CONTENTS

1. STRUCTURE

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

SECTION 1 GENERAL
This section gives the general information of the machine and explains the safety hints for maintenance.

SECTION 2 REMOVAL & INSTALLATION OF UNIT
This section explains the procedures and techniques of removal and installation of each component.

SECTION 3 POWER TRAIN SYSTEM
This section explains the structure of the drive axle unit.

SECTION 4 BRAKE SYSTEM
This section explains the brake mechanism, each component and operation.

SECTION 5 STEERING SYSTEM
This section explains the structure of the steering system.

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

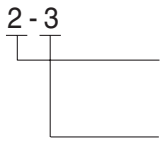
Distribution and updating

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 55 mm 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, 55 mm = 2.165 inches.

2. Convert 550 mm 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 55 mm.

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

(3) The original value (550 mm) 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 550 mm = 21.65 inches.

Millimeters to inches

1 mm = 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

1 mm = 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

1 kg = 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

1 kgf · m = 7.233 lbf · ft

	0	1	2	3	4	5	6	7	8	9
		7.2	14.5	21.7	28.9	36.2	43.4	50.6	57.9	65.1
10	72.3	79.6	86.8	94.0	101.3	108.5	115.7	123.0	130.2	137.4
20	144.7	151.9	159.1	166.4	173.6	180.8	188.1	195.3	202.5	209.8
30	217.0	224.2	231.5	238.7	245.9	253.2	260.4	267.6	274.9	282.1
40	289.3	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

1 kgf / cm² = 14.2233 lbf / in²

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

TEMPERATURE

Fahrenheit-Centigrade Conversion.

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

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

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

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

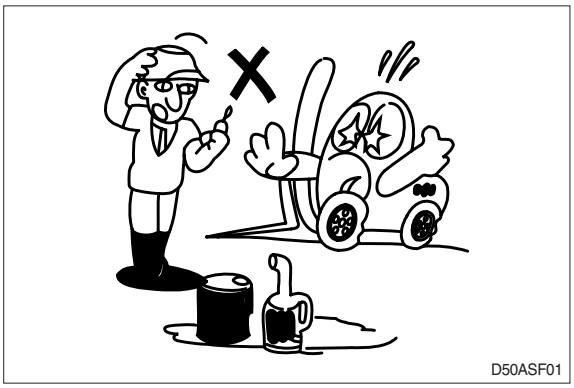
˚C		˚F	˚C		˚F	˚C		˚F	˚C		˚F
-40.4	-40	-40.0	-11.7	11	51.8	7.8	46	114.8	27.2	81	117.8
-37.2	-35	-31.0	-11.1	12	53.6	8.3	47	116.6	27.8	82	179.6
-34.4	-30	-22.0	-10.6	13	55.4	8.9	48	118.4	28.3	83	181.4
-31.7	-25	-13.0	-10.0	14	57.2	9.4	49	120.2	28.9	84	183.2
-28.9	-20	-4.0	-9.4	15	59.0	10.0	50	122.0	29.4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

SECTION 1 GENERAL

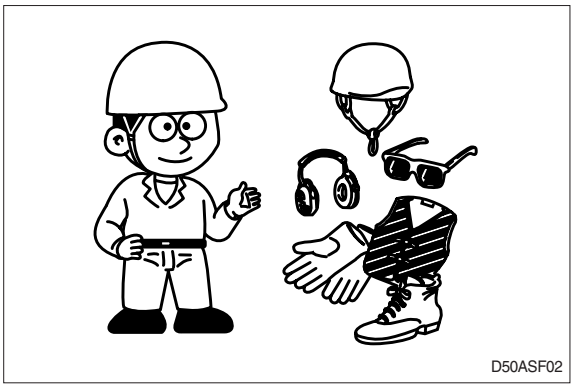
GROUP 1 SAFETY HINTS

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

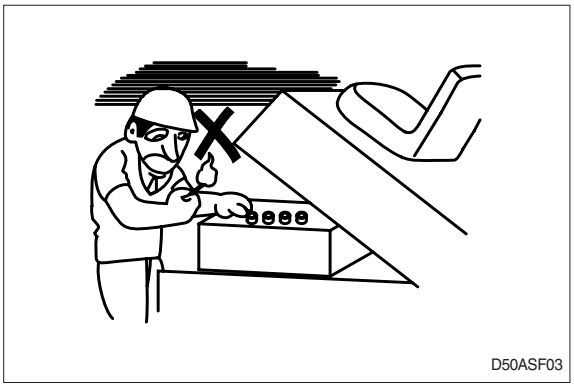
- Oil is a dangerous substance. Never handle oil, grease or oily clothes in places where there is any fire of flame.
  As preparation in case of fire, always know the location and directions for use of fire extinguishers and other fire fighting equipment.


D50ASF01

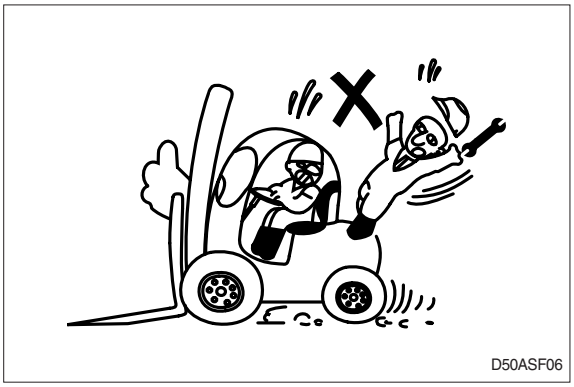
- Wear well-fitting helmet, safety shoes and working clothes. When drilling, grinding or hammering, always wear protective goggles.
  Always do up safety clothes properly so that they do not catch on protruding parts of machines. Do not wear oily clothes.
  When checking, always release battery plug.


D50ASF02

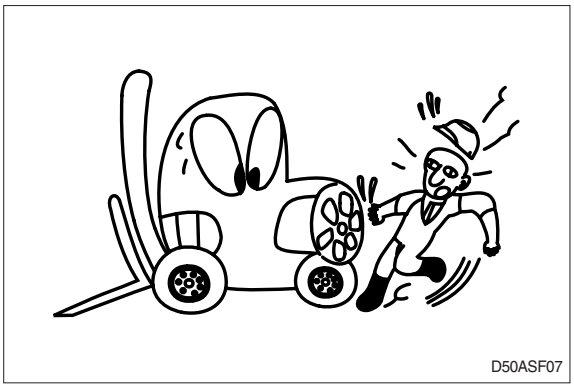
- Flames should never be used instead of lamps. Never use a naked flame to check leaks or the level of oil or electrolyte.


D50ASF03

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

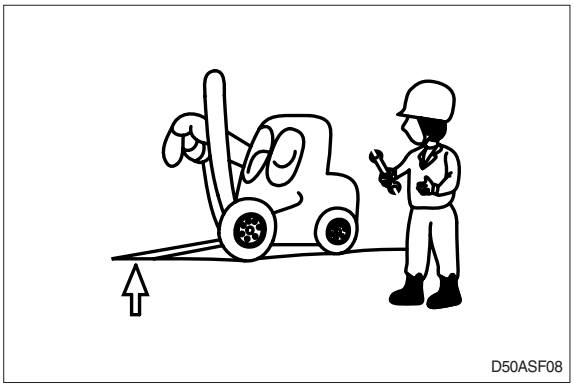

D50ASF06

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

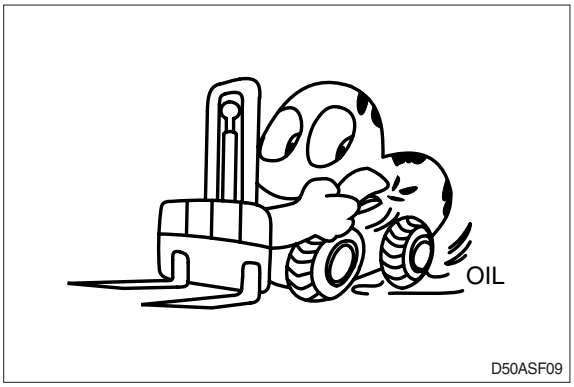

D50ASF07

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

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

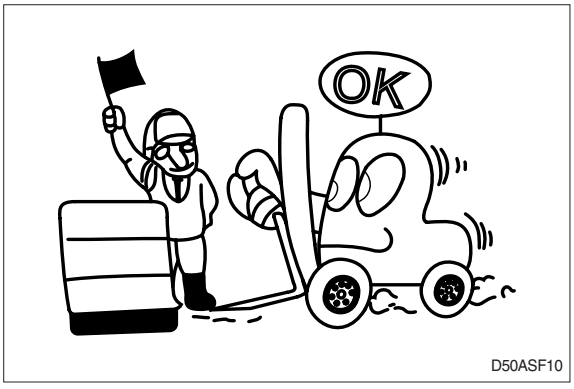

D50ASF08

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



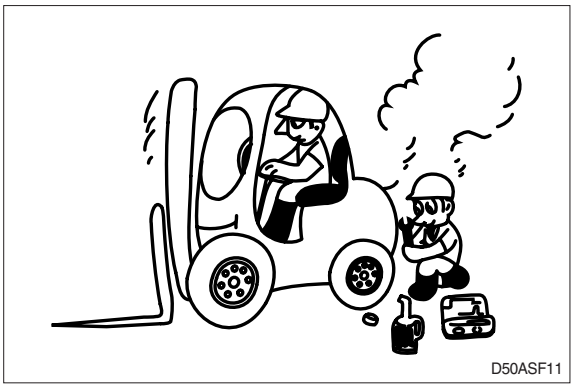
D50ASF09

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



D50ASF10

· 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.

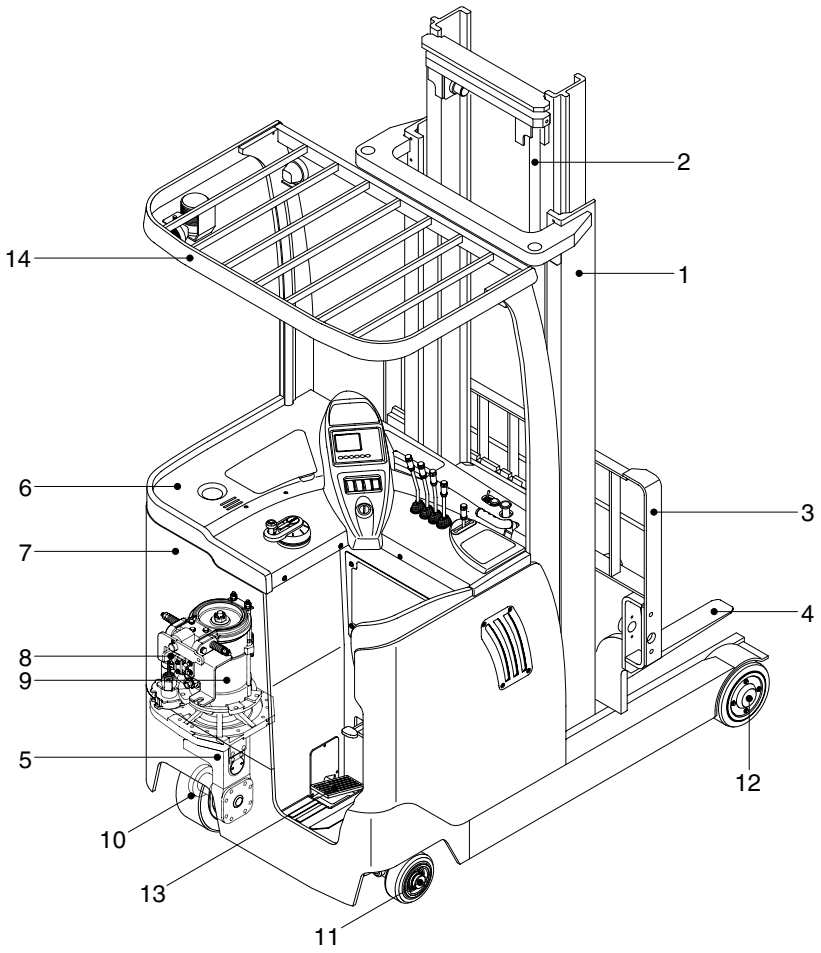

D50ASF11

· 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

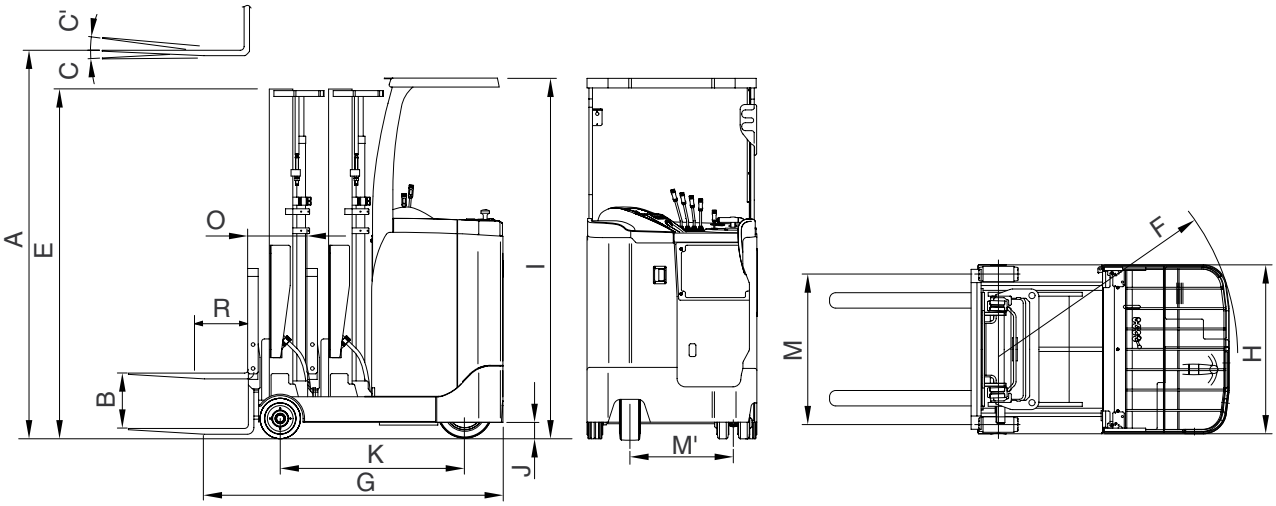
1. GENERAL LOCATIONS



15BR9EOM113

1	Mast	6	Dash board	11	Caster wheel
2	Lift cylinder	7	Frame	12	Load wheel
3	Carriage and backrest	8	EPS motor	13	Brake pedal
4	Forks	9	Drive motor	14	Overhead guard
5	Drive unit	10	Drive wheel		

2. SPECIFICATIONS



18BR9SP01

Model			Unit	15BR-9E
Capacity			kg (lb)	1500 (3000)
Load center		R	mm (in)	500 (24")
Weight (Unloaded, with battery)			kg (lb)	2171 (4790)
Fork	Lifting height	A	mm (ft-in)	3000 (9' 10")
	Free lift	B	mm (in)	105 (4.1")
	Lifting speed (Unload/Load)		mm/sec	500/310
	Lowering speed (Unload/Load)		mm/sec	450/500
	L×W×T	L,W,T	mm (in)	900×100×35 (35.4×3.9×1.4)
Mast	Tilt angle (forward/backward)	C/C'	degree	5/5
	Max height	D	mm (ft-in)	4025 (13' 3")
	Min height	E	mm (ft-in)	1991 (6' 6")
Body	Travel speed (Unload)		km/h	11
	Gradeability (Unload/Load)		%	30/17
	Min turning radius (Outside)	F	mm (ft-in)	1596 (5' 3")
ETC	Max hydraulic pressure		kgf/cm^2	190
	Hydraulic oil tank		ℓ (usgal)	18 (4.76)
Overall length (With fork at reach in)		G	mm (ft-in)	2189 (7' 2")
Overall width (Load wheel)		H	mm (ft-in)	1070 (3' 6")
Overhead guard height		I	mm (ft-in)	2260 (7' 5")
Ground clearance		J	mm (in)	94 (3.7")
Wheel base		K	mm (ft-in)	1315 (4' 4")
Wheel tread (Front/rear)		M/M'	mm (ft-in)	970 /613 (3' 2" /2' 0")
Reach stroke		O	mm (ft-in)	447 (1' 6")

3. SPECIFICATION FOR MAJOR COMPONENTS

1) MOTOR

Item	Unit	Drive motor	Hydraulic pump motor
Model	-	AMDU4004A	ABDK4001
Type	-	AC	←
Rated voltage	Vac	30V 3 ø	←
Output	kW	4.5	9.0
Insulation	-	Class F	←

2) BATTERY

Item	Unit	15BR-9E
Model	-	VCI 230
Rated voltage	V	48
Capacity	AH/hr	230/5
Electrolyte	-	WET
Dimension (W × D × H)	mm	994 × 270 × 581.7
Connector (CE spec)	-	SB350 (SBE320)
Weight	kg	380

3) CHARGER

Item	Unit	15BR-9E
Type	-	Constant current, constant voltage
Battery capacity for charge	V-AH	48-195~230
AC input	V	Triple phase 410
		Single phase 220
		Triple phase 220/380
		Triple phase 440
DC output	V	64±1
Charge time	hr	6±2
Connector (CE spec)	-	SB350 (SBE320)

4) GEAR PUMP

Item	Unit	Specification
Type	–	Fixed displacement gear pump
Capacity	cc/rev	16.5
Maximum operating pressure	bar	210
Rated speed (max/min)	rpm	3000/500

5) MAIN CONTROL VALVE

Item	Unit	Specification
Type	-	3 spool, 4 spool
Operating method	-	Mechanical
Main relief valve pressure	bar	190

6) DRIVE UNIT

Item	Unit	Specification
Gear ratio	-	20.125
Oil quantity	ℓ	1.6

7) WHEELS

Item	15BR-9E
Type (Load / Drive /Caster)	Urethane / Rubber / Rubber
Quantity (Load / Drive /Caster)	2 / 1 / 2
Load wheel	254 × 100
Drive wheel	306 × 127
Caster wheel	178 × 73

8) BRAKES

Item	Specification
Brakes (Service & Parking)	Drum brake.

4. TIGHTENING TORQUE FOR MAJOR COMPONENTS

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		Drive motor mounting bolt	M 8×1.25	2.0±0.2	14.4±1.4
3		Steering motor mounting bolt	M10×1.5	6.9±1.4	50±10
4	Hydraulic system	Hydraulic pump mounting bolt	M10×1.5	5±1.0	36.2±7.2
5		MCV mounting bolt, nut	M 8×1.25	2.5±0.5	18.1±3.6
6	Power train system	Drive wheel mounting bolt	M16×1.5	20.5±1.5	148.3±10.8
7		Load wheel mounting nut	M40×1.5	5±0.5	36.2±3.6
8		Caster wheel mounting bolt	M12×1.75	12.0±1.0	89.8±7.2
9		Drive unit bracket mounting bolt	M12×1.75	14.3±1.0	103.4±7.2
10	Other	Head guard mounting bolt	M14×2.0	19±3.0	137.4±21.7

5. TORQUE CHART

Use following table for unspecified torque.

1) BOLT AND NUT

(1) Coarse thread

Bolt size	8T		10T	
	kgf · m	lbf · ft	kgf · m	lbf · ft
M 6 × 1.0	0.85 ~ 1.25	6.15 ~ 9.04	1.14 ~ 1.74	8.2 ~ 12.6
M 8 × 1.25	2.0 ~ 3.0	14.5 ~ 21.7	2.73 ~ 4.12	19.7 ~ 29.8
M10 × 1.5	4.0 ~ 6.0	28.9 ~ 43.4	5.5 ~ 8.3	39.8 ~ 60
M12 × 1.75	7.4 ~ 11.2	53.5 ~ 79.5	9.8 ~ 15.8	71 ~ 114
M14 × 2.0	12.2 ~ 16.6	88.2 ~ 120	16.7 ~ 22.5	121 ~ 167
M16 × 2.0	18.6 ~ 25.2	135 ~ 182	25.2 ~ 34.2	182 ~ 247
M18 × 2.5	25.8 ~ 35.0	187 ~ 253	35.1 ~ 47.5	254 ~ 343
M20 × 2.5	36.2 ~ 49.0	262 ~ 354	49.2 ~ 66.6	356 ~ 482
M22 × 2.5	48.3 ~ 63.3	350 ~ 457	65.8 ~ 98.0	476 ~ 709
M24 × 3.0	62.5 ~ 84.5	452 ~ 611	85.0 ~ 115	615 ~ 832
M30 × 3.5	124 ~ 168	898 ~ 1214	169 ~ 229	1223 ~ 1655
M36 × 4.0	174 ~ 236	1261 ~ 1703	250 ~ 310	1808 ~ 2242

(2) Fine thread

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

2) PIPE AND HOSE(FLARE TYPE)

Thread size	Width across flat (mm)	kgf · m	lbf · ft
1/4"	19	4	28.9
3/8"	22	5	36.2
1/2"	27	9.5	68.7
3/4"	36	18	130
1"	41	21	152
1-1/4"	50	35	253

3) PIPE AND HOSE(ORFS TYPE)

Thread size	Width across flat (mm)	kgf · m	lbf · ft
9/16-18	19	4	28.9
11/16-16	22	5	36.2
13/16-16	27	9.5	68.7
1-3/16-12	36	18	130
1-7/16-12	41	21	152
1-11/16-12	50	35	253

4) FITTING

Thread size	Width across flat (mm)	kgf · m	lbf · ft
1/4"	19	4	28.9
3/8"	22	5	36.2
1/2"	27	9.5	68.7
3/4"	36	18	130
1"	41	21	152
1-1/4"	50	35	253

6. RECOMMENDED LUBRICANTS

Use only oils listed below or equivalent.
Do not mix different brand oil.

Service point	Kind of fluid	Capacity ℓ (U.S. gal)	Ambient temperature °C (°F)
		15BR-9E	-50 (-58) / -30 (-22) / -20 (-4) / -10 (14) / 0 (32) / 10 (50) / 20 (68) / 30 (86) / 40 (104)
Drive unit	Gear oil	1.6 (0.42)	SAE 80W-90
Hydraulic oil tank	Hydraulic oil	18 (4.0)	★ISO VG 15 / ISO VG 46 / ISO VG 68
Fitting (Grease nipple)	Grease	0.1 (0.03)	★NLGI No.1 / NLGI No.2

★ : Cold region
Russia, CIS, Mongolia

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.

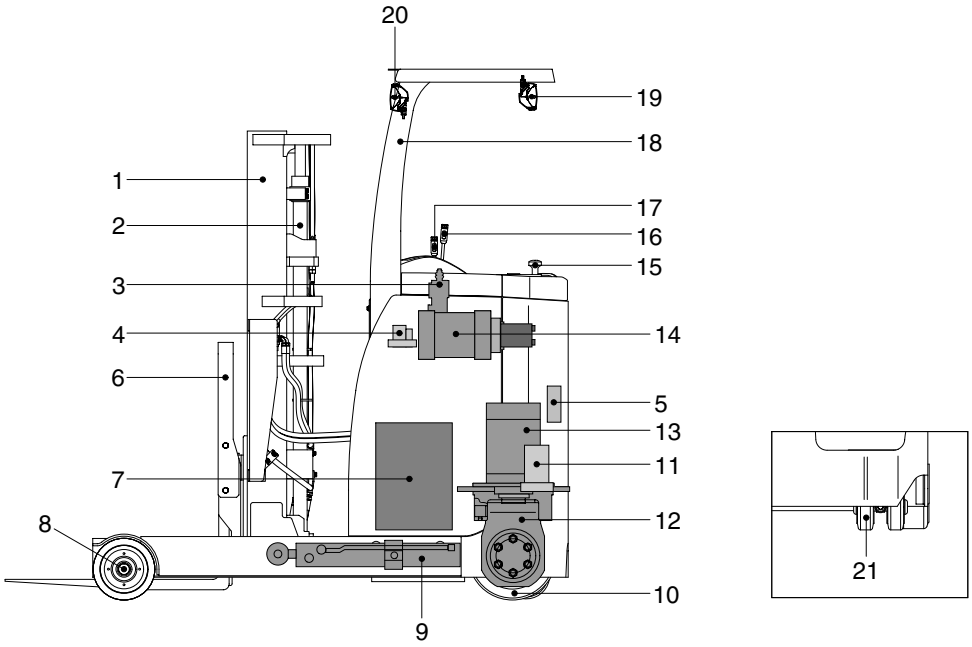
These parts may deteriorate in time and are susceptible to wear. It is difficult to estimate the degree of wear at time of periodic maintenance; therefore, even if no apparent wear is found, always replace with new parts within the prescribed period of replacement (Or earlier if trouble is found).
Note 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	Brake fluid	Every 1 year
3	Differential oil	Every 1 year
4	Gear oil	Every 1 year
5	Wheel bearing grease	Every 1 year
6	Power steering hose	Every 1 year
7	Rubber parts of the power steering inside	Every 2 year
8	Cups and dust seals etc. of cylinder	Every 2 year
9	Reservoir tank tube	Every 1 year
10	Lift chain	Every 2 year
11	Hydraulic equipment hose	Every 2 year
12	Brake switch(hydraulic)	Every 2 year

SECTION 2 REMOVAL & INSTALLATION OF UNIT

GROUP 1 MAJOR COMPONENTS



18BR9RE01

1	Mast	8	Load wheel	15	Steering wheel
2	Lift cylinder	9	Reach cylinder	16	Control levers
3	Main control valve	10	Drive wheel	17	Accelerator
4	EPS filter	11	EPS actuator	18	Overhead guard
5	EPS controller	12	Drive unit	19	Rear work lamp (opt)
6	Carriage & backrest	13	Drive motor	20	Front work lamp
7	Battery	14	Pump motor	21	Caster wheel

GROUP 2 REMOVAL AND INSTALLATION OF UNIT

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

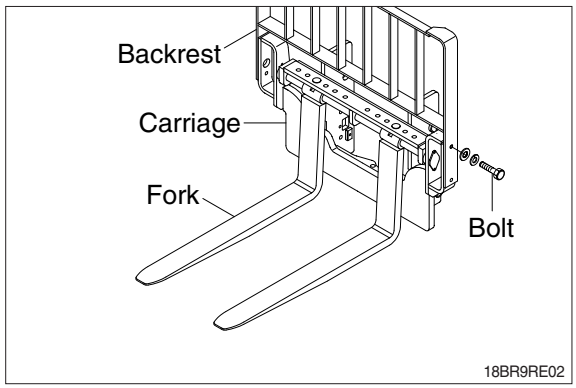
1. MAST

1) REMOVAL

Backrest & fork — Carriage — Piping — Mast

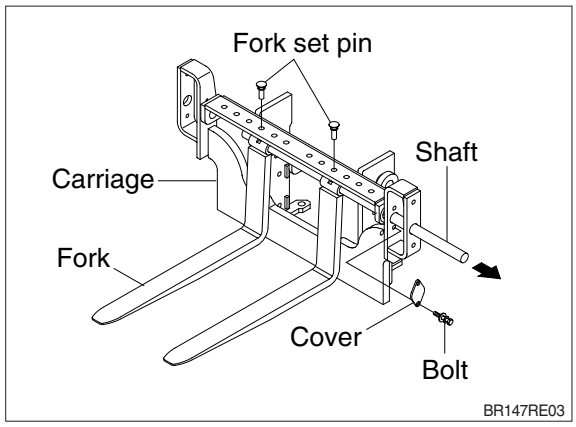
(1) Backrest

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



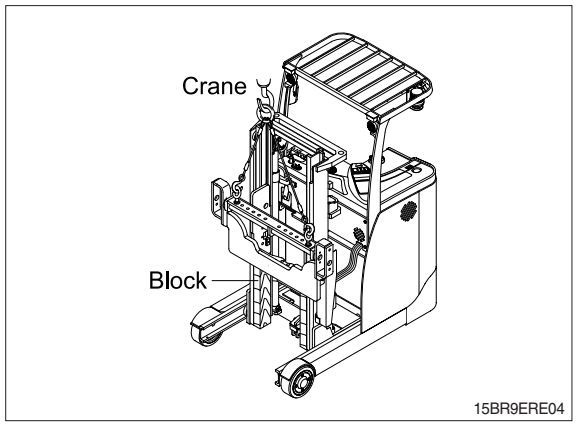
(2) Forks

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

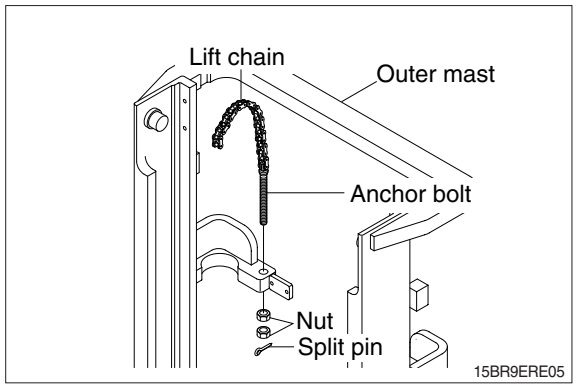


(3) Carriage

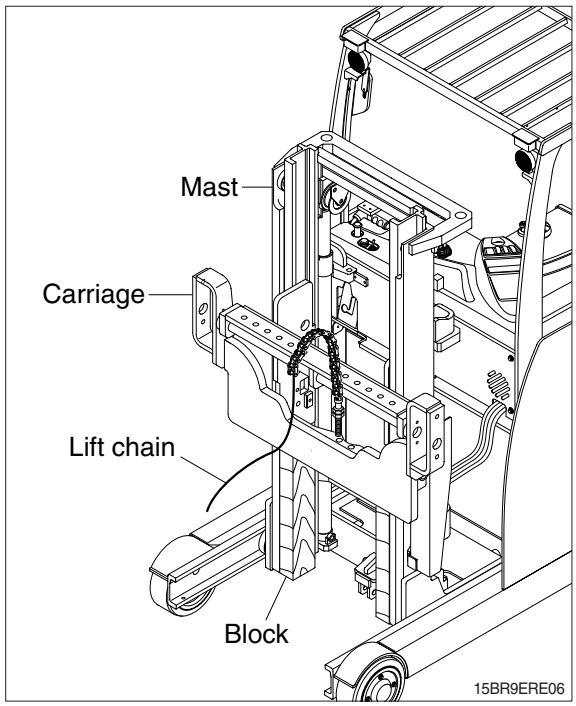
① With the mast vertical, raise the carriage high enough to place blocks under the load forks. This is done to create slack in the load chains when the carriage is lowered. Lower the carriage all the way down to the floor. Make sure the carriage is level, this will prevent any binding when the mast is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



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



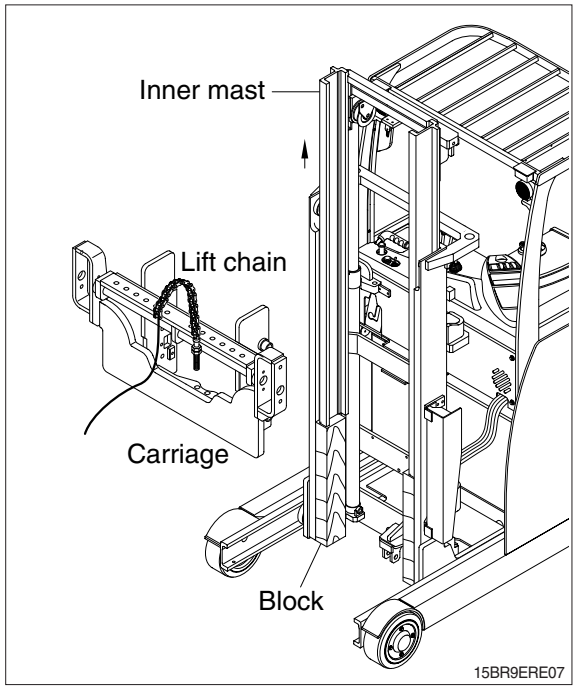
③ Pull the chains out of the sheaves and drape them over the front of the carriage.



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

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

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

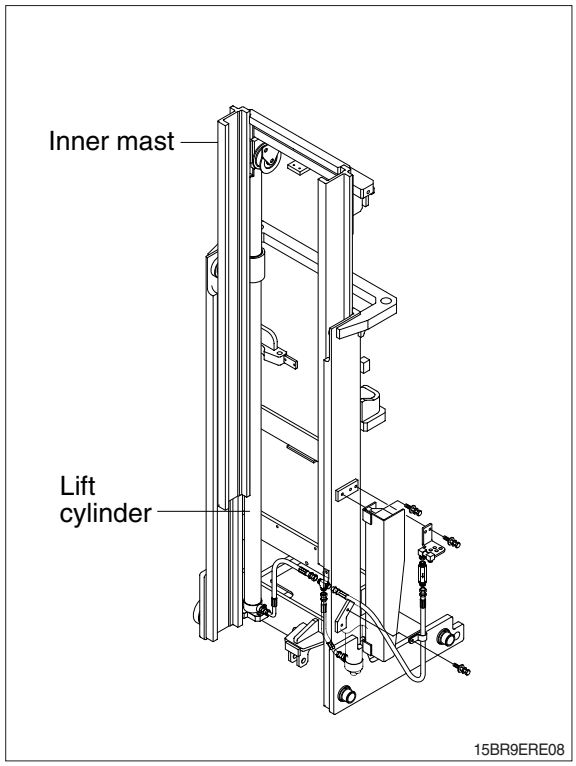


(4) PIPING

① Remove the hoses and clamps attached to the cylinder.

② Remove hose assembly, connector, down safety valve from the lift cylinder.

③ Disconnect hose assembly from the flow regulator.



(5) LIFT CYLINDER

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

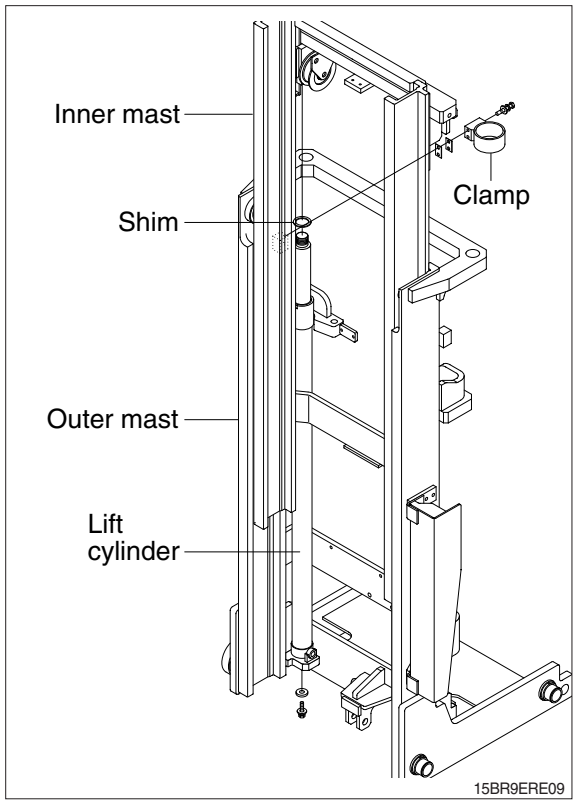
② Bind the lift cylinder with overhead hoist rope and pull up so that the rope has no slack or binding.

⚠ 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.

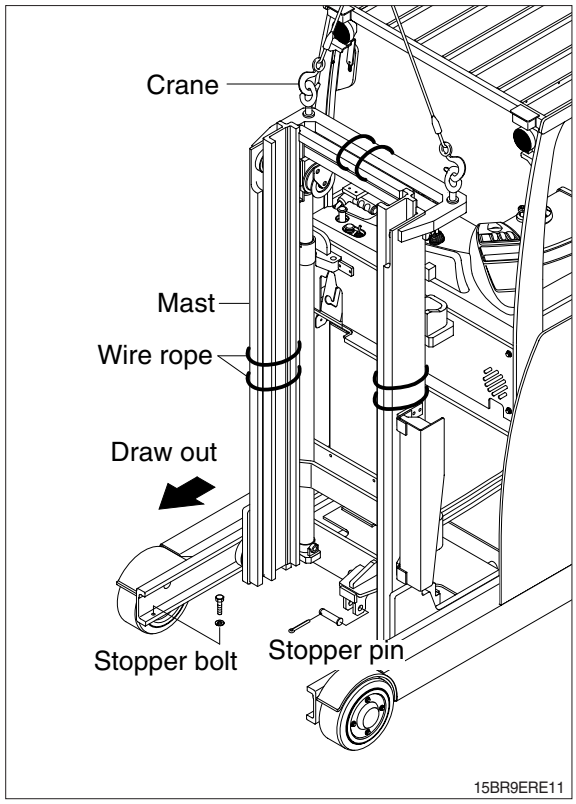
④ Using an overhead hoist, slowly raise the inner mast high enough to clear lift cylinder.

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.

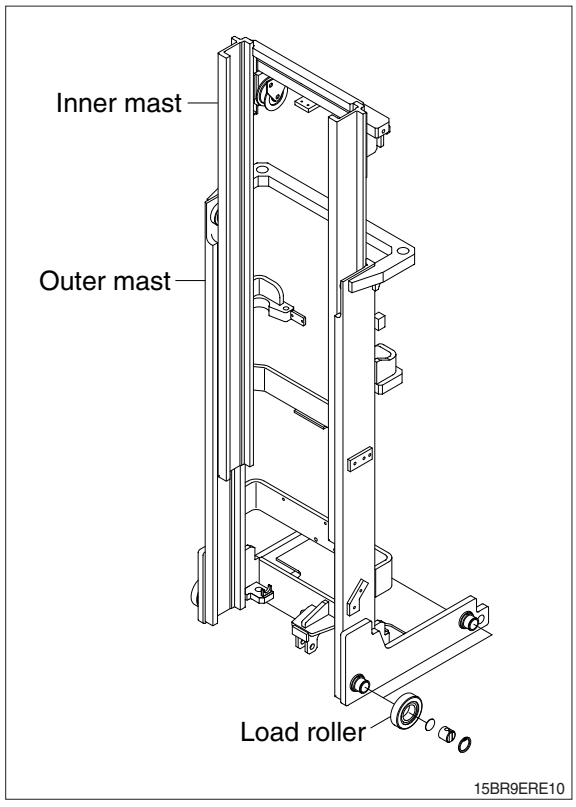


(7) INNER MAST

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

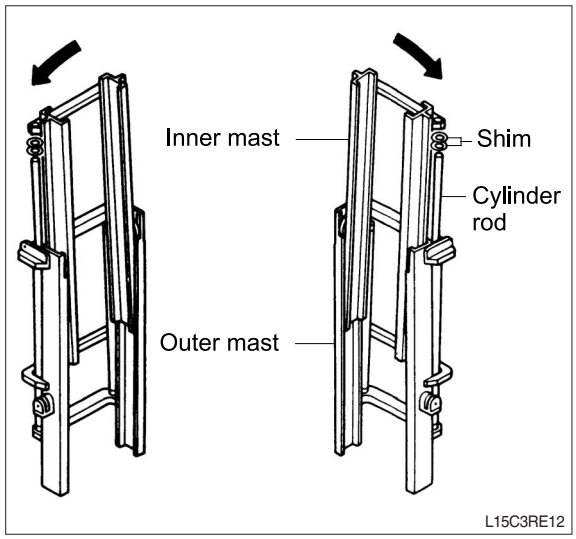
① Assemble the lift cylinder inside the outer mast, then tighten the stopper bolt. If the cylinder assembly has been replaced, adjust as follows so that the left and right cylinders are synchronized at the maximum lifting height.

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 : 1.0 mm (0.04 in)

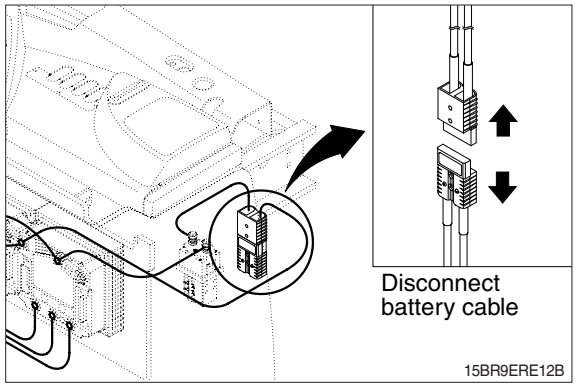


2. POWER TRAIN ASSEMBLY

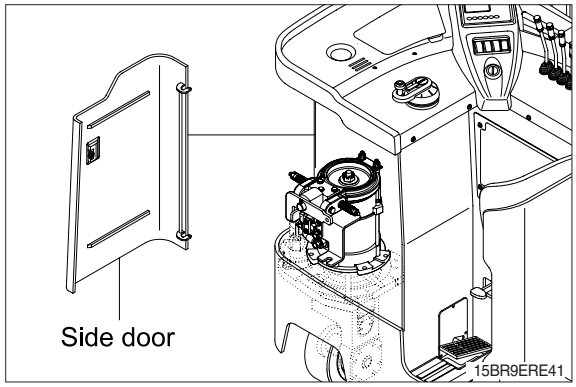
1) REMOVAL

BR7RE001

(1) Disconnect the battery cable.

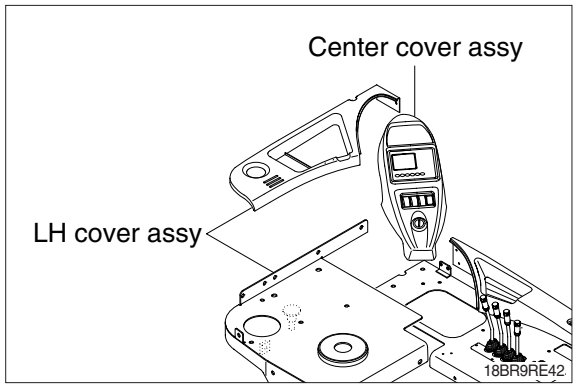


(2) Remove side door.

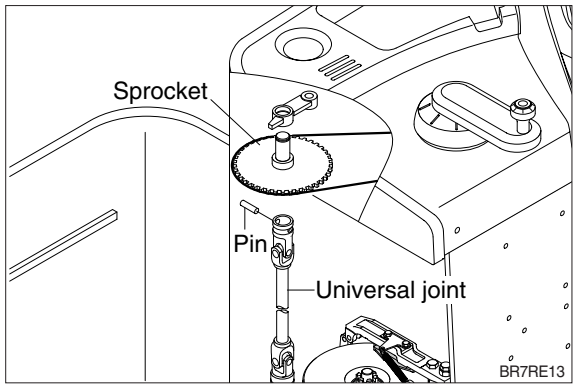


(3) Remove center cover assembly.

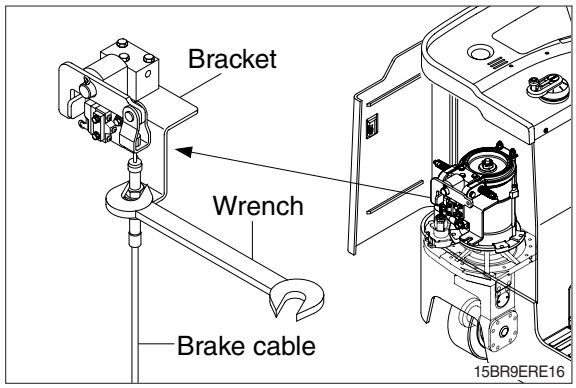
(4) Remove LH cover assembly.



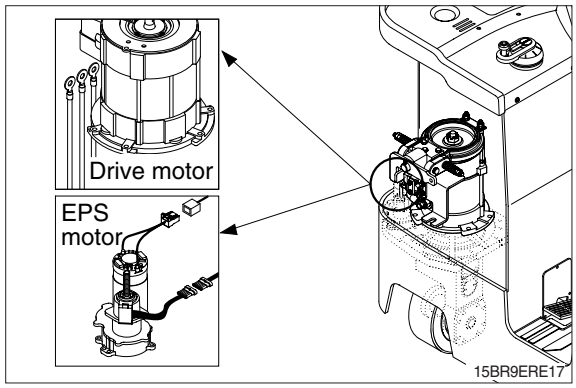
(5) Remove steering joint parts.



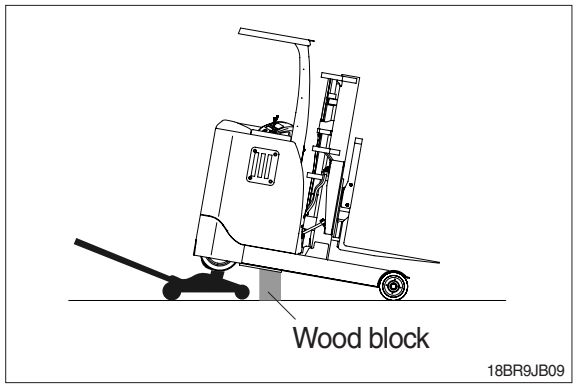
(6) Remove brake cable.



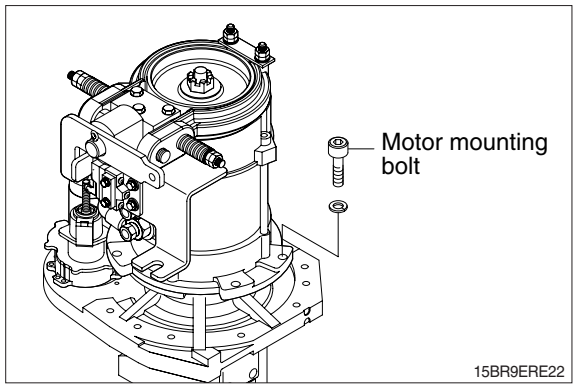
(7) Disconnect the wiring.
① Drive motor wiring
② EPS motor wiring.



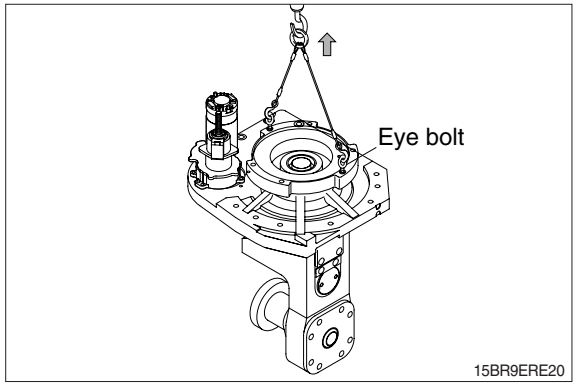
(8) Jack up the frame and support both side of frame on wood block.



(9) Remove motor mounting bolts and motor by lifting.



(10) Remove drive unit mounting bolts and pull out the drive unit by lifting with eye-bolts on motor mounting tap. (M8 × 1.25)

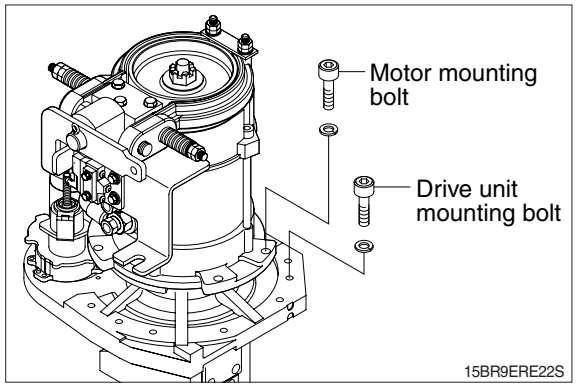


2) INSTALLATION

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

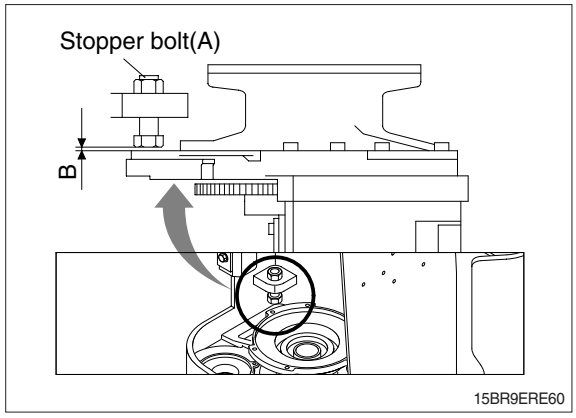
(1) Drive unit mounting bolts (M16 × 2.0)
- Tightening torque : 26.7~32.7 kgf · m (193~237 lbf · ft)

(2) Drive motor mounting bolts (M8 × 1.25)
- Tightening torque : 3.7~4.1 kgf · m (28.2~29.7 lbf · ft)



(3) Adjust stopper bolt (A)
- Tightening torque : 10.0~12.0 kgf · m (72.3~86.8 lbf · ft)

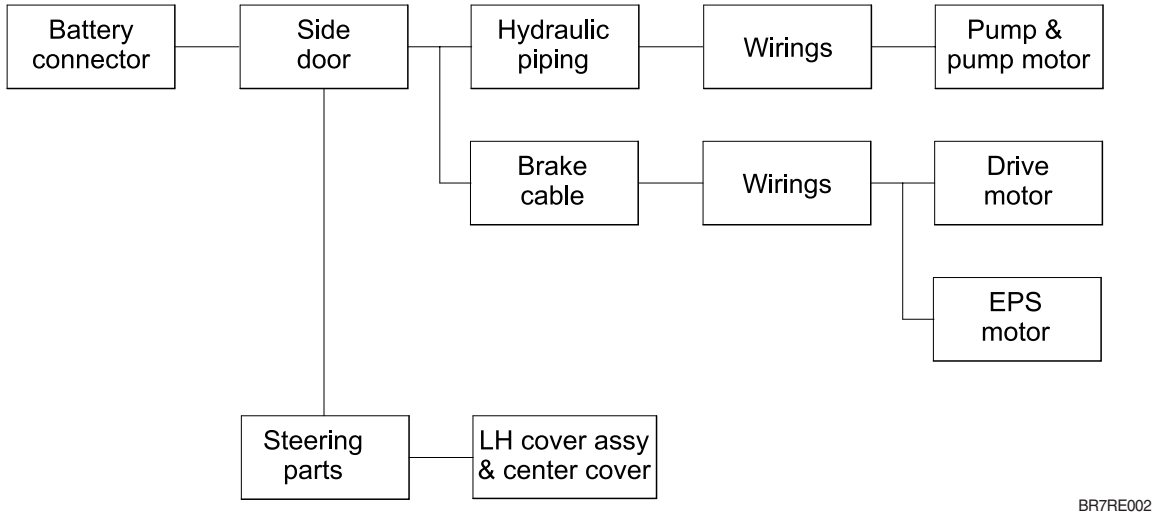
※ Maintain the articulating gap (B) : 3.3 ± 0.5 mm



3. ELECTRICAL COMPONENTS

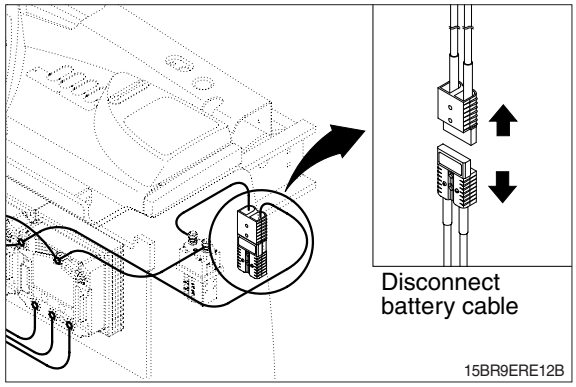
Before removing each component, disconnect cables and earth lines attached to the component.

1) REMOVAL

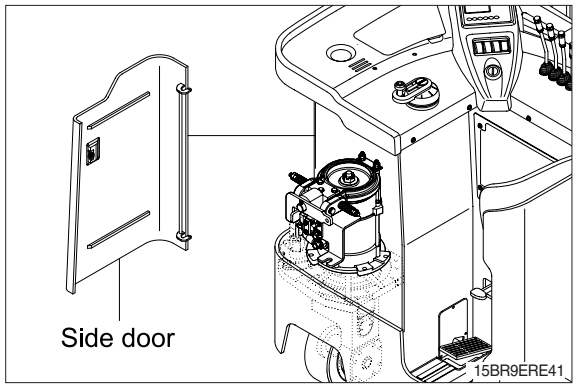


(1) PUMP MOTOR

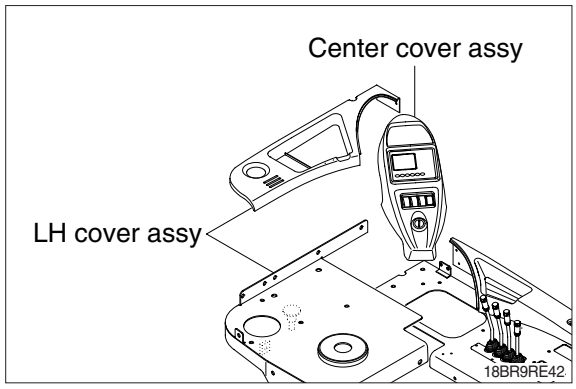
① Disconnect the battery cable.



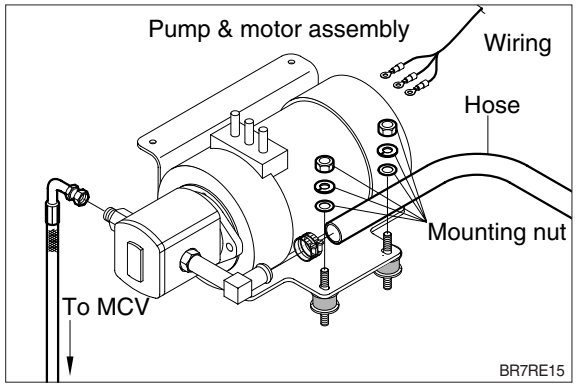
② Remove side door.



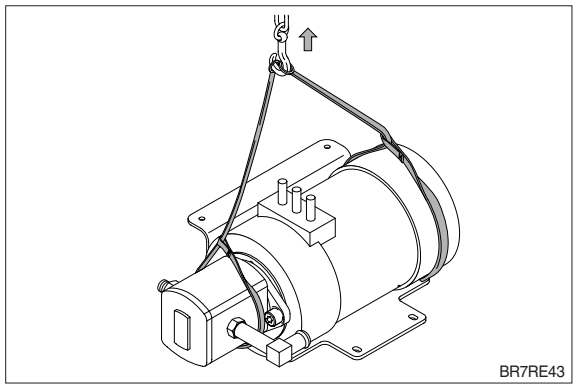
③ Remove LH cover assembly and center cover assembly.



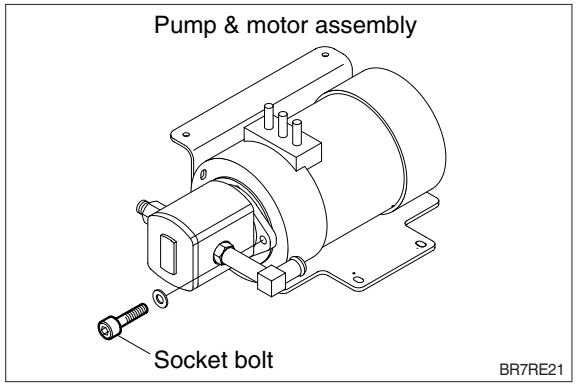
④ Disconnect the hose, pipe and wiring from pump & motor assembly.
Loosen mounting nuts from the bracket and then take out the assembly.



⑤ Tire wire rope around the hydraulic pump & pump motor assembly and lift up slowly.

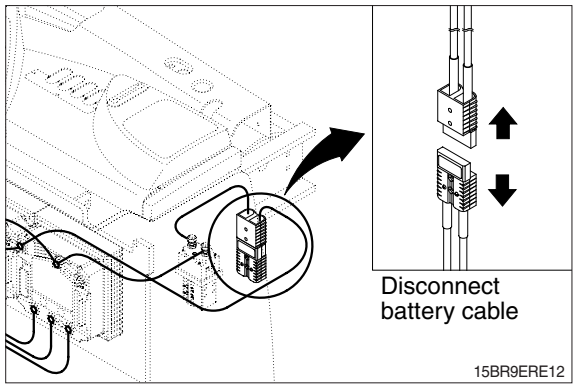


⑥ Remove 2 socket bolts fastening the pump & motor and then disengage the pump from motor.

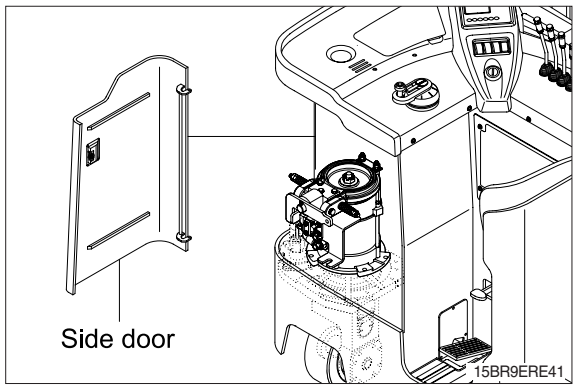


(2) DRIVE MOTOR

① Disconnect the battery cable.

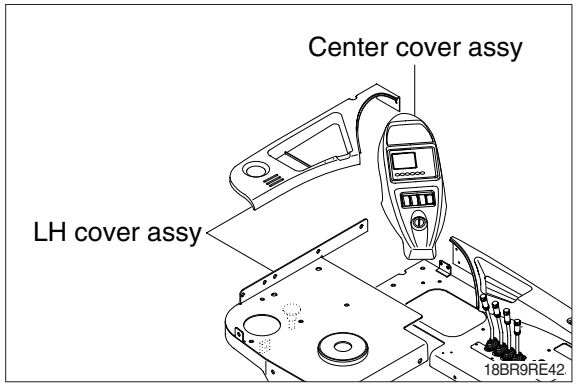


② Remove side door.

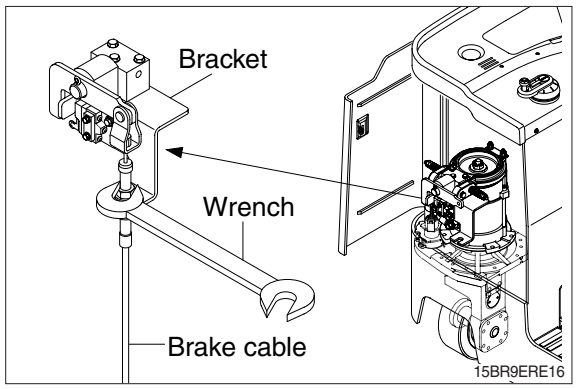


③ Remove center cover assembly.

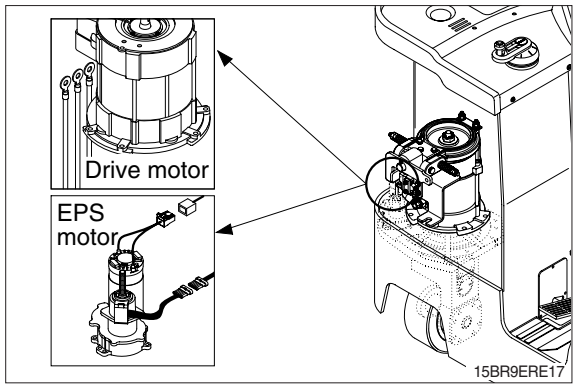
④ Remove LH cover assembly.



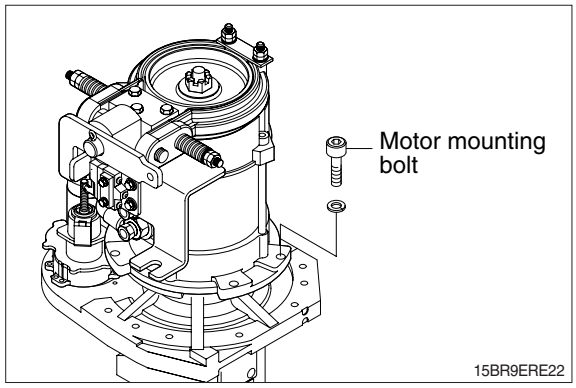
⑤ Remove brake cable.



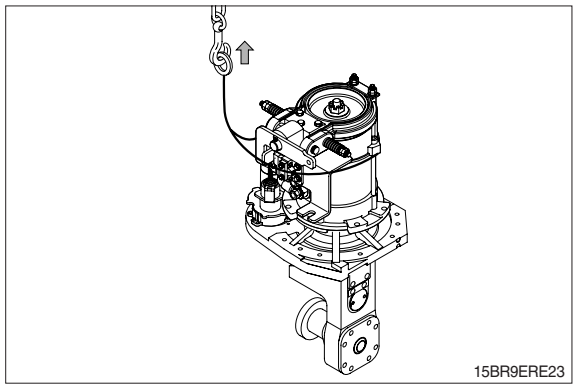
⑥ Disconnect wirings.
a. Drive motor wiring
b. EPS motor wiring



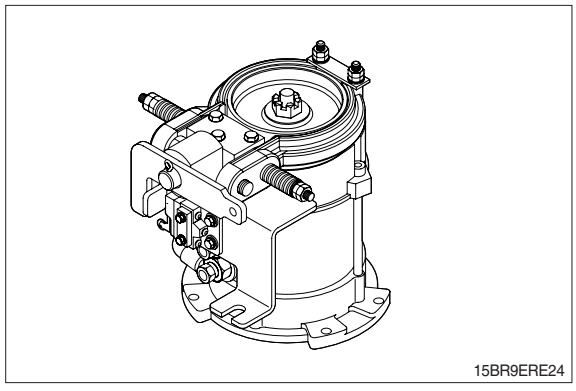
⑦ Remove bolts connecting the motor and drive unit.



⑧ Tie wire rope around the drive motor and lift up slowly.

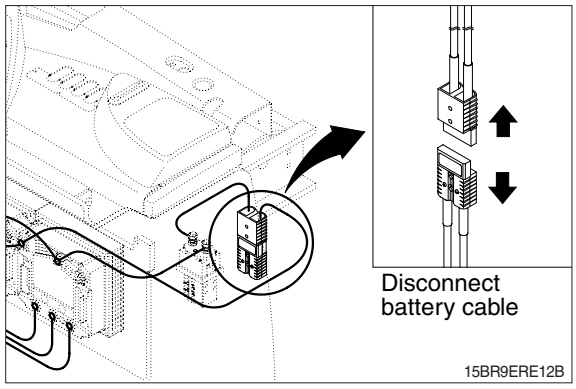


⑨ Put the motor on the clean work bench.

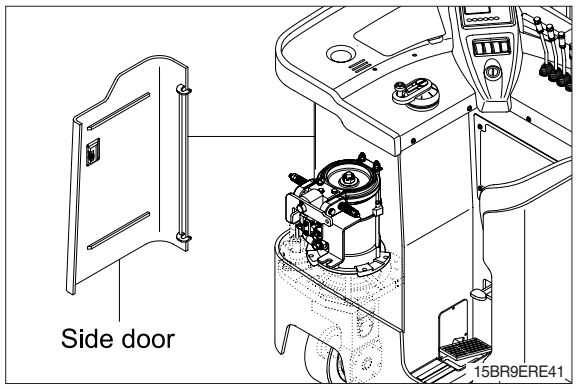


(3) EPS MOTOR

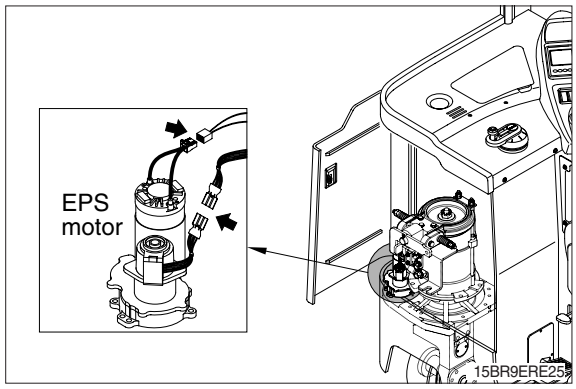
① Disconnect the battery cable.



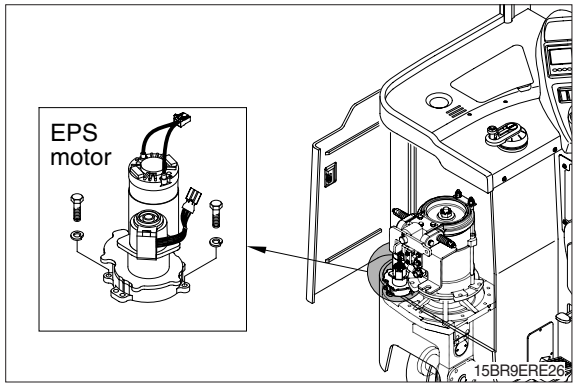
② Remove side door.



③ Disconnect wirings.



④ Loosen bolts and remove EPS motor assembly.



(4) BATTERY

① Turn on the key.

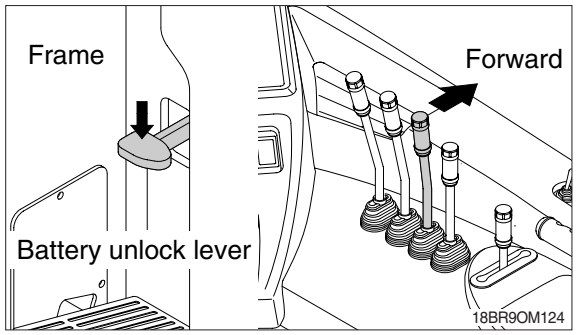
② Foot on the battery unlock lever to unlock the battery assembly.

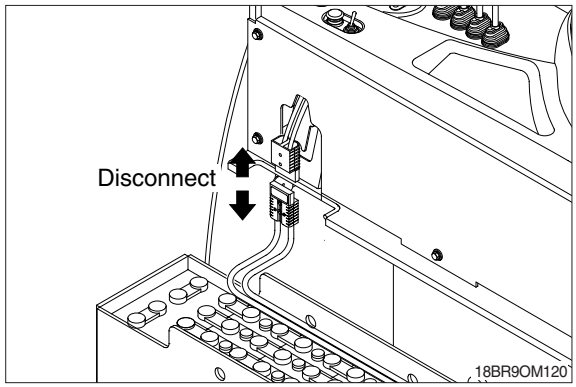
③ Push the reach lever until battery get out of frame inside.

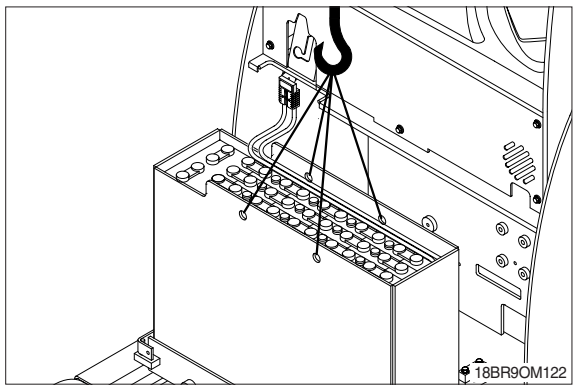
④ Turn off the key.

⑤ Disconnect the battery connector.

⑥ Using a battery hanger or carrier, carefully raise the battery assembly.







2) INSTALLATION

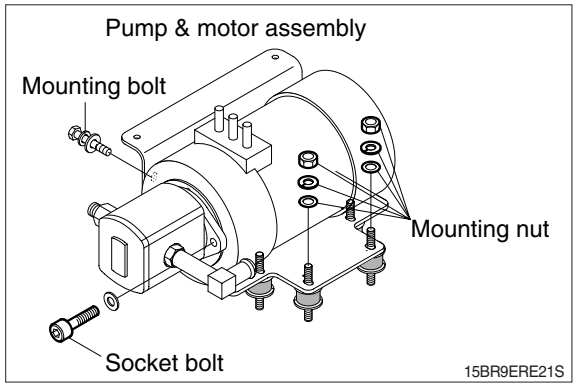
Installation is in the reverse order to removal, but be careful of following points.

(1) PUMP MOTOR

① Pump motor mounting bracket nut.
- Tightening torque : 3.7~4.1 kgf · m (26.8~29.7 lbf · ft)

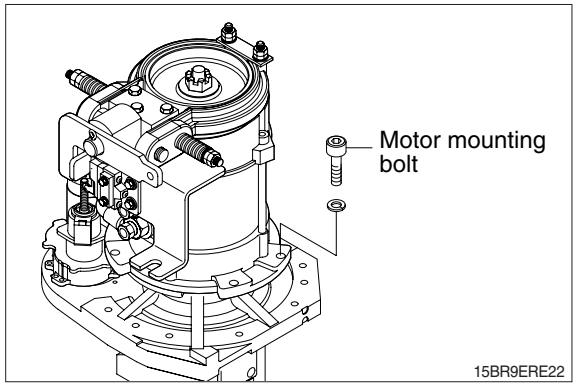
② Hydraulic pump mounting socket bolt
- Tightening torque : 6.57~9.97 kgf · m (47.5~72.1 lbf · ft)

③ Pump motor mounting bolt
- Tightening torque : 5.5~8.3 kgf · m (39.8~60 lbf · ft)



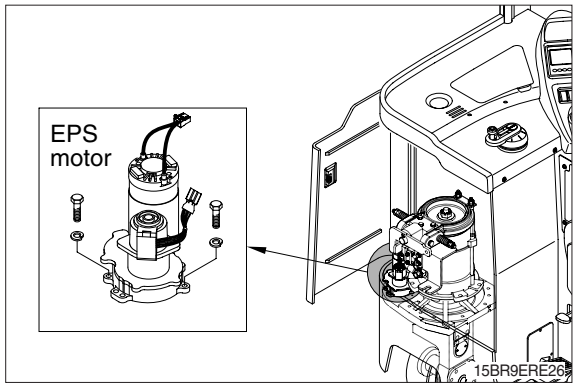
(2) DRIVE MOTOR

① Connection bolts between drive motor and drive unit.
- Tightening torque : 3.7~4.1 kgf · m (26.8~29.7 lbf · ft)



(3) EPS MOTOR

① EPS motor mounting bolts.
- Tightening torque : 3.7~4.1 kgf · m (26.8~29.7 lbf · ft)



(4) BATTERY

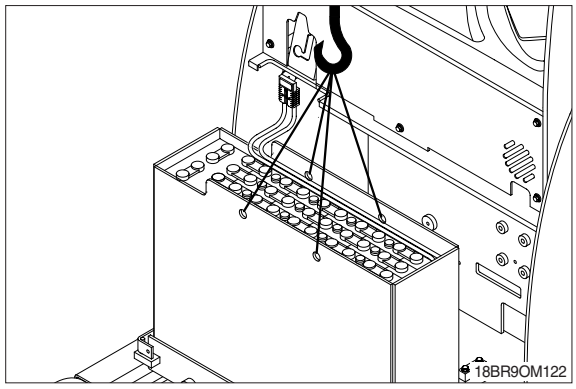
① Using a battery hanger or carrier, carefully put the battery assembly on the guard rail between mast and frame.

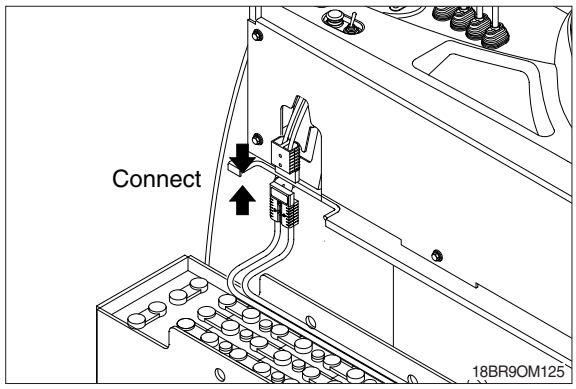
② Connect the battery connector.

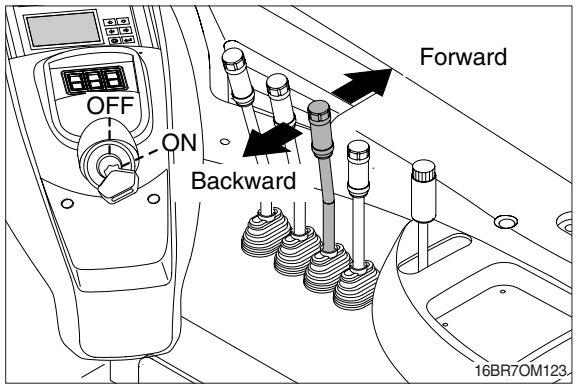
③ Turn on the key.

④ Pull the reach lever until it sounds locked. (Auto lock)

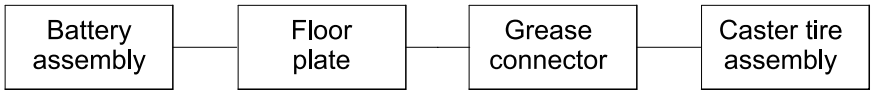
⑤ Complete installation.







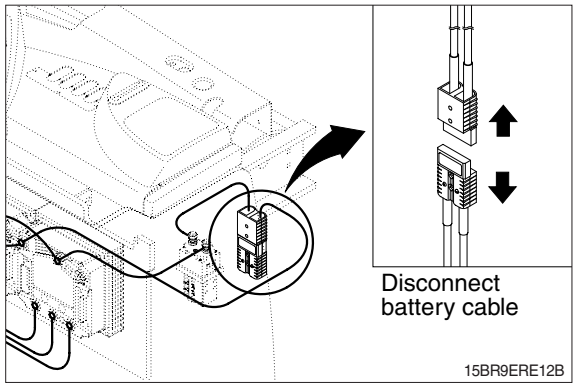
4. CASTER LINK ASSEMBLY



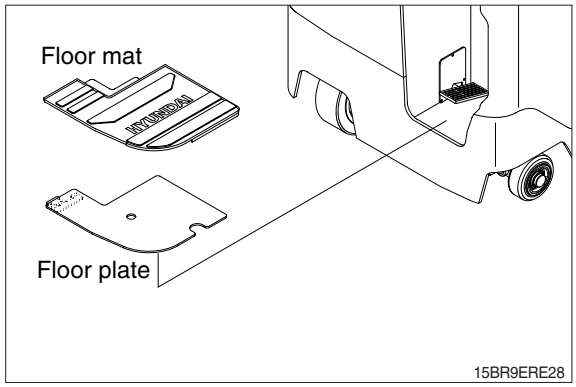
BR7RE003

1) REMOVAL

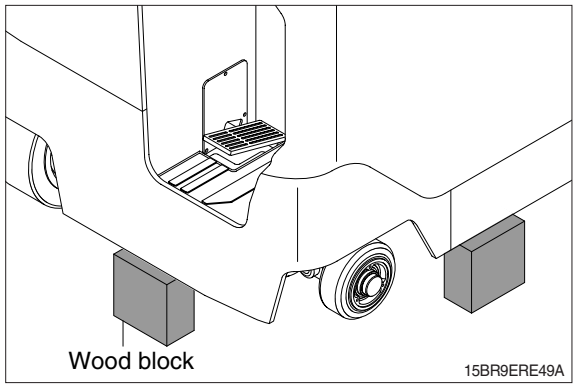
(1) Disconnect the battery cable.



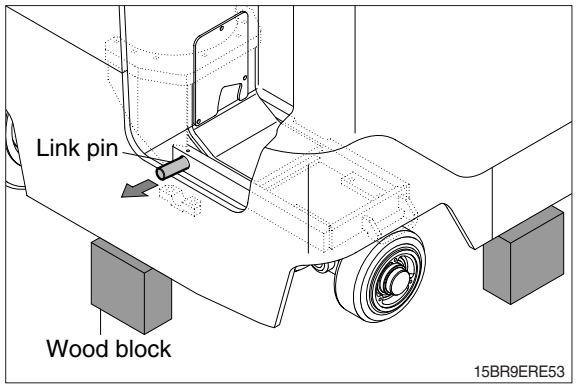
(2) Remove floor mat and floor plate.



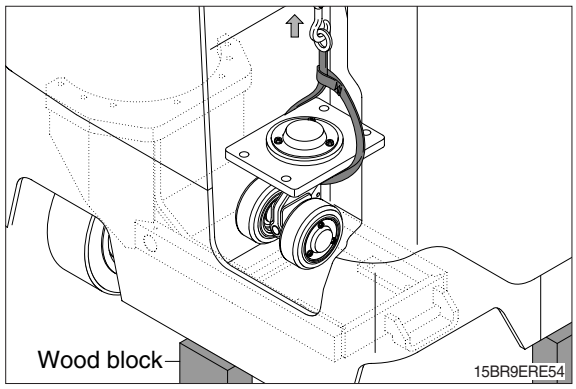
(3) Jack up the frame and support both side of frame on wood block.



(4) Remove the link pin.



(5) Tire wire rope around the bracket and lift up slowly.

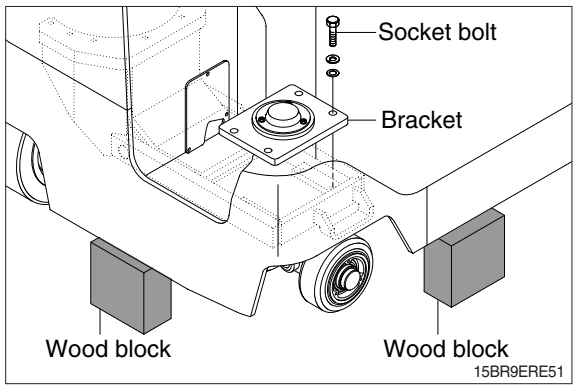


2) INSTALLATION

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

(1) Bracket mounting bolt.

· Tightening torque : 17.0~22.0 kgf · m
(123~159 lbf · ft)



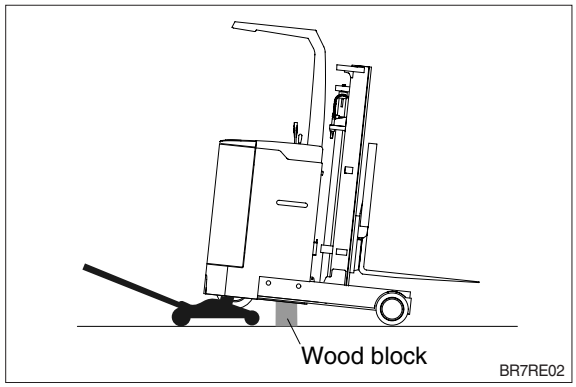
5. TIRE & WHEEL ASSEMBLY

1) REMOVAL

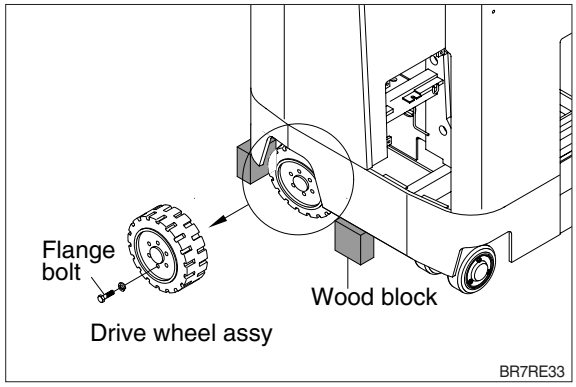
(1) DRIVE TIRE & WHEEL ASSEMBLY

① Jack up the frame and support both side of frame on wood block.

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

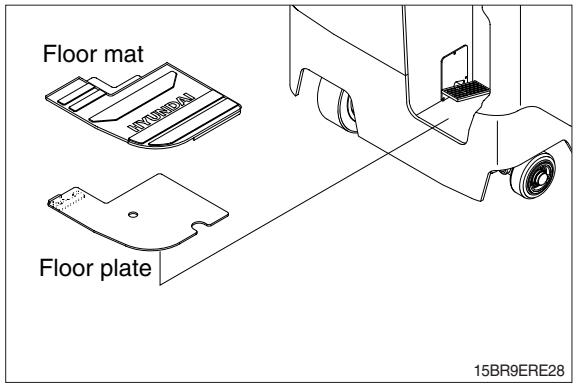


② Remove 6 flange bolts attaching the drive wheel and take off the drive wheel assembly.



(2) CASTER WHEEL ASSEMBLY

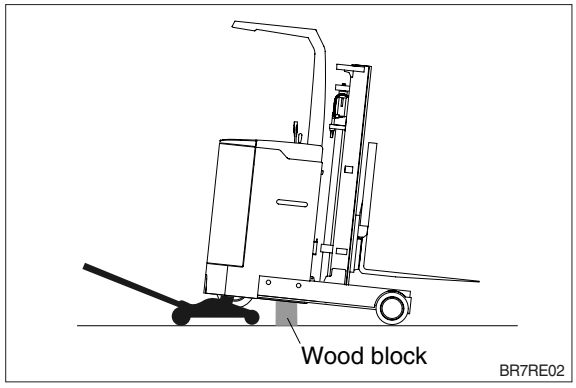
① Remove floor mat and floor plate.



② Jack up the frame.

③ Blocking place under the frame with wood block

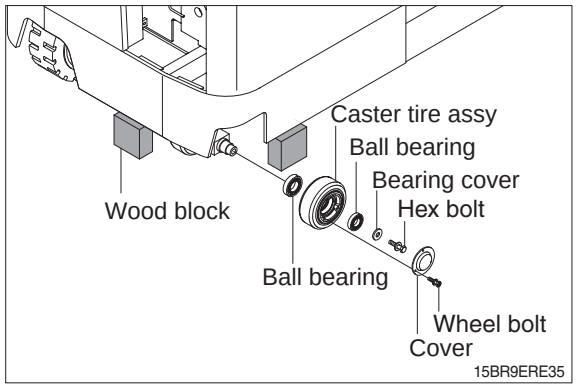
※ **Jack up until the tire clear off the ground.**



④ Remove the wheel bolt and take off the cover.

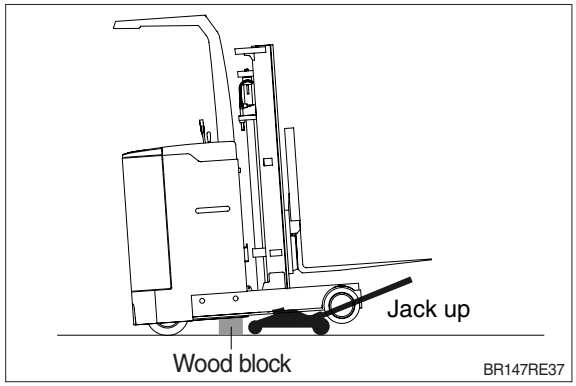
⑤ Remove the hex bolt and take off the bearing cover.

⑥ Remove the caster tire assy and ball bearing.

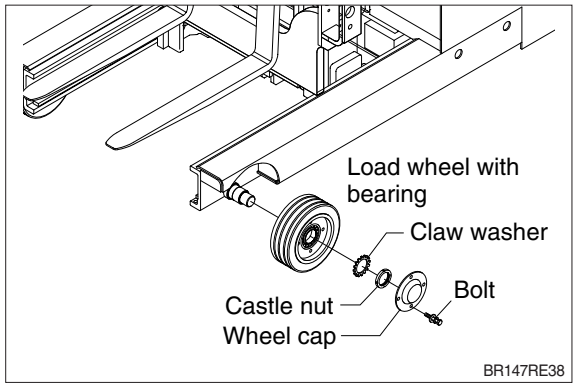


(3) LOAD WHEEL ASSEMBLY

① Jack up the reach legs and fix the machine with wood blocks.



② Take off the load wheel cap, and remove castle nut, and claw washer in succession.
Remove the load wheel together with bearing.



2) INSTALLATION

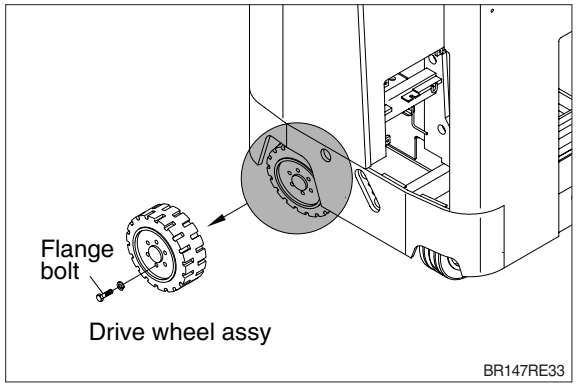
Installation is in the reverse order to removal, but be careful of the following points.

(1) Drive wheel flange bolts

· Tightening torque :

15BR-9E : 26.6~36.0 kgf · m

(193~260 lbf · ft)



(2) Caster wheel bolts.

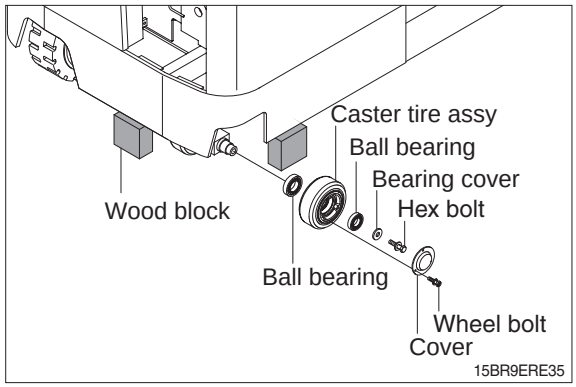
· Tightening torque

- Wheel bolt : 2.0~3.0 kgf · m

(14.5~21.7 lbf · ft)

- Hex bolt : 11.0~13.0 kgf · m

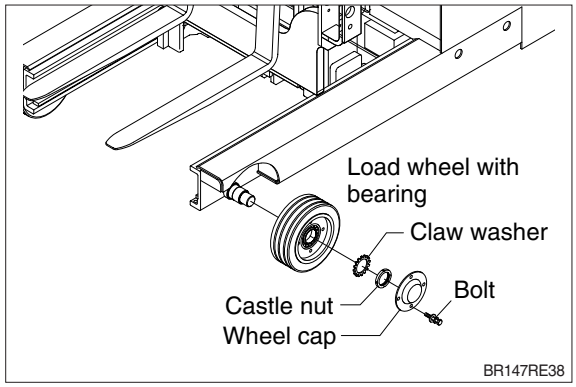
(79.6~94 lbf · ft)



(3) Load wheel bolts.

· Tightening torque : 2.0~3.0 kgf · m

(14.5~21.7 lbf · ft)



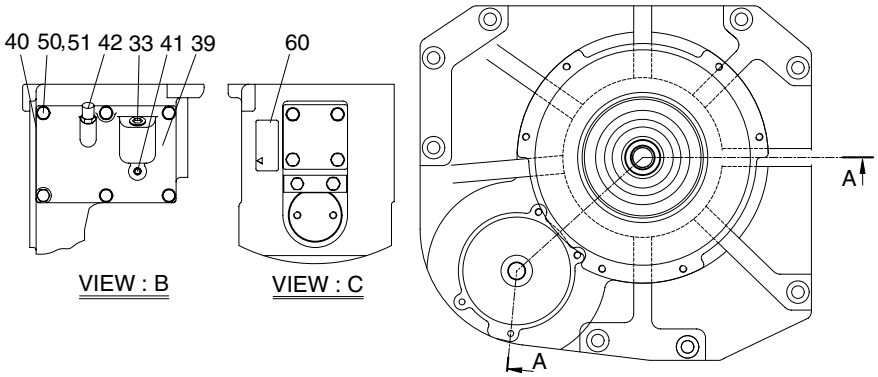
SECTION 3 POWER TRAIN SYSTEM

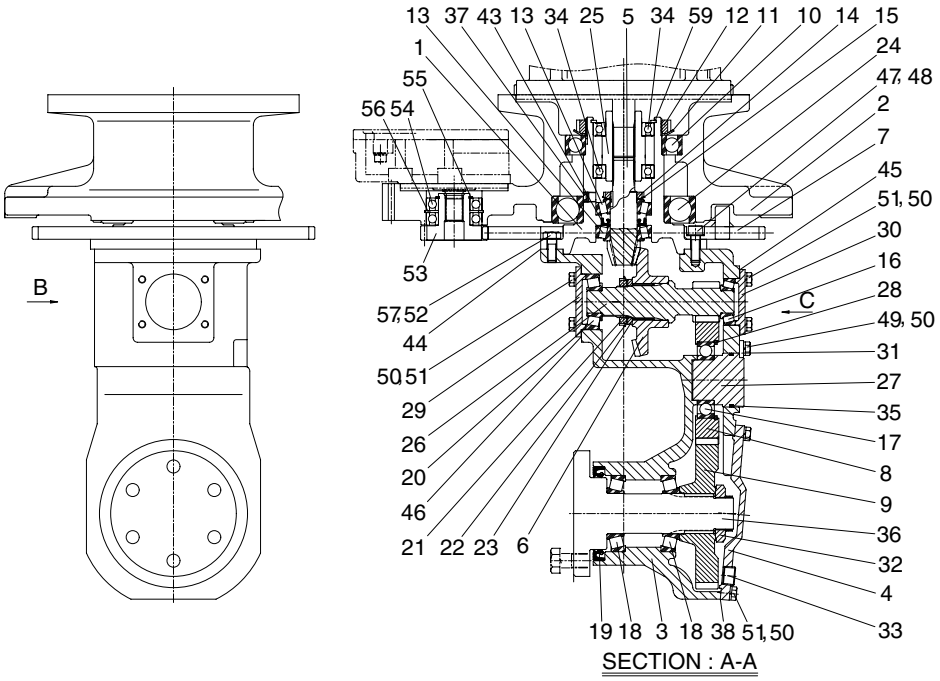
GROUP 1 STRUCTURE AND OPERATION

1. DRIVE AXLE UNIT

1) STRUCTURE

(1) Drive unit

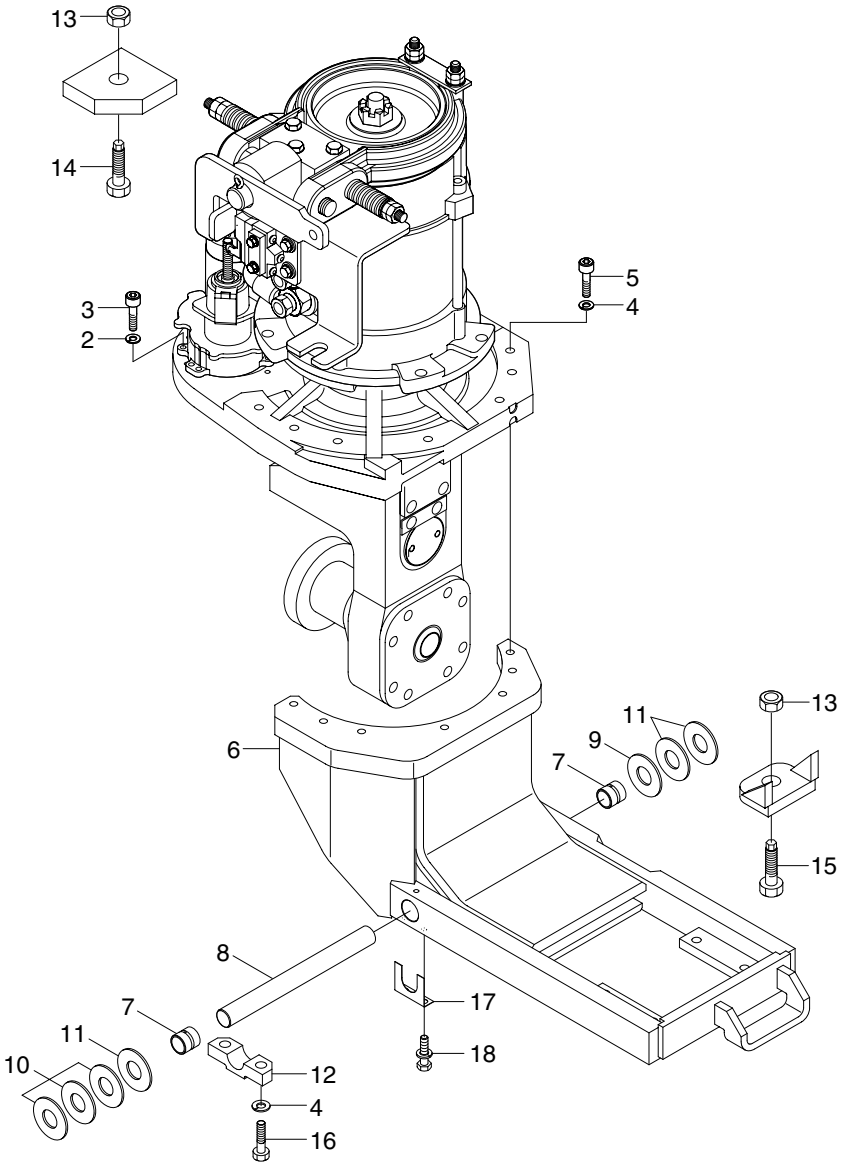




BR7DU100

1	Gear case cover	16	Bearing	31	End plate	46	Shim
2	Bracket	17	Bearing	32	Drive shaft nut	47	Socket bolt
3	Gear box case	18	Bearing	33	Taper plug	48	Washer
4	Case cover	19	Oil seal	34	Bearing	49	Hexagon bolt
5	Spiral bevel pinion	20	Taper roller bearing	35	O-ring	50	Spring washer
6	Spiral bevel gear	21	Bearing lock nut	36	Drive wheel shaft	51	Hexagon bolt
7	Steering gear	22	Bearing lock washer	37	Taper plug	52	Hexagon bolt
8	Idle gear	23	Gear spacer	38	Gasket	53	Pinion gear
9	Gear	24	Bearing	39	Cover	54	Ball bearing
10	Bearing	25	Input sleeve	40	Gasket	55	Snap ring
11	Washer	26	Pinion shaft	41	Plug	56	Snap ring
12	Bearing lock nut	27	Idler gear shaft	42	Breather	57	Spring washer
13	Taper roller bearing	28	Snap ring	43	Oil seal	59	Snap ring
14	Bearing lock nut	29	End cover	44	Shim	60	Name plate
15	Bearing lock washer	30	End cover	45	Shim		

(2) Drive unit mounting



15BR9ESS10

2	Spring washer	8	Link pin	14	Special bolt
3	Socket bolt	9	Shim	15	Special bolt
4	Spring washer	10	Shim (1.0 t)	16	Hex bolt
5	Socket bolt	11	Shim (0.5 t)	17	Shim (0.5 t)
6	Undercarriage	12	Block	18	W/Washer bolt
7	Bronze bushing	13	Hex nut		

2. SPECIFICATION

Item	Unit	Specification
Gear ratio	-	20.125
Oil quantity	ℓ	1.6

GROUP 2 TROUBLESHOOTING

Problem	Probable cause	Remedy
Continuous metallic groan		
1) During acceleration	· Worn out gears.	- Adjust back-lash or replace gears.
	· Pinion and bevel gear meshed too deeply.	
2) During travelling at uniform speed	· Lack of gear oil.	- Refill
	· Worn out gears.	- Replace
	· Loose or worn out bearing.	- Adjust preload or replace.
	· Loose bevel gear wheel	- Replace bolts and washers. Tighten new bolts and washer.
3) When turning corners.	· Worn out differential gear or thrust washer.	- Replace
Continuous knocking sound		
1) During travelling at uniform speed	· Chipped gear teeth.	- Replace
	· Foreign matter in axle case.	- Clean
	· Worn out spline of drive shaft.	- Replace
Oil leakage		
1) Differential housing housing leaks.	· Oil level too high	- Lower oil level
	· Broken oil seal	- Replace
2) Axle case leaks	· Mounting bolts for housing loose.	- Retighten
	· Damaged packing case cracked.	- Replace
	· Worn out hub grease seal.	- Replace
3) Hub, leaks	· Worn out oil seal.	- Replace
	· Worn out bearing or eccentric rotation due to damage.	- Replace
Power is not transmitted		
1) Drive shaft, gear	· Broken or slipped out drive shaft.	- Repair or replace
	· Gear teeth stripped or worn out.	- Replace
	· broken differential case parts.	- Replace
Oil leakage on wheel shaft	· Radial shaft seal wrongly installed or damaged.	· Remove wheel shaft and install a new radial shaft seal.
	· Race on wheel shaft damaged.	· Remove wheel shaft. Check wheel shaft race for reusability; if possible, rework.
Oil leakage on housing cover	· Housing cover not sealed.	· Seal housing cover with LOCTITE No. 574.
	· Housing cover or housing plane face uneven.	· Touch up plane faces with oil rubber.
	· Bolts not tightened according to the specified tightening torque.	· Tighten bolts with the specified tightening torque.

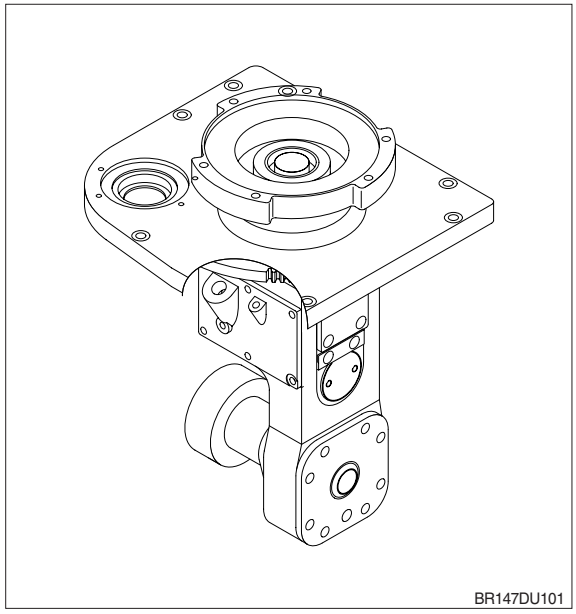
Problem	Probable cause	Remedy
Oil leakage on oil filler or oil drain plug	· Dirt between sealing ring and housing. · Old sealing ring was used. · Bolts not tightened according to the specified tightening torque.	· Cleaning required. · Use new sealing ring · Tighten bolts with the specified tightening torque.
Oil leakage between hous-ing 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 recog-nizable	· Cover disc loosened and dirt enter-ed 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.

1. 15BR-9E

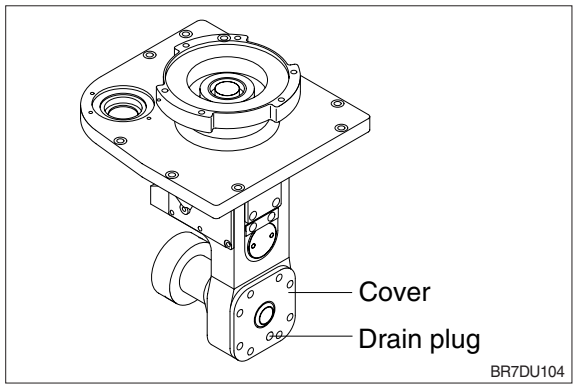
1) DISASSEMBLY

※ Before starting disassembly check the backlash and tooth contact for use as reference during assembly.

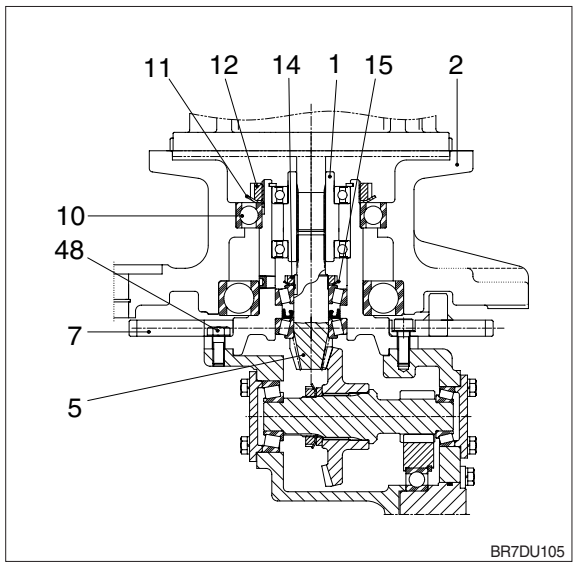
(1) Stabilize the drive unit assembly by using wooden block.



(2) Remove the plug and drain out the oil. Remove the gear case cover and drain out the oil.



(3) Loosen the lock nut and remove the lock nut (12) and washer (11).
(4) Remove drive unit bracket (2). Remove the outer race of bearing (10) and oil seal from bracket.
(5) Remove bolts (48) and remove the steering gear (7).
(6) Remove bolts (11 EA).
(7) Remove the cover (1) of gear case with spiral bevel pinion (5).
(8) Remove bearing nut (14) by straightening the locking part of the bearing washer (15), and remove the spiral bevel pinion (5) from the cover of gear case (1).



(9) Remove the end cover (29, 30).

(10) Remove the bearing (16, 20) installed on the side of spiral bevel gear (6) for pinion shaft (26).

Loose the nut for spiral bevel gear (6) by straightening the locking of the washer and remove the nut (21) and the washer (22).

When loosening the nut, lock the pinion shaft by puting capper for between the idle gear (8) and the pinion shaft (26).

※ After removing the idle gear (8) remove the pinion shaft (26) and spiral bevel gear (6).

(11) Support drive shaft (36) at drive wheel side not to rotate.

Remove the lock nut (32) of drive gear and pull out the drive shaft (36) to drive wheel side.

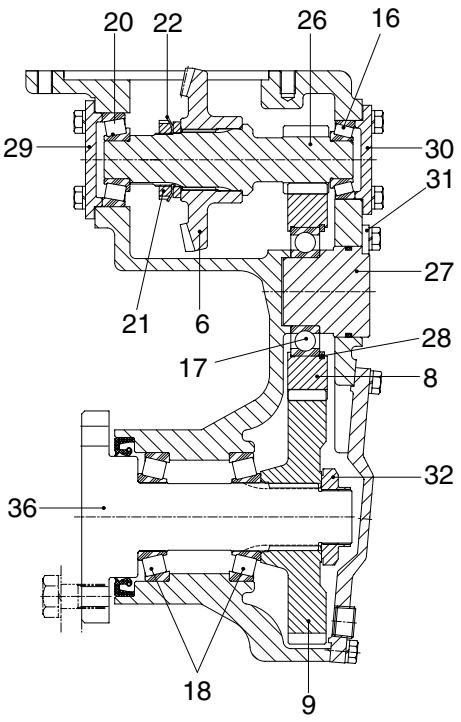
Remove the bearing (18) from drive shaft.

(12) Remove the locking plate (31) for idle gear shaft and remove idle gear shaft (27).

Pull out the idle gear from the side of drive gear (9).

(13) After removing the snap ring (28), remove the bearing (17) for idle gear.

(14) Pull out the pinion shaft (26) and the spiral bevel gear (6).



BR7DU106

2) INSPECTION

(1) Inspect the gear case for cracks, bearing insertion parts for injuries, oil seals for damage and for other defects. Replace if found defective.
Inspect for gear case cracks visually and by use of flaw penetrants.

(2) Inspect the drive unit bracket for cracks, bearing insertion parts for injuries, bushings for damage, and other defects. Replace if found defective.

(3) Inspect the gear case cover for cracks, bearing insertion parts for injuries and for other defects. Replace if found defective.

(4) Inspect the spring adjuster and spring bracket for damage and spring for deterioration.
Replace parts found defective.

(5) Inspect the tooth part and spline part of steering pinion for damage and the bearing for damage, and replace the parts found defective.

(6) Inspect the bearing and oil seal of steering part for damage, and replace the parts found defective.

(7) Inspect the steering gear for damage, and replace parts found defective.

(8) Inspect the spiral pinion shaft, counter gear shaft and idle gear shaft for tooth damage and shaft bend, and the bearings for damage. Replace the parts if found defective.

(9) Inspect the spiral bevel pinion shaft for tooth damage and shaft bend, and the bearing holder and bearing for damage. Also inspect spiral bevel gear for damage.
Replace the parts if found defective.

(10) Inspect the drive wheel shaft for cracks, splines for wear and damage, and the bearings for damage. Replace the parts found defective.

3) ASSEMBLY

(1) Assemble the oil seal to the cover of gear case, assemble the bearing to spiral bevel pinion shaft. Assemble the spiral bevel pinion shaft bearing, washer and nut to the cover of gear case, and screw on the locking nut.
Tighten the locking nut while measuring starting torque required to start the bevel pinion turning.
Bevel pinion starting torque. 2.7~3.0 kgf · cm (0.2~0.22 lbf · ft)

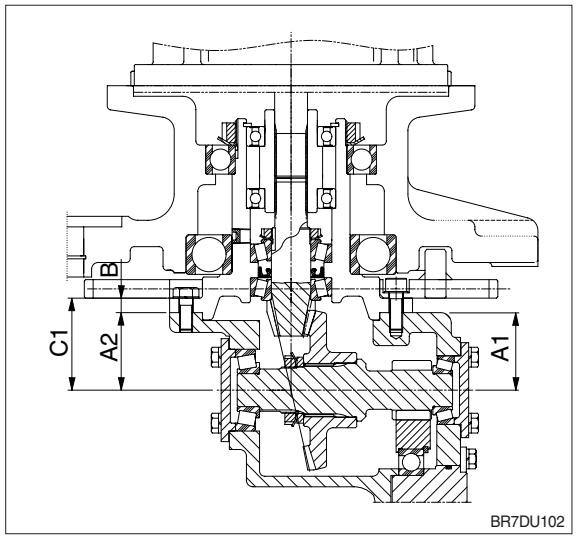
※ Apply loctite #271 white fastening lock nut (Item 12,14,21,32, Refer page 4-1).

(2) Assemble the drive wheel shaft to the gear case, assemble the spur gear from opposite side and screw on the locking nut. Tighten the locking nut while measuring starting torque required to start the spur gear turning. Spur gear starting torque. 23.6~26.3 kgf · cm (1.7~1.9 lbf · ft)

(3) Measure A1, A2 of the gear case and B of the gear case cover, and adjust C to be 69.00~69.10 by shim.

Shim thickness

3329022000 ·····	0.10 mm
3329022100 ·····	0.20 mm
3329022200 ·····	0.30 mm
3329022300 ·····	0.50 mm



(4) On the adjusting the tooth contact of spiral bevel gear, if changing the shim, idle of decrease the shim inserting between the cover of shaft both side and the gear case shim thickness.

Idle gear side		Drive tire side	
No.	Shim thickness	No.	Shim thickness
3329024400	0.10 mm	3329024000	0.10 mm
3329024500	0.20 mm	3329024100	0.20 mm
3329024600	0.30 mm	3329024200	0.30 mm
3329024700	0.50 mm	3329024300	0.50 mm

(5) Adjust the backlash between spiral bevel pinion and bevel gear.
Mount the dial gauge on gear case and read the backlash while rotating the drive wheel shaft.
Backlash 0.15~0.20 mm
If the backlash is not within the specified range, readjust the bevel gear shims. Increase the shim thickness if the backlash is too large, and decrease if too small.

(6) Check the contact between the drive pinion and bevel gear tooth.
Clean the gear tooth and apply red lead of the surfaces of 8 or 9 bevel gear tooth.
Turn the bevel gear in both forward and reverse directions and determine by the patterns made on the tooth face whether the tooth is contacting properly.

4) INSTALLATION

Perform the removal in reverse order.

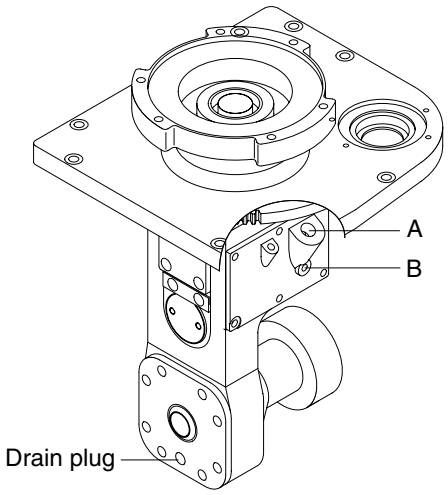
5) LUBRICATION PROCEDURES

Lubrication of drive unit gear case is performed as follows :

※ **Cover the brakes and drive motor with waste to prevent the gear oil from splashing on these parts.**

(1) Fill in oil through the filler hole A.

(2) After operating the vehicle for several hours, remove plug B and check the oil level. Replenish it now.

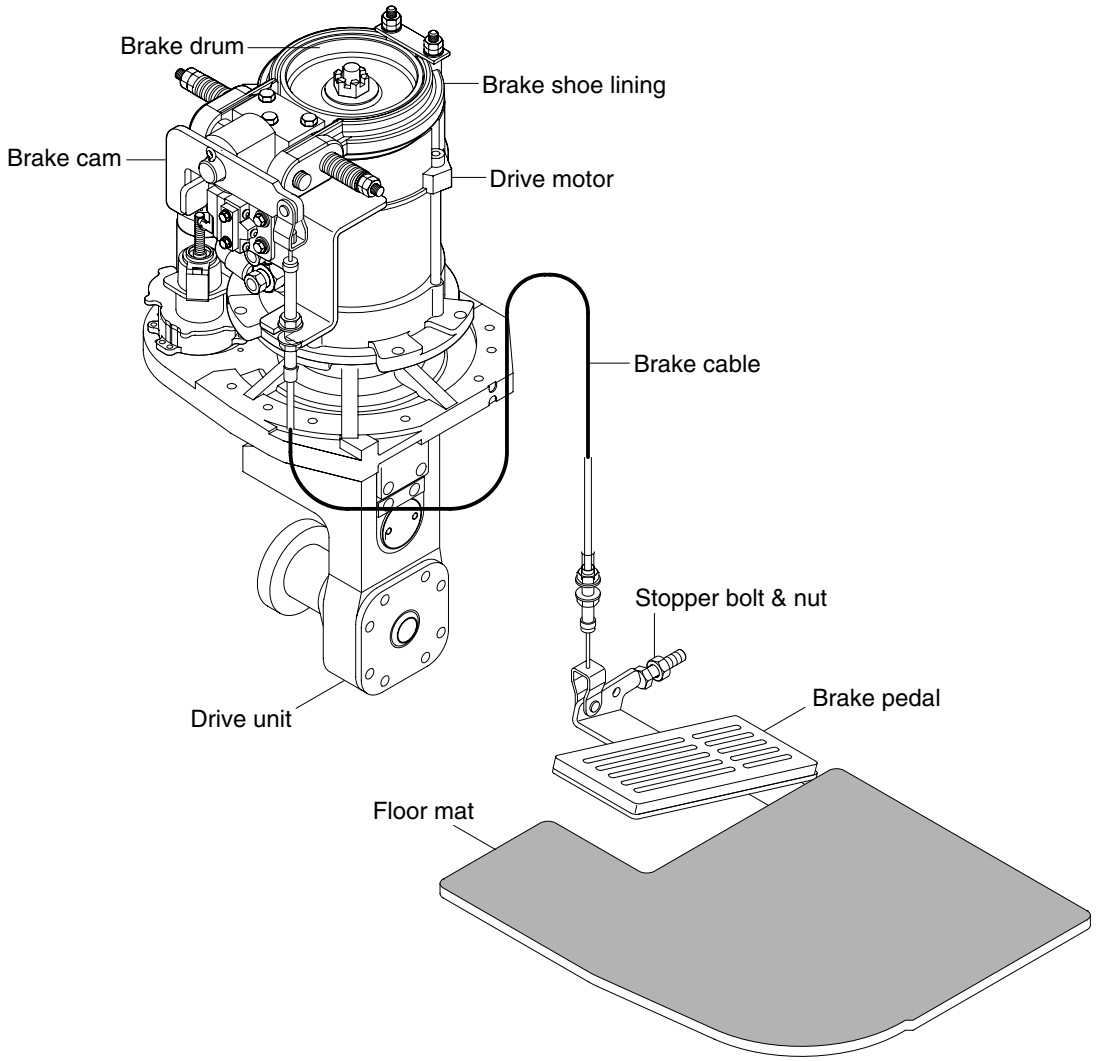


BR7DU107

SECTION 4 BRAKE SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. OUTLINE



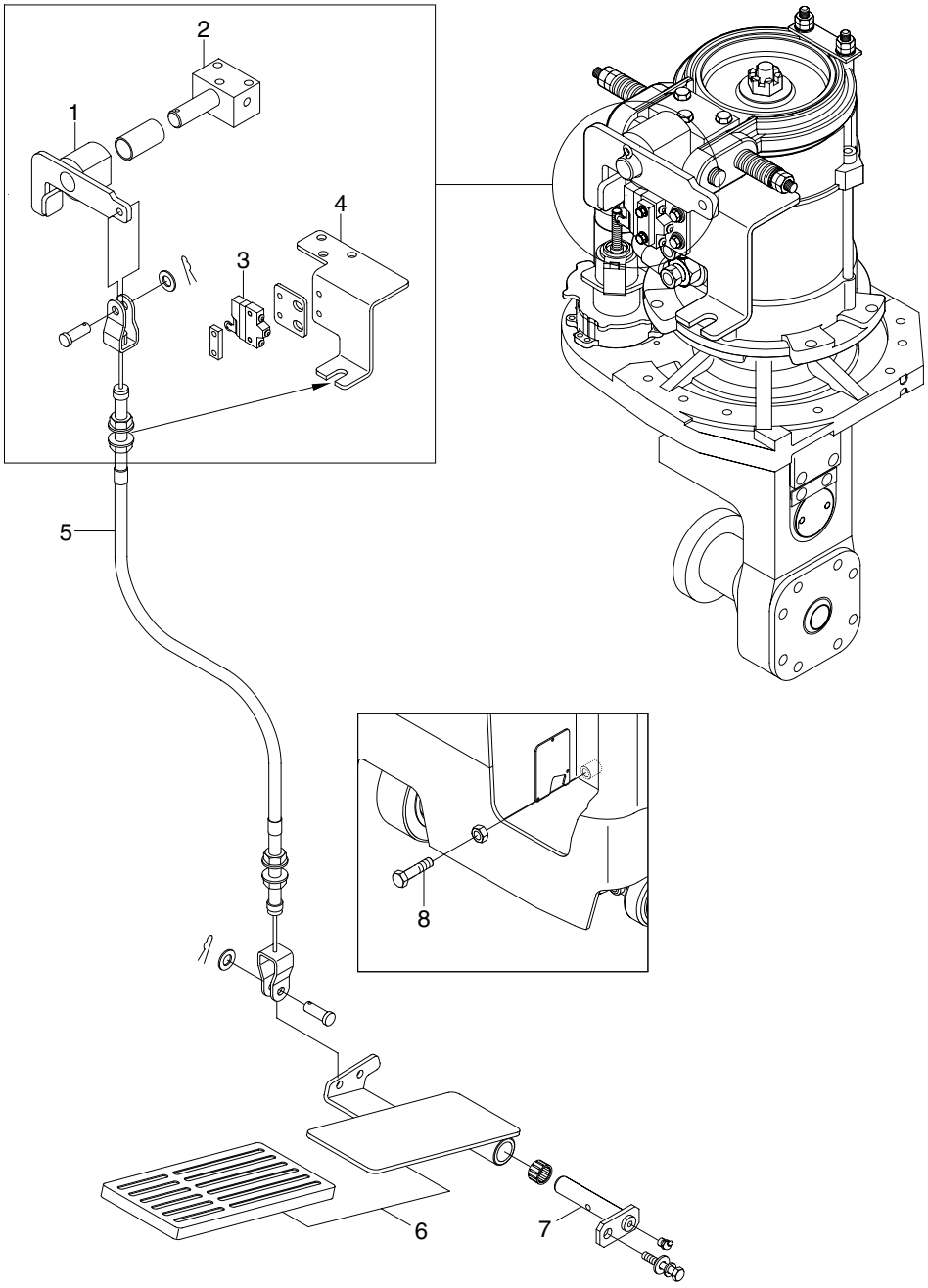
15BR9EBS01

2. SPECIFICATION

Item		15BR-9E
Type		Center brake
Brake pad	Material	Rubber mould
	W × L × T	40 × 110 × 5 mm (1.6 × 4.3 × 0.2 in)
	Area	44 cm² (6.8 in²)
Brake drum diameter	New	120 mm (4.7 in)
	Repair	117 mm (4.6 in)
Brake pedal play		10~15 mm (0.4~0.6 in)
Brake distance	Unloaded	Less than 5.0 m (197 in)
	Loaded	Less than 2.0 m (79 in)

3. BRAKE PEDAL AND PIPING

1) STRUCTURE



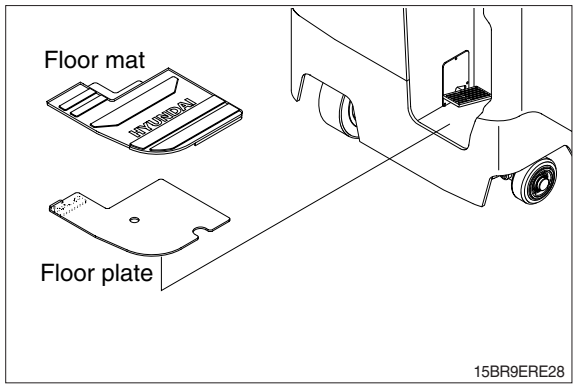
15BR9EBS02

1	Brake cam	5	Brake cable
2	Brake cam lever	6	Brake pedal
3	Brake switch	7	Pin
4	Bracket	8	Stopper bolt

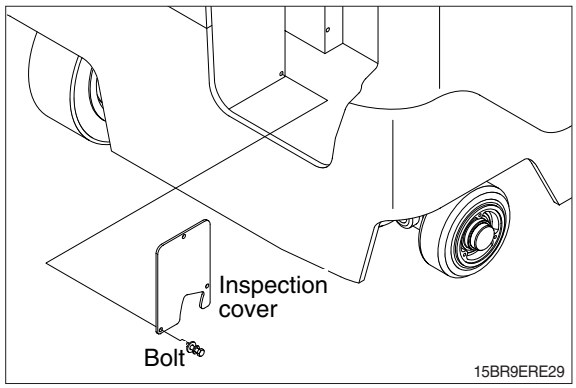
2) DISASSEMBLY AND ASSEMBLY

(1) Disassembly

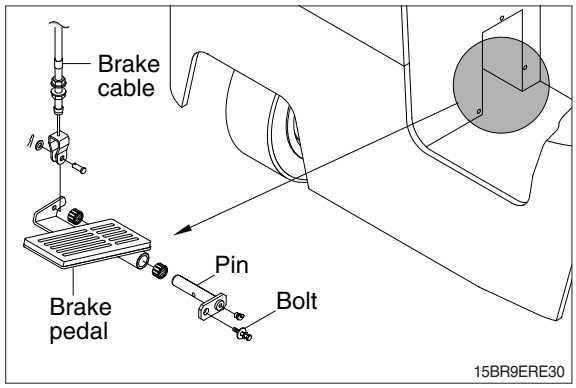
① Remove floor mat and floor plate.



② Remove inspection cover



③ Remove bolt, pin, spring and brake cable to remove brake pedal assembly.

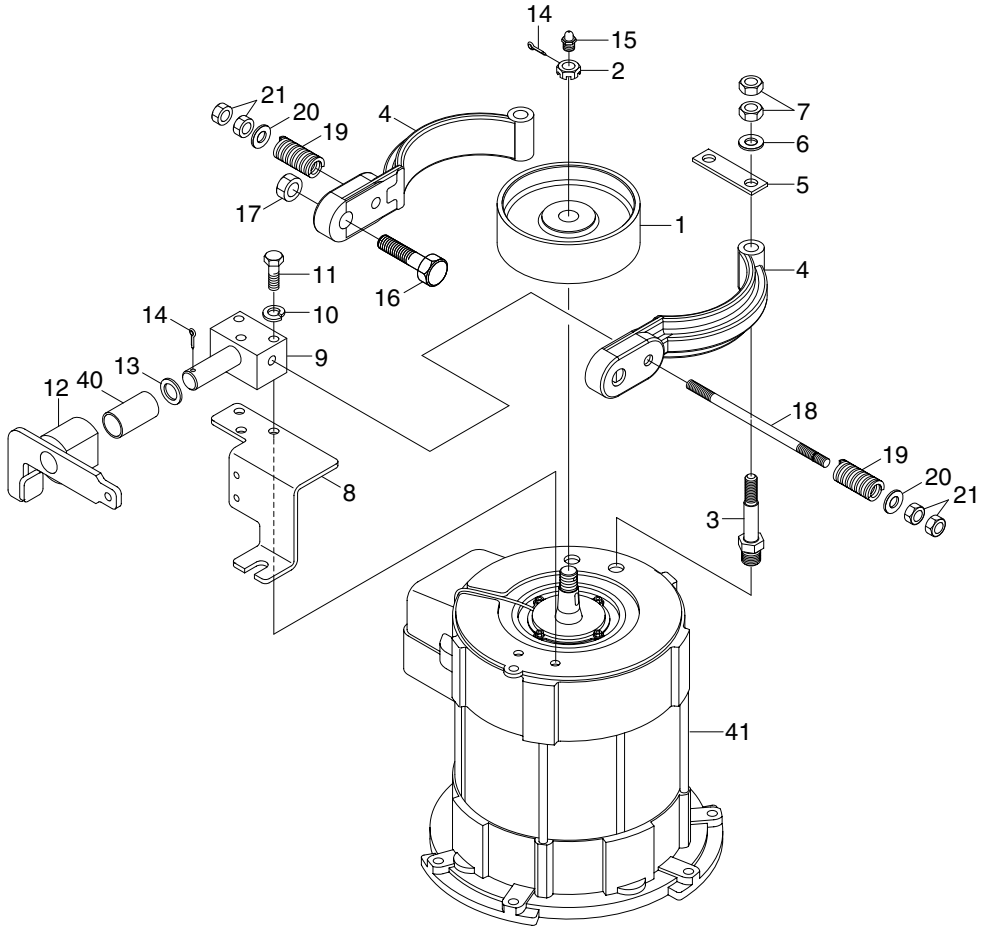


(2) Assembly

Perform disassembly in reverse order.

4. BRAKE SYSTEM

1) STRUCTURE



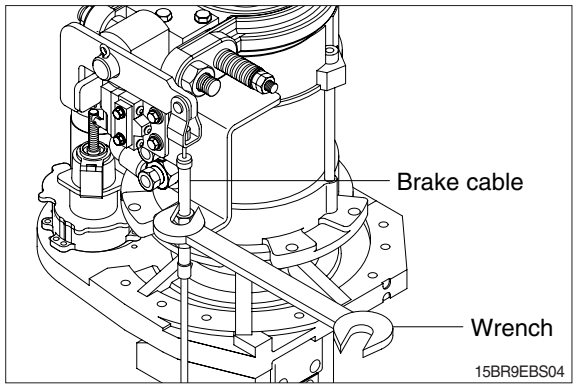
15BR9EBS03

1	Brake drum	9	B/cam bracket	17	Hex nut
2	Low castle nut	10	Spring washer	18	Brake rod
3	Brake shoe pin	11	Hex bolt	19	Spring
4	Lining brake shoe	12	Brake cam	20	Plain washer
5	Lock plate	13	Plain washer	21	Hex nut
6	Plain washer	14	Split pin	40	Du-bushing
7	Hex nut	15	Grease nipple	41	Traction motor
8	Cable bracket	16	Cam bolt		

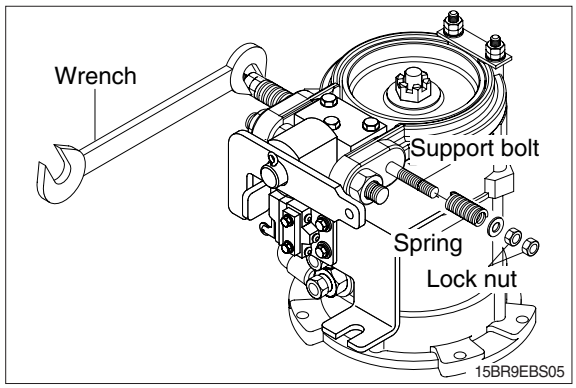
2) DISASSEMBLY AND ASSEMBLY

(1) Disassembly

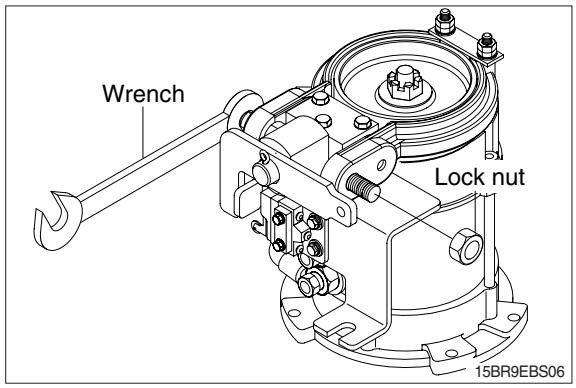
① Remove the brake cable from bracket.



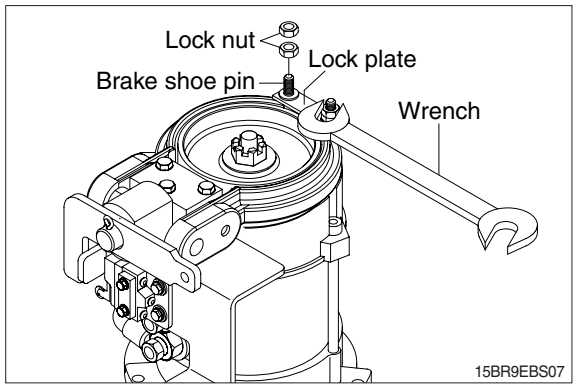
② Remove spring and support bolts after removing lock nut of brake spring.



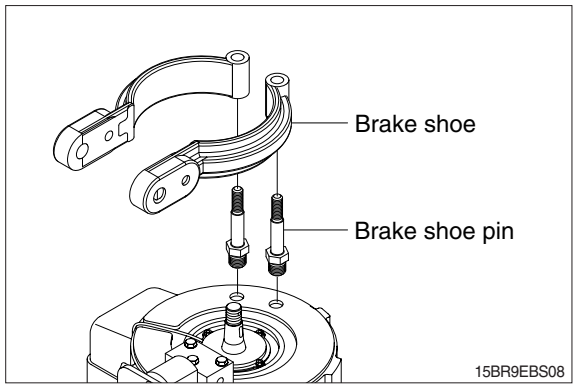
③ Remove lock nut for adjusting bolt.



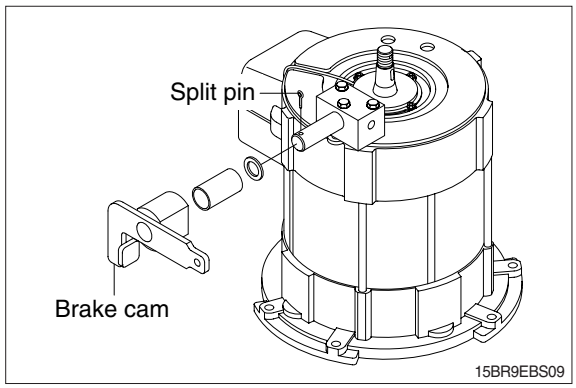
④ Remove lock nut of brake shoe pin and take lock plate of shaft.



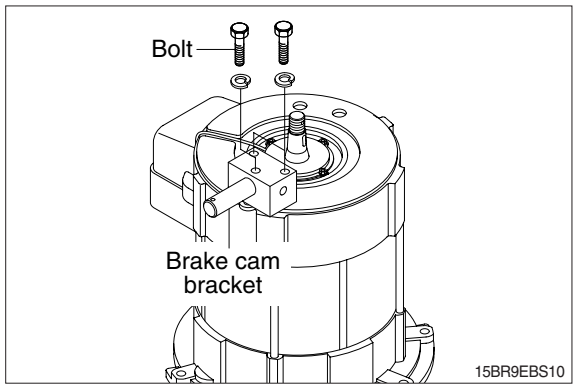
⑤ Take off brake shoe lifting up straightly.



⑥ Remove the split pin from the bracket of cam and remove the cam.

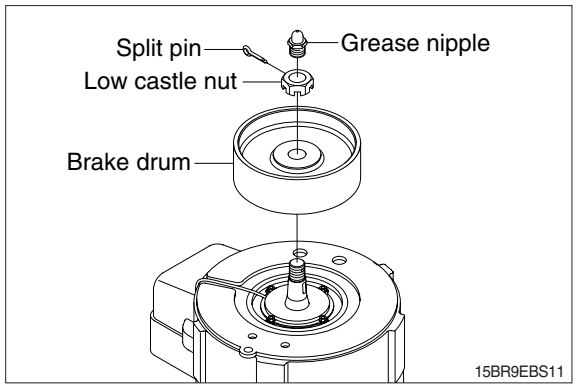


⑦ Remove 3 bolts attached on bracket and take off brake cam bracket.



⑧ Remove the split pin from brake drum mounting bolt and remove the nut.

⑨ Remove brake drum from motor shaft.

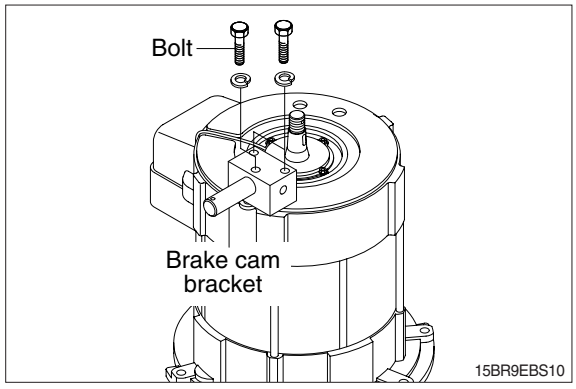


(2) Assembly

Assembly is in the reverse order to disassembly but be careful of following points.

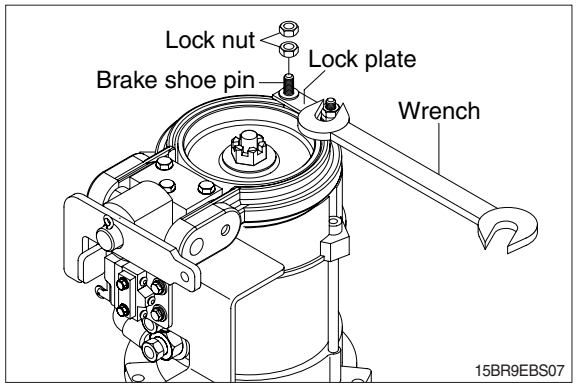
① Brake cam bracket mounting bolts.
- Tightening torque : 1.6~1.9 kgf · m (12~14 lbf · ft)

※ Apply loctite #277

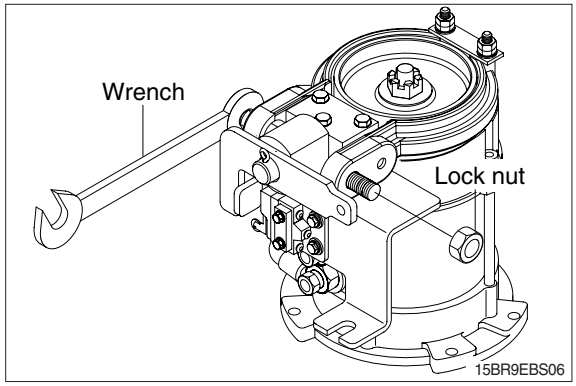


② Brake shoe support pin mounting.
- Tightening torque : 14.6~16 kgf · m (106~116 lbf · ft)

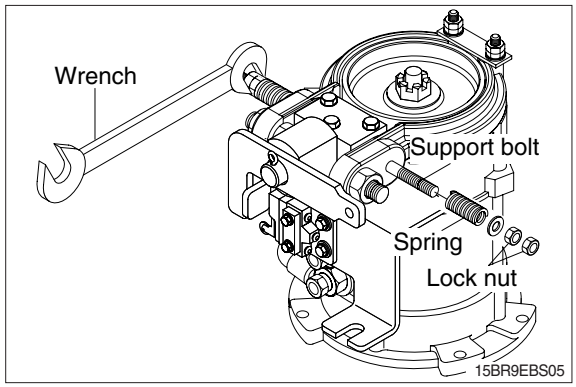
※ Apply loctite #277



③ Adjusting bolt lock nuts.
- Tightening torque : 11.4~12.6 kgf · m (82~91 lbf · ft)



④ Support bolts lock nuts.
- Tightening torque : 2.3~2.8 kgf · m (16.6~20.3 lbf · ft)



5. INSPECTION

1) Lining inspection

(1) Contact normally?
(2) Any injuries?
(3) Any one sided contact?
(4) Service limit : 1.5 ㎜ (0.059")

※ Lining should be replaced together with brake shoe.

2) Brake drum inspection

(1) Any damage or wear?
If so, plane the disc for revising.
(2) Drum die should not exceed ; under 3 ㎜ (0.012")

3) Spring inspection

(1) Are the springs weakened or damaged?

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

1) BRAKE PEDAL OPERATION

(1) Once the pedal released, the machine must remain stopped.
(2) Check the free play of pedal is 10~15 mm (0.4~0.6 in).
(3) Check the pedal height is 58~63 mm (2.3~2.5 in).

2) BRAKE SYSTEM OPERATION

(1) Check the operation of brake cam.
(2) Measure lining at point with most wear, and check that lining thickness is at least 2.0 mm (0.08 in).
(3) Measure inside diameter of drum and check that it is within the specification limit. (see 4-1 table)

3) BRAKE FORCE

(1) Select a dry, flat, paved surface and drive truck at maximum speed when signal is given, stop truck immediately and measure distance from point where signal was given to point where truck stopped. (Unloaded)
  · Stopping distance : Within 5 m (16' 5")
(2) Check that there is no pulling of steering wheel, pulling by brakes to one side or abnormal noise when making emergency stops.

2. TROUBLESHOOTING

Problem	Cause	Remedy
Brake drags	· Brake spring out of adjustment. · Brake spring broken. · Brake drum worn or rusted. · Brake switch defective. · Brake pedal play excessive. · Brake lining insufficient contact. · Motor shaft key broken. · Motor shaft damage.	· Check and adjust. · Replace. · Check, and replace if defective. · Check, and replace if defective. · Adjust brake pedal play. · Adjust and replace if defective. · Replace. · Replace.
Poor braking effect	· Brake spring out of adjustment. · Brake spring broken or deteriorated. · Brake pedal play excessive. · Faulty return due to rusting of parts. · Brake shoes worn.	· Check and adjust. · Replace. · Adjust brake pedal play. · Disassemble and clean or replace. · Replace.
Brake squeaks	· Brake shoe glazed or dirty, brake shoe worn, brake dust accumulation. · Brake drum warped or scored. · Defective adhesion between brake shoe and lining.	· Replace brake shoe, clean brake drum circumference. · Repair or replace. · Replace.
Brake shoe not releasing	· Heavy tightening of stopper. · Wheel cylinder damaged. · Master cylinder damaged.	· Adjust. · Check for oil leakage, volume, air mixing, and repair if defective. Replace wheel cylinder if defective. · Check connection between master cylinder and pedal, and replace master cylinder if defective.

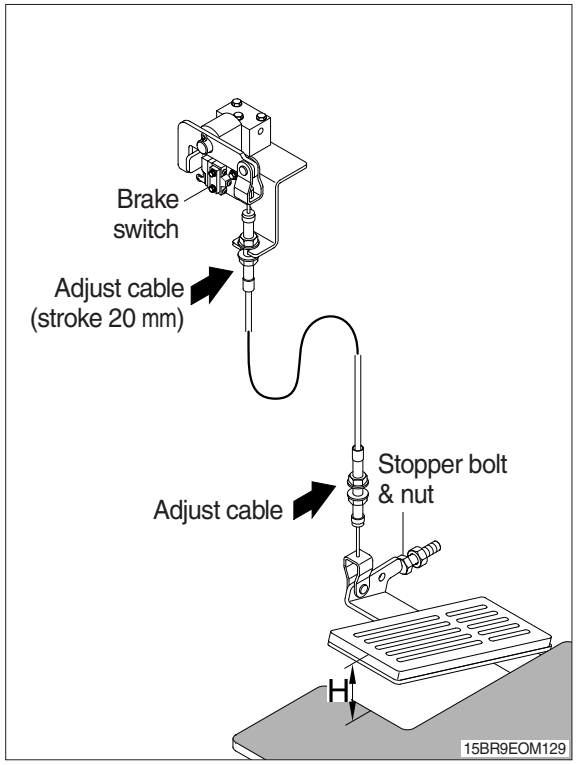
GROUP 3 TEST AND ADJUSTMENT

1. CHECK AND ADJUSTMENT OF THE SERVICE BRAKE SYSTEM

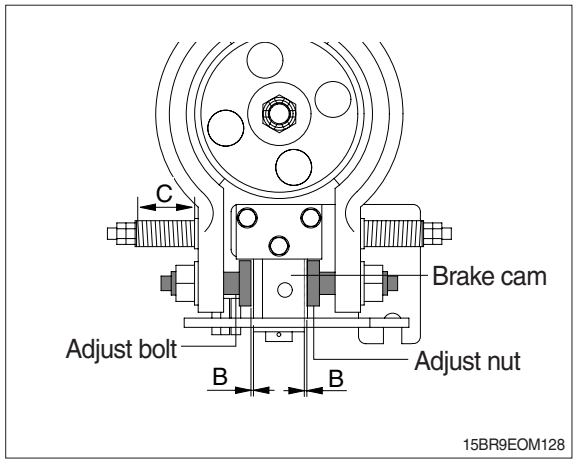
1) Check the pedal height (H) and adjust the stopper bolt & nut : 75 $^{+5}_{0}$ mm

2) After adjusting the pedal height set vertically the brake cam and set the brake cable.
Tighten nut for brake cable.

3) Check the brake switch to be operating condition while the pedal is depressed.



4) Check the gap (B) between brake cam and adjusting bolt.
· B : 0.5~1.0 mm
If the gap is too long and short adjust the adjusting bolt.
· Adjust nut tightening torque
11.0~13.0 kgf · m (79.6~94.0 lbf · ft)



5) Check the brake lining wear or any damage.
If brake lining is contacted any one side or lining thickness is 1.5 mm, brake lining and shoe assy should be replaced together.

6) Check the height (C) of brake spring and adjust the spring.

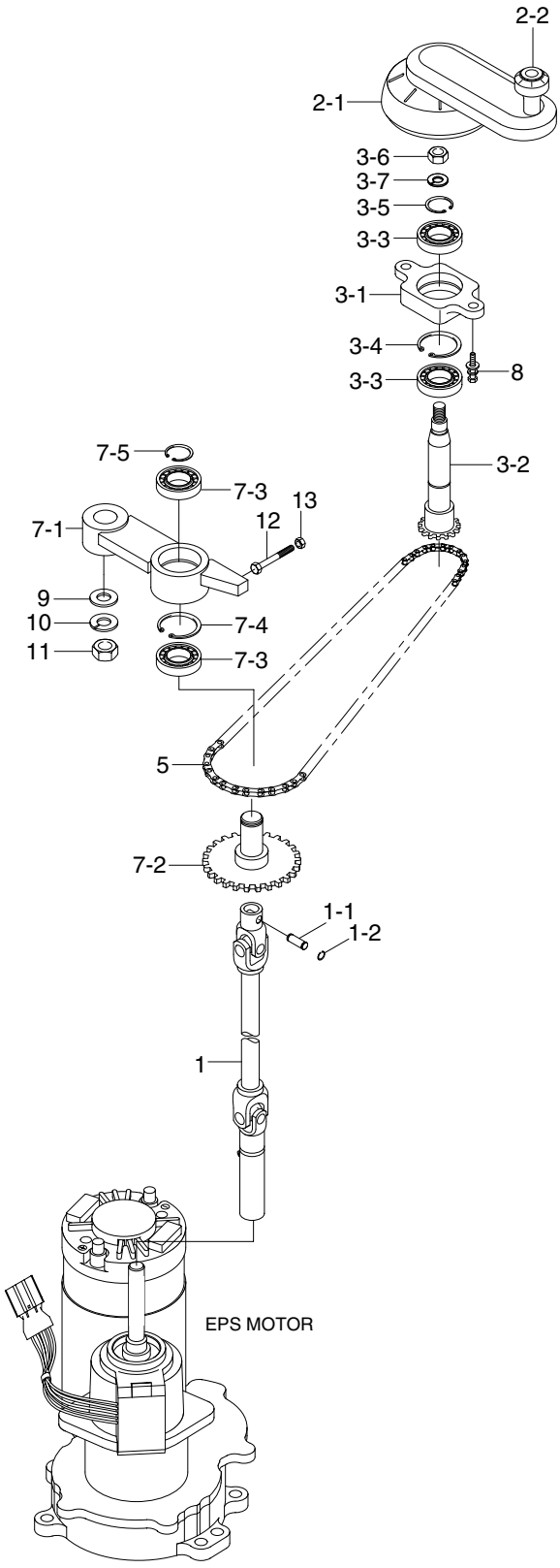
Model	Height (mm)
15BR-9E	40 $^{+5}_{0}$

· Spring nut tightening torque
2.0~3.0 kgf · m (14.4~21.6 lbf · ft)

SECTION 5 STEERING SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. OUTLINE



1	U-joint assy
1-1	Straight pin
1-2	Snap ring
2-1	Steering wheel
2-2	Steering wheel knob
3-1	Steering wheel bracket
3-2	Steering wheel shaft
3-3	Ball bearing
3-4	Retaining ring
3-5	Retaining ring
3-6	Hexagon nut
3-7	Spring washer
5	Roller chain
7-1	Steering bracket
7-2	Sprocket assy
7-3	Ball bearing
7-4	Retaining ring
7-5	Retaining ring
8	W/washer bolt
9	Plain washer
10	Spring washer
11	Hexagon nut
12	Bolt
13	Hexagon nut

15BR9ESE03

2. SPECIFICATIONS AND SERVICE STANDARD

Type	Unit	1st stage	Chain
		2st stage	Gear
Steering wheel diameter (mm)		ø 300	
Steering wheel free play (mm)		25~50	
Steering chain slack (mm)		3~5	
Steering angle	Right turn	79°	
	Left turn	101°	
Minimum turning radius (mm)	15BR-9E	1605	

3. TROUBLE SHOOTING

Problem		Cause	Remedy
Heavy steering	At traveling	· Damage of bearing at steering pinion	· Replace bearing
		· Damage of bearing of steering shaft of drive unit	· Replace bearing
		· Lack of grease of bearing	· Lubricate grease
	At releasing joint at spline	· Damage of bearing in steering racket	· Replace bearing
		· Over tension of roller chain	· Adjust the tension
Steering play is large (STD : 25~50 mm)		· Looseness of roller chain	· Adjust the tension
		· Extension of roller chain	· Adjust the tension or replace the chain
		· Looseness of rubber coupling is large	· Replace coupling
		· Looseness of spline and joint is large	· Replace
		· Backlash of steering pinion and gear is large	· Replace
Steering wheel is robbed in one way during traveling		· Eccentric wear of tire	· Replace
		· Transformation of drive unit-rear axle	· Repair or replace
		· Transformation of frame	· Repair or replace

GROUP 2 DISASSEMBLY AND ASSEMBLY

1. TOOL

1) Standard tool

2) Universal puller

3) Vernier caliper

2. DISASSEMBLY

1) Remove the cap of steering wheel (2-1) and remove the hexagon nut (3-6) by means of box spanner.

2) Remove the steering wheel (2-1).

3) Loosen the nut (11) fixing the steering bracket (7-1).
   · Tightening torque (11) : 16±2 kgf · m
   (116±4.5 lbf · ft)

4) Loosen the bolt (12) that extends chain.

5) Remove the bolt (8) fixing the steering wheel bracket (3-1).
   · Tightening torque (8) : 7±0.7 kgf · m
   (50.6±5.1 lbf · ft)

6) Lift up the cover straighting up and remove the cover.

7) Remove the steering wheel bracket (3-1).

8) Take off the steering wheel shaft (3-2) after removing the snap ring (3-5).

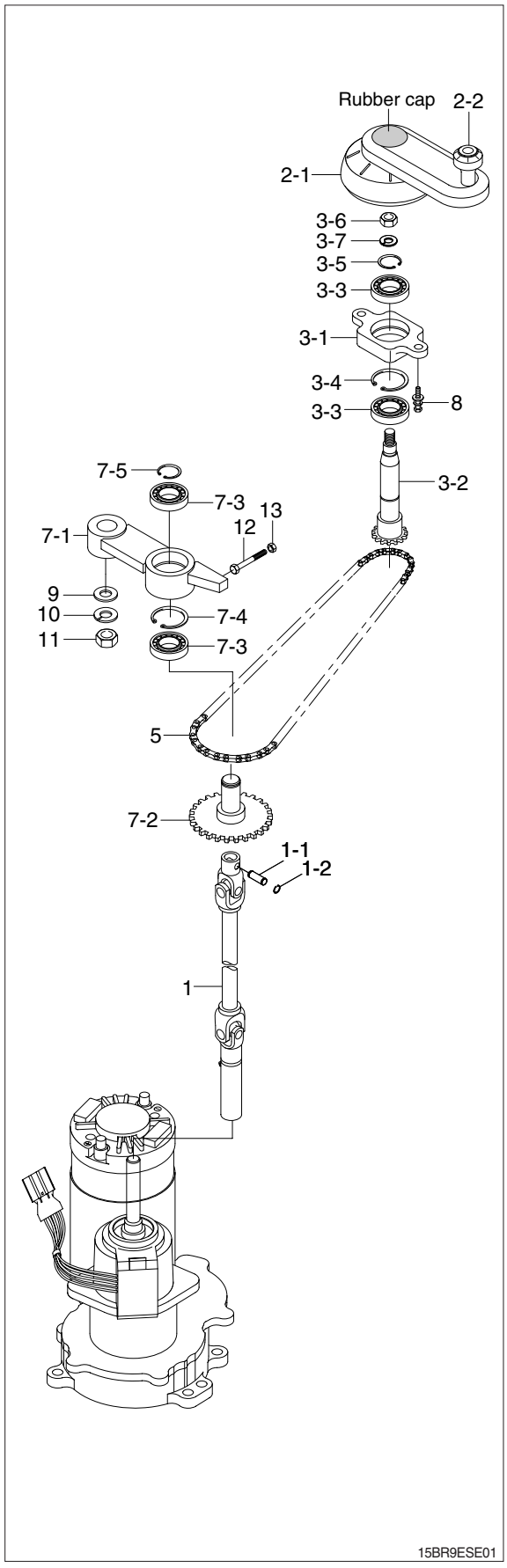
9) Remove the steering bracket (7-1).

10) Take off the sprocket assy (7-2) after removing the snap ring (7-5, 1-2) and straight pin (1-1).

11) Remove the U-joint assy (1).

3. ASSEMBLY

Perform the disassembly in reverse order.



4. INSPECTION

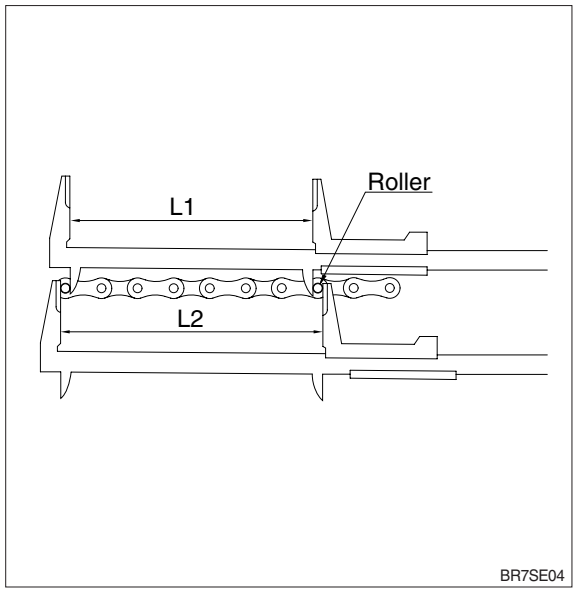
1) Inspect the steering chain for extension, cracks and damage and replace if defective.

$$L = \frac{L1 + L2}{2}$$

Standard : L = 76.20 mm (3.00 in) (6Link)
Limit : L = 77.34 mm (3.04 in)

2) Inspect the sprockets assy and steering wheel shaft for cracks and damage, and replace if defective.

3) Inspect the rubber coupling for cracks and the universal joint for faulty operation, and replace if defective.



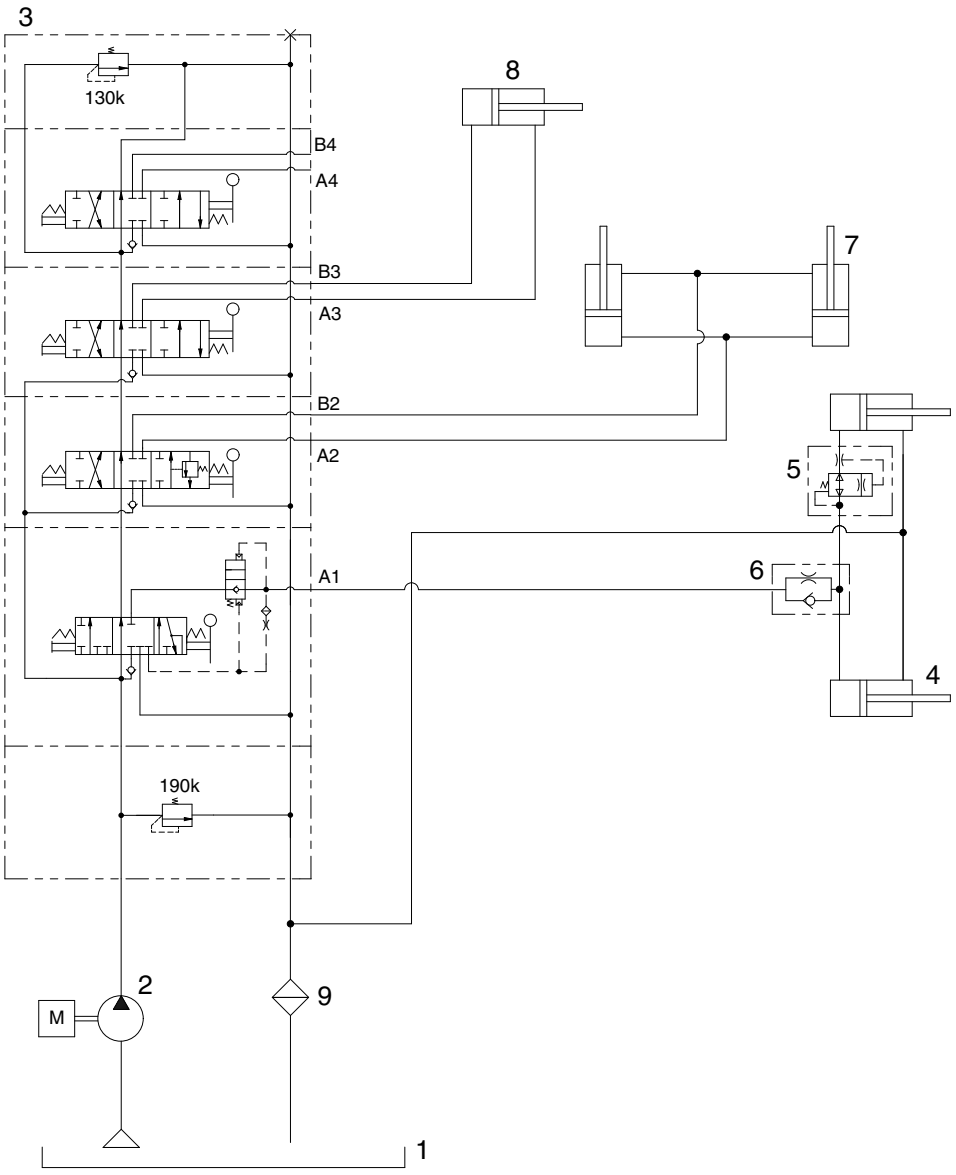
5. ADJUSTMENT

- Adjust the steering chain tension through the adjusting link so that the chain deflection will be 3-5 mm (0.12~0.20 in).
- Adjust the steering play to 25~80 mm (1.0~3.0 in).
- Adjust the steering wheel to close to operator's stand through fixing of spline in traveling.

SECTION 6 HYDRAULIC SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. HYDRAULIC CIRCUIT

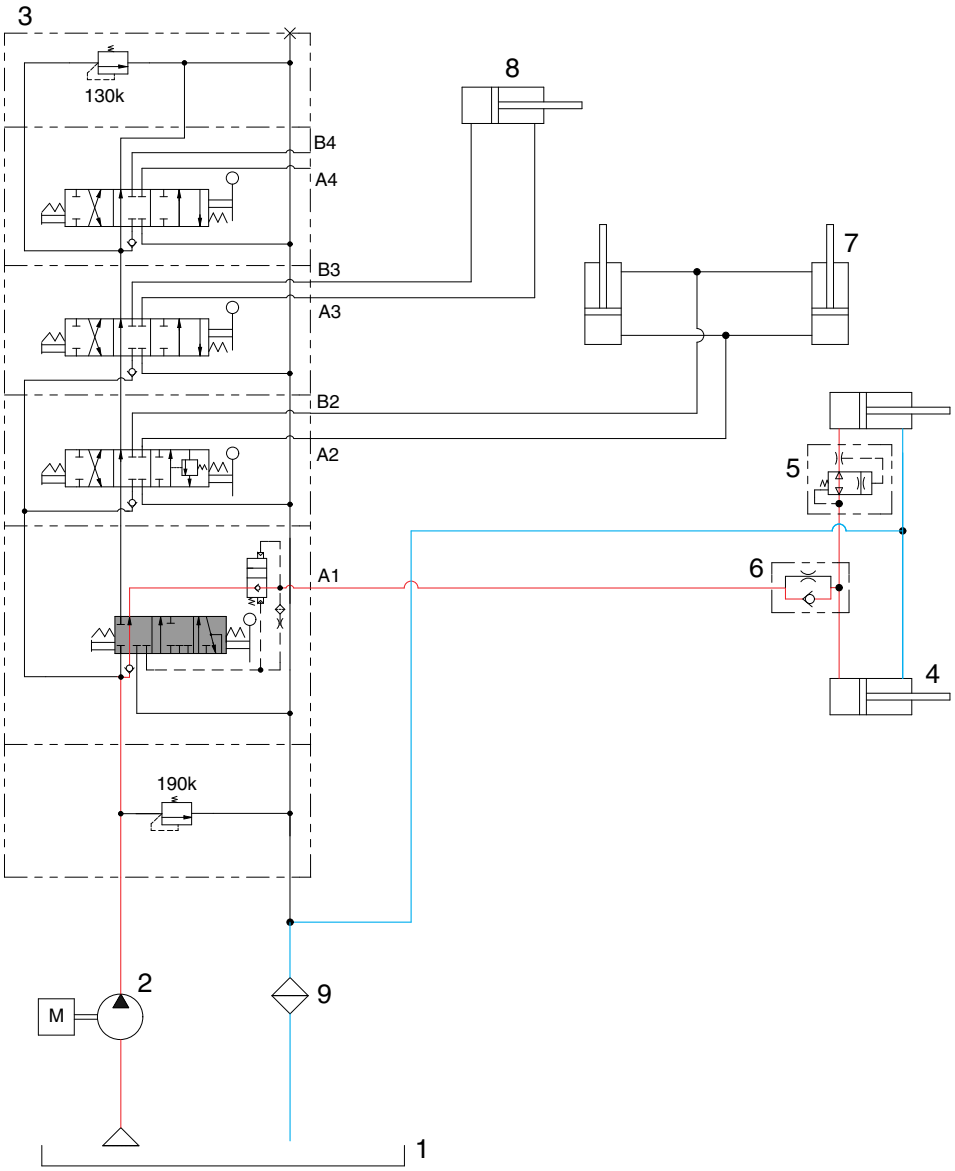


15BR9EHS01

1 Hydraulic tank
2 Hydraulic pump
3 Main control valve
4 Lift cylinder
5 Down safety valve
6 Down control valve
7 Tilt cylinder
8 Reach cylinder
9 Return filter

※ The circuit diagram may differ from the equipment, so please check before a repair.

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

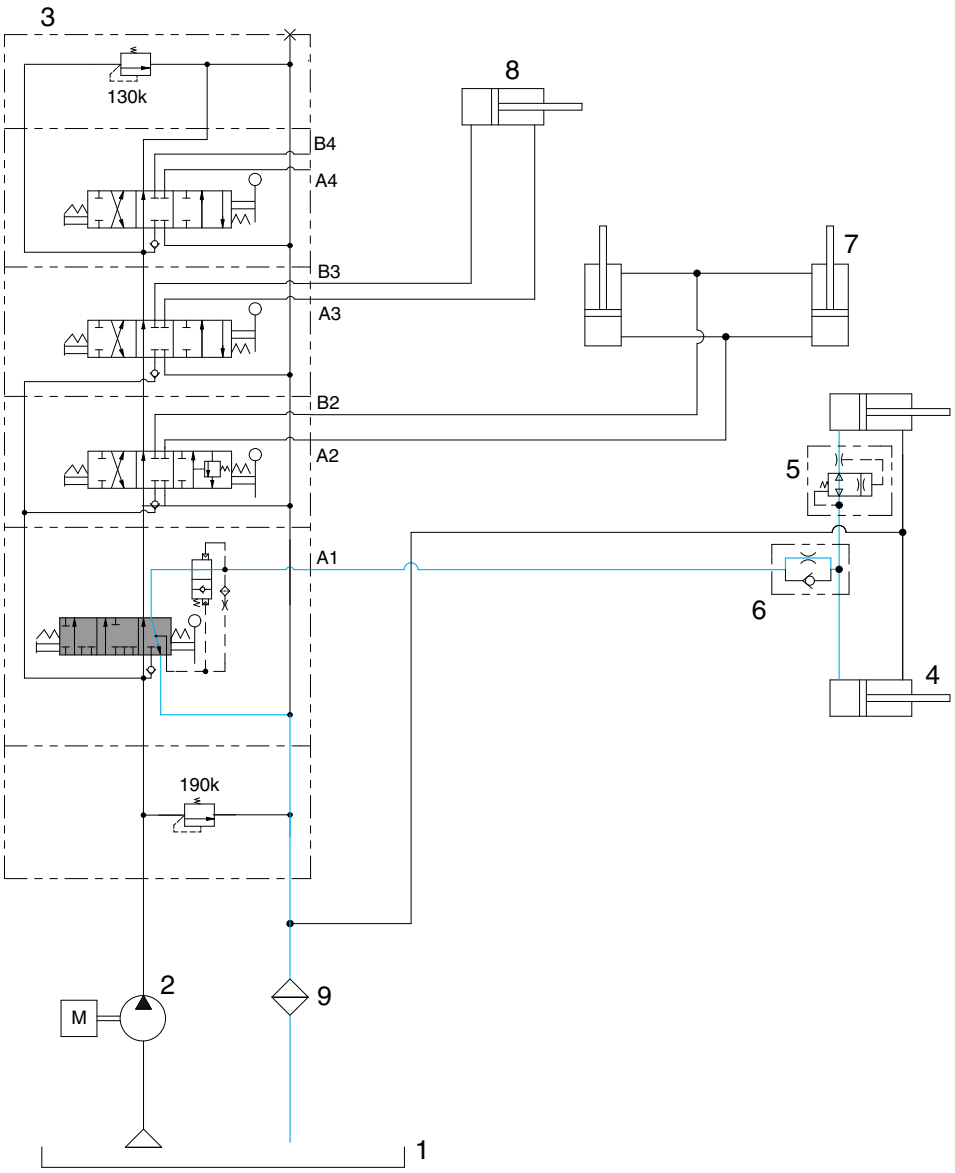


15BR9EHS02

When the lift control lever is pulled back, the spool on the first block is moves to lift position.
The oil from hydraulic gear pump (2) flows into main control valve (3) and then goes to the large chamber of lift cylinder (4) by pushing the load check valve of the spool.
The oil from the small chamber of lift cylinder (4) returns to hydraulic oil tank (1) at the same time.
When this happens, the forks go up.

※ The circuit diagram may differ from the equipment, so please check before a repair.

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

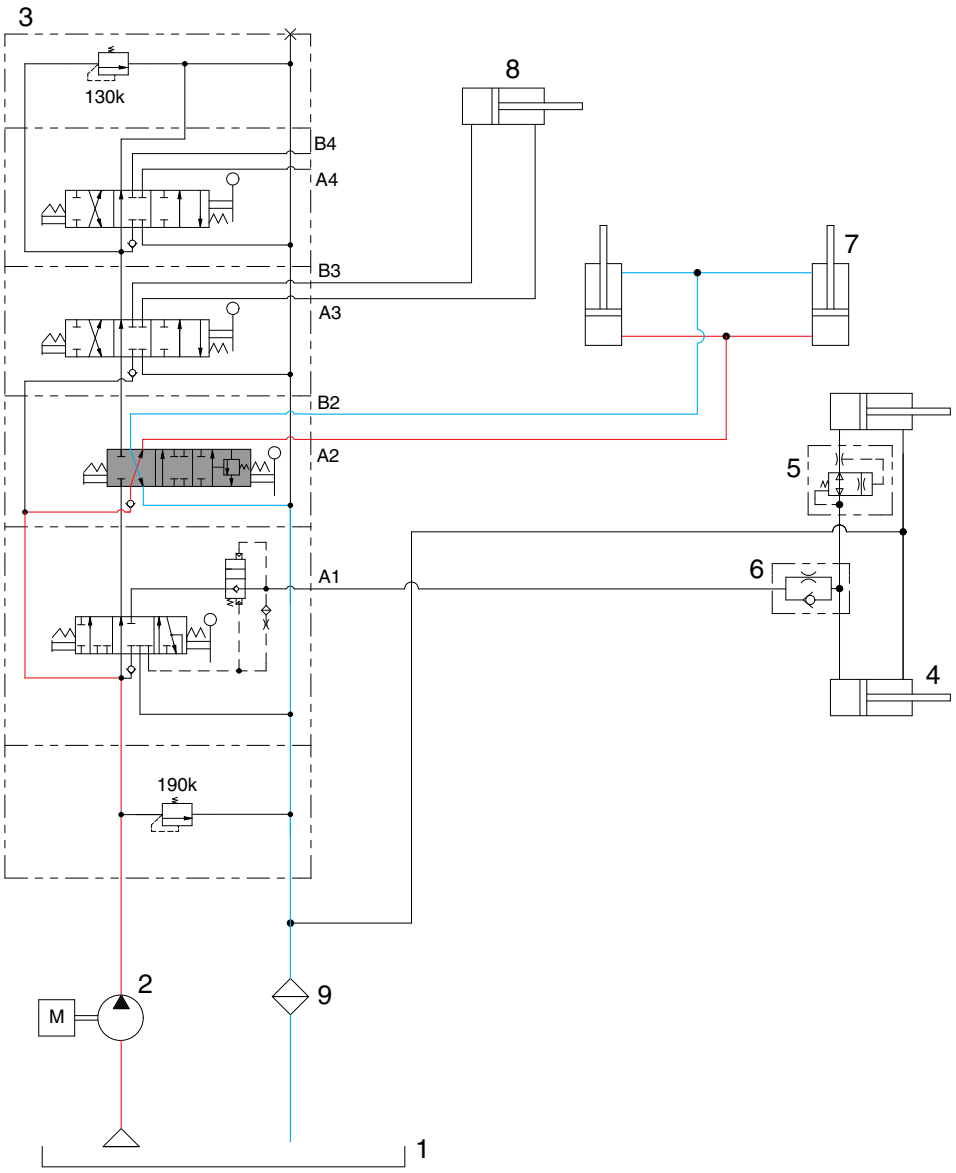


15BR9EHS03

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

※ The circuit diagram may differ from the equipment, so please check before a repair.

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

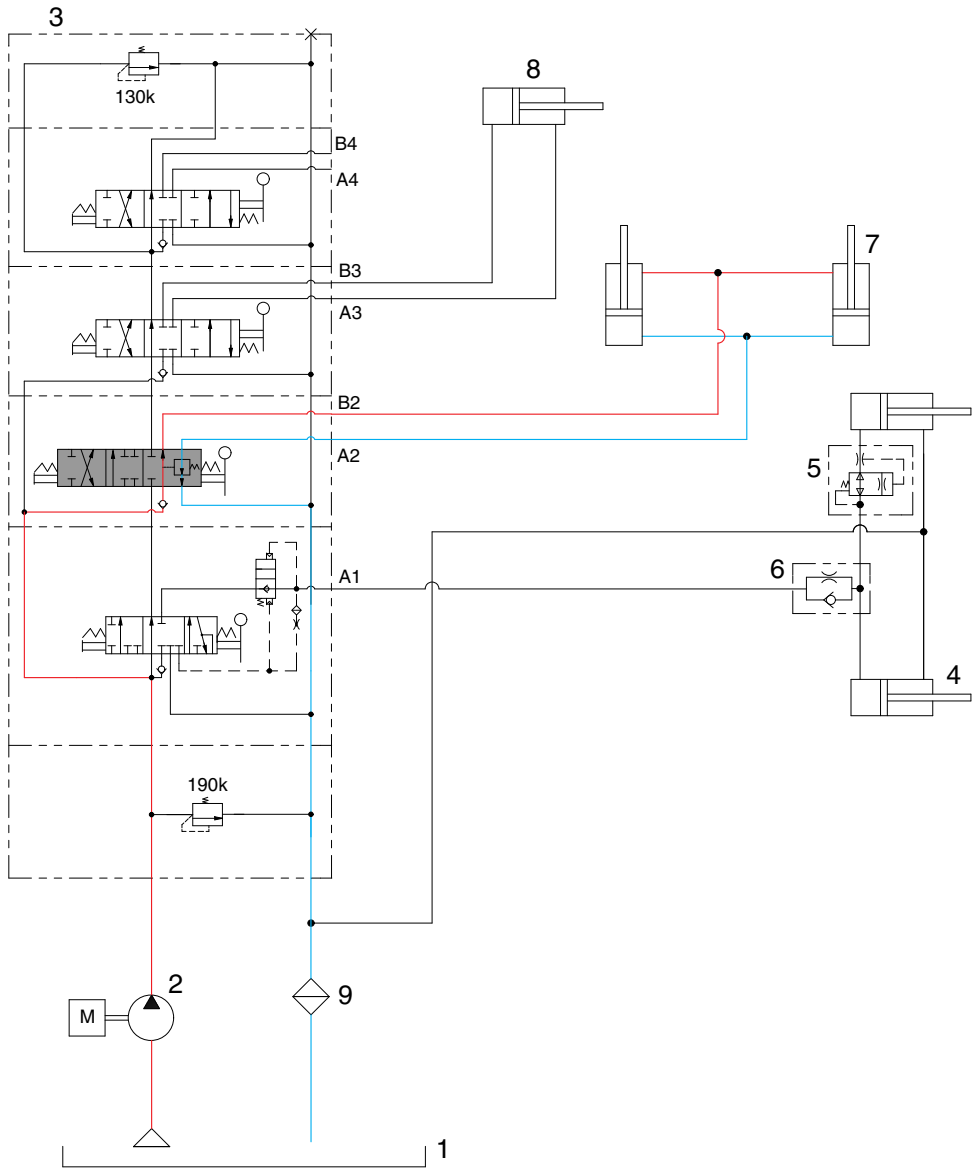


15BR9EHS04

When the tilt control lever is pulled back, the spool on the second block is moved to tilt backward position.
The oil from hydraulic gear pump (2) flows into main control valve (3) and then goes to the large chamber of tilt cylinder (7) by pushing the load check valve of the spool.
The oil at the small chamber of tilt cylinder (7) returns to hydraulic tank (1) at the same time.
When this happens, the mast tilt backward.

※ The circuit diagram may differ from the equipment, so please check before a repair.

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

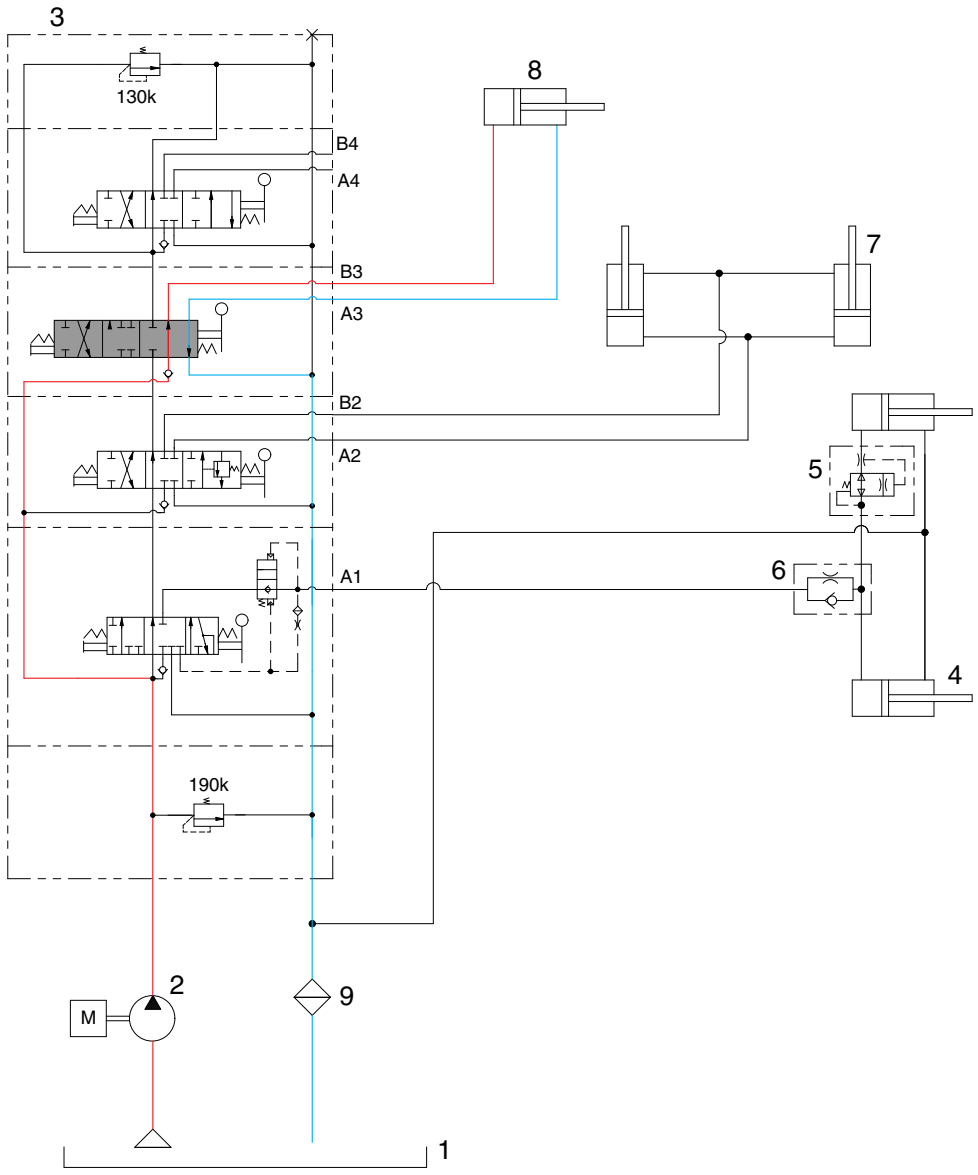


15BR9EHS05

When the tilt control lever is pushed forward, the spool on the second block is moved to tilt forward position.
The oil from hydraulic gear pump (2) flows into main control valve (3) and then goes to the small chamber of tilt cylinder (7) by pushing the load check valve of spool.
The oil at the large chamber of tilt cylinder (7) returns to hydraulic tank (1) at the same time.
When this happens, the mast tilt forward.

※ The circuit diagram may differ from the equipment, so please check before a repair.

5) WHEN THE REACH CONTROL LEVER IS IN THE forWARD POSITION

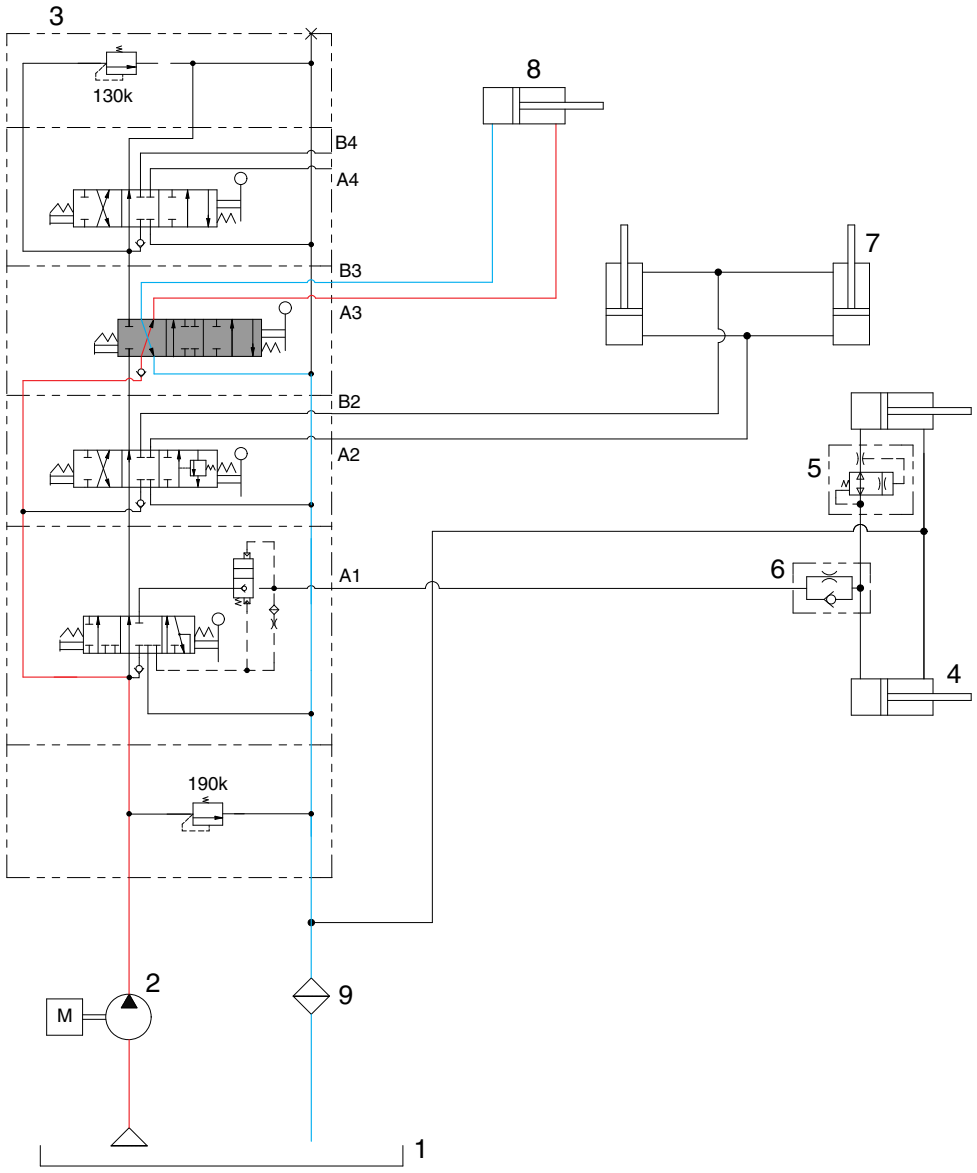


15BR9EHS06

When the reach control lever is pushed forward, the spool on the third block is moved to reach forward position.
The oil from hydraulic gear pump (2) flows into main control valve (3) and then goes to the large chamber of reach cylinder (8) by pushing the load check valve of spool.
The oil at the small chamber of reach cylinder (8) returns to hydraulic tank (1) at the same time.
When this happens, the mast reaches forward.

※ The circuit diagram may differ from the equipment, so please check before a repair.

6) WHEN THE REACH CONTROL LEVER IS IN THE BACKWARD POSITION



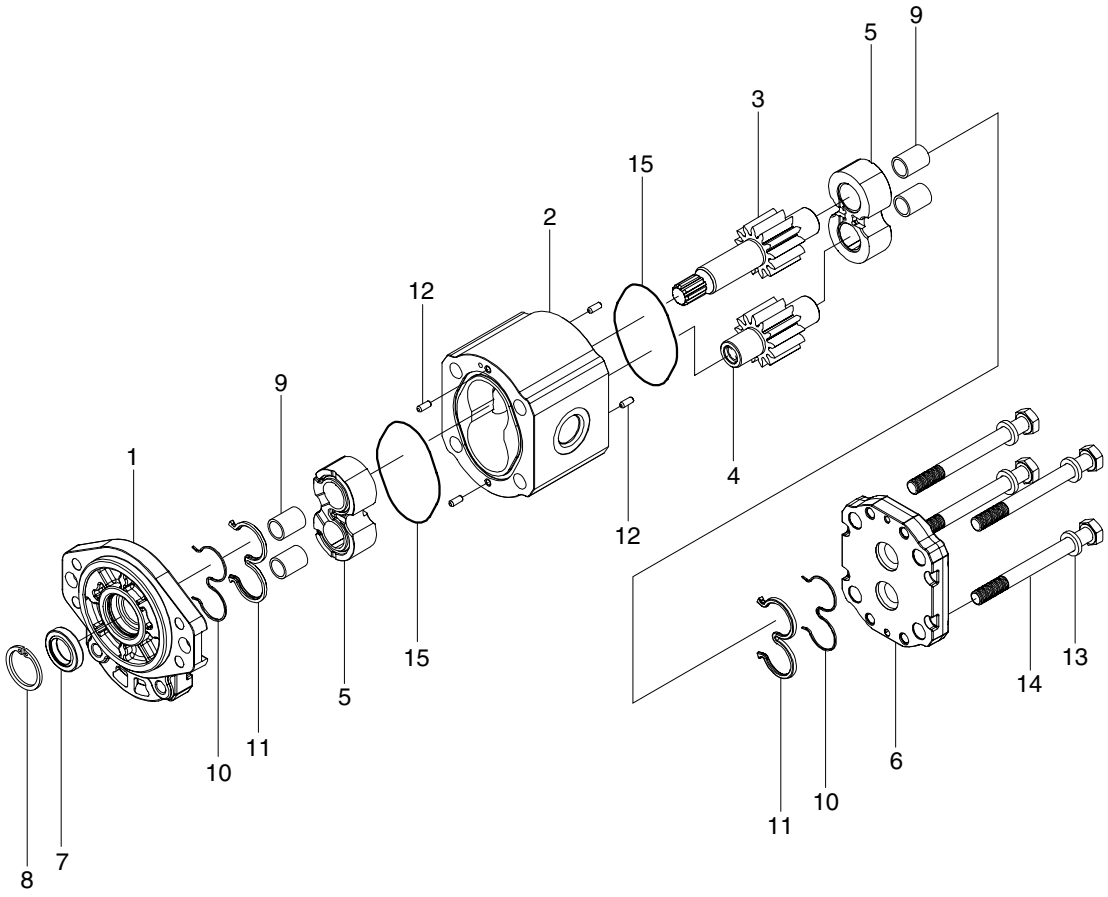
15BR9EHS07

When the reach control lever is pulled backward, the spool on the third block is moved to reach backward position.
The oil from hydraulic gear pump (2) flows into main control valve (3) and then goes to the small chamber of reach cylinder (8) by pushing the load check valve of spool.
The oil at the large chamber of reach cylinder (8) returns to hydraulic tank (1) at the same time.
When this happens, the mast reaches backward.

※ The circuit diagram may differ from the equipment, so please check before a repair.

2. HYDRAULIC GEAR PUMP

1) STRUCTURE



15BR9EHS19A

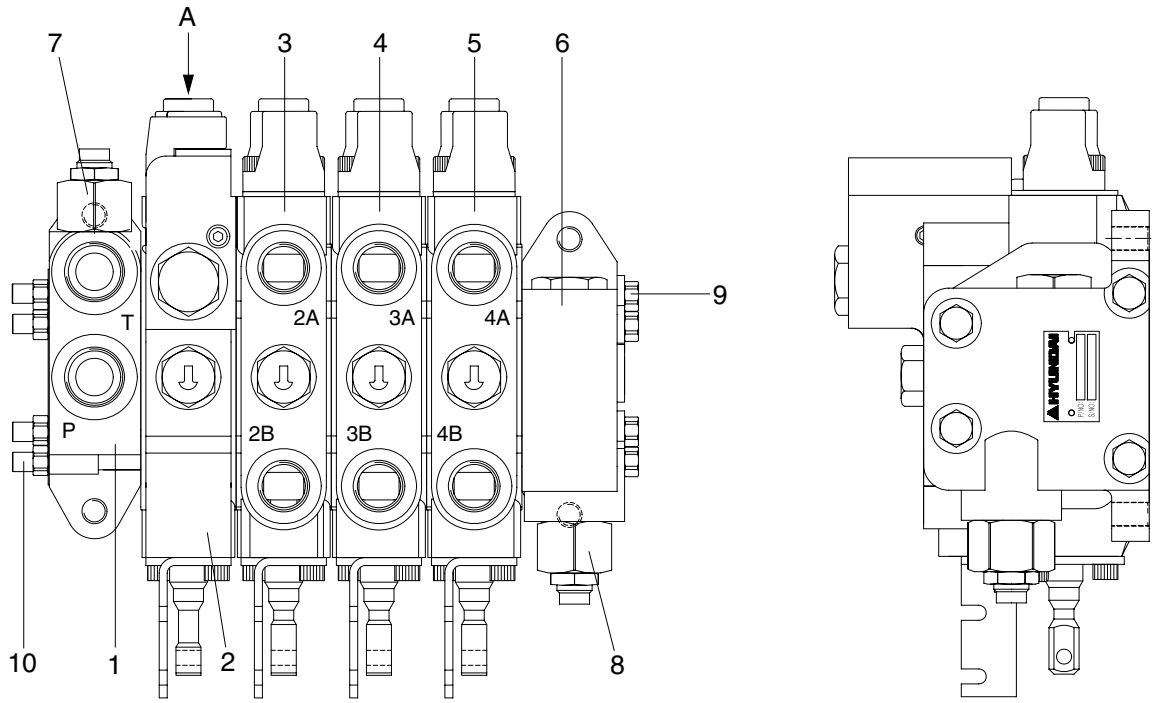
1	Housing	6	Rear cover	11	E back up ring
2	Body	7	Oil seal	12	S pin
3	Drive gear	8	Snap ring	13	Washer
4	Idler shaft	9	Du bush	14	Bolt
5	Side plate	10	E seal	15	Square seal

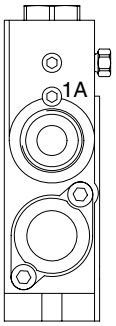
2) OPERATION

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.

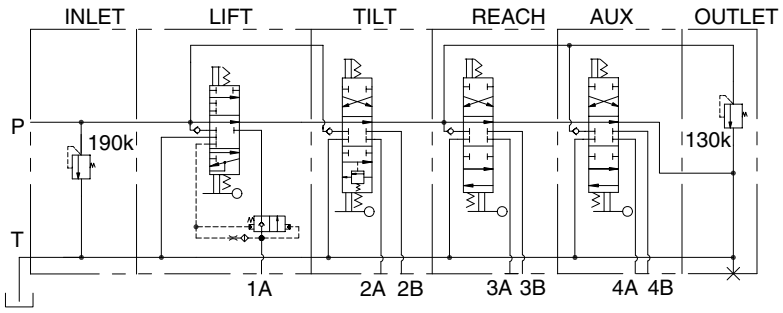
3. MAIN CONTROL VALVE

1) STRUCTURE (4 Spool)





VIEW A

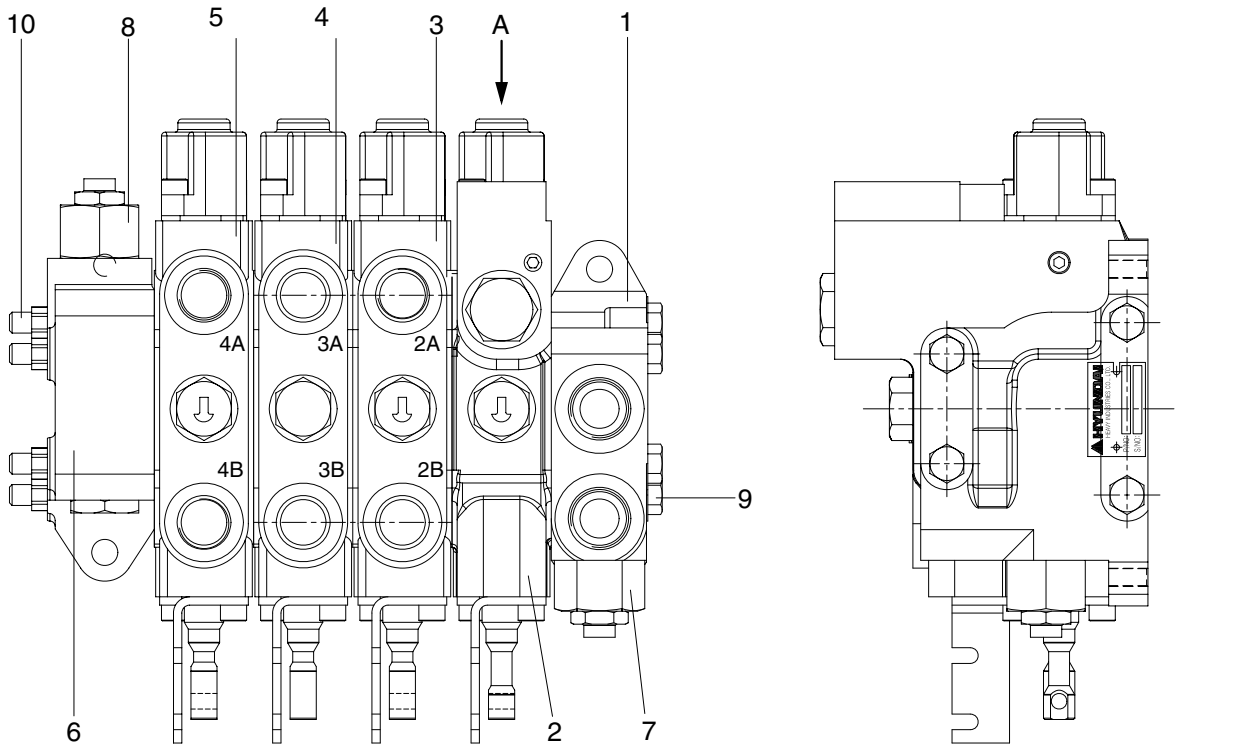


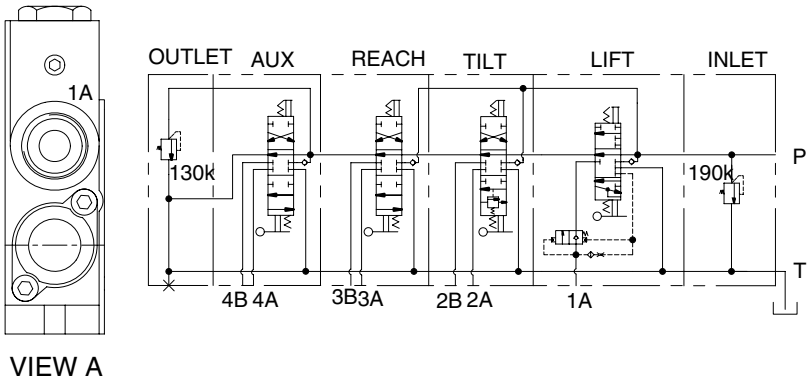
Port name	Size	Port
Inlet port	7/8-14UNF	P
Outlet port	7/8-14UNF	T
Work port	7/8-14UNF	1A
Work port	3/4-16UNF	2A, 2B, 3A, 3B, 4A, 4B

15BR9EHS08

1 Inlet block assy
2 Lift block assy
3 Tilt block assy
4 Reach block assy
5 Aux block assy
6 Outlet block assy
7 Main relief valve assy
8 Auxiliary relief valve assy
9 Long bolt
10 Nut

2) STRUCTURE (4 Spool, Reverse)





VIEW A

Port name	Size	Port
Inlet port	7/8-14UNF	P
Outlet port	7/8-14UNF	T
Work port	7/8-14UNF	1A
Work port	3/4-16UNF	2A, 2B, 3A, 3B, 4A, 4B

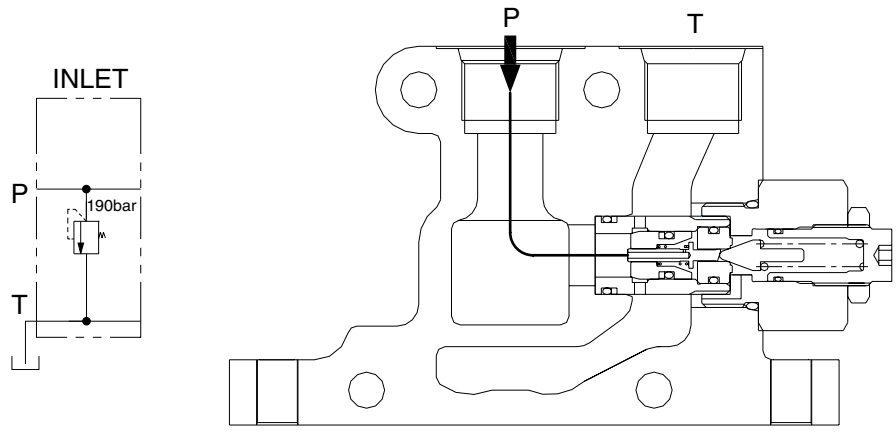
15BR9EHS08R

1 Inlet block assy
2 Lift block assy
3 Tilt block assy
4 Reach block assy
5 Aux block assy
6 Outlet block assy
7 Main relief valve assy
8 Auxiliary relief valve assy
9 Long bolt
10 Nut

3) INLET SECTION

(1) Operation

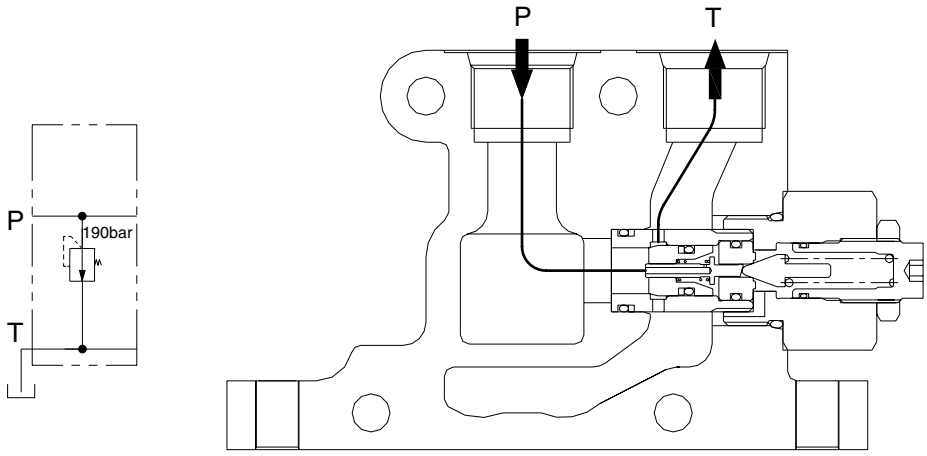
The inlet section contains the pump inlet connection and main relief valve.



22B7HS09

(2) Operation of relief valve at setting pressure

When the pressure at inlet reaches to setting pressure, the pilot poppet which is in the main relief valve is opened by pressure. At this condition the flow divert from the pump directly to the outlet tank.



22B7HS10

4) LIFT SECTION

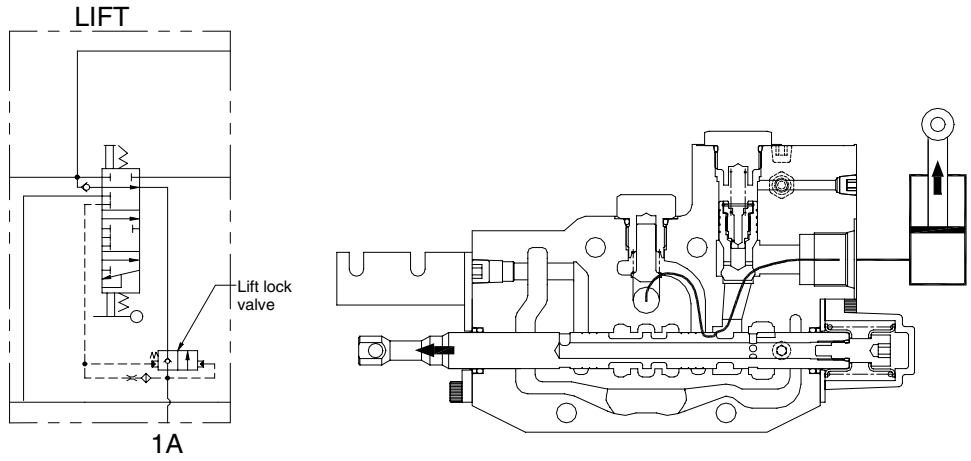
(1) Operation

The lift section has a single work port to direct flow to the lift cylinder. Only one work port is used, because the lift cylinder is single-acting (gravity returns the mast to the lowered position).

The lift section also contains part of the components which comprise the safety features. There is a lift lock check valve. At the neutral position, pressures in the lock valve are equalized across the lift lock poppet. In this manner, the spring bias keeps the lift lock valve closed and prevents lowering of the mast.

① Lifting

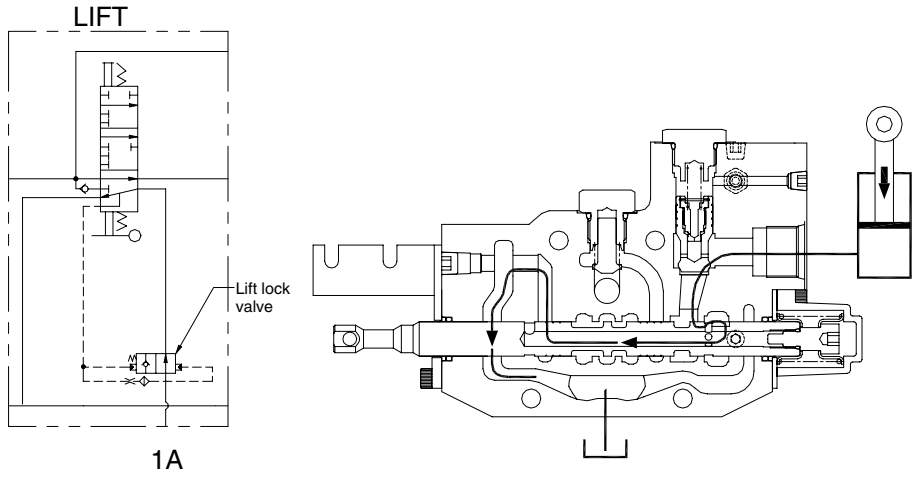
When the operator shifts the lever backwards, the spool is extended out of the valve, and this opens the internal fluid passages that lift the mast. Oil flows through the high pressure parallel cavity, past the load check valve, through the spool metering notches, past the lift lock check valve, and to the head side of the lift cylinder.



BR7HS11S

② Lowering

When the seated operator shifts the lever forwards, the spool retracts into the valve, and the oil is directed from the cylinder, past the lift lock check valve, past the spool metering notches, and to the common tank cavity.



BR7HS12S

Pressure is limited by the main relief valve.

5) TILT SECTION

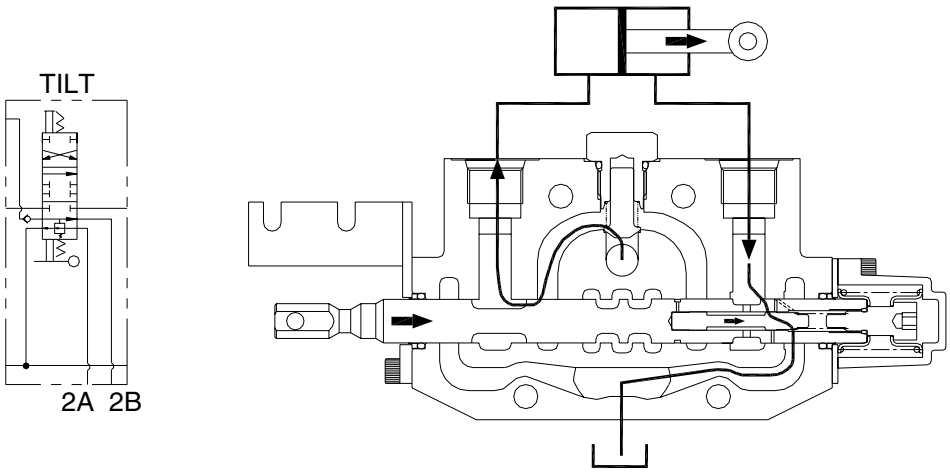
(1) Operation

The tilt spool contains an internal plunger which acts to stop tilt forward actuation when the battery power is off.

① Tilt forward

When the seated operator shifts the lever forward, pressure is applied to the head of the tilt cylinder, and the forks tilt forward. Oil is directed from the high pressure parallel passage past the load check valve, past the spool metering notches, and towards the cylinder head.

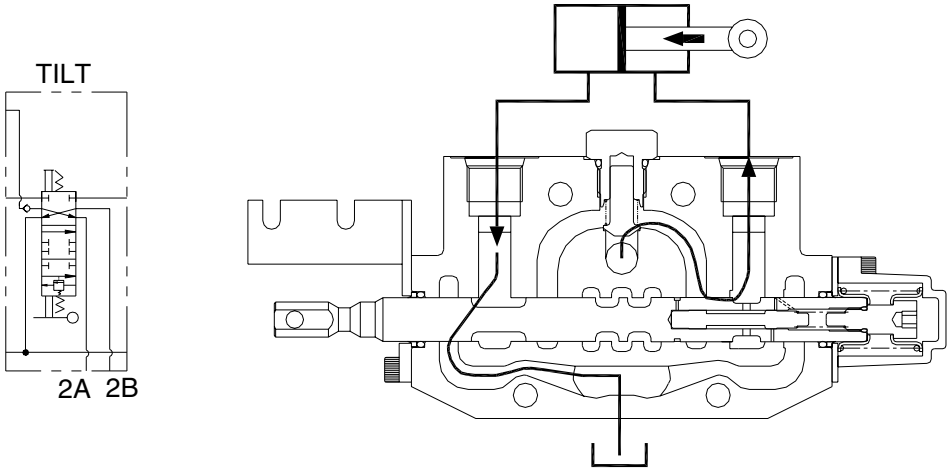
Simultaneously, the high pressure acts upon the end of the tilt lock plunger to move it towards the spring end of the spool. This plunger movement opens additional spool metering notches which control oil flow from the rod end of the cylinder to the tank return line.



22B7HS13

② Tilt back

When the seated operator shifts the lever back, the high pressure oil from the parallel passage is directed past the load check valve, past the spool metering notches, and to the rod side of the cylinder. Exhaust oil from the head side of the cylinder is directed past the spool metering notches to tank.



22B7HS14

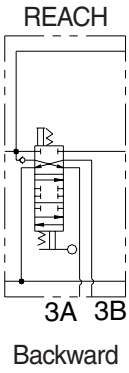
Pressure is limited by the main relief valve.

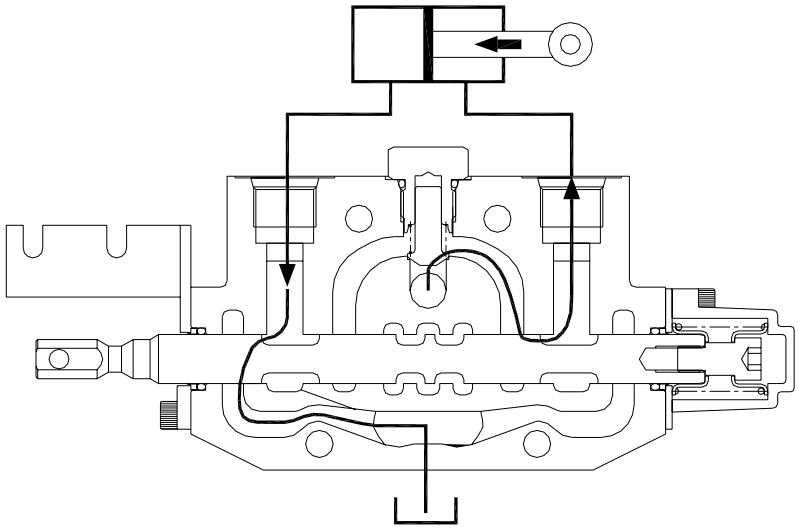
6) REACH SECTIONS

(1) Operation

① Reach back

When the seated operator shifts the lever back, the high pressure oil from the parallel passage is directed past the load check valve, past the spool metering notches, and to the rod side of the cylinder. Exhaust oil from the head side of the cylinder is directed past the spool metering notches to tank.

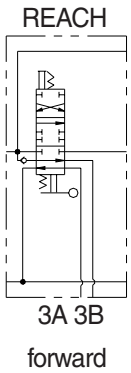


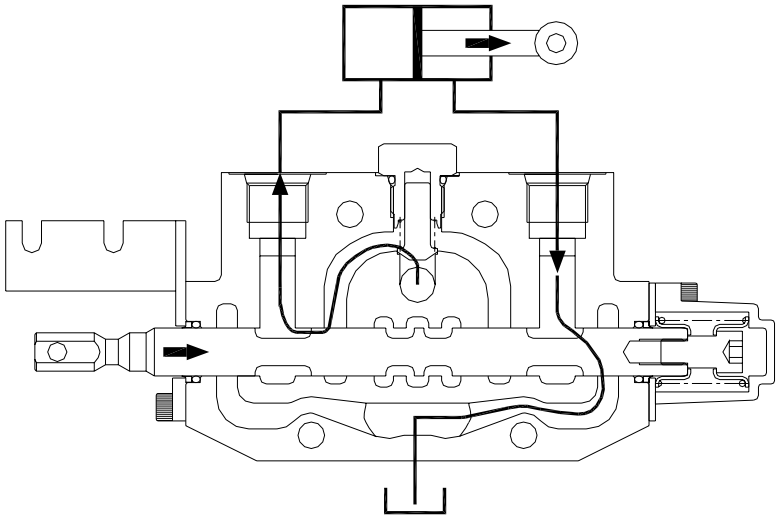


BR7HS15R

② Reach forward

When the seated operator shifts the lever forward, pressure is applied to the head of the reach cylinder, and the forks tilt forward. Oil is directed from the high pressure parallel passage past the load check valve, past the spool metering notches, and towards the cylinder head.





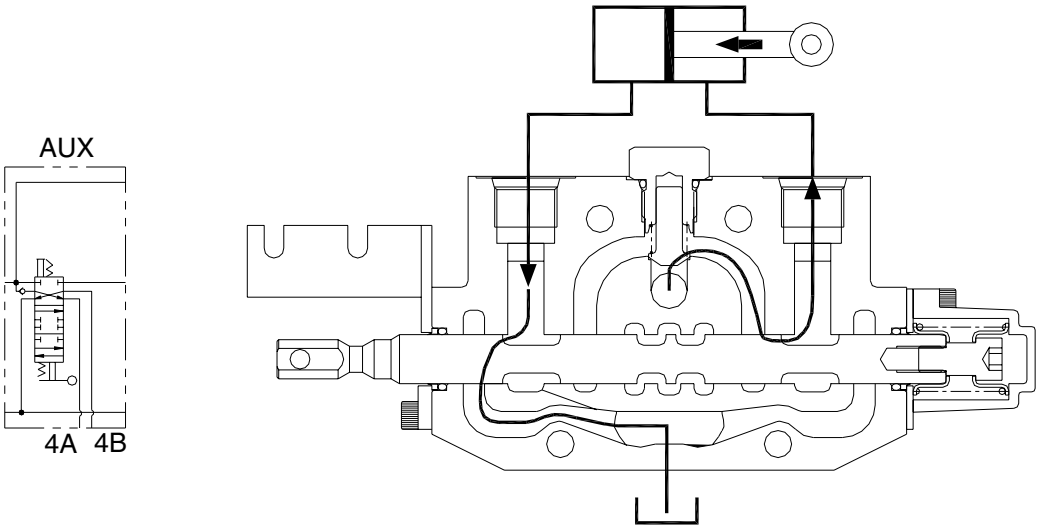
BR7HS16R

Pressure is limited by the main relief valve.

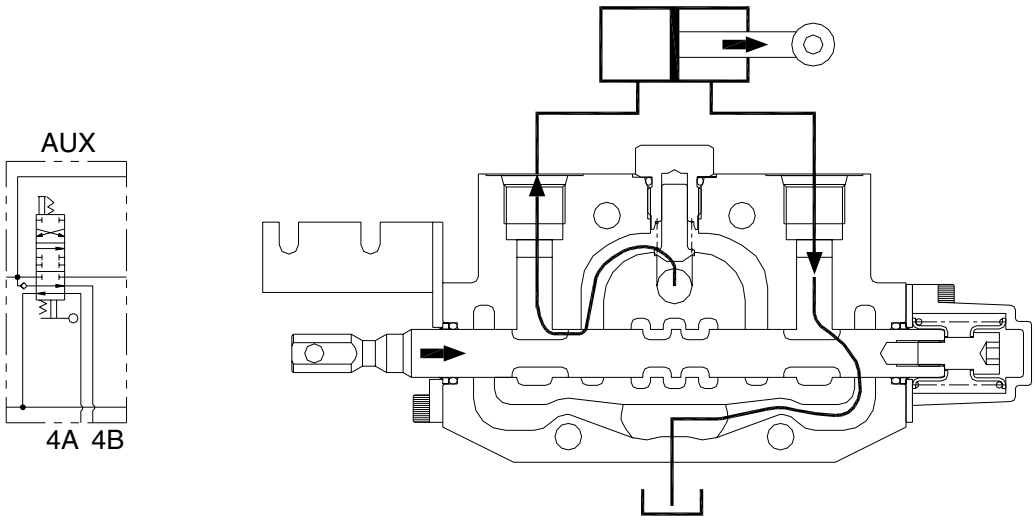
7) AUXILIARY SECTION

(1) Operation

Many different functions can be controlled by the auxiliary spool sections. In general, one work port is pressurized by high pressure oil from the parallel passage, past the load check valve, past the metering notches, and to the cylinder. Simultaneously, oil from the other work port is directed across the spool metering notches to tank.



BR7HS15



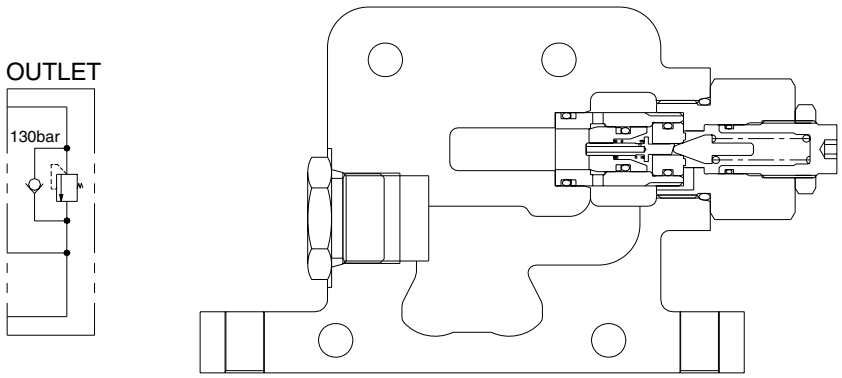
BR7HS16

Pressure is limited by the secondary main relief valve.

8) OUTLET SECTION

(1) Operation

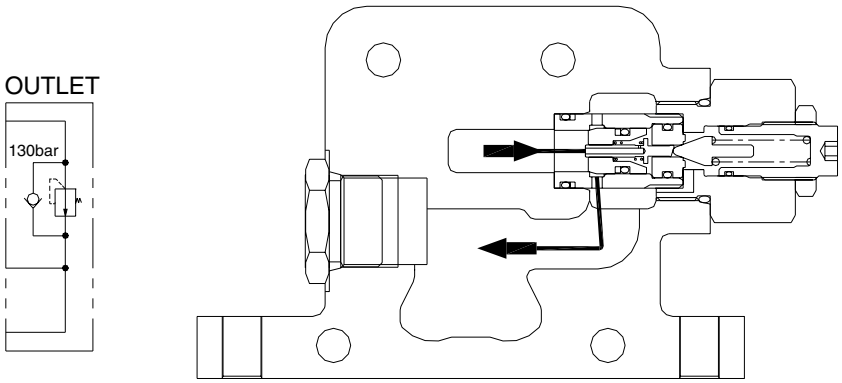
The outlet section contains the tank port and the secondary relief valve (with built-in anti-cavitation feature).



22B7HS17

(2) Operation of relief valve at setting pressure

When the pressure at outlet reaches to setting pressure, the pilot poppet which is in the main relief valve is opened by pressure. At this condition the flow divert from the pump directly to the tank line.

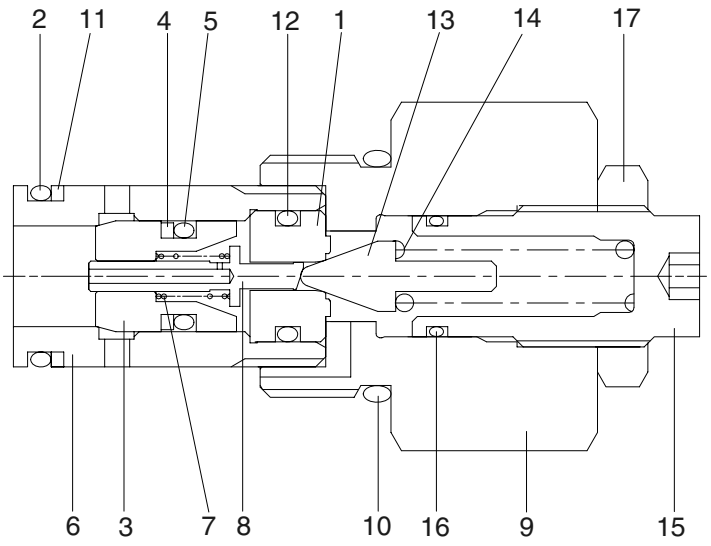


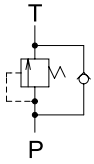
22B7HS18

9) MAIN RELIEF VALVE

This valve is a type of pilot piston to prevent hydraulic components and pipes from being broken by high pressure so, it keeps under pressure limited.

Relief valve pressure varies by 130 kgf/cm^2 in accordance with 1 revolution of adjust bolt.





· Main relief valve : 190 kgf/cm^2

· Secondary main relief valve : 130 kgf/cm^2
(For 4 spool only)

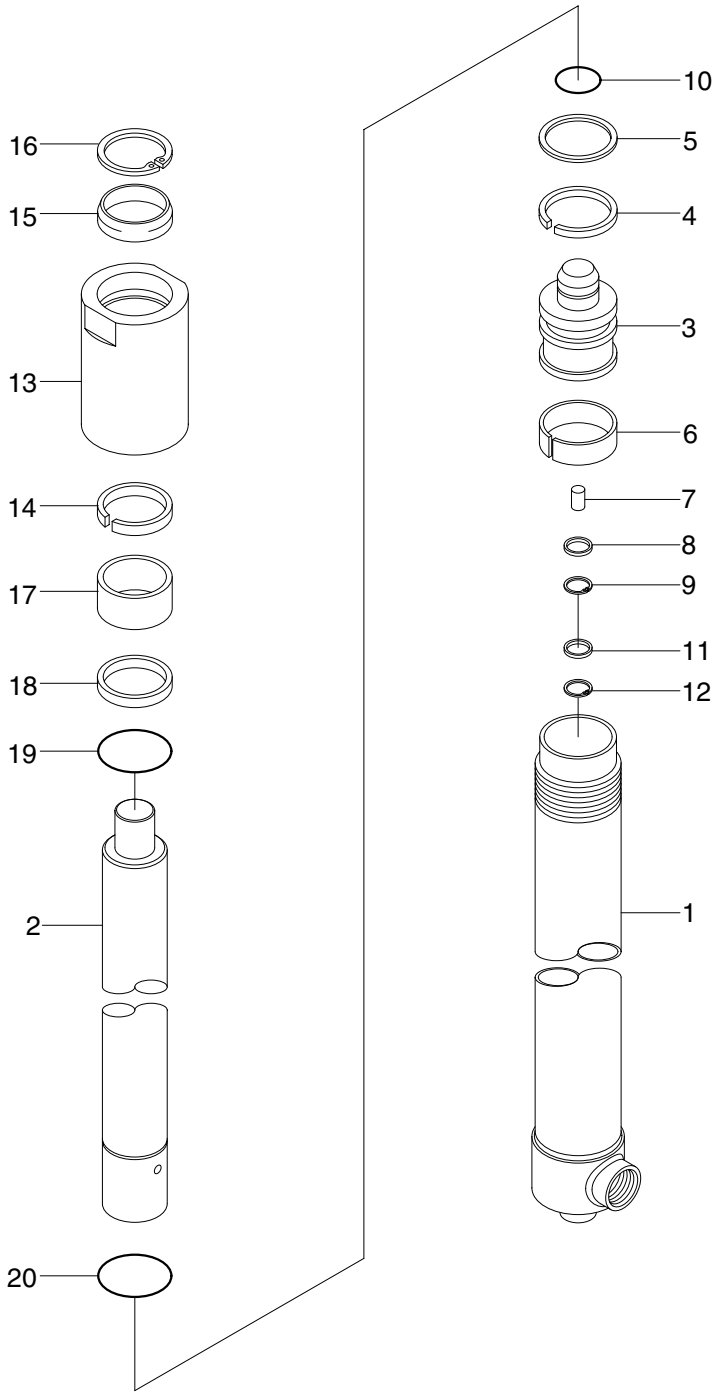
· NOTE : 1) Max. pressure of relief valve : 250 kgf/cm^2
2) Used pressure of hyd control valve : 190 kgf/cm^2

15BR9EHS20A

1	Pilot seat	7	Main spring	13	Pilot poppet
2	O-ring	8	Piston	14	Pilot spring
3	Main poppet	9	Body	15	Adjust screw
4	Back up ring	10	O-ring	16	O-ring
5	O-ring	11	Back up ring	17	Lock nut
6	Socket	12	O-ring		

4. LIFT CYLINDER

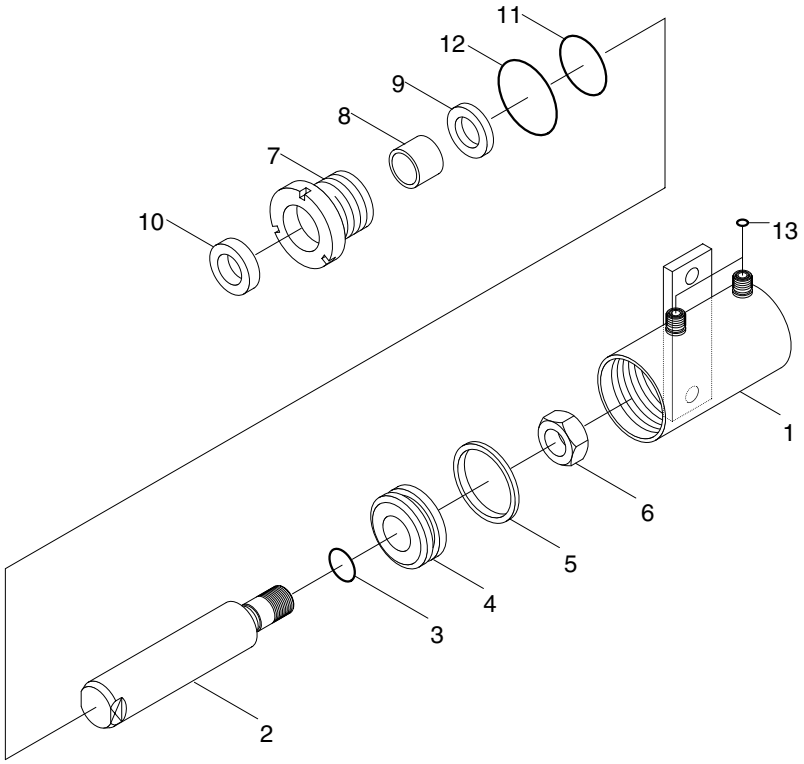
1) V-MAST



18BR9HS33

1	Tube assy	8	Spacer	15	Dust wiper
2	Rod	9	Retaining ring	16	Retaining ring
3	Piston	10	Stop ring	17	Rod bush
4	U-packing	11	Cushion seal	18	Spacer
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		

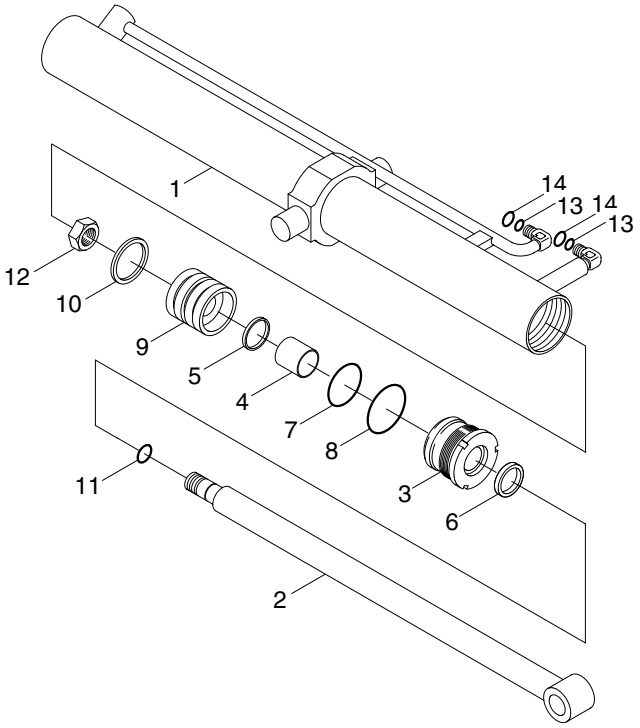
5. TILT CYLINDER



15BR9EHS19

1	Tube assembly	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		

6. REACH CYLINDER

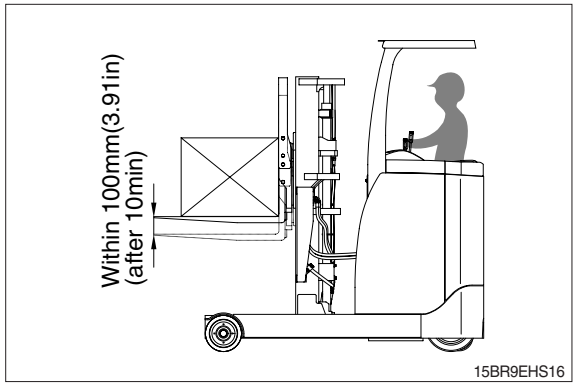


15BR9EHS14

1	Tube assembly	6	Dust wiper	11	O-ring
2	Rod assembly	7	O-ring	12	Nylon hex nut
3	Rod cover	8	O-ring	13	O-ring
4	Rod bush	9	Piston	14	O-ring
5	U packing	10	Piston seal		

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS



1) CHECK ITEM

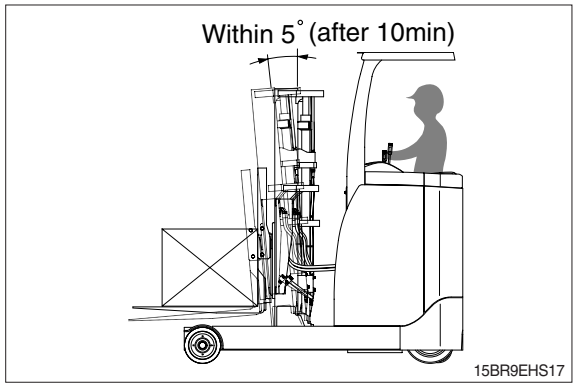
(1) Check visually for deformation, cracks or damage of rod.

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

· **Hydraulic drift**

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

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

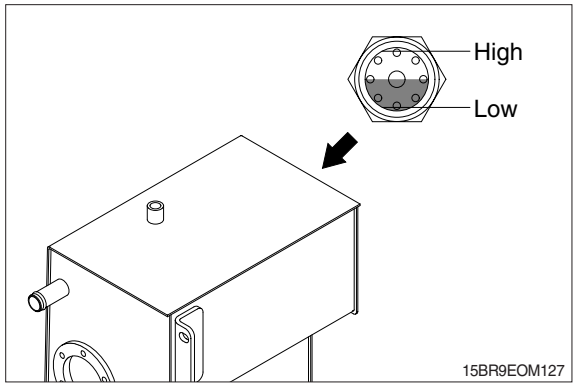


(3) Check that clearance between tilt cylinder bushing and mounting pin is within standard range.

mm (in)

Standard	Under 0.6 (0.02)

2) CHECK AND SUPPLY HYDRAULIC OIL



Check the hydraulic sump tank fluid level. Correct fluid level is important for proper system operation. Low fluid level can cause pump damage.

Hydraulic fluid expands as its temperature rises. Therefore, it is preferable to check the fluid level at operating temperature (after approximately 30 minutes of truck operation).

To check the fluid level, first park the truck on a level surface and apply the parking brake.

Put the mast upright in a vertical position and lower the fork carriage fully down. Check the hydraulic oil level. Keep the oil level above the LOW mark by adding recommended hydraulic fluid only, as required . **Do not overfill**.

Check the condition of the hydraulic fluid (age, color or clarity, contamination). Change (replace) the oil as necessary.

3) CONTROL VALVE

(1) Raise forks to maximum height and measure oil pressure. Check that oil pressure.

· 15BR-9E : 190 kgf/cm^2 (2700 psi)

2. TROUBLESHOOTING

1) SYSTEM

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

2) HYDRAULIC GEAR PUMP

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

3) MAIN RELIEF VALVE

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

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

- Loosen lock nut.
- Set adjusting nut to desired pressure setting.
- If desired pressure setting cannot be achieved, tighten or loosen the adjusting screw 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 suface of tube. · Foreign matters in piston seal.	· Smooth rod surface with an oil stone. · Replace cylinder tube. · Replace piston seal.
Wear (clearance between cylinder tube and wear ring)	· Excessive clearance between cylinder tube and wear ring.	· Replace wear ring.
Abnormal noise is produced during tilting operation	· Insufficient lubrication of anchor pin or worn bushing and pin. · Bent tilt cylinder rod.	· Lubricate or replace. · Replace.

GROUP 3 DISASSEMBLY AND ASSEMBLY

1. HYDRAULIC GEAR PUMP

※ **Tools required**

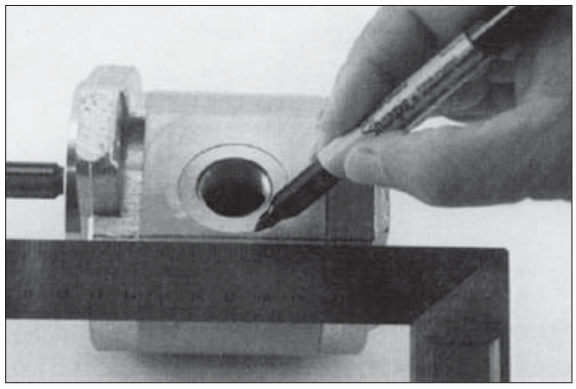
- Metric socket set
- Internal snap ring pliers
- Shaft seal sleeve
- Torque wrench

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

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

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

(4) Remove key from drive shaft if applicable.

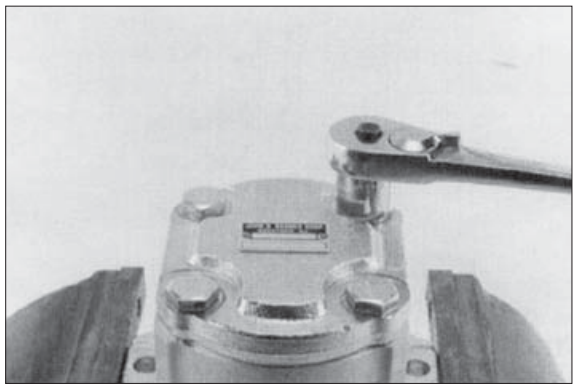


PUMP 01

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

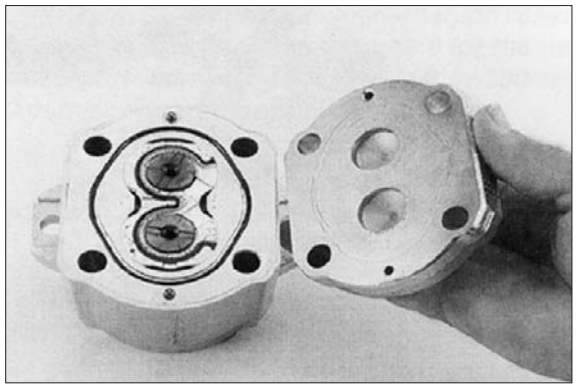
(6) Loosen the four metric hexagon head bolts.

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



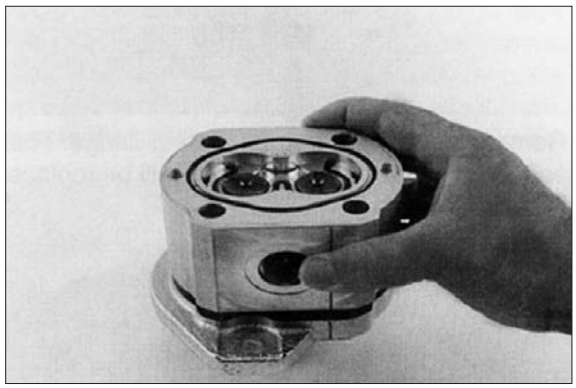
PUMP 02

(8) Lift and remove end cover.



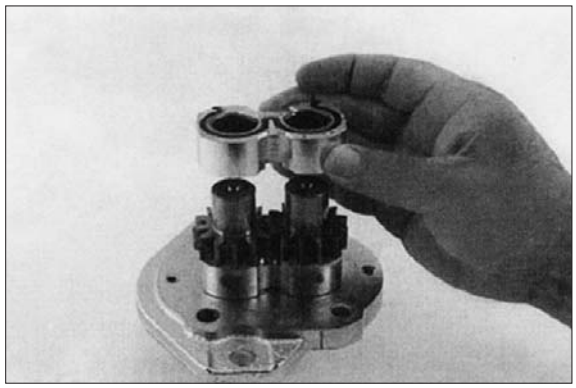
PUMP 03

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



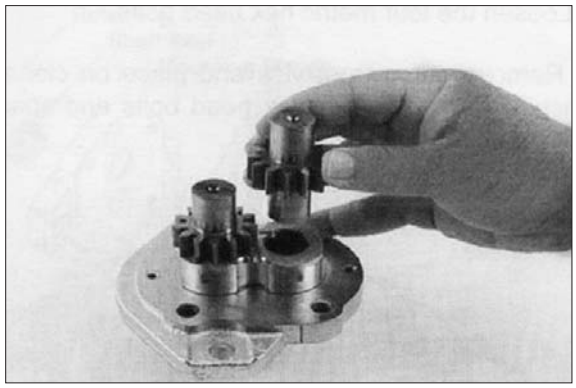
PUMP 04

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



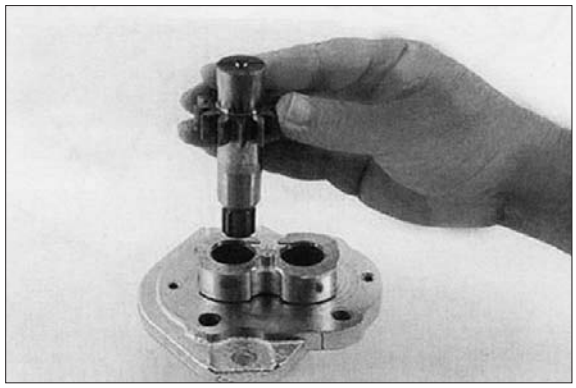
PUMP 05

(11) Remove idler shaft from bearing block.



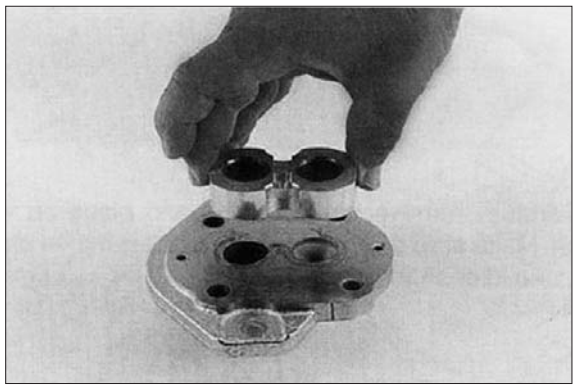
PUMP 06

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



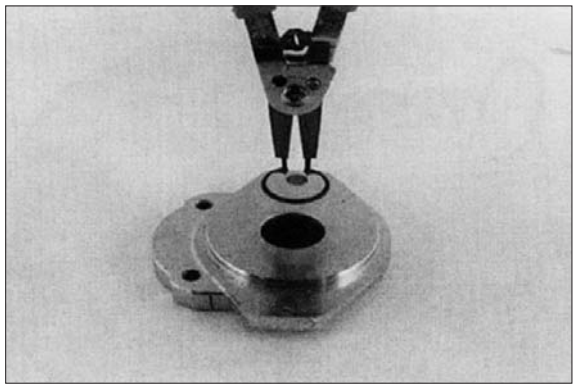
PUMP 07

(13) Remove the front bearing block.



PUMP 08

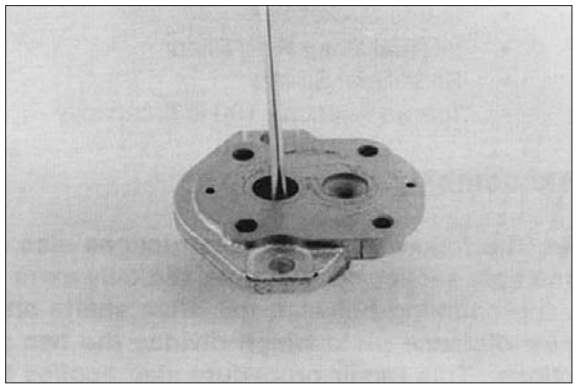
(14) Turn mounting flange over, with shaft seal up, and remove the retaining ring with proper snap ring pliers.



PUMP 09

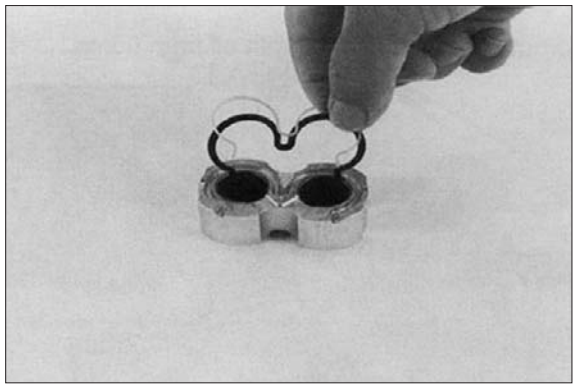
(15) Remove the oil seal from mounting flange, be careful not to mar or scratch the seal bore.

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



PUMP 10

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



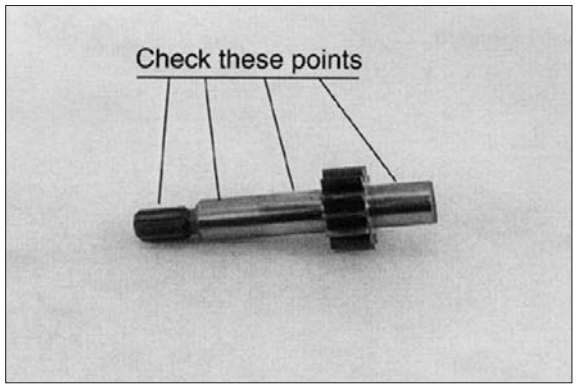
PUMP 11

2) INSPECT PARTS FOR WEAR

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

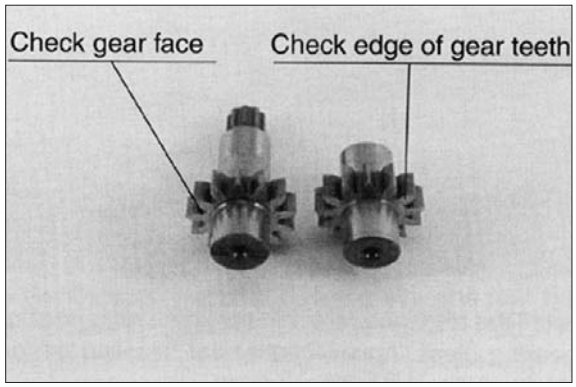
(2) Check drive shaft spline for twisted or broken teeth, check keyed drive shaft for broken or chipped keyway. No marks or grooves on shaft in seal area, some discoloration of shaft is allowable.

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



PUMP 12

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



PUMP 13

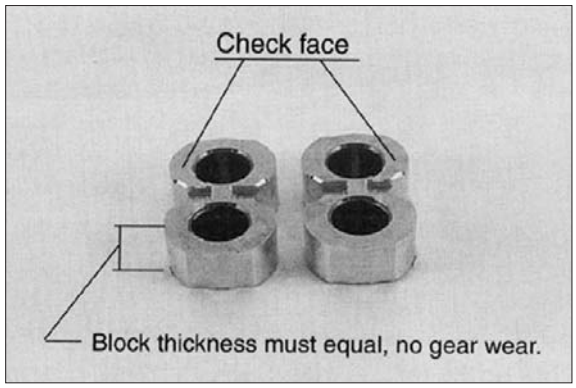
(5) Inspect bearing blocks for excessive wear or scoring on the surfaces which are in contact with the gears. Also inspect the bearings for excessive wear or scoring.

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

※ **General information**

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

※ **This pump is not bi-rotational.**

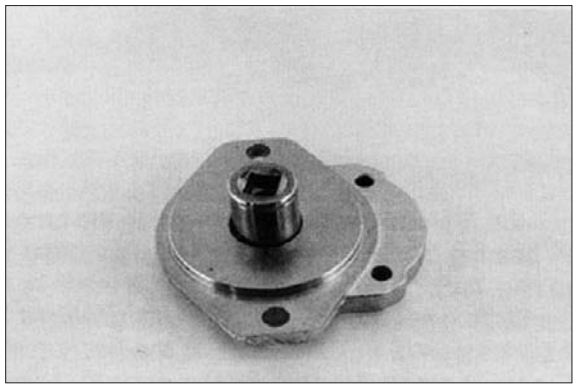


PUMP 14

3) ASSEMBLY

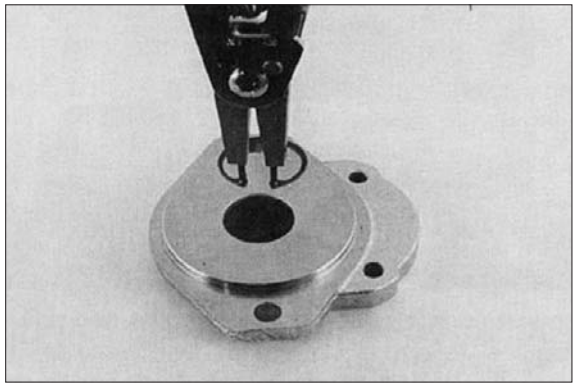
※ **New seals should be installed upon reassembly of pump.**

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



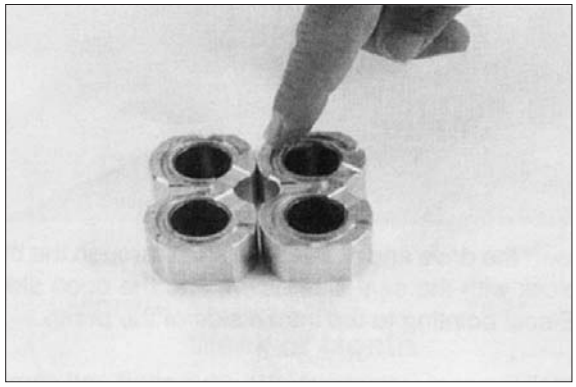
PUMP 15

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



PUMP 16

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

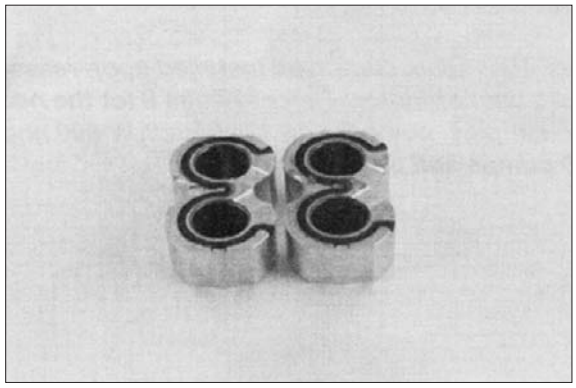


PUMP 17

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

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

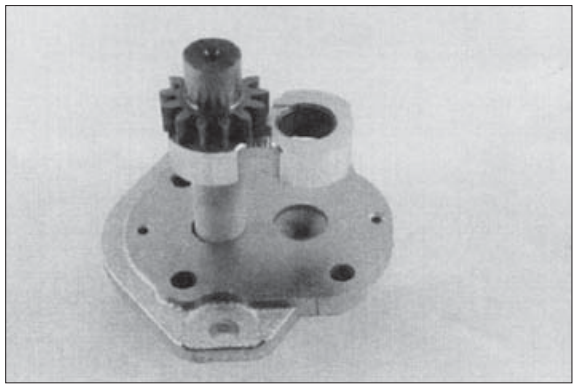
(6) Apply a light coating of petroleum jelly to the exposed face of the front bearing block.



PUMP 18

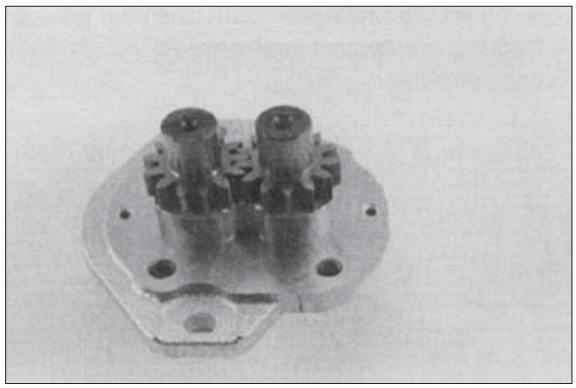
(7) Insert the drive end of the drive shaft through the bearing block with the seal side down, and the open side of the E-seal pointing to the intake side of the pump.

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



PUMP 19

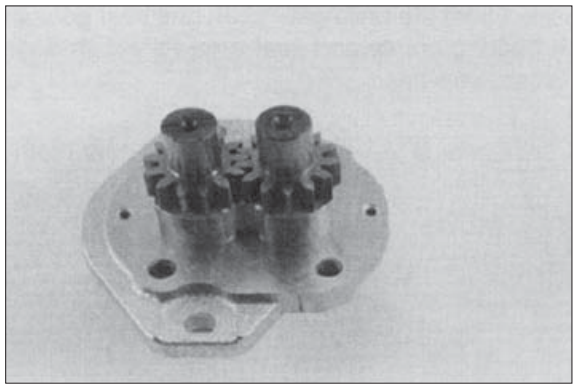
(9) Install the idler gear shaft in the remaining position in the bearing block. Apply a light coat of clean oil to the face of the drive and idler gears.



PUMP 20

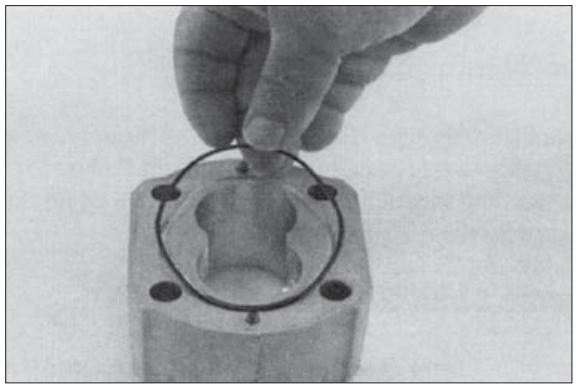
(10) Pick up the rear bearing block, with seal side up and with open end of the E-seal facing the intake side of the pump, place over the drive and idler gear shafts.

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



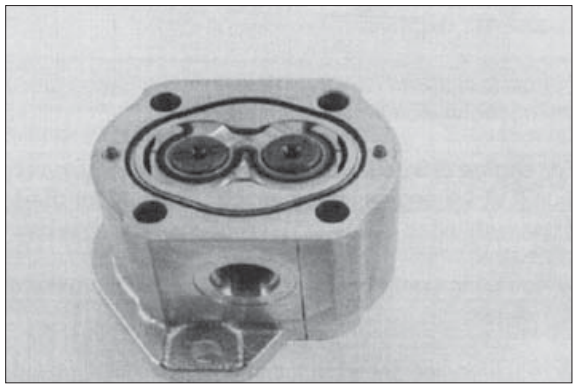
PUMP 21

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



PUMP 22

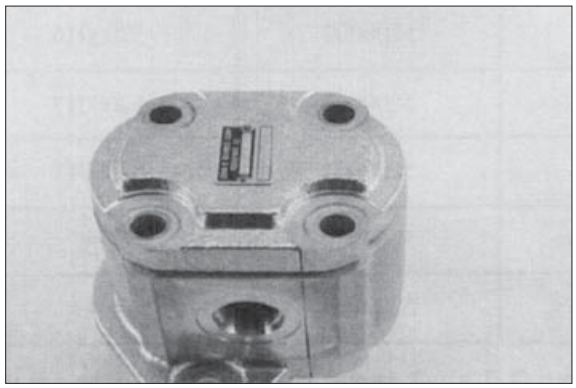
(13) Gently slide the gear housing over the rear bearing block assembly, slide housing down until the housing engages the dowel pins. Press firmly in place with hands, do not force or use any tool.
Check to make sure the intake port in the housing in on the same side as the open end of the E-seal and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



PUMP 23

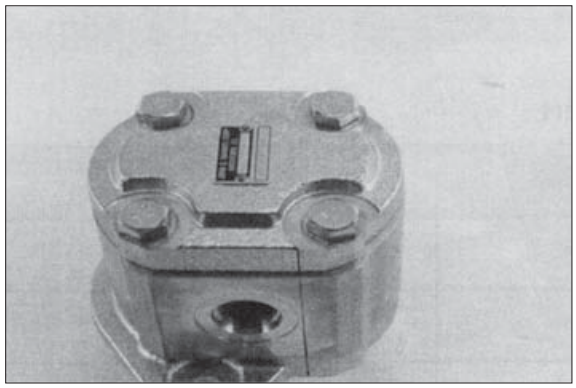
(14) The surface of the rear bearing block should be slightly below the face of the gear housing. If the bearing block sits higher then the rear face of the gear housing then the E-seal or O-ring have shifted out of the groove. If this is the case, remove the gear housing and check for proper seal installation.

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



PUMP 24

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



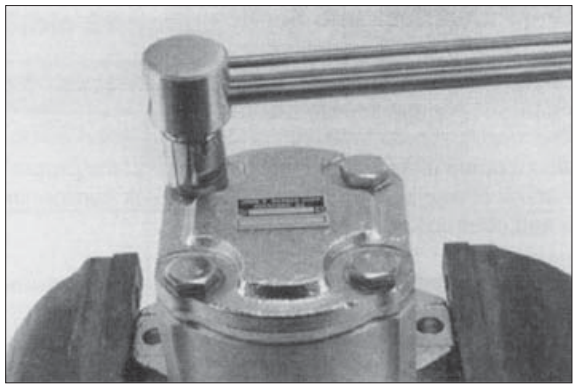
PUMP 25

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

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

(18) Remove pump from vise.

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



PUMP 26

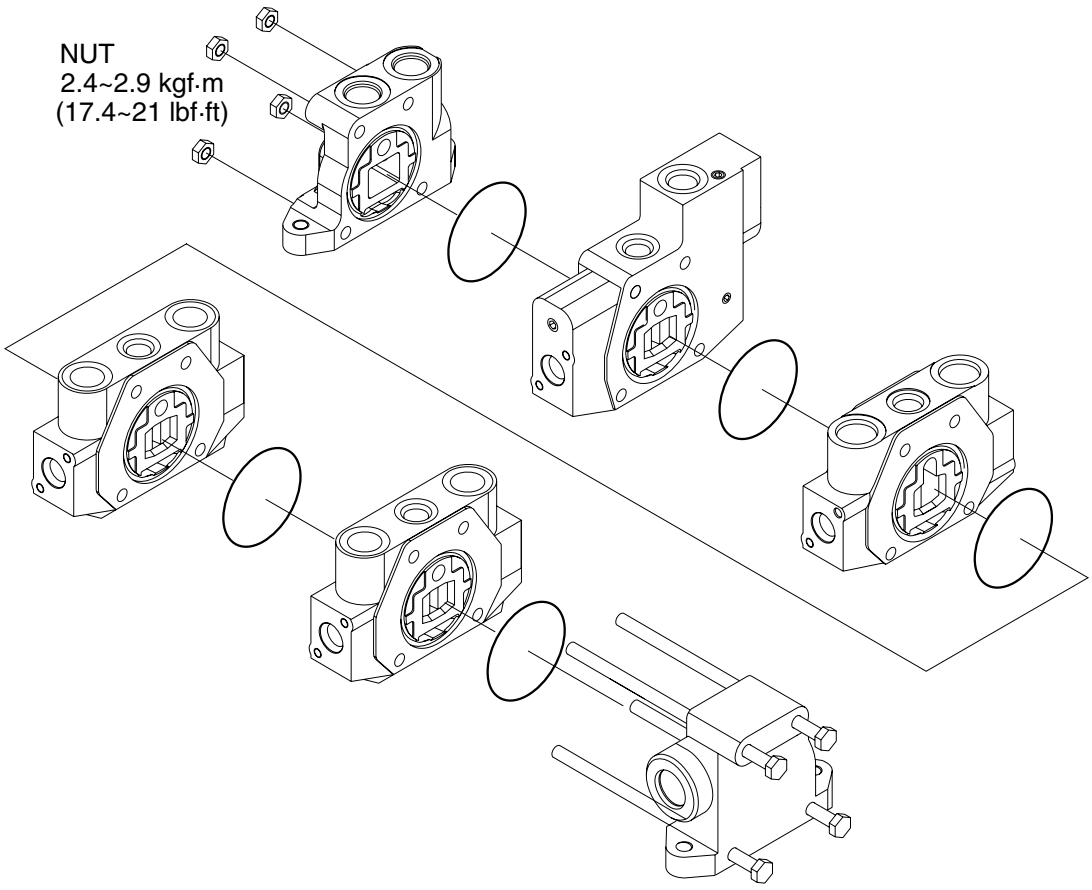
2. MAIN CONTROL VALVE

1) ASSEMBLY

(1) General

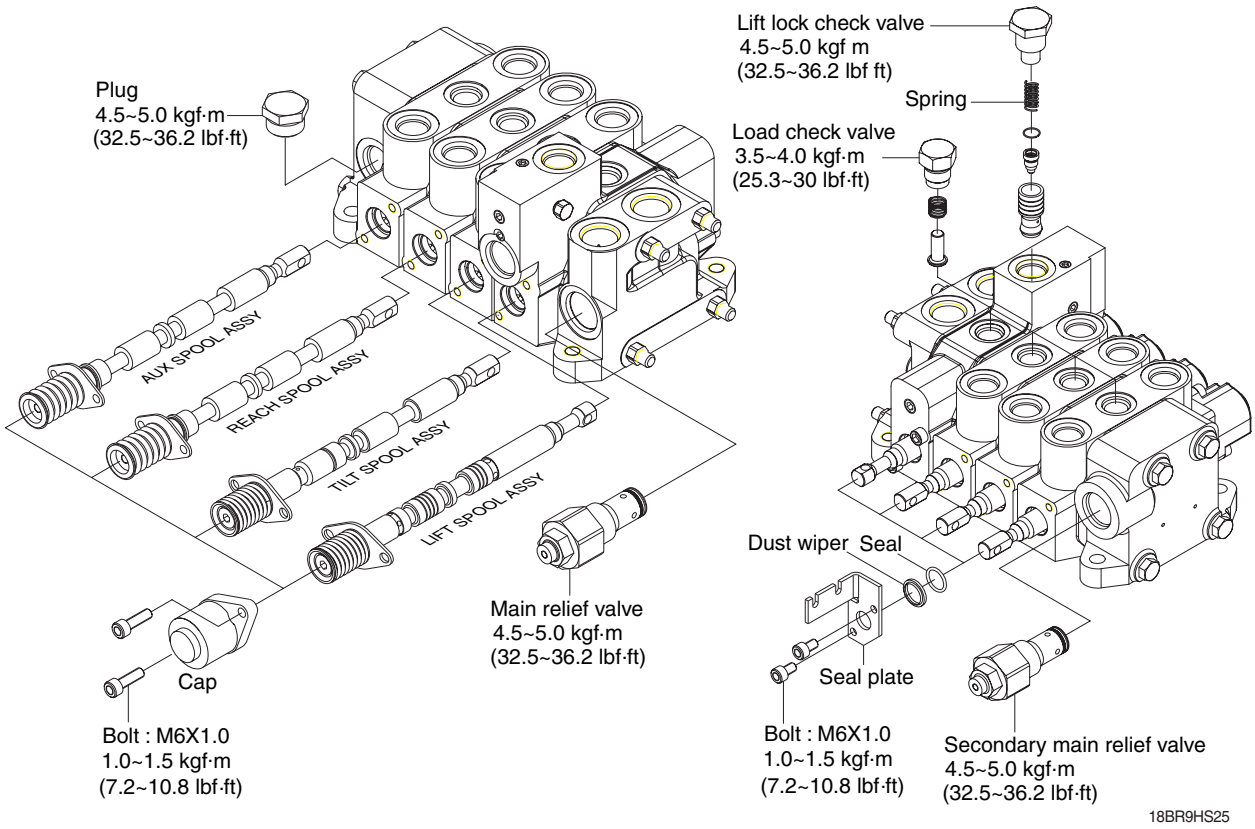
① Ensure that the assembly area will be clean and free of contamination.
② Use a flat (within 0.2 ㎜) work surface when bolting the valve sections together.
③ Use calibrated torque wrenches and instrumentation.
④ The formal Bills of Material, descriptions, and views are found in the attached documentation.
⑤ Additional auxiliary valve sections may be added to the main control valve in a similar manner as indicated below, as approved by the O.E.M.

(2) Block subassembly



22B7HS21

① Attach all the O-rings to the appropriate grooves between the spool sections.
② Stack the valve sections such that all the work ports are facing up, the spool ends are all in the same direction, and they are resting on a flat (within 0.2 ㎜), uniform surface.
③ Insert all the tie rods through the drilled holes in each of the housings.
④ Press the sections together, being carefully not to damage sealing surfaces or seals.
⑤ Install nuts to both ends of all tie rods and progressively torque in a circular pattern until reaching a torque of 2.4~2.9 ㎏f · ㎞ (17.4~21 lbf · ft) on all tie rods. Periodically, make sure that the valve remains flat while applying torque.



(3) Inlet section

① Install the main relief valve assembly into the lower side cavity of the inlet section, as illustrated. Torque to 4.5~5.0 kgf · m (32.5~36.2 lbf · ft).

② Install the plug assembly in the tank port of the inlet section.
Torque to 4.5~5.0 kgf · m (32.5~36.2 lbf · ft)

(4) Lift section

① The spool assembly should already consist of the lift spool, the return spring, one spring seat on either end of the spring, the seal plate, a spool seal, and a dust wiper. All of these are assembled on the end of the spool opposite the clevis.

② Insert the clevis end of the spool into the right-hand side of the spool bore(the tallest end of the housing). Place the spool cap over the spool and spring assembly and connect the cap to the housing using two bolts. Torque both bolts alternatively until a torque of 1.0~1.5 kgf · m (7.2~10.8 lbf · ft) is reached on both bolts.

③ Install the second spool seal and dust wiper over the clevis end of the spool and retain with a seal plate and two bolts. Torque both bolts alternatively until a torque of 1.0~1.5 kgf · m (7.2~10.8 lbf · ft) is reached on both bolts.

④ The load check assembly is inserted into the top center cavity. Torque to 3.5~4.0 kgf · m (25.3~30 lbf · ft)

⑤ Install the lift lock check valve assembly in the remaining open cavity in the top of the housing. Torque to 4.5~5.0 kgf · m (32.5~36.2 lbf · ft)

(5) Tilt section

① The spool assembly should already consist of the tilt spool(with tilt plunger and spring inserted into the bore on the spring end), the return spring, one spring seat on either end of the spring, the seal plate, a spool seal, and a dust wiper. All of these are assembled on the end of the spool opposite the clevis.

② Insert the clevis end of the spool into the right-hand side of the spool bore(the tallest end of the housing). Place the spool cap over the spool and spring assembly and connect the cap to the housing using two bolts. Torque both bolts alternatively until a torque of 1.0~1.5 kgf · m (7.2~10.8 lbf · ft) is reached on both bolts.

③ Install the second spool seal and dust wiper over the clevis end of the spool and retain with a seal plate and two bolts. Torque both bolts alternatively until a torque of 1.0~1.5 kgf · m (7.2~10.8 lbf · ft) is reached on both bolts.

④ The load check assembly is inserted into the top center cavity.
Torque to 3.5~4.0 kgf · m (25.3~30 lbf · ft).

⑤ Install the anti-cavitation check valve in the housing cavity on the clevis end directly above the spool assembly. Torque to 4.5~5.0 kgf · m (32.5~36.2 lbf · ft).

⑥ Install the plug in the housing cavity above the spool assembly.
Torque to 3.5~4.0kgf · m (25.3~30 lbf · ft).

(6) Reach section

※ Same procedure for all aux sections, but spool assembly components may vary.

① The spool assembly should already consist of the proper reach spool, the return spring, one spring seat on either end of the spring, the seal plate, a spool seal, and a dust wiper. All of these are assembled on the end of the spool opposite the clevis.

② Insert the clevis end of the spool into the right-hand side of the spool bore (the tallest end of the housing). Place the spool cap over the spool and spring assembly and connect the cap to the housing using two bolts. Torque both bolts alternatively until a torque of 1.0~1.5 kgf · m (7.2~10.8 lbf · ft) is reached on both bolts.

③ Install the second spool seal and dust wiper over the clevis end of the spool and retain with a seal plate and two bolts. Torque both bolts alternatively until a torque of 1.0~1.5 kgf · m (7.2~10.8 lbf · ft) is reached on both bolts.

④ The load check assembly is inserted into the top center cavity.
Torque to 3.5~4.0kgf · m (25.3~30lbf · ft).

(7) Auxiliary section

※ Same procedure for all aux sections, but spool assembly components may vary.

① The spool assembly should already consist of the proper aux spool, the return spring, one spring seat on either end of the spring, the seal plate, a spool seal, and a dust wiper. All of these are assembled on the end of the spool opposite the clevis.

② Insert the clevis end of the spool into the right-hand side of the spool bore(the tallest end of the housing). Place the spool cap over the spool and spring assembly and connect the cap to the housing using two bolts. Torque both bolts alternatively until a torque of 1.0~1.5 kgf · m (7.2~10.8 lbf · ft) is reached on both bolts.

③ Install the second spool seal and dust wiper over the clevis end of the spool and retain with a seal plate and two bolts. Torque both bolts alternatively until a torque of 1.0~1.5 kgf · m (7.2~10.8 lbf · ft) is reached on both bolts.

④ The load check assembly is inserted into the top center cavity.
Torque to 3.5~4.0 kgf · m (25.3~30lbf · ft).

(8) Outlet section

① Install the secondary main relief valve into the cavity on the clevis end of the housing.
Torque to 4.5~5.0 kgf · m (32.5~36.2 lbf · ft)

2) DISASSEMBLY

(1) General

① Subassemblies (such as relief valves, check valves, and spools) may be removed without having to loosen the tie rods and disassembling the entire valve.

② Disassemble the valve sections on a flat working surface.

③ Ensure that the disassembly area will be clean and free of contamination.

④ Keep the disassembly area neat to avoid loss or damage of parts.

(2) Disassembly

① Loosen the tie rod nuts and remove the tie rods from the valve sections.

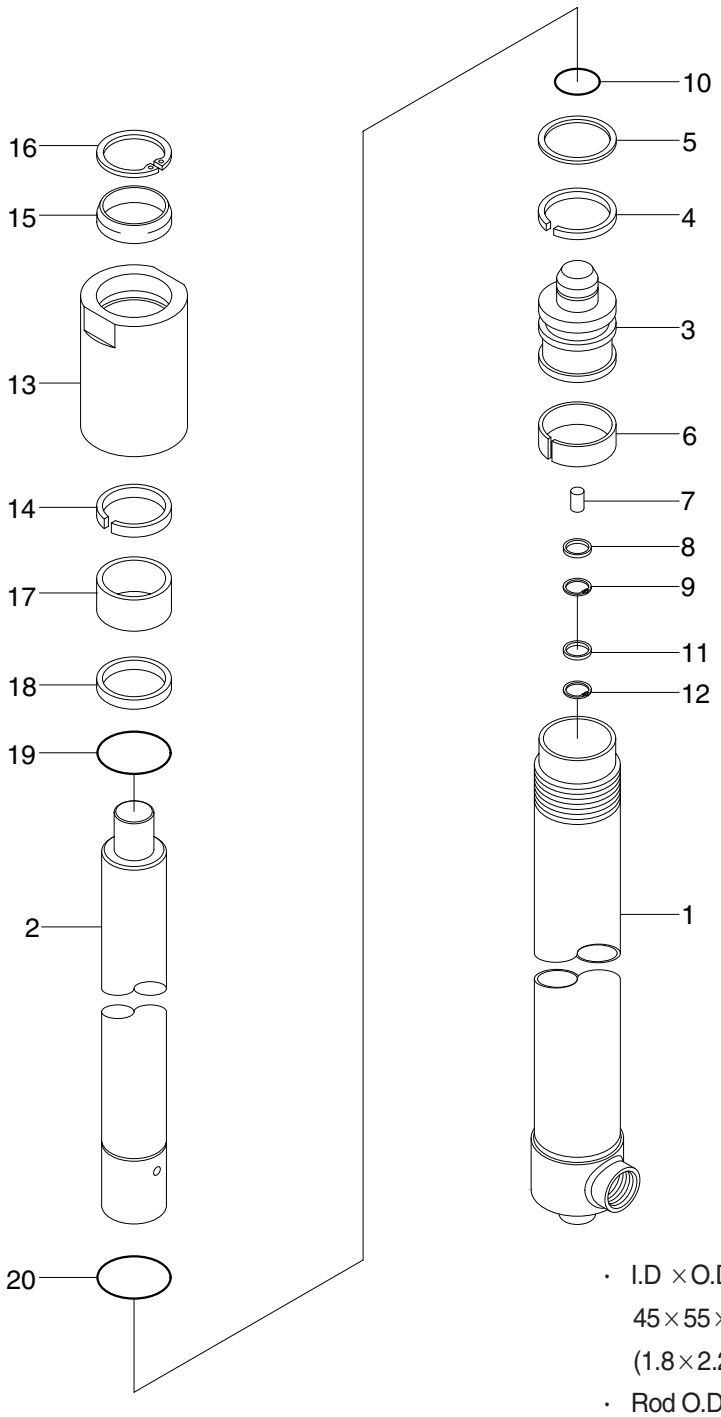
② Remove O-rings between valve sections and set aside to avoid damage.

③ Spools, relief valves, load check valves, lift lock poppet, solenoid valves, and plugs can all be removed from the valve sections. Refer to the associated assembly procedures, above, for specific torque and handling details. Inspect and repair or replace the assemblies as complete units, as may be necessary.

④ Valve components are precision items, and care must be taken when handing them to avoid damage or the introduction of contamination that could adversely affect performance.

3. LIFT CYLINDER

1) STRUCTURE



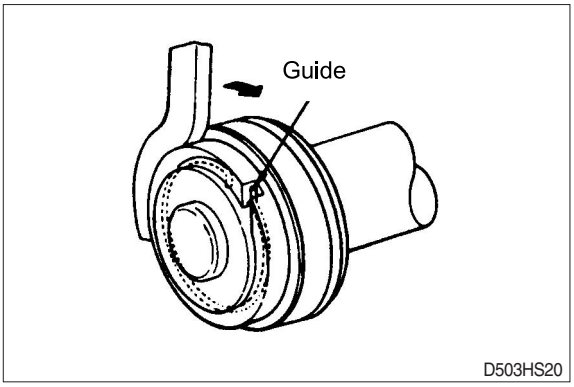
- I.D × O.D × Stroke (standard)
  45 × 55 × 1645 mm
  (1.8 × 2.2 × 65 in)
- Rod O.D : 35 mm (1.4 in)

18BR9HS33

1	Tube assy	8	Spacer	15	Dust wiper
2	Rod	9	Retaining ring	16	Retaining ring
3	Piston	10	Stop ring	17	Rod bush
4	U-packing	11	Cushion seal	18	Spacer
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		

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.



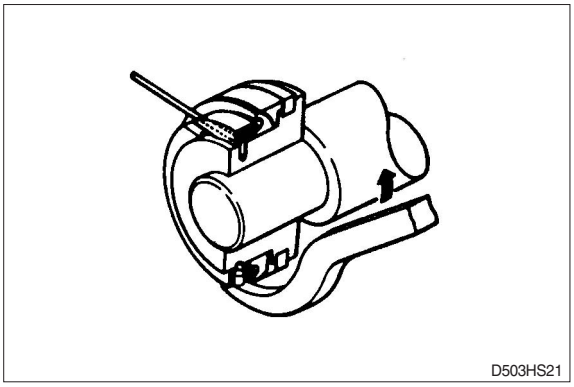
3) CHECK AND INSPECTION

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

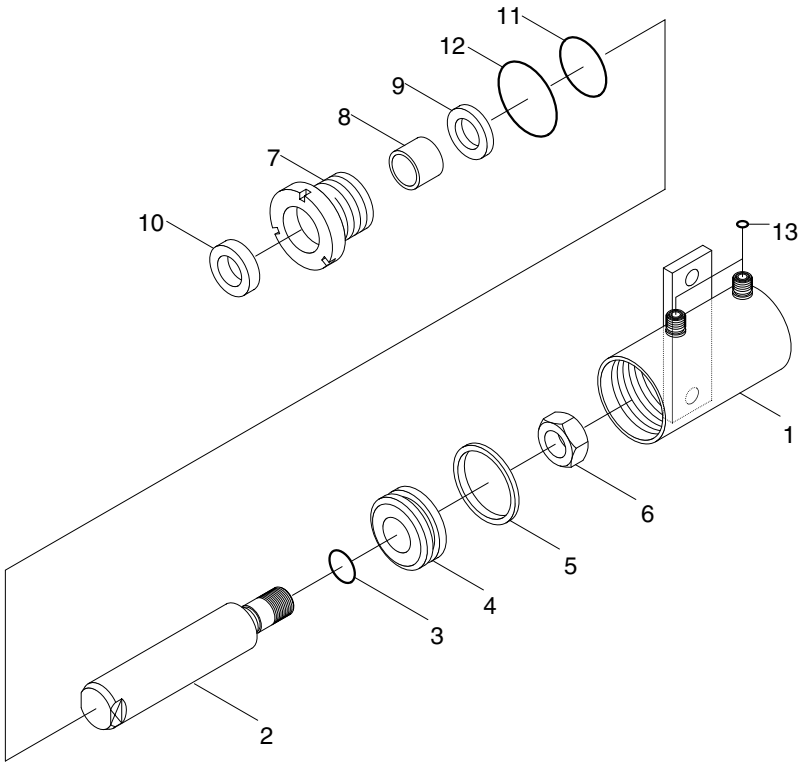
4) ASSEMBLY

(1) Soak the piston ring in hydraulic oil at a temperature of 40 to 50℃, 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

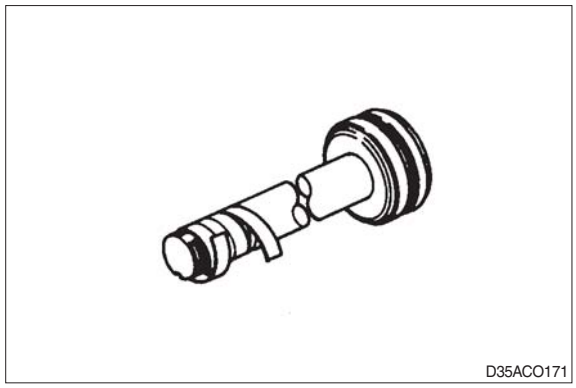


15BR9EHS19

1	Tube assembly	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) DISASSEMBLY

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



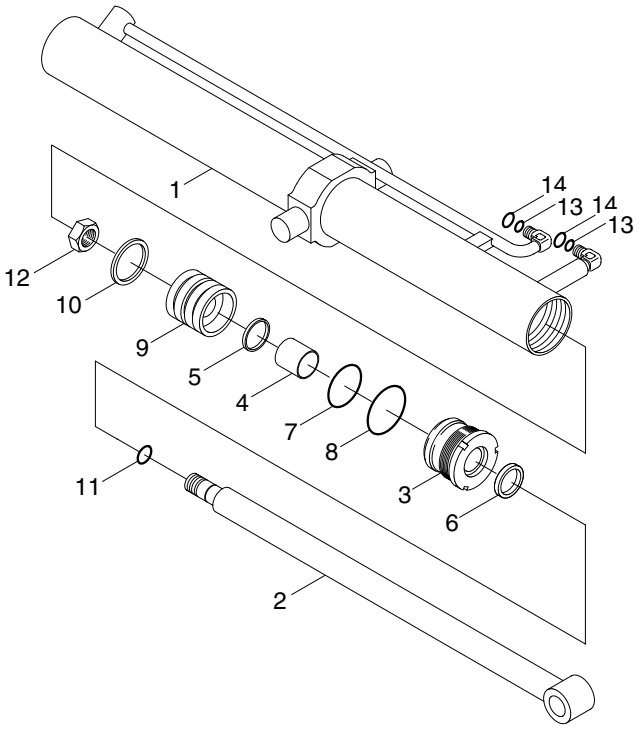
3) CHECK AND INSPECTION

mm (in)

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

5. REACH CYLINDER

1) STRUCTURE

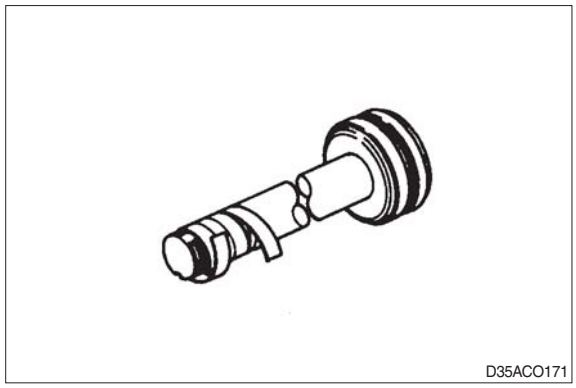


15BR9EHS14

1	Tube assembly	6	Dust wiper	11	O-ring
2	Rod assembly	7	O-ring	12	Nylon hex nut
3	Rod cover	8	O-ring	13	O-ring
4	Rod bush	9	Piston	14	O-ring
5	U packing	10	Piston seal		

2) DISASSEMBLY

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



3) CHECK AND INSPECTION

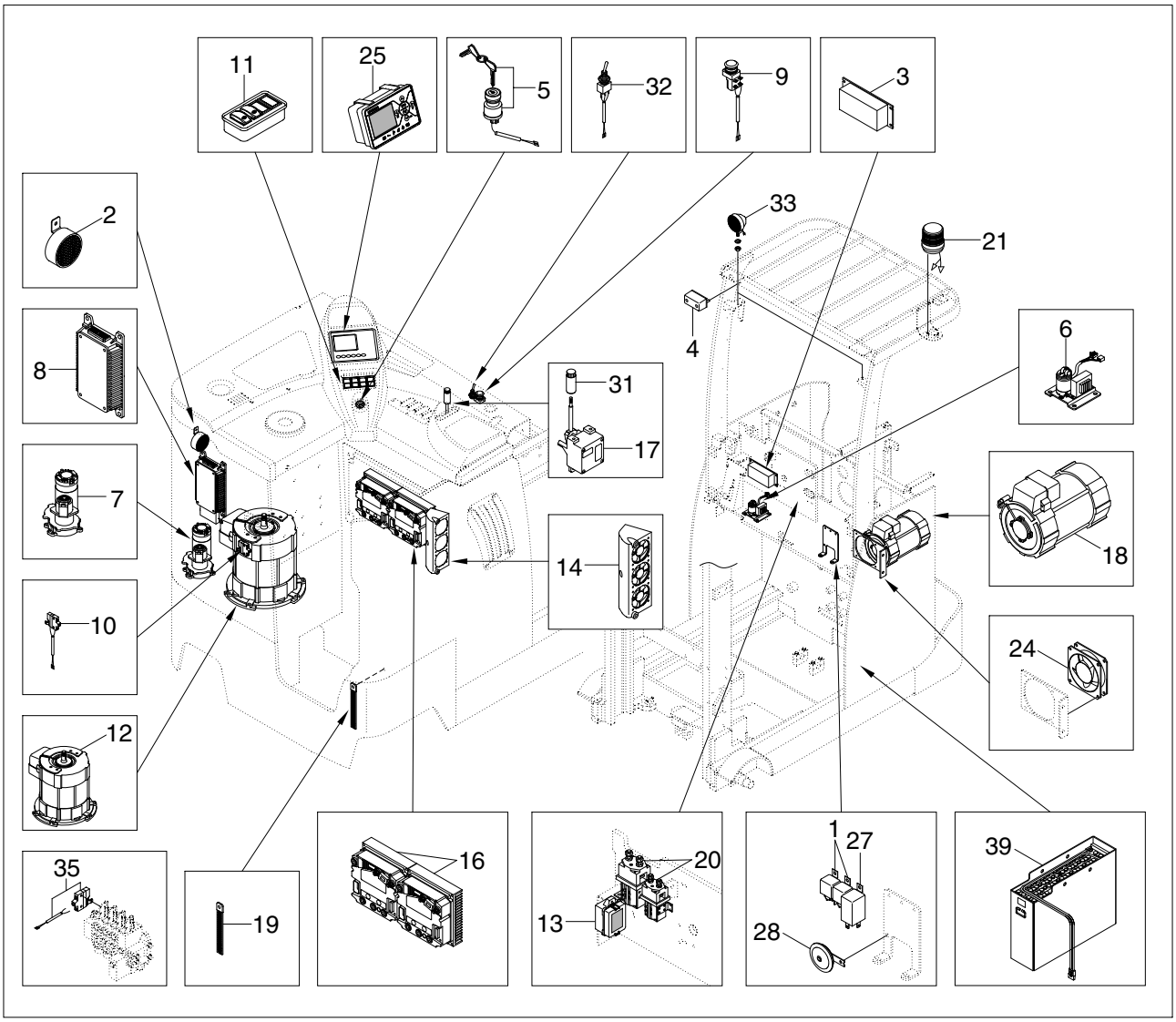
mm (in)

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

SECTION 7 ELECTRICAL SYSTEM

SECTION 7 ELECTRICAL SYSTEM

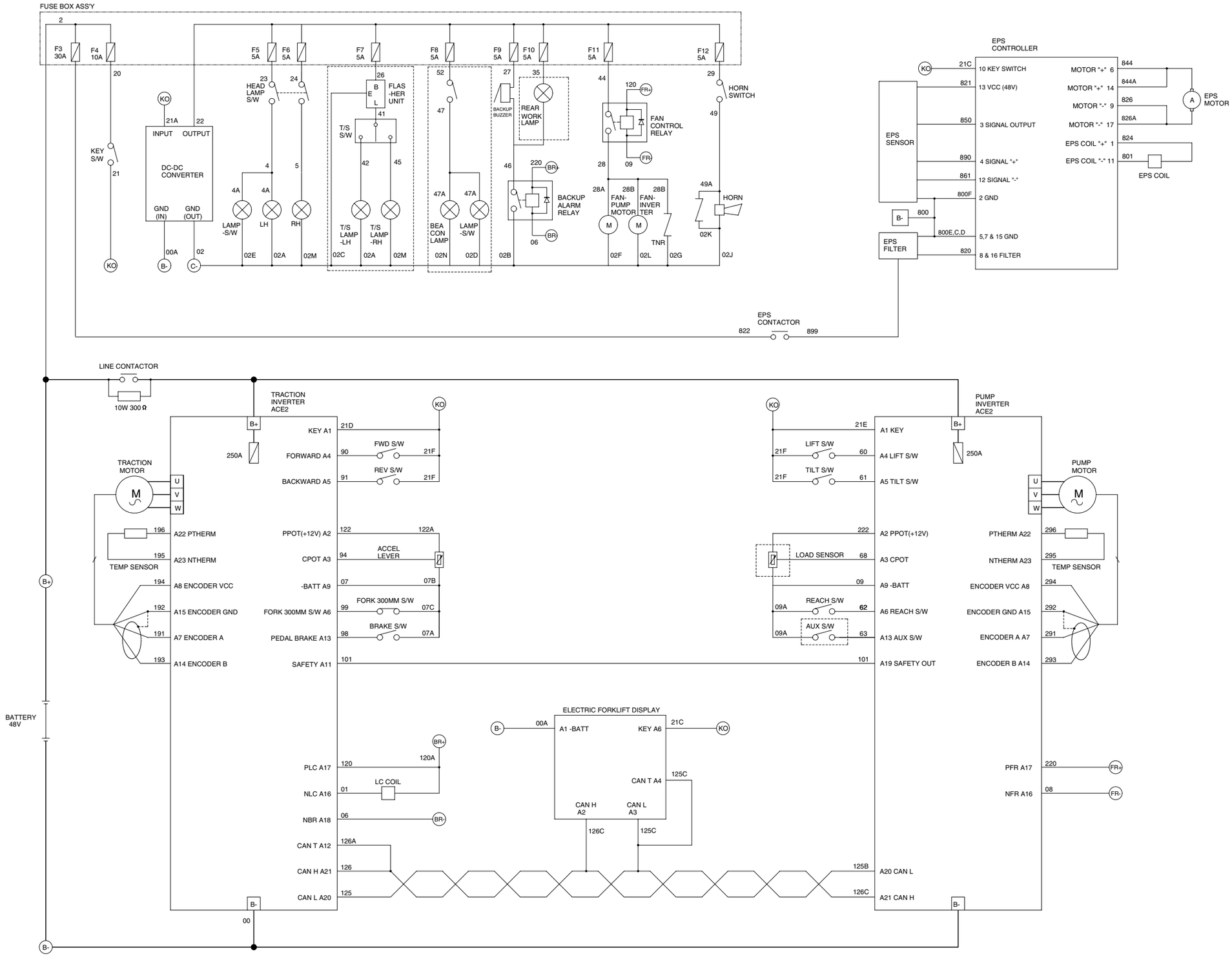
GROUP 1 COMPONENT LOCATION



15BR9EEL01

1	Relay	11	Switch assy	24	Fan
2	Back buzzer	12	Traction motor	25	Display
3	DC-DC converter	13	Fuse box assy	27	Flasher unit assy
4	Turn signal lamp	14	Fan assy	28	High horn
5	Key switch assy	16	ACE2-Inverter	31	Knob
6	EPS filter assy	17	Accelerator assy	32	Toggle switch
7	EPS actuator	18	Pump motor	33	Work-lamp sub assy
8	EPS controller	19	Static strap	35	Switch assy
9	Horn switch	20	Contactor	39	Battery
10	Micro switch	21	Beacon lamp		

GROUP 2 ELECTRICAL CIRCUIT



15BR9EEL02

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.

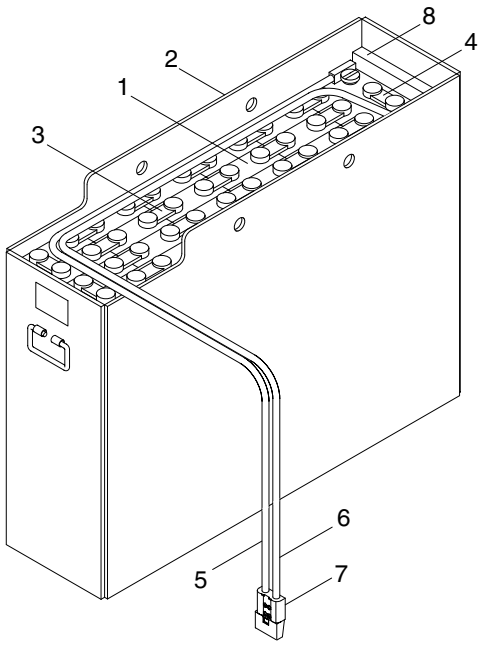
To drive the fork lift truck, a DRIVING CONTROL SYSTEM and some electric components such as direction change lever(forward/reverse section switch) and accelerator are required to select the driving direction and to control the speed of driving motor.

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

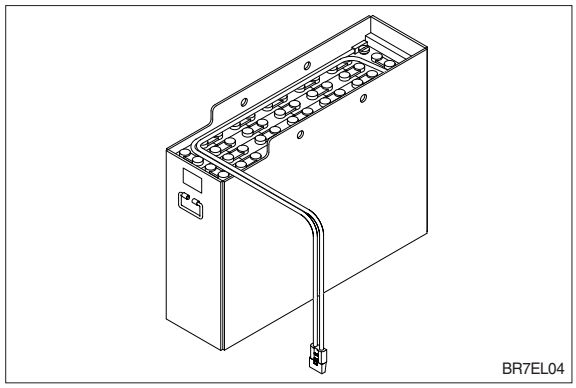


BR7EL03

1	Cells	5	Positive leading cable
2	Steel box	6	Negative leading cable
3	Cell connector	7	Plug
4	Row connector	8	Spacer

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

Item	Unit	15BR-9E
Type	-	VCI 230
Rated voltage	V	48
Capacity	AH/hr	230/5
Electrolyte	-	WET
Dimension (W × D × H)	mm	994 × 270 × 581.7
Connector (CE spec)	-	SB 350 (SBE 320)
Weight	kg	380

Fully charged specific gravity	1.280 (25°C)
End of discharge specific gravity	1.130 (25°C)
Discharge end voltage	48 V
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 1.5 V.

(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°C by the following formula.

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

Where, S_{25} : Specific gravity at 25°C

S_t : Actually measured specific gravity at t °C

t : Electrolyte temperature (°C)

The standard specific gravity for this type of battery is 1.280±0.01 (25°C) 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°C, and the temperature during the charge should be maintained at no higher than 55°C. (Under any unavoidable situations, it should never be above 55°C). Methods of charging vary 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 completes 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 $\times$1.0~1.5" at the start of charging, and at the final stage it is "5 hour rate current $\times$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 is in most cases provided with timer, extend the time setting for 3-6 more hours.

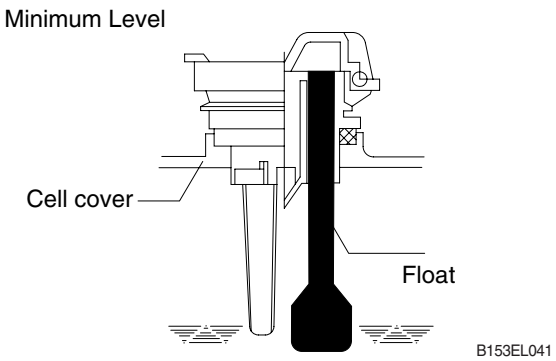
⑥ **Water replenishment**

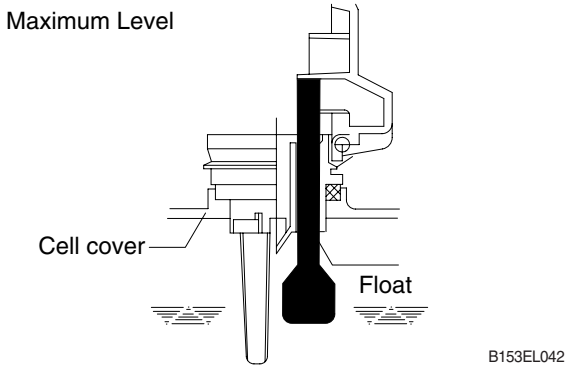
Only the water content of electrolyte is decreased due to electrolysis of water during charge and natural evaporation. If a battery used with the electrolyte decreased excessively, plates will deteriorate resulting in markedly shortening of battery life. Be sure to check the electrolyte level once every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

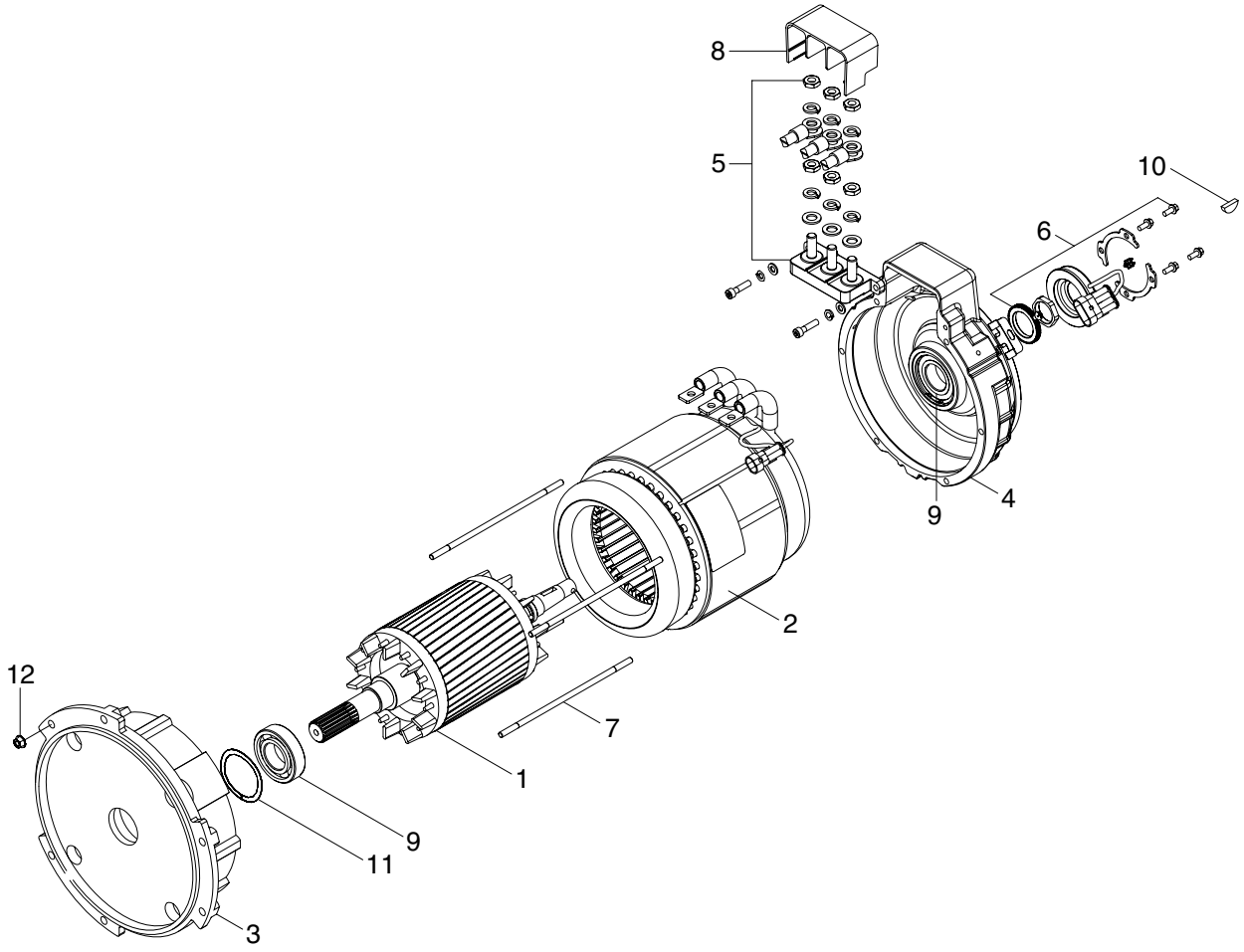
The operating temperature range of batteries is -10~45°C (temperature of electrolyte). If the batteries are exposed to cold atmosphere in discharged condition, the electrolyte may freeze, and in extreme cases, the capacity will be decreased, but, if not frozen, no adverse effects will be exerted over 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	Corrective Action
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 · Termination of connector or pole post etc.	· External impact, improper handling, excessive vibration · Excessive temperature rising or vibration/external impact	· Replace or install a new one · Replace
Sulfate	· Specific gravity drops and capacity is decreased. · Charge voltage rises rapidly with immature gassing in earlier stage but specific gravity does not rise and charge can't be carried out.	· When left in state of discharge or left long without equalizing charge. · Insufficient charge. · When electrolyte is so decreased that plate is deposed. · When concentration of electrolyte rises. · When impurities are mixed in electrolyte.	· Need equalizing charge · Need equalizing charge · Need equalizing charge · Adjust specific gravity · 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. · When left long period without refilling of water. · Short circuit.	· Replace · Refill water in regular period · Replace
Rise of specific gravity	· May be easily detected by measurement of the specific gravity.	· Diluted sulfuric acid is used in refilling. · When the electrolyte level excessively drops.	· Adjust specific gravity after full charge. · Refill distilled water.
Mixing of impurities	· Decrease of capacity. · Drop of charge and discharge voltage. · Odor of generated gas and coloring of the electrolyte.	· Metals such as iron, copper nickel and manganese. · Impurities such as sea water, chloric acid, nitric acid etc. · Filling of impure water.	· 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.

3. DRIVE MOTOR

1) STRUCTURE



15BR9EEL06A

1	Rotor	5	Block-terminal A	9	Bearing
2	Stator	6	Speed sensor kit	10	Woodruff key
3	Endbell de	7	Stud bolt	11	Wave washer
4	Endbell	8	Protector-terminal	12	Flange nut

2) SPECIFICATION

Item	Unit	15BR-9E
Type	-	AMDU4004A
Rated voltage	Vac	30
Rated output	kW	4.5
Insulation	-	Class F

3) MAINTENANCE INSTRUCTION

(1) Inspection

① Rotor assembly inspection

Rotor should always be cleaned with compressed air.

If the dirt will not come off lightly wipe off with piece of cotton or soft cloth wetted with gasoline.

Rotor out diameter : ø 123.1 ± 0.05

Tool : Vernier calipers and standard tool

18BR9EL41

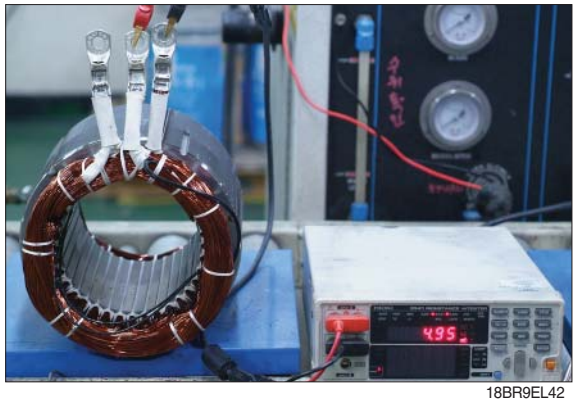
② Stator assembly inspection

Stator should always be cleaned with compressed air.

If the dirt will not come off lightly wipe off with piece of cotton or soft cloth wetted with gasoline, using care not to damage the coil insulation.

Use mmΩ tester and check for two power line of stator repeatedly (U-V, V-W, W-U).

At that time resistance is around 6.3 mmΩ.

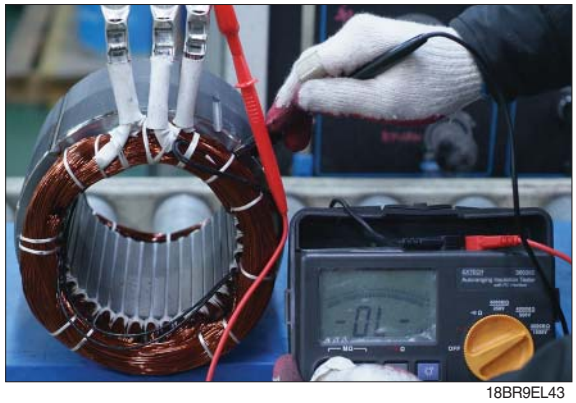


18BR9EL42

Insulation test

Use insulation tester (1000 Vac, Min. 10 MΩ) and measure as a picture.

If the insulation is defective, replace with new parts.

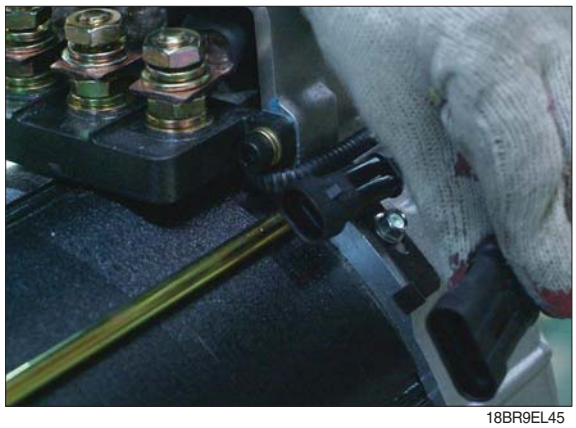


18BR9EL43

(2) Disassembly for AC motor

① Before disassembling motor, remove terminal protector from the motor and separate thermistor and speed sensor connectors from hanger.

18BR9EL44



18BR9EL45

② Remove 3-nuts from terminal block of the motor to disassemble terminal block from the motor.

18BR9EL46

③ Remove 4 screw fixing speed sensor on the enbell side and then disassemble speed sensor, fixed nut and toothed wheel of the motor.

18BR9EL47

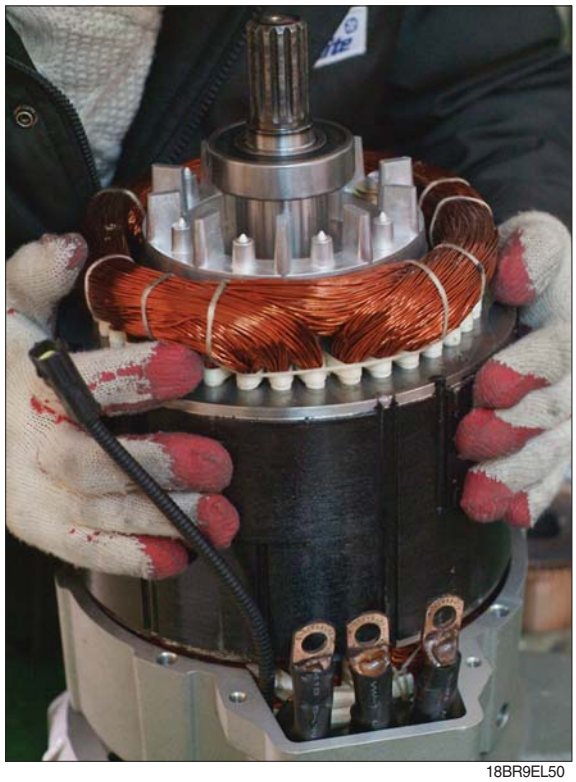
④ Remove 4 flange nuts with available general tool on the endbell drive side.

18BR9EL48

⑤ Remove endbell de and wave washer.

18BR9EL49

⑥ Remove stator assembly by hand or suitable tool.

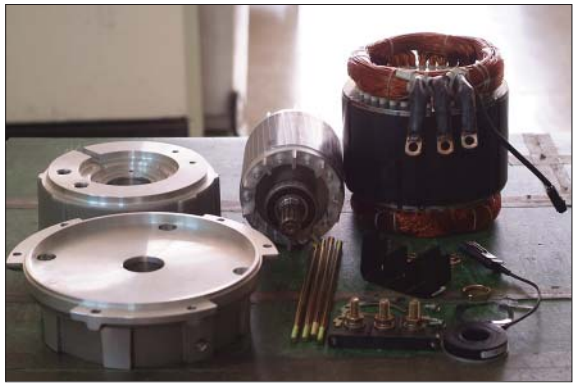


18BR9EL50

⑦ Remove endbell from rotor assembly by hand-puller as a right picture.

18BR9EL51

⑧ The motor are composed of 5-parts (rotor assembly, stator assembly, enbell de, endbell, etc).

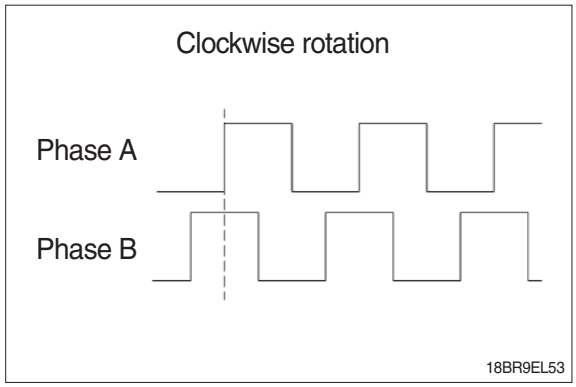


18BR9EL52

(3) Assembly and installation

Perform assembly in the reverse order of disassembling.

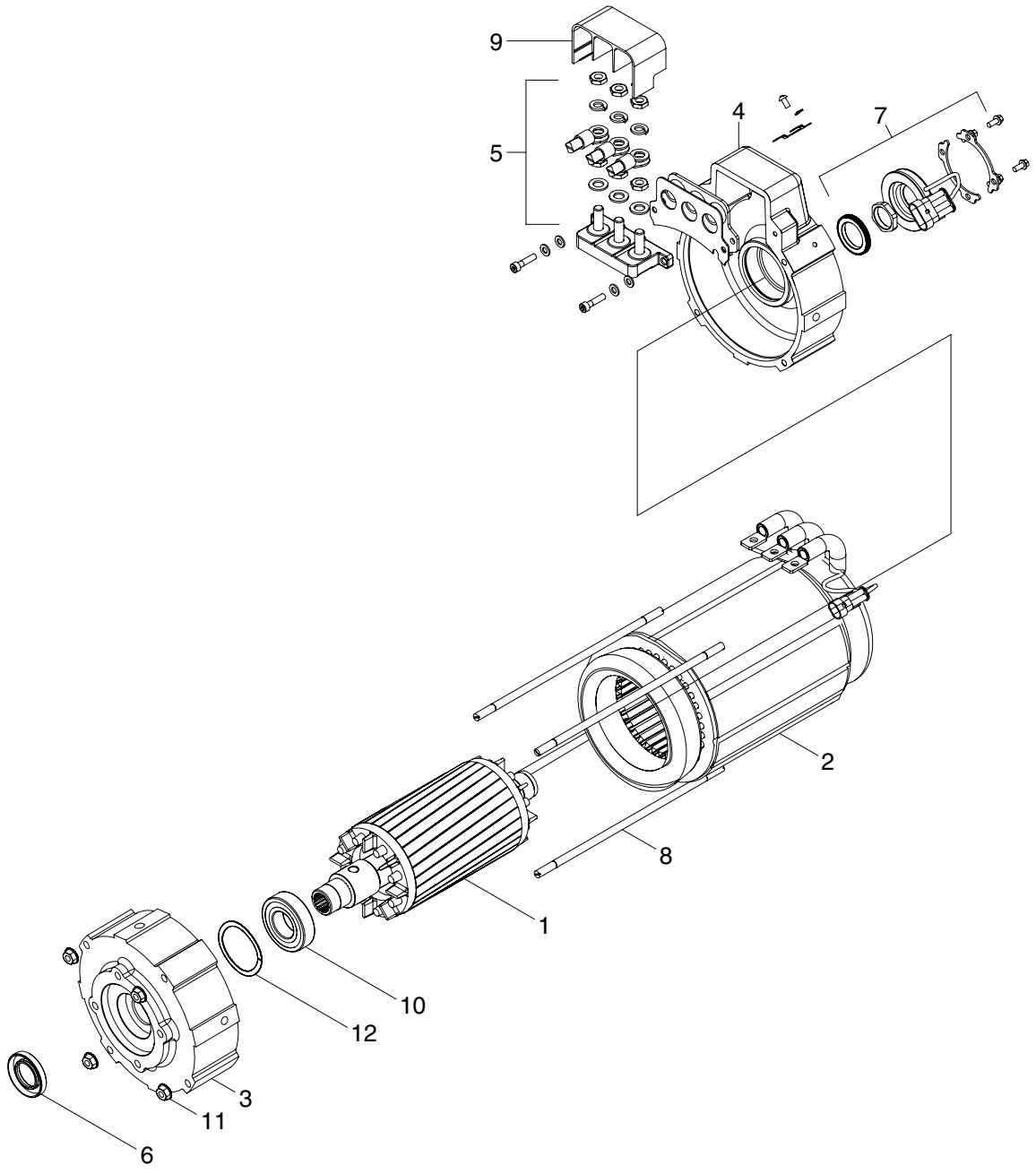
After assembling, check for speed sensor. Normal signal is as right.



18BR9EL53

4. PUMP MOTOR

1) STRUCTURE



18BR9EL16

1	Rotor	5	Block-terminal A	9	Protector-terminal
2	Stator	6	Oil seal	10	Bearing
3	Endbell De	7	Speed sensor kit	11	Flange nut
4	Endbell	8	Stud bolt	12	Wave washer

2) SPECIFICATION

Item	Unit	Specification
Type	-	ADBK4001
Rated voltage	Vac	30
Rated output	kW	9.0
Insulation	-	Class F
Speed	rpm	2180
Freq.	Hz	75
P.F.	-	0.827
Duty	%	S3-15
Voltage	V	30
Current	A	237

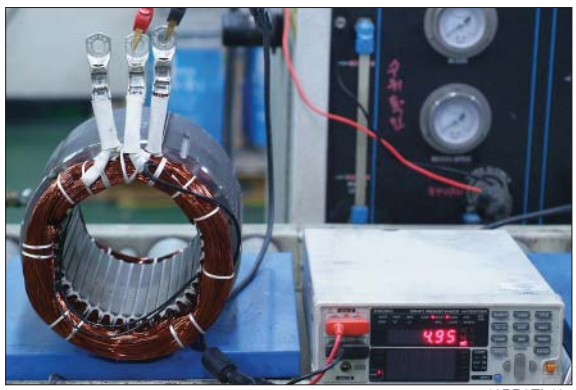
3) INSPECTION

(1) Rotor assembly inspection

① Rotor should always be cleaned with compressed air.
If the dirt will not come off lightly wipe off with piece of cotton or soft cloth wetted with gasoline.
Rotor out diameter : ø 104.1 ± 0.05
Tool : Vernier calipers and standard tool

18BR9EL54

② **Stator assembly inspection**
Stator should always be cleaned with compressed air.
If the dirt will not come off lightly wipe off with piece of cotton or soft cloth wetted with gasoline, using care not to damage the coil insulation.
Use mmΩ tester and check for two power line of stator repeatedly (U-V, V-W, W-U).
At that time resistance is around 5.4 mmΩ.

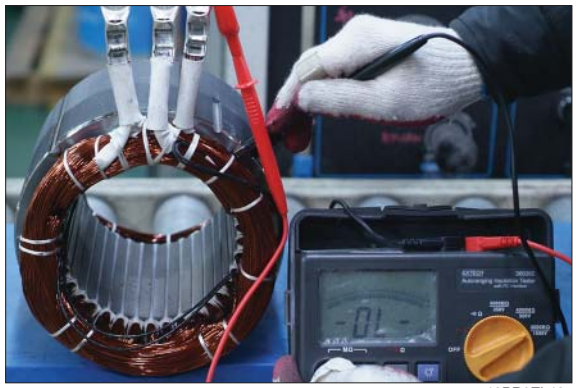


18BR9EL42

Insulation test

Use insulation tester (1000 Vac, Min. 10 MΩ) and measure as a picture.

If the insulation is defective, replace with new parts.

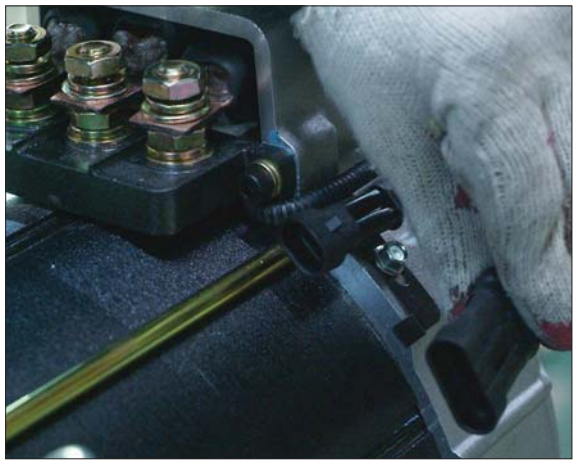


18BR9EL43

4) Disassembly for AC motor

① Before disassembling motor, remove terminal protector from the motor and separate thermistor and speed sensor connectors from hanger.

18BR9EL44



18BR9EL45

② Remove 3-nuts from terminal block of the motor to disassemble terminal block from the motor.

18BR9EL46

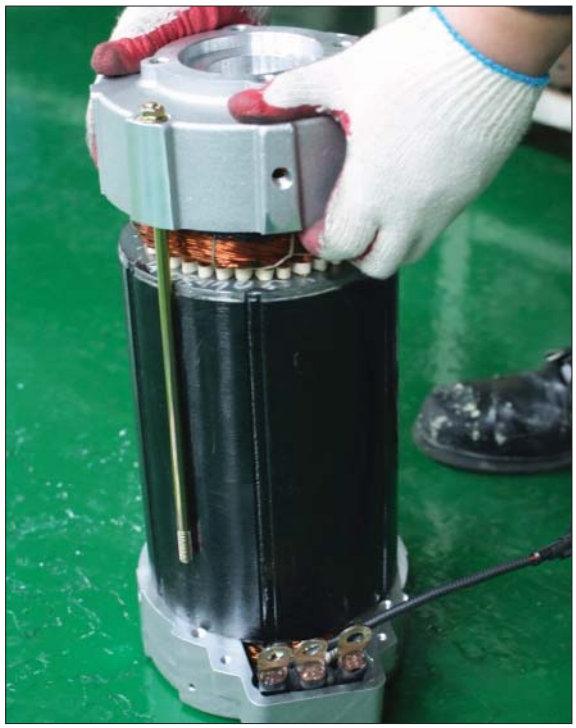
③ Remove 4 screw fixing speed sensor on the endbell side and then disassemble speed sensor, fixed nut and toothed wheel of the motor.

18BR9EL55

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

18BR9EL56

⑤ Remove endbell de and wave washer.



18BR9EL57

⑥ Remove stator assembly by hand or suitable tool.

18BR9EL58

⑦ Remove endbell from rotor assembly by hand-puller as a right picture.

18BR9EL51

⑧ The motor are composed of 5-parts (rotor assembly, stator assembly, enbell de, endbell, etc).

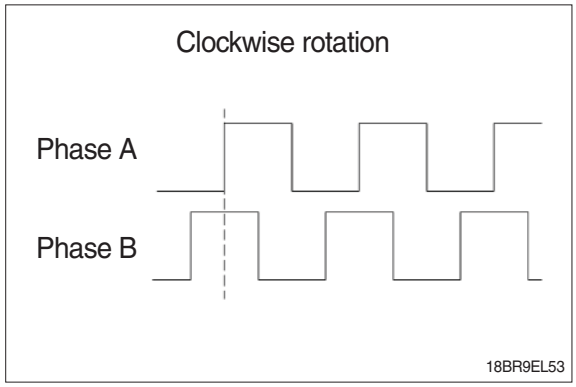
18BR9EL59

5) Assembly and installation

Perform assembly in the reverse order of disassembling.

After assembling, check for speed sensor.

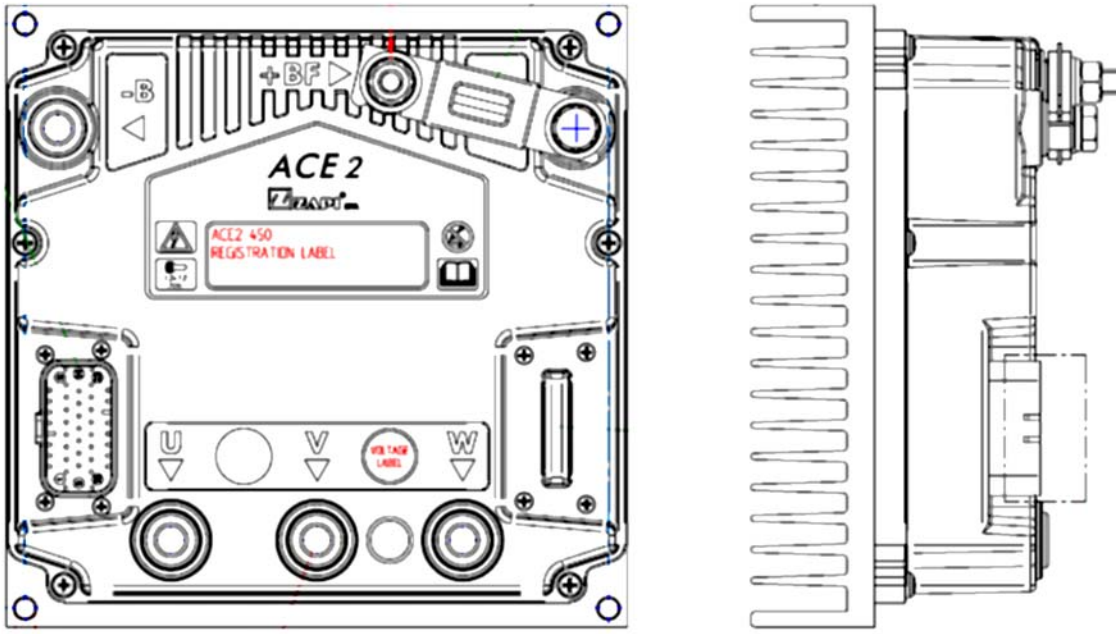
Normal signal is as right.



18BR9EL53

5. CONTROLLER SYSTEM

1) STRUCTURE



18BR9EL11

(1) Specifications

Model	Model	Application	Type	Power	Current limit
15BR-9E	ACE2	Traction	AC	36-48V, 350A	350A/3min
	ACE2	Pump	AC	36-48V, 350A	350A/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 Electronic steering function:
⑪ Backing forward and reverse options are available, with the tune and the speed of the function programmable with Zapi 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 Zapi console for checking main parameters.
⑰ Built in BDI feature.
⑱ Flash memory, software downloadable via serial link and via CANBUS.

(2) Diagnosis

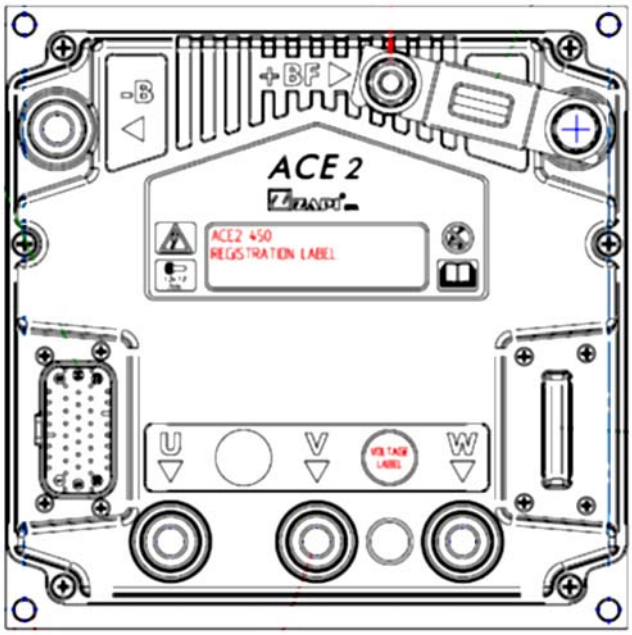
The microcontrollers continually monitor the inverter and carry out a diagnostic procedure on the main functions. The diagnosis is made in 4 points.

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 μ CS, 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



18BR9EL12

No. of pin	Function	Description
A1	KEY	Input of the key switch signal.
A2	PPOT (+12V)	Power supply (+12 V) of accel lever.
A3	CPOT	Accel lever analog signal input.
A4	FORWARD	Forward signal input.
A5	BACKWARD	Backward signal input.
A6	FORK 300MM S/W	Fork lifting height 300 mm sensing switch input.
A7	ENC A	Traction motor encoder phase A.
A8	ENC VCC	Encoder positive supply.
A9	- BATT	Negative power supply. Negative of accel lever, brake switch, fork 300 mm switch.
A10	CPOT SS	Steering analog signal input (Null).
A11	SAFETY	Connect to pump inverter A19 for the safety check.
A12	CANT	If it is connected with A21, it introduces the120 Ohm termination resistance between CAN-L and CAN-H.
A13	PEDAL BRAKE	Brake switch input.
A14	ENC B	Traction motor encoder phase B.
A15	ENC GND	Negative of encoder.
A16	NLC	Line contactor coil driver negative output.

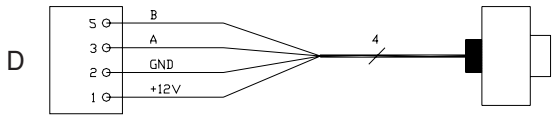
No. of pin	Function	Description
A17	PLC	Positive output of line contactor & back buzzer relay coil.
A18	NBR	Back buzzer relay coil driver negative output.
A19	EPS FAULT	EPS fault signal input (Null).
A20	CAN L	Low level CAN-BUS voltage I/O.
A21	CAN H	High level CAN-BUS voltage I/O.
A22	PTHERM	Input for motor temperature sensor.
A23	NTHERM	Negative of motor temperature sensor.

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.

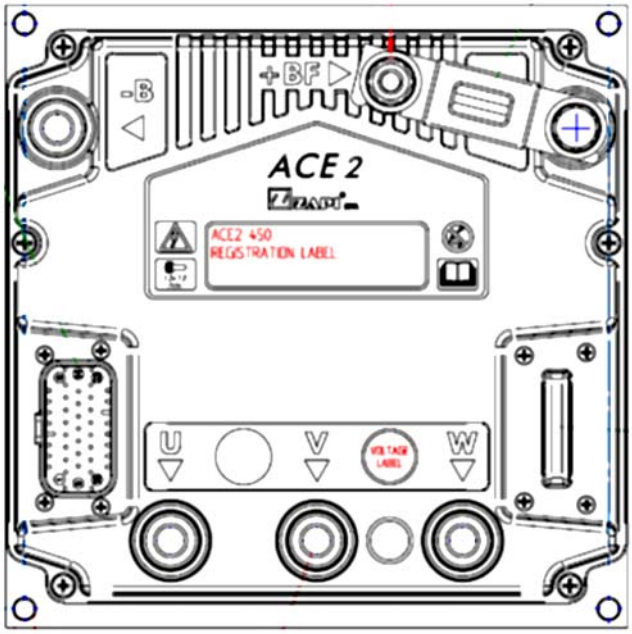
D1 : +12V - Positive of encoder power supply.
D2 : GND - Negative of encoder power supply.
D3 : A - Phase A of encoder.
D5 : B - Phase B of encoder.

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



BRJ7EL26

(2) Pump controller



18BR9EL12

No. of pin	Function	Description
A1	KEY	Input of the key switch signal.
A2	PPOT(+12V)	Power supply (+12V) of load sensor (opt).
A3	CPOT	The analog signal input of the load sensor.
A4	LIFT S/W	Lift switch input.
A5	TITL S/W	Tilt switch input.
A6	REACH S/W	Reach switch input.
A7	ENC A	Pump motor encoder phase A.
A8	ENC VCC	Encoder positive supply.
A9	- BATT	Negative power supply. Negative of reach switch, aux switch (opt), load sensor (opt).
A10	NA	-
A11	NA	-
A12	NA	-
A13	AUX S/W	Aux switch (opt) input.
A14	ENC B	Pump motor encoder phase B.
A15	ENC GND	Negative of encoder.
A16	NFR	Fan relay coil driver negative output.
A17	PFR	Positive output of fan relay coil.

No. of pin	Function	Description
A18	NA	-
A19	SAFETY OUT	Connect to traction inverter A11 for the safety check.
A20	CAN L	Low level CAN-BUS voltage I/O.
A21	CAN H	High level CAN-BUS voltage I/O.
A22	PTHERM	Input for motor temperature sensor.
A23	NTHERM	Negative of motor temperature sensor.

4) FUNCTION CONFIGURATION

■ TRACTION CONTROLLER

Using the CONFIG MENU of the programming console, the user can configure the following functions.

(1) Submenu "SET OPTIONS"

① **Hour counter**

This option specifies the hour counter mode. It can be set one of two :

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

② **Battery check**

This option specifies the handling of the low battery charge detection. There are three levels:

- Level 0 : Nothing happens, the battery charge level is calculated but is ignored, it means no action is taken when the battery is discharged.
- Level 1 : BATTERY LOW alarm is raised when the battery level is calculated being less than or equal to 10% of the full charge. The BATTERY LOW alarm inhibits the lifting function.
- Level 2 : BATTERY LOW alarm is raised when the battery level is calculated being less than or equal to 10% of the full charge. The BATTERY LOW alarm reduces the maximum truck speed down to 24% of the full truck speed and it inhibits the lifting function.

③ **Steer sensor**

This option set the steer sensor function.

- ON : Steering angle display on monitor and travel speed control is activated as the steer angle cutback setting (STEER DEAD ANGLE, MIDDLE ANGLE, MID. CURVE CTB. , CURVE CUTBACK). Steer sensor check function is enable.
- OFF: Steering angle doesn't display on monitor and travel speed control is not activated. Steer sensor check function is disable.

④ **Set motor temperature**

It can be set:

1. ANALOG : An analogue sensor for the control of the motor temperature is connected to CNA#22. Typically the temperature sensor is a PTC (positive thermal coefficient resistance), providing the sensor characteristic to Zapi the correct table can be loaded in the controller software (analog temperature sensor).
2. DIGITAL : A digital (on/off) sensor for the motor temperature monitoring is connected to CNA#22 input (digital temperature sensor).
3. NONE : No temperature sensor is connected.

⑤ **Stop on ramp**

Only when the encoder is present, it is possible to electrically hold the truck on a slope when the accelerator is released but the tiller is not released.

- ON : The stop on ramp feature (truck electrically hold on a ramp) is managed for a time established by AUXILIARY TIME parameter.
- OFF : The stop on ramp feature is not performed. That means the truck comes down slowly during the AUXILIARY TIME.

⑥ **Display**

This option set the communication check between traction and display.

- ON : Communication check is enable. If the traction can not detect the display communication signal, CAN BUS KO DISP is occured and travel speed cutback to turtle speed.
- OFF : Communication check is disable.

⑦ **Pedal brake stop**

- ON : The truck is stopped when the pedal brake is pressed.
- OFF : The traction current is reduced to the half of the maximum current.

⑧ **EPS error check**

- ON : Traction inverter check EPS fault signal. If EPS fault signal is detected, Stop the travel function.
- OFF : Traction inverter doesn't check EPS fault signal.

⑨ **A-18 diag active**

- ON : Traction inverter check A18 port (Backbuzzer relay coil).
- OFF : Traction inverter doesn't check A18 port (Backbuzzer relay coil).

⑩ **Model truck**

This set model. Threre are 2 options.

- 10/13BR
- 15BR-9E
- This parameter must be set "15BR-9E" for 15BR-9E truck.

(2) Submenu "ADJUSTMENTS"

① **Adjust battery**

Fine adjustment of the battery voltage measured by the controller.

② **Throttle 0 zone**

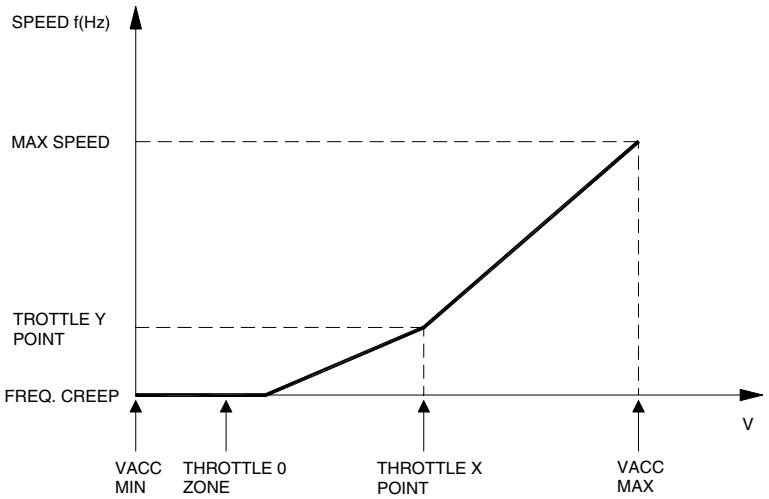
Establishes a deadband in the accelerator input curve.

③ **Throttle X point**

This parameter, together with the THROTTLE Y POINT, changes the characteristic of the accelerator input curve : when the accelerator is depressed to X point percent, the corresponding truck speed is Y point percent of the maximum truck speed. The relationship between the accelerator position and the truck speed is linear between the THROTTLE 0 ZONE and the X point and also between the X point and the maximum accelerator position but with two different slopes (See below figure).

④ **Throttle Y point**

This parameter, together with the THROTTLE X POINT, changes the characteristic of the accelerator input curve : when the accelerator is depressed to X point percent, the corresponding truck speed is Y point percent of the maximum truck speed. The relationship between the accelerator position and the truck speed is linear between the THROTTLE 0 ZONE and the X point and also between the X point and the maximum accelerator position but with two different slope (See below figure).



20B7EL17

⑤ **BAT. MIN ADJ.**

Adjust the lower level of the battery charge table (-12.7%~+12.6%).

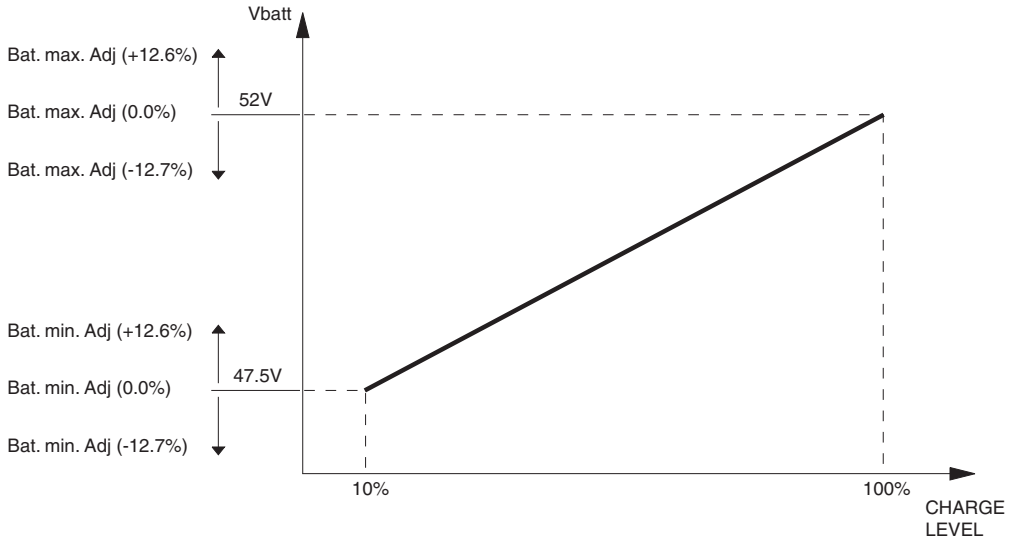
⑥ **BAT. MAX ADJ.**

Adjust the upper level of the battery charge table (-12.7%~+12.6%).

⑦ **BDI ADJ STARTUP**

Adjust the upper level of the battery charge table (-12.7%~+12.6%).

When the key on, this setting table is applied.



18BR9EL61

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 **Main cont. volt**

%. This parameter stores the PWM value applied to MC coil for the first second of the output activation. It is expressed in percentage of battery voltage.

⑩ **Aux output volt**

%. This parameter stores the PWM value applied to AUX COIL for the first second of the output activation. It is expressed in percentage of battery voltage.

⑪ **Main cont. V rid**

%. This parameter stores the PWM value applied to MC coil after the first second of the output activation. It is expressed in percentage of MAIN CONT. VOLT.

⑫ **DISP SPD factor**

It adjusts the speed coefficient to have the correct speed indication on the display. This coefficient has to be regulated depending on truck mechanic characteristics. It results from the following formula :

Speed factor = 88*rr*p/ ø

where : rr = total gearbox ratio

ø = traction wheel diameter (cm)

P = number of pair poles of the motor

⑬ **Chat time delay**

In seconds. When truck is key on, if the operator doesn't use the truck for the time (CHAT TIME DELAY), main contactor is open to save energy.

⑭ **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”.

(3) Submenu "PARAMETER CHANGE"

① **Acceleration 0** : Seconds. It specifies the motor acceleration at 0 Hz. The parameter sets the time needed to accelerate the traction motor from 0Hz to 100Hz.

② **INV. accel 0** : Seconds. It specifies the motor acceleration at 0 Hz after an inversion of direction. The parameter sets the time needed to accelerate the traction motor from 0Hz to 100Hz.

③ **Acceleration 1** : Seconds. It specifies the motor acceleration at ACC PROF. FREQ 1 [Hz]. The parameter sets the time needed to accelerate the traction motor from 0Hz to 100Hz.

④ **Acceleration 2** : Seconds. It specifies the motor acceleration at ACC PROF. FREQ 2 [Hz]. The parameter sets the time needed to accelerate the traction motor from 0Hz to 100Hz.

⑤ **Acceleration 3** : Seconds. It specifies the motor acceleration at ACC PROF. FREQ 3 [Hz]. The parameter sets the time needed to accelerate the traction motor from 0Hz to 100Hz.

⑥ **ACC PROF. FREQ 1** : In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 1 parameter.

⑦ **ACC PROF. FREQ 2** : In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 2 parameter.

⑧ **ACC PROF. FREQ 3** : In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 3 parameter.

⑨ **Release braking** : Seconds. It controls the deceleration ramp when the travel request is released. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz.

⑩ **Inverse braking** : Seconds. It controls the deceleration ramp when the direction switch is inverted during travel. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz.

⑪ **Decel braking** : Seconds. It controls the deceleration ramp when the accelerator has turned down but not completely released. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz.

⑫ **Pedal braking** : Seconds. This parameter determines the deceleration ramp when the travel request is released and the brake pedal switch is closed. It sets the time needed to decelerate the traction motor from 100Hz to 0Hz.

⑬ **Speed limit BRK** : Seconds. It controls the deceleration ramp when a speed reduction has been activated. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz.

⑭ **Curve braking** : Seconds. It controls the deceleration ramp when a curve speed reduction has been activated. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz.

⑮ **Max speed forward** : Hz. It determines the maximum speed in forward direction.

⑯ **Max speed backward** : Hz. It determines the maximum speed in backward direction.

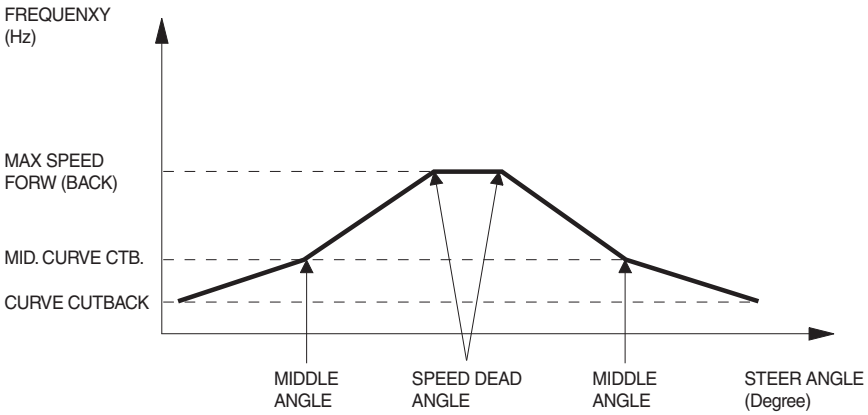
⑰ **Turtle speed** : Hz. It determines the maximum speed when turtle mode is activated.

⑱ **Steer dead angle** : %. It determines the steer tire angle range be able to get MAX SPEED FORW (BACK) speed. For example, if setting is 10% , it means truck maximun speed is same as MAX SPEED FORW (BACK) within 9˚. If steer angle is over 9˚, the maximun speed is reduced by the angle linealy.

⑲ **Middle angle** : %. It determines the steer tire angle range be able to get MID. CURVE CTB speed. This setting value is always higher than STEER DEAD ANGLE

⑳ **Mid. curve CTB** : Hz. It determines the maximum speed when truck steer angle is over MIDDLE ANGLE.

㉑ **Curve cutback** : Hz. It determines the maximum speed when truck steer angle is right turn and left turn end.



18BR9EL60

㉒ **Frequency creep** : Hz value. This is the minimum speed applied when the forward or reverse switch is closed, but the accelerator is at its minimum.

㉓ **Maximum current** : Maximum level of the current (percentage of the maximum current of the controller).

㉔ **BRK smooth** : It gives a parabolic form to the deceleration ramp.

㉕ **Stop BRK smooth** : Hz. It sets the level of frequency where the smooth effect of the deceleration parabolic form ends.

㉖ **Auxiliary time** : Time units value (seconds). For the encoder version, it determines the time duration the truck is hold on the ramp if the STOP ON RAMP option is ON.

■ PUMP CONTROLLER

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

(1) Submenu "SET OPTIONS"

① **Load sensor**

- ON : Load sensing function is activated.
- OFF : Load sensing function is disactivated.

② **Hour counter**

This option specifies the hour counter mode. It can be set one of two :

- RUNNING : The counter registers travel time only.
- KEY ON : The counter registers when the “key” switch is closed.

③ **Set motor temperature**

It can be set:

1. ANALOG : An analogue sensor for the control of the motor temperature is connected to CNA#22. Typically the temperature sensor is a PTC (positive thermal coefficient resistance), providing the sensor characteristic to Zapi the correct table can be loaded in the controller software (analog temperature sensor).
2. DIGITAL : A digital (on/off) sensor for the motor temperature monitoring is connected to CNA#22 input (digital temperature sensor).
3. NONE : No temperature sensor is connected.

④ **Cooling fan work**

Cooling fans installed on nearby motors and controllers will work as follows;

- None : fans don't work.
- Option #1 : fans work always.
- Option #2 : fans work in case a temperature of controller or motor exceeds a temperature set in START TEMP. FAN menu
- Option #3 : fans work when motors work.

⑤ **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.

⑥ **A-16 diag active**

- ON : Pump inverter check A16 port (Fan relay coil).
- OFF : Pump inverter doesn't check A16 port (Fan relay coil).

⑦ **Model truck**

This display model setting from traction inverter . Threre are 2 models.

- 10/13BR
- 15BR-9E (Model setting is only avalible at the traction inverter side.)
- This parameter must be set "15BR-9E" for 15BR-9E truck.

(2) Submenu "ADJUSTMENTS"

① **Overload type** : This option specifies how overload alarm works in overloaded situation.
- NONE : There would'n be any kind of alarms or limitations. If re-configuration of V.A.S.S LOAD is required, please set this parameter as NONE, then proceedure-configuration.
- Option #1 : If the weight of load filed on forks exceeds the overload weight set in overload parameter, OVERLOAD alarm will be displayed and followed by traction & pump limitation except lift down & steering function.
- Option #2 : If the weight of load filed on forks exceeds the overload weight set in overload parameter, OVERLOAD alarm will be displayed.

② **REF. load weight** : This parameter is used to show and configurate the reference load weight.

③ **Overload weight** : This parameter is used to show and configurate the trigger condition for OVERLOAD alarm. If the loaded weight exceeds the weight indicated in this paramter, OVERLOAD alarm and function limitation will occur accroding to OVERLOAD TYPE paramter.

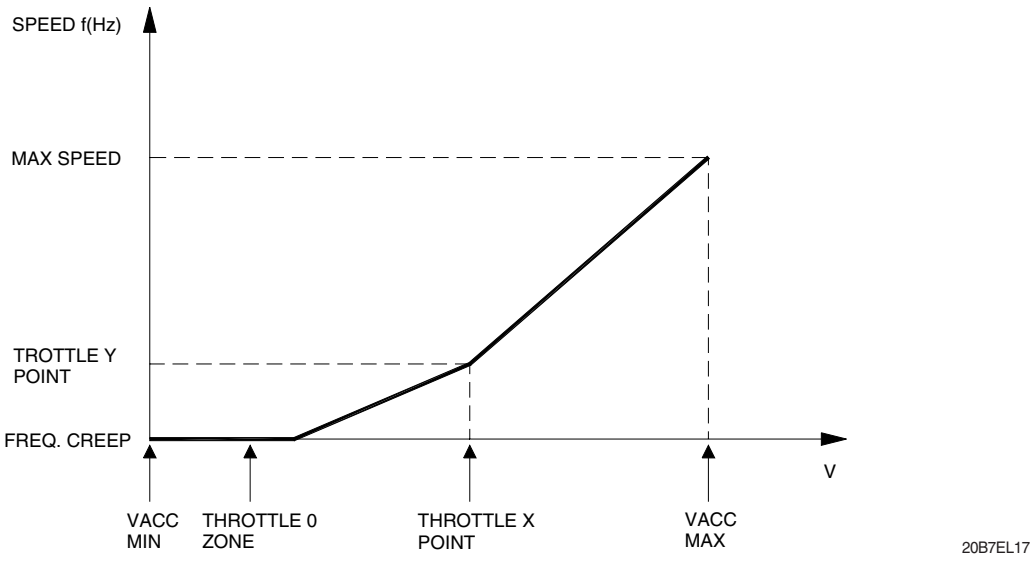
④ **Load speed UPD** : For accuracy, Load Sensor only works when the traction motor speed is lower than as set in this parameter.

⑤ **Adjust battery** : Fine adjustment of the battery voltage measured by the controller.

⑥ **Throttle 0 zone** : It establishes a dead band in the lift potentiometer input curve.

⑦ **Throttle X point** : This parameter, together with the THROTTLE Y POINT, changes the characteristic of the lift potentiometer input curve : when the potentiometer is depressed to X point percent, the corresponding pump speed is Y point percent of the maximum pump speed. The relationship between the lift potentiometer position and the pump speed is linear between the THROTTLE 0 ZONE and the X point and also between the X point and the maximum potentiometer position but with two different slopes (See below figure).

⑧ **Throttle Y point** : This parameter, together with the THROTTLE X POINT, changes the characteristic of the lift potentiometer input curve : when the potentiometer is depressed to X point percent, the corresponding pump speed is Y point percent of the maximum pump speed. The relationship between the potentiometer position and the pump speed is linear between the THROTTLE 0 ZONE and the X point and also between the X point and the maximum accelerator position but with two different slope (See below figure).



⑨ **Main cont. volt**

%. This parameter stores the PWM value applied to MC coil for the first second of the output activation. It is expressed in percentage of battery voltage.

⑩ **Aux output volt**

%. This parameter stores the PWM value applied to AUX COIL for the first second of the output activation. It is expressed in percentage of battery voltage.

⑪ **Main cont. V rid**

%. This parameter stores the PWM value applied to MC coil after the first second of the output activation. It is expressed in percentage of MAIN CONT. VOLT.

⑫ **Adjustment #04**

This parameter determines the motor temperature level at which the “Motor temperature” alarm is signalled. The range is from 70°C to 160°C with 10°C steps. This parameter must be adjusted only if the “Set motor temperature” (menu “Set option”) parameter is programmed “Analog”.

⑬ **Start temp. fan**

if COOLING FAN WORK menu is set as option #2, this menu is used to set a temperature limitation which allows fans to work when a temperature of controller or motor exceeds the limitation.

(3) Submenu "PARAMETER CHANGE"

① **Acceleration 0** : Seconds. It specifies the motor acceleration at 0 Hz. The parameter sets the time needed to accelerate the traction motor from 0Hz to 100Hz.

② **Acceleration 1** : Seconds. It specifies the motor acceleration at ACC PROF. FREQ 1 [Hz]. The parameter sets the time needed to accelerate the traction motor from 0Hz to 100Hz.

③ **Acceleration 2** : Seconds. It specifies the motor acceleration at ACC PROF. FREQ 2 [Hz]. The parameter sets the time needed to accelerate the traction motor from 0Hz to 100Hz.

④ **Acceleration 3** : Seconds. It specifies the motor acceleration at ACC PROF. FREQ 3 [Hz]. The parameter sets the time needed to accelerate the traction motor from 0Hz to 100Hz.

⑤ **ACC PROF. FREQ 1** : In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 1 parameter.

⑥ **ACC PROF. FREQ 2** : In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 2 parameter.

⑦ **ACC PROF. FREQ 3** : In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 3 parameter.

⑧ **Release braking** : Seconds. It controls the deceleration ramp when the travel request is released. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz.

⑨ **Max speed limit** : Hz, It determines the maximum lifting speed.

⑩ **Tilt speed** : Hz, It determines the tilt speed.

⑪ **Reach speed** : Hz, It determines the reach speed.

⑫ **Aux speed** : Hz, It determines the aux speed.

⑬ **Frequency creep** : Hz value. This is the minimum speed applied when the forward or reverse switch is closed, but the accelerator is at its minimum.

⑭ **Maximum current** : Maximum level of the current (percentage of the maximum current of the controller).

⑮ **Auxiliary time** : Time units value (seconds). For the encoder version, it determines the time duration the pump motor is hold when deceleration is activated under 2 Hz.

5) PROGRAMMING & ADJUSTMENTS

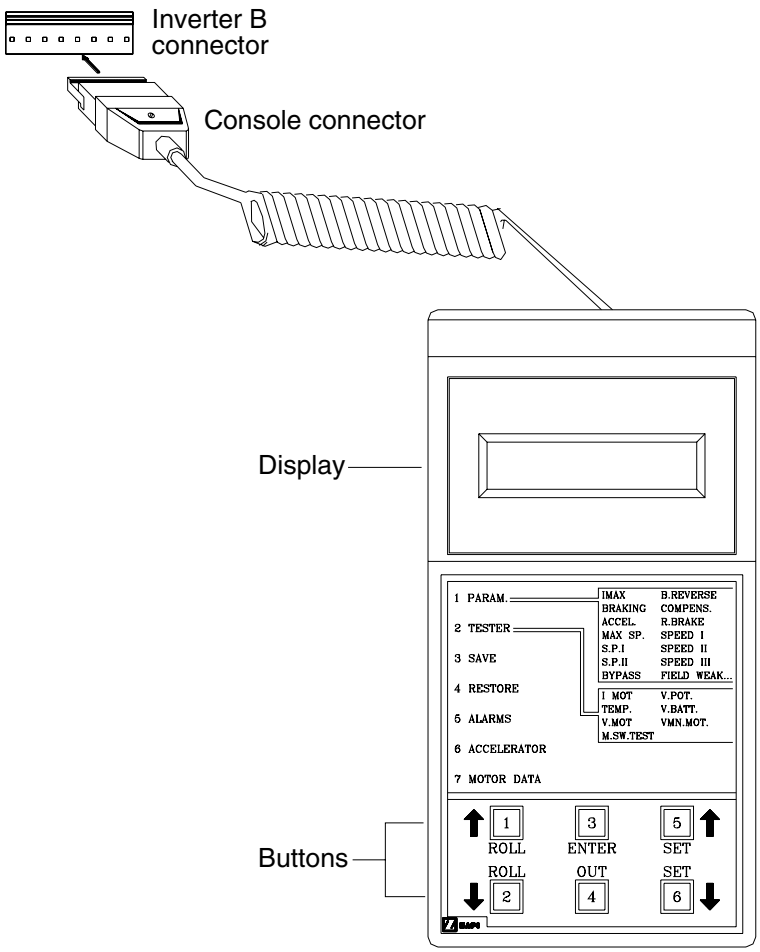
There are two ways to adjust parameter via a console or buttons on a display.

※ Adjustments via buttons on a display, please refer to the display section. (page 7-46)

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

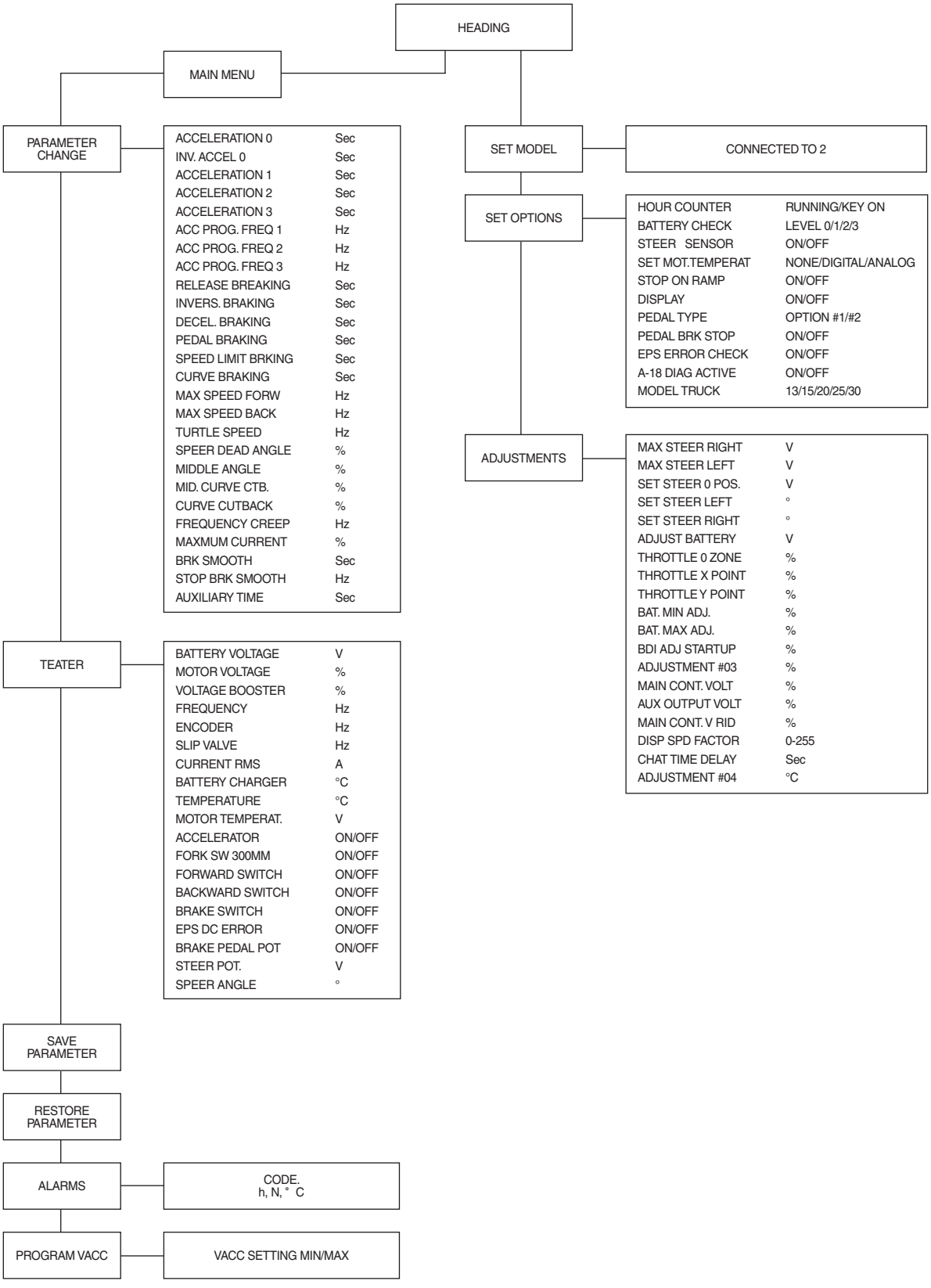


20B7EL15

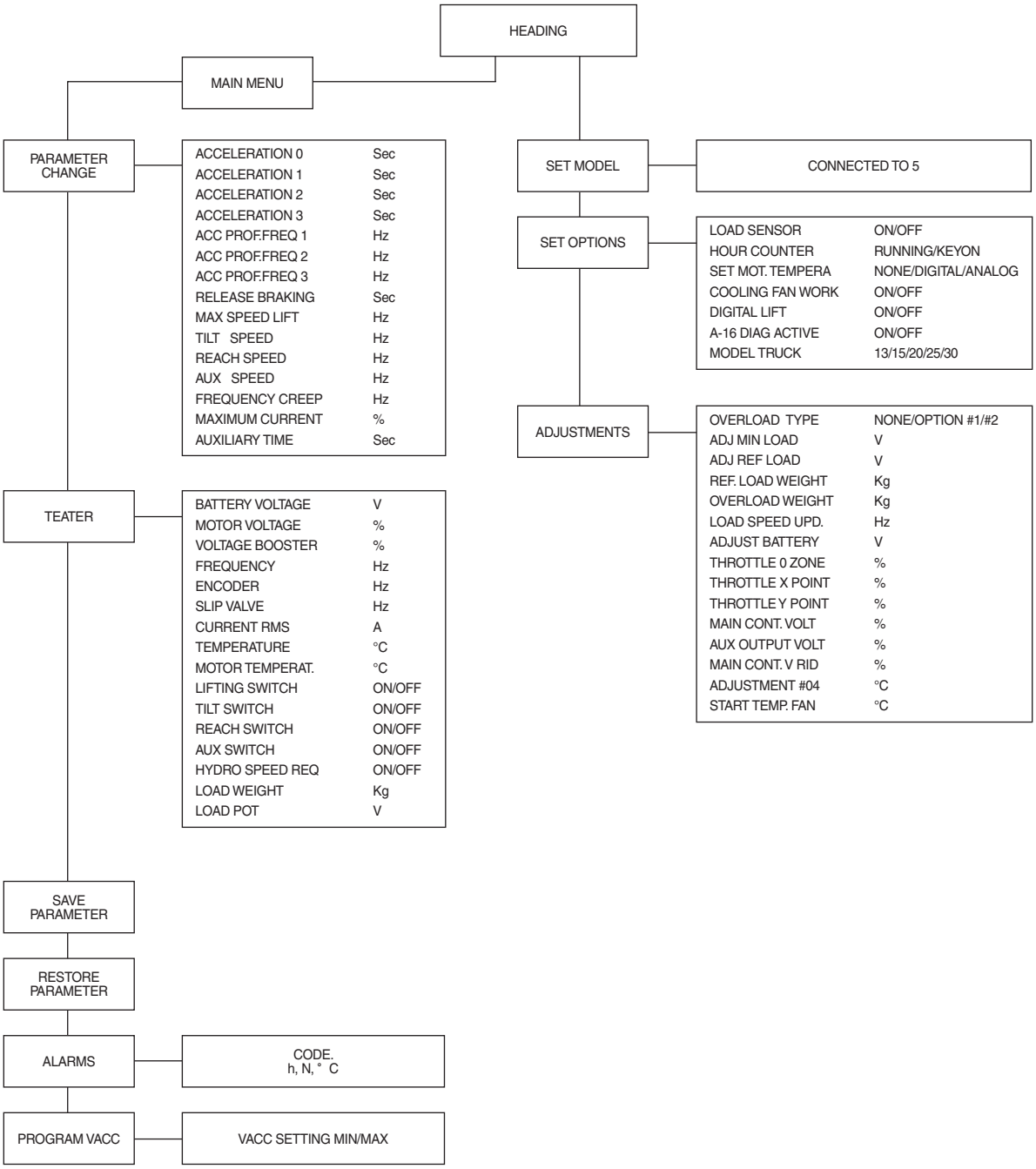
※ Digital consoles used to communicate with AC inverter controllers must be fitted with EPROM CK ULTRA, minimum "Release number 3.02".

(2) Description of standard console menu

① Traction controller



② Pump controller



(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.

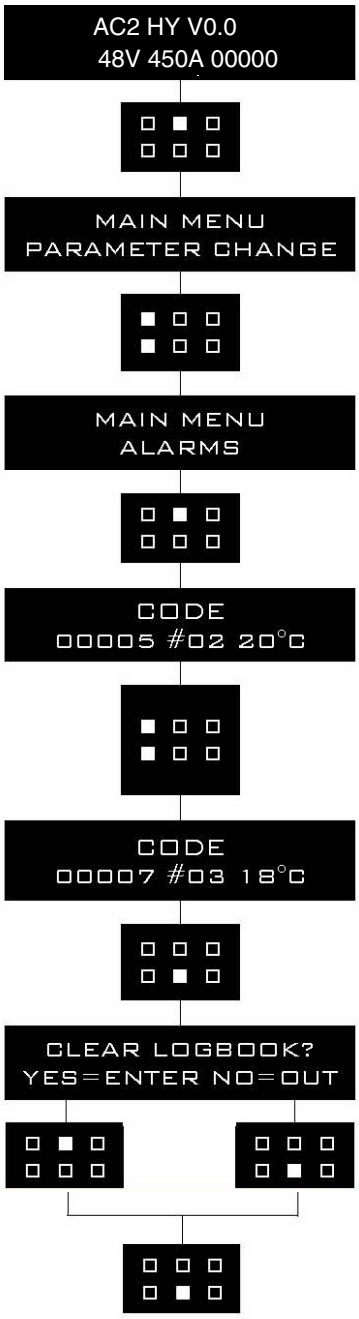
⑨ If an alarm has not occurred, the display will show: ALARM NULL.

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 **Battery voltage**

Voltage value with 1 decimal digit. Battery voltage value measured at the key on.

② **Motor voltage**

Percentage value. It is the voltage generated by the inverter expressed in percent of the actual battery voltage. 100% means the sine wave width is close to the actual battery voltage; 0% means the sine wave width is null.

③ **Voltage booster**

Percentage value. It is the booster contribute to the voltage really supplied to the motor expressed in percent of the actual battery voltage.

④ **Frequency**

Hz value. This is the frequency of the sine waves the inverter is supplying.

⑤ **Encoder**

Hz value. This is the speed of the motor measured with the encoder and expressed in the same unit of the FREQUENCY reading.

⑥ **Slip value**

"Hz value. This is the slip between the frequency and the speed of the motor
(SLIP VALUE = FREQUENCY-ENCODER)."

⑦ **Current RMS**

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

⑧ **Battery charge**

Percentage value. It supplies the residual charge of the battery as a percentage of the full charge level.

⑨ **Temperature**

°C value. This is the temperature of the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm detection.

⑩ **Motor temperature**

°C value. This is the temperature of the motor windings picked up with an analog sensor inside the motor. Normally this sensor is a PTC Philips KTY84-130. This temperature is used only to raise a warning when the motor temperature overtakes the MOTOR OVERTEMP setting.

⑪ **Accelerator**

From 0.0V to 5.0V. ACCELERATOR reading is in the range 0.0 to 5.0 Vdc.

⑫ **Fork SW 300MM**

ON/OFF. This is the status of fork 300mm switch.

⑬ **Forward switch**

ON/OFF. This is the status of forward signal.

⑭ **Backward switch**

ON/OFF. This is the status of backward signal.

⑮ **Brake switch**

ON/OFF. This is the status of foot brake switch.

⑯ **EPS DC error**

ON/OFF. This is the status of EPS fault signal.

⑰ **Steer pot.**

From 0.0V to 5.0V. Steer angle sensor reading is in the range 0.0 to 5.0Vdc.

⑱ **Steer angle**

˚ value. This is the angle of steering wheel.

(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 **Battery voltage**

Voltage value with 1 decimal digit. Battery voltage value measured at the key on.

② **Motor voltage**

Percentage value. It is the voltage generated by the inverter expressed in percent of the actual battery voltage. 100% means the sine wave width is close to the actual battery voltage; 0% means the sine wave width is null.

③ **Voltage booster**

Percentage value. It is the booster contribute to the voltage really supplied to the motor expressed in percent of the actual battery voltage.

④ **Frequency**

Hz value. This is the frequency of the sine waves the inverter is supplying.

⑤ **Encoder**

Hz value. This is the speed of the motor measured with the encoder and expressed in the same unit of the FREQUENCY reading.

⑥ **Slip value**

Hz value. This is the slip between the frequency and the speed of the motor
(SLIP VALUE = FREQUENCY-ENCODER).

⑦ **Current rms**

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

⑧ **Temperature**

°C value. This is the temperature of the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm detection.

⑨ **Motor temperat.**

°C value. This is the temperature of the motor windings picked up with an analog sensor inside the motor. Normally this sensor is a PTC Philips KTY84-130. This temperature is used only to raise a warning when the motor temperature overtakes the MOTOR OVERTEMP setting.

⑩ **Lifting switch**

ON/OFF. This is the status of the lifting switch.

⑪ **Tilt switch**

ON/OFF. This is the status of the tilt switch.

⑫ **Reach switch**

ON/OFF. This is the status of the reach switch.

⑬ **Aux switch**

ON/OFF. This is the status of the aux switch.

⑭ **Hydro speed req.**

Status of the hydro speed request of the pump.

- ON = an hydro speed request is received via canbus.
- OFF = no hydro speed request active.

⑮ **Load weight**

kg . This displays load weight when LOAD SENSOR option is on.

⑯ **Load pot**

From 0.0V to 5.0V. Load sensor reading is in the range 0.0 to 5.0 Vdc.

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.

8) EPS TROUBLESHOOTING

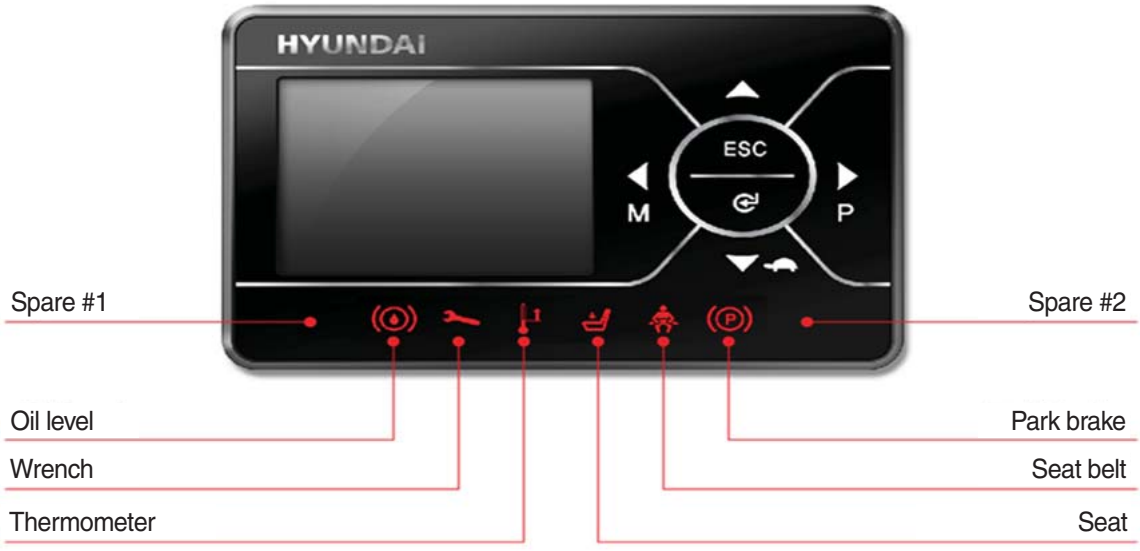
Problem	Preparable cause	Remedy
No working	※ Although the key is turned, It doesn't operate. · Check the input power. · Can you measure 20~60V in No.2 & No.10 controller? ↓ It's not power problem. · Connector contact of torque sensor is unstable. · Check the contact condition. · Although connector is equipped again, is it impossible to operate it? (At that time, check the operation with repeating key ON/OFF.) ↓ It is disrelated. · Is output power of torque sensor normal? · Check the voltage between No. 5 controller and No. 3 controller whether it is 3V~9V. ↓ It is under specification. · Check the operation of contactor. · Is the voltage between No. 1 controller and No.11 controller similar with input power. (Key on) ↓ It is similar with input power. · Check connector whether it is contacted. · Can you measure the input power between No.15 controller (-) and No. 16 controller? (Key on) ↓ It is similar with input power. · Check the motor electric wiring and burning. · Check the commutator after removing motor maintenance cover. (Key on) ↓ It's clean. · Controller failure → Replace it.	→ No power · It's not EPS problem. Power charging condition or main contactor isn't operated. The other system error. → It operate occasionally. · Replace or repair connector pin. → It is not 3V~9V. · Check the electric wiring. · Electric wiring of torque sensor failure · Torque sensor failure → Replacement → It's close to 0V. · Connector failure → Replacement · Check whether connector terminal is combined abnormally, · Check the filter wiring and terminal. → It is getting black and dug.
Weighty feeling of steering wheel	※ Steering wheel is getting weighty during driving (It differ from weighty feeling of EPS OFF condition). Is getting light when wheel is rotated other side. · If key switch is turned on after being turned off, Is steering wheel getting light? ↓ It's still weighty. · Is it similar with input power when the voltage of No. 5 terminal (-) and No. 13 terminal (+) of controller is measured. ↓ It's similar with input power. · Can you measure 3V~9V between No. 5 terminal (-) and No. 3 terminal of controller when motor connector is removed and steering wheel is rotated left and right. ↓ Voltage is less 4~8V than specification. · Torque sensor is failed. Replace it. ※ Does this problem happen occasionally?	→ Yes · It is normal. In case of long time steering to one way, controller reduce current automatically. → It is getting light. · It which operate normally now is caused by input power malfunction. → It's close to 0V. · Inner parts failure of controller. → Replace or repair it. → Yes · Check the motor whether it was burnt out. → Yes · It return to normal caused by main power. · Check the contact of torque sensor harness. · Check the motor whether it was burnt out.

Problem	Preparable cause	Remedy
Weighty feeling of steering wheel	※ Is one way of steering wheel light and is the other way weighty?	→ Yes ・ Torque sensor replacement (low wheel speed condition). ・ Controller replacement (Between low wheel speed and high wheel speed symptom is same, FET burn).
Wheel locking	※ Suddenly, wheel is locked during driving. (EPS stop) Is it normal when main power is turned off and turned on. ↓ Yes, and repeat again. ・ Check the motor whether it was burnt out. ・ Check the commutator after removing cover. ↓ It is clean. ・ Connector contact of torque sensor is unstable. ・ Check the contact. Is it impossible to operate it when connector is moved or installed again. (At that time, check whether it can be operated. ↓ It's same. ・ Check the output value of torque sensor. ・ Check whether between No. 5 controller and No.3 controller is under 3~9V.	→ No operation. ・ Refer to trouble table. → It's getting black and burnt out. ・ Replace motor. → It operate occasionally according to contact of wiring. ・ Replace or repair connector pin.
Wheel locking momentarily	※ It is getting normal when you stop to rotate steering wheel momentarily and rotate it again. ↓ Yes, and repeat again. ・ Check the motor whether it was burnt out. ・ Check the commutator after removing cover. → It was and burnt out.	→ No operation. ・ Refer to trouble table. → Replace motor.
Wheel shaking	※ Steering wheel shake during driving. Steering wheel shake in the special range. ↓ It is still shaked. ・ Controller amplifier rate is too high. (Carry out amplifier rate test with shifting down step by step.)	→ Yes ・ Is it uneven place? ・ Chain tension or chain gear ablation is strong. ・ Is spline shaft of torque sensor bent or eccentric by the external force.
Wheel rotation	※ Steering wheel rotate to one way automatically.	・ Replace torque sensor as manufacture failure. ・ Replace torque sensor as life limit.
A few wheel rotation	※ Steering wheel rotate as 0°~90° when main power is supplied or stopped.	・ In case of uneven, problem happen. ・ In case chain tension is too strong, problem happen. ・ Check disconnection. (It should be disconnected with torque sensor input power.) (Check whether it connected with the other line.)

6. INSTRUMENT PANEL : DISPLAY

1) STRUCTURE

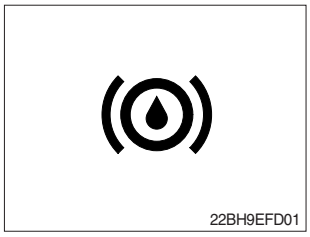
The DISPLAY has 6 red LEDs indicating the status information of the lift truck to the driver.



22BH9OM65

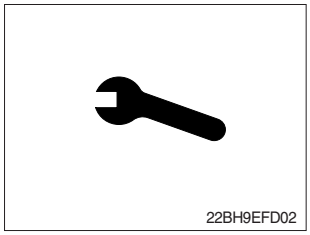
2) WARNING LAMP

(1) Brake oil level warning lamp



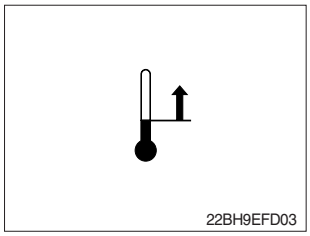
Lights when the brake oil level in the reservoir is below the lower limit.

(2) Wrench warning lamp



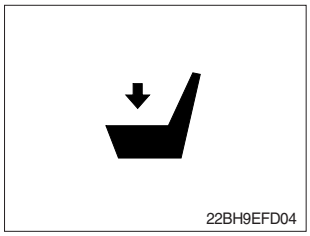
This LED lights when an electric device (controller, motor, cable, etc.) is in alarm condition.

(3) Thermometer warning lamp



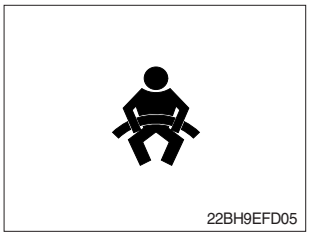
This LED lights when the controller or motor temperature is high.

(4) Seat warning lamp



This LED lights when the operator is not on the seat.

(5) Seat belt warning lamp

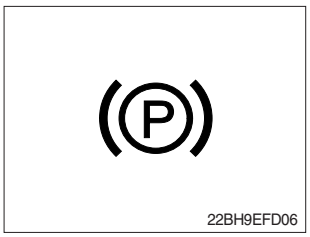


(1) This LED blinks in following 2 cases.

① When operator starts the truck, LED blinks for 5 seconds, which means initial diagnosis is on going, and buttons on display will work properely just after the diagnosis is completed.

② LED blinks when the seat belt is not correctly fastened.

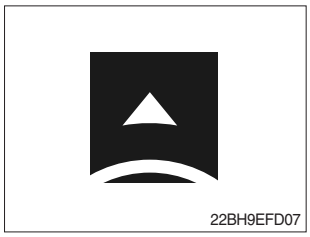
(6) Handbrake warning lamp



(1) This LED lights when the handbrake is activated.

3) BUTTONS

(1) UP button

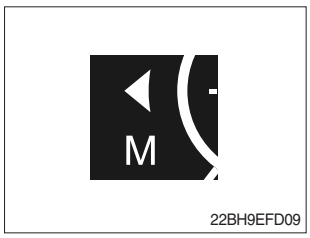


Press to select upward move

(2) DOWN button (DOWN/TURTLE button)

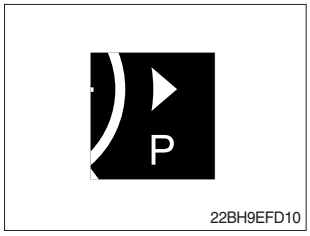
Press to select downward move
TURTLE MODE ON/OFF

(3) LEFT/MENU button



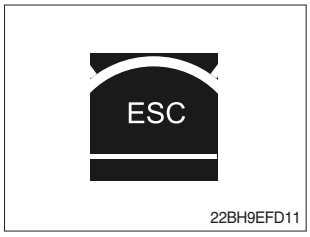
Press to select leftward move
Go into the menu

(4) RIGHT/PERFORMANCE button



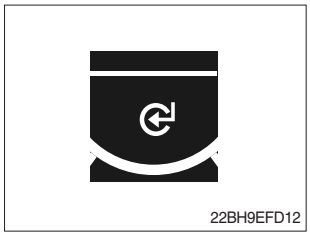
Press to select rightward move
POWER MODE H/N/E

(5) Cancel (ESC) button



Press to select cancel
Keep pressing this button shows PASSWORD entry field.

(6) ENTER button



Press to select Enter

4) LCD FUNCTION (MAIN SCREEN)

MAIN SCREEN

22BH9EFD13

1	Current time	6	Hour meter
2	Turtle mode	7	Wheel position and running direction
3	Truck speed pointer	8	Power mode
4	Speed level	9	BDI (Battery Discharge Indicator)
5	Truck speed	10	Load weight (option)

(1) Current time

The number shows the current time according to the setting, which can be changed by DISPLAY Setting [6. 5), Page 7-51].

(2) Turtle mode

The turtle symbol is normally off. When this symbol appears, the Turtle Mode is activated regardless of the Power Mode of the truck to reduce the maximum speed to the setpoint. This mode can be activated by pressing the  button.

(3) Truck speed pointer

The speed of the truck is indicated with a pointer.

(4) Speed level

This indicator shows the truck speed same as the (3) Speed pointer.

(5) Truck speed

The truck speed is shown in number. According to the DISPLAY setting km/h or mph unit is available.

(6) Hour meter

The number shows the hours worked. The letter present near the hour meter shows which hour meter is displayed.

- hK: the Key Hour shows the truck Key ON time;
- hT: the Traction Hour shows the Gate ON (driven) time of the traction motor.
- hP: the Pump Hour shows the Gate ON (driven) time of the pump motor.

(7) Wheel position and running direction

The arrow point is up when the truck is forward running and points down when the truck is reverse running. The arrow point is moved to the leftward or the rightward according as the direction of the steering angle.

(8) Power mode

The letter; H, N, or E, shows the Power Mode which is being used in the controller. The mode can be scrolled by pressing the 

button sequentially. When a mode is selected, the related information will be sent via CAN-BUS to traction and pump controllers that will manage this data.

H (High) - corresponds to the highest performance
N (Normal) - corresponds to normal performance
E (Economic) - corresponds to economic performance

(9) BDI (Battery Discharge Indicator)

The battery state of charge is shown by ten bars. Each bar represents the 10% of the battery charge. As the battery becomes discharged, the bars turn off progressively, one after another, in proportion to the value of the residual battery charge. When the residual battery charge is 20% or under, the bars displayed become red.

※ How to adjust BDI

If necessary, service man can a adjust BDI with adjustment #1, #2 BDI menu.

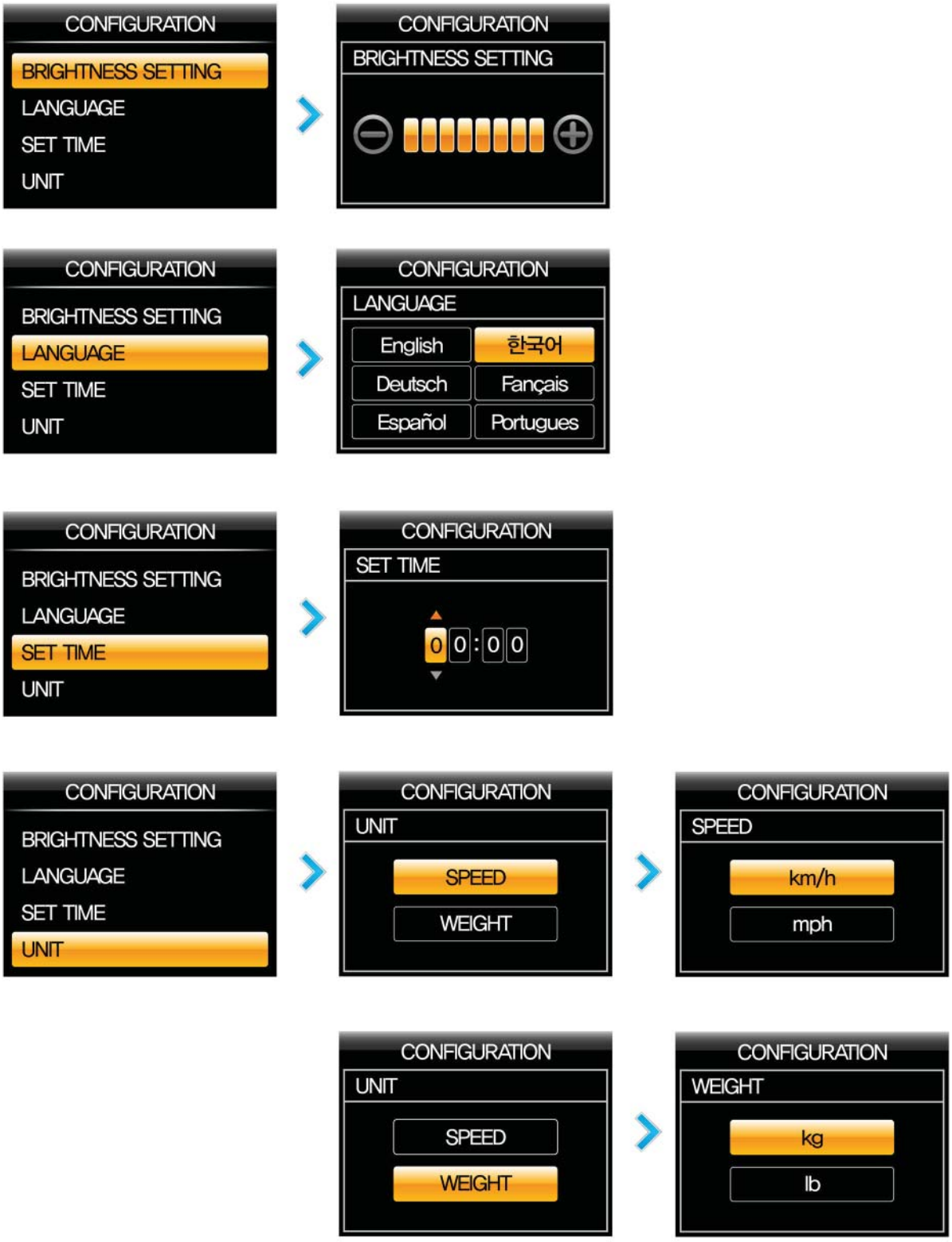
① BAT. MAX ADJ.

It adjusts the upper level of the battery discharge table. Higher value means higher voltage.

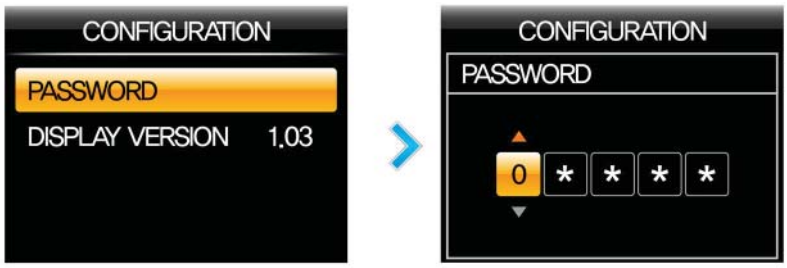
② BAT. MIN ADJ.

It adjusts the lower level of the battery discharge table. Higher value means higher voltage. (for detail menu, please refer to page 7-30)

5) HOW TO USE DISPLAY MENU



22BH9EFD14


CONFIGURATION
PASSWORD
DISPLAY VERSION 1.03
CONFIGURATION
PASSWORD
0 * * * *

20BC9EFD15

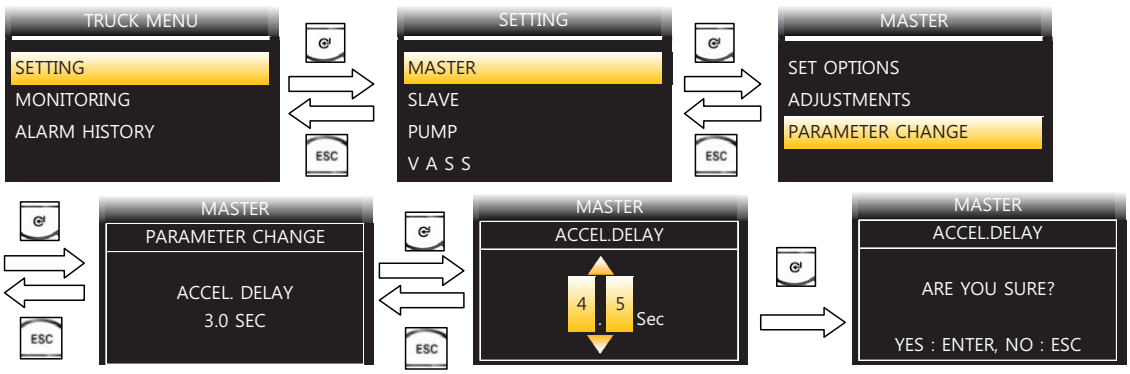
6) DESCRIPTION OF THE TRUCK MENU

(1) Access to truck menu

ESC If this button is pressed long, the PASSWORD dialog appears.
Enter correct PASSWORD, then on MAIN SCREEN, Press M button to access the controller "TRUCK MENU"

(2) How to change detail menus

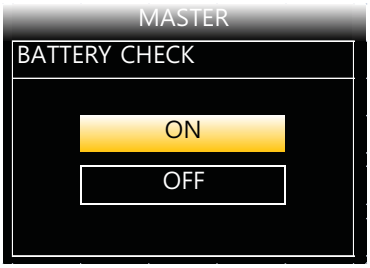
The detail items of menu can be changed as follows ;



22B9EL24

Selection can be made in 4 methods as follows ;

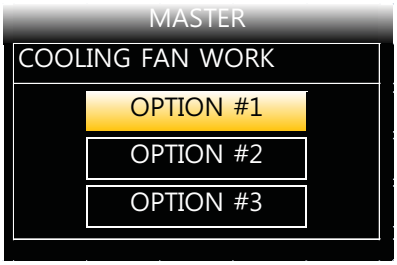
- ON/OFF Selection



22B9EL25

Select a desired value with ▲ , ▼ button, then save with ↵ button or press ESC button to escape without saving.

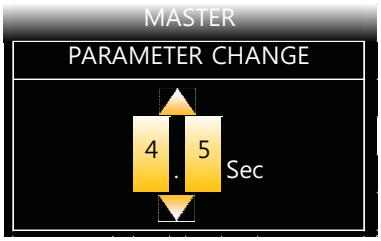
- Type Selection



22B9EL30

Select a desired value with ▲ , ▼ button, then save with ↵ button or press ESC button to escape without saving.

- Level Selection



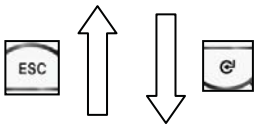
22B9EL30

Select a desired value with ▲ , ▼ button, then save with ↵ button or press ESC button to escape without saving.

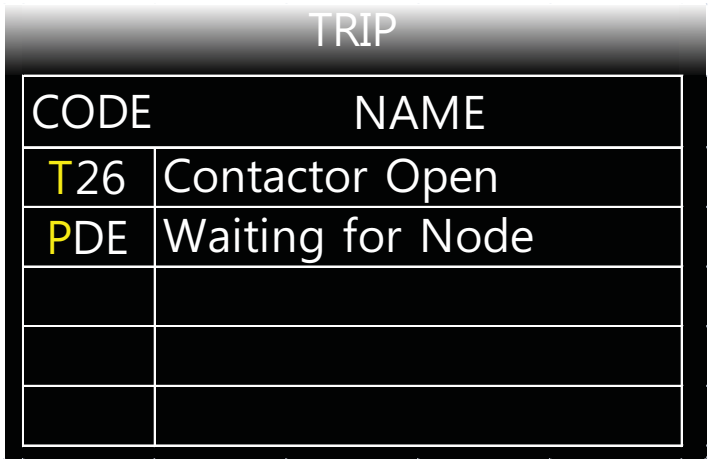
7) ALARM & ALARM HISTORY

(1) How to check alarms

Normally, ALARM SCREEN pops up if any kind of a alarm happens, but service man can switch between a MAIN SCREEN and ALARM SCREEN with ESC , ↵ buttons as follows :

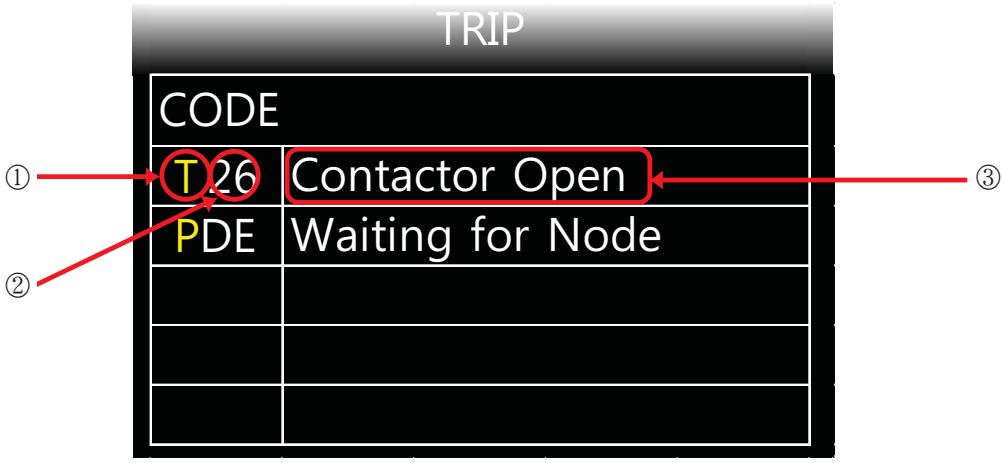


(Press more than 1 sec)



18BR9EL35

(2) Detail description of ALARM SCREEN

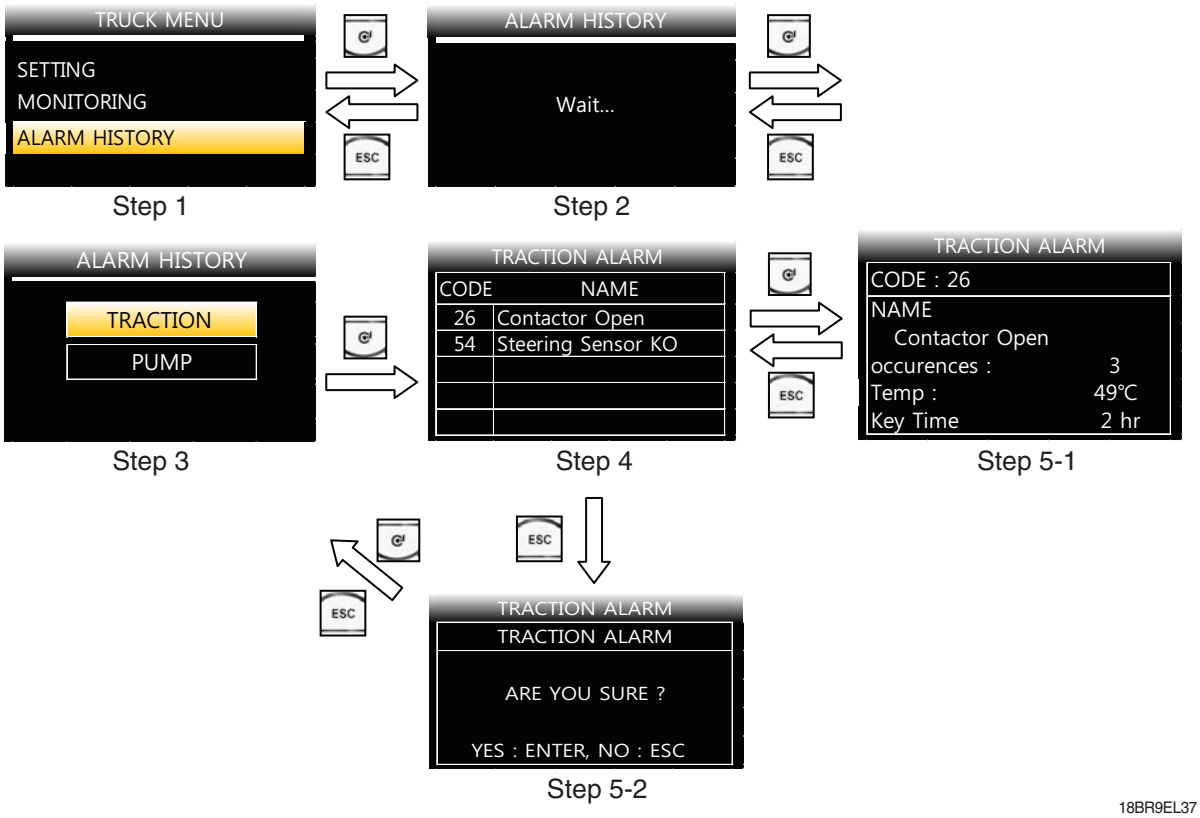


18BR9EL36

① First yellow capital letter shows in which controller the alarm happens as below;
T : Traction
P : Pump
② Following two letters or digits show alarm code. Please refer to 7. ALARM CODE (Page 7-63).
③ This shows a name of ALARM. Please refer to 7. ALARM CODE (page 7-63).

(3) Alatm history

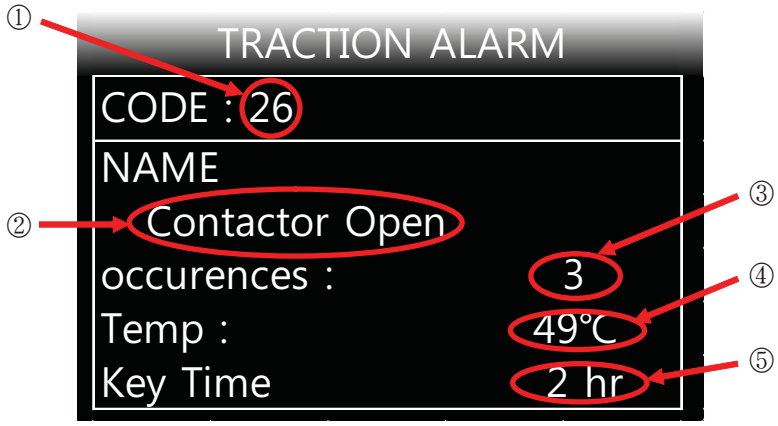
Alarm History can be looked up as follows ;



18BR9EL37

① Step 1 : Service man can check the alarm history on ALARM HISTORY menu
② Step 2 : When service man enter the ALARM HISTORY menu, display read entire alarm records of all controller. So it takes 9~15 seconds to read.
③ Step 3 : When display finish to read alarm records, service man can choose each controller to read the alarm history.
④ Step 4 : When service man enters each controller's alarm history, service man can check simply up to 5 alarms and choose a specific alarm to read detail alarm information.
⑤ Step 5-1 : When service man press [↵] button at Step 4, operator can see a detail alarm information of chosen alarm. Please refer to 6-7)-(4) DETAIL ALARM INFORMATION (page 7-57)
⑥ Step 5-2 : When service man press [ESC] button at Step 4, service man can see a alarm clear menu. If service man press [↵] button, Recorded alarms of selected controller will be erased.
(to verify cleaned alarm records, service man should be back to Step 1 & 2 to refresh.)
If operator press [ESC] button, just escape to step 3 without clearing

(4) Detail alarm information



22B9EL38

① Code of alarm
② Name of alarm
③ Count of alarm
④ Temperature of controller as alarm occurs.
⑤ Hourmeter of controller as alarm occurs.

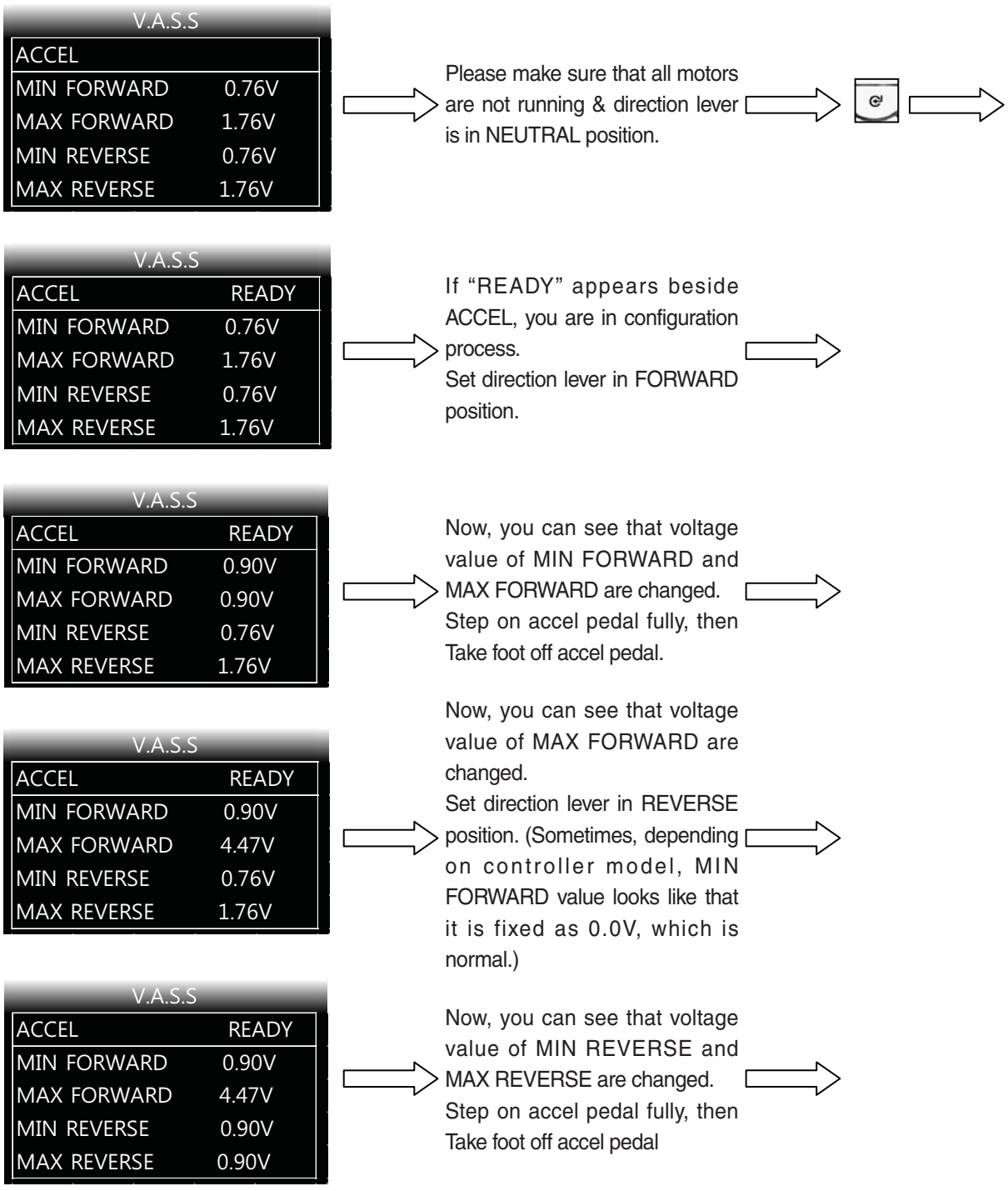
8) VASS SETUP USING DISPLAY MENU

This function searches and memorizes the minimum and maximum potentiometer wiper voltage of the accelerator pedal, lift lever, and steering sensor which use potentiometer sensors. The belows show how to use the VASS function of DISPLAY.

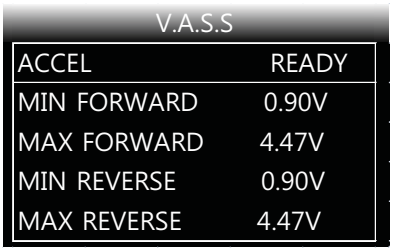
(All figures in belows are just example.)

※ While even a motor is running, VASS can not be configurated properly, so please be sure that all motors are not running before entering configuration process & saving.

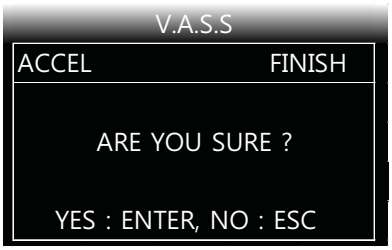
(1) ACCEL VASS setting method



22B9EL39-1

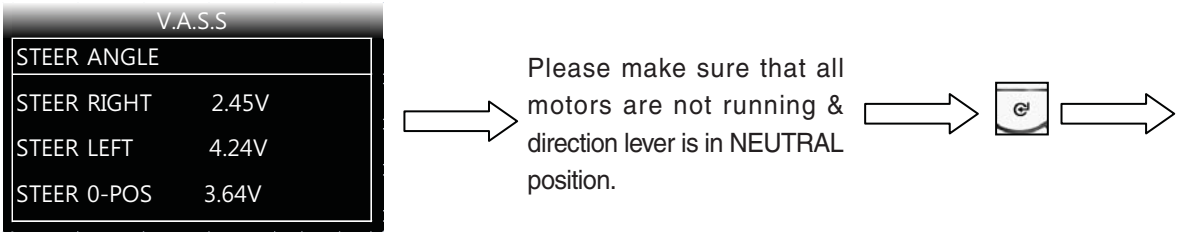


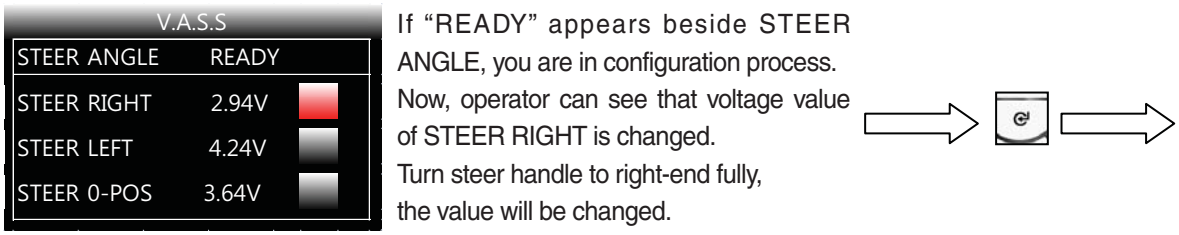
Now, you can see that voltage value of MAX REVERSE are changed.
Please make sure that all motors are not running & direction lever is in NEUTRAL position.

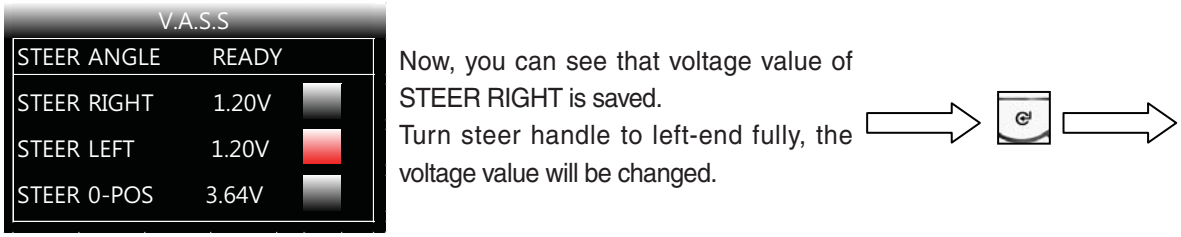


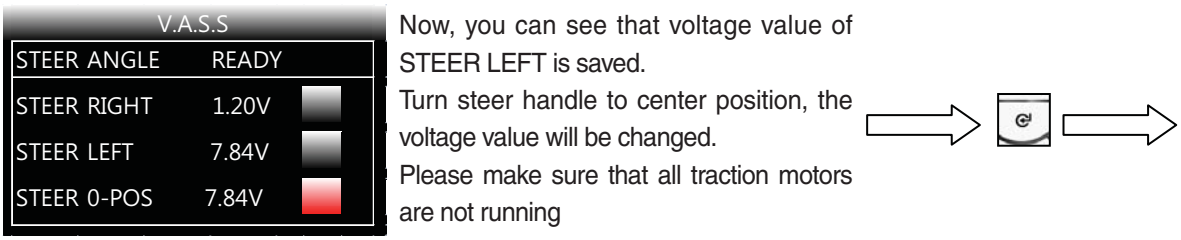
22B9EL39-2

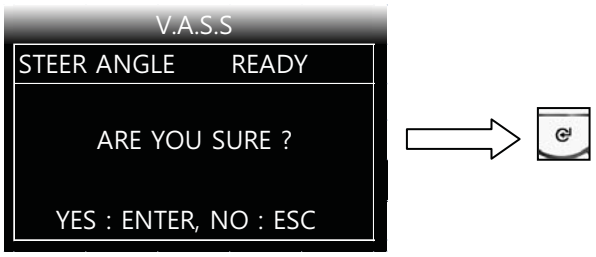
(2) STEER ANGLE VASS setting method











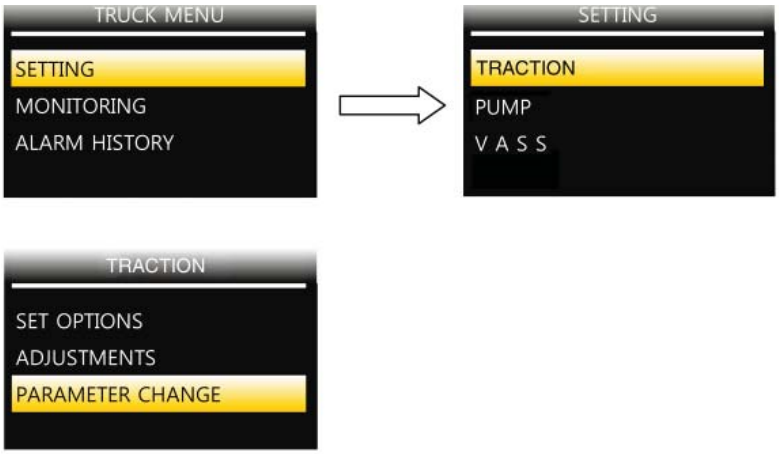
22B9EL41

9) STRUCTURE OF TRUCK MENU

TRUCK MENU is in order to make configuration of truck easily, and consists of 3 major categorys : SETTING, MONITORING, ALARM HISTORY.

[To know how to get in to TRUCK MENU, refer to 6-6)-(1) “ACCESS TO TRUCK MENU” page 7-53]

(1) Settings



20BC9EL42

In SETTINGS, service man can choose a specific controller’s submenu or VASS menu.

① TRACTION->SET OPTIONS
Refer to 5-4)- ■ “TRACTION CONTROLLER”-(1) “SET OPTIONS” (page 7-28)

② TRACTION->ADJUSTMENTS
Refer to 5-4)- ■ ”TRACTION CONTROLLER”-(2) “ADJUSTMENTS” (page 7-29)

③ TRACTION->PARAMETER CHANGE
Refer to 5-4)- ■ ”TRACTION CONTROLLER”-(3) “PARAMETER CHANGE” (page 7-31)

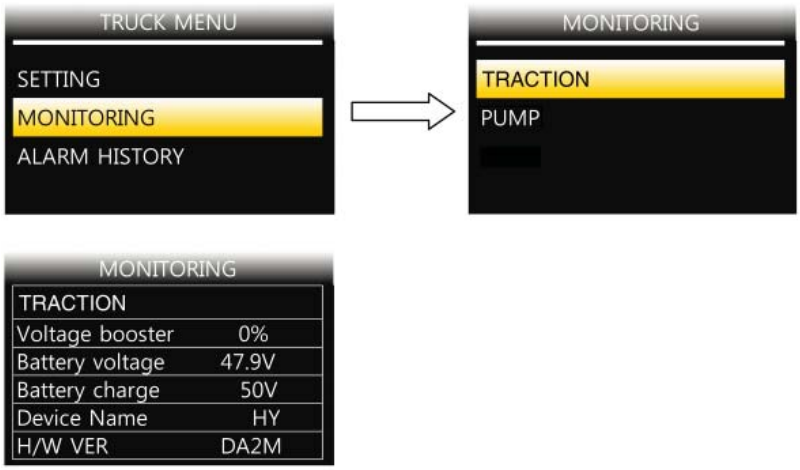
④ PUMP->SET OPTIONS
Refer to 5-4)- ■ “PUMP CONTROLLER”-(1) “SET OPTIONS” (page 7-33)

⑤ PUMP->ADJUSTMENTS
Refer to 5-4)- ■ ”PUMP CONTROLLER”-(2) “ADJUSTMENTS” (page 7-34)

⑥ PUMP->PARAMETER CHANGE
Refer to 5-4)- ■ ”PUMP CONTROLLER”-(3) “PARAMETER CHANGE” (page 7-35)

⑦ V.A.S.S
Refer to 6-8) “VASS SETUP USING DISPLAY MENU” (page 7-58)

(2) Monitoring



20BC9EL43

In MONITORING MENU, service man can check various stats of trucks.

① TRACTION

Refer to 5-6)-(1) “Traction controller” (page 7-40)

② PUMP

Refer to 5-6)-(3) “Pump controller” (page 7-41)

(3) Alarm history

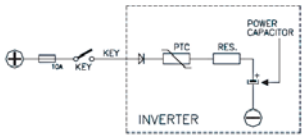
Refer to 6-7) “ALARM & ALARM HISTORY” (page 7-55)

7. ALARM CODE

1) TRACTION CONTROLLER

No	Code	Alarm name	Traction (T)	Pump (P)	Description	
					Cause	Troubleshooting
1	D	EEPROM KO	○	○	It's due to a Hardware or Software defect of the non-volatile embedded memory supporting the controller parameters. This alarm does not inhibit the machine operations, but the truck will work with the default values.	- Try to execute a CLEAR EEPROM operation (Please ask to the engineer). Switch the key off and on to check the result. If the alarm occurs permanently, it is necessary to replace the controller. If the alarm disappears, the previously stored parameters will have been replaced by the default parameters.
2	11	Logic Failure#3	○	○	Hardware problem in the logic card circuit for high current (overload) protection.	- This type of fault is not related to external components, so, when it is present it is necessary to replace the ACE logic board.
3	12	Logic Failure#2	○	○	Fault is in the hardware section of the logic board which manages the phase's voltage feedback.	- This type of fault is not related to external components, so when it happens it is necessary to replace the ACE2 logic board.
4	13	Logic Failure#1	○	○	This fault is displayed when the controller detects an over voltage or under voltage condition. In 48V controller over voltage threshold is 65V, under voltage threshold is 11V.	Troubleshooting of fault displayed at start-up or in standby; in these cases it is very likely the fault is due to an under voltage, so it is suggested to check: - Key input signal down-going pulses (below under voltage threshold) due to external loads, like DC/DC converters starting-up, relays or contactor switching, solenoids energizing / de-energizing. - Check the connection of power cables to the battery terminal, positive and negative, to MC and to controller +Batt and –Batt, which must be screwed with a torque comprised in the range 13 Nm÷15 Nm. - If no voltage transient is detected on the supply line and the alarm is present every time the key is switched ON, the failure is probably in the controller hardware, so it is necessary to replace the logic board. Troubleshooting of fault displayed during motor driving; in this case it can be an under voltage or an over voltage condition. - If the alarm happens during traction acceleration or driving hydraulic functions, it is very likely it is an under voltage condition; check battery charge condition, power cable connection. - If the alarm happens during release braking, it is very likely it is due to over voltage condition; check line contactor contact, battery power cable connection.

No	Code	Alarm name	Traction (T)	Pump (P)	Description	
					Cause	Troubleshooting
5	1E	VMN Low	○	○	Start-up test. Before switching the LC on, the software checks the power bridge: it turns on alternatingly the High side Power Mosfets and expects the phases voltage to increase toward the rail capacitor value. If the phases voltage is less than 66% of the rail capacitor voltage, this alarm occurs.	- If the problem occurs at start up (the LC does not close at all), check: - Motor internal connections (ohmic continuity) - Motor power cables connections. - Motor leakage to truck frame. - If the motor connections are OK, the problem is inside the controller, replace it.
					Motor running test. When the motor is running, power bridge is ON, the motor voltage feedback is tested; if it is lower than commanded value (a window of values are considered) fault status is entered.	- If the alarm occurs during motor running, check: - Motor connections. - If motor phases windings/cables have leakages towards truck frame. - That the LC power contact closer properly, with a good contact. - If no problem are found on the motors, the problem is inside the controller, replace it.
6	1F	VMN High	○	○	Before switching the LC on, the software checks the power bridge: it turns on alternatingly the Low side Power Mosfets and expects the phases voltage to decrease down to -BATT. If the phases voltage is higher than 10% of nominal battery voltage, this alarm occurs.	- If the problem occurs at start up (the LC does not close at all), check: - Motor internal connections (ohmic - continuity). - Motor power cables connections. If the motor connection are OK, the problem is inside the controller, replace it.
					This alarm may occur also when the start up diagnosis is overcome, and so the LC is closed. In this condition, the phases' voltages are expected to be lower than 1/2 Vbatt. If it is higher than that value, fault status is entered.	- If the problem occurs after closing the LC (the LC closed and then opens back again), check: - Motor connections. - If motor phases windings/cables have leakages towards truck frame. - If no problem are found on the motors, the problem is inside the controller, replace it.
7	25	Contector Closed	○		Before driving the MC coil, the controller checks if the contactor is stuck. The controller drives the bridge for some tens milliseconds, trying to discharge the capacitors bank. If the capacitor voltage does decrease by 20% of the key voltage the alarm is generated.	- It is suggested to verify the power contacts of LC; to replace the LC is necessary.

No	Code	Alarm name	Traction (T)	Pump (P)	Description	
					Cause	Troubleshooting
8	26	Contactor Open	○	○	The main contactor coil has been driven by the controller, but the contactor does not close.	- It could be a problem of the contacts in the MC that are not working (does not pull-in), try replacing the MC. - If the contactors of MC are working correctly than the problem is in the controller, replace it.
9	35	Stby I High	○	○	The current transducer or the current feedback circuit is damaged in the controller.	- This type of fault is not related to external components so, when it is present, it is necessary to replace the controller.
10	3C	CAPACITOR CHARGE	○	○	 When the key is switched ON, the inverter tries to charge the power capacitors through a series of a PTC and a power resistance, and check if the capacitor are charged within a timeout. If the capacitor voltage measured is less than 20% of the nominal battery voltage, an alarm is signalled; the main contactor is not closed.	- There is an external load in parallel to capacitor bank, which sinks current from the controller capacitors pre-charging circuit, thus preventing the caps from charging. Check if a lamp or a dc/dc converter or an auxiliary load is placed in parallel to - capacitor bank. The charging resistance or PTC is opened; insert a power resistance across line contactor power terminals; if the alarm disappears, it means the controller internal - charging resistance is damaged. The charging circuit has a failure, inside the - controller. There is a problem in the controller power section.
11	3E	TH. Protection	○	○	This alarm occurs when the temperature of the base plate is higher than 85°C. Then the maximum current decreases proportionally with the temperature increases from 85°C up to 105°C. At 105°C the current is limited to 0 Amps.	- It is necessary to improve the controller cooling. For realise an adequately cooling in case of finned heat sink are important factor the flux (m^3/h) and temperature (°C) of cooling air. In case of thermal dissipation realised with the controller base plate installed on truck frame it is important the thickness of frame and the planarity and roughness of its surface. If the alarm is signalled when the controller is cold, the possible reasons are a thermal sensor failure or a failure in the logic card. In this case, it is necessary to replace the controller.
12	41	Motor Temperat.	○	○	This warning occurs when the temperature sensor is opened (if digital) or has overtaken the threshold of 150°C (if analogue).	- Check the thermal sensor inside the motor (use the MOTOR TEMPERATURE reading in the MONITOR menu); check the sensor ohmic value and the sensor wiring. If the sensor is OK, improve the cooling of the motor. If the warning is present when the motor is cool, then the problem is inside the controller.

No	Code	Alarm name	Traction (T)	Pump (P)	Description	
					Cause	Troubleshooting
13	42	BATTERY LOW	○		If the "battery check" option is Level 1 or Level 2, a battery discharge algorithm is carried out. When the charge level is 10%, this alarm is signalled	- Check the battery voltage and charge the battery.
14	4A	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	This type of fault is not related to external components; replace the ACE2 logic board.
15	4B	Contactor Driver	○	○	The MC coil driver is not able to drive the load. The device itself or its driving circuit is damaged.	This type of fault is not related to external components; replace the ACE2 logic board.
16	4E	VACC Not OK	○		The test is made at key-on and immediately after that both the travel demands have been turned off. This alarm occurs if the ACCELERATOR reading in the TESTER menu' is 1.0V higher than VASS min acquisition when the accelerator is released.	Acquire the maximum and minimum potentiometer value through the VASS function. If the alarm is still present, check the mechanical calibration and the functionality of the potentiometer. If the alarm is not disappeared the failure is in the ACE logic board, replace it.
17	4F	Incorrect Start	○	○	This is a warning for an incorrect starting sequence.	The possible reasons for this alarm are (use the readings in the MONITOR menu to facilitate the troubleshooting): - A travel demand active at key on - Presence man sensor active at key on Check the wirings. Check the micro switches. It could be also an error sequence made by the operator. A failure in the logic is possible too; so when all of the above conditions were checked and nothing was found, replace the ACE logic board.
18	50	FORW + BACK	○		This alarm occurs when both the travel demands (Fwd and Bwd) are active at the same time.	Check the wiring of the Fwd and Rev travel demand inputs (use the readings in the TESTER to facilitate the troubleshooting). Check the microswitches for failures. A failure in the logic is possible too. So, when you have verified the travel demand switches are fine working and the wiring is right, it is necessary to replace the ACE-2 logic board.

No	Code	Alarm name	Traction (T)	Pump (P)	Description	
					Cause	Troubleshooting
19	52	Encoder Error	○	○	This fault is signalled in following conditions: the frequency supplied to the motor is higher than 40 Hz and the signal feedback from the encoder has a jump higher than 40 Hz in few tens mSec. This condition is related to a malfunctioning of the encoder.	Check both the electric and the mechanical encoder functionality, the wires crimping. - Check the encoder mechanical installation, if the encoder slips inside its compartment raising this alarm condition. - Also the electromagnetic noise on the sensor bearing can be a cause for the alarm. In these cases try to replace the encoder. - If the problem is still present after replacing the encoder, the failure is in the controller.
20	54	Steer Sensor KO	○		Steering sensor signal out of range	Check the steering sensor wiring connection. If wiring is ok, measure sensor output is within 5 V. If so, do the setting procedure. If problem is not clear, change the controller. If remove the steer sensor function, steer sensor set to off. In this case, travel speed cutback function is not activated and can't display the steer angle.
21	CA	CANBUS DISP. KO	○		Traction inverter can't detect the Display CAN signal.	Check display wiring. If it is ok, replace the display.
22	CB	TRUCK MISMATCH	○		Mode truck setting is different between traction inverter and pump inverter.	Recycle the key.
23	CC	EPS DC Error	○		Traction inverter detect EPS fault signal.	If EPS system is down, check EPS system. If EPS system works well, check the EPS fault signal wiring.
24	CD	Pedal Wire KO	○		Detect the fault in accelerator negative (NPOT) input circuit.	Check the wiring between accelerator and controller. If wiring is ok, check the curcuit inside the accelerator. If the accelerator is ok, replace the controller.
25	D9	Sens Mot Temp KO	○	○	The output of the motor thermal sensor is out of range.	Check the sensor ohmic value and the sensor wiring. If the sensor is OK, then the problem is inside the ACE logic board, replace it.
26	DA	Load Sens. Error		○	Load weight sensor detects that loaded weight exceeds the weight limitation, or load weight sensor is not working properly	Check the load weight sensor.
27	DB	Over Load		○	Load weight sensor detects that loaded weight exceeds the weight limited in OVERLOAD WEIGHT programming.	Remove the warning condition.

No	Code	Alarm name	Traction (T)	Pump (P)	Description	
					Cause	Troubleshooting
28	DE	Waiting for Node	○	○	Controller detects that the other Controller is malfunctioning or ALARM occurs.	Check if any other alarm happens (Some alarms such as CHAT TIME or PEDAL WIRE KO, alarms related to CONTACTOR, DISPLAY ENABLE, alarms related to CANBUS can make this alarm sometimes.) Check the communication with all controllers (display TRUCK MENU->MONITORING ->choose controller->H/W VER, S/W VER. If CAN communication is not availabel, H/W VER, S/W VER will be blank.) Check other controllers.
29	DF	Watchdog#1	○	○	At start-up the watch dog signal is already active before the software has generated it. At stby or running condition the watch dog signal is not active (in alarm status).	The WD hardware circuit or microcontroller output port are damaged. In both cases no external component are involved. Replace the logic board.
30	E0	AUX Coil Short	○	○	This alarm occurs when there is a short circuit of the AUX coils connected to CNA#18 output. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand.	- The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads. - In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.
31	E2	VACC Out range	○		The CPOT input red by the microcontroller is not comprised in the range Vacc_min ÷ Vacc_max, programmed through the “VASS” function.	Acquire the maximum and minimum potentiometer value through the VASS function. If the alarm is still present, check the mechanical calibration and the functionality of the potentiometer. If the alarm is not disappeared the failure is in the ACE logic board, replace it.
32	E3	Watchdog#2	○	○	At start-up the watch dog signal is already active before the software has generated it. At stby or running condition the watch dog signal is not active (in alarm status).	The WD hardware circuit or microcontroller output port are damaged. In both cases no external component are involved. Replace the logic board.
33	E4	Chat Time	○		The chat time has expired.	To activate traction or pump request.
34	E5	Safety Input	○	○	The safety input is opened and accordingly the MC is opened an EB/AUX OUT coil is driven.	Check the CAN#11 input, if it is connected to –Batt and the alarm is generated then there is a fault in the SAFETY IN hardware circuit. Replace the logic board

No	Code	Alarm name	Traction (T)	Pump (P)	Description	
					Cause	Troubleshooting
35	E6	MC Coil Short	○	○	This alarm occurs when there is a short circuit of the MC coils connected to CNA#16 output. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand.	- The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads. - In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.
36	E7	Coil Short HW KO	○	○	The hardware circuits which manages short circuits protection of LC and AUX coils has a problem.	This type of fault is not related to external components; replace the ACE logic board.
37	E8	Key Off Short	○	○	This fault is displayed when the controller detects a low logic level of Key-Off signal during Start-Up diagnosis.	It is very likely the fault is due to an under voltage, so it is suggested to check: - Key input signal down-going pulses (below under voltage threshold) due to external loads, like DC/DC converters starting-up, relays or contactor switching, solenoids energizing / de-energizing. - Check the connection of power cables to the battery terminal, positive and negative, to MC and to controller +Batt and –Batt, which must be screwed with a torque comprised in the range 13 Nm÷15 Nm. - If no voltage transient is detected on the supply line and the alarm is present every time the key is switched ON, the failure is probably in the controller hardware, so it is necessary to replace the logic board.
38	E9	Power MOS Short	○	○	Before switching the MC on, the software checks the power bridge: it turns on alternatingly the Low side and High side Power Mosfets and expects the phases voltage to decrease down to –BATT (increase up to +Batt). If the phases voltage do not follow the commands, this alarm occurs.	This type of fault is not related to external components; replace the controller.
39	EC	Curremt Gain	○	○	The Maximum current gain parameters are at the default values, which means the maximum current adjustment procedure has not been carried out yet.	Ask the assistance of an engineer at the developement department to do the correct adjustment procedure of the current gain parameters

No	Code	Alarm name	Traction (T)	Pump (P)	Description	
					Cause	Troubleshooting
40	ED	Analog Input	○	○	This alarm occurs when the A/D conversion of the analog inputs gives frozen value, on all of the converted signals, for more than 400msec. The goal of this diagnosis is to detect a failure of the A/D converter or a problem in the code flow that omits the refreshing of the analog signal conversion.	If the problem occurs permanently it is necessary to substitute ACE logic board.
41	EE	Wrong 0 Voltage	○	○	At start-up the high resolution VMN feedback is not comprised in a permitted window of values centred around 2,5V. The circuit is damaged in the controller.	It is suggested to check: - Motor internal connections. (ohmic - continuity) - Motor power cables connections. - Motor leakage to truck frame. If the motor connections are OK, the problem is inside the controller, replace the logic board.
42	EF	Safety Output	○	○	The safety out driver is shorted.	- Check if there is a short or a low impedance pull-down between SAFETY OUT (CAN#19) and –BATT. - The driver circuit is damaged in the logic board, which has to be replaced.
43	F0	Hardware Fault	○	○	The Mosfets driver are not switched off from Watch-dog signal during alarm status.	Replace the logic board.
44	F1	Flash CheckSUM	○	○	After Key-on the software verifies the integrity of program stored in the flash memory, if the verify has a negative result this alarm is generated.	The problem is in the microcontroller flash memory, which could be damaged, or in the program stored inside, which could be corrupted. Try to program the logic again, if the alarms is still signalled the problem is in the microcontroller. Replace the ACE logic board.
45	F2	Motor Stall	○	○	The encoder signal is constantly zero when the maximum torque is applied to the motor.	If motor is moving, problem is in the encoder sensor signal. Check the wire connection and encoder sensor output. If motor doesn't move, it is mechnical problem. please check whether motor stuck or not. If not, problem is inside the controller. in this case, replace the controller.
46	F3	SEQUENCE FAULT	○		The wrong operation sequence to begin traction(es. First accel lever signal activated and then forward switch activated)	Check the accel lever signal of forward and backward and accel potentiometer. If it is ok, replace the controller.

No	Code	Alarm name	Traction (T)	Pump (P)	Description	
					Cause	Troubleshooting
47	F4	Software Error	○	○	CAN BUS LINE of ACE2 is in CAN BUS LINE OFF condition.	Check CAN BUS connection. If CAN BUS connection is ok replace the logic of ACE2.
48	F5	Wrong Ram memory	○	○	The algorithm implemented to check the main RAM registers finds a wrong contents: the register is “dirty”. This alarm inhibit the machine operations.	Try to switch the key off and then on, if the alarm is still present replace the ACE2 logic board.
49	F6	AUX Driv. Open	○	○	The AUX coil driver is not able to drive the load. The device itself or its driving circuit is damaged.	This type of fault is not related to external components; replace the ACE2 logic board.
50	F7	Data Acquisition	○	○	Date communication is now processing.	If this alarm occurs. When sensor setting procedure, after finishing the procedure, recycle the key.
51	F8	NO CAN MSG.	○	○	Controller doesn't receive any message from CAN line	Check the CAN line connection. If wiring is ok. Check the communication with all controllers (display TRUCK MENU→MONITORING→choose controller→H/W VER, S/W VER. If CAN communication is not availabel, H/W VER, S/W VER will be blank.)
53	FA	Thermic Sens. KO	○	○	The output of the controller thermal sensor is out of range.	This type of fault is not related to external components; replace the controller.
54	FB	Wrong Set BAT.	○	○	The battery voltage does not correspond to SET BATTERY programming	Check the battery type setting and battery status.
55	FD	Slip Profile	○	○	There is an error on the choice of the parameters of the slip profile.	Ask to the engineer at the development department.
56	FE	AUX Driv. Shrt.	○	○	The driver of the auxiliary coil is shorted.	- Check if there is a short or a low impedance pull-down between NEB/NAUX (CNA#18) and –BATT. - The driver circuit is damaged in the logic board, which has to be replaced.

8. 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.

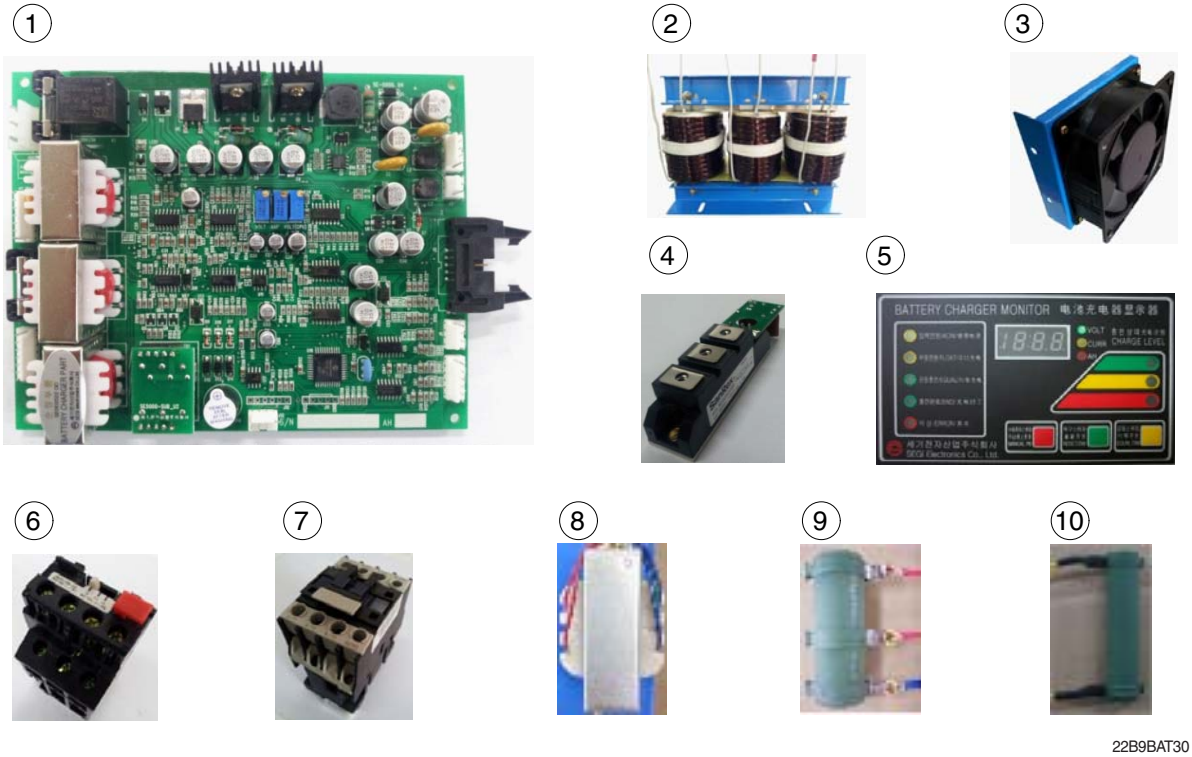
④ Check the electrolyte of the battery every week and provide distilled water immediately if it is required. (Electrolyte has to be provided between 10~12 ㎜ level on the positive plate inside storage battery)

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)



22B9BAT30

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

2) CHARGER INSTALLATION METHOD

(1) Location for charger installation

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

(2) Check points before installing charger

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

(3) Table for capacity of charger input cable

48 V battery	Capacity of cable	Input voltage	Remarks
200-365 AH	4P - 2.5 mm^2	Based on 3 ø 380 V 3 ø 440 V	For 3 ø 220V, one step higher capacity cable should be used. (2.5 mm^2 → 4mm^2)
400-580 AH	4P - 4 mm^2		
600-800 AH	4P - 6 mm^2		
850-1000 AH	4P - 10 mm^2		
24 V battery	-		
200-600 AH	4P - 2.5 mm^2		
700-1000 AH	4P - 4 mm^2		
80V battery	-		
500-600 AH	4P - 6 mm^2		
700-800 AH	4P - 10 mm^2		

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.

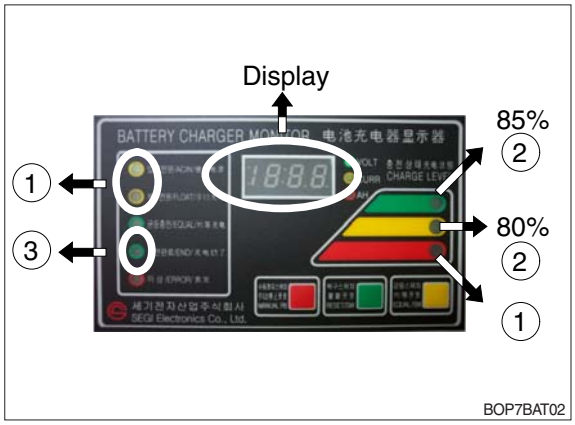
· **According to charging condition**

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 A charging voltage, current, amount and time are displayed in order on a monitor display window.

③ 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.

④ 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.

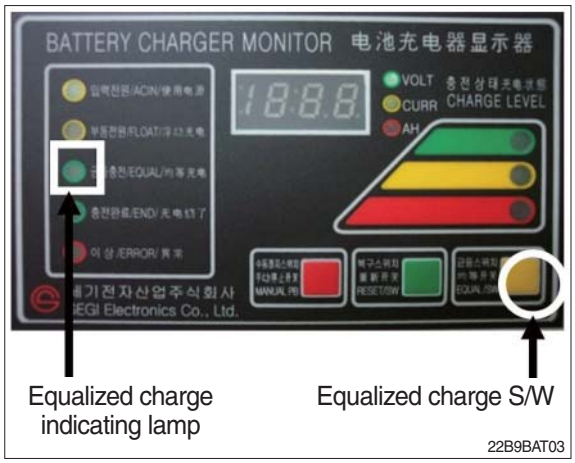
When equalized charging is required?

- 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.**



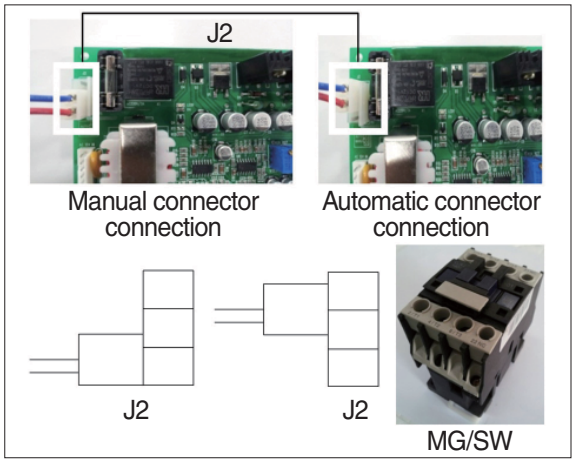
22B9BAT03

(3) Automatic/Manual switching method

Automatic connector. Manual switching connector (J2) is located on a left top corner of PCB.

※ **In case of manual switching for charger checking, make sure that the battery connector is separated beforehand.**

⊙ MG/SW operation
(Refer to the charger trouble SHEET components manual)



22B9BAT04

(4) Checking charging voltage soft start function (Refer to the monitor)

① Plug it into a manual connector and input after 5 sec., a floating charge, charging status red LED lights up.
② After 15 sec., charging status yellow LED lights up.
③ After a green LED lights up, if measured voltage comes out as lula64V by measuring output voltage of battery connector side with multi-meter, then it is normal.
④ After 30 sec. of switching to a manual connector, if a buzzer sound rings continuously for 10 sec. and completion LED lights up, then it is normal.
⑤ If you confirm that the charger operates in normal after checking manual switching of the charger, make sure that the charger is switched to automatic.

BOP7BAT10

⑥ If charger's out voltage is under 60 V, it is abnormal.
Please refer to the error sheet.

⑦ When the charging voltage is indicated as normal condition (64 V), convert automatic / manual switch to automatic and start charging.

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

22B9BAT11

No	Code	Description of error
1	E.F	EPROM fail
2	O.V	Over voltage - Refer to page 7-82
3	O.C	Over current - Refer to page 7-81, 7-83.
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 7-80.
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.

4) CHECK POINTS BEFORE APPLYING A/S

(1) AC input power source switch is input.

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

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

(4) Check the front cover indicator.

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

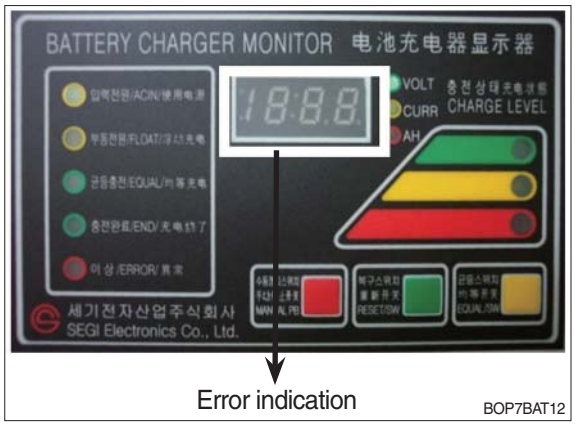
② A.O : Error on selection of input power source of 220V or 380V - Check it appropriately with full three phases.

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

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

⑤ O.V : Check the voltage, as charging voltage of the battery is over-voltage condition (66V).
Normally it is 64V±1.0V.

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



5) 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"

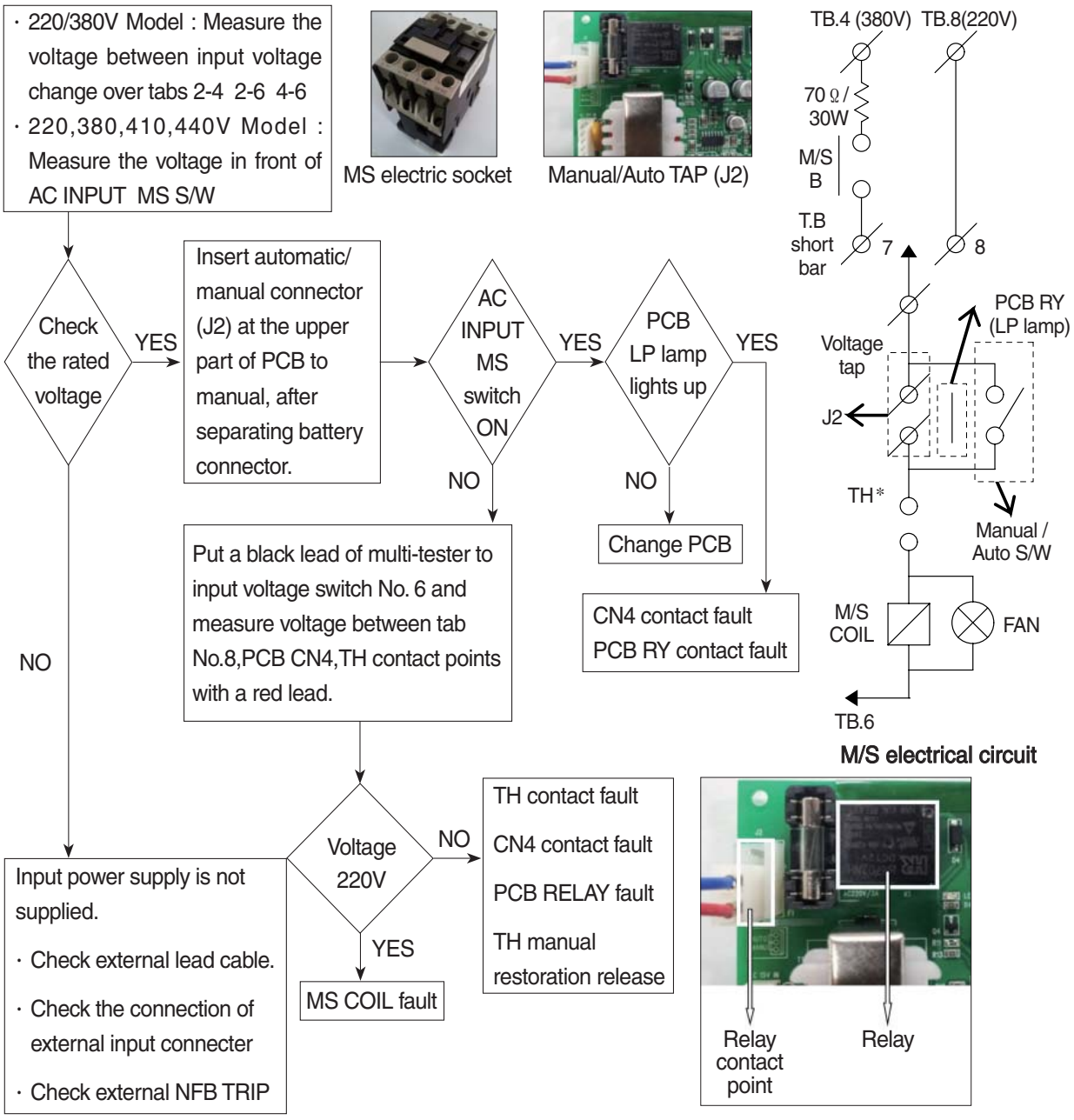
⑤ Charger TRIP is occurred after it started charging and charging completion lamp is on.

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

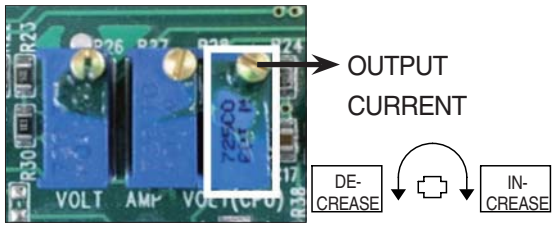
⑦ SCR module checking method

(2) Troubleshooting

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

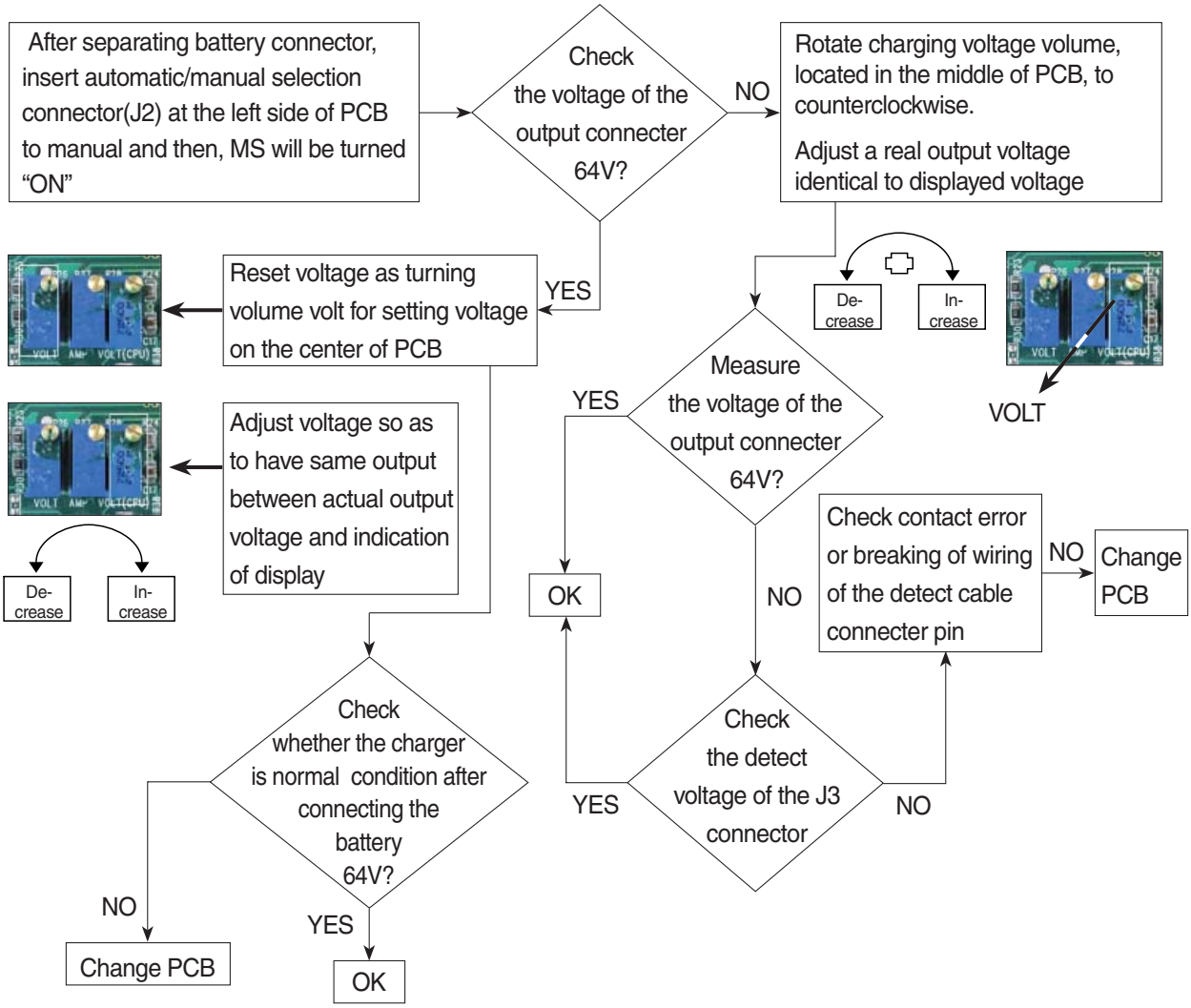


② ON and OFF is repeated with a few minutes intervals after starting charging.
Indicate "O.C" on the monitor.
- TH is operated (AC input over-current TRIP).

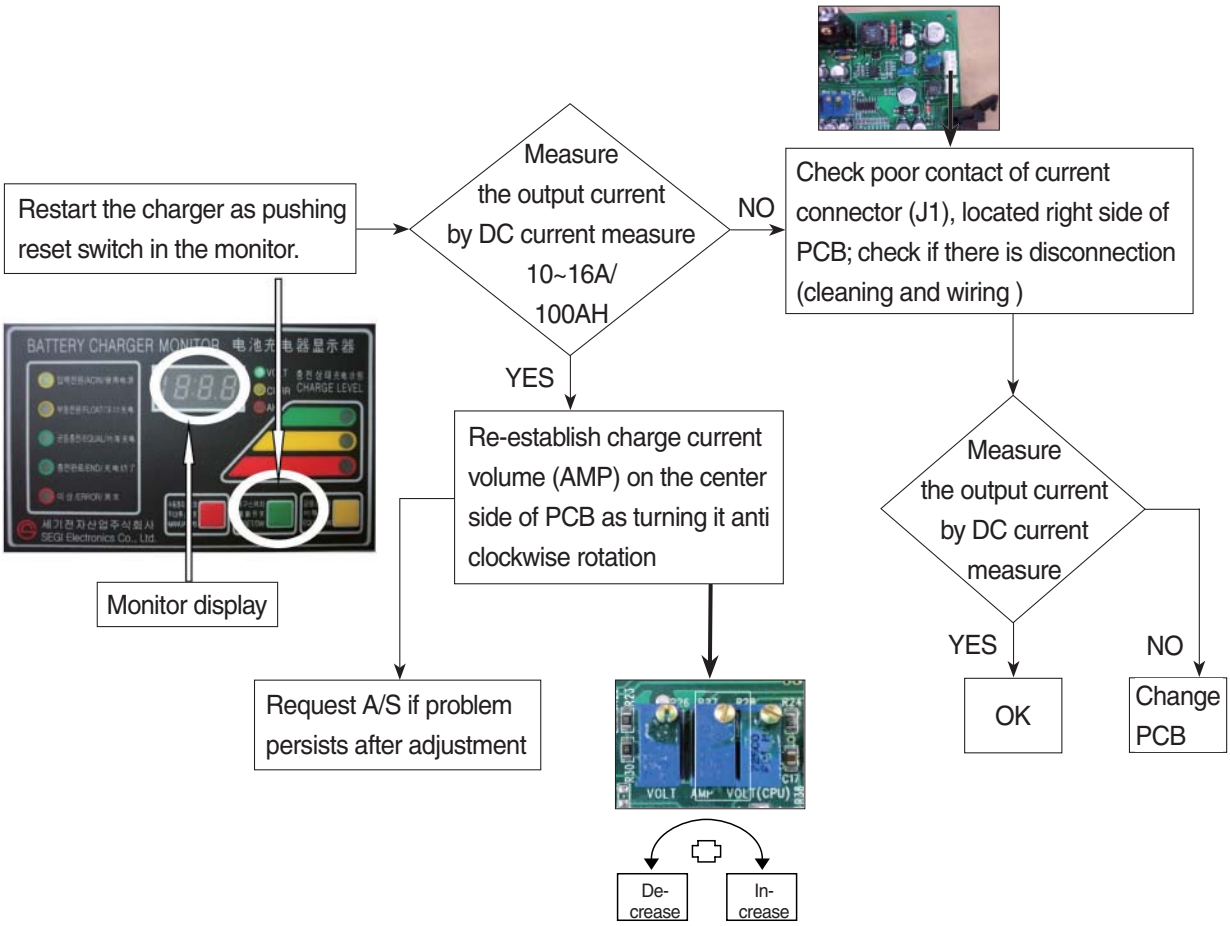


Trans noise is severe at MS ON status
NO
Measure output current using DC current measure
Current value : 10~16A /100AH
NO
Exceed Standard current
Adjust output current AMP, VR within PCB Re-adjust to VR
YES
· TH Setting fault
· Re-adjust TH setting value
TH. TRIP
YES
Change TH
NO
Complete
YES
* Refer to SCR Module checking method
Rated Current SETTING
YES
NO
Complete
Change PCB
Separate the battery connector and tune the charger off
Check SCR Module
NO
Change SCR MODULE
YES
Check MAIN TRANS VOLT
NO
Change PCB
YES
Check the normal operating condition of the charger

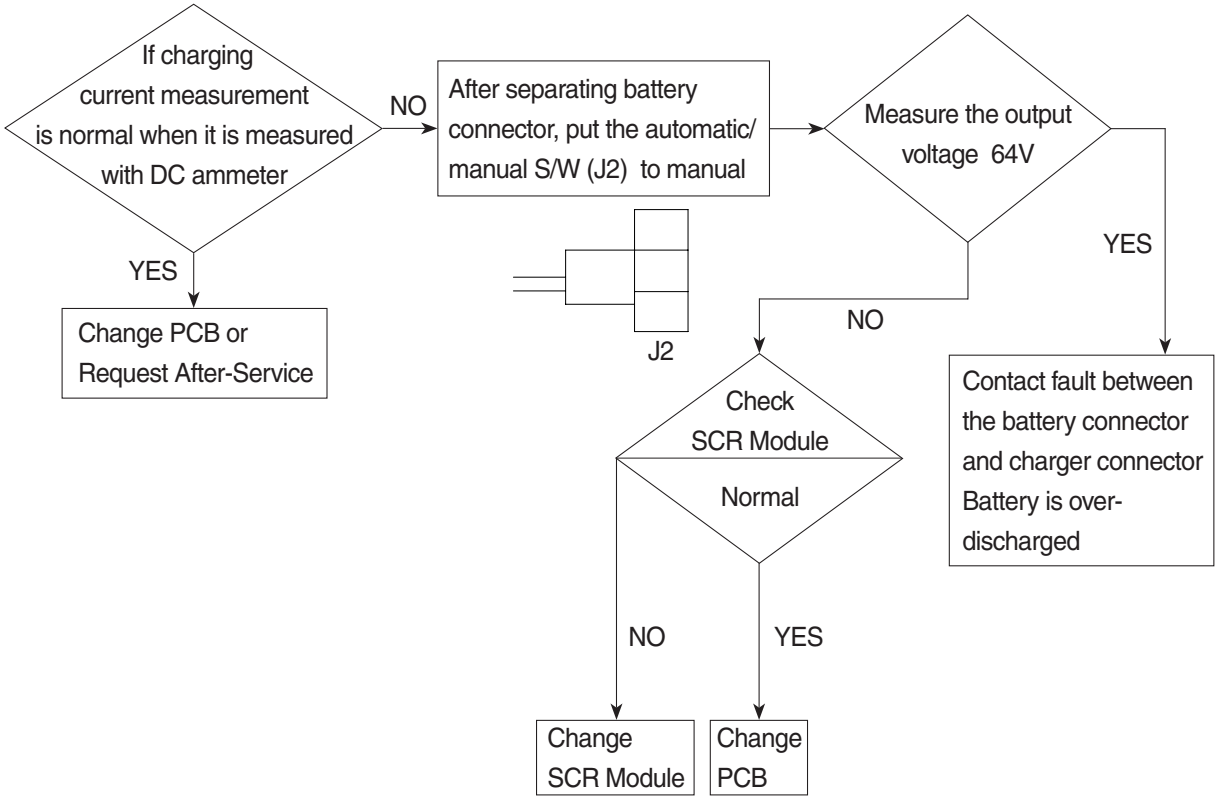
③ **Charger TRIP is occurred after abnormality lamp is on.**
In case error code is "O.V" → Over-voltage output / Set at 66V (In case of BATT 48V)
34V (In case of BATT 24V)
108V (In case of BATT 80V)



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

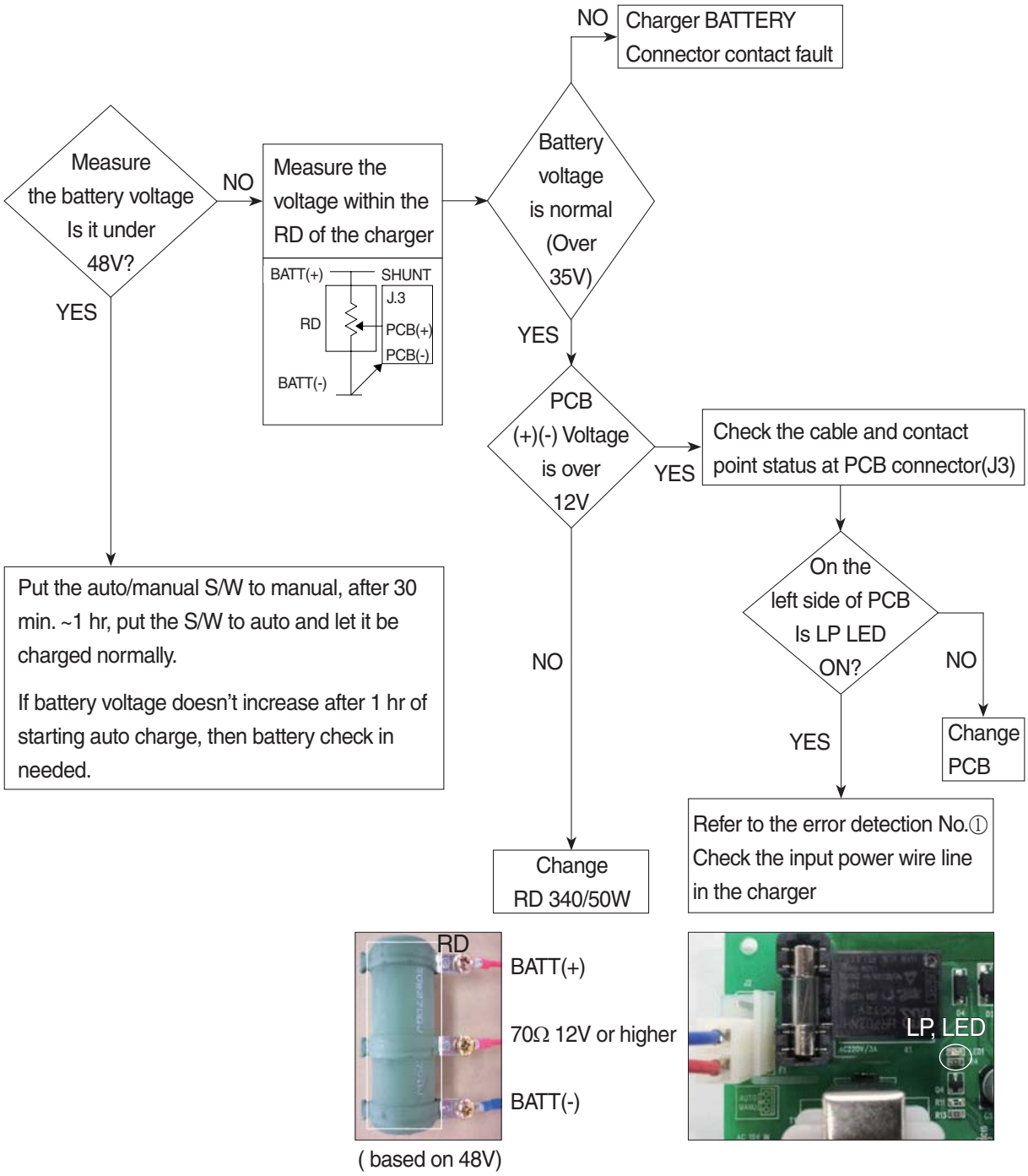


⑤ **Charger TRIP is occurred after it started charging and charging completion lamp is on.**
(In case input voltage is normal - Refer to the error detection No. 1)
Restore the charger as pushing reset switch.



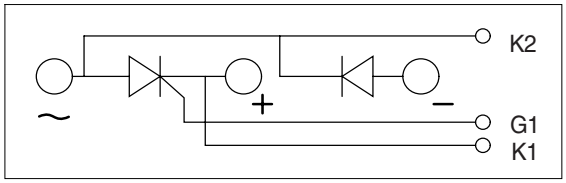
⑥ **Charger has no response even if the battery connector is connected.**

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

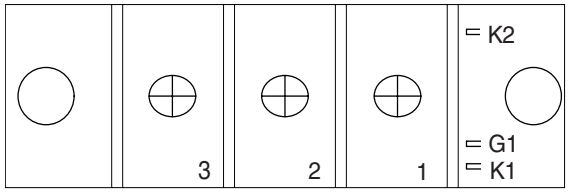


7) HOW TO CHECK THE SCR MODULE

Circuit

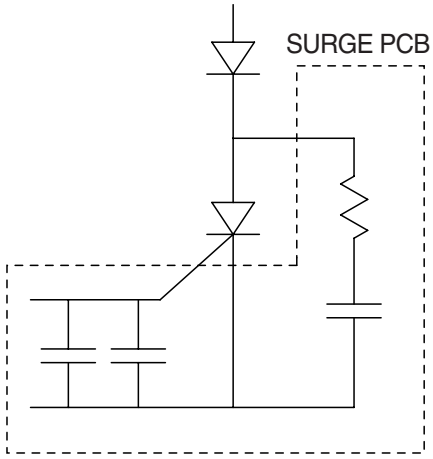


Real diagram

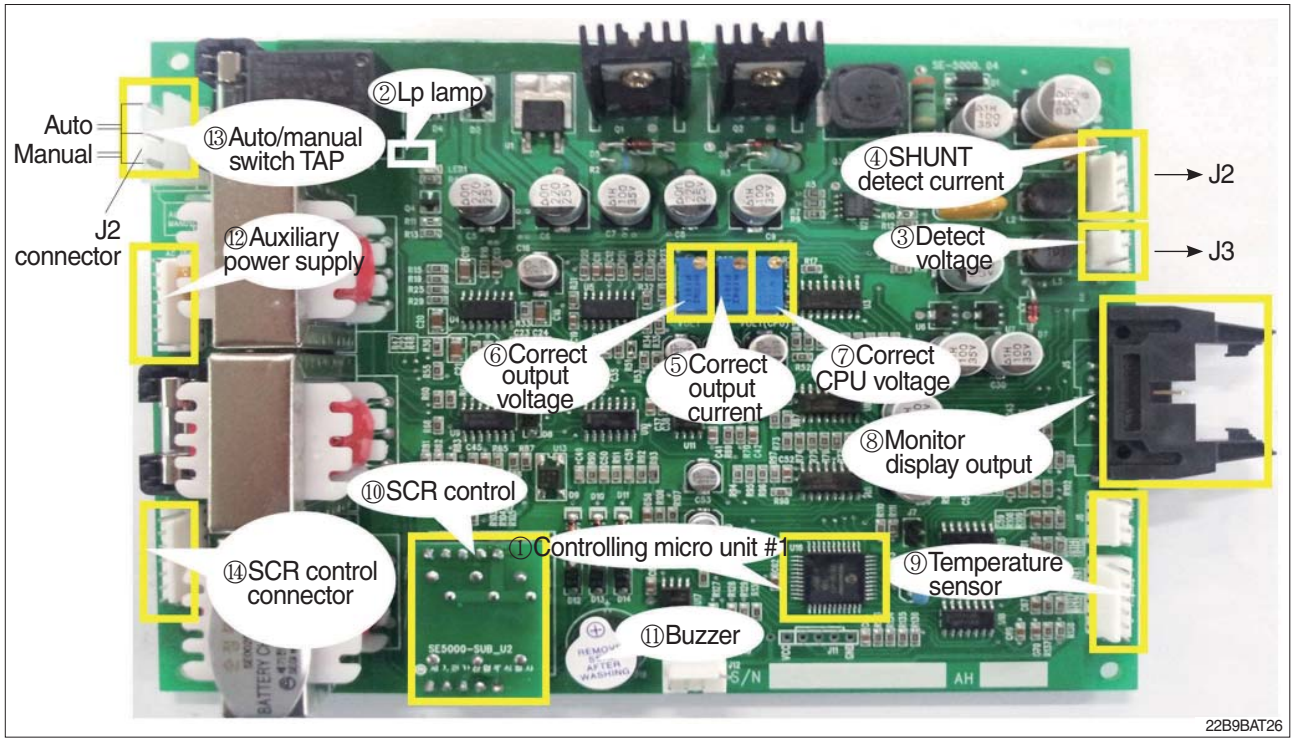


* Before checking SCR MODULE, be sure to disconnect bus bar and wire on the terminal.

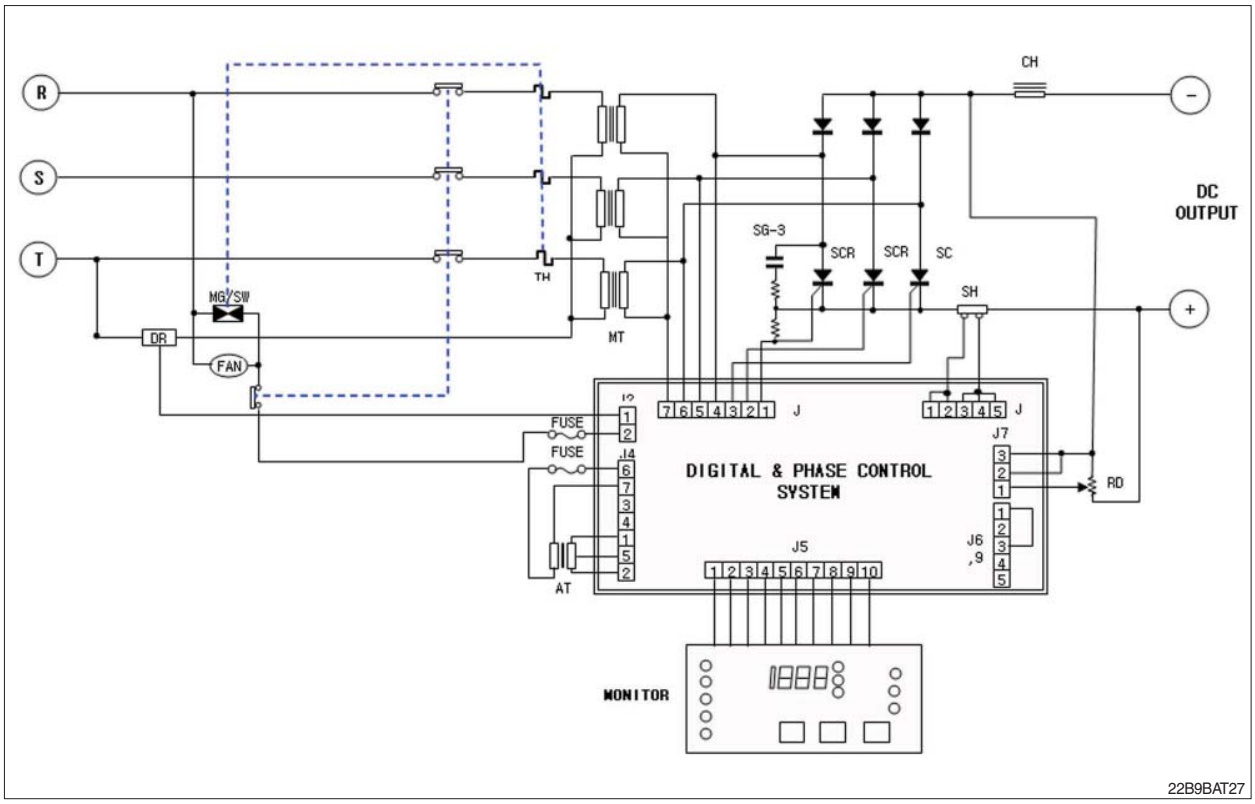
No.	Measuring point (Real diagram)	Measure value (Measurement of digital tester)
1	No.1 ~ No.3	Forward : Under 100 k ohm Reverse : Infinity (∞)
2	No.2 ~ No.3	Forward : Infinity (∞) Reverse : Infinity (∞)
3	G1 ~ K1	Forward : Under 100 ohm Reverse : Under 100 ohm But It depends on the module. If it is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



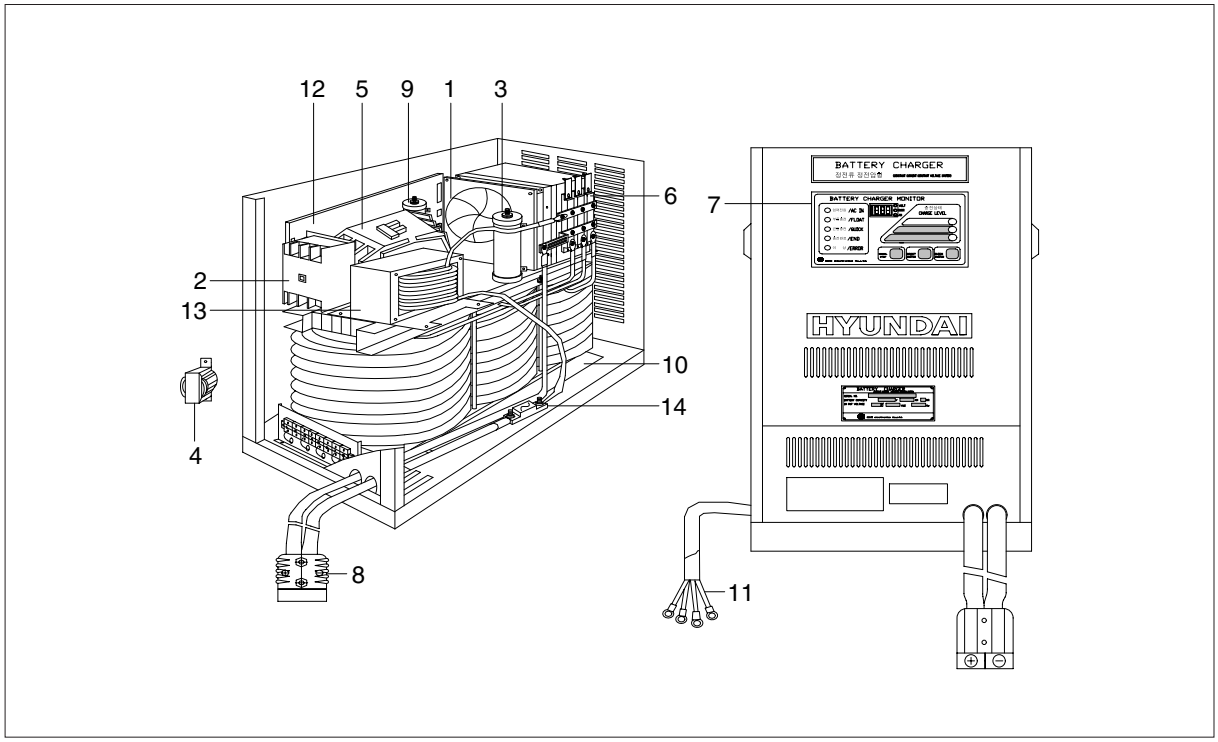
8) PCB MAJOR PARTS (NAME AND LOCATION)



1	Controlling MICOM #1	6	Correct output voltage	11	Buzzer
2	Lp lamp	7	Correct CPU voltage	12	Auxiliary power supply
3	Detect voltage	8	Monitor display output	13	Auto/manual switch TAP
4	SHUNT detect current	9	Temperature sensor	14	SCR control connector
5	Correct output current	10	SCR control		


R
S
T
MG/SW
DR
FAN
TH
MT
CH
SG-3
SCR
SCR
SC
SH
DC
OUTPUT
FUSE
FUSE
AT
DIGITAL & PHASE CONTROL
SYSTEM
J5
J6
J7
RD
MONITOR
22B9BAT27

CHARGER INTERIOR PARTS



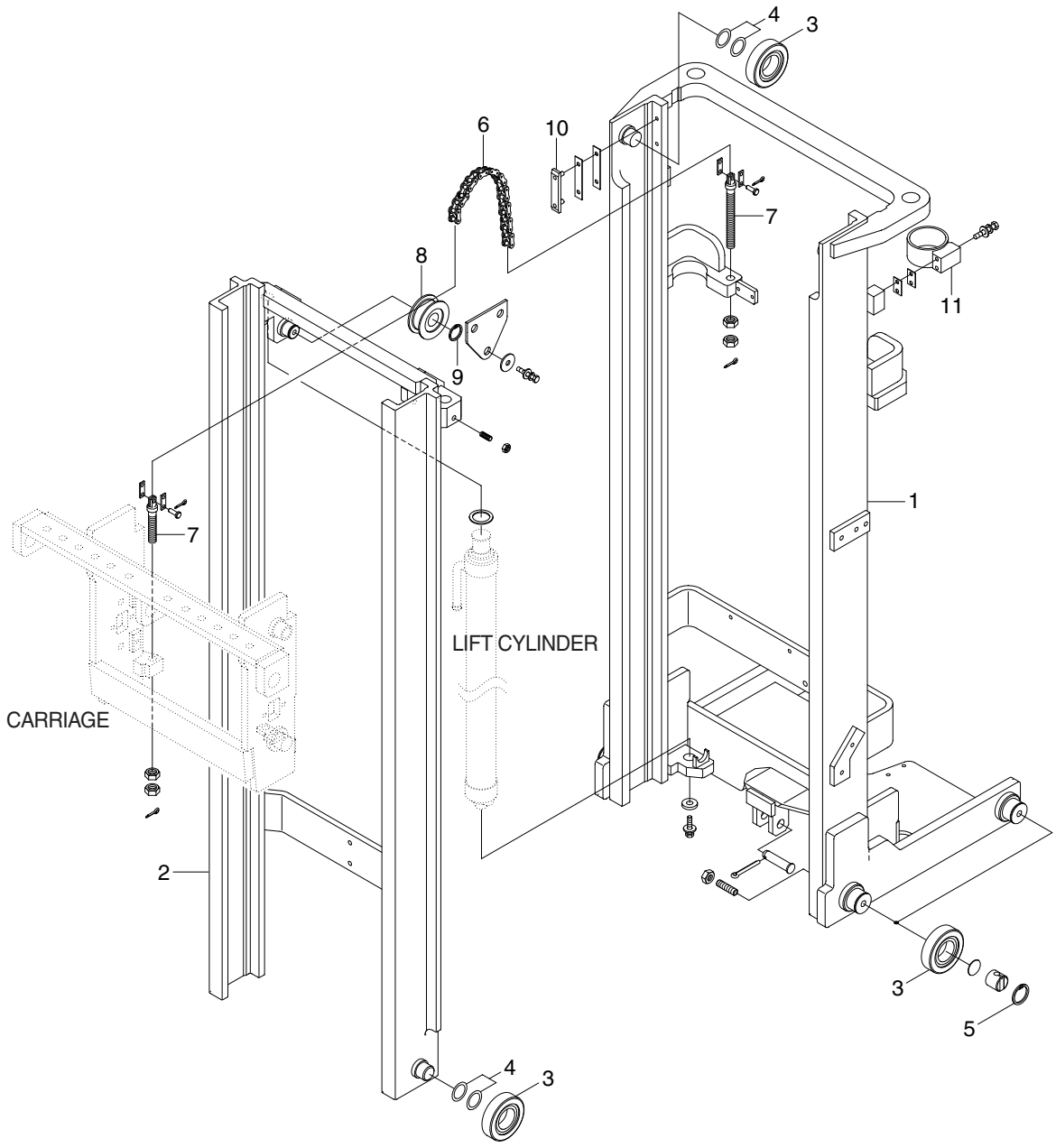
22B9BAT28

No	Part name	Remarks
1	AC fan	
2	Over load	
3	Resister RD	
4	Trans-aux	
5	Magnet switch	
6	SCR module	
7	Monitor	
8	DC out cable	
9	Resister DR	
10	Main transformer	
11	AC input cable	
12	Main control board	
13	Filter	
14	Fuse	

SECTION 8 MAST

GROUP 1 STRUCTURE

1. 2 STAGE MAST (V MAST)

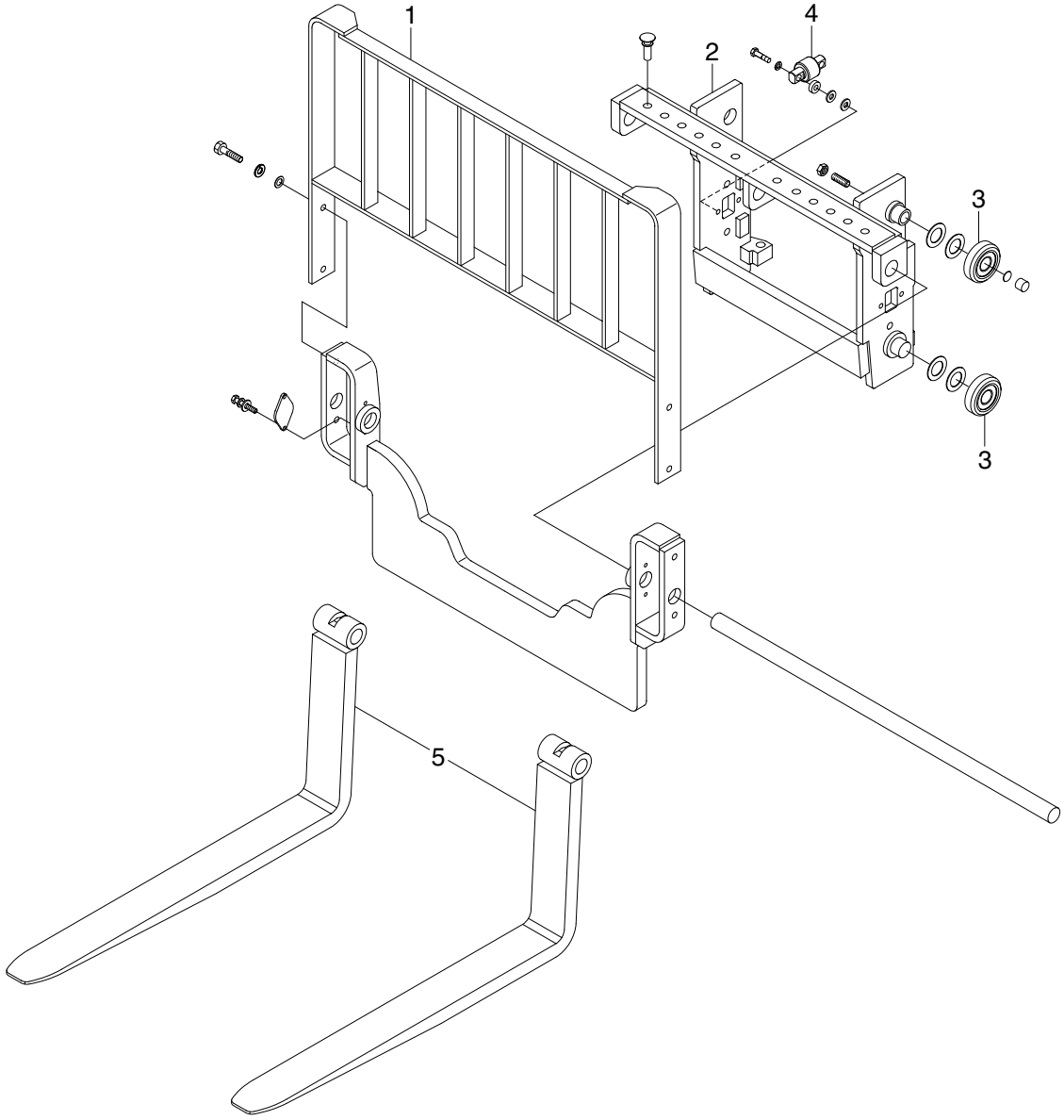


15BR9EMS01

1	Outer mast	5	Retaining ring	9	Retaining ring
2	Inner mast	6	Lift chain	10	Back up liner
3	Roller	7	Anchor bolt	11	Clamp
4	Shim (0.5, 1.0t)	8	Chain sheave		

2. CARRIAGE, BACKREST AND FORK

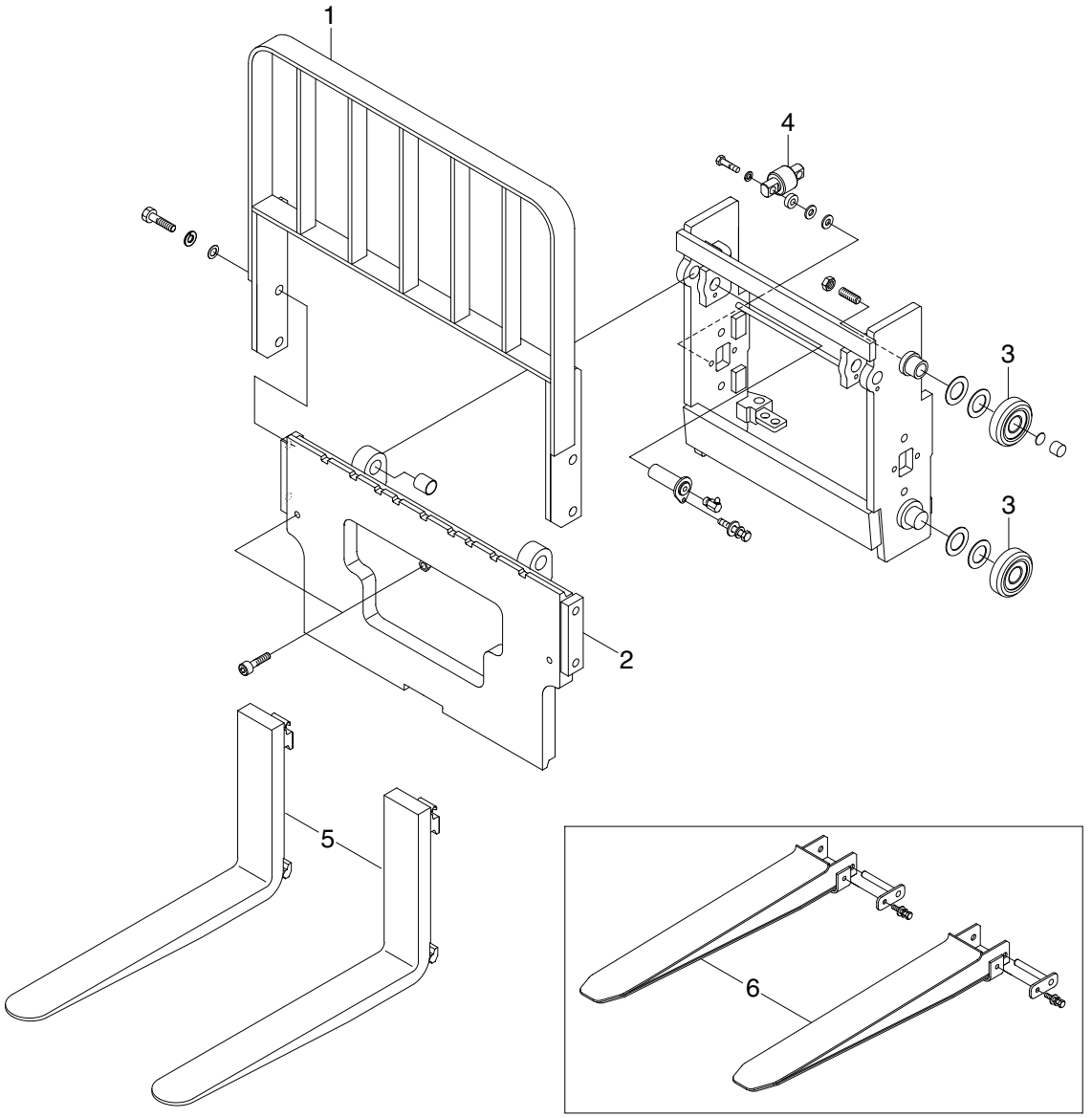
1) SHAFT TYPE



15BR9EMS04

1	Backrest	4	Side roller
2	Carriage	5	Fork assy
3	Load roller		

2) HOOK TYPE



15BR9EMS05

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

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

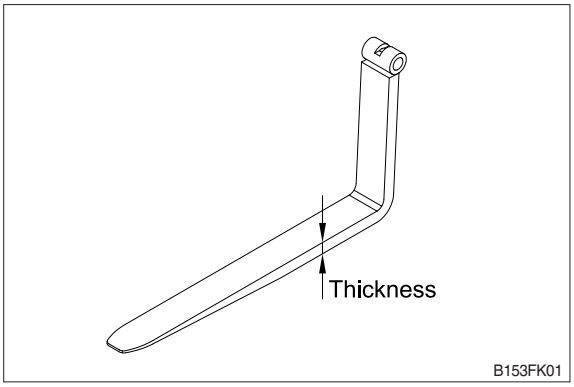
1. OPERATIONAL CHECKS

1) FORKS

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

mm(in)

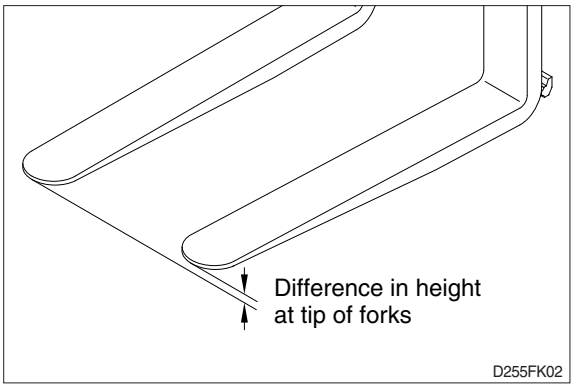
STD Fork assy	Applicable model	Standard	Limit
64FY-11030	15BR-9E	35 (1.4)	32 (1.3)



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

mm

Model	Fork length	Height difference
15BR-9E	equal or below 1500	3
	above 1500	4



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

2. MAST

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

2. TROUBLESHOOTING

1) MAST

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

2) FORKS

<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 1500</td><td>3</td></tr>
<tr><td>above 1500</td><td>4</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

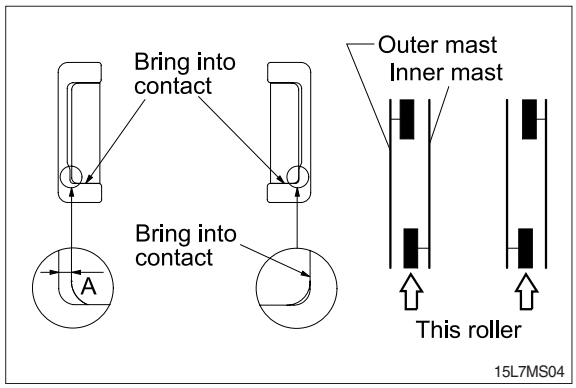
(1) Measure the clearance with the mast overlap at near 480 ㎜.

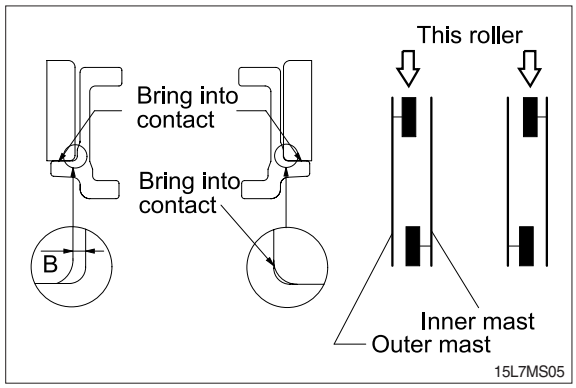
(2) Shift the inner mast to one side to bring the roller into contact with the outer mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner/outer mast roller shim.

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

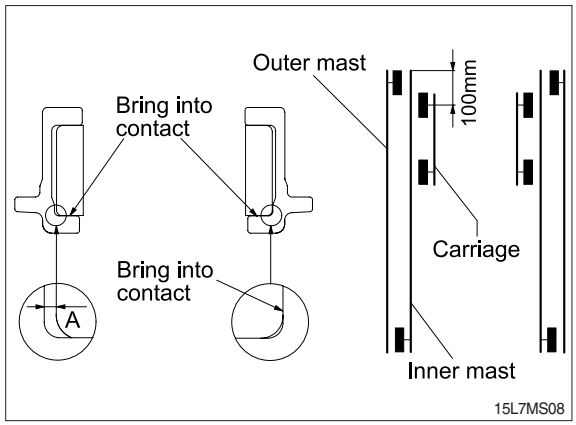
(3) Distribute the shim thickness equally to the left and right roller. Refer to Mast load roller and back up liner, removal and Installation.

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





2) CARRIAGE LOAD ROLLER



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

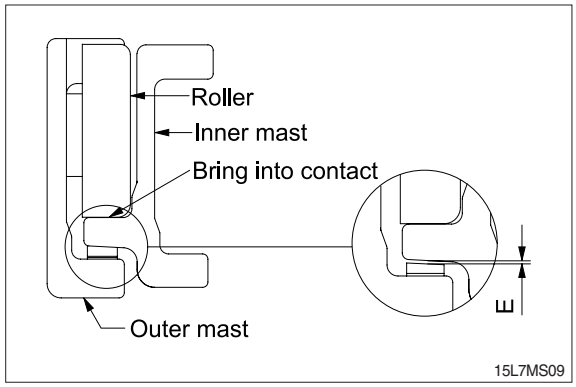
(2) Measure the clearance at upper, lower rollers after loosen the adjust screws from the side rollers. Shift the carriage to one side to bring the roller into contact with the inner mast, and measure the clearance between the roller side face and mast at the closest position on the opposite side to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

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

(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.

3) 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.

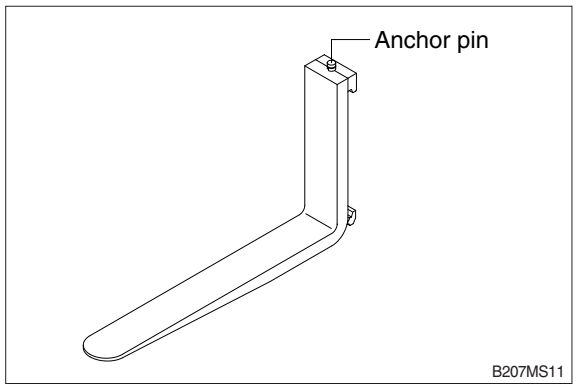
- Standard clearance E = 0.5~1.0 mm
- Shim thickness 0.5, 1.0 mm

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

GROUP 4 REMOVAL AND INSTALLATION

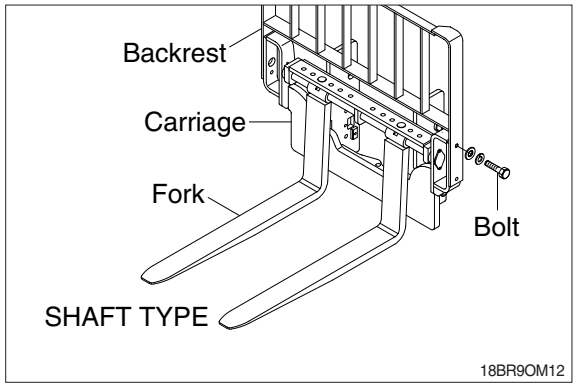
1. FORKS

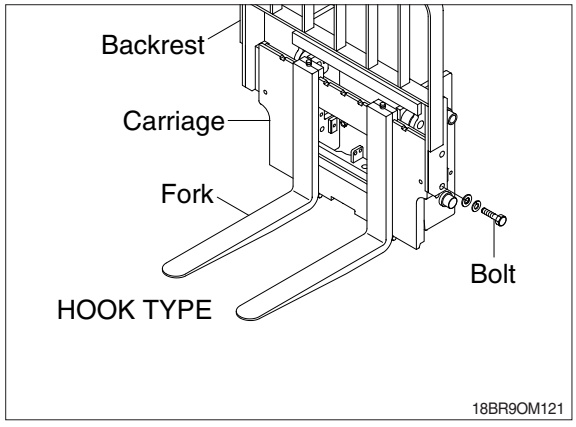
1) Lower the fork carriage until the forks are approximately 25 mm (1 inch) from the floor.
2) Release fork anchor pins and slide forks, one by one, toward the center of the carriage where a notch has been cut in the bottom plate for easy fork removal.
3) Remove the fork one by one. On larger forks it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



2. BACKREST

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





3. CARRIAGE ASSEMBLY

1) CARRIAGE

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

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

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

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

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

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

(6) Reverse the above steps to reinstall.

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

2) SIDE ROLLER

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

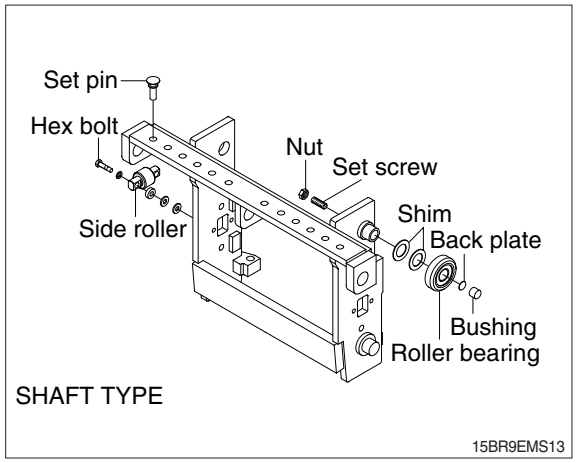
(2) Loosen and remove hex bolts and side rollers from carriage side pate.

(3) Thoroughly clean, inspect and replace all worn or damaged parts.

(4) Reverse the above procedure to assembly.

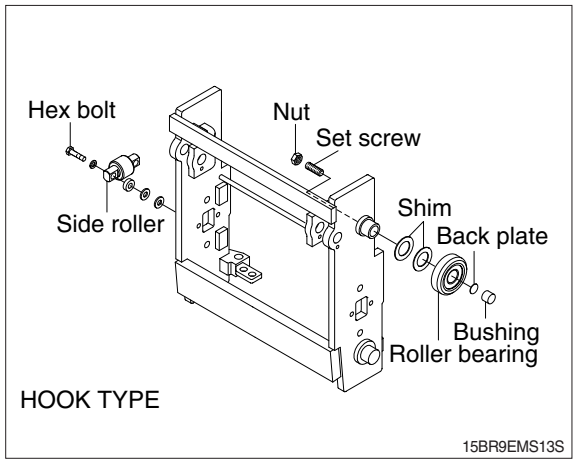
※ **Adjustment**

- Once carriage is properly installed, loosen hex bolts, (if not already done) allowing carriage to be centered in the inner mast.
- Adjust side roller by tightening hex bolts until side roller just makes contact with mast.
- Adjust side bush by tightening set screw until side bush just makes contact with mast.
- Run carriage up and down for the inner mast to be sure the carriage has free movement and does not stick. Also, make sure chains are properly adjusted. Refer to chain adjustment paragraph. Make adjustment when necessary and recheck operation of carriage.



SHAFT TYPE

15BR9EMS13

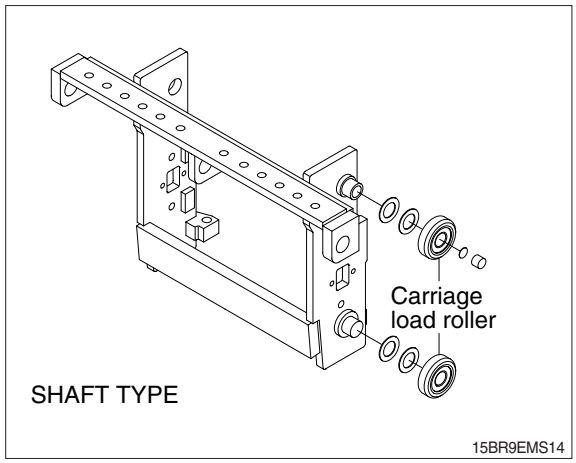


HOOK TYPE

15BR9EMS13S

3) CARRIAGE LOAD ROLLER

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



SHAFT TYPE
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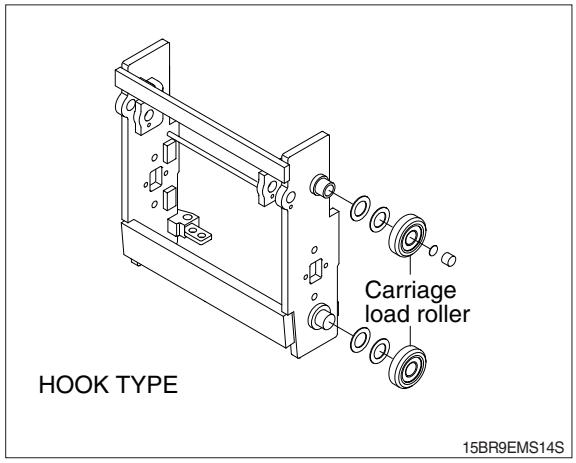
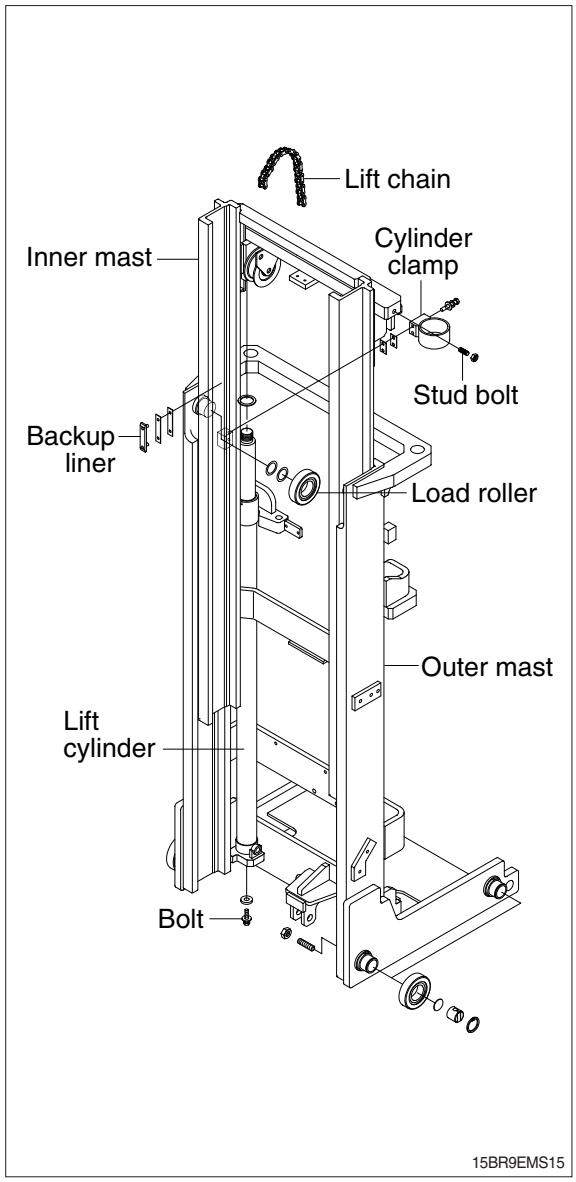


HOOK TYPE
15BR9EMS14S

4) MAST LOAD ROLLER AND BACK UP LINER

(1) 2 stage mast (V mast)

① Remove the carriage assembly and move them to one side.
② Loosen and remove hexagon bolts and washers securing lift cylinders to inner mast.
③ Loosen and remove hexagon bolts and nuts securing lift cylinders to inner mast.
④ Attach chains or sling to the inner mast section at top crossmember. Using an overhead hoist, slowly raise the inner mast high enough to clear lift cylinder.
⑤ After lowering the lift cylinder rods, and disconnecting lift cylinder hose, tilt the lift cylinders LH and RH and them with ropes to the outer mast.
⑥ Using the overhead hoist, lower inner mast until top and bottom rollers and back up liners are exposed.
⑦ Using a pryer, remove load rollers from load roller bracket. Remove back up liners and shims.
⑧ Thoroughly clean, inspect and replace all worn or damaged parts.
⑨ Reverse the above procedure to assemble. Refer to MAST LOAD ROLLER ADJUSTMENT paragraph.



5) ELEVATING MAST

(1) Inner mast (V mast)

① After completing all necessary steps for load rollers and back up liner removal use an overhead hoist and sling or chain around upper crossmember of the inner mast section.
② Lift inner mast upright straight up and out of outer mast section.
③ Replace and reverse above procedure to install. Make all necessary measurements and adjustments.

6) CHAIN

(1) Chain sheave (V mast)

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

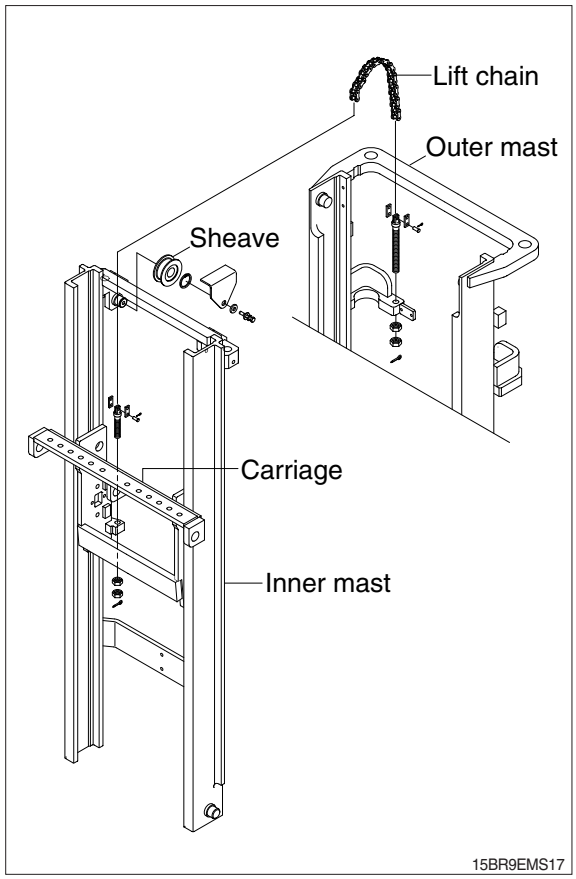
② Remove the split pin securing the chain anchor pins and discard. While supporting the chains, remove the chain anchor pins and drape the chains over the carriage.

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

④ Remove bearing retaining ring from sheave and press bearings from sheaves.

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

⑥ Reverse the above to assemble and install. Use new split pins in chain anchor pins.



(2) 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.

(3) 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 develops in service is due to material being worn off pin outer diameter and pitch hole inner diameter on the inside plate.

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

② Rust and corrosion

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

③ Cracked plate

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

④ Tight joints

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

Tight joints in lift chains can be caused by :

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

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

⑤ **Protruding or turned pins**

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

⑥ **Chain side wear**

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

⑦ **Chain anchors and chain wheel bearings**

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

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

⑧ **Chain wear scale**

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

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

(4) 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.