITION



BRP7HS03

When the joystick is pushed forward, the m2 valve on the lift block is moved to open position.
The work port(H) and the large chamber are connected to the return passage, so the lift will be lowered due to its own weight.

3) WHEN THE BUTTON ON THE JOYSTICK IS PUSHED FOR THE REACH OUT POSITION



BRP7HS05

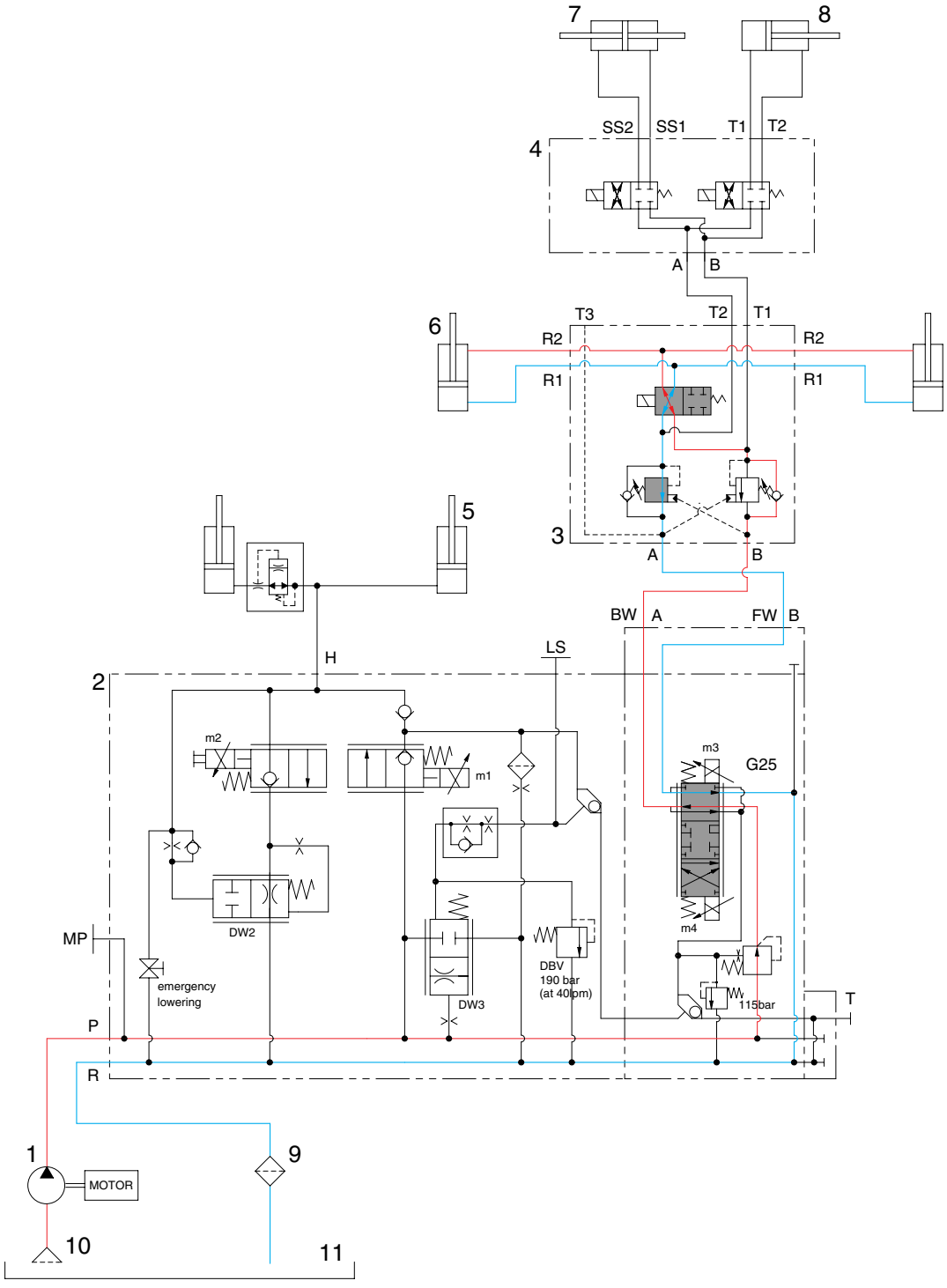
When the button on the joystick is pushed upward, the spool on the third block is moved to reach out position.

The oil from hydraulic gear pump(1) flows into main control valve(2) and then goes to the large chamber of reach cylinder(6).

The oil at the small chamber of reach cylinder(6) returns to hydraulic tank(11) at the same time.

When this happens, the mast reaches out.

4) WHEN THE BUTTON ON THE JOYSTICK IS PUSHED FOR THE REACH IN POSITION



BRP7HS04

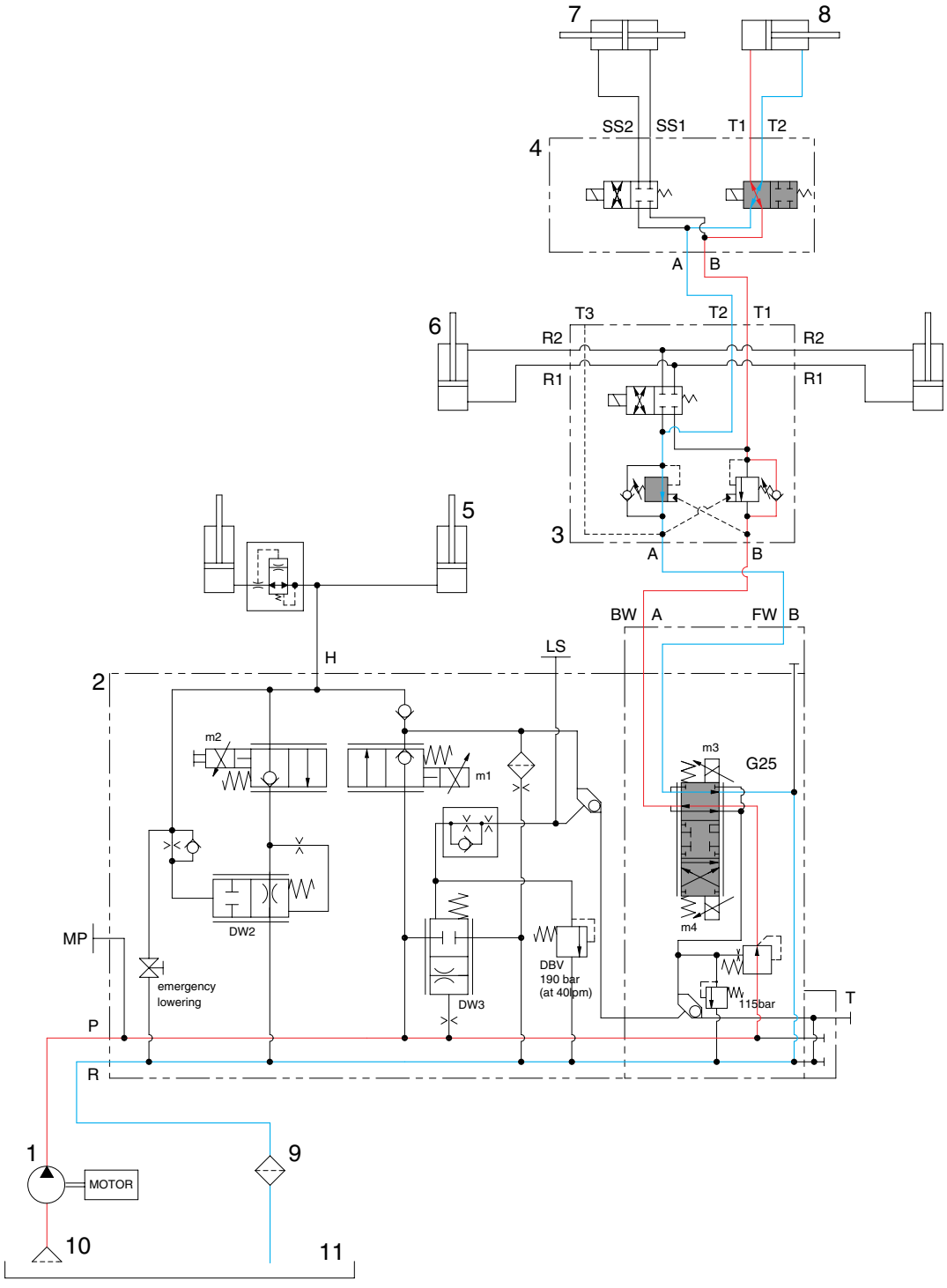
When the button on the joystick is pushed downward, the spool on the third block is moved to reach in position.

The oil from hydraulic gear pump(1) flows into main control valve(2) and then goes to the small chamber of reach cylinder(6).

The oil at the large chamber of reach cylinder(6) returns to hydraulic tank(11) at the same time.

When this happens, the mast reaches in.

5) WHEN THE JOYSTICK IS IN THE BACKWARD TILT POSITION



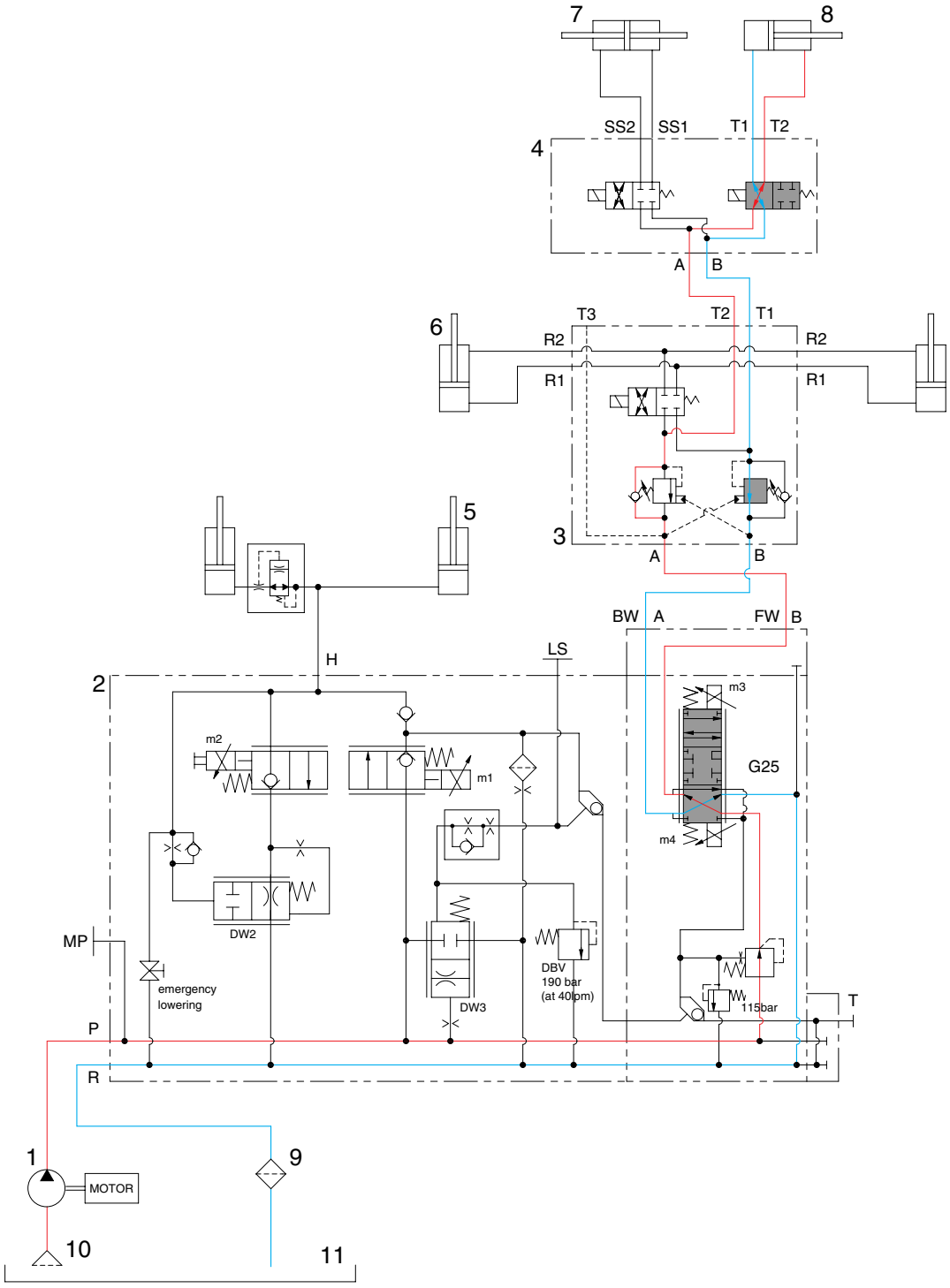
BRP7HS06

When the joystick is pulled during pressing the tilt button, the spool on the second block is moved to tilt backward position.

The oil from hydraulic gear pump(1) flows into main control valve(2) and then goes to the large chamber of tilt cylinder(8).

The oil at the small chamber of tilt cylinder(8) returns to hydraulic tank(11) at the same time.

6) WHEN THE JOYSTICK IS IN THE FORWARD TILT POSITION



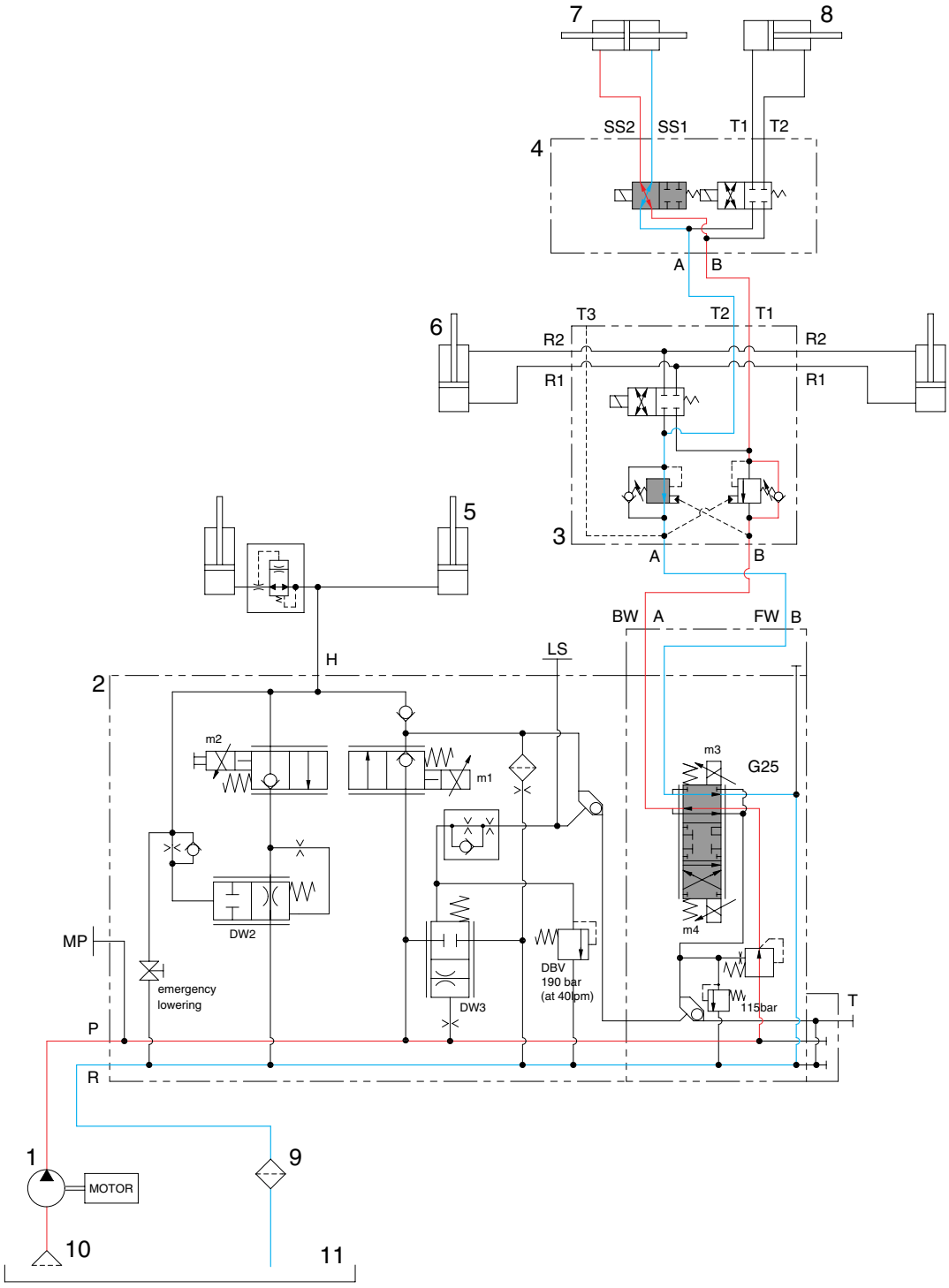
BRP7HS07

When the joystick is pushed forward during pressing the tilt button, the spool on the second block is moved to tilt forward position.

The oil from hydraulic gear pump(1) flows into main control valve(2) and then goes to the small chamber of tilt cylinder(8).

The oil at the large chamber of tilt cylinder(8) returns to hydraulic tank(11) at the same time.

7) WHEN THE JOYSTICK IS IN THE RIGHT POSITION FOR THE SIDE SHIFT MOVEMENT



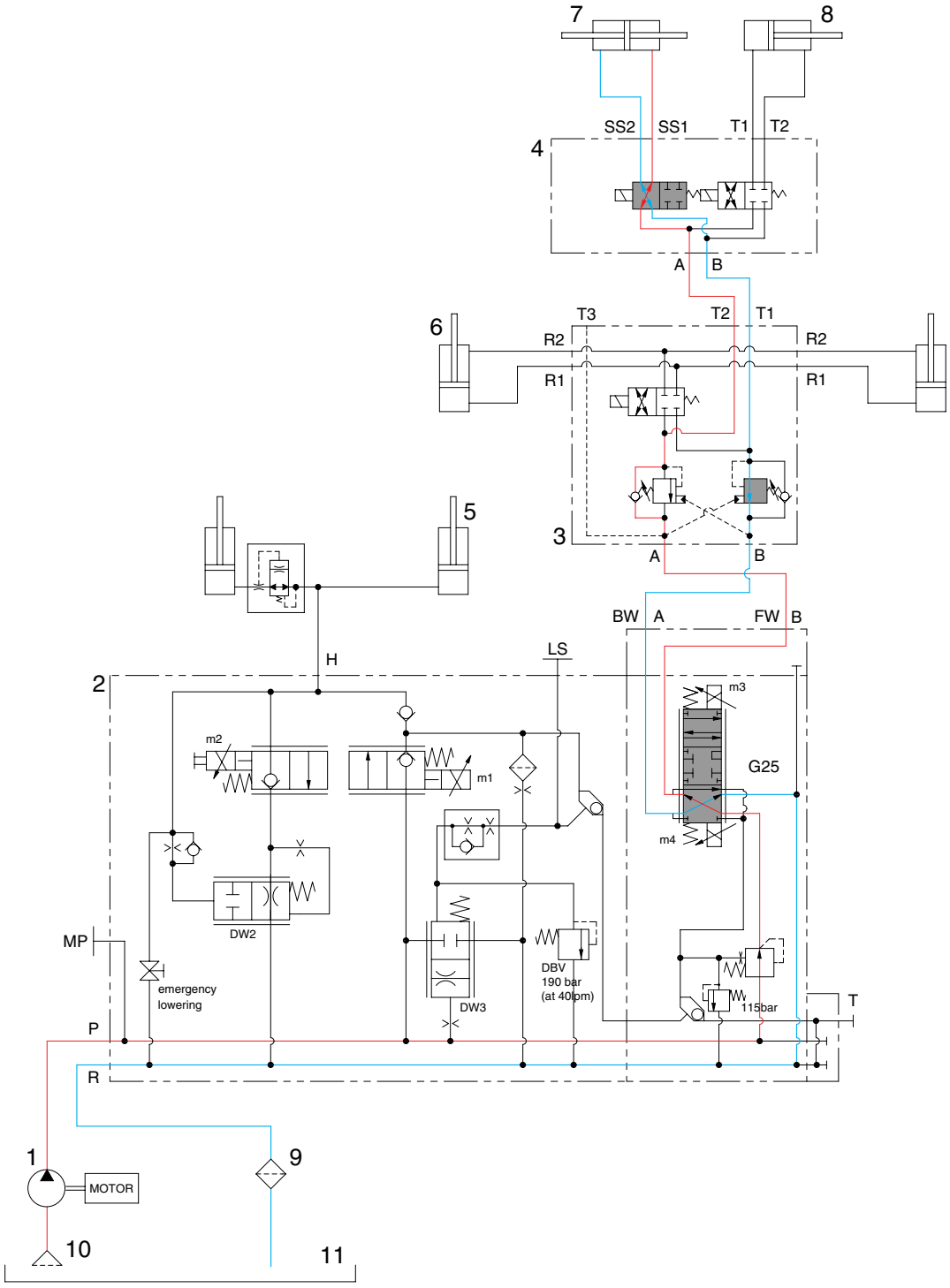
BRP7HS08

When the joystick is pulled backward during pressing the side shift button, the spool on the second block is moved to side shift right position.

The oil from hydraulic gear pump(1) flows into main control valve(2) and then goes to the large chamber of side shift cylinder(7).

The oil at the small chamber of side shift cylinder(7) returns to hydraulic tank(11) at the same time.

8) WHEN THE JOYSTICK IS IN THE LEFT POSITION FOR THE SIDE SHIFT MOVEMENT



BRP7HS09

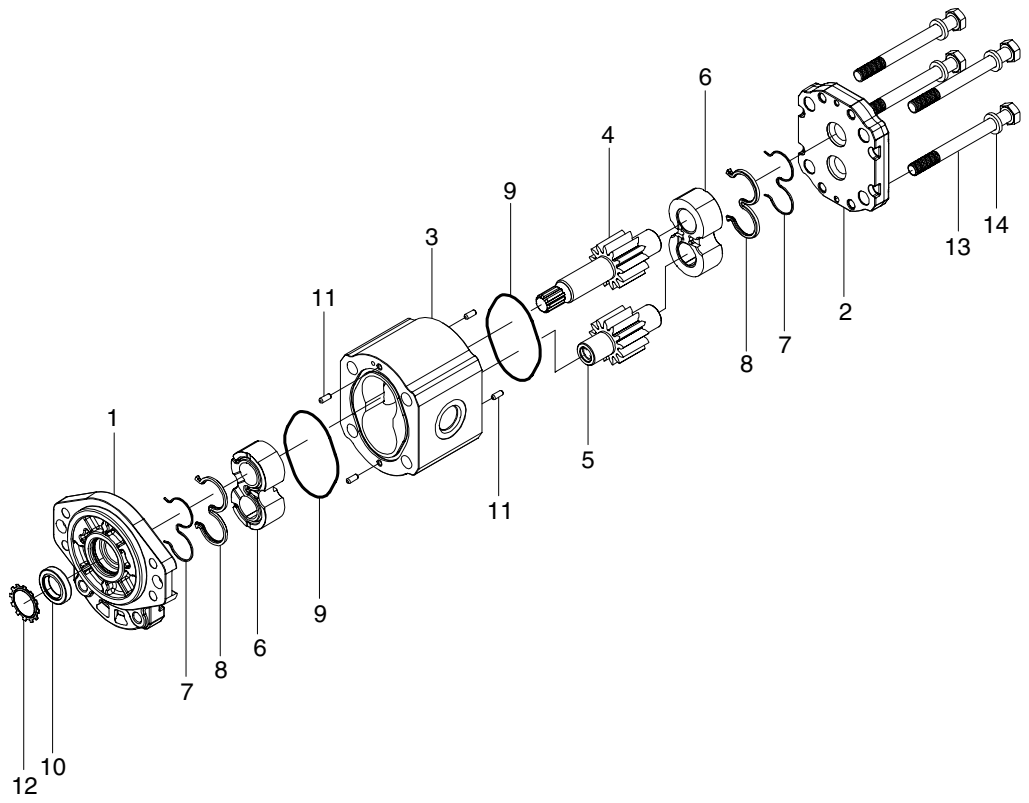
When the joystick is pushed forward during pressing the side shift button, the spool on the second block is moved to side shift left position.

The oil from hydraulic gear pump(1) flows into main control valve(2) and then goes to the large chamber of side shift cylinder(7).

The oil at the small chamber of side shift cylinder(7) returns to hydraulic tank(11) at the same time.

2. HYDRAULIC GEAR PUMP

1) STRUCTURE



BRJ7HS19

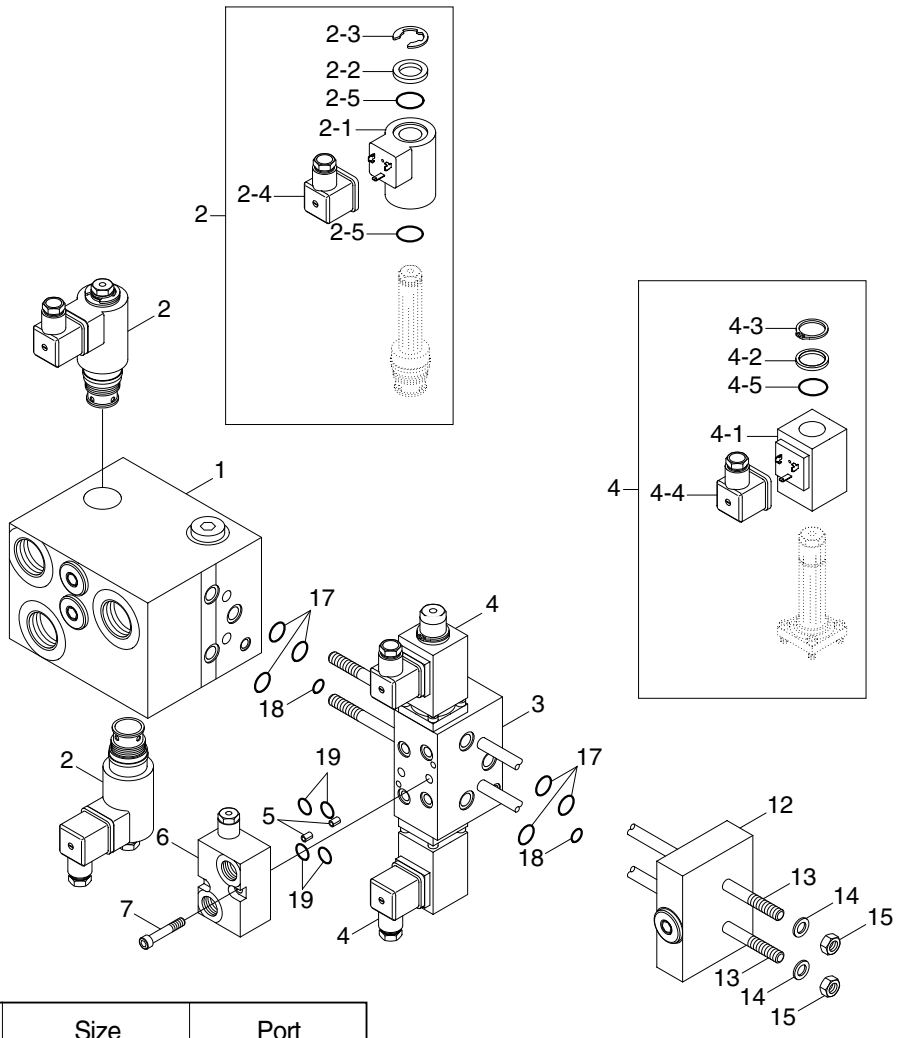
1	Mounting flange	6	Bearing block	11	Dowel pin
2	End cover	7	Backup ring	12	Start ring
3	Gear housing	8	Seal	13	Socket head bolt
4	Drive gear	9	O-ring	14	Spring washer
5	Idler shaft	10	Shaft seal		

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. MAIN CONTROL VALVE

1) STRUCTURE (2 Spool)



Port name	Size	Port
Inlet port	1 1/16-12UN	P
Outlet port	1 1/16-12UN	R
Work port	1 1/16-12UN	H
Work port	9/16-18 UNF	A, B

BRP7HS12

1	Main block	4	Solenoid valve	7	Head screw
2	Solenoid valve (Lift)	4-1	Coil	12	End block
2-1	EVI coil	4-2	Disc	13	Tension rod
2-2	Washer	4-3	Circlip	14	Shape washer
2-3	Lock washer	4-4	Black plug	15	Hexagon nut
2-4	Black plug	4-5	O-ring	17	O-ring
2-5	O-ring	5	Roll pin	18	O-ring
3	Tilt block	6	Adapter	19	O-ring

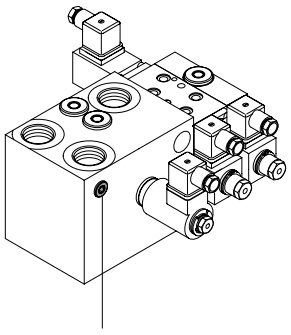
2) EMERGENCY LOWERING

In case of the mast cannot be lowered due to a problem in the controller, active the emergency lowering valve on the valve block with hexagonal wrench.

(1) Turn off the electric emergency switch.

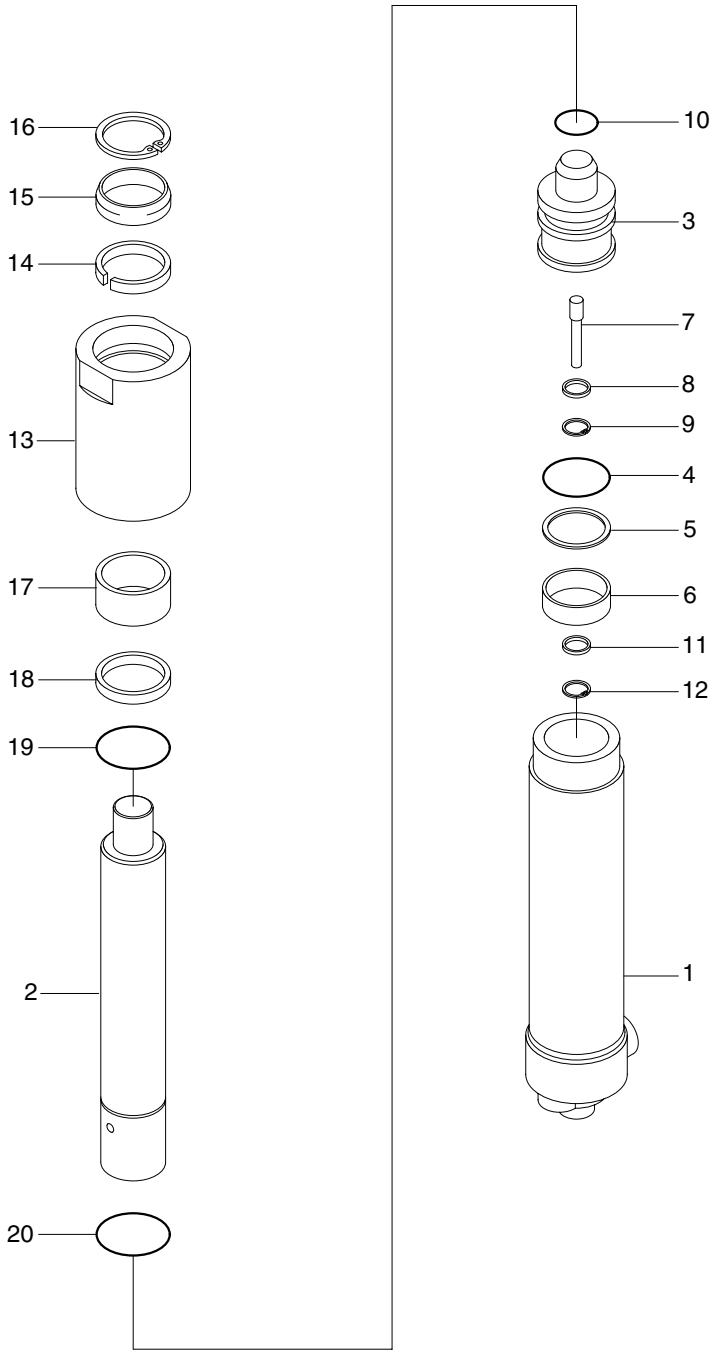
(2) Open the lowering valve using the 5㎜ hexagonal wrench. Slowly lower the mast and the load carriage.

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



15BRP7OM145

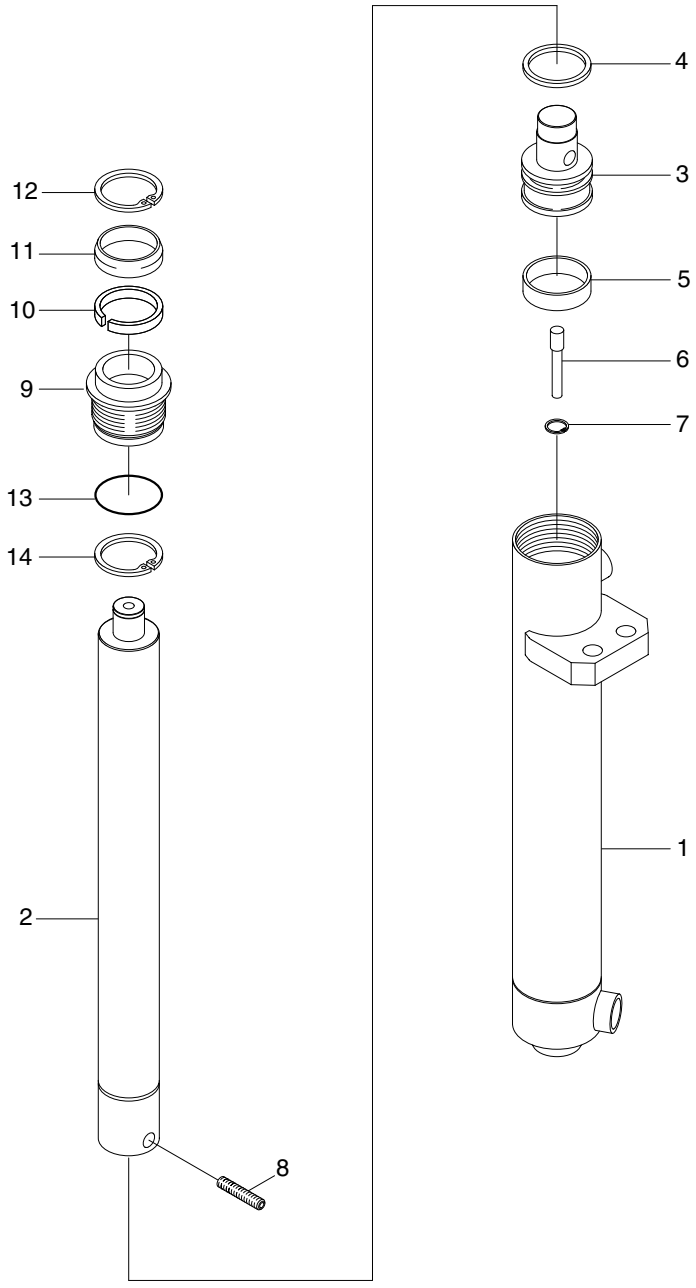
4. LIFT CYLINDER



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		

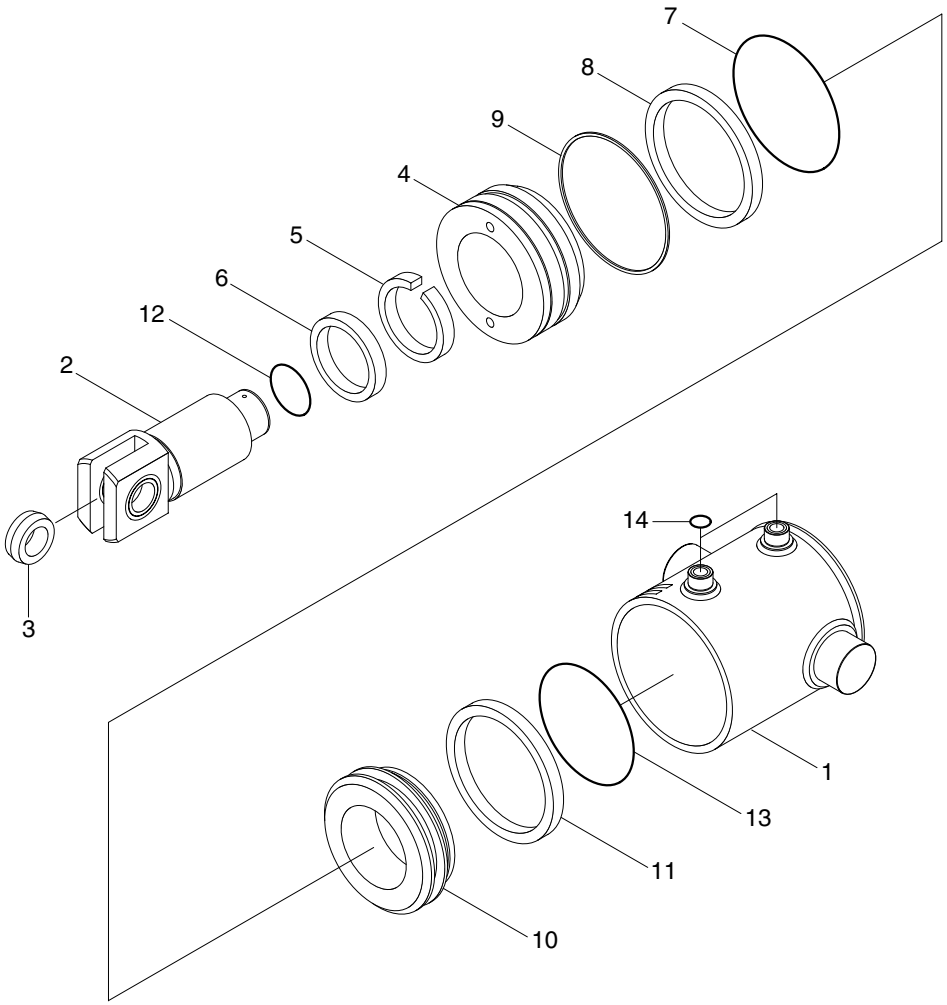
5. FREE LIFT CYLINDER



BRP7HS23

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		

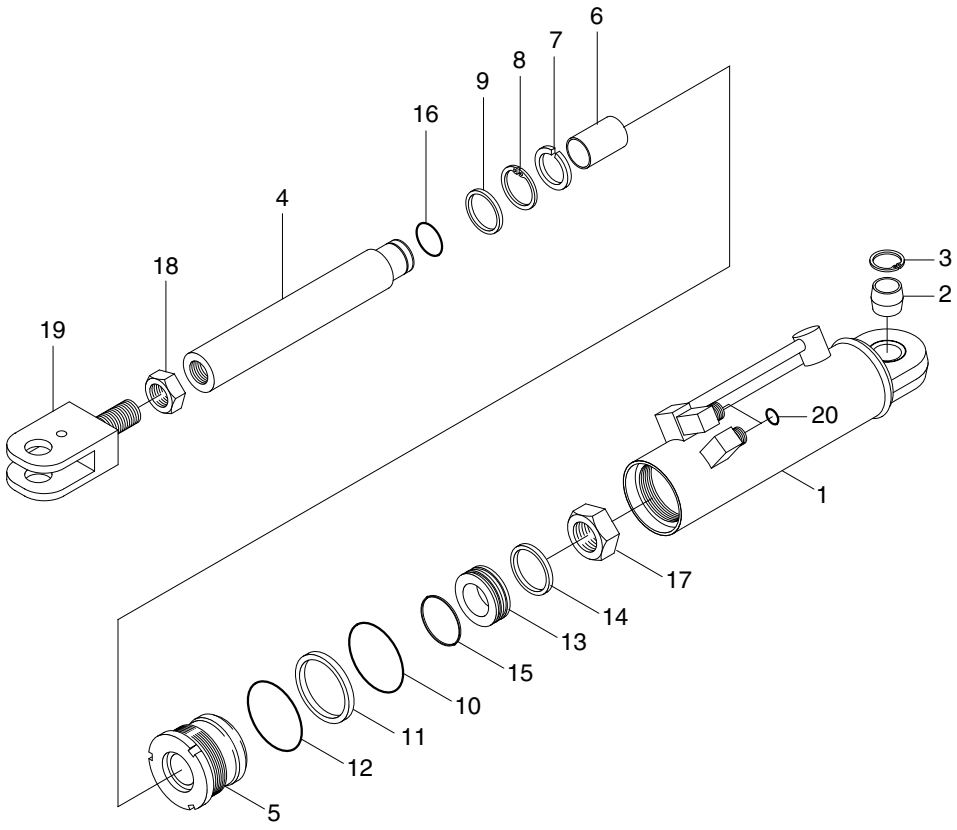
6. TILT CYLINDER



BRP7HS25

1	Tube assy	6	Dust wiper	11	Piston seal
2	Rod	7	O-ring	12	O-ring
3	Bushing	8	Back up ring	13	Locking ring
4	Rod cover	9	Locking wire	14	O-ring
5	U-packing	10	Piston		

7. REACH CYLINDER



BRP7HS27

1	Tube assy	8	Back up ring	15	Wear ring
2	Spherical bearing	9	Dust wiper	16	O-ring
3	Retaining ring	10	O-ring	17	Nylon nut
4	Rod	11	Back up ring	18	Hex nut
5	Rod cover	12	O-ring	19	Eye
6	Bushing	13	Piston	20	O-ring
7	U-packing	14	Piston seal		

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

1) CHECK ITEM

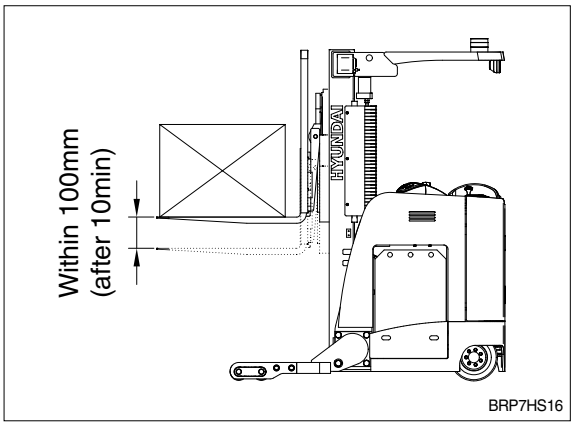
(1) Check visually for deformation, cracks or damage of rod.

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

· **Hydraulic drift**

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

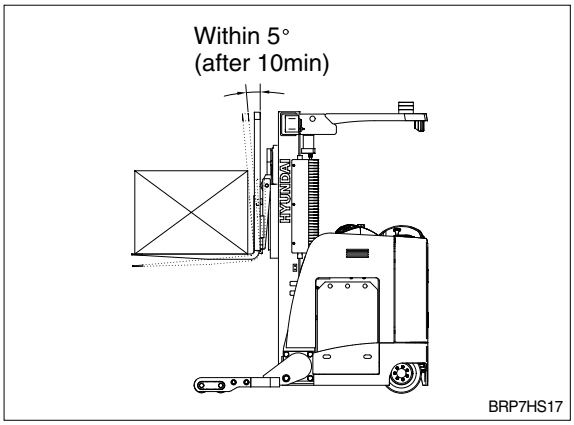
If the hydraulic drift is more than the specified value, replace the control valve or cylinder packing.



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

mm (in)

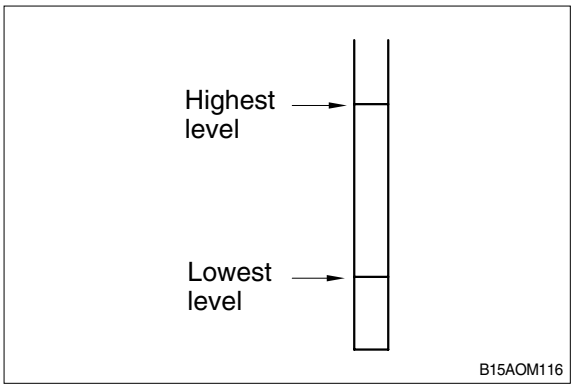
Standard	Under 0.6 (0.02)



2) HYDRAULIC OIL

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

(2) When changing hydraulic oil, clean suction strainer(screwed into outlet port pipe) and return filter(screwed into inlet pipe). Return filter uses paper element, so replace periodically(2000 hours).



3) CONTROL VALVE

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

2. TROUBLESHOOTING

1) SYSTEM

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

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

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

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

4) LIFT CYLINDER

Problem	Cause	Remedy
Oil leaks out from 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**

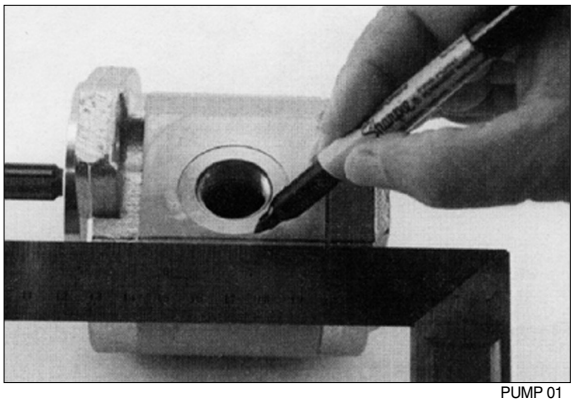
- Metric socket set
- Internal snap ring pliers
- Shaft seal sleeve
- Torque wrench

(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.

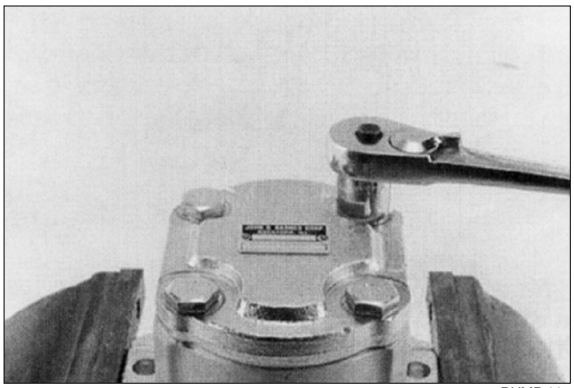


PUMP 01

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

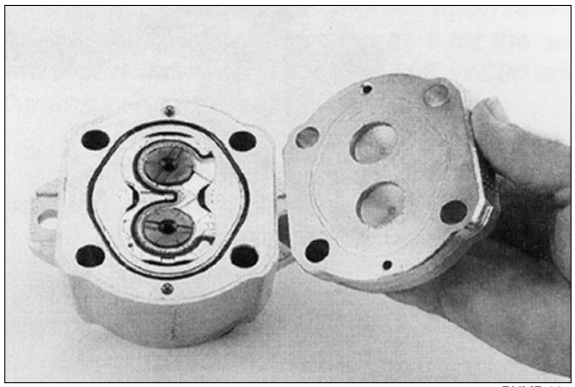
(6) Loosen the four metric hexagon head bolts.

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



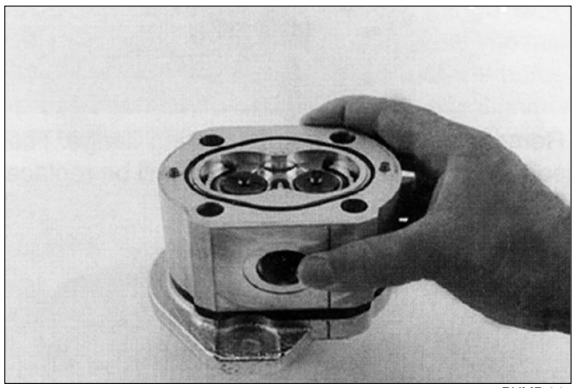
PUMP 02

(8) Lift and remove end cover.



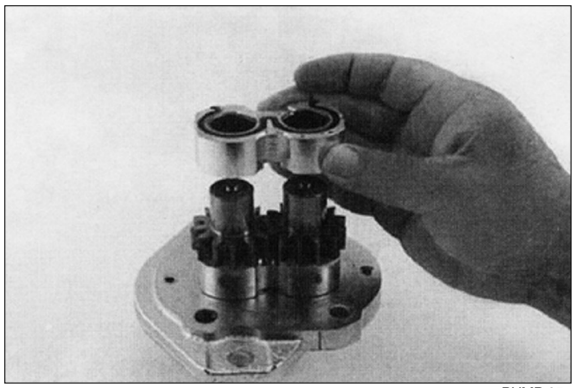
PUMP 03

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



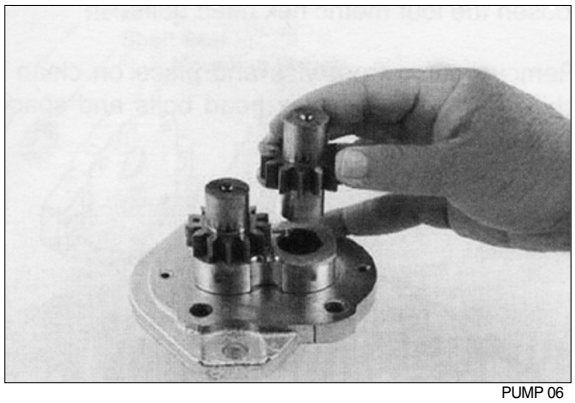
PUMP 04

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



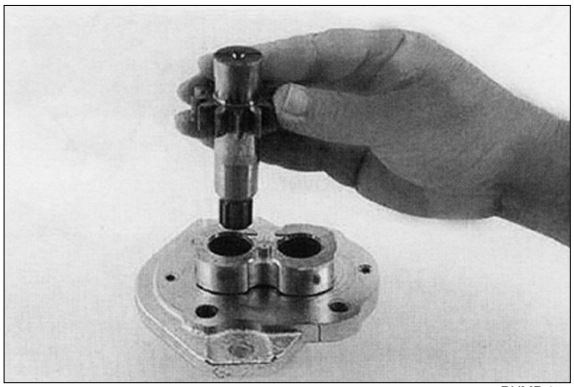
PUMP 05

(11) Remove idler shaft from bearing block.



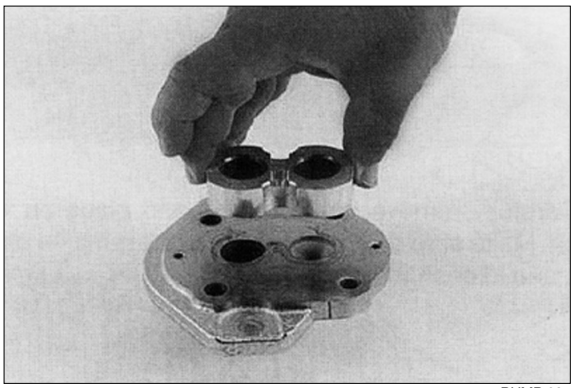
PUMP 06

(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.



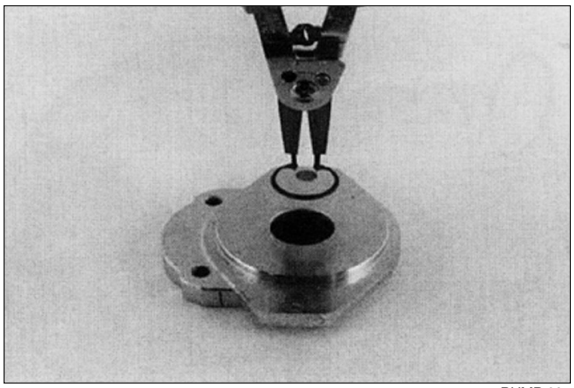
PUMP 07

(13) Remove the front bearing block.



PUMP 08

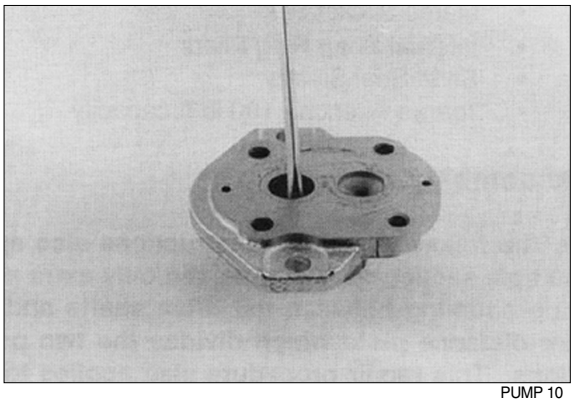
(14) Turn mounting flange over, with shaft seal up, and remove the retaining ring with proper snap ring pliers.



PUMP 09

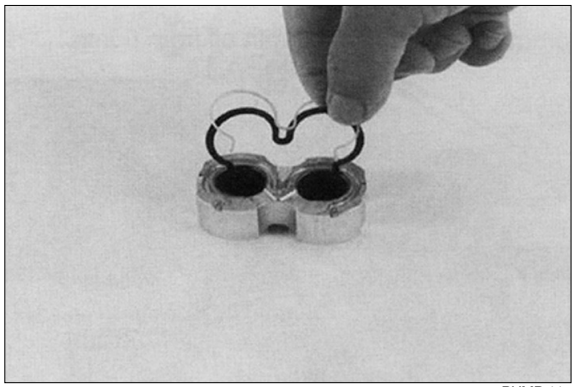
(15) Remove the oil seal from mounting flange, be careful not to mar or scratch the seal bore.

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



PUMP 10

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



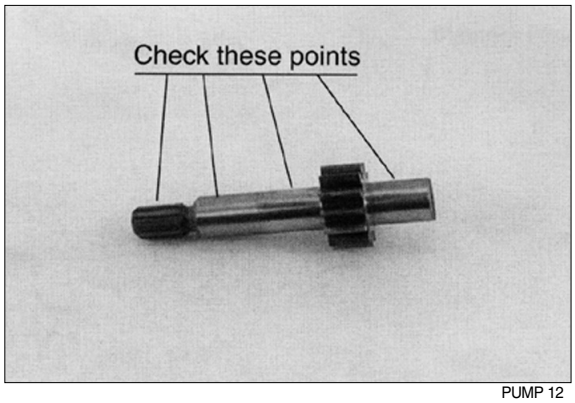
PUMP 11

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.

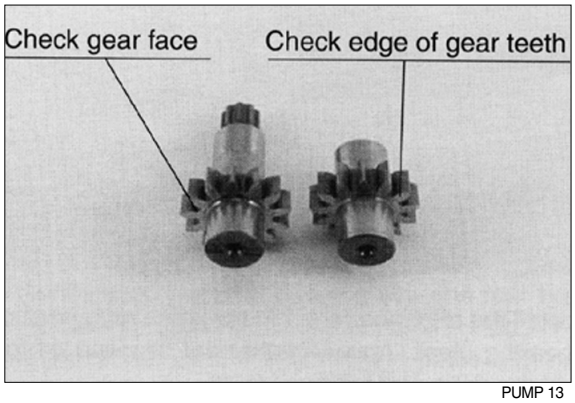
(2) Check drive shaft spline for twisted or broken teeth, check keyed drive shaft for broken or chipped keyway. No marks or grooves on shaft in seal area, some discoloration of shaft is allowable.

(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

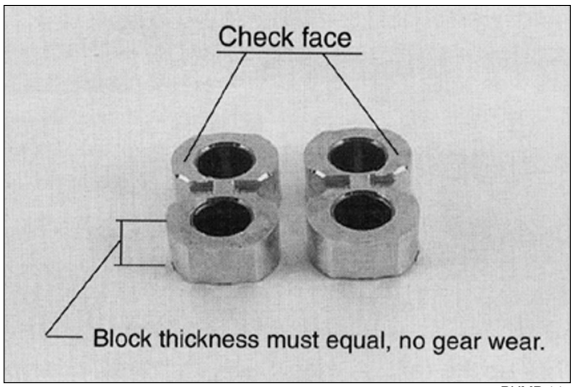
(4) Inspect gear face for scoring or excessive wear. If the face edge of gear teeth are sharp, they will mill into the bearing blocks. If wear has occurred, the parts are unusable.



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**

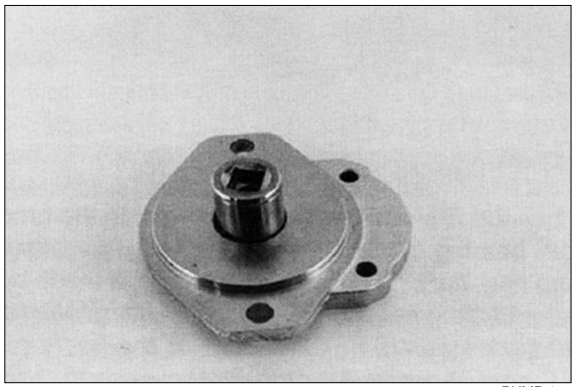
It is important that the relationship of the mounting flange, bearing blocks and gear housing is correct. Failure to properly assemble this pump will result with little or no flow at rated pressure.

※ **This pump is not bi-rotational.**

3) ASSEMBLY

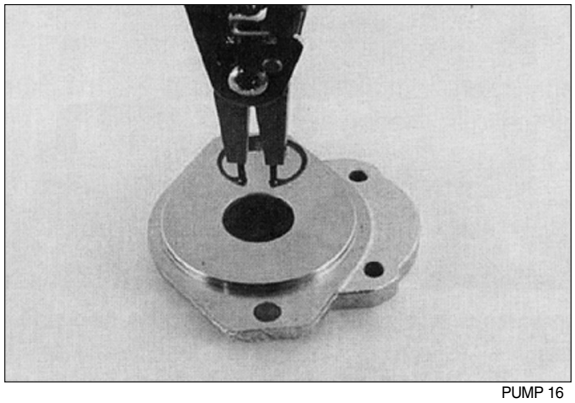
※ **New seals should be installed upon reassembly of pump.**

(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.



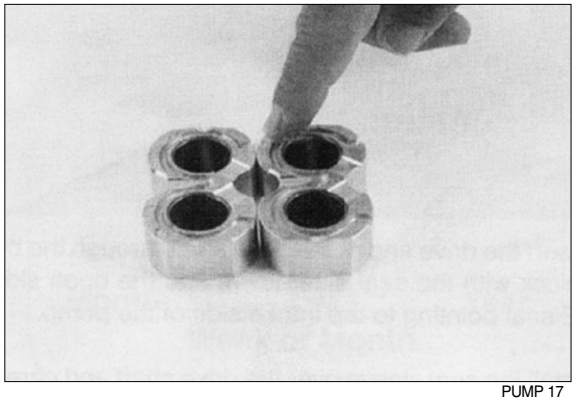
PUMP 15

(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.

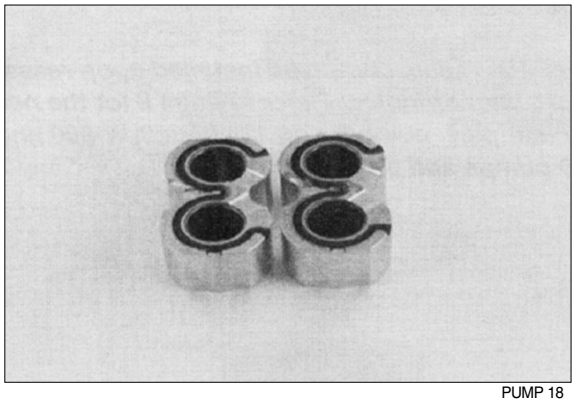


PUMP 17

(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.

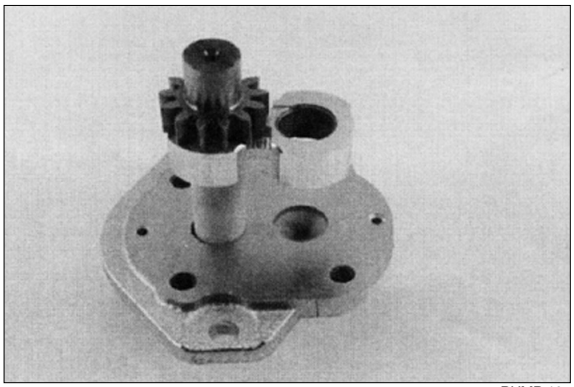
(6) Apply a light coating of petroleum jelly to the exposed face of the front bearing block.



PUMP 18

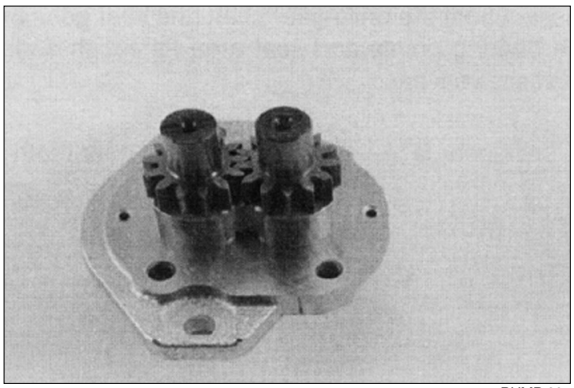
(7) Insert the drive end of the drive shaft through the bearing block with the seal side down, and the open side of the E-seal pointing to the intake side of the pump.

(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

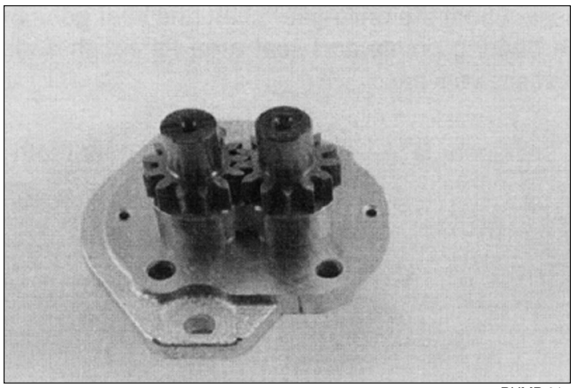
(9) Install the idler gear shaft in the remaining position in the bearing block. Apply a light coat of clean oil to the face of the drive and idler gears.



PUMP 20

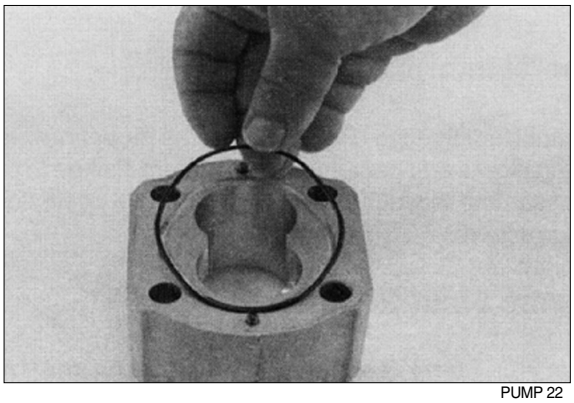
(10) Pick up the rear bearing block, with seal side up and with open end of the E-seal facing the intake side of the pump, place over the drive and idler gear shafts.

(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.



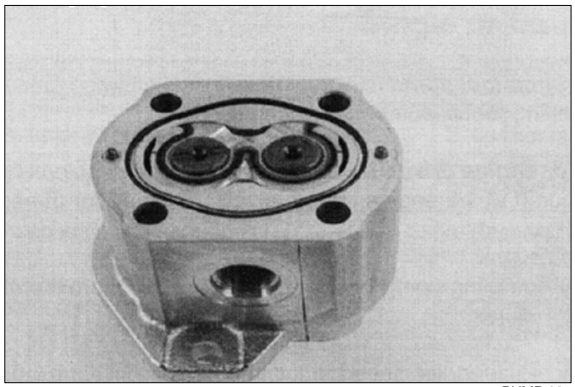
PUMP 21

(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.



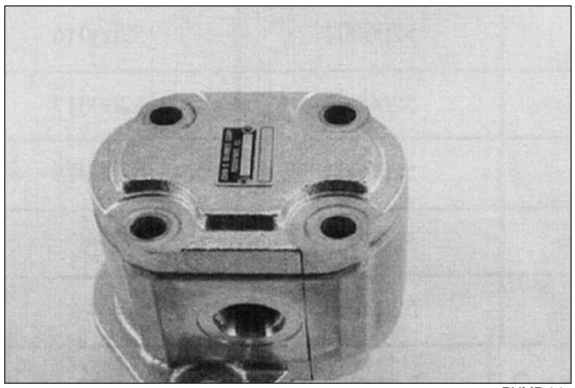
PUMP 22

(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.

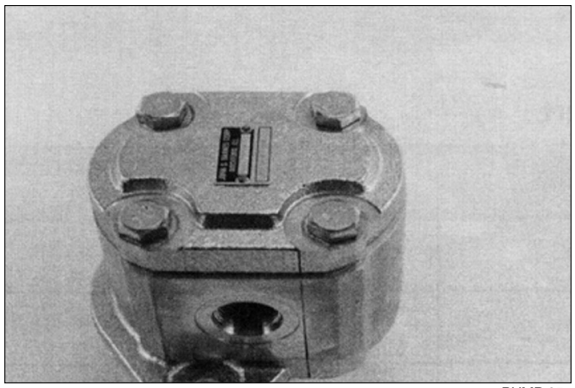

PUMP 23

(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.

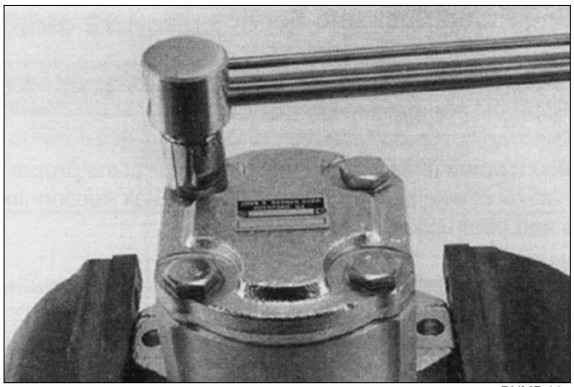

PUMP 25

(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)

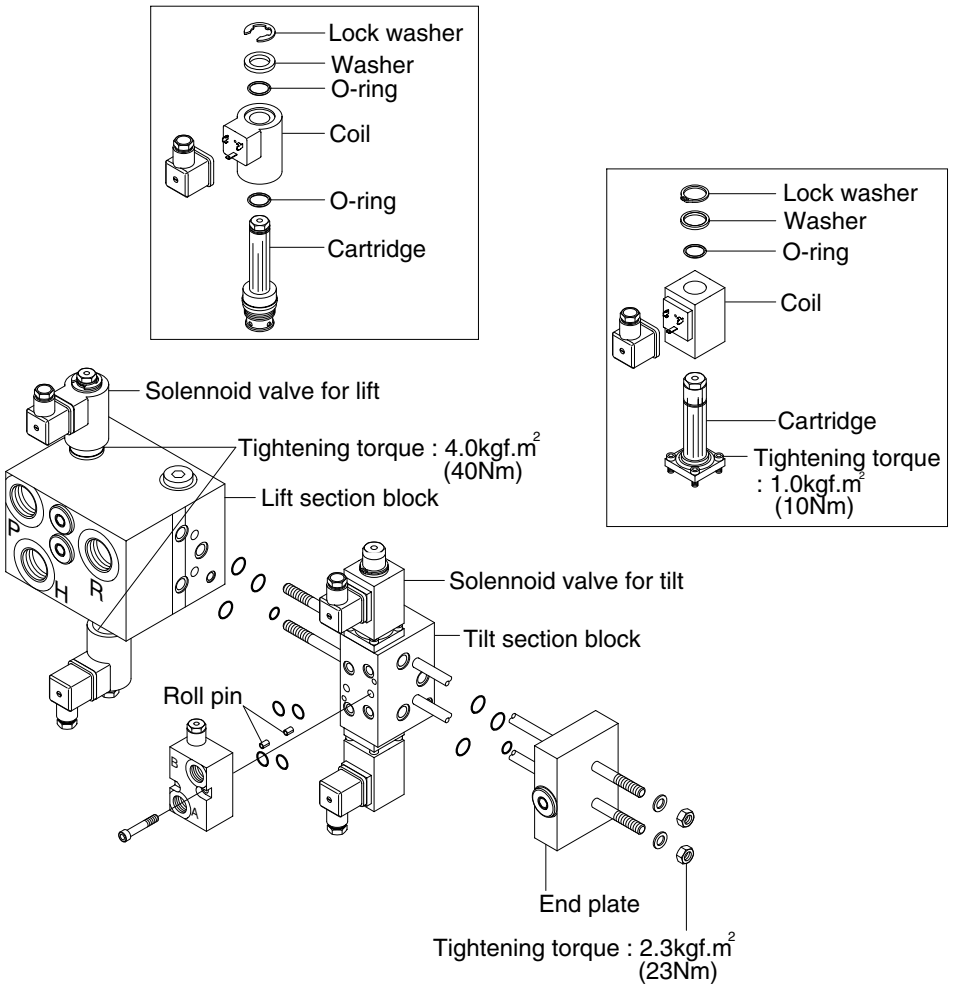
(18) Remove pump from vise.

(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. MAIN CONTROL VALVE



BRP7HS13

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) Block subassembly

① Attach all the O-ring to the appropriate grooves between the spool section.
② Stack the valve section as above picture on a flat surface.
③ Insert all the tie rod through the drilled holes in each of the housings.
④ Press the sections together being careful not to damage sealing surface or seals.
⑤ Install nuts to tie rod and progressively torque in a circular pattern until reaching a torque of 2.3 ㎏f · ㎝²(23Nm) on all the rods.

(3) Lift block solenoid assembly

① The solenoid is installed upper side and below side cavities in lift block. Torque to 4.1kgf · cm^2 (40Nm)
② Install the O-ring, coil, O-ring and washer to the assembled cartridge.
③ Insert the lock washer to the groove of the cartridge.

(4) Tilt & Auxiliary section assembly

① The solenoid is installed upper side and below side in tilt & auxiliary block with bolts.
Torque to 1kgf · m(10Nm)
② Install the coil, O-ring and washer to the assembled cartridge.
③ Insert the snap ring to the groove of the cartridge.
④ Insert the roll pin to the pin hole on the front side of each block.
⑤ Place the O-rings in the O-ring grooves.
⑥ Install the ancillary blocks to the each body with bolts.

2) DISASSEMBLY INSTRUCTION

(1) General

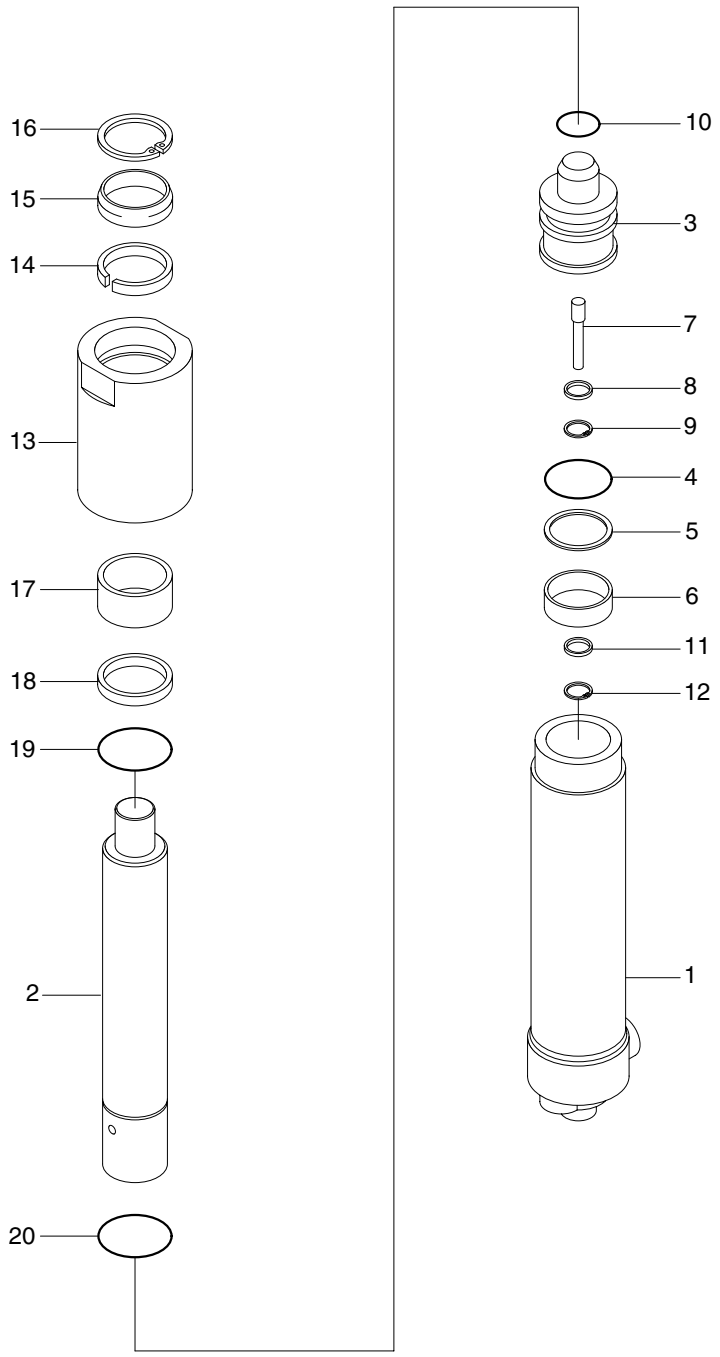
① Disassemble the valve sections on the flat working surface.
② Ensure that the disassembly area will be clean and free of contamination.
③ Keep the disassembly area neat to avoid loss or damage of parts.

(2) Perform the assembly in reverse order

① Remove the solenoid valves and ancillary blocks from the main blocks.
② Loosen the tie-rods from the valve section.
③ Remove the seals between valve section.
④ 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

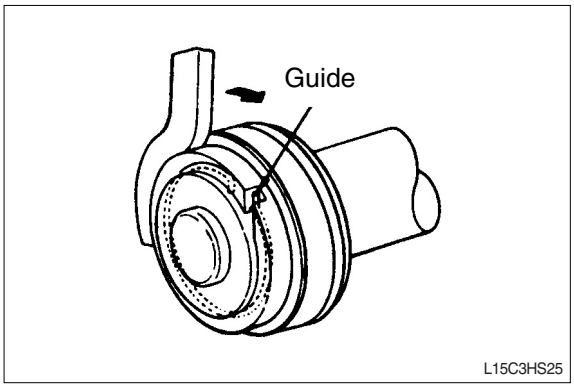


BRP7HS21

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.



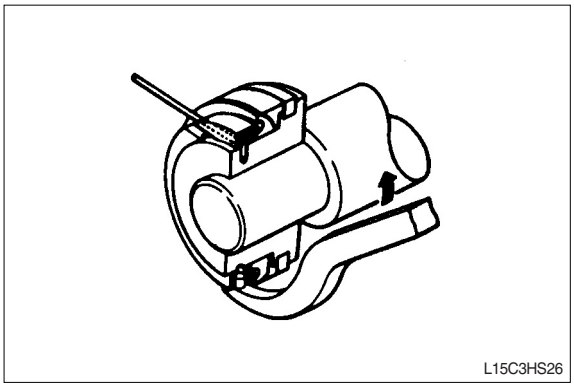
3) CHECK AND INSPECTION

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

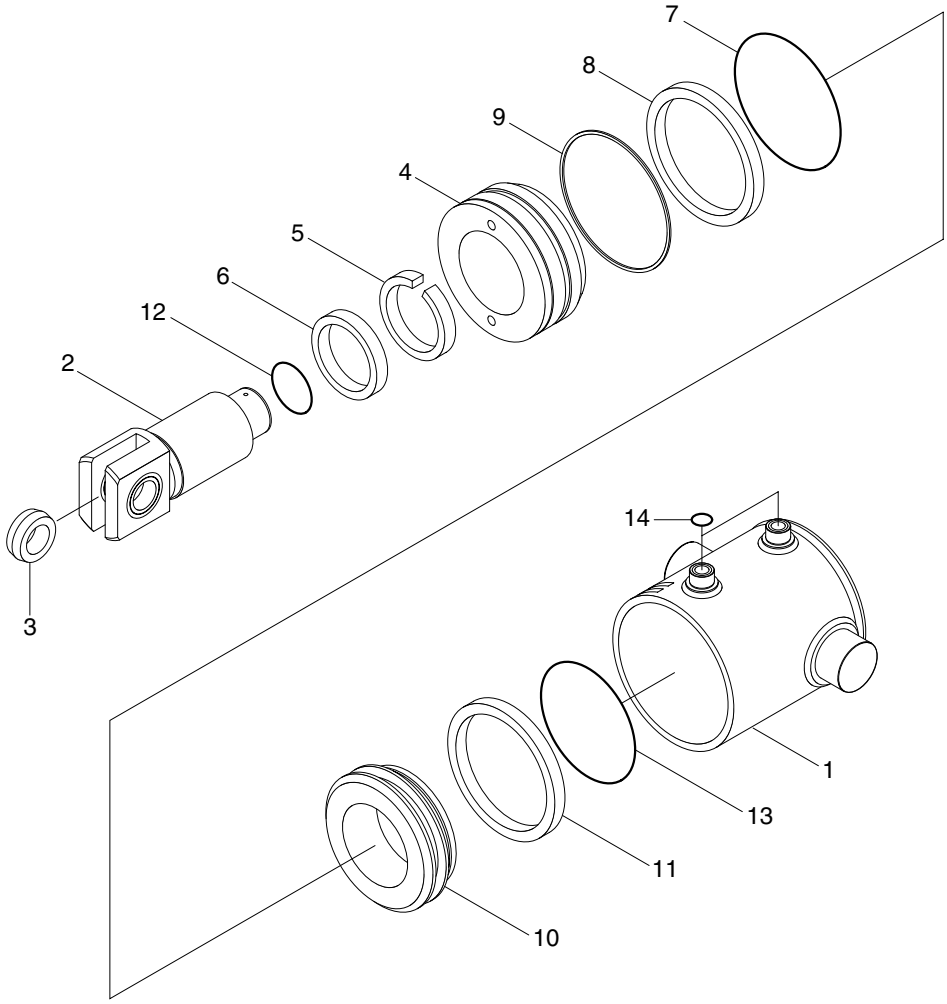
4) ASSEMBLY

(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.



4. TILT CYLINDER

1) STRUCTURE



BRP7HS25

1	Tube assy	6	Nylon nut	11	O-ring
2	Rod	7	Gland	12	O-ring
3	O-ring	8	DU bushing	13	O-ring
4	Piston	9	Rod seal		
5	Piston seal	10	Dust wiper		

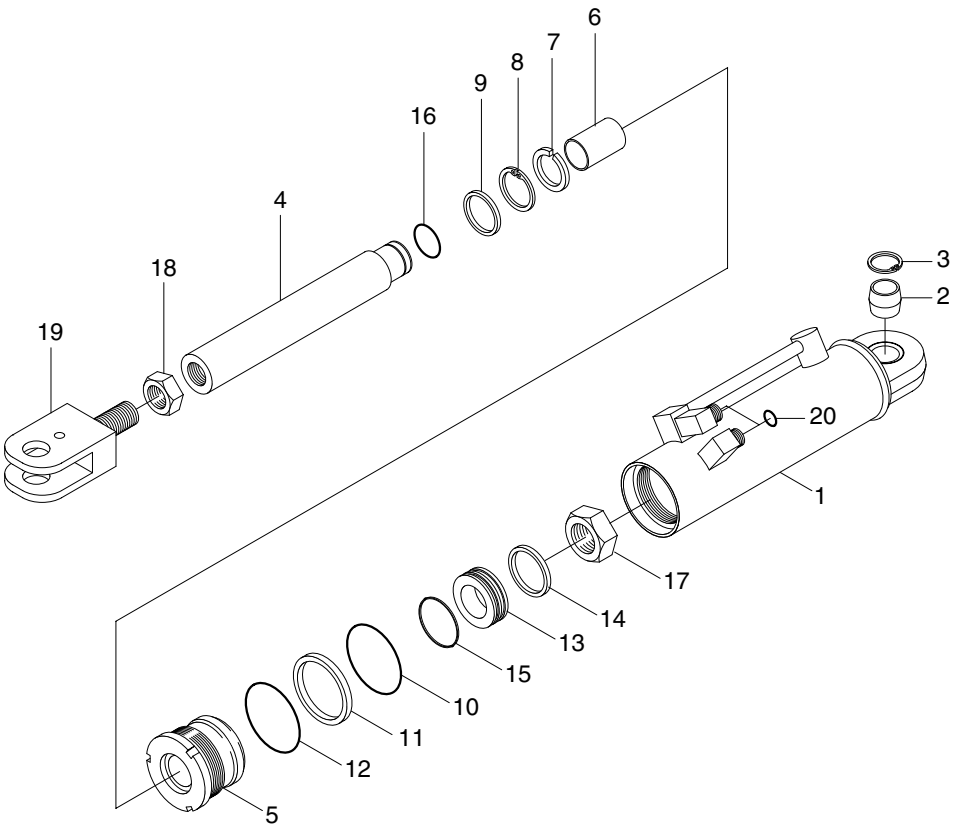
2) CHECK AND INSPECTION

mm(in)

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

5. REACH CYLINDER

1) STRUCTURE



BRP7HS27

1	Tube assy	7	Rod cover	13	Back up ring
2	Spherical bearing	8	Rod bush	14	O-ring
3	Retaining ring	9	U-packing	15	Piston
4	Spherical bearing	10	Back up ring	16	Piston seal
5	Retaining ring	11	Dust wiper	17	O-ring
6	Rod assy	12	O-ring	18	Hex nut

2) CHECK AND INSPECTION

mm(in)

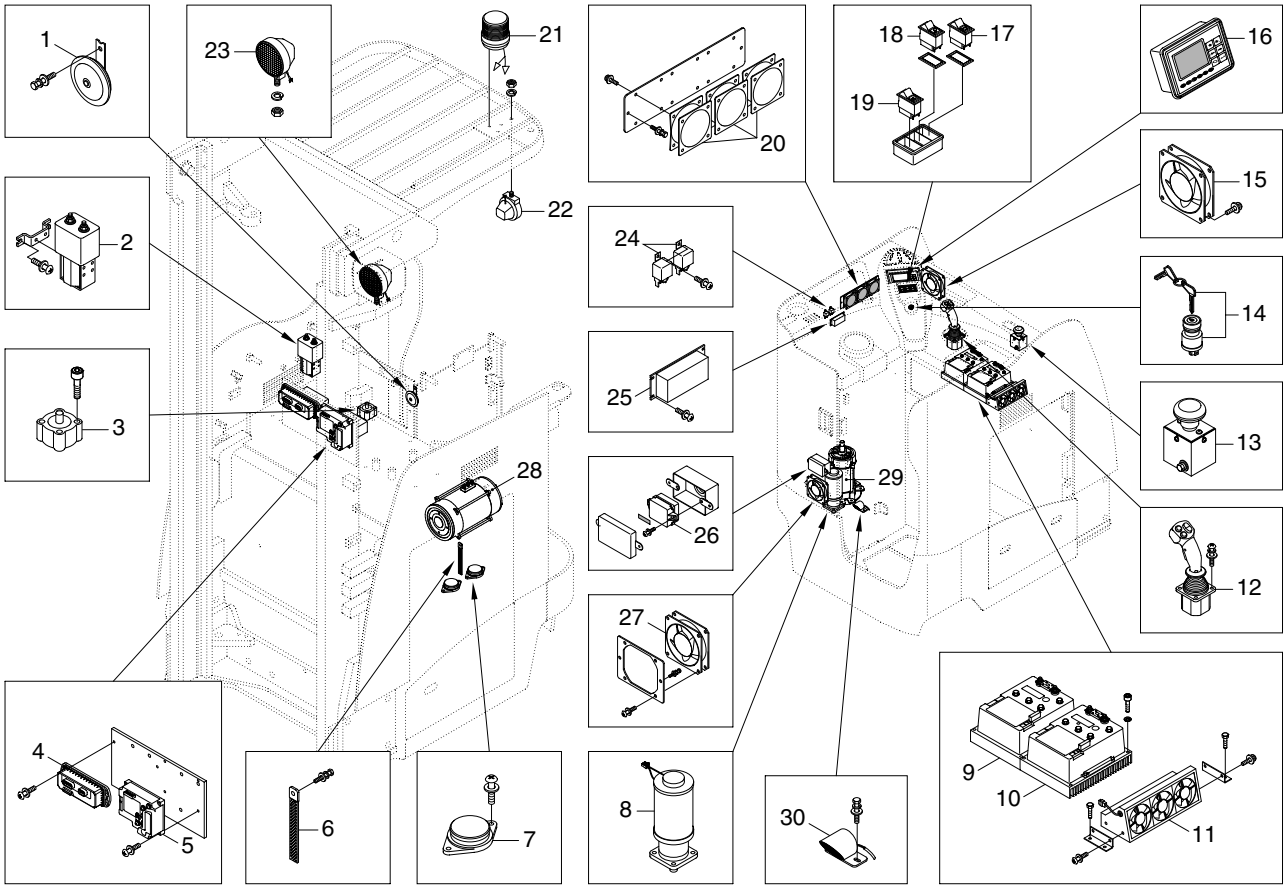
Check item	Standard size	Repair limit	Remedy
Clearance between cylinder rod & bushing	0.072~0.288 (0.003~0.011)	0.5 (0.020)	Replace bushing
Clearance between rod head bushing & pin	0.10~0.35 (0.004~0.014)	0.6 (0.024)	Replace bushing

SECTION 7 ELECTRICAL SYSTEM

Group 1 Component location ····· 7-1
Group 2 Electrical circuit ····· 7-2
Group 3 Electric components ····· 7-3

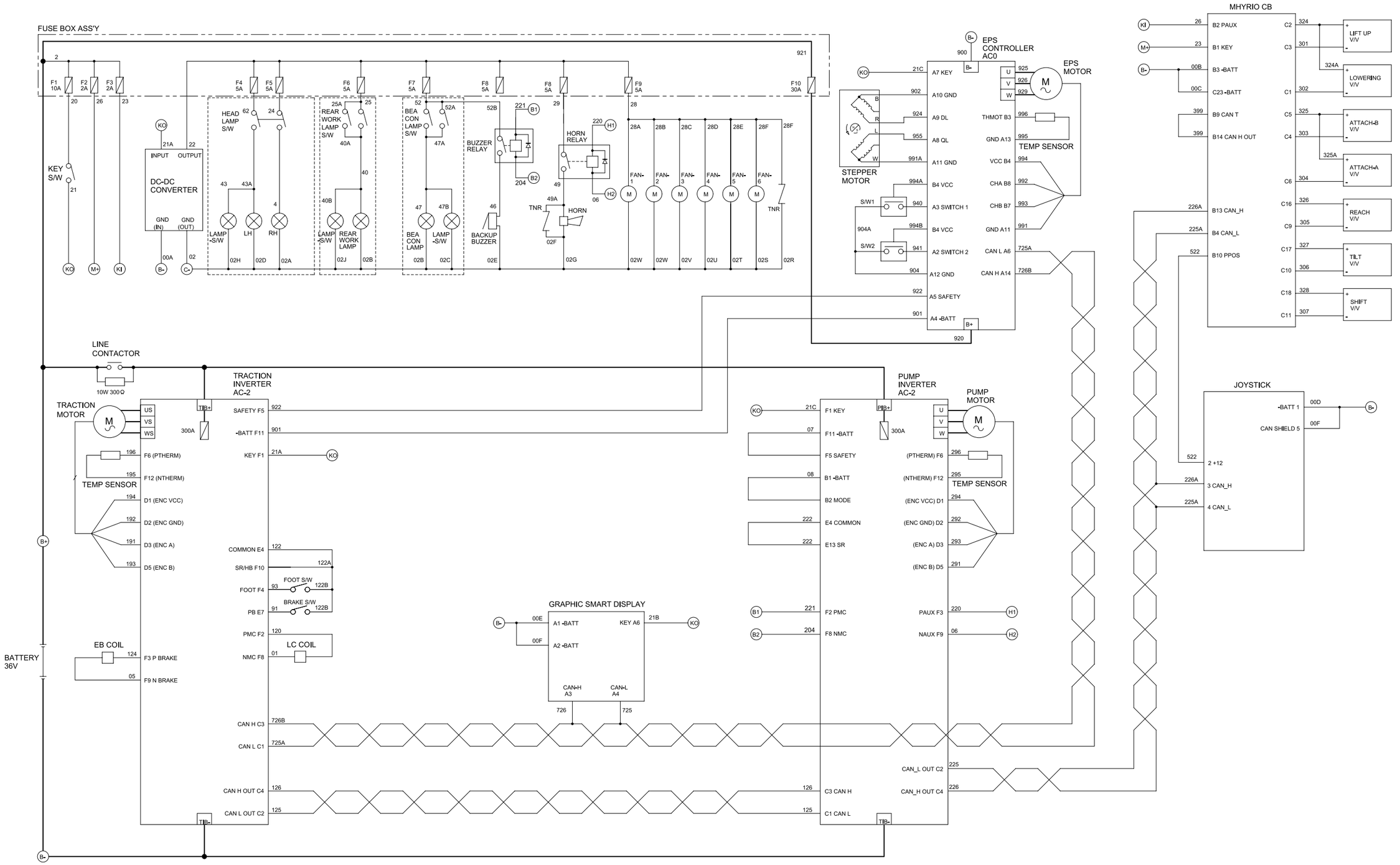
SECTION 7 ELECTRICAL SYSTEM

GROUP 1 COMPONENT LOCATION



BRP7EL01

1	High horn	11	Fan assy	21	Beacon lamp
2	Contactor	12	Joystick	22	Rear work lamp
3	Stepping & gear motor	13	Emergency switch	23	Front work lamp
4	Fingertip controller	14	Key switch assy	24	Relay
5	EPS control	15	Fan	25	DC converter
6	Static strap	16	Display	26	Fuse box assy
7	Dead man switch	17	Beacon switch	27	Fan
8	EPS motor	18	Work lamp switch	28	Pump motor
9	Inverter	19	Head right switch	29	Traction motor
10	Inverter	20	Fan	30	Back buzzer


FUSE BOX ASS'Y
F1 10A
F2 2A
F3 2A
F4 5A
F5 5A
F6 5A
F7 5A
F8 5A
F8 5A
F9 5A
F10 30A
KEY S/W
DC-DC CONVERTER
INPUT
OUTPUT
HEAD LAMP S/W
REAR WORK LAMP S/W
BEA CON LAMP S/W
BUZZER RELAY
HORN RELAY
HORN
BACKUP BUZZER
TNR
FAN-1
FAN-2
FAN-3
FAN-4
FAN-5
FAN-6
LAMP -S/W
LH
RH
REAR WORK LAMP
BEA CON LAMP
STEPPER MOTOR
EPS CONTROLLER AC0
EPS MOTOR
TEMP SENSOR
MHYRIO CB
B2 PAUX
B1 KEY
B3 -BATT
C23 -BATT
B9 CAN T
B14 CAN H OUT
B13 CAN_H
B4 CAN_L
B10 PPOS
LIFT UP V/V
LOWERING V/V
ATTACH-B V/V
ATTACH-A V/V
REACH V/V
TILT V/V
SHIFT V/V
JOYSTICK
-BATT 1
CAN SHIELD 5
2 +12
3 CAN_H
4 CAN_L
LINE CONTACTOR
10W 300Ω
TRACTION INVERTER AC-2
TRACTION MOTOR
TEMP SENSOR
EB COIL
LC COIL
BATTERY 36V
PUMP INVERTER AC-2
PUMP MOTOR
GRAPHIC SMART DISPLAY
CAN H C3
CAN L C1
CAN H OUT C4
CAN L OUT C2
CAN_L OUT C2
CAN_H OUT C4

BRP7EL02

GROUP 3 ELECTRIC COMPONENTS

1. FUNCTIONS OF BATTERY FORKLIFT TRUCK AND ELECTRIC COMPONENTS.

The major functions of forklift 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.

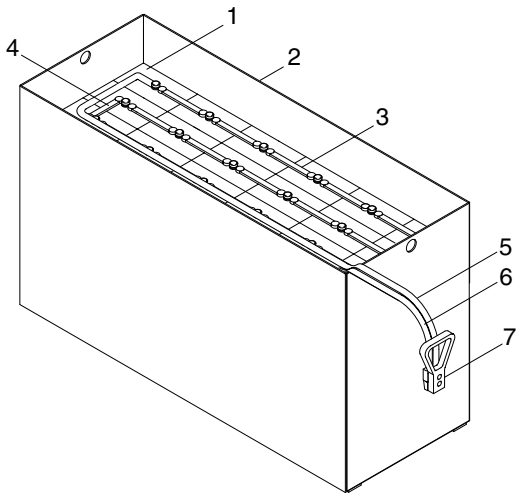
To drive the fork lift truck, a DRIVING CONTROL SYSTEM and a joystick is required to select the driving direction and to control the speed of driving motor.

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 forklift 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 his seat, and the SELF-DIAGNOSTIC function displays current status of truck in working.

2. BATTERY

1) STRUCTURE

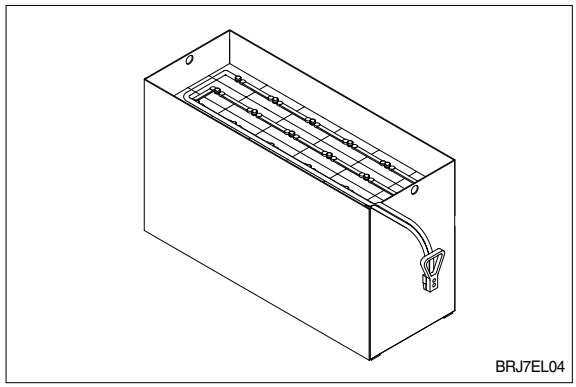


BRJ7EL03

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 forklift, the battery is an energy source, the handling of the battery is very important. The life and performance 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	36V
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.

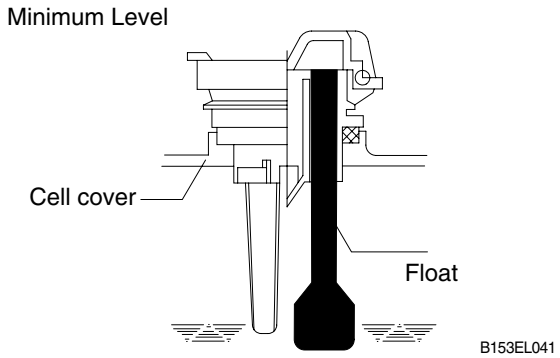
⑥ **Water replenishment**

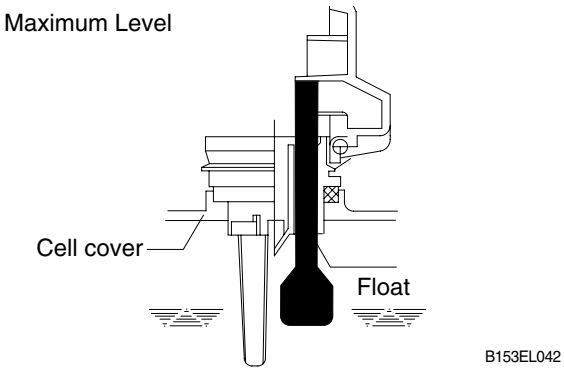
Only the water content of electrolyte is decreased due to electrolysis of water during charge and natural evaporation. If a battery used with the electrolyte decreased excessively, plates will deteriorate resulting in markedly shortening of battery life. Be sure to check the electrolyte level once every 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**

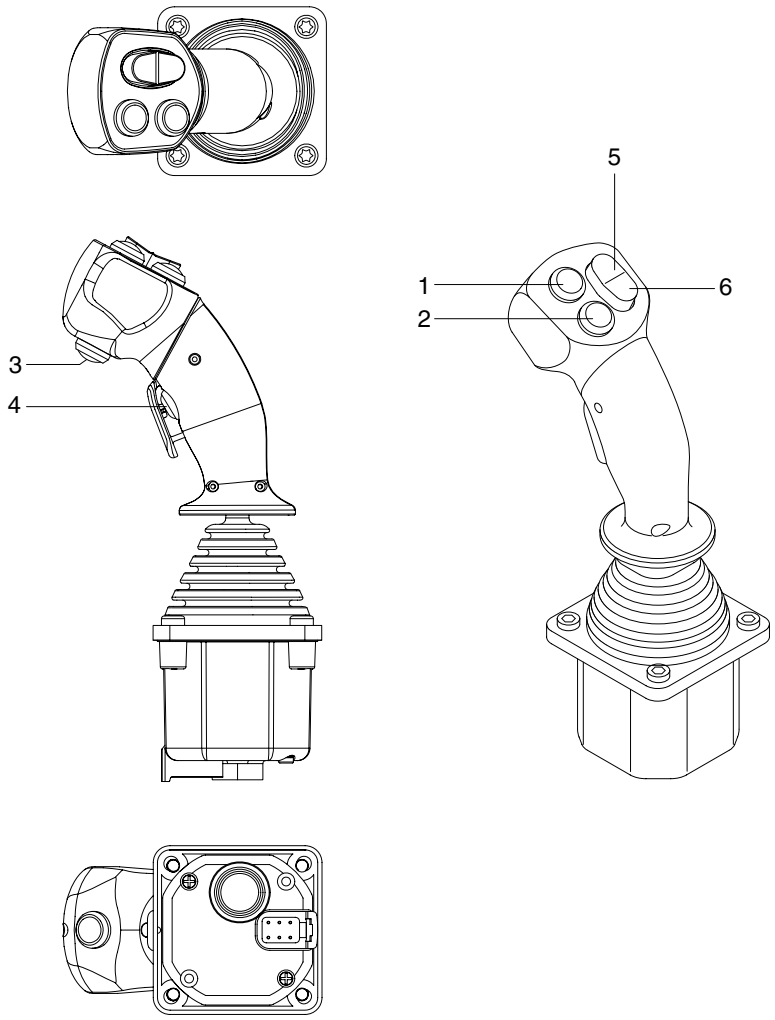
The operating temperature range of batteries is -10~45°C(temperature of electrolyte). If the batteries are exposed to cold atmosphere in discharged condition, the electrolyte may freeze, and in extreme cases, the capacity will be decreased, but, if not frozen, no adverse effects will be exerted over 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. JOYSTICK

1) STRUCTURE



BRP7JS01

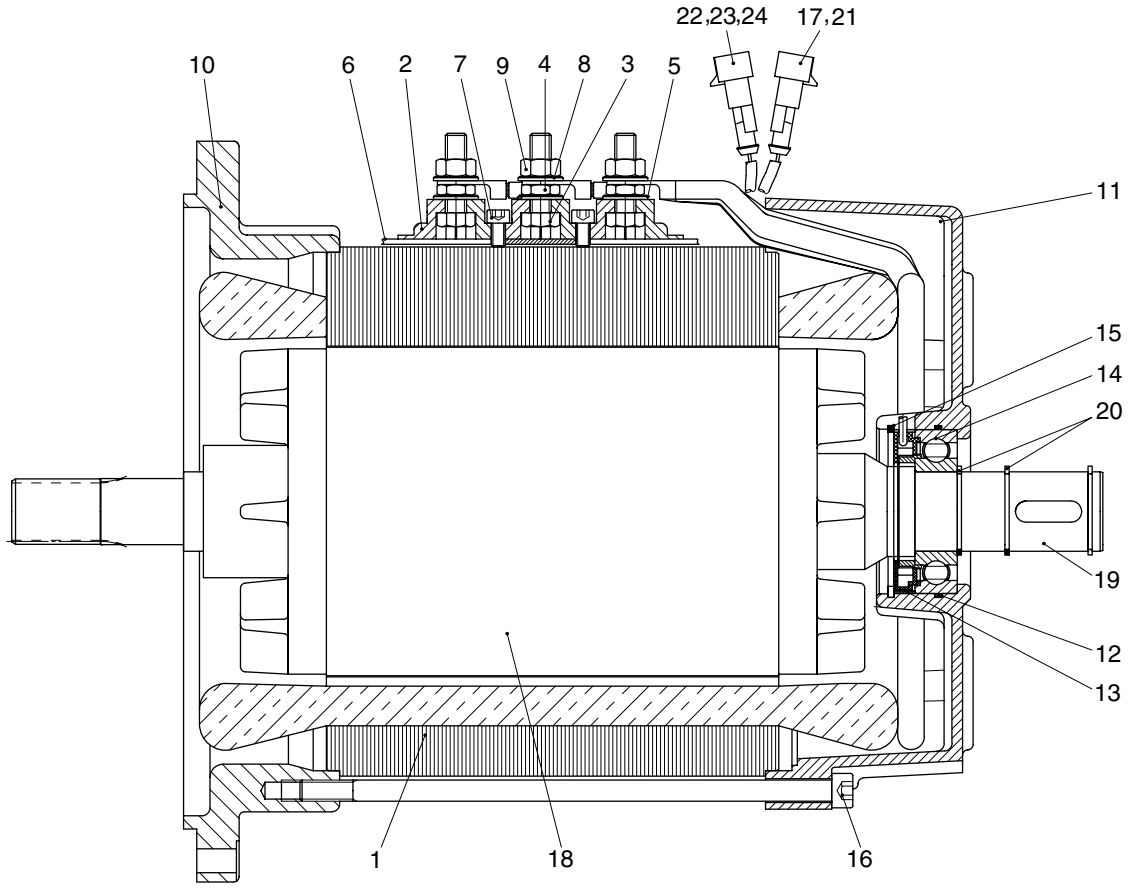
1 Tilt button
2 Side shift button
3 Horn button
4 Traction enable button
5 Reach button-out
6 Reach button-in

2) SPECIFICATION

Description			Unit	Specification
Electrical	Supply voltage		Vdc	9 to 36
	Maximum survival		Vdc	36
	Maximum current draw		mA	90
	CAN bus baund rate		kB	125 required
Mechanical	Mechanical angle		deg	±20 Nominally
	Operating force		N	12 to 19
	Operating life		cycle	15 million
	Seat		-	Heavy biased axis
	Mass		g	750 (without handle fitted)
Environmental characterstics	Operating temperature		°C	-40 to 70
	IP rating		-	IP66 above / below panel
	EMI/RFI rating		V/m	100
	Vibration (Sinusoidal)	Level 3.6G rms	-	Frequency range 10 to 200Hz (duration 2 hours each axis)
		Level ±3G peak	-	Frequency range 10 to 200Hz (duration 2 hours each axis)

3. DRIVE MOTOR

1) STRUCTURE



BRP7EL06

1	Stator	9	Hexagon nut	17	Thermal sensor
2	Terminal	10	Drive end ring	18	Rotor CPL
3	Hexagon screw	11	Commutator end plate	19	Key
4	Hexagon nut	12	O-ring	20	Circlip
5	Disk	13	Distance ring	21	Connector
6	Terminal base	14	Sensor bearing	22	Connector
7	Cylinder screw	15	Circlip	23	Flat-tabs
8	Disk	16	Screw	24	Plug seal

2) SPECIFICATION

Item	Unit	Specification
Type	-	TSA200-160-104
Rated voltage	Vac	24
Rated output	kW	6.8
Insulation	-	Class F

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.

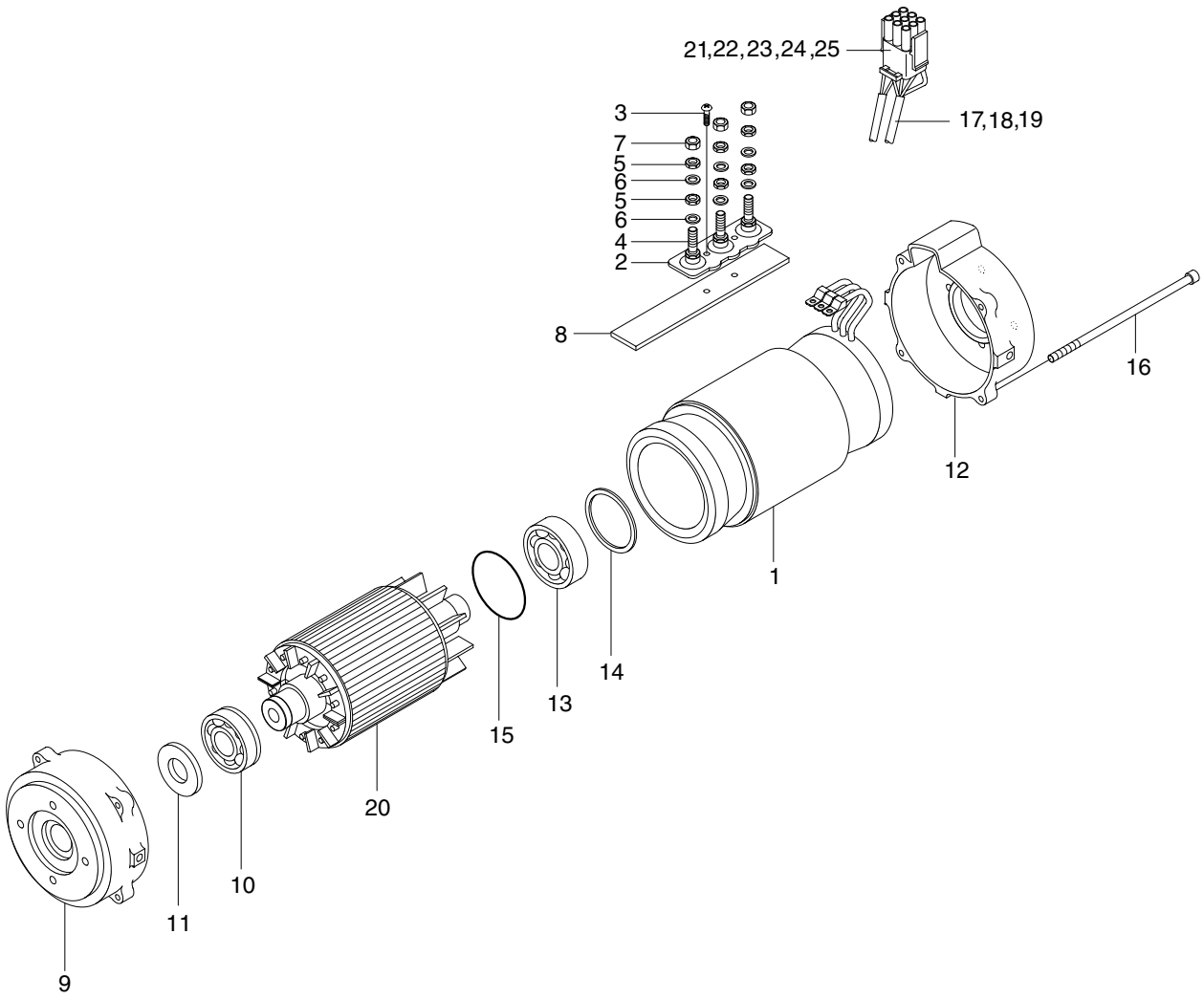
After approximately 10,000 operating hours the bearings have to be replaced.

(2) Disassembly and assembly

The motor is assembled and disassembled according to the relevant sectional drawing and part list. (See page 7-14)

4. PUMP MOTOR

1) STRUCTURE



BRP7EL07

1	Stator	10	Ball bearing	19	Pin
2	Terminal	11	Shaft seal	20	Rotor
3	Cylinder screw	12	Commutator end plate	21	Plug
4	Hexagon screw	13	Sensor bearing	22	Pin
5	Hexagon nut	14	Wavy washer	23	Keying plug
6	Disk	15	O-ring	24	Wire seal
7	Hexagon nut	16	Cylinder screw	25	Interface seal
8	Terminal base	17	Temperature sensor		
9	Drive end cover	18	Tube		

2) SPECIFICATION

Item	Unit	Specification
Type	-	TSA170-210-115
Nominal motor voltage	V	24
Rated output	kW	16
Insulation	-	Class F

3) INTERNAL INVOLUTE SPLINE DATA

Item	Unit	Specification
Flat root side fit	-	Class 7
No of teeth	EA	9
Spline pitch	mm	16/32
Pressure angle	Degree	30
Major diameter	mm	16.535
Form diameter	mm	15.977
Minor diameter	mm	12.9286
Pin diameter	mm	2.743
Measurement over 2 pins	mm	10.251/-0.1

4) MAINTENANCE INSTRUCTION

※ Before starting the maintenance please disconnect the power supply.

(1) Ball bearing

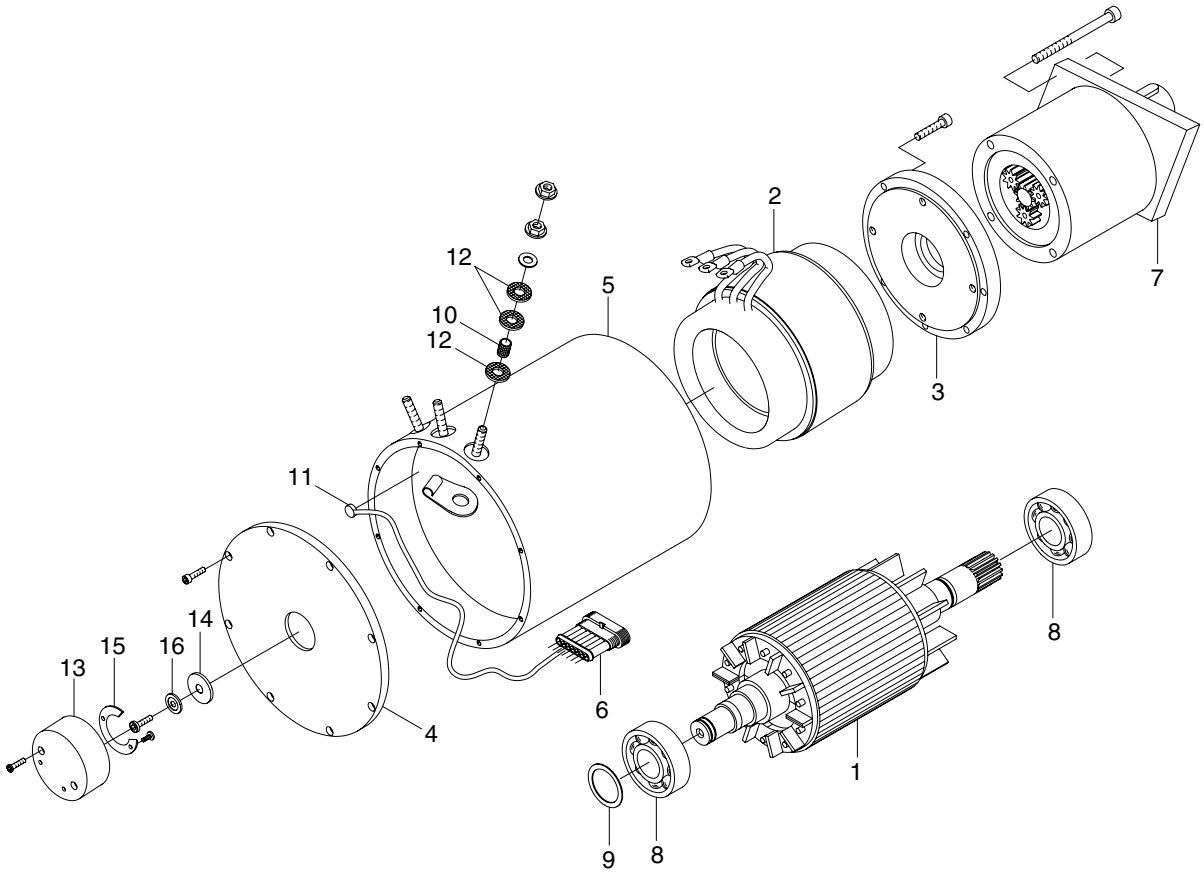
Both ball bearing are maintenance free. Should it be necessary to remove the bearings in case of repair, they should be replaced. In any case the sealing parts (shaft sealing ring etc.) have to be replaced.

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.

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

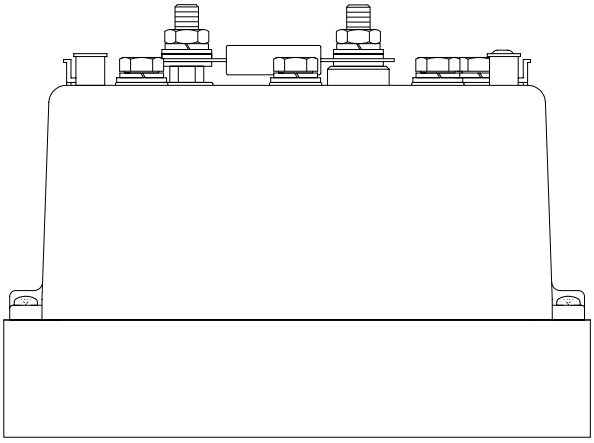
Both ball bearing are maintenance free. Should it be necessary to remove the bearings in case of repair, they should be replaced. In any case the sealing parts (shaft sealing ring etc.) have to be replaced.

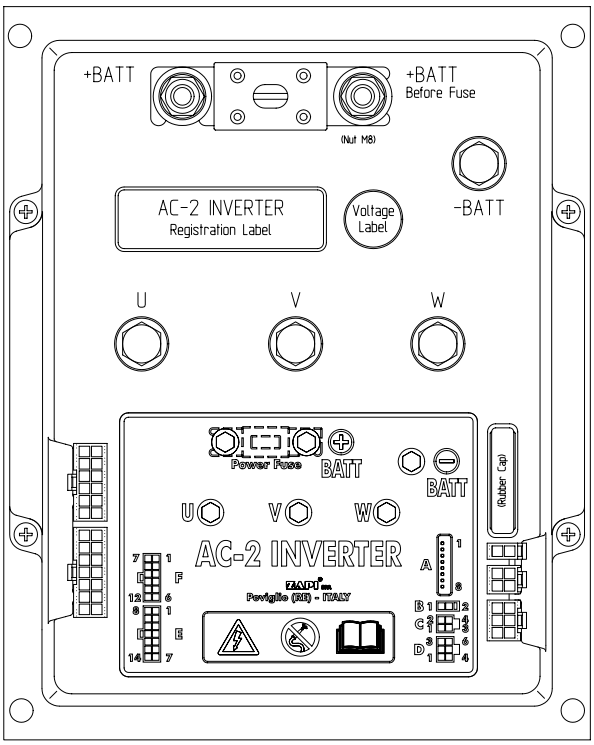
If a bearing which is to be replaced has only one sealing lip, this should be greased with quality bearing grease.

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

6. CONTROLLER SYSTEM

1) STRUCTURE





BRP7EL11

(1) Specifications

Model	Model	Application	Type	Power	Current limit
15/18/20/23BRP-7	AC2	Traction	AC	36-48V, 550A	550A/3min
	AC2	Pump	AC	36-48V, 450A	450A/3min

2) OPERATIONAL FEATURES

(1) Features

① Speed control.
② Optimum behavior an a slope due to the speed feedback:
- The motors speed follows the accelerator, starting a regenerative braking if the speed overtakes the speed set-point.
- The system can perform an electrical stop on a ramp (the machine is electrically hold on a slope) for a programmable time.

③ Electronic differential feature with torque balance between external and internal wheel.
④ Regenerative release braking based upon deceleration ramps.
⑤ Regenerative braking when the accelerator pedal is partially released (deceleration).
⑥ Direction inversion with regenerative braking based upon deceleration ramp.
⑦ Regenerative braking and direction inversion without contactors: only the main contactor is present.
⑧ Optimum sensitivity at low speeds.
⑨ Voltage boost at the start and with overload to obtain more torque (with current control).
⑩ Hydraulic steering function:
- The traction inverter sends a "hydraulic steering function" request to the pump inverter on the can-bus line.

⑪ Backing forward and reverse options are available, with the tune and the speed of the function programmable with a console or buttons on a display.
⑫ High efficiency of motor and battery due to high frequency commutations.
⑬ Modification of parameters through the programming console or buttons on a display.
⑭ Internal hour-meter with values that can be displayed on the console.
⑮ Memory of the last five alarms with relative hour-meter and temperature displayed on the console.
⑯ Diagnostic function with a console for checking main parameters.
⑰ Built in BDI feature.
⑱ Flash memory, software downloadable via serial link and via CANBUS.

(2) Diagnosis

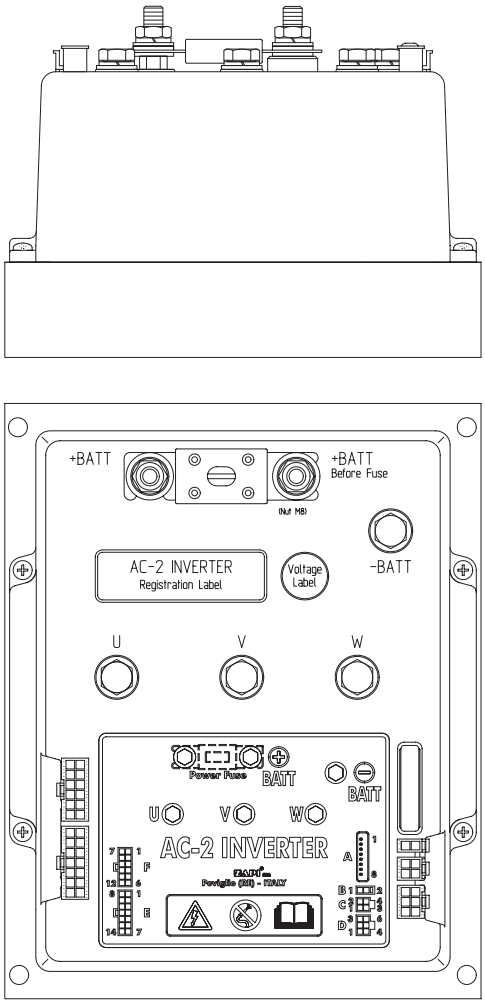
The microcontrollers continually monitor the inverter and carry out a diagnostic procedure on the main functions. The diagnosis is made in 4 points.

① Diagnosis on key switch closing that checks: watchdog circuit, current sensor, capacitor charging, phase's voltages, contactor drivers, can-bus interface, if the switch sequence for operation is correct and if the output of accelerator unit is correct, correct synchronization of the two μCS, integrity of safety related inputs hardware.
② Standby diagnosis in standby that checks: Watchdog circuit, phase's voltages, contactor driver, current sensor, can-bus interface.
③ Diagnosis during operation that checks: Watchdog circuits, contactor driver, current sensors, can-bus interface.
④ Continuous diagnosis that checks: Temperature of the inverter, motor temperature.

Diagnosis is provided in two ways. The digital console can be used, which gives a detailed information about the failure; the failure code is also sent on the Can-Bus.

3) DESCRIPTION OF THE CONNECTORS

(1) Traction controller



BRP7EL12

No. of Pin	Function	Description
A1	PCLRXD	Positive serial reception.
A2	NCLRXD	Negative serial reception.
A3	PCLTXD	Positive serial transmission.
A4	NCLTXD	Negative serial transmission.
A5	GND	Negative console power supply.
A6	+12	Positive console power supply.
A7	FLASH	It must be connected to A8 for the flash memory programming.
A8	FLASH	It must be connected to A7 for the flash memory programming.
C1	CAN_L	Low level CAN-BUS voltage I/O.
C2	CAN_L_OUT	Low level CAN-BUS voltage I/O.
C3	CAN_H	High level CAN-BUS voltage I/O.
C4	CAN_H_OUT	High level CAN-BUS voltage I/O.
D1~D6		Incremental ENCODER connector.
E4	COMMON	Common of pedal/FWD/REV/ENABLE/PB microswitches.

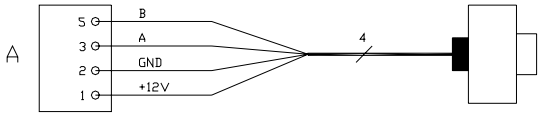
No. of Pin	Function	Description
E7	PB	Brake request input. It must be connected to the brake pedal switch, active high.
E10	NPO TB	-BATT.
E14	ENABLE	Accelerator enable function input. It must be connected to the accelerator enable switch. Active high.
F1	KEY	Connected to the power supply through a microswitch (CH) with a 10A fuse in series.
F2	PMC	Positive of main contactor coil.
F3	PBRAKE	Positive of the electro mechanical brake coil.
F4	PEDAL S/W	PEDAL S/W ; It must be connected to the PEDAL microswitch ; It is active high.
F5	SAFETY	If not connected to -Batt the MC coil power output will be disabled. It can also be used as a general purpose input.
F6	PTHERM	Input for motor temperature sensor.
F8	NMC	Negative of main contactor coil.
F9	NBRAKE	Output for driving a brake or an hydraulic steering contactor coil ; It drives the load to -Batt maximum current : 3A.
F10	SR/HB	Speed reduction (hand brake) input. Active low (switch opened). See also option chapter.
F11	GND	-Batt.
F12	NTHERM	-Batt.

Encoder installation

① Traction controller card is fit for different types of encoder. To control AC motor with a inverter, it is necessary to install an incremental encoder with 2 phases shifted of 90°. The encoder power supply can be +12V. It can have different electronic output.

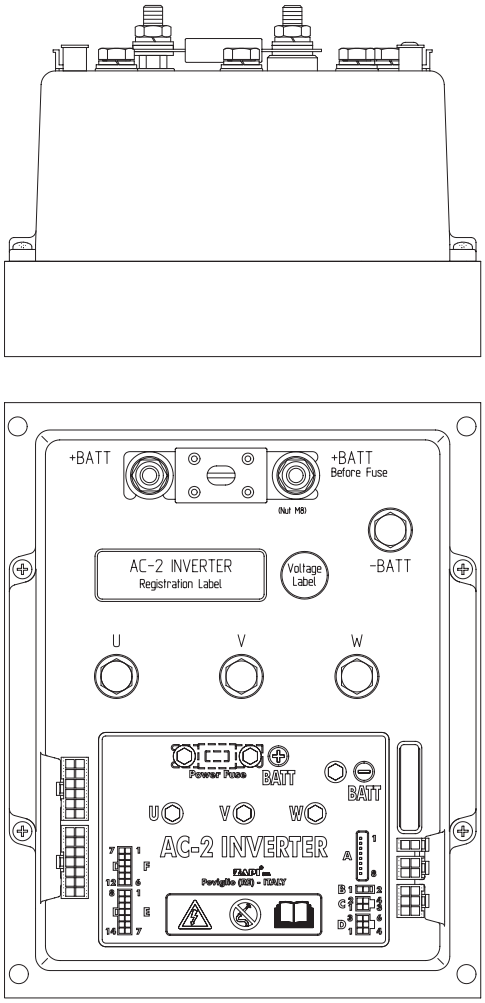
D1 : +12V - Positive of encoder power supply.
D2 : GND - Negative of encoder power supply.
D3 : A - Phase A of encoder.
D4 : B - Phase B of encoder.

② Connection of encoder with open collector output ; +12V power supply.



BRJ7EL26

(2) Pump controller



BRP7EL12

No. of Pin	Function	Description
A1	PCLRXD	Positive serial reception.
A2	NCLRXD	Negative serial reception.
A3	PCLTXD	Positive serial transmission.
A4	NCLTXD	Negative serial transmission.
A5	GND	Negative console power supply.
A6	+12	Positive console power supply.
A7	FLASH	It must be connected to A8 for the flash memory programming.
A8	FLASH	It must be connected to A7 for the flash memory programming.
B1	-BATT	-Batt.
B2	MODE	This input allows the customer to select the software for traction or lifting application. Configuration : Mode : Open (not connected) : Traction inverter Mode : Close (connected with B1) : Pump inverter
C1	CAN_L	Low level CAN-BUS voltage I/O.
C2	CAN_L_OUT	Low level CAN-BUS voltage I/O.
C3	CAN_H	High level CAN-BUS voltage I/O.
C4	CAN_H_OUT	High level CAN-BUS voltage I/O.

No. of Pin	Function	Description
D1~D6		Incremental ENCODER connector.
E4	CM	Positive of height limit microswitch
E13	HEIGHT LIMIT	Speed reduction input. Active low (switch opened).
F1	KEY	Connected to the power supply through a microswitch (CH) with a 10A fuse in series.
F2	P	Positive of buzzer relay output.
F3	P	Positive of horn relay output.
F5	SAFETY	If not connected to -Batt. the MC coil power output will be disabled. It can also be used as a general purpose input.
F6	PTHERM	Input for motor temperature sensor.
F8	N	Negative of buzzer relay output.
F9	N	Negative of horn relay output.
F11	BATT.	-Batt.
F12	NTHERM	-Batt.

4) FUNCTION CONFIGURATION

■ TRACTION CONTROLLER

Using the CONFIG MENU of the programming console, the user can configure the following functions (see "OPERATIONAL FEATURE" chapter for an explanation of "hydraulic steering function") :

(1) Submenu "SET OPTIONS"

① **Hour counter**
- RUNNING : The counter registers travel time only.
- KEY ON : The counter registers when the "key" switch is closed.

② **Battery check**
- ON : The battery discharge level check is carried out; when the battery level reaches 10%, an alarm is signalled and the maximum current is reduced to the half of the programmed value.
- OFF : The battery discharge level check is carried out but no alarm is signalled.

③ **Cutback mode**
- PRESENT : Input F10 is managed as a cutback speed input.
- ABSENT : Input F10 is managed as a handbrake input.

④ **Traction cutout**

When the alarm "BATTERY LOW" appears, if this option is programmed to ON the traction maximum speed is reduced to 60Hz.

⑤ **Lift cutout**

When the alarm "BATTERY LOW" appears, if this option is programmed to ON the lift function is disabled.

⑥ **Stop on ramp**
- ON : The stop on ramp feature (truck electrically hold on a ramp) is managed for a fixed time (6 sec.).
- OFF: The stop on ramp feature is not performed.

⑦ **Pedal brake**
- ANALOG : The mechanical brake pedal has a switch and a potentiometer installed. When the accelerator is released and the pedal brake is pushed the inverter performs an electrical braking whose intensity is proportional to the brake pedal potentiometer. The minimum intensity is established by the "Release braking" parameter, when the brake pedal is slightly pressed (brake switch close but brake potentiometer at the minimum). The maximum intensity is established by the "Pedal braking" parameter when the brake pedal is fully pressed (brake potentiometer at the maximum). In the middle positions, the electrical braking intensity is a linear function between minimum and maximum intensity.
- DIGITAL : The truck does not have a potentiometer installed on the mechanical brake pedal, but only a microswitch; when the accelerator pedal is released and the brake pedal is pushed (brake switch closed), the inverter performs an electrical braking following "Pedal braking" parameter.

⑧ **Set temperature**
- DIGITAL : A digital (ON/OFF) motor thermal sensor is connected to C25 (C35) input.
- ANALOG : An analog motor thermal sensor is connected to C25 (C35) (the curve can be customized on a customer request).
- NONE : No motor thermal sensor switch is connected.

⑨ **EPS**

- ON : If this option is set to ON, electric power steering function is used.
- OFF : If this option is set to OFF, electric power steering function isn't used.

⑩ **Display**

If this option is set to on the communication with the graphic display is enabled.

⑪ **S.R.O.**

If this option is set to on the static return to off is requested for starting the truck.
The required sequence is :
- Seat-direction lever-accelerator pedal or :
- Seat-accelerator pedal-direction lever within the weq. delay time

If this option is set to off the required sequence to start the truck is :
- Direction lever-accelerator pedal or :
- Accelerator pedal-direct lever within the seq. delay time

⑫ **Pedal type**

- OPTION #1 : The pedal position is sent to the display for graphic indication.
- OPTION #2 : The speed set-point is sent to the display for graphic indication.

⑬ **Pedal brake stop**

If set to on the truck is stopped when the pedal brake is pressed.
If set to off the traction current is reduced to the half of the maximum current.

⑭ **Model selection**

There are 2 options, 16/25.
In case of BRP-7 truck, it has to be selected 16 or 25(15/18BRP-7→16, 18/20/23BRP-7→25).

⑮ **Lift limit**

If the mast is lifted preset height, traction speed reduction is working depends on the setting status of this function.
- ON : If set to on this function, traction speed control is performed.
- OFF : If set to off this function, traction speed control isn't performed.

(2) Submenu "ADJUSTMENTS"

① **Set battery type**

It selects the nominal battery voltage.

② **Adjust battery**

Fine adjustment of the battery voltage measured by the controller.

③ **Throttle 0 zone**

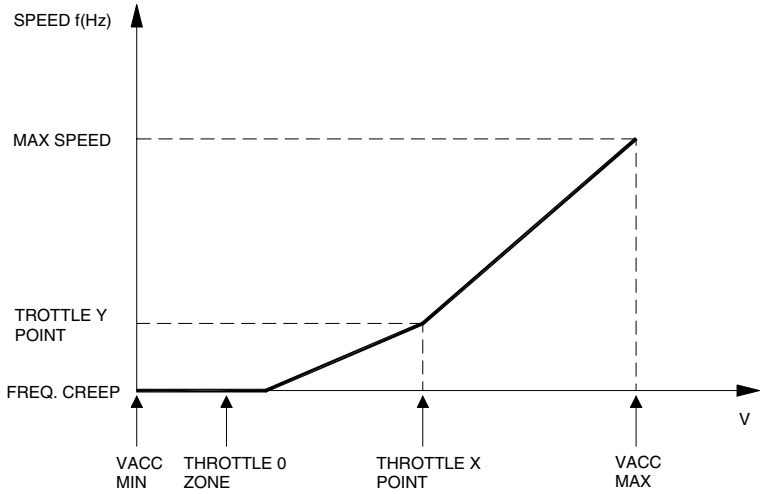
It establishes a deadband in the accelerator input curve (see also curve below).

④ **Throttle X point**

This parameter changes the characteristic of the accelerator input curve.

⑤ **Throttle Y point**

This parameter changes the characteristic of the accelerator input curve.



20B7EL17

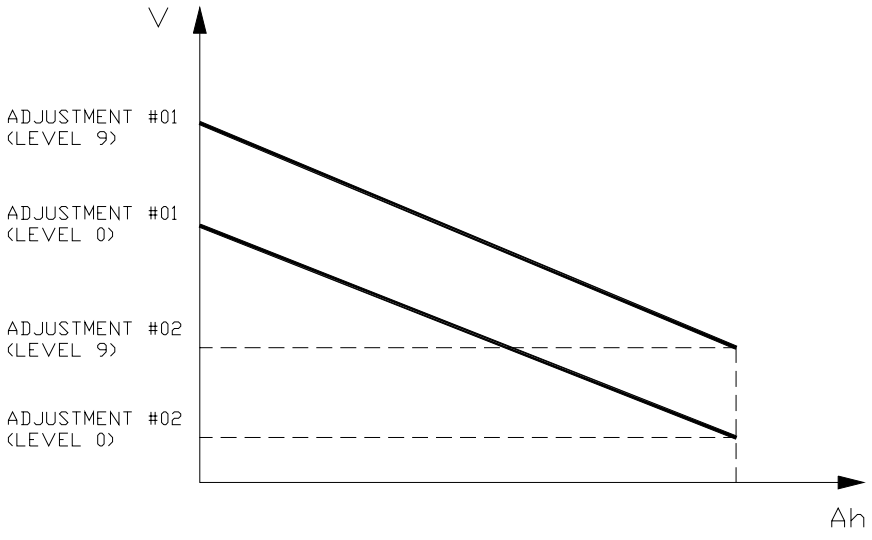
VACC MIN and VACC MAX are values programmable by the "Program Vacc" function.

⑥ **Adjustment #2 bdi**

It adjusts the lower level of the battery discharge table.

⑦ **Adjustment #1 bdi**

It adjusts the upper level of the battery discharge table.



BRJ7EL13

⑧ **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.

⑨ **PWM on main contactor**

- OFF : The inverter applies the battery voltage to the coil on F8 output.
- ON : The PWM reduces the voltage to the set value.

⑩ **PWM on aux output**

- OFF : The inverter applies the battery voltage to the coil on F9 output.
- ON : The PWM reduces the voltage to the set value.

⑪ **MC/AUX PWM** : It sets the PWM level in % on the outputs F8 and F9. Here is used to drive a main contactor.

⑫ **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"

⑬ **Speed factor**

It adjust 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(㎝)

P = number of pair poles of the motor

(3) Submenu "PARAMETER CHANGE"

① **Acceleration delay** : It determines the acceleration ramp.

② **Acceleration cutback** : It controls the acceleration ramps when lift limit is on.

③ **Release braking** : It controls the deceleration ramp when the travel request is released.

④ **Inverse braking** : It controls the deceleration ramp when the direction switch is inverted during travel.

⑤ **Pedal braking** : It determines the deceleration ramp when the travel request is released and the brake pedal switch is closed.

⑥ **Speed limit braking** : Deceleration ramp when the pedal position is changed but not completely released.

⑦ **Brake cutback** : It determines the deceleration ramp when the speed reduction input becomes active and the motor slow down.

⑧ **Max speed forward** : It determines the maximum speed in forward direction.

⑨ **Max speed backward** : It determines the maximum speed in backward direction.

⑩ **Turtle speed** : It determines the maximum speed at turtle mode.

⑪ **Cutback speed 1** : Typically from 10% to 100%. It determines the percentage of the max speed applied when the cutback switch is active. When set to 100% the speed reduction is ineffective.

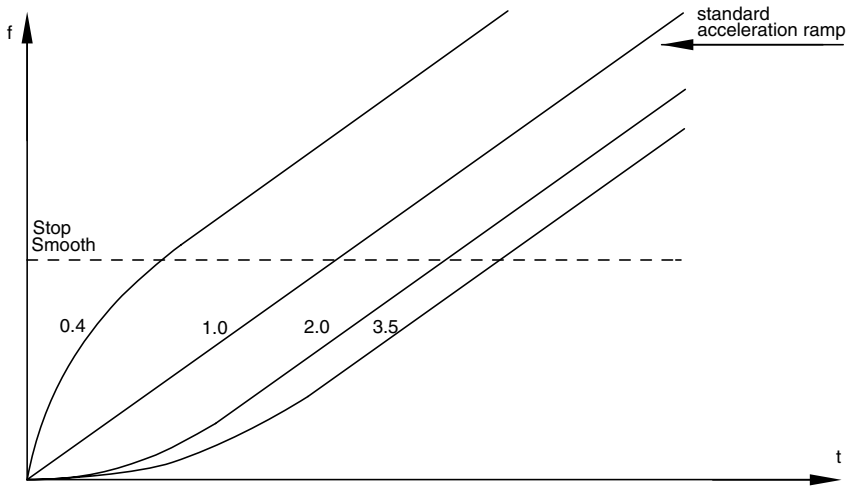
⑫ **Frequency creep** : Minimum speed when the forward or reverse switch is closed, but the accelerator is on a minimum position.

⑬ **Maximum current** : This parameter changes the maximum current of the inverter.

⑭ **Acc. smooth** : It gives a different from to the acceleration curve in the frequency range 0 Hz to "Stop smooth" value (seel the figure below).

⑮ **INV. smooth** : It gives a different from to the acceleration curve after a direction inversion in the frequency range 0 Hz to "Stop smooth" value (see the figure below).

⑯ **Stop smooth** : It sets the level of frequency where the smooth effect on the acceleration ramp ends.



BRJ7EL14A

⑰ **Seat delay time** : It sets the delay time after the seat switch is off.
⑱ **Sequence delay** : It sets the delay from the accelerator enable to direction signal input.
⑲ **Chat time** : It sets the time from the time main contactor is on to the time seat switch is on.
⑳ **Curve cutback** : Speed reduction when the truck is doing a curve. The parameter sets the speed setpoint when the truck driving wheels are running in opposite direction or when the maximum steering angle is reached.
㉑ **Dead angle** : It determines the tire angle range be able to get full speed.
㉒ **Lift limit CTB** : It sets the traction speed when lift limit is on.

■ PUMP CONTROLLER

Using the config menu of the programming console, the user can configure the following functions.

(1) Submenu "SET OPTIONS"

① **Hour counter**
- RUNNING : The counter registers travel time only.
- KEY ON : The counter registers when the "key" switch is closed.

② **Set temperature**
- DIGITAL : A digital (ON/OFF) motor thermal sensor is connected to A25 input.
- ANALOG : An analog motor thermal sensor is connected A25 (the curve can be customized on a customer request).
- NONE : No motor thermal sensor switch is connected.

③ **Mode selection**

there are 2 options, 16/25.

In case of BRP-7 truck, It has to be selected 16 or 25 (15/18BRP-7→16, 20/23BRP-7→25)

④ **Digital lift**
- OFF : The lift sensor includes a lift switch and an analogue lift sensor. Lift speed can be controlled proportionally with lever position.
- ON : The lift sensor includes a lift switch only. Lift speed cannot be controlled proportionally.

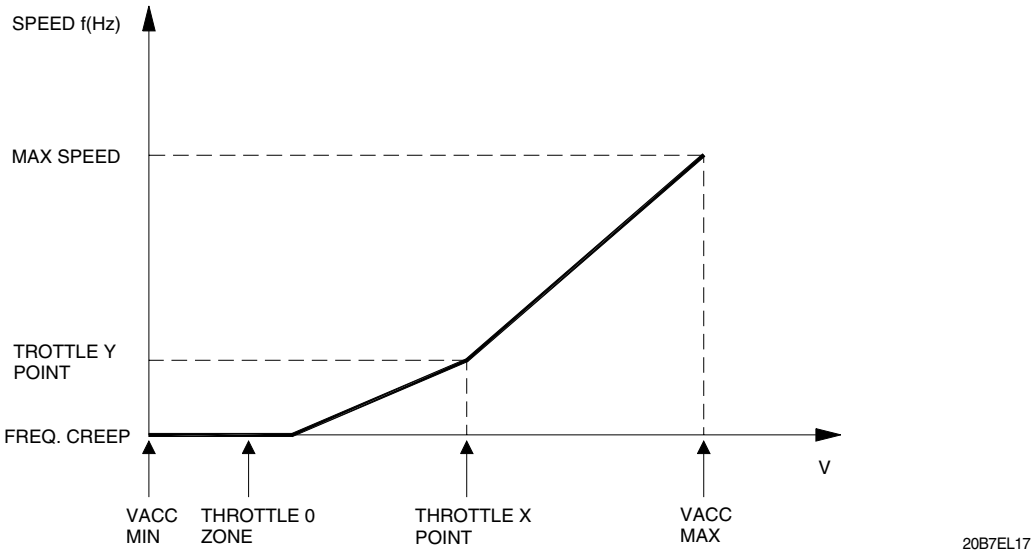
⑤ **Lifting Cutback**

If the mast is lifted preset height, Lift speed reduction is working depends on the setting status of this function.

- ON : If set to on this function, Lift speed control is performed.
- OFF : If set to off this function, Lift speed control isn't performed.

(2) Submenu "ADJUSTMENTS"

① **Set battery type** : Selects the nominal battery voltage.
② **Adjust battery** : Fine adjustment of the battery voltage measured by the controller.
③ **Throttle 0 zone** : Establishes a deadband in the accelerator input curve (see also curve below).
④ **Throttle X zone** : This parameter changes the characteristic of the accelerator input curve.
⑤ **Throttle Y zone** : This parameter changes the characteristic of the accelerator input curve.



VACC MIN and VACC MAX are values programmable by the "PROGRAM VACC" function.

⑥ **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"

⑦ **PWM on main contactor**

-OFF: The inverter applies the battery voltage to the coil on F8 output.
-ON: The PWM reduces the voltage to the set value.

⑧ **PWM on aux output**

-OFF: The inverter applies the battery voltage to the coil on F9 output.
-ON: The PWM reduces the voltage to the set value.

⑨ **MC/AUX PWM**: It sets the PWM level in % on the outputs F8 and F9.

(3) Submenu "PARAMETER CHANGE"

① **Acceleration delay :** It determines the acceleration ramp.
② **Deceleration delay :** It determines the acceleration ramp.
③ **Max speed up :** It determines the maximum lifting speed with a potentiometer control.
④ **Min speed up :** It determines the minimum lifting speed with a potentiometer control when the lifting enable switch is closed.
⑤ **Cutback speed :** Speed reduction when the cutback switch is active.
⑥ **Reach speed :** It determines the reach speed.
⑦ **Shift speed :** It determines the side shift speed.
⑧ **Tilt speed :** It determines the tilt speed.
⑨ **Aux speed :** It determines the aux speed.
⑩ **Maximum current :** This parameter changes the maximum current of the inverter.
⑪ **Lifting speed 2 :** It determines the lifting speed when lift limit is on.
⑫ **ADJ curr buzzer :** It is the setting value to ring the back buzzer.

5) PROGRAMMING & ADJUSTMENTS

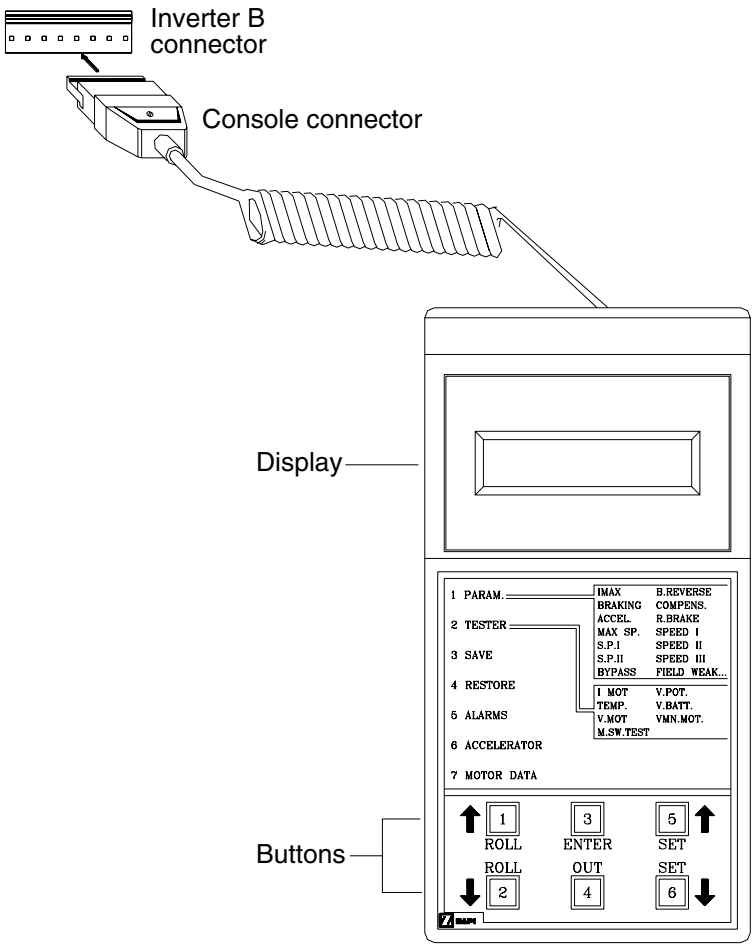
There are two ways to adjust parameter via a console or buttons on a display.

※ Adjustments via buttons on a display, please refer to the display section. (page 7-44)

ADJUSTMENTS VIA CONSOLE (Option)

Adjustment of parameters and changes to the inverter's configuration are made using the digital console. The console is connected to the "B" connector of the inverter.

(1) Descriptions of console

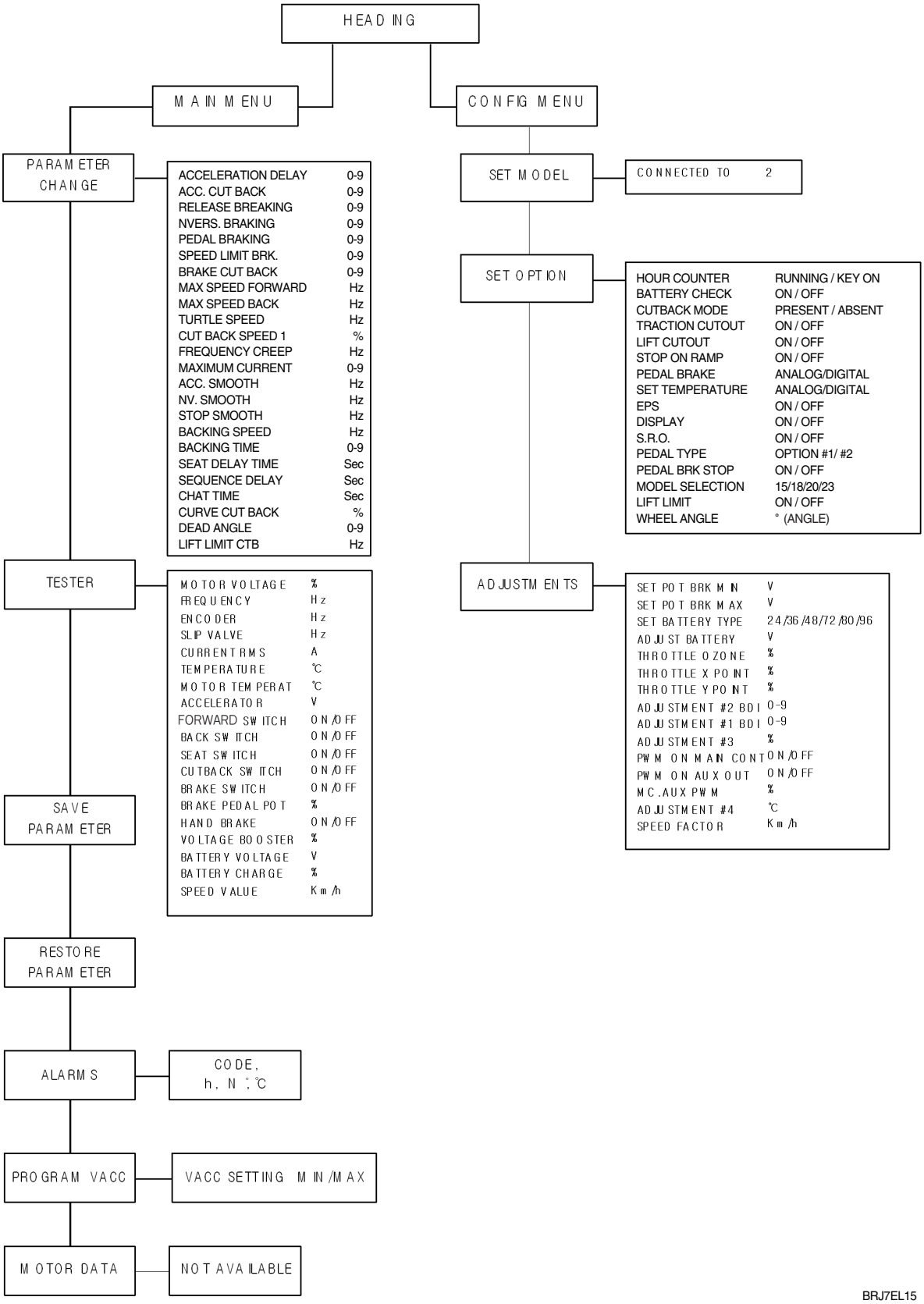


20B7EL15

※ Digital consoles used to communicate with AC inverter controllers must be fitted with EPROM CK ULTRA, minimum "Release number 3.02".

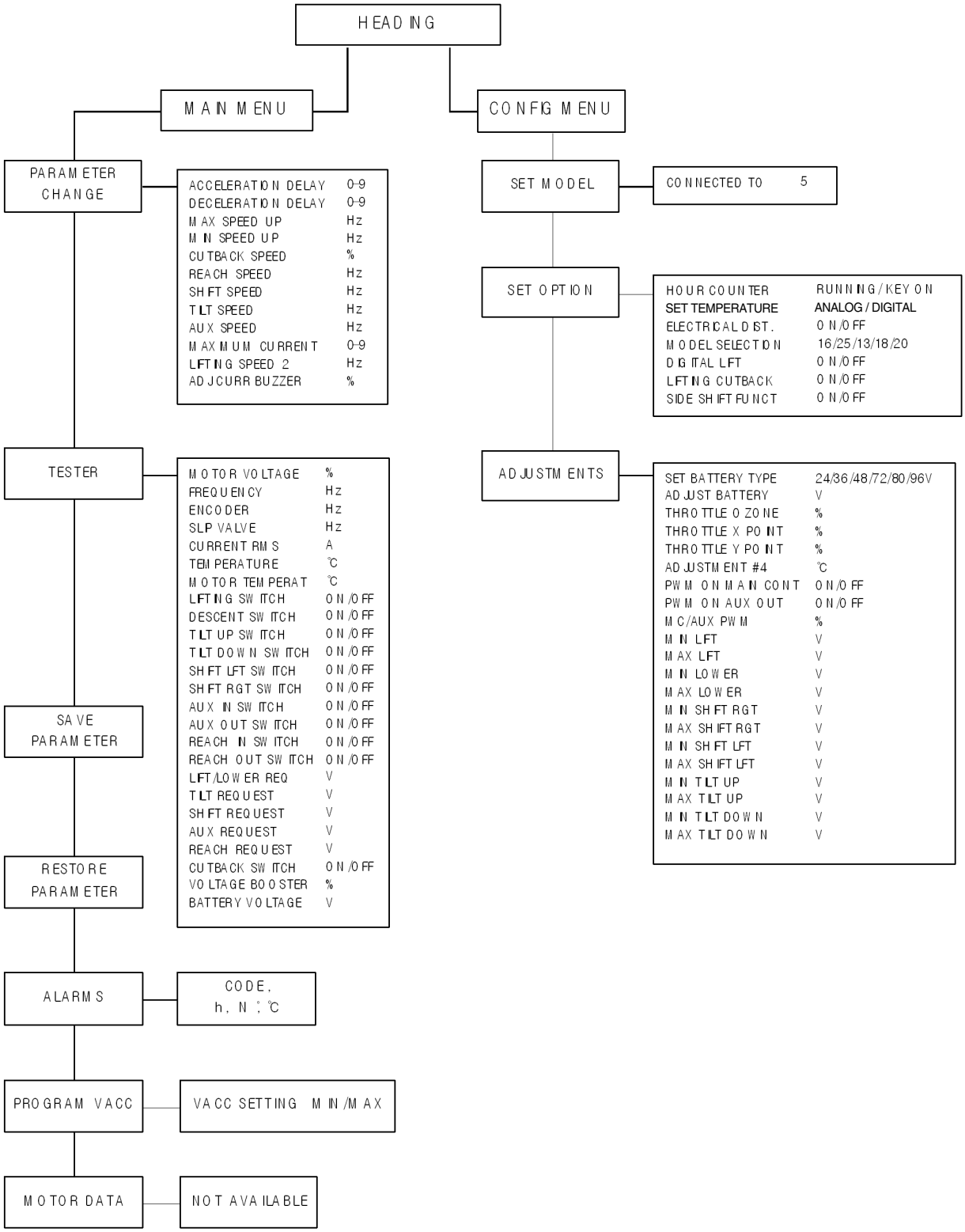
(2) Description of standard console menu

① Traction controller



BRJ7EL15

② Pump controller



BRJ7EL16

(3) Description of ALARMS 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, the hour meter count, and the inverter temperature.
This function permits a 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 display.

② Press ENTER to go into the general menu.

③ The display will show:

④ Press ROLL UP or ROLL DOWN button until PARAMETER CHANGE. appear on the display.

⑤ The display shows:

⑥ Press ENTER to go into the ALARMS function.

⑦ The display will show the most recent alarm.

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

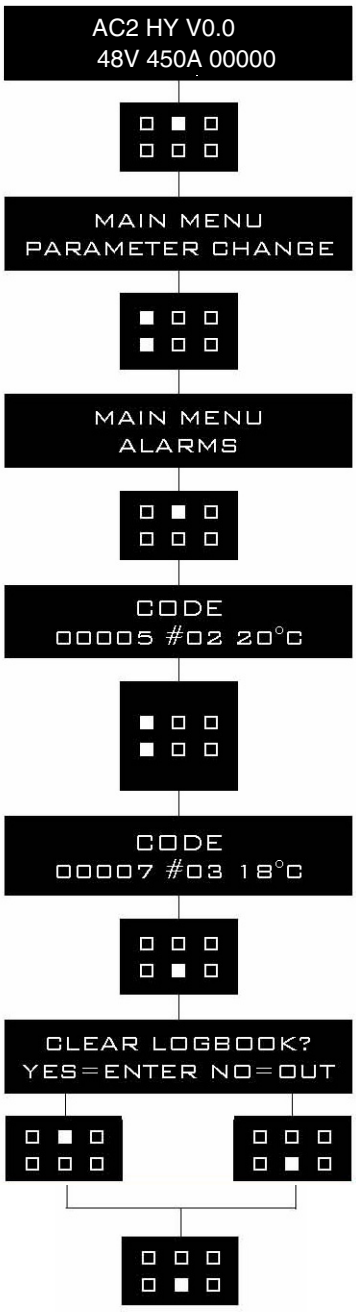
⑨ If an alarm has not occurred, the display will show: ALARM NULL.

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

⑪ The display will ask "CLEAR LOGBOOK?".

⑫ Press ENTER for yes, or OUT for NO.

⑬ Press OUT to return to the opening Zapi display.



BRJ7EL23

6) TESTER MENU

(1) Traction controller

The most important input or output signals can be measured in real time using the TESTER function of the console. The Console acts as a multimeter able to read voltage, current and temperature. In the following chapter a list of relative measurements for different configurations.

① **Motor voltage**

This is the voltage supplied to the motor by the inverter; it is expressed as a percentage of the full voltage (which depends of the battery voltage).

② **Frequency**

This is the frequency of the voltage and current supplied to the motor.

③ **Encoder**

This is the speed of the motor, expressed in the same unit of the frequency; this information comes from the speed sensor.

④ **Slip value**

This is the difference of speed between the rotating field and the shaft of the motor, expressed in the same unit of the frequency.

⑤ **Current rms**

Root Mean Square value of the motor current.

⑥ **Temperature**

The temperature measured on the aluminum heat sink holding the MOSFET devices.

⑦ **Motor temperature**

This is the temperature of the motor; if the option is programmed "None" it shows 0°.

⑧ **Accelerator**

The voltage of the accelerator potentiometer's wiper (CPOT). The voltage level is shown on the left hand side of the console display and the value in percentage is shown on the right hand side.

⑨ **Forward switch**

The level of the forward direction digital entry FW.

- ON / +VB = Active entry of closed switch.
- OFF / GND = Non active entry of open switch.

⑩ **Backward switch**

The level of the reverse direction digital entry BW.

- ON / +VB = Active entry of closed switch.
- OFF / GND = Non active entry of open switch

⑪ **Dead man switch**

The level of the dead man microswitch digital entry.

- ON / +VB = Active entry of closed switch.
- OFF / GND = Non active entry of open switch.

⑫ **Cutback switch**

The level of the speed reduction microswitch.

- ON / GND = Input active, switch opened
- OFF / +VB = Input non active, switch closed.

⑬ **Brake switch**

The level of the pedal brake microswitch.

- ON / +VB = Input active, switch closed.
- OFF / GND = Input non active, switch open.

⑭ **Brake pedal pot.**

Voltage of the brake potentiometer's wiper (CPOTB). The parameter is active only if the PEDAL BRAKING parameter is set ANALOG.

⑮ **Hand brake**

The level of the handbrake microswitch.

- ON / GND = Input active, switch opened.
- OFF / +VB = Input non active, switch closed.

⑯ **Voltage booster**

This is the booster of the voltage supplied to the motor in load condition; it is expressed in a percentage of the full voltage.

⑰ **Battery voltage**

Level of battery voltage measured at the input of the key switch.

⑱ **Battery charge**

The percentage charge level of the battery.

⑲ **Speed value**

This is the speed value of drive.

(2) Pump controller

The most important input or output signals can be measured in real time using the TESTER function of the console. The Console acts as a multimeter able to read voltage, current and temperature. In the following chapter a list of relative measurements for different configurations.

① **Motor voltage**

This is the voltage supplied to the motor by the inverter; it is expressed as a percentage of the full voltage (which depends of the battery voltage).

② **Frequency**

This is the frequency of the voltage and current supplied to the motor.

③ **Encoder**

This is the speed of the motor, expressed in the same unit of the frequency; this information comes from the speed sensor.

④ **Slip value**

This is the difference of speed between the rotating field and the shaft of the motor, expressed in the same unit of the frequency.

⑤ **Current RMS**

Root mean square value of the motor current.

⑥ **Temperature**

The temperature measured on the aluminum heat sink holding the MOSFETdevices.

⑦ **Motor temperature**

This is the temperature of the motor; if the option is programmed "None" it shows 0°.

⑧ **Lifting switch**

Status of the lifting switch.

- ON / +VB = Active entry of closed switch.
- OFF / GND = Non active entry of open switch.

⑨ **Descent switch**

Status of the lowering speed switch of the pump.

- ON / +VB = Active entry of closed switch.
- OFF / GND = Non active entry of open switch.

⑩ **Tilt up switch**

Status of the tilt up switch of the pump.

- ON / +VB = Active entry of closed switch.
- OFF / GND = Non active entry of open switch.

⑪ **Tilt down switch**

Status of the tilt down switch of the pump.

- ON / +VB = Active entry of closed switch.
- OFF / GND = Non active entry of open switch.

⑫ **Shift left switch**

Status of the shift left speed switch of the pump.

- ON / +VB = Active entry of closed switch.
- OFF / GND = Non active entry of open switch.

⑬ **Shift right switch**

Status of the shift right speed switch of the pump.

- ON / +VB = Active entry of closed switch.
- OFF / GND = Non active entry of open switch.

⑭ **Aux in switch**

Status of the aux in switch of the pump.

- ON / +VB = Active entry of closed switch.
- OFF / GND = Non active entry of open switch.

⑮ **Aux out switch**

Status of the aux out switch of the pump.

- ON / +VB = Active entry of closed switch.
- OFF / GND = Non active entry of open switch.

⑯ **Reach in switch**

Status of the reach in switch of the pump.

- ON / +VB = Active entry of closed switch.
- OFF / GND = Non active entry of open switch.

⑰ **Reach out switch**

Status of the reach out switch of the pump.

- ON / +VB = Active entry of closed switch.
- OFF / GND = Non active entry of open switch.

⑱ **Lift/lower request**

Level of the lift and lower analogue signal. The voltage is shown on the left hand side of the display and the value in percentage on the right hand side.

⑲ **Tilt request**

Level of the tilt analogue signal. The voltage is shown on the left hand side of the display and the value in percentage on the right hand side.

⑳ **Shift request**

Level of the shift analogue signal. The voltage is shown on the left hand side of the display and the value in percentage on the right hand side.

㉑ **Aux request**

Level of the auxiliary analogue signal. The voltage is shown on the left hand side of the display and the value in percentage on the right hand side.

㉒ **Reach request**

Level of the reach analogue signal. The voltage is shown on the left hand side of the display and the value in percentage on the right hand side.

㉓ **Cutback switch**

The level of the speed reduction microswitch.

- ON / GND = Input active, switch opened.
- OFF / +VB = Input non active, switch closed.

㉔ **Voltage booster**

This is the booster of the voltage supplied to the motor in load condition; it is expressed in a percentage of the full voltage.

㉕ **Battery voltage**

Level of battery voltage measured at the input of the key switch.

7) GENERAL SUGGESTION FOR SAFETY

For a proper installation take care of the following recommendations:

⚠ After operation, even with the key switch open, the internal capacitors may remain charged for some time. For safe operation, we recommend that the battery is disconnected, and a short circuit is made between battery positive and battery negative power terminals of the inverter using a resister between 10 ohm and 100 ohm.

⚠ Do not connect the inverter to a battery with a nominal value different from the value indicated on the controller plate. If the battery value is greater, the MOS may fail; if it is lower, the control unit does not "power up"

⚠ During battery charge, disconnect the controller from the battery.

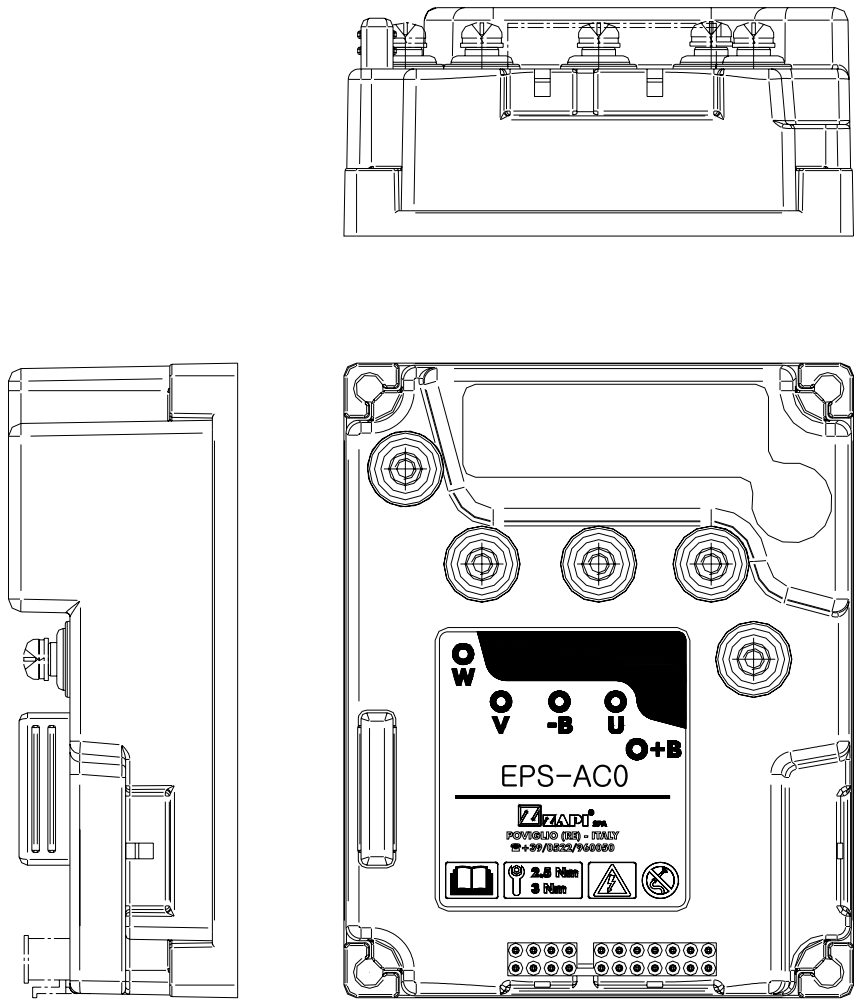
⚠ Do not connect the controller to a battery with a nominal voltage different than the value indicated on the controller label. A higher battery voltage may cause power section failure. A lower voltage may prevent the logic operating.

⚠ Before doing any operation, ensure that the battery is disconnected and when all the installation is completed start the machine with the drive wheels raised from the floor to ensure that any installation error do not compromise safety.

⚠ Take care all the inductive devices in the truck (horn, solenoid valves, coils, contactors) have a proper transient suppression device.

7. EPS CONTROLLER

1) STRUCTURE



BRJ7EL51

(1) Specifications

Model	Model	Application	Type	Power	Current limit
15/18/20/23BRP-7	AC0	EPS	AC	36-48V, 45A	45A/2min

2) OPERATIONAL FEATURES

(1) Features

A list of eps-ac0 operational features follows below:

① Static sensitivity boost in open loop (steering sensitivity increases for a slow moving steering wheel).
② Static numbness in closed loop (steering sensitivity decreases for handle steer close to the straight-ahead direction).
③ Dynamic numbness in open loop (steering sensitivity reduces when the truck speed increases).
④ Dynamic numbness on request in closed loop (steering sensitivity reduces when the truck speed increases).
⑤ Truck speed reduces when the steering angle increases.
⑥ Alignment at the rest position in open loop application (to avoid the drift of the steered wheel when travelling with released steering wheel).
⑦ Embedded PID algorithm for automatic functions (AUTC).
⑧ Special debugging & troubleshooting system makes easier the fault catching.
⑨ Possibility to run in a stand-alone (not CAN Bus supported) configuration.
⑩ Motor control may be performed with encoder.
⑪ Redundant processing (two microprocessors aboard) fulfils the category #3 requirement including the set-point comes via CAN Bus from a remote unit.
⑫ Redundant set point and feedback sensors fulfil the category #3 requirement.

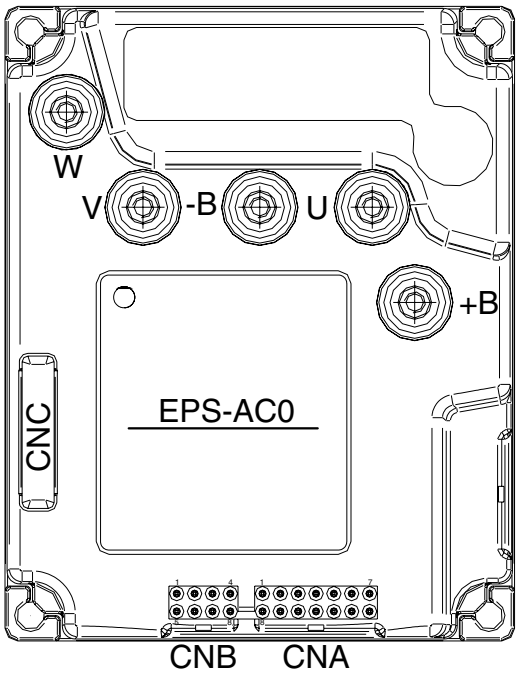
(2) Diagnosis

According to EN1175, most of the diagnoses deenergize steer and traction in less then 100 msec. Few secondary alarm conditions require longer time for detection. They too deenergize steer and traction.

Diagnosis is provided in two ways. The digital console and a display can be used, which gives a detailed information about the failure; the failure code is also sent on the Can-Bus.

3) DESCRIPTION OF CONNECTORS

(1) EPS controller



BRJ7EL52

No. of Pin	Function	Description
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 themal sensor negative.
A14	CANH	Can bus high.
B3	THMOT	Motor themal sensor (KTY84-130) input.
B4	VDC	Encoder positive supply.
B7	CHB	Encoder channel B.
B8	CHA	Encoder channel A.

No. of Pin	Function	Description
C1	PCLRXD	Positive serial reception.
C2	NCLRXD	Negative serial reception.
C3	PCLTXD	Positive serial transmission.
C4	NCLTXD	Negative serial transmission.
C5	GND	Negative console power supply.
C6	+12	Positive console power supply.
C7	FLASH	It must be connected to A8 for the flash memory programming.
C8	FLASH	It must be connected to A7 for the flash memory programming.

4) FUNCTION CONFIGURATION

Using the config menu of the programming console, the service engineer can configure the following functions.

(1) Submenu "SET OPTIONS"

① HOUR COUNTER

RUNNING : The counter registers travel time only.

KEY ON : The counter registers when the "key" switch is closed.

② 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.

③ 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.

④ 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.

⑤ 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.

⑥ 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.

⑦ **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.

⑧ **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).

⑨ **COMBI CAN PROT.(N/A)**

It's always set to absent.

(2) Submenu "ADJUSTMENTS"

① **ADJUSTMENT #01**

This setting is used to acquire the motor resistance.

② **SET CURRENT**

This setting is factory adjusted to calibrate the ADJUSTMENT #03 and #04 below.

③ **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 with the procedure 12.2 or may be set by rolling up or down this adjustment.

④ **ADJUSTMENT #03**

(Factory adjusted). Parameter to compensate for the gain of the current amplifier in phase W.

⑤ **ADJUSTMENT #04**

(Factory adjusted). Parameter to compensate for the gain of the current amplifier in phase V.

⑥ **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.

⑦ **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.

⑧ **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).

⑨ **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.

⑩ **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

⑪ **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

⑫ **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.

⑬ **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.

⑭ **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.

⑮ **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.

⑯ **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.

⑰ **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 .

⑱ **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 ouple of values is not consistent they were not saved and the display switches cyclically from the collected data to the DATA ACQUISITION inscription.

(3) Submenu "PARAMETER CHANGE"

① **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.

② **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.

③ **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.

④ 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.

⑤ 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.

⑥ 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.

⑦ 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.

⑧ 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 %.

⑨ **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 gets its 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.

⑩ **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)

⑪ **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.

⑫ **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.

⑬ **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.

⑭ **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.

⑮ **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).

⑯ **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).

4) SPECIAL FUNCTIONS

(1) Acquiring the motor resistance

When it is possible, the steering motor is controlled sensorless. To get the best performance in terms of the max torque generated, it is necessary to compensate for the drop in the motor resistance. So the correct value of the motor resistance must be known.

Eps-ac0 provides a self-acquisition procedure to acquire the motor resistance.

It is just enough to connect the eps-ac0 to the battery, to the motor and to the wiring in order no alarm occurs.

Then:

① Enter the ADJUSTMENTS menu searching for ADJUSTMENT #01 setting.
② Turn ADJUSTMENT #01 to Level 1. (A DATA ACQUISITION alarm occurs and a half Imax DC current is automatically injected in the motor).
③ Wait about 2 secs.
④ Roll ADJUSTMENT #01 back to Level 0.
⑤ Save the new setting.

With this procedure the resistance between two motor terminals is automatically measured and recorded (in milliohms) on the ADJUSTMENT #02.

It is also possible to adjust the motor resistance value without self-acquisition by rolling the ADJUSTMENT #02.

The acquisition of the motor resistance should be performed to find the correct value when developing a new truck prototype; the correct value will be the default setting for the mass production of that truck.

(2) Alignment at the rest position

In the open loop applications (i.e. when the stepper motor is used in the steering wheel or the steer command is a speed information coming via CAN bus) an alignment at the rest position is automatically performed when the steered wheel has a drift with a released steering wheel. To enable this function, turn RECOVERY AT REST to On and recycle the key. This alignment at the rest position is handled closed loop.

(3) Straight ahead steering numbness

In closed loop applicant It is possible to reduce the steering sensitivity while the steered wheel is close to be straight ahead by using the NUMBNESS setting in the PARAMETERS CHANGE menu. Increasing the NUMBNESS parameter gets the steering less responsive when the truck is driving next to the straight ahead direction (i.e. a certain increment of the steering wheel angle gets a smaller increment of the steered wheel angle when the truck is driving straight ahead than when it is angled).

Higher NUMBNESS setting results in higher numbness of the steering at low steered wheel angle. NUMBNESS to Level 0 results in a linear relationship between the command and the steered wheel angle(no sensitivity reduction in straight ahead).

(4) Overshooting and damping avoid

To optimize the steer performance in closed loop application, the following simple test should be tried.

Turn the tiller in a shot from a limiting position to the straight ahead direction. The steered wheel is expected to turn from the limiting position to the straight head at full steering motor speed. Then it must suddenly stop in the straight ahead direction without overshooting or damping (overshooting means the steered wheel temporary overtakes the commanded position; damping means the steered wheel slows down in advance respect to the commanded position).

Actions to neutralize overshooting are :

① Increase parameter change LEAD FB REGULAT

② Reduce parameter change KP or POS ACCURACY. This action reduces also the accuracy of the pursuing at the commanded position

Actions to neutralize damping are :

① Reduce parameter change LEAD FB REGULAT

② Increase parameter change KP or POS ACCURACY. This action increases also the accuracy of the pursuing at the commanded position.

5) PROGRAMMING & ADJUSTMENTS

There are two ways to adjust parameter via a console or a buttons on a display.

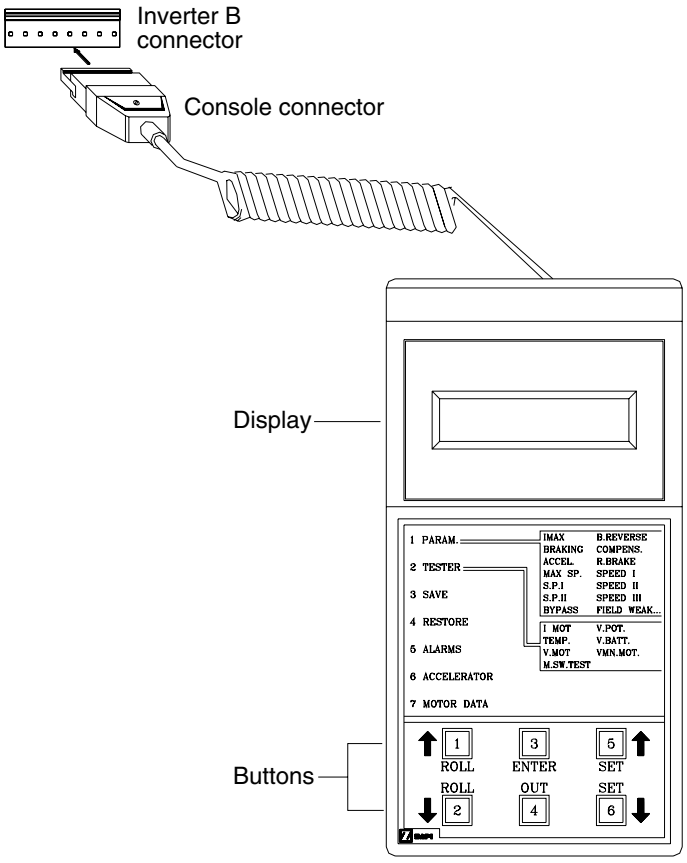
※ **Adjustments via buttons on a display, please refer to the display section.**

ADJUSTMENTS VIA CONSOLE (Option)

Adjustment of Parameters and changes to the inverter¡¯s configuration are made using the Digital Console.

The Console is connected to the CNC connector of the inverter.

(1) Description of console



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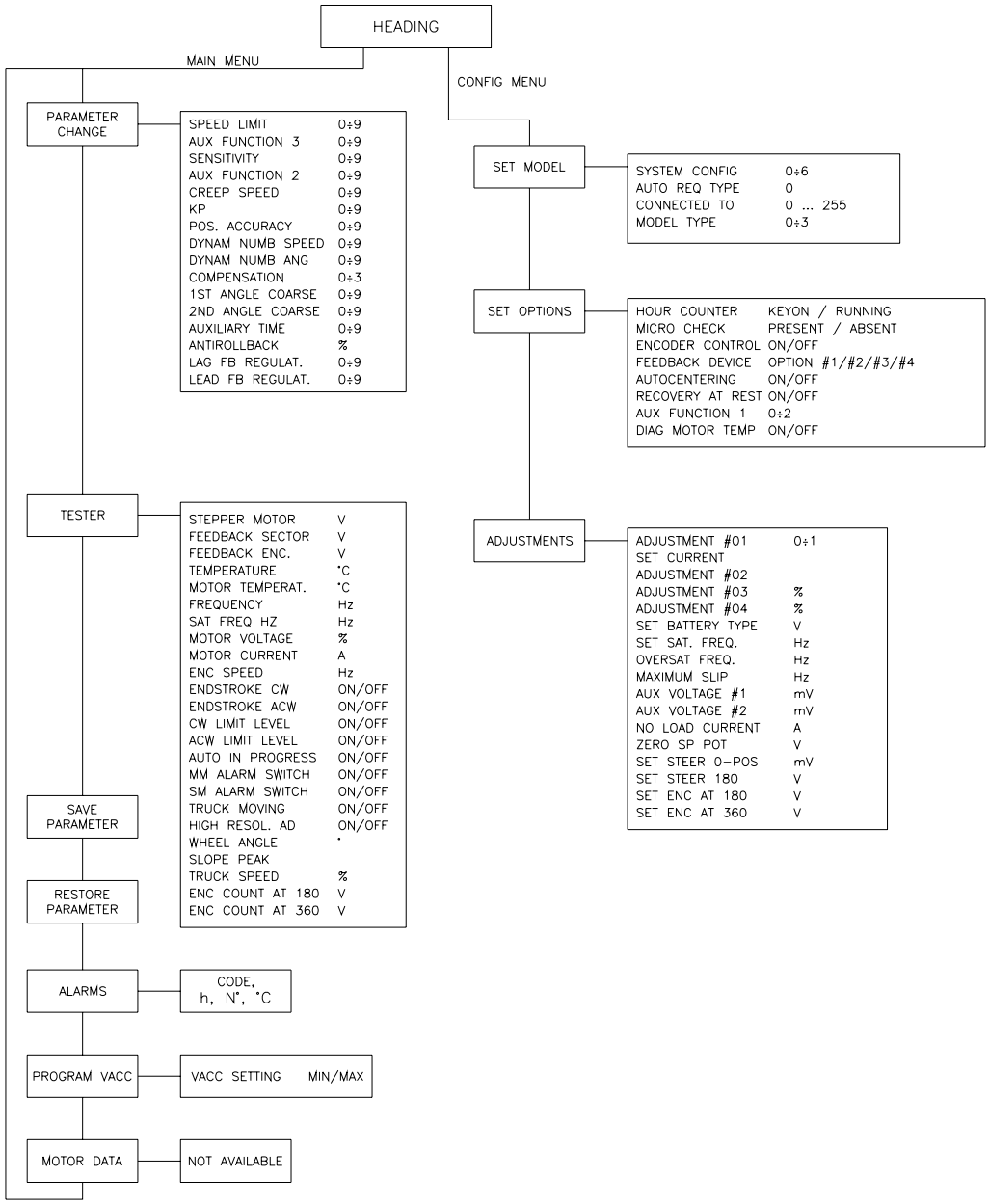
※ **Digital consoles used to communicate with AC inverter controllers must be fitted with EPROM CK ULTRA, minimum "Release Number 3.02".**

(2) Description of standard console menu



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6) TESTER MENU

The most important input or output signals can be measured in real time using the TESTER function of the console. The Console acts as a multimeter able to read voltage, current and temperature. In the following chapter a list of relative measurements for different configurations.

(1) Stepper motor

Voltage value with 2 decimal digit. Measurement of the stepper motor speed with sign in the range 0 to 5 Vdc.

(2) 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.

(3) 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.

(4) Temperature

Degrees. Temperature of the controller base plate.

(5) Motor temperature

Degrees. Temperature of the motor windings measured with the thermal sensor inside the motor and connected to CNB#3.

(6) Frequency

Hertz value with 2 decimal digit. This is the frequency applied to the steering motor.

(7) 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.

(8) Motor voltage

It is a percentage. 100% means the sine waves in the motor have the maximum PWM amplitude.

(9) Motor current

Ampere value. Root Mean Square value of the line current in the motor.

(10) ENC speed

Hertz value with 2 decimal digit. This is the speed of the motor measured with the encoder on the motor shaft.

(11) 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.

(12) 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.

(13) 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).

(14) 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).

(15) Auto in progress

Provides real time the information the eps-ac0 follows the manual command (AUTO IN PROGRESS is OFF) or is executing an automatic centering (AUTO IN PROGRESS is ON).

(16) MM alarm switch

It is On when the safety contact belonging to the main uC is closed.

(17) SM alarm switch

It is On when the safety contact belonging to the slave uC (supervisor) is closed.

(18) 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).

(19) 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).

(20) Wheel angle

It provides the current angle of the drive wheel by the degree.

(21) Slope peak

This reading is just for debugging the maximum slope of the potentiometers connected to the eps-ac0. 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, changes 61*5/1024 =0.3 V in 16 msec.).

Obviously the SLOPE PEAK reading must be compared with the threshold for the STEER SENSOR KO alarmThe STEER SENSOR KO alarm may be adjusted.

(22) 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).

(23) 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.

See also 10.5 and 10.6. This reading may be manually saved on the adjustments SET ENC AT 360.

(24) 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 (measured between the first and the seconds end of the iron plate in figure 4-4- and 4-5) 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. See also 10.5 and 10.6. This reading may be manually saved on the adjustments SET ENC AT 180.

ENC COUNT AT 180 is expected being about a half of the ENC COUNT AT 360.

8. FINGERTIP CONTROLLER

1) INTRODUCTION OF FINGER TIP

The general forklift performs lifting and tilting using the mechanical lever mounted on MCV (Main Control Valve) by an operator.

A new system is designed in order to improve operator's convenience and match up with marketing trend. That is what is called a finger tip or mini- lever system. The system is to apply electric levers and proportional valve instead of mechanical levers and MCV. The attachments are operated as controlling the solenoid of a proportional valve according to the voltage of an electric lever.

2) GENERAL CHARACTERISTIC

(1) Functional characteristics

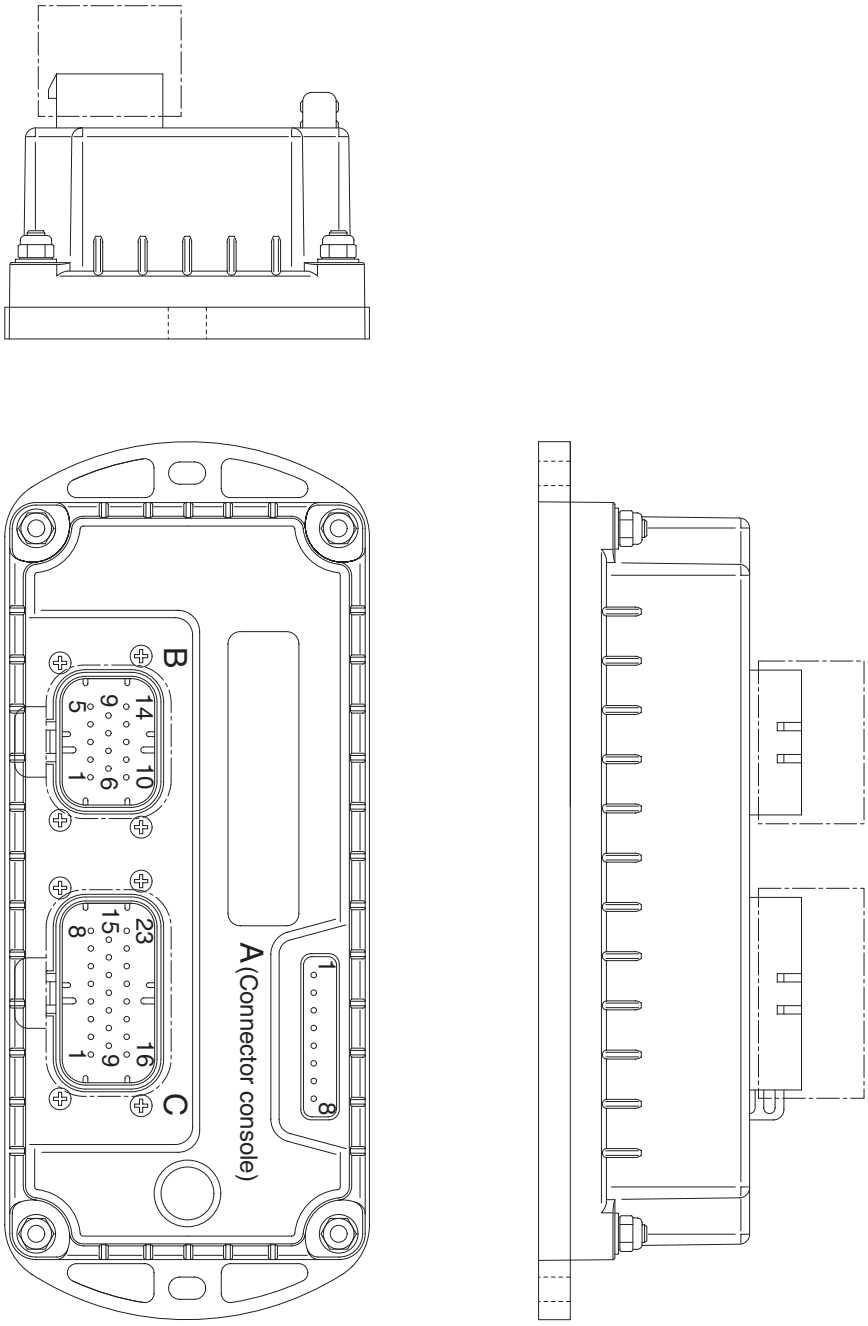
Voltage [V] ····· 24/36/48/80V
Output for ON-OFF valves [n°] ····· 3
Output for proportional valves [n°] ····· 9
Digital inputs [n°] ····· 3
Analog inputs [n°] ····· 1
RS-232 [n°] ····· 1
CAN [n°] ····· 1
Protection ····· IP65

(2) Input

Analog inputs : Mhyrio provides 1 analog input. The analog device can be supplied at +12. It is necessary to specify in the order the voltage selected. The supply output is able to deliver max 100 mA.

Proportional valves are driven in current mode with programmable frequency. The valves voltage supply is the same used for ON-OFF valves and the current range have to be defined. Via console or display it is adjustable in a big range, but the shunts can be adapted to every types of valves (minimum current 200 mA, maximum current up to 2 A).

3) STRUCTURE



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4) Description of connectors

No. of Pin	Function	Description
A1	PCLRXD	Serial communication interface
A2	NCLRXD	Serial communication interface
A3	PCLTXD	Serial communication interface
A4	NCLTXD	Serial communication interface
A5	GND	Negative supply.
A6	+12	+12V supply.
A7	-	
A8	-	
B1	+KEY	Mhyrio CB positive power supply
B2	PAUX	Input of valves positive power supply
B3	-BATT	Mhyrio CB negative supply
B4	CAN_L	CAN low signal in
B9	CAN_T	CAN termination : connect to CANH_OUT to insert a 120 ohm termination resistance
B10	PPO_S	Positive supply of analog devices (+12 V)
B13	CAN_H	Can high signal in
B14	CANH_OUT	Can high signal out
C1	NEVP1	Negative of the proportional electro valve lift up.
C2	PEVP1/2	Positive of the proportional electro valves lift up & lowering.
C3	NEVP2	Negative of the proportional electro valve lowering.
C4	NEVP3	Negative of the proportional electro valve reach in.
C5	PEVP3/4	Positive of the proportional electro valves reach in & reach out.
C6	NEVP4	Negative of the proportional electro valve reach out.
C7	NEVP5	Negative of the proportional electro valve tilt up.
C8	PEVP5/6	Positive of the proportional electro valves tilt up & tilt down.
C12	NEVP7	Negative of the proportional electro valve side shift right.
C13	PEVP7/8	Positive of the proportional electro valves side shift right & left.
C14	NEVP8	Negative of the proportional electro valve side shift left.
C15	NEVP6	Negative of the proportional electro valve tilt down.
C19	NEVP	Negative of buzzer relay
C20	PEVP	Positive of buzzer relay
C23	-BATT	Mhyrio CB negative supply

Type	Function	Description
SET BATTERY TYPE	12/24/36 /48/72/80	This parameter sets the battery nominal voltage, that is the key input voltage (MHYRIO supply)
V valves coil	12/24/36 /48/72/80	This parameter sets the ON/OFF valves coil nominal voltage.
Valves supply	12/24/36 /48/72/80	This parameter sets the voltage of the valve's coil positive supply.
EVP type	DIGITAL	It sets EVP single to ON-OFF valve type
	ANALOG	It sets EVP single to proportional valve type
EVP1 type	DIGITAL	It sets EVP1 to ON-OFF valve type
	ANALOG	It sets EVP1 to PROPORTIONAL valve type
EVP2 type	DIGITAL	It sets EVP2 to ON-OFF valve type
	ANALOG	It sets EVP2 to PROPORTIONAL valve type
EVP3 type	DIGITAL	It sets EVP3 to ON-OFF valve type
	ANALOG	It sets EVP3 to PROPORTIONAL valve type
EVP4 type	DIGITAL	It sets EVP4 to ON-OFF valve type
	ANALOG	It sets EVP4 to PROPORTIONAL valve type
EVP5 type	DIGITAL	It sets EVP5 to ON-OFF valve type
	ANALOG	It sets EVP5 to PROPORTIONAL valve type
EVP6 type	DIGITAL	It sets EVP6 to ON-OFF valve type
	ANALOG	It sets EVP6 to PROPORTIONAL valve type
EVP7 type	DIGITAL	It sets EVP7 to ON-OFF valve type
	ANALOG	It sets EVP7 to PROPORTIONAL valve type
EVP8 type	DIGITAL	It sets EVP8 to ON-OFF valve type
	ANALOG	It sets EVP8 to PROPORTIONAL valve type
MODEL TRUCK	OPTION #1	It sets every parameter to counter balanced type truck

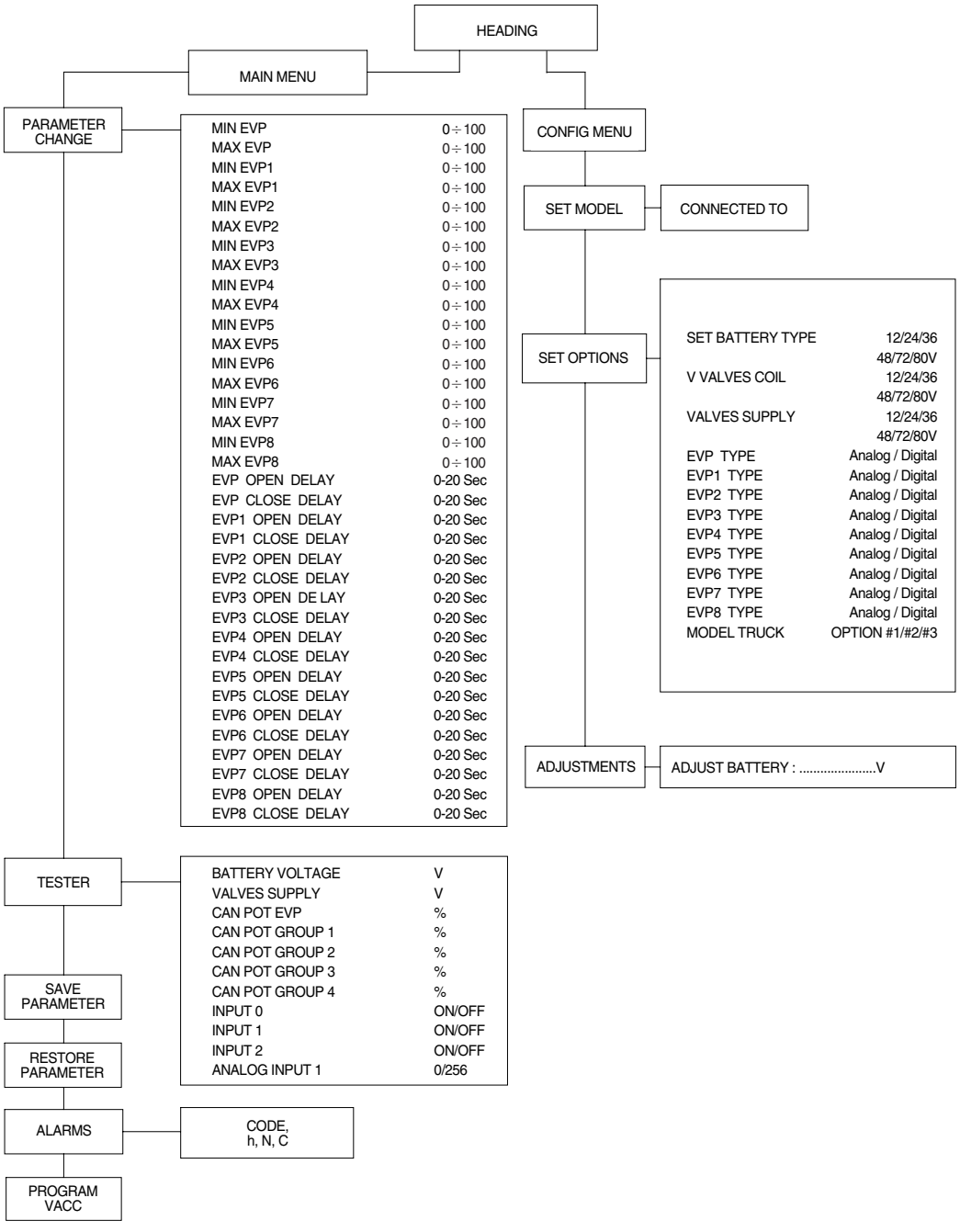
5) ADJUSTMENTS & FUNCTION

There are two ways to adjust parameter via a console or buttons on a display.

(1) Adjustments via console or buttons on a display

Adjustment of Parameters and changes to the controller's configuration are made using the Digital Console or buttons on a display. The console can be connected directly to Mhyrio CB (connector A), or it can be physically connected to another controller in the CANBUS net, then virtually connected to Mhyrio CB (which is node 9 of the net). If you don't have the console, you can do adjustments using the buttons on a display easily.

(2) Description of standard console menu



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(3) Description of parameters that may be programmed (parameter change)

In addition to the configuration, parameter settings can be factory set (default parameters), or the customer can make changes according to the application, using a digital console or a display. During the setting up procedure on the machine, the console can remain connected to the controller during travel. The parameters can be modified in real time, during operation. Pay attention to the polarity of the console connector. Refer to chapter 7.1 and 7.2 of this manual for connection details.

CONNECTION OF THE CONSOLE TO THE CONTROLLER MUST BE MADE WITH THE KEY SWITCH TURNED OFF.

The following parameters can be modified:

① **Min EVP**

This parameter adjusts the minimum current of the SINGLE valve, if it is set as proportional (see "set option menu").

② **Max EVP**

This parameter adjusts the MAXIMUM current of the SINGLE valve, if it is set as proportional (see "set option menu").

③ **Min EVP1**

This parameter adjusts the minimum current of valve 1, if it is set as proportional (see "set option menu").

④ **Max EVP1**

This parameter adjusts the maximum current of valve 1, if it is set as proportional (see "set option menu").

⑤ **Min EVP2**

This parameter adjusts the minimum current of valve 2, if it is set as proportional (see "set option menu").

⑥ **Max EVP2**

This parameter adjusts the maximum current of valve 2, if it is set as proportional (see "set option menu").

⑦ **Min EVP3**

This parameter adjusts the minimum current of valve 3, if it is set as proportional (see "set option menu").

⑧ **Max EVP3**

This parameter adjusts the maximum current of valve 3, if it is set as proportional (see "set option menu").

⑨ **Min EVP4**

This parameter adjusts the minimum current of valve 4, if it is set as proportional (see "set option menu").

⑩ **Max EVP4**

This parameter adjusts the maximum current of valve 4, if it is set as proportional (see "set option menu").

⑪ **Min EVP5**

This parameter adjusts the minimum current of valve 5, if it is set as proportional (see "set option menu").

⑫ **Max EVP5**

This parameter adjusts the maximum current of valve 5, if it is set as proportional (see "set option menu").

⑬ **Min EVP6**

This parameter adjusts the minimum current of valve 6, if it is set as proportional (see "set option menu").

⑭ **Max EVP6**

This parameter adjusts the maximum current of valve 6, if it is set as proportional (see "set option menu").

⑮ **Min EVP7**

This parameter adjusts the minimum current of valve 7, if it is set as proportional (see "set option menu").

⑯ **Max EVP7**

This parameter adjusts the maximum current of valve 7, if it is set as proportional (see "set option menu").

⑰ **Min EVP8**

This parameter adjusts the minimum current of valve 8, if it is set as proportional (see "set option menu").

⑱ **Max EVP8**

This parameter adjusts the maximum current of valve 8, if it is set as proportional (see "set option menu").

⑲ **EVP Open delay**

Single proportional valve current ramping up time: this parameter sets the single valve current ramp, to change from 0 A to operating current.

⑳ **EVP Close delay**

Single proportional valve current ramping down time: this parameter sets the single valve closing ramp, to change from operating current to 0 A.

㉑ **EVP1 Open delay**

EVP1 proportional valve current ramping up time: this parameter sets the EVP1 valve current ramp, to change from 0 A to operating current.

㉒ **EVP1 Close delay**

EVP1 proportional valve current ramping down time: this parameter sets the EVP1 valve closing ramp, to change the coil current from operating current to 0 A.

㉓ **EVP2 Open delay**

EVP2 proportional valve current ramping up time: this parameter sets the EVP2 valve current ramp, to change from 0 A to operating current.

㉔ **EVP2 Close delay**

EVP2 proportional valve current ramping down time: this parameter sets the EVP2 valve closing ramp, to change the coil current from operating current to 0 A.

㉕ **EVP3 Open delay**

EVP3 proportional valve current ramping up time: this parameter sets the EVP3 valve current ramp, to change from 0 A to operating current.

㉖ **EVP3 Close delay**

EVP3 proportional valve current ramping down time: this parameter sets the EVP3 valve closing ramp, to change the coil current from operating current to 0 A.

㉗ **EVP4 Open delay**

EVP4 proportional valve current ramping up time: this parameter sets the EVP4 valve current ramp, to change from 0 A to operating current.

㉘ **EVP4 Close delay**

EVP4 proportional valve current ramping down time: this parameter sets the EVP4 valve closing ramp, to change the coil current from operating current to 0 A.

㉙ **EVP5 Open delay**

EVP5 proportional valve current ramping up time: this parameter sets the EVP5 valve current ramp, to change from 0 A to operating current.

㉚ **EVP5 Close delay**

EVP5 proportional valve current ramping down time: this parameter sets the EVP5 valve closing ramp, to change the coil current from operating current to 0 A.

㉛ **EVP6 Open delay**

EVP6 proportional valve current ramping up time: this parameter sets the EVP6 valve current ramp, to change from 0 A to operating current.

㉜ **EVP6 Close delay**

EVP6 proportional valve current ramping down time: this parameter sets the EVP6 valve closing ramp, to change the coil current from operating current to 0 A.

㉝ **EVP7 Open delay**

EVP7 proportional valve current ramping up time: this parameter sets the EVP7 valve current ramp, to change from 0 A to operating current.

㉞ **EVP7 Close delay**

EVP7 proportional valve current ramping down time: this parameter sets the EVP7 valve closing ramp, to change the coil current from operating current to 0 A.

㉟ **EVP8 Open delay**

EVP8 proportional valve current ramping up time: this parameter sets the EVP8 valve current ramp, to change from 0 A to operating current.

㊱ **EVP8 Close delay**

EVP8 proportional valve current ramping down time: this parameter sets the EVP8 valve closing ramp, to change the coil current from operating current to 0 A.

(3-1) Description to change parameters by a console

The flow chart shows how to change parameters by a console.

① Opening finger tip controller menu (MHY CB)

② Press ENTER to go into the GENERAL MENU.

③ The display will show: PARAMETER CHANGE.

④ Press ENTER to go into the PARAMETER CHANGE menu.

⑤ The display will show the first parameter.

⑥ Press ROLL UP and ROLL DOWN buttons until desired parameter appears.

⑦ The names of the parameters appear on the display.

⑧ When the desired parameter appears, the display will show a level number that will be between 0 and 9. Press either SET UP or SET DOWN buttons to change the Level value.

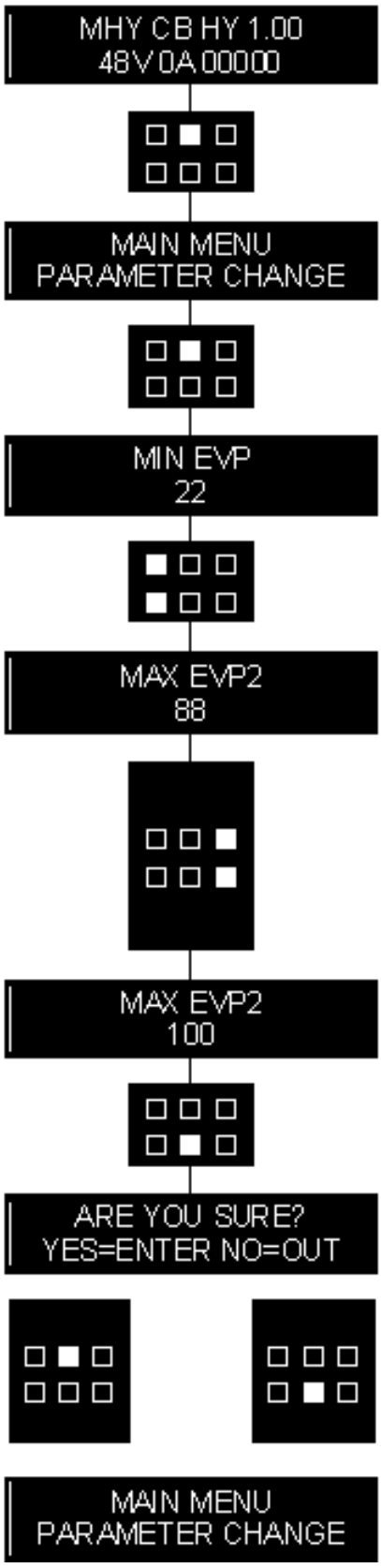
⑨ The display will show the new level.

⑩ When you are satisfied with the results of the changes you have made, press OUT.

⑪ The display asks: "ARE YOU SURE?".

⑫ Press ENTER to accept the changes, or press OUT if you do not wish to accept the changes and wish to make further modifications to the parameters.

⑬ The display will show: PARAMETER CHANGE.



BRJ7EL63

(3-2) Description to change parameters by a display

The flow chart shows how to change parameters by buttons on a display.

① Press [O] to enter password for 2~3 seconds.
The display will show: ENTER PASSWORD.

② Enter the password using [←] [→] and [↵].
After finishing entering it, press [←] for 2~3 sec

③ The display will show: TRUCK MENU.

④ Press [↵].

⑤ The display will show : CONNECTED TO :

⑥ If the display doesn't show : MHY CB HY 1.00,
Press [↑] or [↓] until MHY CB HY 1.00 appears on the display. After that, press [↵]

⑦ The display will show : CONNECTED TO:
With more information.

⑧ Press [↵] to go into the GENERAL MENU.

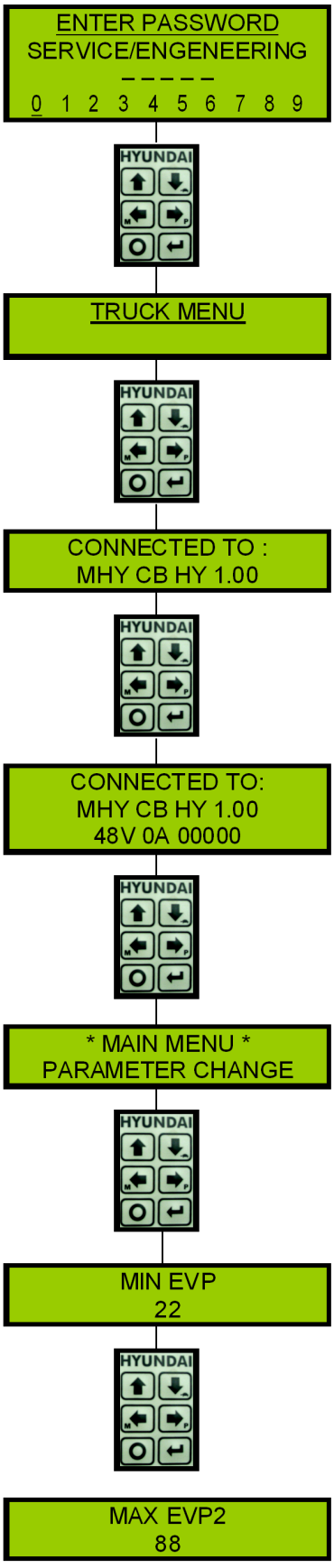
⑨ The display will show :.PARAMETER CHANGE

⑩ Press [↵] to go into the PARAMETER CHANGE menu.

⑪ The display will show : MIN EVP

⑫ Press [↑] and [↓] until desired parameter appears.

⑬ The names of parameters appear on the display.



BRJ7EL64

① When the desired parameter appears, the display will show a level number that will be between 0 and 9. Press either [←] or [→] to change the level value

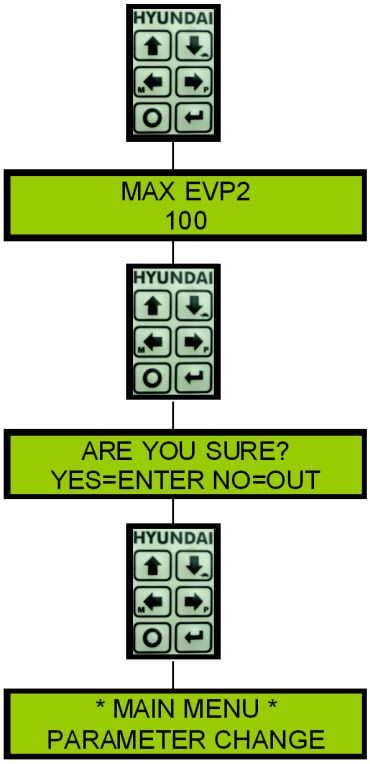
② The display will show the new level.

③ When you are satisfied with the results of the changes you have made, press [O].

④ The display asks : "ARE YOU SURE?"

⑤ Press [↵] to accept the changes,or press [O] if you do not wish to accept the changes and wish to make further modifications to the parameters.

⑥ The display will show: PARAMETER CHANGE



BRJ7EL65

(4) TESTER MENU

Following parameters can be measured in real time in the TESTER menu:

① Battery voltage
Level of battery voltage measured at the input of the key switch.

② Valves supply
Level of voltage at the positive valve supply input (B2).

③ CAN POT EVP
Single proportional valve current set point, received by canbus.

④ CAN POT group 1
Group 1 proportional valves current set point, received by canbus.

⑤ CAN POT group 2
Group 2 proportional valves current set point, received by canbus.

⑥ CAN POT group 3
Group 3 proportional valves current set point, received by canbus.

⑦ CAN POT group 4
Group 4 proportional valves current set point, received by canbus.

⑧ Input 0
Level of digital input 0:
- ON / +VB : input active, switch closed
- OFF / COND : input not active, switch open.

⑨ Input1
Level of digital input 1:
- ON / +VB : input active, switch closed
- OFF / COND : input not active, switch open.

⑩ Input 2

Level of digital input 2 :

- ON / +VB : input active, switch closed
- OFF / COND : input not active, switch open.

⑪ Analog input 1

Voltage of the analog input.

(4-1) Description to check data by a console

The flow chart shows how to use the TESTER function of the digital console.

① Opening finger tip controller menu (MHY CB)

② Press ENTER to go into the GENERAL MENU.

③ The display will show: PARAMETER CHANGE.

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

⑤ The display shows: TESTER.

⑥ Press ENTER to go into the TESTER function.

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

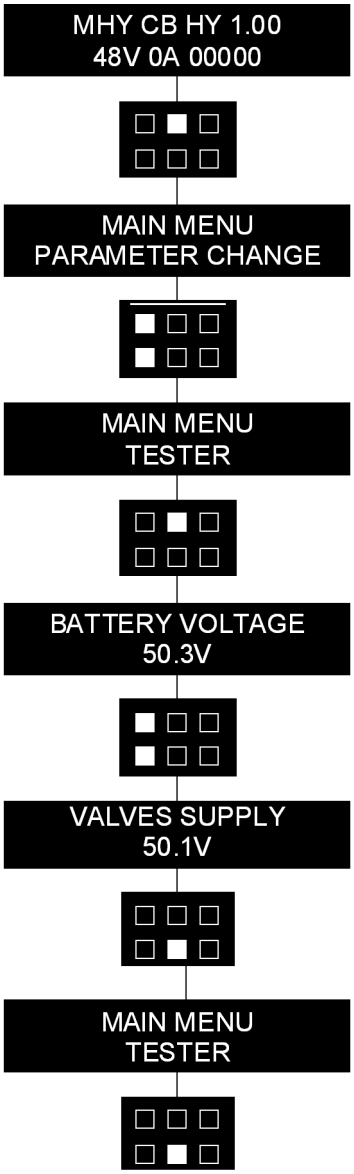
⑧ Press either ROLL UP or ROLL DOWN buttons.

⑨ Next variable for measurement appears.

⑩ When you have finished, press OUT.

⑪ The display shows: TESTER.

⑫ Press OUT again and return to opening HY menu.



BRJ7EL66

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.

(4-2) Description to check data by a display

The flow chart shows how to use the TESTER function of buttons on a display.

① Press [O] to enter password for 2~3 seconds.
The Display will show: ENTER PASSWORD.

② Enter the password using [M] [P] and [↵].
After finishing entering it, press [M] for 2~3 sec

③ The display will show: TRUCK MENU.

④ Press [↵]

⑤ The display will show : CONNECTED TO :

⑥ If the display doesn't show : MHY CB HY 1.00,
Press [↑] or [↓] until MHY CB HY 1.00 appears on the display. After that, press [↵]

⑦ The display will show : CONNECTED TO:
With more information.

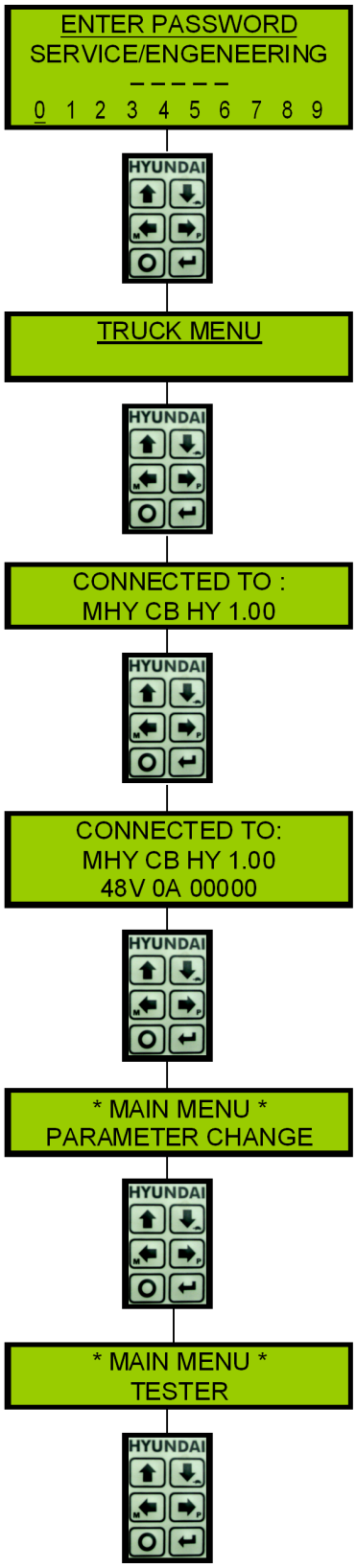
⑧ Press [↵] to go into the GENERAL MENU.

⑨ The display will show : PARAMETER CHANGE

⑩ Press [↑] or [↓] until TESTER menu appears on the display.

⑪ The display shows : TESTER

⑫ Press [↵] to go into the TESTER function.



BRJ7EL67

① The first variable to be tested is shown on the display

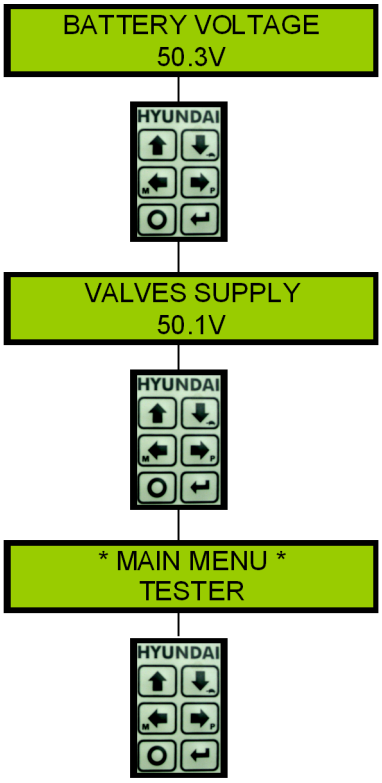
② Press either ⬆ or ⬇.

③ Next variable for measurement appears.

④ When you have finished, press O.

⑤ The display shows : TESTER

⑥ Press O again and return to MHY CB HY.



BRJ7EL68

6) ANALYSIS OF ALARMS

① **EEPROM KO**

Fault in the area of memory where the adjustment parameters are stored. This Alarm does not inhibit machine operation but operation goes on with default values; if fault is still present when the Key Switch is re-cycled, replace the logic. If the fault disappears, the previously stored Parameters will have been replaced by the default parameters.

② **CAN BUS KO**

There is a problem related to the CAN-BUS line. The error is signalled if the MHYRIO controller 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.

③ **Watchdog**

The test is made in both running and standby. It is a self-diagnosing test within the logic. If an alarm should occur, replace the logic.

④ **WRONG SET BATTERY**

This fault is signalled if the battery voltage is non consistent with the set battery programmed in the 'set option' menu.

⑤ **Undervoltage**

This fault is signalled if an undervoltage condition is detected in the MHYRIO power supply.

⑥ **FF valves**

Flip-flop circuit, that manages on/off valve drivers short-circuit protection, does not reset in the correct way. The problem is probably in the hardware circuit.

⑦ **Coil shorted**

ON/OFF valves drivers are protected against coil short circuit; if a short is present across the coil, the flip-flop circuit is set and the alarm is signalled.

⑧ **EV driver short**

One of the on/off valves driver is shorted; check the external connection, if it is ok the driver is probably damaged.

⑨ **EVP driver short**

The single proportional valve driver is shorted; check the external connection, if it is ok the driver is probably damaged.

⑩ **EVPG1 driver short**

One of the Group 1 valves drivers is shorted; check the external connection, if it is ok the driver is probably damaged.

⑪ **EVPG2 driver short**

One of the Group 2 valves drivers is shorted; check the external connection, if it is ok the driver is probably damaged.

⑫ **EVPG3 driver short**

One of the Group 3 valves drivers is shorted; check the external connection, if it is ok the driver is probably damaged.

⑬ **EVPG4 driver short**

One of the Group 4 valves drivers is shorted; check the external connection, if it is ok the driver is probably damaged.

⑭ **EV driver KO**

One of the On/Off valves drivers is open (it does not close when it is commanded by the microcontroller).

⑮ **EVP driver KO**

The single proportional valve driver is open (it does not close when it is commanded by the microcontroller).

⑯ **EVPG1 driver KO**

One of the Group 1 valves drivers is open (it does not close when it is commanded by the microcontroller).

⑰ **EVPG2 driver KO**

One of the Group 2 valves drivers is open (it does not close when it is commanded by the microcontroller).

⑱ **EVPG3 driver KO**

One of the Group 3 valves drivers is open (it does not close when it is commanded by the microcontroller).

⑲ **EVPG4 driver KO**

One of the Group 4 valves drivers is open (it does not close when it is commanded by the microcontroller).

⑳ **HI side driver KO**

The high side driver which supply the valves coils positive is shorted or open.

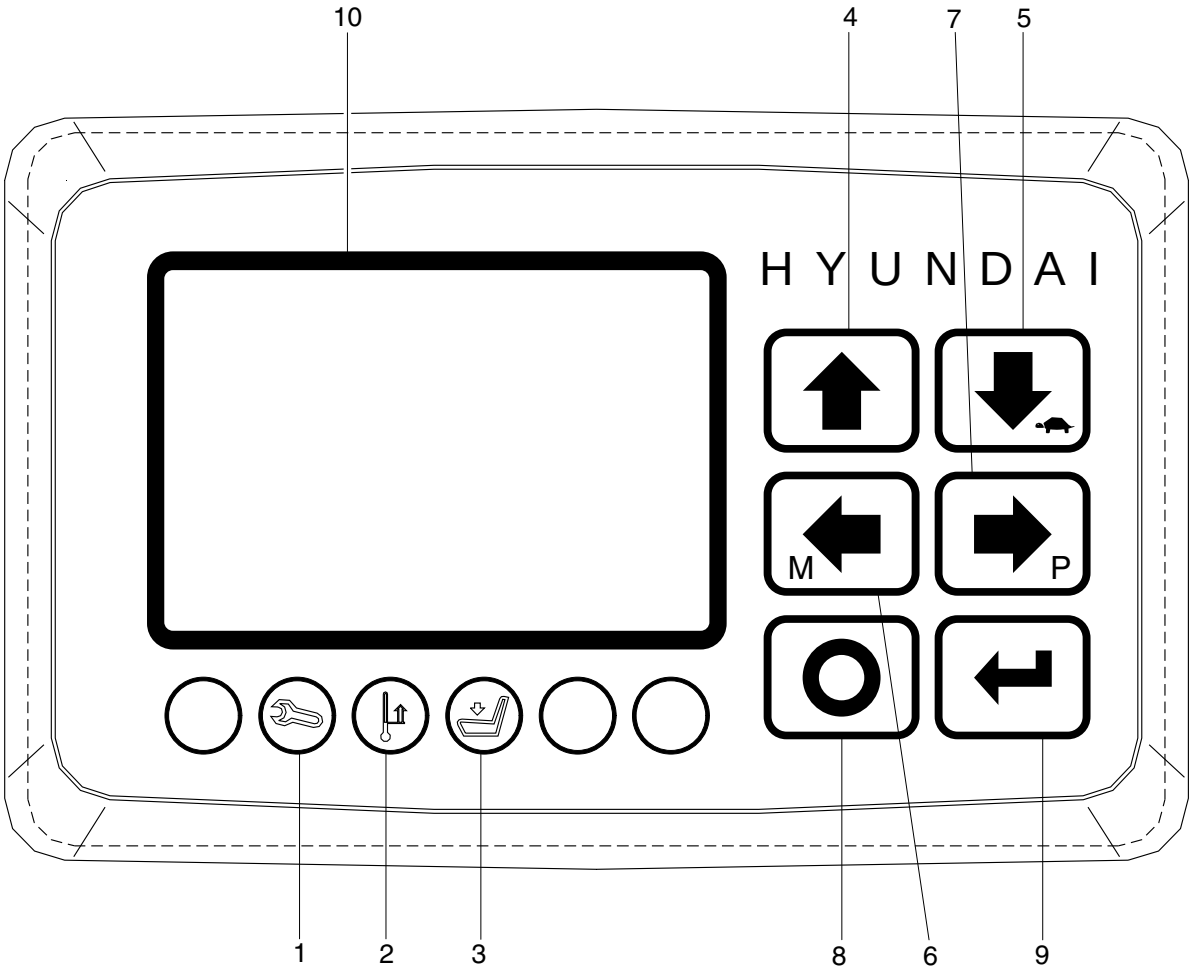
㉑ **Waiting for PEV**

There isn't the valves positive power supply. Check B2 input then verify the VALVES SUPPLY parameter is correctly set.

9. 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.



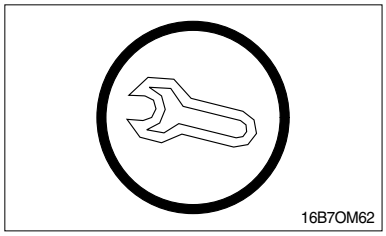
15BRP7OM65

1	Wrench warning lamp	6	Key 3 button
2	Thermometer warning lamp	7	Key 4 button
3	Dead man warning lamp	8	Key 5 button
4	Key 1 button	9	Key 6 button
5	Key 2 button	10	LCD function

2) WARNING LAMP

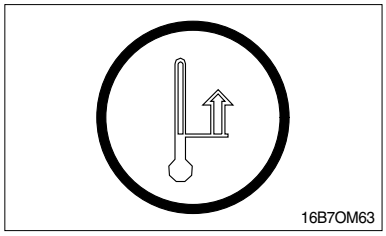
When the key switch is OFF, the display makes a general test lighting and switching OFF all the LED in sequence.

(1) Wrench warning lamp



This LED blinks when truck is in alarm condition.

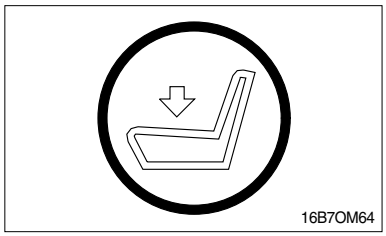
(2) Thermometer warning lamp



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

※ IMS : Input motor switch

(3) Dead man warning lamp

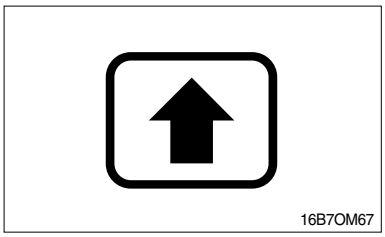


This LED lights when the operator is not stepped on the dead man switch.

3) TESTER MENU

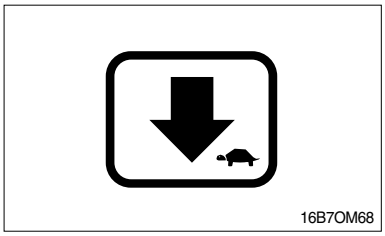
Status of keyboard buttons can be monitored in real time in the TESTER menu.

(1) Key 1 button



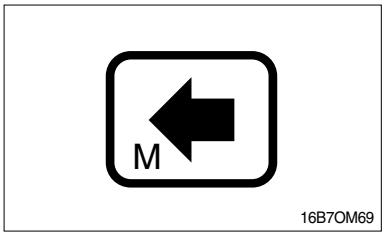
Status of ↑ keyboard button:
ON = Input active, button pushed
OFF = Input not active, button released

(2) Key 2 button



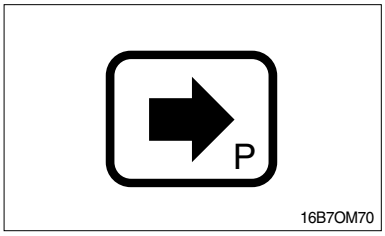
Status of ↓ TURTLE keyboard button:
ON = Input active, button pushed
OFF = Input not active, button released

(3) Key 3 button



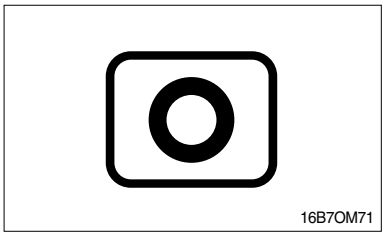
Status of ← M (Menu) keyboard button:
ON = Input active, button pushed
OFF = Input not active, button released

(4) Key 4 button



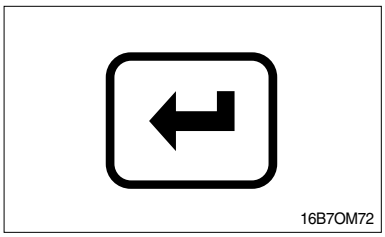
Status of → P (Performance) keyboard button:
ON = Input active, button pushed
OFF = Input not active, button released

(5) Key 5 button



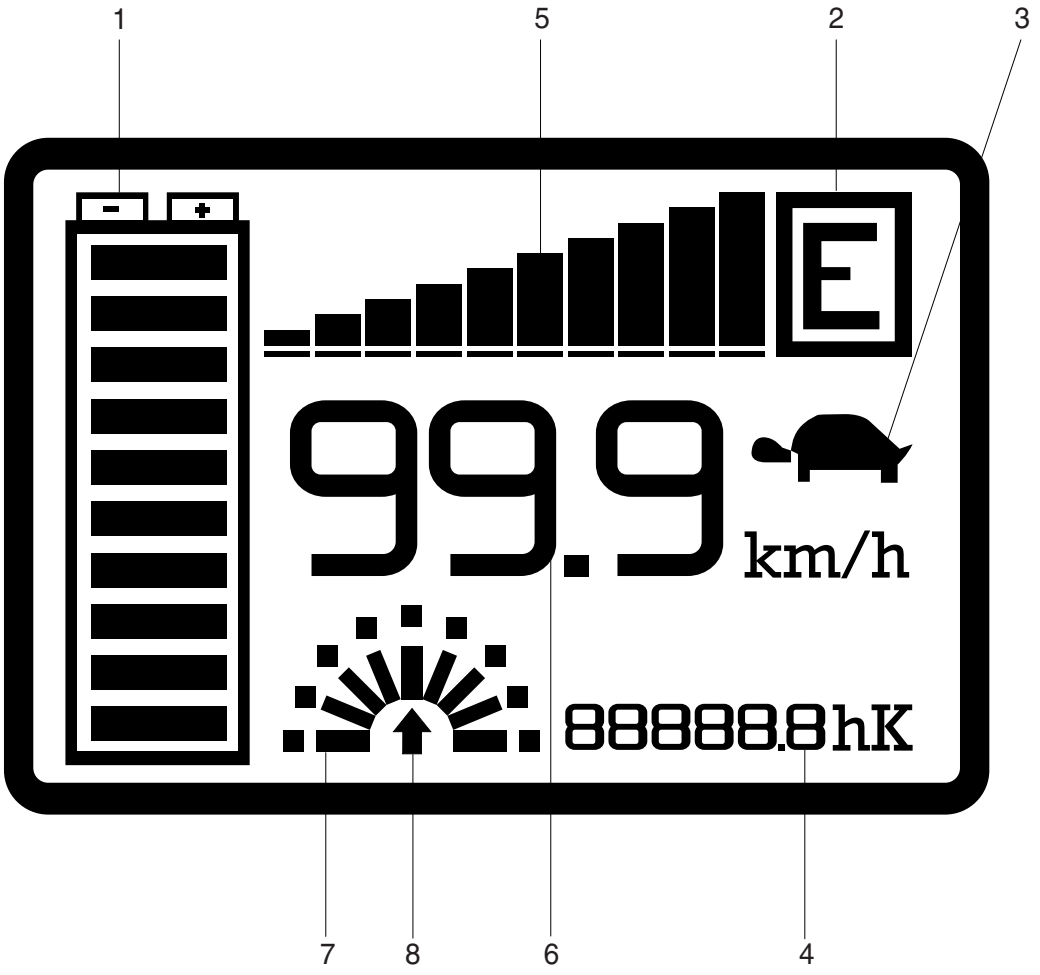
Status of ○ (Esc) keyboard button:
ON = Input active, button pushed
OFF = Input not active, button released

(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.

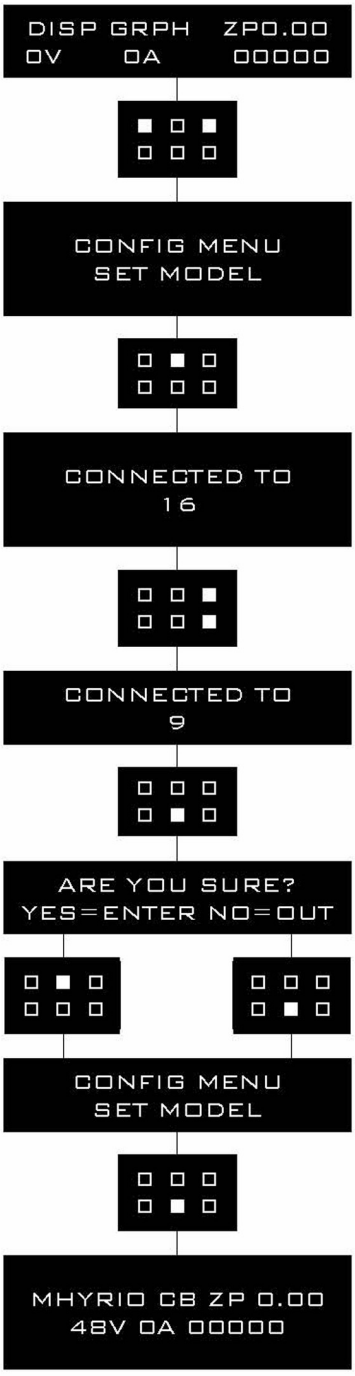
⑨ The display will ask "ARE YOU SURE?"

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.

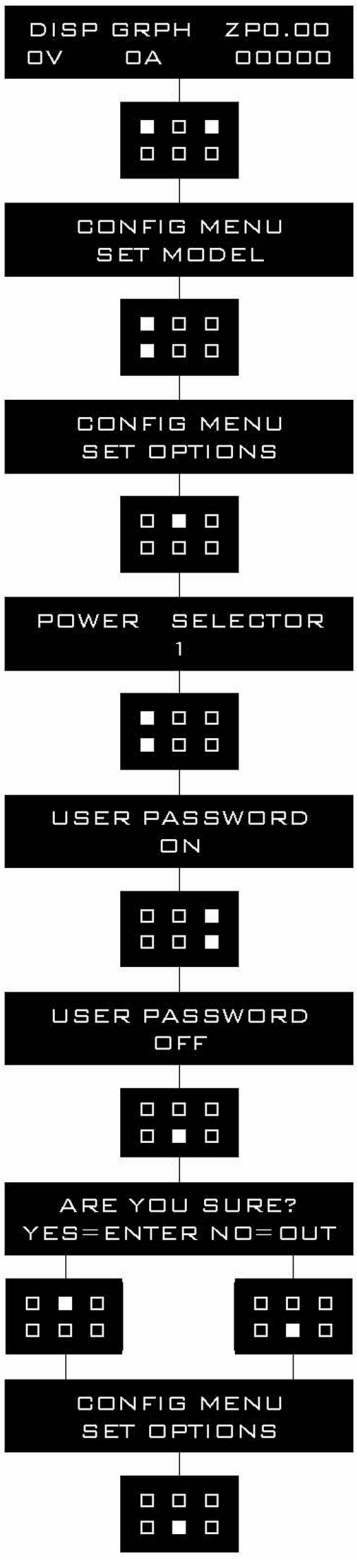
⑫ Press OUT to exit the menu.

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.

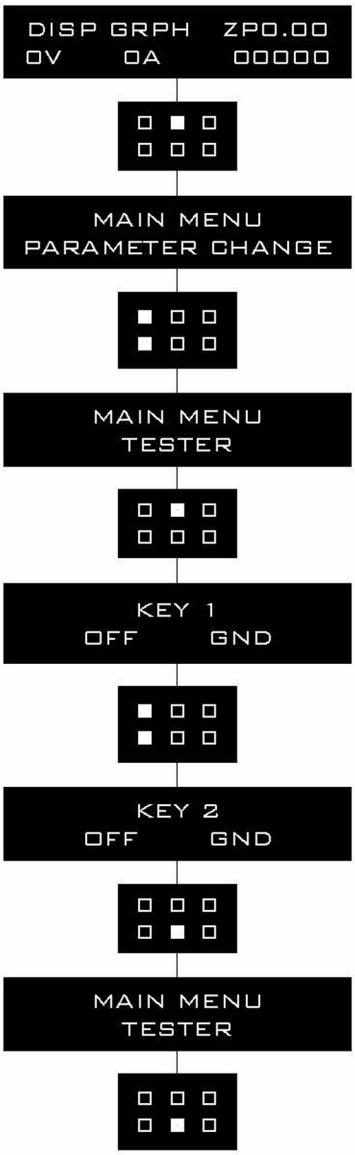
⑧ Press either ROLL UP or ROLL DOWN buttons.

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.

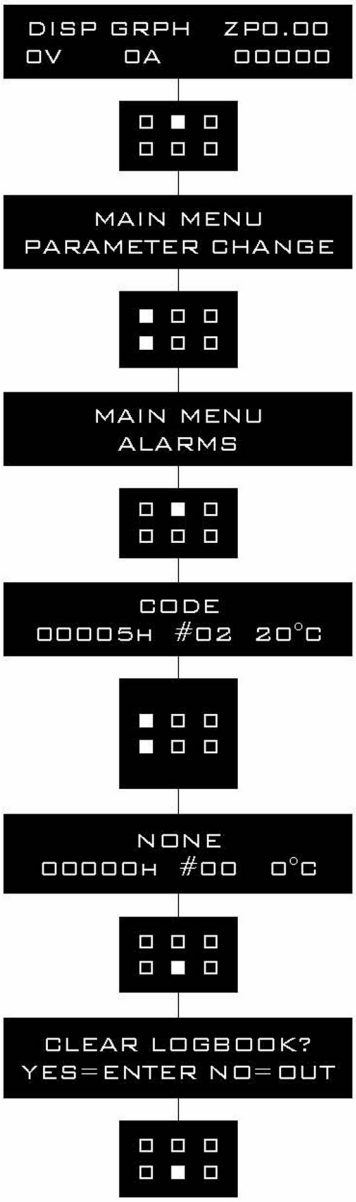
⑧ Each press of ROLL UP button brings up following alarms. Pressing ROLL DOWN returns to the most recent.

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.

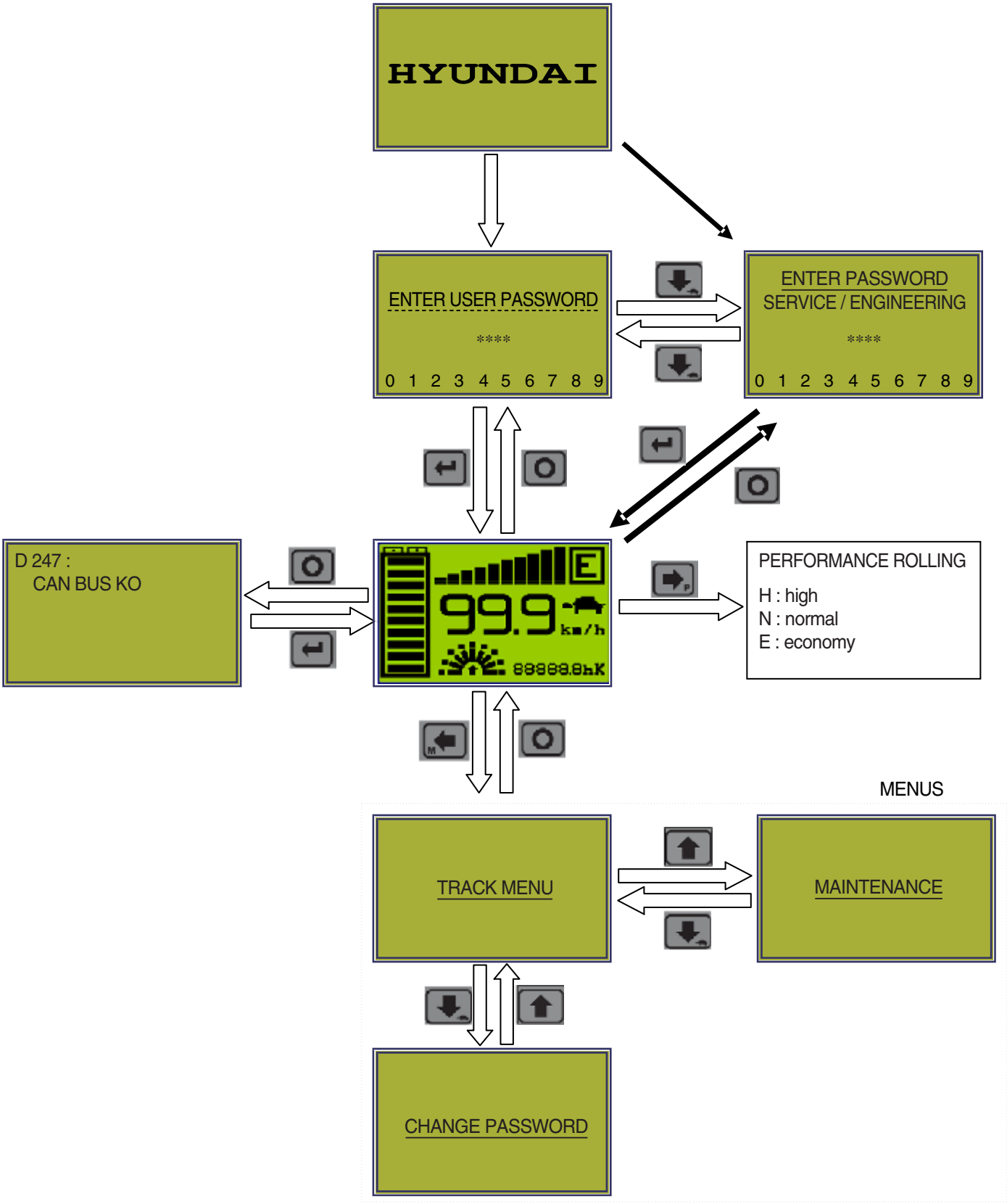
At turn on the display shows the HYUNDAI logo for some seconds, then asks the starting password to have access to the main page (if "USER PASSWORD" option is ON), otherwise it shows directly the main page (if "USER PASSWORD" option is OFF).

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.

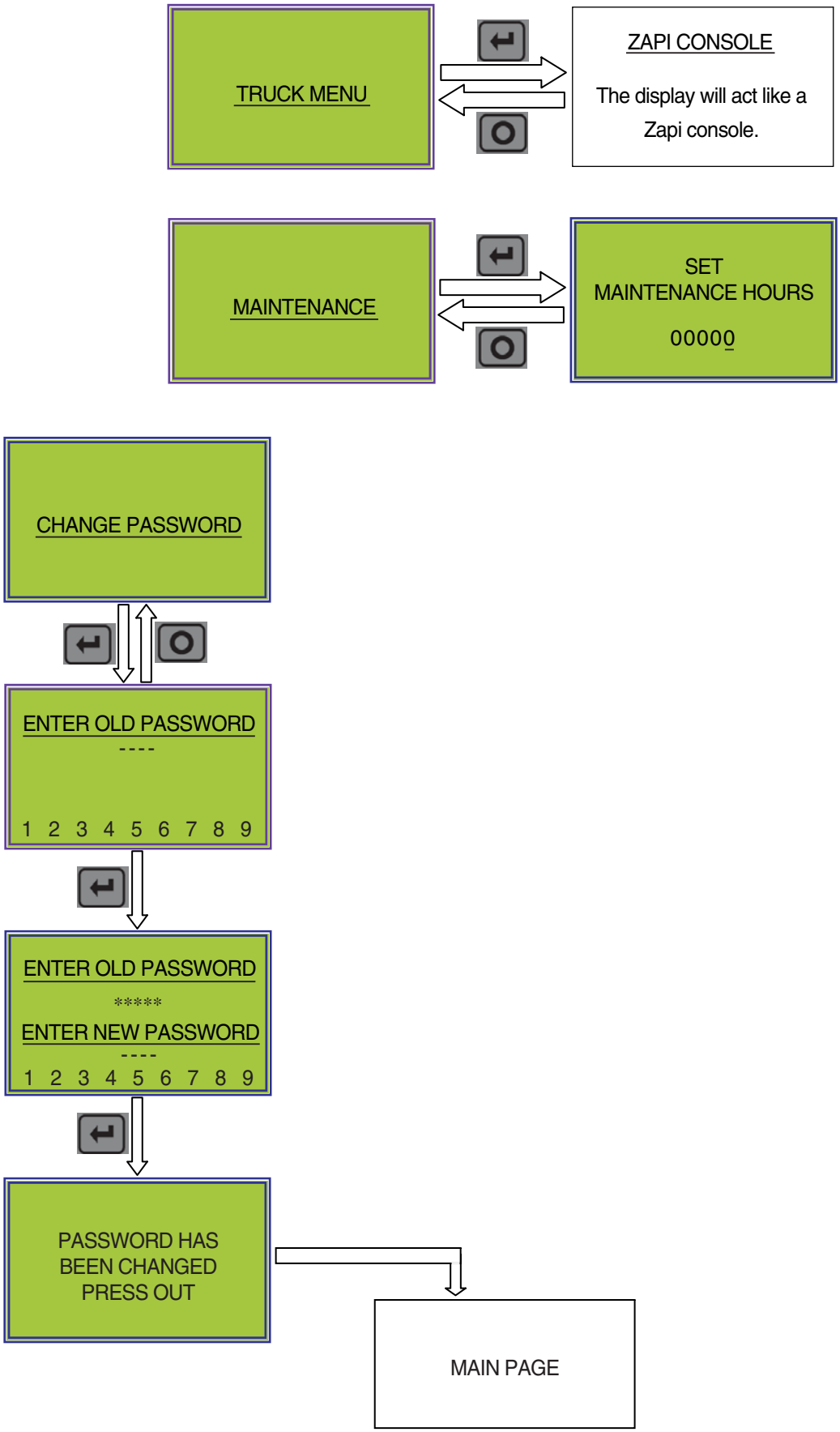
From the main page it is possible to have access to the ALARM page (if alarms occur) and to MENUS page. The CHANGE PASSWORD MENU is always accessible and visible, while the others ones are accessible and showed, by entering service password. To enter this password is necessary to push the out button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

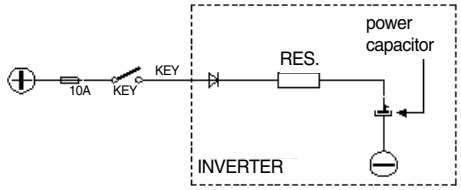
```
M 245:
    WRONG SET BAT
```

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.

10) DIAGNOSTIC FAULT CODES

Code	Alarm	Traction (T)	Pump (P)	Mhyrio (V)	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	○	○	○		The test is made in both running and standby. It is a self-diagnosing test within the logic. If an alarm should occur, replace the logic.
13	EEPROM KO	○	○	○	○	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	○				Fault in the hardware section of the logic board which manages the hardware current protection. Replace the 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	○	○			Fault in the hardware section of the logic board which manages the phase's voltage feedback. Replace the 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 alarm signals that an undervoltage / overvoltage protection operation has occurred. Two possible reasons: A) A real undervoltage / overvoltage situation happened. B) Fault in the hardware section of the logic board which manages the overvoltage protection. Replace the logic card.
					○	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.
30	VMN LOW	○	○			The test is carried out during initial diagnosis and in standby. Possible causes: A) Problem with the motor connections or the motor power circuit; check if the 3 phases are correctly connected; check if there's a dispersion of the motor towards ground; B) Inverter failure, replace it

Code	Alarm	Traction (T)	Pump (P)	Mhyrio (V)	EPS (E)	Description
31	VMN HIGH	○	○			The test is carried out during initial diagnosis and in standby. Possible causes: A) Problem with the motor connections or the motor power circuit; check if the 3 phases are correctly connected; check if there's a dispersion of the motor towards ground; B) Inverter failure, replace it
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	○				The main contactor is truck closed. Please check contactor's contact point.
38	CONTACTOR OPEN	○				The main contactor coil has been driven by the logic board, but the contactor does not close. Two possible reasons: A) The wires to the coil are interrupted or not well connected. B) The contact of the contactor is not properly working.
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.
49	I=0 EVER	○	○			Traction or pump controller current too low
53	STBY I HIGH	○	○			Test carried out in standby. Check if the current is 0. If not verified, an alarm is signalled which inhibits machine operations. Possible causes: A) Current sensor failure; B) Logic failure: first replace the logic; if the defect persists, replace the power unit.
					○	This alarm occurs two ways: 1) 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. 2) 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.
60	CAPACITOR CHARGE	○	○			Follows the charging capacitor system:  When the key is switched ON, the inverter tries to charge the capacitor through a power resistance, and check if the capacitor are charged within a timeout. If this is not true: an alarm is signalled; the main contactor is not closed. Possible reasons: A) The charging resistance is opened; if it is opened. B) The charging circuit has a failure. C) There is a problem on the power modules.

Code	Alarm	Traction (T)	Pump (P)	Mhyrio (V)	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.
65	MOTOR TEMPERATURE	○	○		○	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.
66	BATTERY LOW	○	○			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.
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	○	○			When the key is switched ON, the μP checks that the MC coil driver is not shorted; if it is, this alarm is signalled; replace the logic board.
75	CONTACTOR DRIVER		○			When the initial diagnosis is finished, the traction logic closes the MC and checks the voltage on the drain of the driver. If this is not low, an alarm is signalled. Replace the logic.

Code	Alarm	Traction (T)	Pump (P)	Mhyrio (V)	EPS (E)	Description
76	COIL SHORTED	○	○			When the key is switched ON the μP checks the MC driver FF SR. If it does not react in a correct way to the μP stimulus, the alarm is signalled. Replace the logic board. The FF SR makes an hardware control of the current in the MC coil. If this is too high, it opens the MC and the alarm is signalled. Check if there are external shortcircuit and if the ohmic value of the MC is correct; otherwise replace the logic.
77	COIL INTERRUPTED	○	○			Main contactor line is interrupted
78	VACC NOT OK	○	○			The test is made in standby. This alarm indicates that the accelerator voltage is 1 V greater than the minimum value programmed by the PROGRAM VACC function. Possible causes: A) The potentiometer is not correctly calibrated; B) The potentiometer is defective.
79	INCORRECT START	○	○			This alarm signals an incorrect starting sequence. Possible causes: A) Running microswitch failure; B) Error in sequence made by the operator; C) Incorrect wiring; D) If the default persists, replace the logic.
80	FORW + BACK	○	○			The test is carried out continuously. An alarm is signalled when a double running request is made simultaneously. Possible causes: A) Defective wiring; B) Running microswitch failure; C) Incorrect operation; D) If the defect persists, replace the logic.
82	ENCODER ERROR	○	○			Two consecutive readings of the encoder speed are too much different in between: because of the inertia of the system it is not possible the encoder changes its speed a lot in a short period. Probably an encoder failure has occurred (e.g. one or two channels of the encoder are corrupted or disconnected). Check both the electric and the mechanical encoder functionality. Also the electromagnetic noise on the sensor bearing can be a cause for the alarm.
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	○	○			This alarm is signalled if a fault is detected in the accelerator unit wiring (NPOT or PPOT cable is interrupted).

Code	Alarm	Traction (T)	Pump (P)	Mhyrio (V)	EPS (E)	Description
99	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.
212	MICRO SLAVE #8				○	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	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.
214	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	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.
218	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	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.
220	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.

Code	Alarm	Traction (T)	Pump (P)	Mhyrio (V)	EPS (E)	Description
221	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	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.
225	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	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.
227	SLIP PROFILE		○			Slip profile is wrong (es. slip freq0 > slip freq1)
	SLAVE COM.ERROR				○	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.

<table>
<tr><th>Code</th><th>Alarm</th><th>Traction (T)</th><th>Pump (P)</th><th>Mhyrio (V)</th><th>EPS (E)</th><th>Description</th></tr>
<tr><td>228</td><td>POSITION ERROR</td><td></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>
<tr><td></td><td>MODEL MISMATCH</td><td></td><td>○</td><td></td><td></td><td>Model truck selected for the pump is not the same of traction one</td></tr>
<tr><td></td><td>EVPG1 DRIV SHORT</td><td></td><td></td><td>○</td><td></td><td>One of the group 1 valves drivers is shorted; check the external connection, if it is ok the driver is probably damaged.</td></tr>
<tr><td>229</td><td>EVPG2 DRIV SHORT</td><td></td><td></td><td>○</td><td></td><td>One of the group 2 valves drivers is shorted; check the external connection, if it is ok the driver is probably damaged.</td></tr>
<tr><td>230</td><td>EVPG3 DRIV SHORT</td><td></td><td></td><td>○</td><td></td><td>One of the group 3 valves drivers is shorted; check the external connection, if it is ok the driver is probably damaged.</td></tr>
<tr><td>231</td><td>EVPG4 DRIV SHORT</td><td></td><td></td><td>○</td><td></td><td>One of the group 4 valves drivers is shorted; check the external connection, if it is ok the driver is probably damaged.</td></tr>
</table>

Code	Alarm	Traction (T)	Pump (P)	Mhyrio (V)	EPS (E)	Description
232	EVP DRIVER SHORT			○		One of the on/off valves driver is shorted; check the external connection, if it is ok the driver is probably damaged.
233	EV DRIVER SHORT			○		One of the on/off valves driver is shorted; check the external connection, if it is ok the driver is probably damaged.
235	JOYSTICK ERROR		○			Joystick is in alarm.
236	CAN BUS KO JOY		○			No joystick can message on canbus. Check joystick and connecting status.
237	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.
	SAFETY	○				This alarm is signalled when the "SAFETY" input is open. The "SAFETY" circuit gets active and opens the drivers of LC and EB and stops the machine. Verify the "SAFETY" input connection.
238	SAFETY KO	○				This alarm is present in combi systems (traction + pump). If a stopping alarm is detected on the pump, the traction also stops. The failure must be looked for in the pump inverter.
	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	SLIP PROFILE	○				Slip profile is wrong (es.slip freq0 >slip freq1)
	EVP5_OPEN _DELAY			○		EVP Coil line is interrupt
	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.
240	MOTOR STALL	○				Encoder locked

Code	Alarm	Traction (T)	Pump (P)	Mhyrio (V)	EPS (E)	Description
241	DATA ACQUISITION	○	○			This alarm is signalled in the current gain acquisition phase. Wait the end of the acquisition activity.
	CAN BUS KO			○		There is a problem related to the CAN-BUS line. The error is signalled if the MHYRIO controller 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.
	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	STEAR DEAD ANGLE	○				EPS Relay is open
	MOTOR STALL		○			Encoder locked
	COIL SHORTED			○		ON/OFF valves drivers are protected against coil short circuit; if a short is present across the coil, the flip-flop circuit is set and the alarm is signalled.
	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	SEQUENCE FAULT	○				Wrong Sequence to begin traction(es. First pedal activated and then forward switch activated)
	EV DRIVER KO			○		One of the On/Off valves drivers is open (it does not close when it is commanded by the microcontroller).
	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	ANGLE NOT VALID	○				Angle from EPS is not valid
	JOYSTICK ERROR		○			Joystick is in alarm.
	EVPG1 DRIVER KO			○		One of the group 1 valves drivers is open (it does not close when it is commanded by the microcontroller).

Code	Alarm	Traction (T)	Pump (P)	Mhyrio (V)	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	WRONG SET BATT.	○	○			When the key is turned ON, the controller check the battery voltage and verifies it is within a window around the nominal value. Replace the battery with a correct battery.
	EVPG2 DRIVER KO			○		One of the group 2 valves drivers is open (it does not close when it is commanded by the microcontroller).
	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	SAFETY		○			This alarm is signalled when the "SAFETY" input is open. The "SAFETY" circuit gets active and opens the drivers of LC and EB and stops the machine. Verify the "SAFETY" input connection.
	EVPG3 DRIVER KO			○		One of the group 3 valves drivers is open (it does not close when it is commanded by the microcontroller).
	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.
247	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.
	EVPG4 DRIVER KO			○		One of the group 4 valves drivers is open (it does not close when it is commanded by the microcontroller).

Code	Alarm	Traction (T)	Pump (P)	Mhyrio (V)	EPS (E)	Description
248	DISPLAY ENABLE	○				Communication with display ok but waiting for display message
	UNDER VOLTAGE			○		This fault is signalled if an undervoltage condition is detected in the MHYRIO power supply
	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	THERMIC SENSOR	○	○			The range of inverter temperature sensor is always checked and a warning is signalled if it is out of range. When this alarm is signalled, check the connection of the sensors.
	EVP DRIVER KO			○		The single proportional valve driver is open (it does not close when it is commanded by the microcontroller).
250	HANDBRAKE	○				The truck does not start because the handbrake switch is opened. Possible causes: A) Defective wiring; B) Failure of the microswitch; C) Incorrect operation of the operator; D) If the defect persist, replace the logic.
	HI SIDEDRIVER KO			○		The high side driver which supply the valves coils positive is shorted or open.
	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	WAITING FOR NODE	○				The controller receives from a remote module via CAN BUS the information that it isn't possible to close the LC (the module isn't ready locked in an alarm state). Verify the other modules to determinate in which of them there is the problem.
	WAITING FOR TRAC		○			
	WRONG SET BAT.			○		This fault is signalled if the battery voltage is non consistent with the set battery programmed in the 'set option' menu.
	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.

Code	Alarm	Traction (T)	Pump (P)	Mhyrio (V)	EPS (E)	Description
252	CHAT MODE	○				No command(traction or pump) for CHAT TIME minutes
	HW PROTECTION		○			
	FF VALVES			○		Flip-flop circuit, that manages on/off valve drivers short-circuit protection, does not reset in the correct way. The problem is probably in the hardware circuit.
	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.
253	AUX OUTPUT KO	○	○			The μP checks the driver of the electromechanical brake. If the status of the driver output does not correspond to the signal coming from the μP, the alarm is signalled. Replace the logic.
	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	CAN BUS DISP KO	○				No Can Communication with display
	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.

10. 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.

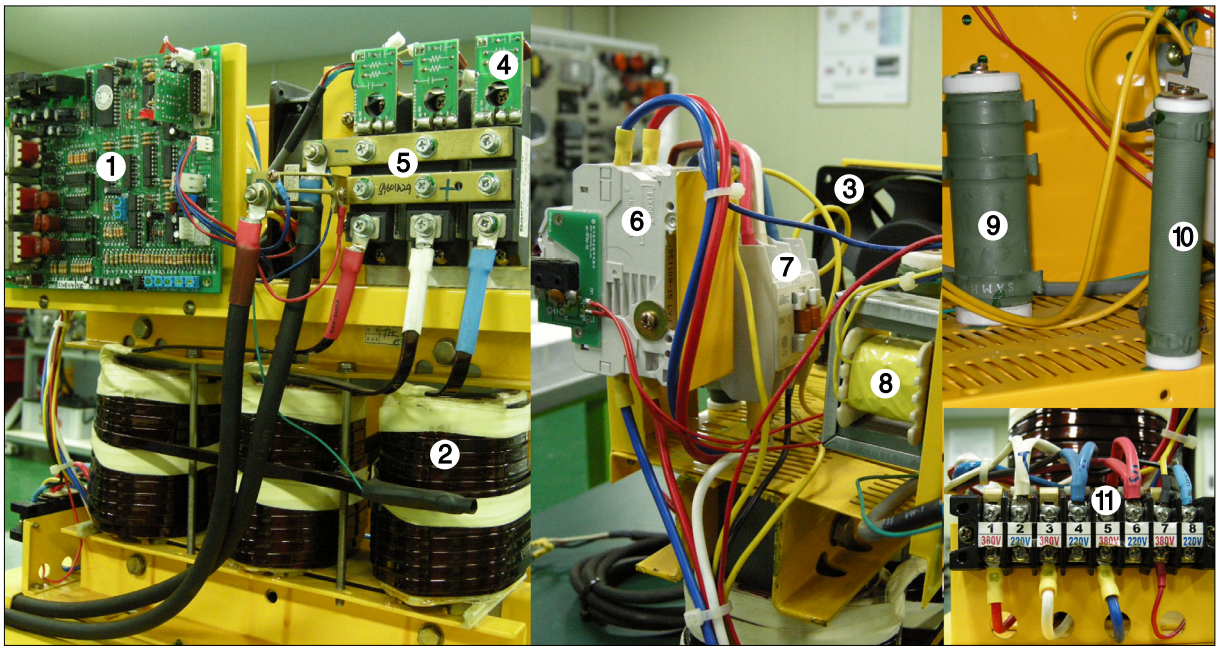
④ Check the electrolyte of the battery every week and provide distilled water immediately if it is required. (Electrolyte has to be provided between 10~12㎜ level on the positive plate inside storage battery)

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)



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1	Main PCB board	5	Shunt	9	Resistance (RD)
2	Main trans (Class H)	6	NFB	10	Resistance (DR)
3	Cooling fan	7	MG S/W	11	TAP changer
4	SCR module	8	Assistant trans		

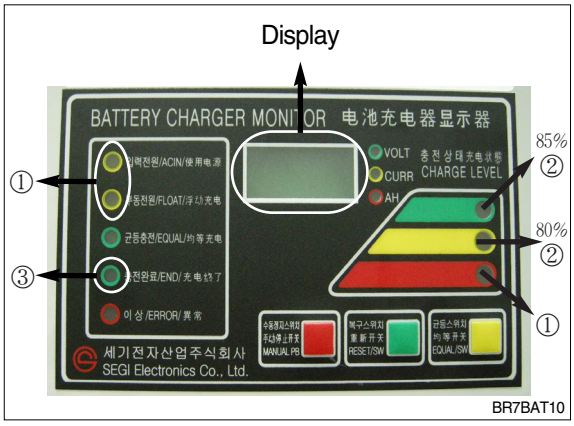
2) CHARGER INSTALLATION METHOD

(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.



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.

· 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.

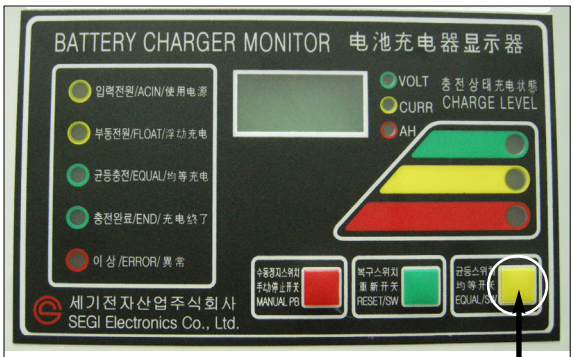
When equalized charging is required?

- 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.**



Equalized charging switch

BR7BAT10

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

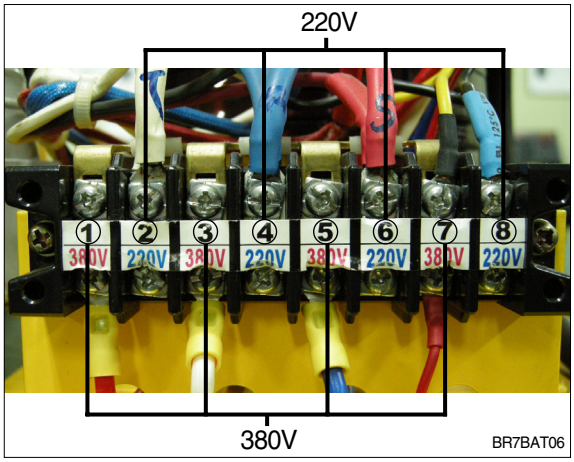
※ **Above cases are under normal operations.**

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

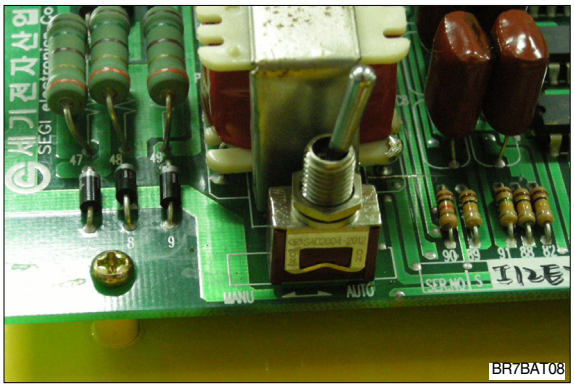
Refer to No. 2 of the charger installation method for the terminal connection method.

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

It should be connected to the terminal.



(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.



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(5) MG/SW operation
(This switch is operated automatically.)

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

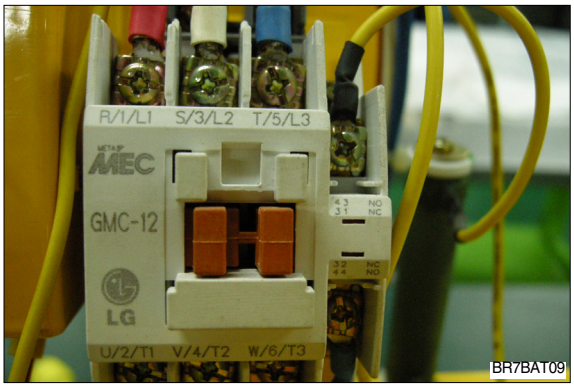
① After 5 seconds next to turn the manual switch on.
Input, floating charge and red charging condition lamp is on.

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

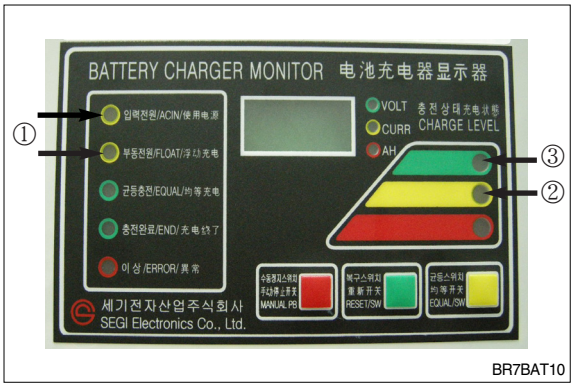
③ After green lamp becomes on, measure the output voltage of the battery connector by multi measure. If measured voltage is between 62.5V ~ 63.5V, it is normal. (Rated voltage : 63V)

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



BR7BAT09

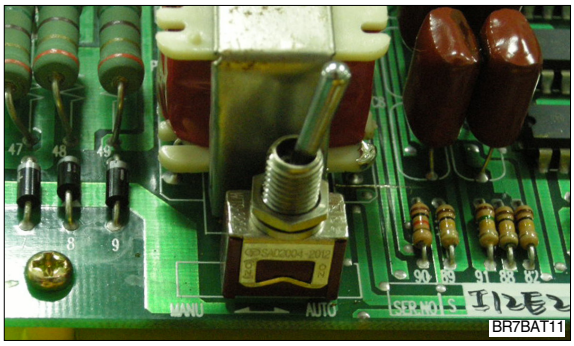


BR7BAT10

(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 (63V), convert automatic / manual switch to automatic and start charging.

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



No	Code	Description of error
1	E.F	EPROM fail
2	O.V	Over voltage - Refer to page 7-73
3	O.C	Over current - Refer to page 7-72, 74.
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 7-71.
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 forklift 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.

BR7BAT10

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"

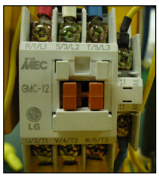
④ Charger TRIP is occurred after abnormality lamp is on.
In case error code is "O.C"

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

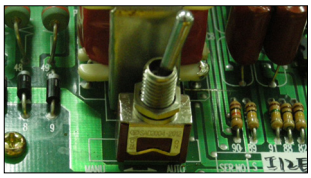
⑥ Charger has no response even the battery connector is connected.

(2) Troubleshooting

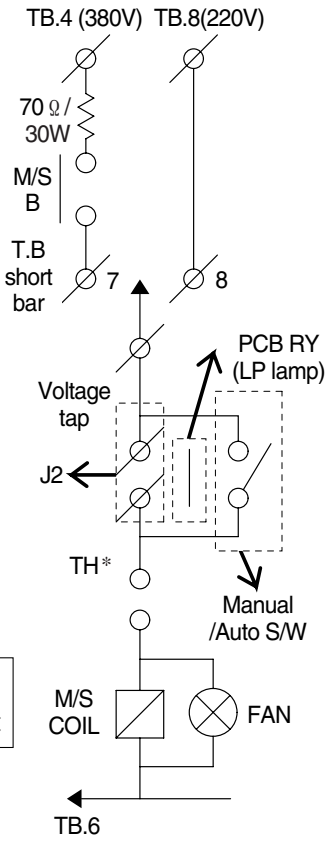
① Only floating charge lamp is on after indicating "A.O", It's not charged.



In front of MS



Manual/Auto TAP Changer



M/S electrical circuit

- 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

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

NO → Change PCB

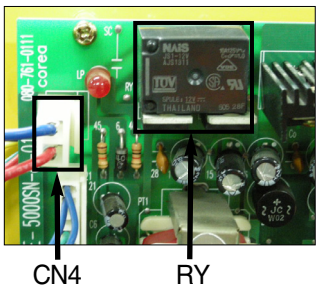
NO → Apply multi tester for input voltage change over tab no. 6
Measure voltage between input tab no.8, PCB CN4, and contact points with red reed putting black reed on the other side
Apply multi tester for input voltage change over tab no. 6

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

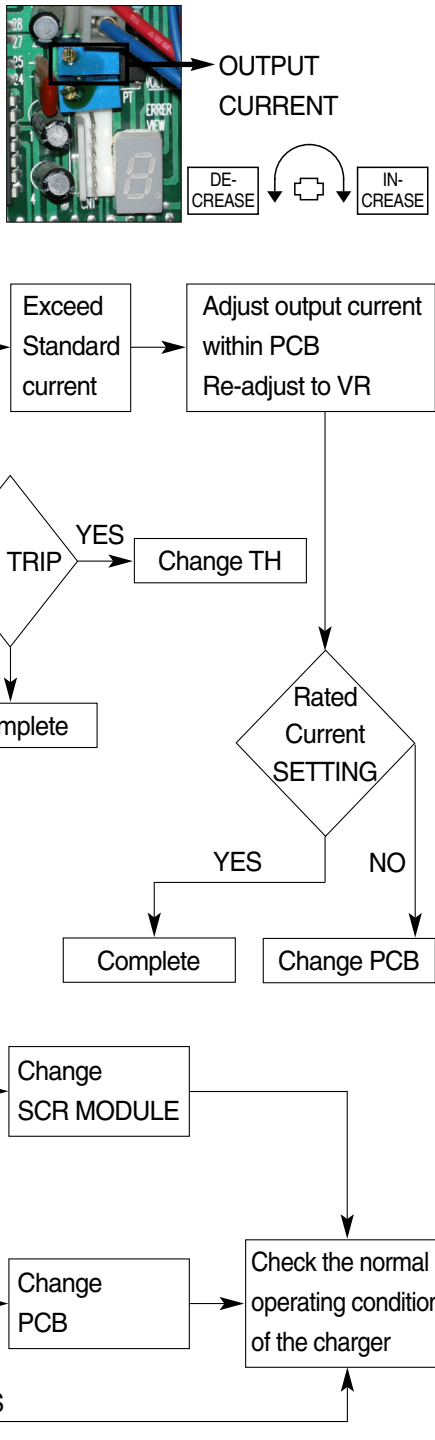
Voltage 220V?

NO → TH contact fault
CN4 contact fault
PCB RELAY fault
TH manual restoration release

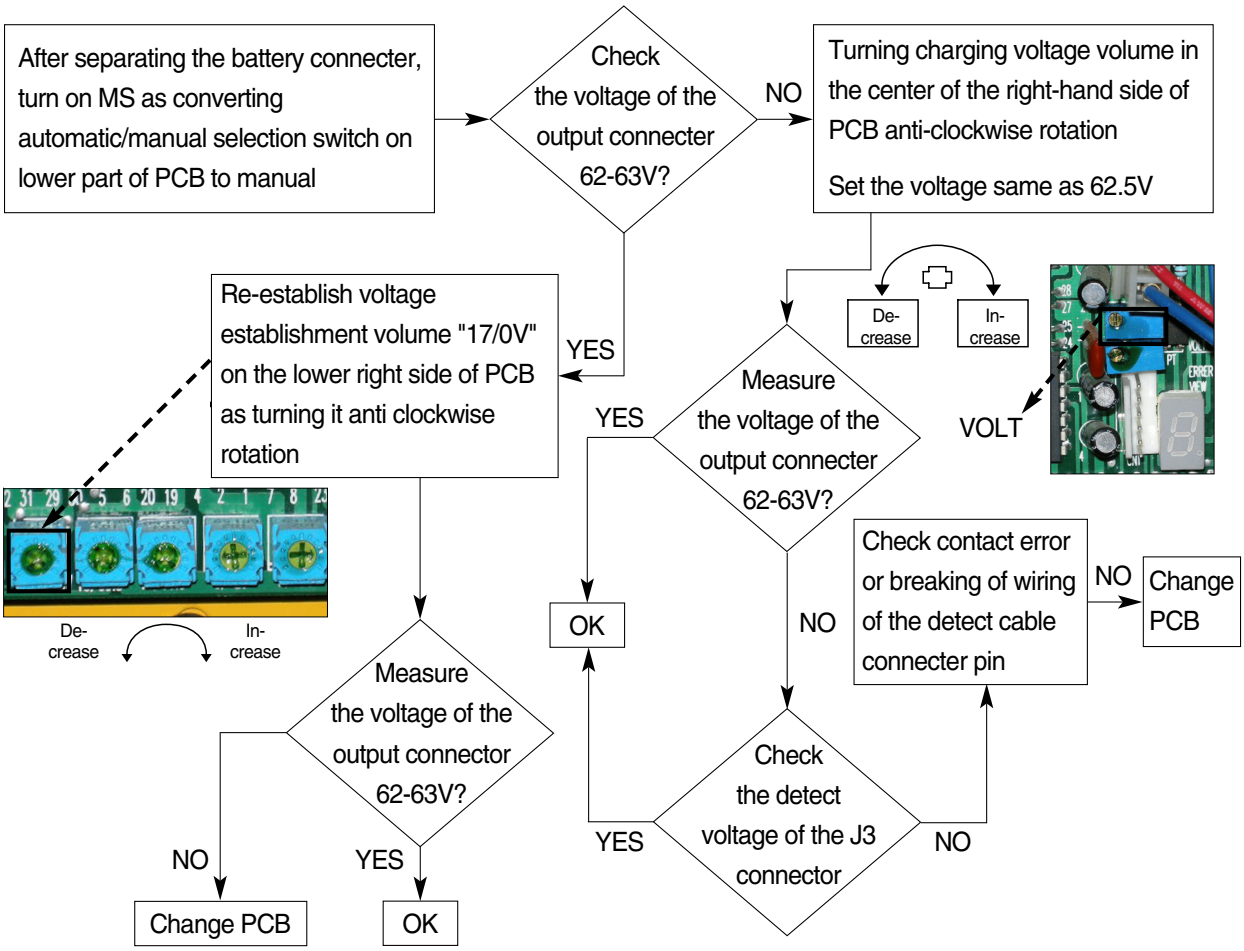
YES → MS COIL fault



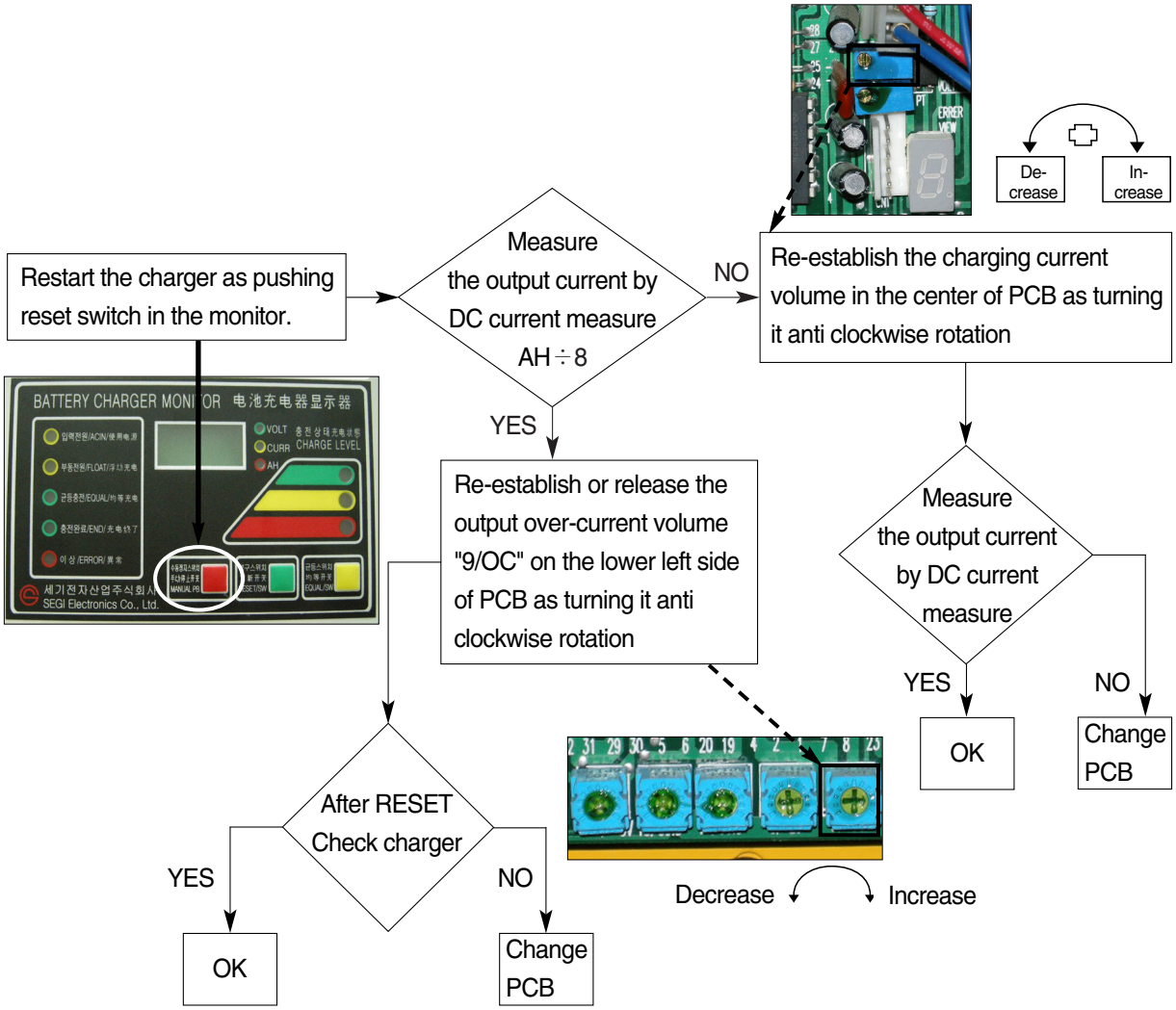
② ON and OFF is repeated with a few minutes intervals after starting charging.
Indicate "O.C" on the monitor.
- TH is operated (AC input over-current TRIP).



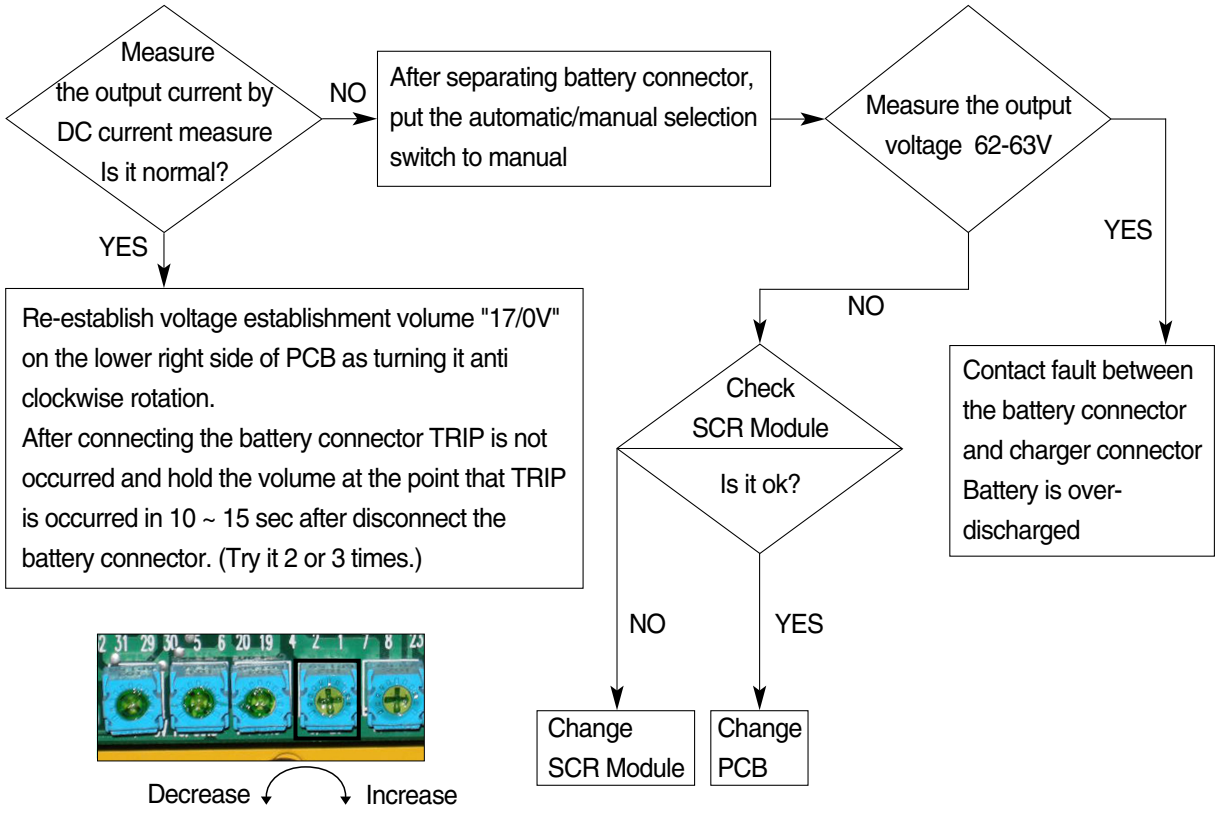
③ **Charger TRIP is occurred after abnormality lamp is on.**
In case error code is "O.V" → Over-voltage output / Set at 66Vdc (In case of BATT 48V)



④ **Charger TRIP is occurred after abnormality lamp is on.**
In case error code is "O.C" → Output over current, established as 120% of the rated current.

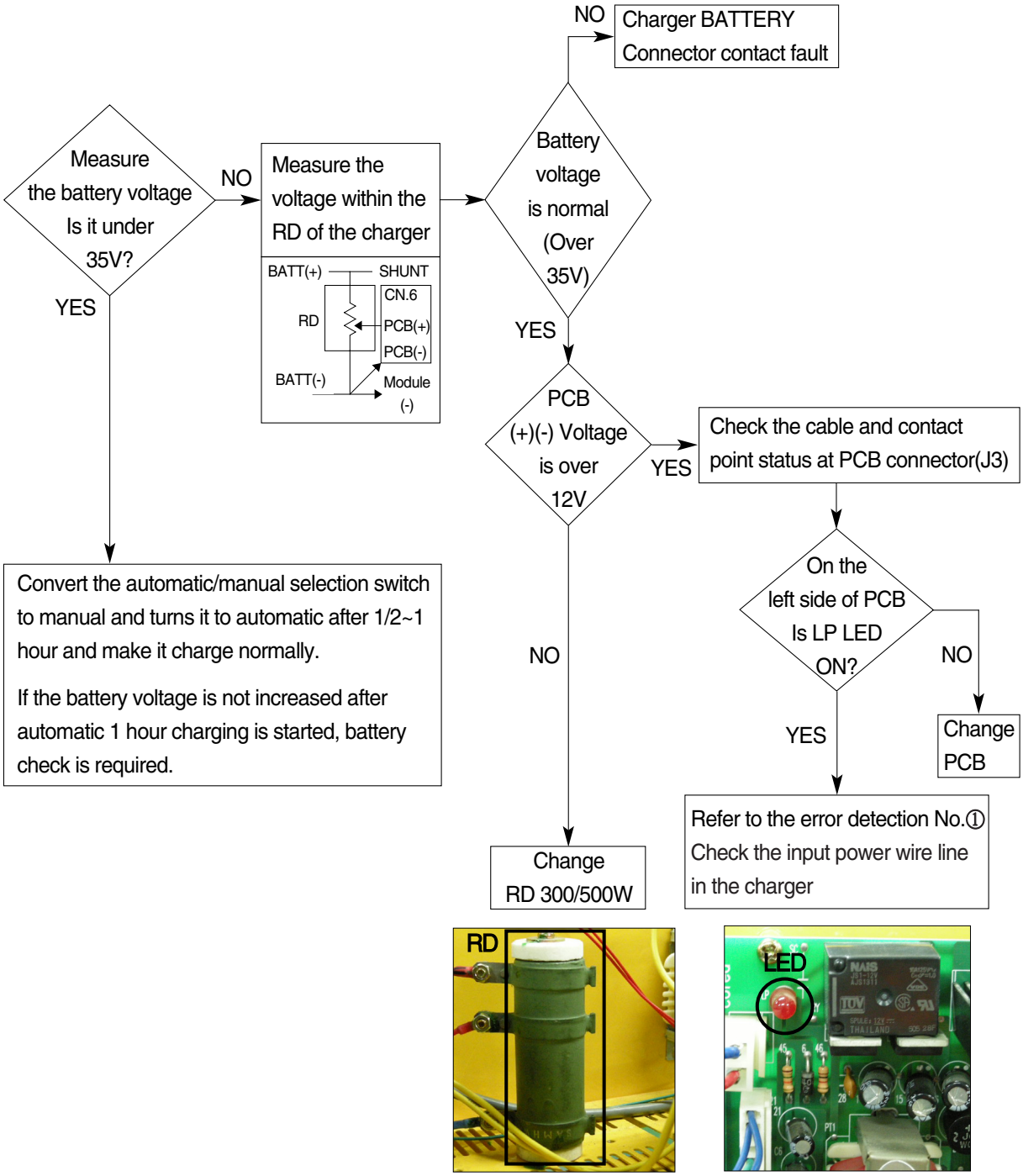


⑤ **Charger TRIP is occurred after it started charging and charging completion lamp is on.**
(In case input voltage is normal - Refer to the error detection No. 1)
Restore the charger as pushing reset switch.



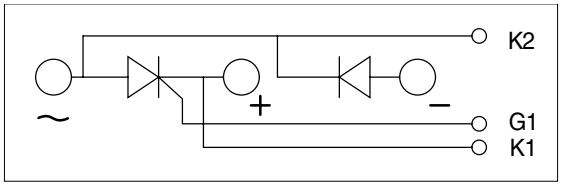
⑥ Charger has no response even if the battery connector is connected.

- 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)

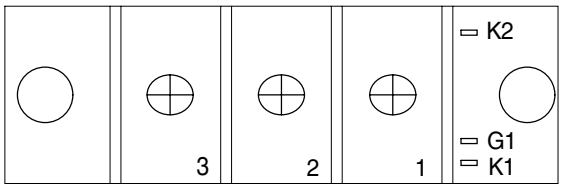


7) HOW TO CHECK THE SCR MODULE

Circuit

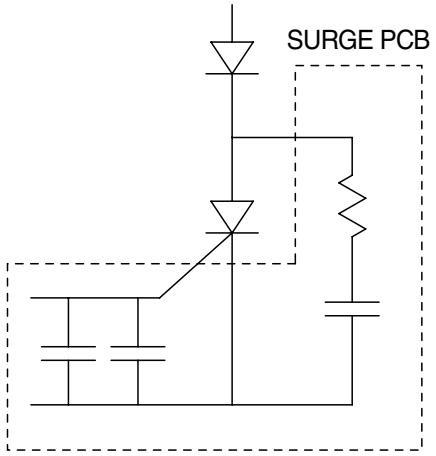


Real diagram

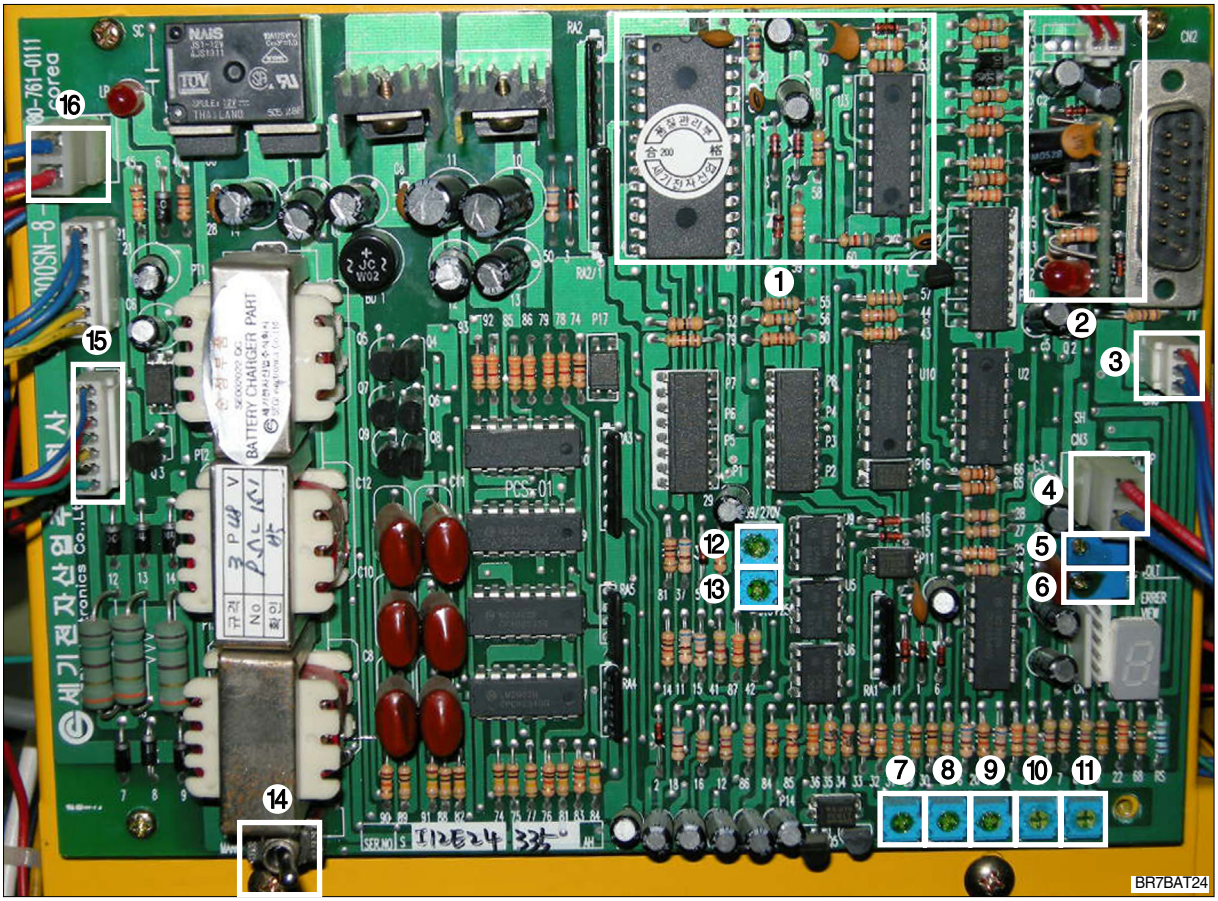


* Before checking SCR MODULE, be sure to disconnect bus bar and wire on the terminal.

No.	Measuring point (Real diagram)	Measure value
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



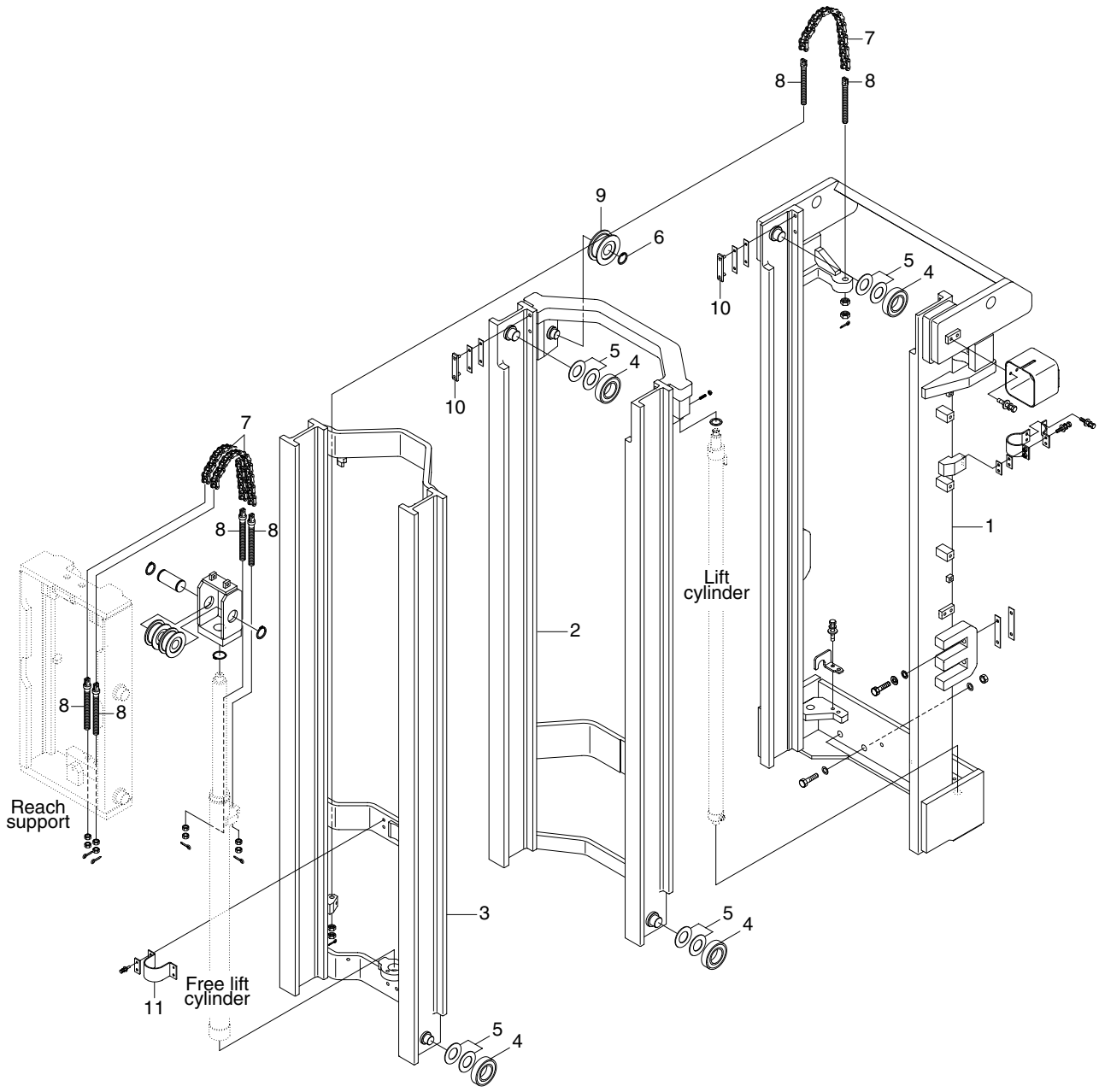
1	Micro control unit #1	7	Over voltage	13	Set input over current
2	Micro control unit #2	8	Monitor level yellow	14	Auto/manual switch
3	CN6 voltage detect	9	Monitor level green	15	SCR control connector
4	SH current detect	10	Under current	16	CN4 RY contact point
5	Adjust charging current	11	Over current		
6	Adjust charging voltage	12	Set input over voltage		

SECTION 8 MAST

Group 1 Structure ····· 8-1
Group 2 Operational checks and troubleshooting ····· 8-3
Group 3 Adjustment ····· 8-6
Group 4 Disassembly and assembly ····· 8-9

GROUP 1 STRUCTURE

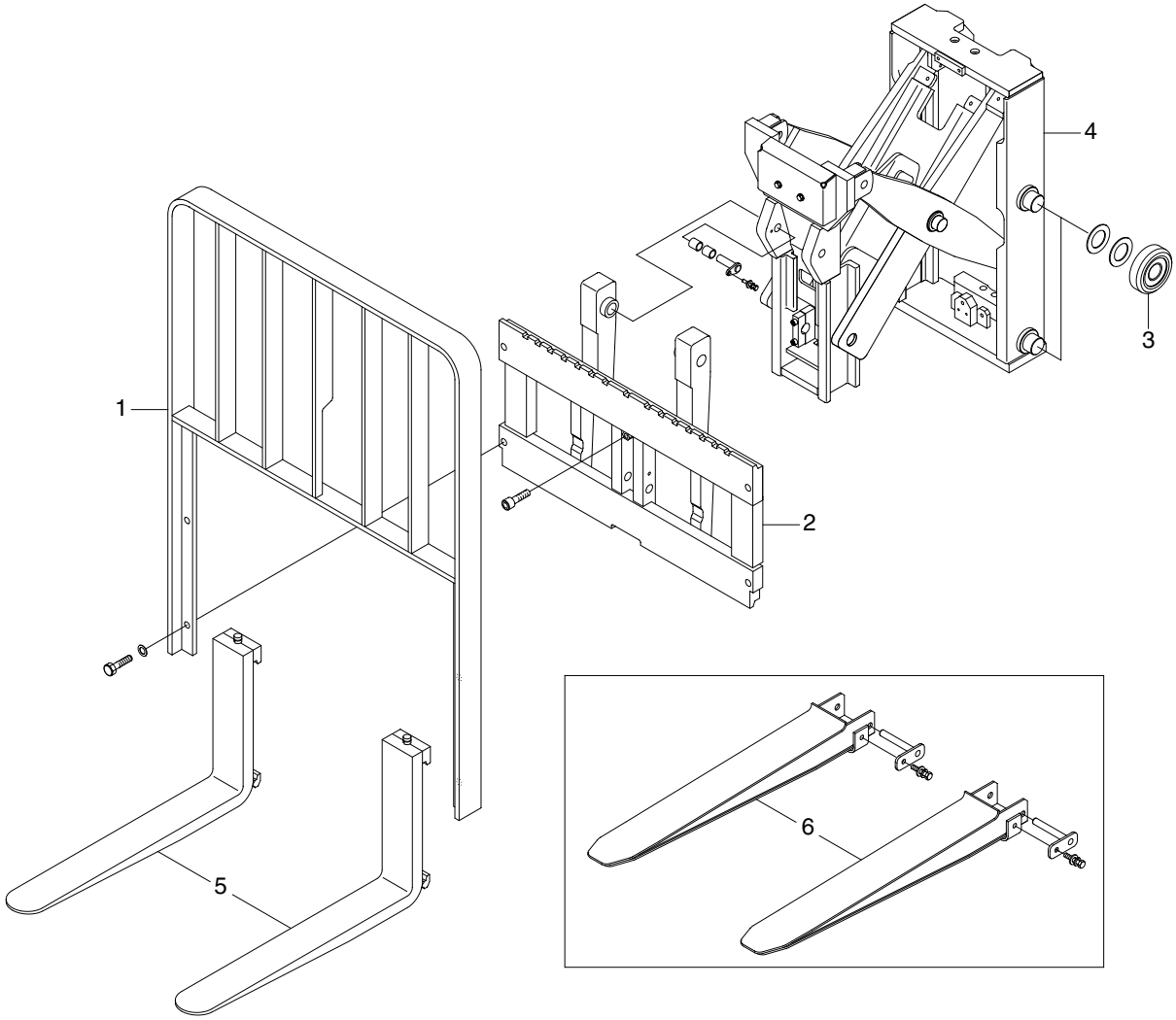
1. 3 STAGE MAST(TF MAST)



BRP7MS03

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	Clamp
4	Roller	8	Anchor bolt		

2. CARRIAGE, BACKREST AND FORK



BRP7MS05

1	Backrest	4	Reach support and carriage
2	Carriage	5	Fork assy
3	Load roller	6	Extension fork

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

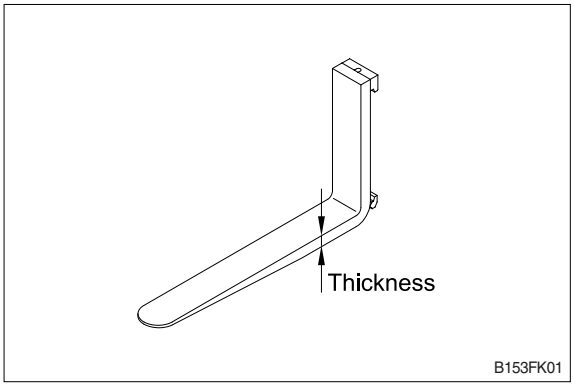
1. OPERATIONAL CHECKS

1) FORKS

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

mm(in)

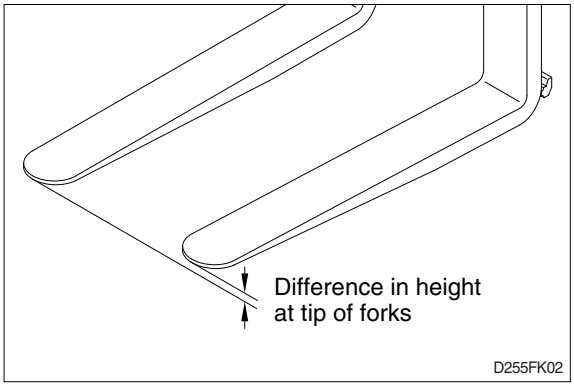
STD Fork assy	Applicable model	Standard	Limit
64HM-11060	15/18BRP-7	40(1.6)	36(1.4)
64HN-13030	20BRP-7	45(1.8)	40(1.6)
64HN-12030	23BRP-7	45(1.8)	40(1.6)



(2) Set forks in middle and measure difference in height at tip of forks.

mm

Model	Fork length	Height difference
15/18/20/23BRP-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 cracks at mast stay, tilt cylinder bracket, guide bar, fork carriage and roller shaft weld. Check visually or use crack detection method. Repair any abnormality.
2) Set mast vertical, raise forks about 10cm from ground and check front-to-rear clearance and left-to-right clearance between inner mast and fork carriage, and between outer mast and inner mast. Use these figures to judge if there is any play at roller or rail.
   - Front-to-rear clearance : Within 2.0mm(0.08in)
   - Left-to-right clearance : Within 2.5mm (0.10in)
3) Check that there is an oil groove in bushing at mast support.
4) Set mast vertical, raise forks about 10cm from ground, and push center of lift chain with finger to check for difference in tension.
   If there is any difference in tension, adjust chain stopper bolt.
5) Check visually for abnormalities at thread of chain anchor bolt, and at contact surface between chain wheel and chain.
   Rotate chain wheel by hand and check for any play of bearing.

2. TROUBLESHOOTING

1) MAST

Problem	Cause	Remedy
Forks fail to lower.	· Deformed mast or carriage.	· Disassemble, repair or replace.
Fork fails to elevate	· Faulty hydraulic equipment.	· 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

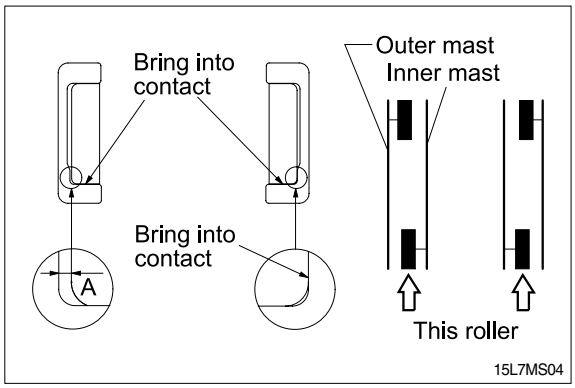
(1) Measure the clearance with the mast overlap at near 480mm.

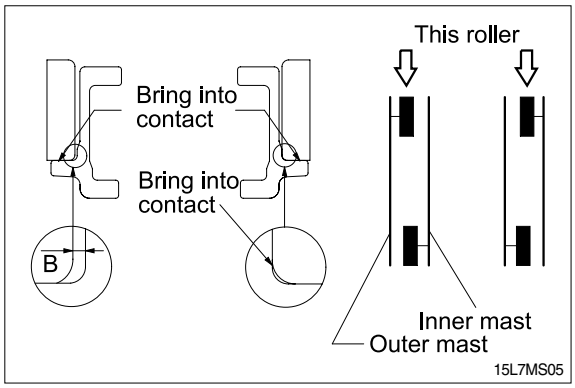
(2) Shift the inner mast to one side to bring the roller into contact with the outer mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner/outer mast roller shim.

- 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.

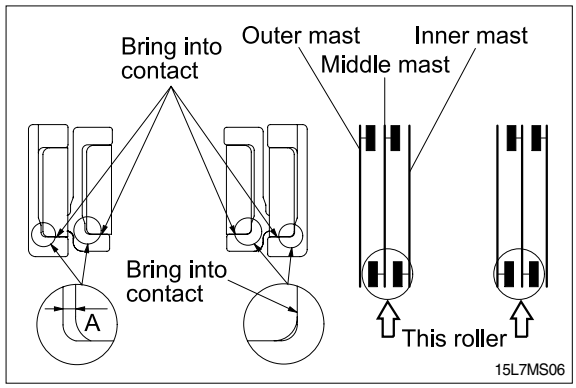
(4) After the adjustment, check that the inner mast moves smoothly in the outer mast.





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.

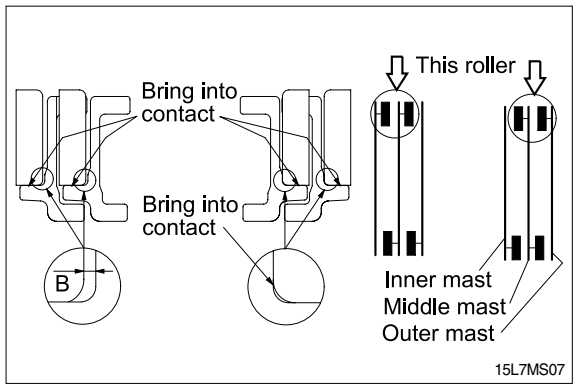
(2) Shift the inner mast to one side to bring the roller into contact with the outer mast and the middle mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner and middle mast roller shim, respectively.

- 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.

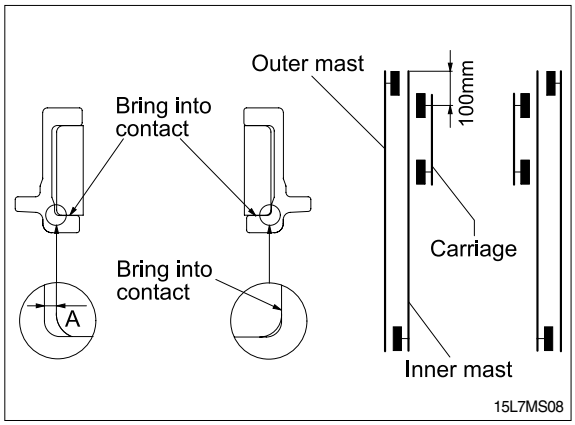
(2) Shift the inner mast to one side to bring the roller into contact with the middle mast and the inner mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the outer and middle mast roller shim, respectively.

- 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 100㎜ from the top of the inner mast.

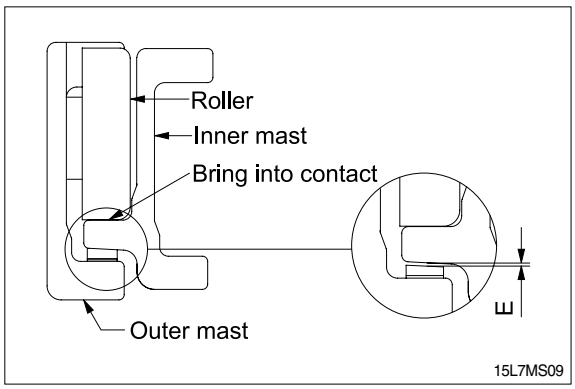
(2) Measure the clearance at upper, lower rollers after loosen the adjust screws from the side rollers. Shift the carriage to one side to bring the roller into contact with the inner mast, and measure the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the carriage roller shim.

- Standard clearance C = 0.3~0.6㎜
- Shim thickness 0.5, 1.0㎜

(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.

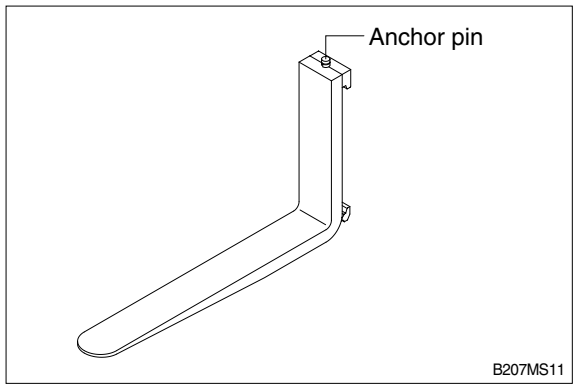
- Standard clearance E = 0.5 ~ 1.0㎜
- Shim thickness 0.5, 1.0㎜

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

GROUP 4 REMOVAL AND INSTALLATION

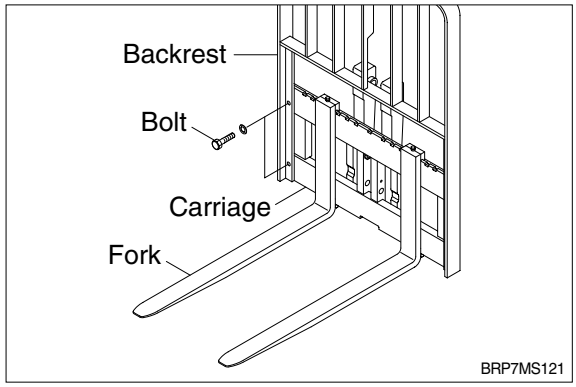
1. FORKS

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



2. BACKREST

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



3. CARRIAGE ASSEMBLY

1) CARRIAGE

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

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

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

(4) Slowly raise elevating upright until mast clears top of fork carriage. Move carriage to work area and lower mast.

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

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

(6) Reverse the above steps to reinstall.

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

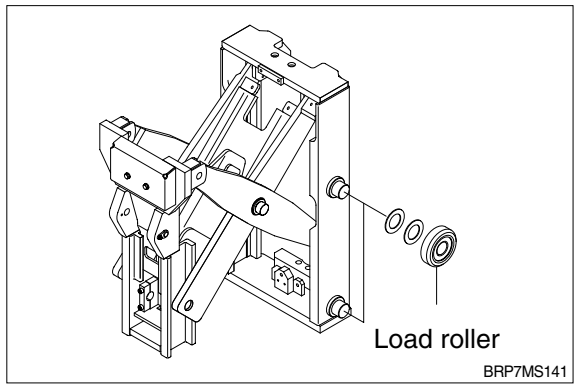
2) CARRIAGE LOAD ROLLER

(1) Remove carriage as outlined in the carriage assembly removal paragraph.

(2) Loosen and remove flat head bolts and plain washers from top load roller bracket.

(3) Using a pryer, remove load rollers from load roller bracket.

(4) Reverse the above procedure to assemble. Refer to MAST ROLLER ADJUSTMENT paragraph.



4) MAST LOAD ROLLER AND BACK UP LINER

(1) 3 stage mast(TF mast)

① Remove the carriage assembly and move to one side.

② Loosen and remove hexagon bolt securing bottom cylinder from outer mast.

③ Loosen and remove bolts and special washers securing lift cylinders to middle mast.

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

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

⑥ Using the overhead hoist raise inner and middle masts. Place 4 inch block of wood under the free lift cylinder bracket of the inner mast then lower mast sections (this will create slack in the chains).
Remove retaining rings securing chain sheaves to sheave support brackets.

⑦ 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.

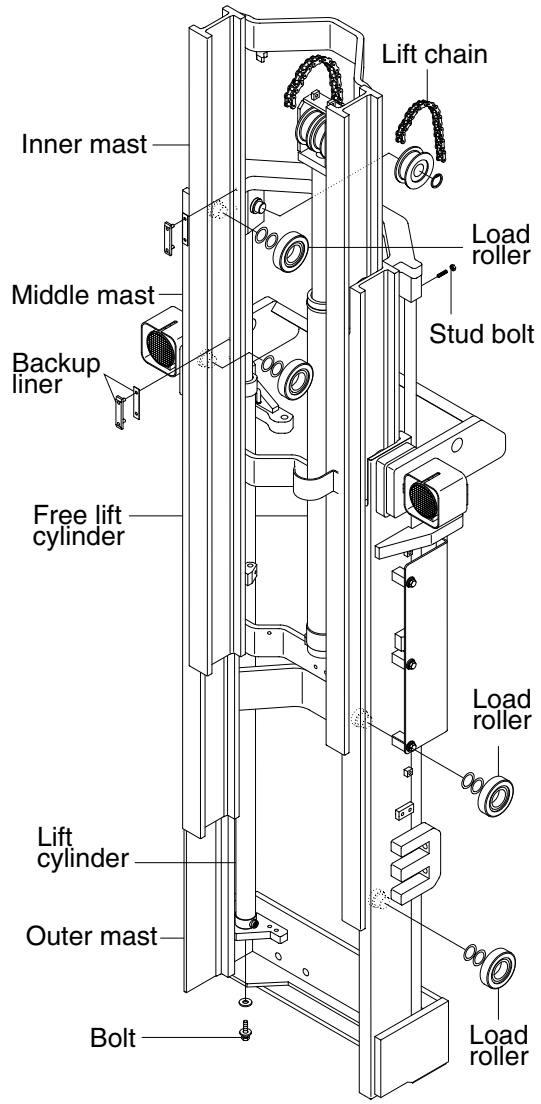
⑧ Using a pryer, remove load rollers from load bracket. Remove back up liners and shims.

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.



BRP7MS16

5) 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.

6) CHAIN

(1) Rear chain sheave(TF mast)

① Raise and securely block carriage and inner mast section.

② Remove the split pin securing the chain anchor pins and discard. While supporting the chains, remove the chain anchor pins from outer mast section.

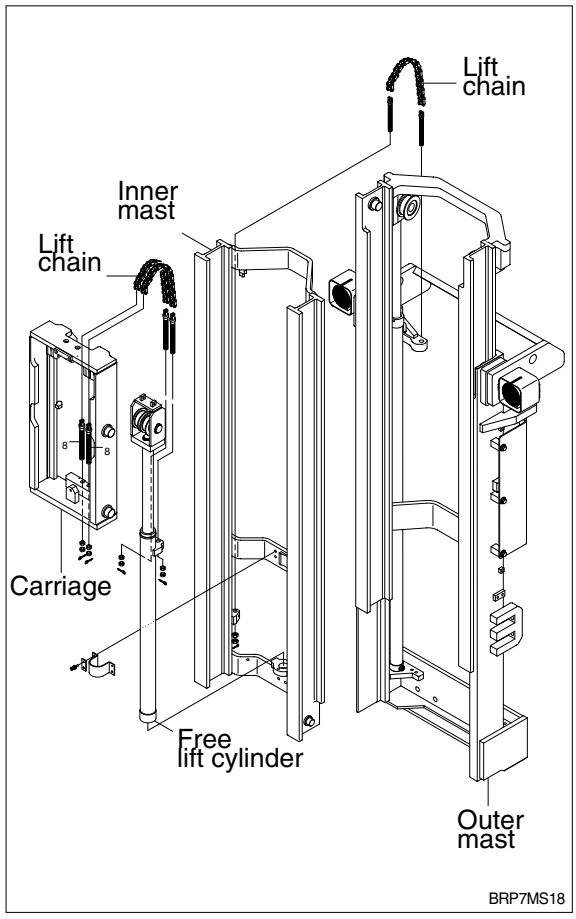
③ Remove chains.

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

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

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

⑦ Reverse the above procedure to assemble and install. Use new split pins in chain anchor pins.



(2) Chain wheel bearing support(TF mast)

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

(3) Rear chain(TF mast)

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

(4) Carriage chain

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

(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 our the worn section and splicing in a new piece. If part of the chain is worn, replace all the chains on the truck.

② Rust and corrosion

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

③ Cracked plate

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

④ Tight joints

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

Tight joints in lift chains can be caused by :

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

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

⑤ Protruding or turned pins

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

⑥ Chain side wear

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

⑦ Chain anchors and chain wheel bearings

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

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

⑧ **Chain wear scale**

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

- Determine pitch length of chain using 6 inch scale on one side of wear scale.
- If pitch is 1/2(12.7㎜), 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.