CONTENTS

1. STRUCTURE

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

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

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

SECTION 3 POWER TRAIN SYSTEM
This section explains the structure of the transmission as well as control valve and drive axle.

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

SECTION 5 STEERING SYSTEM
This section explains the structure of the steering unit, priority valve, trail axle as well as steering circuit and operation.

SECTION 6 HYDRAULIC SYSTEM
This section explains the structure of the gear pump, main control valve as well as work equipment circuit, each component and operation.

SECTION 7 ELECTRICAL SYSTEM
This section explains the electrical circuit and each component.
It serves not only to give an understanding electrical system, but also serves as reference material for troubleshooting.

SECTION 8 MAST
This section explains the structure of mast, carriage, backrest and forks.

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

2. HOW TO READ THE SERVICE MANUAL

Distribution and updating

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

Filing method

1. See the page number on the bottom of the page.
   File the pages in correct order.
2. Following examples shows how to read the page number.
   Example 1
   2 - 3
   - 2: Item number (2. Structure and Function)
   - 3: 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.
   5 - 4
   5 - 4 - 1 ⎤ Added pages
   5 - 4 - 2 ⎦
   5 - 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

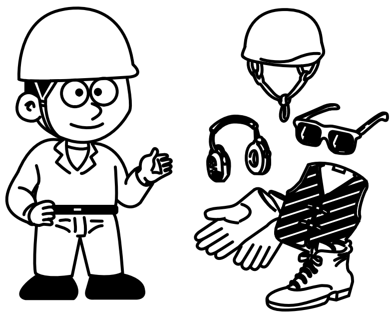
GROUP 1 SAFETY HINTS

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.

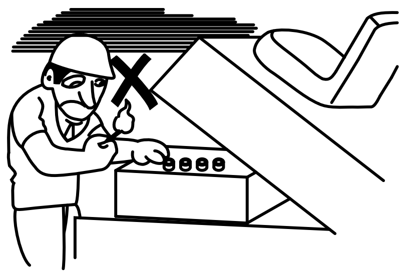
D50ASF01

· 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.

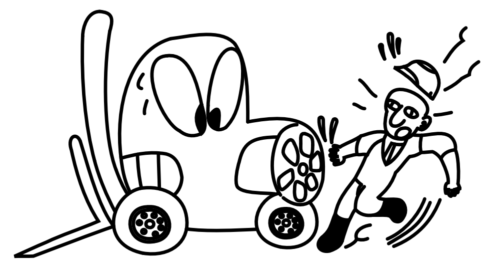


D50ASF03

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

D50ASF06

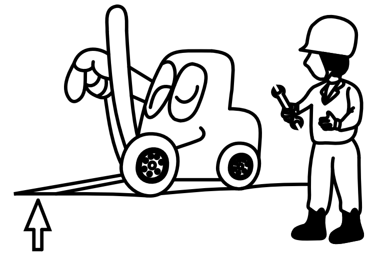
· Hand a caution sign in the operator's compartment (For example Do not start or Maintenance in progress). This will prevent anyone from starting or moving the machine by mistake.



D50ASF07

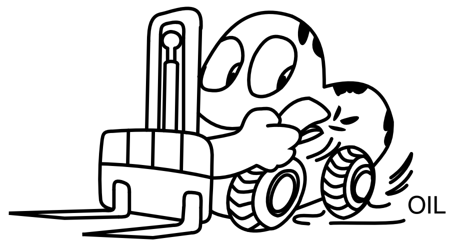
When inspecting running parts or near such parts, always stop the machine first.
Before checking or servicing accumulator or piping, depress brake pedal repeatedly to release pressure.

· 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.

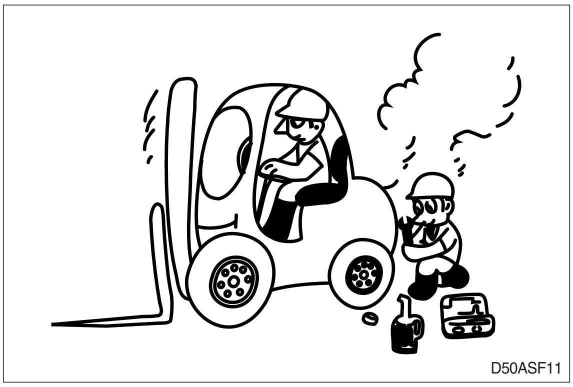


D50ASF09

· 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.



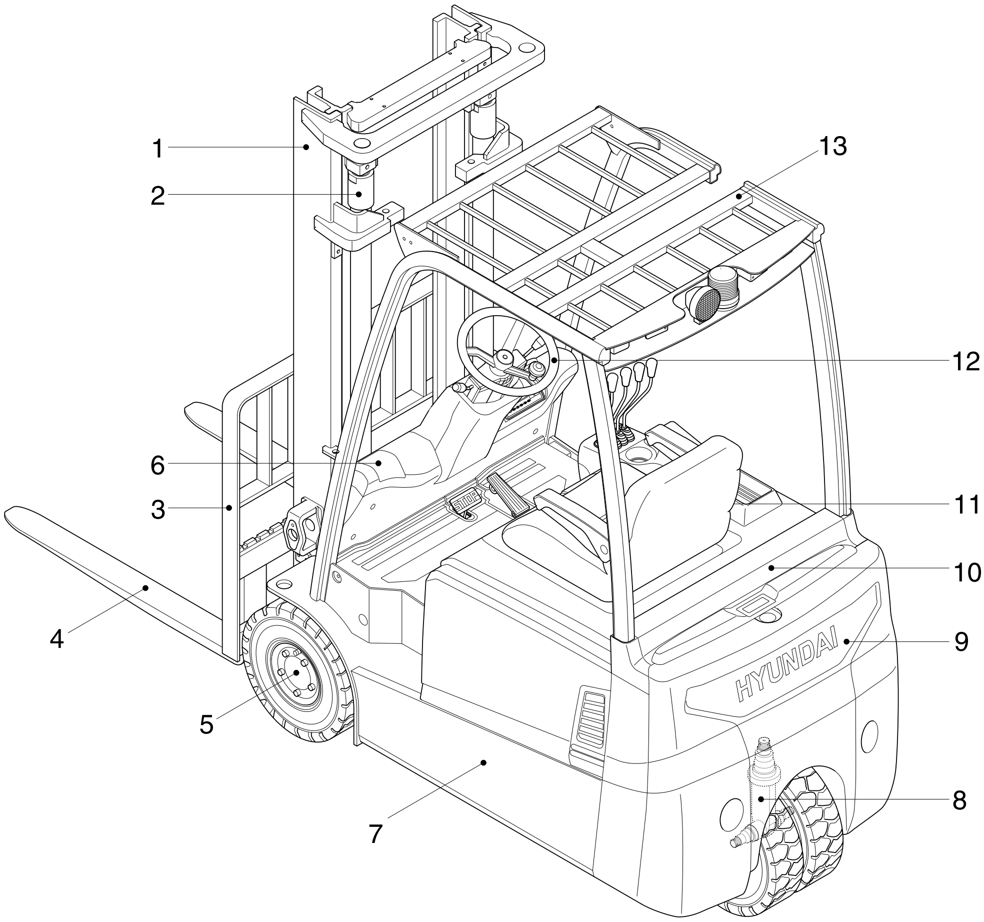
D50ASF11

· Unless you have special instructions to the contrary, maintenance should always be carried out with the machine stopped. If maintenance is carried out with the machine running, there must be two men present : one sitting in the operator's seat and the other one performing the maintenance. In such a case, never touch any moving part.
· 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 40C.
· 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

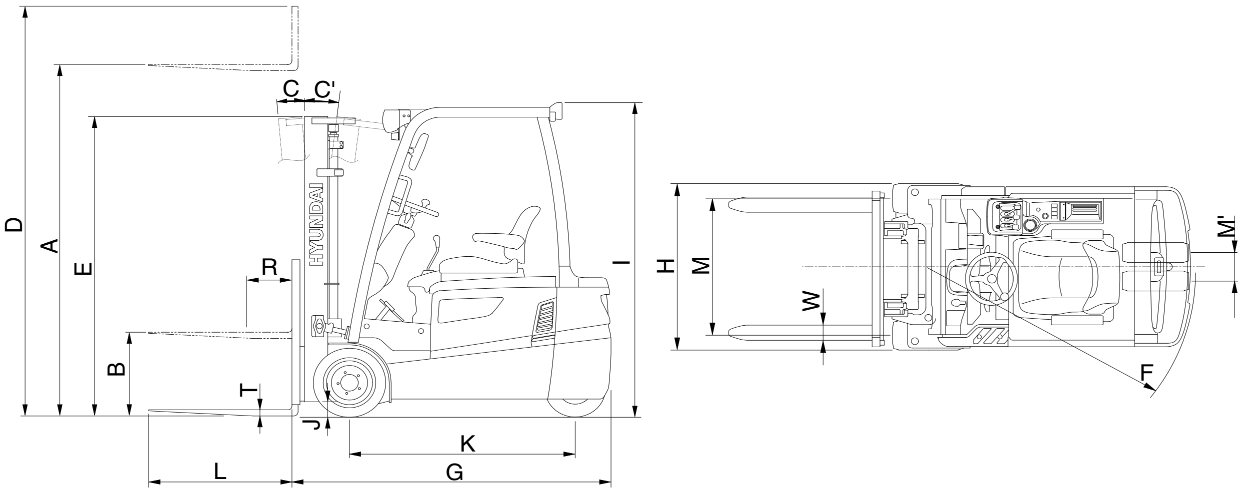
1. GENERAL LOCATIONS



15BT9UOM0101

1	Mast	6	Dash board	11	Seat
2	Lift cylinder	7	Frame	12	Steering wheel
3	Carriage and backrest	8	Steering axle	13	Overhead guard
4	Forks	9	Counterweight		
5	Drive unit	10	Battery cover		

2. SPECIFICATIONS



15BT9USM0102

Model			Unit	15BT-9U	18BT-9U	20BT-9U
Capacity			kg (lb)	1500 (3000)	1800 (3500)	2000 (4000)
Load center		R	mm (ft-in)	500 (24")	←	←
Weight			kg (lb)	3143 (6929)	3427 (7555)	3561 (7850)
Fork	Lifting height	A	mm (ft-in)	3330 (10' 11")	←	←
	Free lift	B	mm (in)	40 (1.6")	←	←
	Lifting speed [Load/Unload]		mm/sec	400/550	←	←
	Lowering speed [Load/Unload]		mm/sec	550/450	←	←
	L × W × T	L,W,T	mm (in)	900 × 100 × 40 (35.4 × 4 × 1.6)	←	←
Mast	Tilt angle forward/backward	C/C'	degree	5/7	←	←
	Max height	D	mm (ft-in)	4320 (14' 2")	←	←
	Min height	E	mm (ft-in)	2120 (6' 11")	←	←
Body	Travel speed [Unload/Load]		km/h	16	←	←
	Gradeability [Load]		%	29.5	27.5	24.5
	Min turning radius [Outside]	F	mm(ft-in)	1540 (5' 1")	1630 (5' 4")	1660 (5' 5")
ETC	Max hydraulic pressure(sys/attach)		kgf/cm^2	190/130	←	←
	Hydraulic oil tank		l(usgal)	20 (5.28)	←	←
Overall length		G	mm (ft-in)	1900 (6' 3")	1990 (6' 6")	2025 (6' 8")
Overall width		H	mm (ft-in)	1074 (3' 6")	1105 (3' 8")	←
Overhead guard height		I	mm (ft-in)	2065 (6' 9")	←	←
Ground clearance (Mast)		J	mm (in)	87 (3' 4")	89 (3' 5")	←
Wheel base		K	mm (ft-in)	1345 (4' 5")	1430 (4' 8")	←
Wheel tread front/Rear		M	mm (ft-in)	895/184 (2' 11"/0' 7")	905/184 (3' 0"/0' 7")	←

3. SPECIFICATION FOR MAJOR COMPONENTS

1) CONTROLLER

Item	Unit	Traction motor controller	Pump motor controller
Model		ACE2	ACE2
Type	-	AC Zapi patented control	←
Dimension	mm	200×150×120	200×200×120
Current limit	Arms / min	350 / 2	450 / 2
Communication	-	CAN	←

2) MOTOR

Item	Unit	Traction	Pump
Model	-	TSA200-100-269	TSA170-210-063
Type	-	AC	AC
Rated voltage	Vac	32	32
Output	kW	5.4	14.9
IP Grade	-	54	43

3) BATTERY

Item	Unit	15BT-9U	18/20BT-9U
Rated voltage	V	48	←
Dimension(W×L×H)	mm	983×553×650	983×638×650
Battery weight(STD)	kg	820	1000
Connector(CE spec)	-	SB 350 or SR350 (SBE 320)	

4) CHARGER

Item	Unit	15BT-9U	18/20BT-9U
Type	-	Constant current, constant voltage	
Battery capacity for charge	V-AH	48-440~520	48-530~600
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)	-	SB 350 or SR350 (SBE 320)	

5) GEAR PUMP

Item	Unit	Specification
Type	-	Gear type hydraulic pump
Capacity	cc/rev	18.4
Rated Pressure	MPa	21.0
Speed(max/min)	rpm	3500/500

6) MAIN CONTROL VALVE

Item	Unit	Specification
Type	-	2, 3, 4 spool
Operating Force	kgf	Max 27
Main relief valve pressure	bar	190
Rated Flow	l / min	65

7) DRIVE UNIT

Item	Unit	Specification
Max. axle load	kg/lb	3850/8818
Max. input speed	rpm	5000
Max. output torque (wheel)	N·m	1320
Gear ratio	-	26.75
Weight without fluid	kg/lb	31 / 68
Oil quantity	l /U.S · qt	0.35/0.37

8) WHEELS

Item	15BT-9U	18BT-9U	20BT-9U
Type (STD / OPT)	SOLID / Non-marking		
Quantity(front / rear)	2 / 2		
Front-drive	18×7-8	200×50-10	←
Rear-steering	15×4.5-8	←	←

9) BRAKES & STEERING

Item		Specification
Brakes	Travel	Front wheel, wet disc brake
	Parking	Electric Auto parking(2EA)
Steering	Type	Electric Power Steering
	Steering angle	90° to both right and left angle, respectively

4. TIGHTENING TORQUE FOR MAJOR COMPONENTS

No.	Descriptions		Size	Torque	
				kgf·m	lbf·ft
1	Electric system	Hyd pump motor mounting bolt	M 8 × 1.25	2.5±0.5	18.1±3.6
2		Traction motor mounting bolt	M 8 × 1.25	2.5±0.5	18.1±3.6
3	Hydraulic system	Hydraulic pump mounting bolt	M 8 × 1.25	2.5±0.5	18.1±3.6
4		MCV mounting bolt, nut	M 8 × 1.25	2.5±0.5	18.1±3.6
6		Brake cylinder mounting bolt	M10×1.5	5±1	36±7.2
7		Hydraulic oil tank mounting bolt	M 8 × 1.25	2.5±0.5	18.1±3.6
8	Power train system	Drive axle mounting bolt, nut	M14×2.0	13.8±1.2	99.8±8.7
9		Steering axle mounting bolt, nut	M16×2.0	35.6±5.3	257.4±38.3
10		Front wheel mounting nut	M14×1.5	14±1.5	101±10.8
11		Rear wheel mounting nut	M14×1.5	14±1.5	101±10.8
12	ETC	Counterweight mounting bolt	M30×3.5	199±15	1439±108
13		Seat mounting bolt	M 8 × 1.25	2.5±0.5	18.1±3.6
14		Head guard mounting bolt	M12×1.75	12.8±3.0	93±22

5. TORQUE CHART

Use following table for unspecified torque.

1) BOLT AND NUT

(1) Coarse thread

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

(2) Fine thread

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

2) PIPE AND HOSE(FLARE TYPE)

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

3) PIPE AND HOSE(ORFS TYPE)

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

4) FITTING

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

6. RECOMMENDED LUBRICANTS

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

Service point	Kind of fluid	Capacity ℓ (U.S. gal)	Ambient temperature °C (°F) -50 (-58) -30 (-22) -20 (-4) -10 (14) 0 (32) 10 (50) 20 (68) 30 (86) 40 (104)
Axle	Gear oil	0.35 (0.1)	ATF Dexron Ⅲ
Hydraulic oil tank	Hydraulic oil	20 (5.2)	★ISO VG 15 ISO VG 46 ISO VG 68
Brake system	Brake oil	0.5 (0.13)	DOT 3
Fitting (Grease nipple)	Grease	0.1 (0.03)	★NLGI No.1 NLGI No.2

·ATF : Automatic Transmission Fluid
·API : American Petroleum Institute
·SAE : Society of Automotive Engineers
·ISO : International Organization for Standardization
·NLGI : National Lubricating Grease Institute

★ : 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.

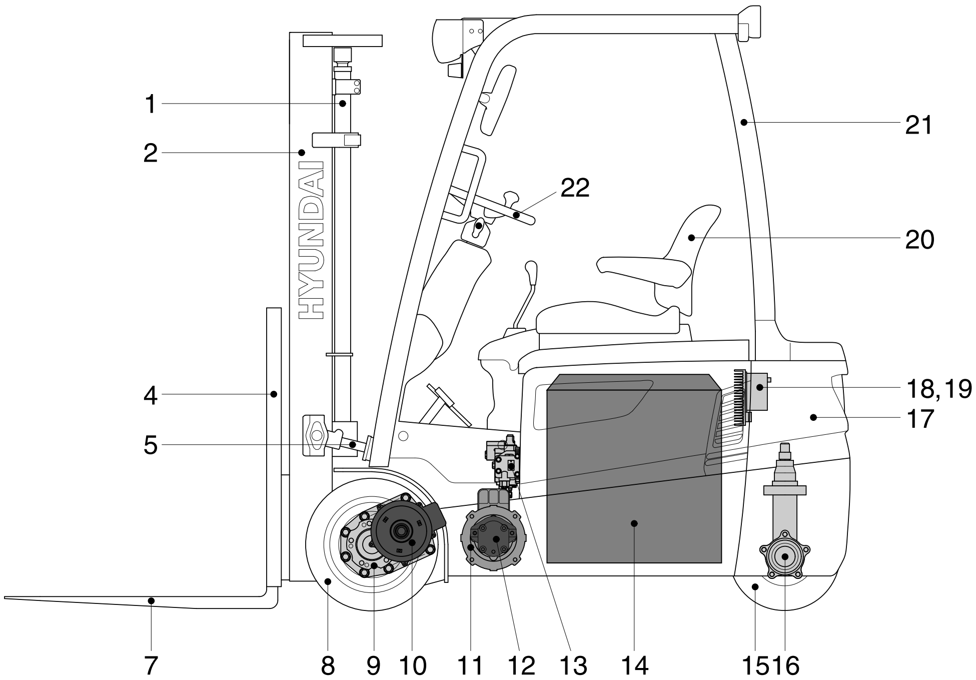
※ Replacement of consumable service parts is not covered under warranty.

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	Parking, seal and O-ring of steering cylinder	Every 2 year
8	Parking, seal and O-ring of lift and tilt 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 hose or tube	Every 1 or 2 year

SECTION 2 REMOVAL & INSTALLATION OF UNIT

SECTION 2 REMOVAL & INSTALLATION OF UNIT

GROUP 1 MAJOR COMPONENTS



15BT9USM0201

1	Lift cylinder	10	Drive motor	17	Counterweight
2	Mast	11	Hydraulic motor	18	Traction controller
4	Backrest	12	Pump motor	19	Pump controller
5	Tilt cylinder	13	Main control valve	20	Seat
7	Forks	14	Battery	21	Overhead guard
8	Front wheel	15	Rear wheel	22	Steering wheel
9	Drive unit	16	Steering axle		

GROUP 2 REMOVAL AND INSTALLATION OF UNIT

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

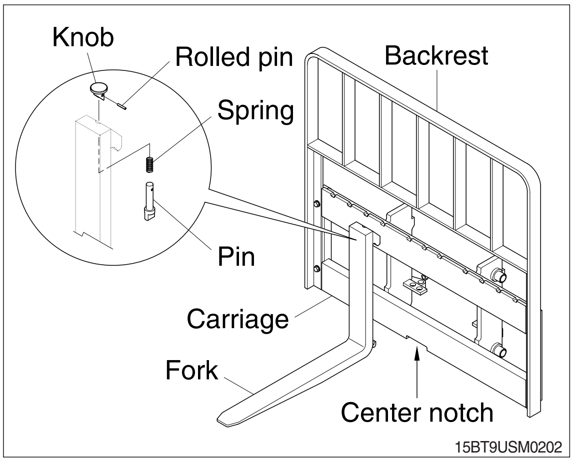
1. MAST

1) REMOVAL

Fork — Carriage — Piping — Mast

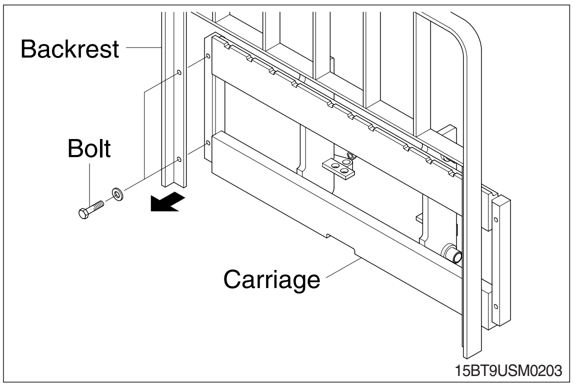
(1) Forks

① Lower the fork carriage until the forks are approximately 25mm(1in) from the floor.
② Turn knob up and slide one fork at a time toward the center of the carriage where a notch has been cut in the bottom plate for easy removal.
③ Remove only one fork at a time.
※ On larger forks it may be necessary to use a block of wood.



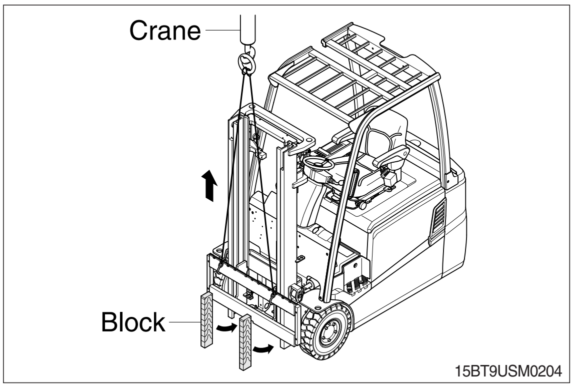
(2) Backrest(If necessary)

① Remove bolts securing backrest to fork carriage. Disassemble the backrest from the carriage.

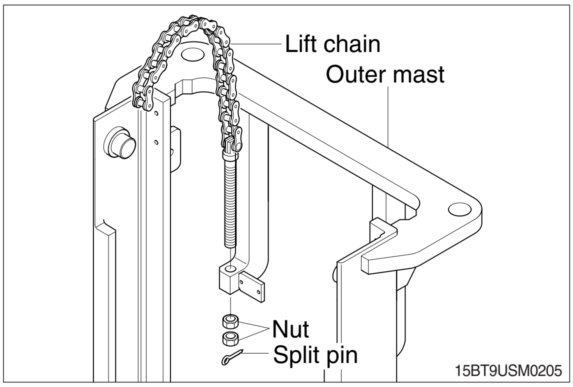


(3) Carriage

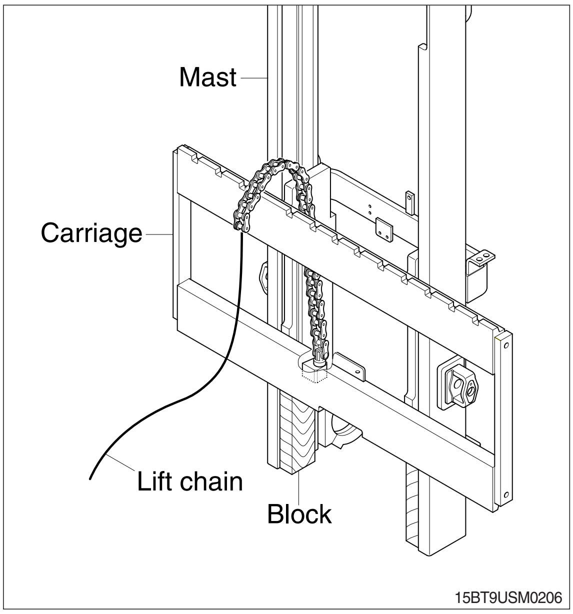
① With the mast vertical, raise the carriage high enough to place blocks under the load forks. This is done to create slack in the load chains when the carriage is lowered. Lower the carriage all the way down to the floor. Make sure the carriage is level, this will prevent any binding when the mast is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



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



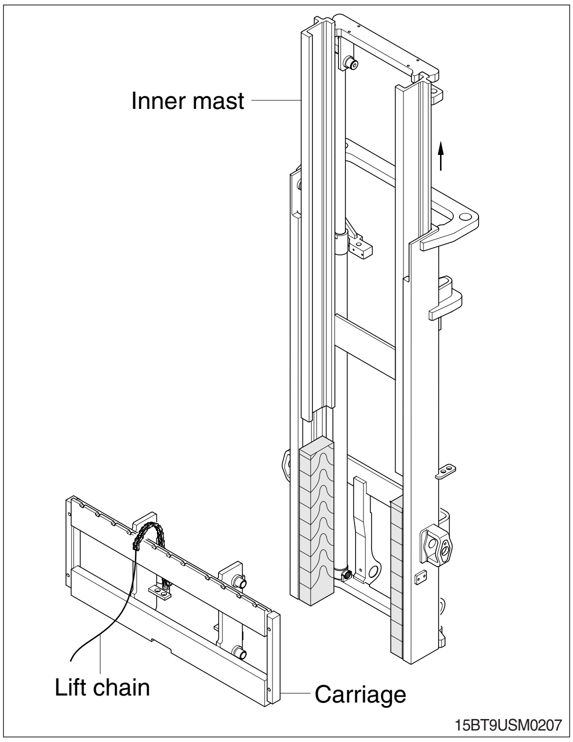
③ Pull the chains out of the sheaves and drape them over the front of the carriage.



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

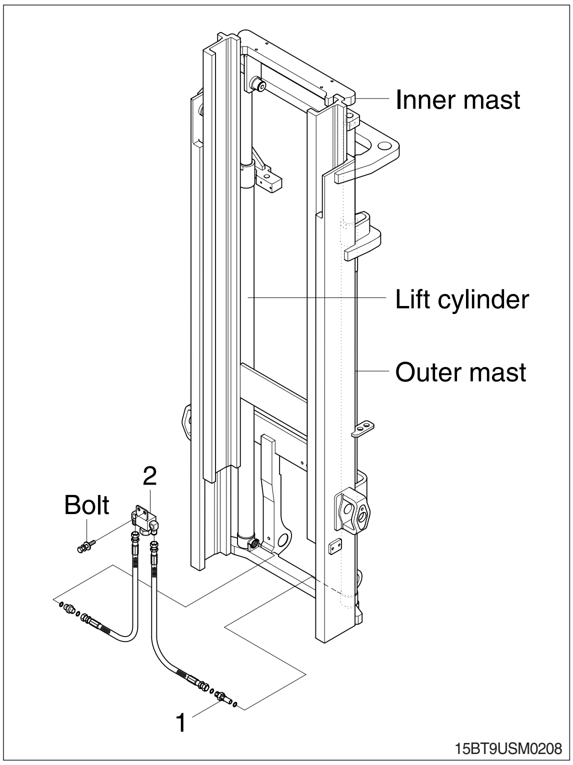
⚠ Make sure that carriage remains on floor and does not bind while mast is being raised.

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



(4) Piping

① Loosen the bolts (2EA) of the weld-connector (2) from low crossmember of the outer mast.
② Disconnect the connectors from the lift cylinders.
③ Disassemble the velocity fuse valve (1), hoses, and weld-connector (2).

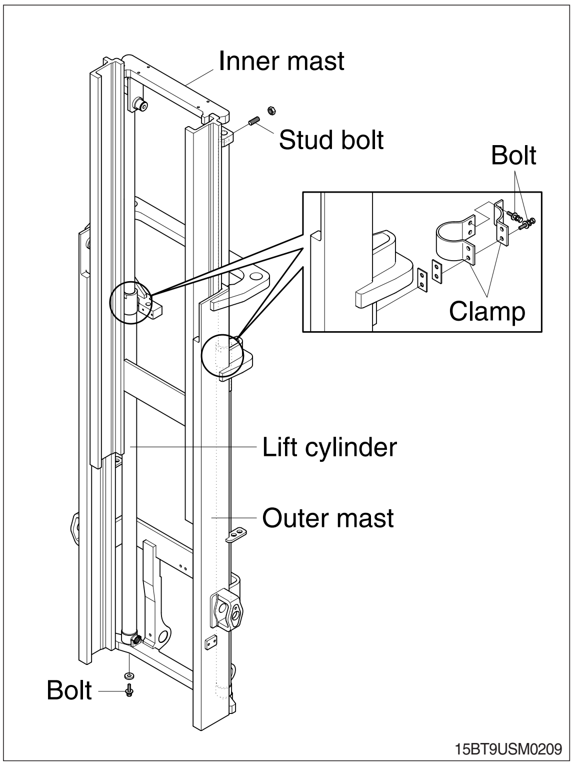


(5) Lift cylinder

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

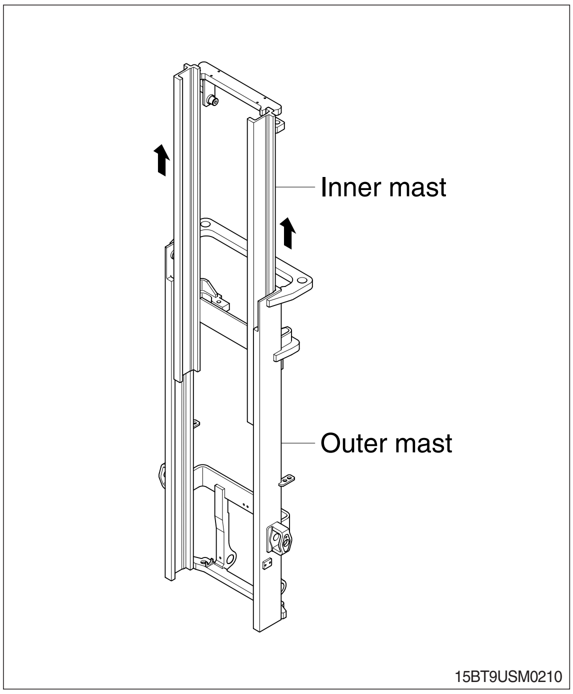
③ Loosen and remove hexagon bolts and clamp securing the lift cylinder to outer mast.
④ Using an overhead hoist, slowly raise the inner mast high enough to clear lift cylinder.
⑤ Using an overhead hoist, draw out lift cylinder carefully and put down on the work floor.



(6) Inner mast

① Using an overhead hoist raise the inner mast straight and carefully draw out of outer mast section.

⚠ Be careful the mast not to swing or fall.

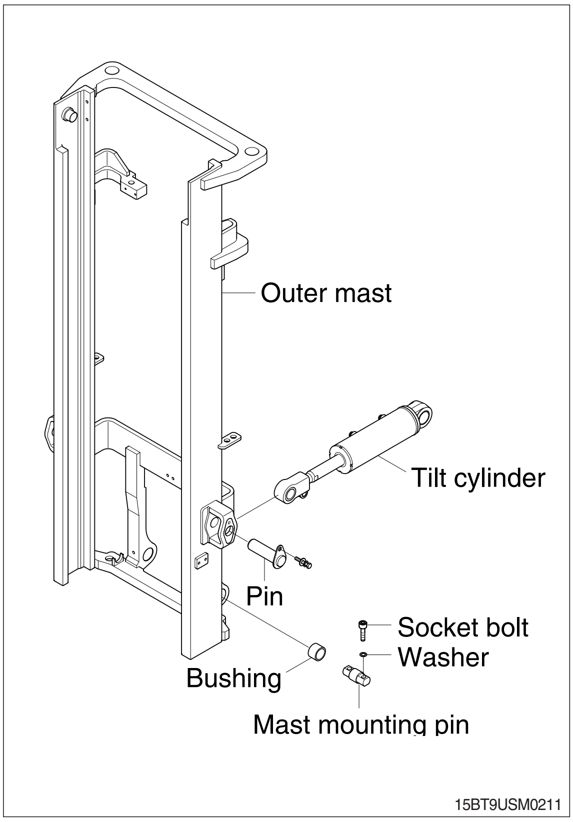


(7) Tilt cylinder pin

① Attach a crane to the stay at the top of the outer mast, and raise enough to sustain jacked up machine.

※ This operation is carried out from under the machine, so use a pit, or if there is no pit, jack up the machine and loosen with on impact wrench.

② Remove the socket bolts, washers from the mast mounting pins and take out the mast mounting pins, and then slowly raise up the outer mast



2) INSTALLATION

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

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

(1) Brone bushings

① Check the inside of the bronze bushings for wear which are the contact area with the mast mounting pins.

② Jack up the machine so that the front is raised and then using an overhead hoist assemble outer mast to drive axle unit.

(2) Tilt cylinder pin

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

(3) Lift cylinder installation and adjustment

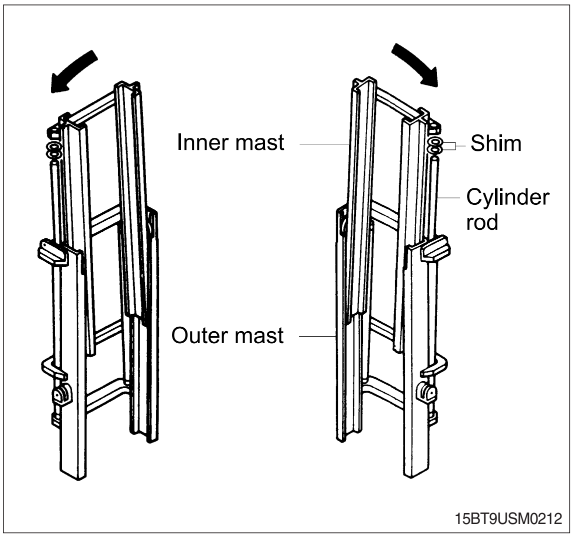
① Assemble the lift cylinder inside the outer mast, then tighten the stopper bolt. If the cylinder assembly has been replaced, adjust as follows so that the left and right cylinders are synchronized at the maximum lifting height.

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

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

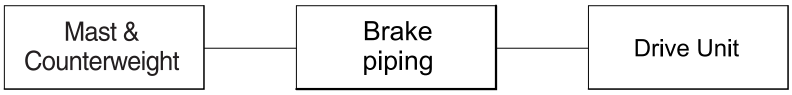
※ If play is to RIGHT, install adjustment shim to RIGHT cylinder.

· Shim thickness : 1.0mm(0.04in)



2. POWER TRAIN ASSEMBLY

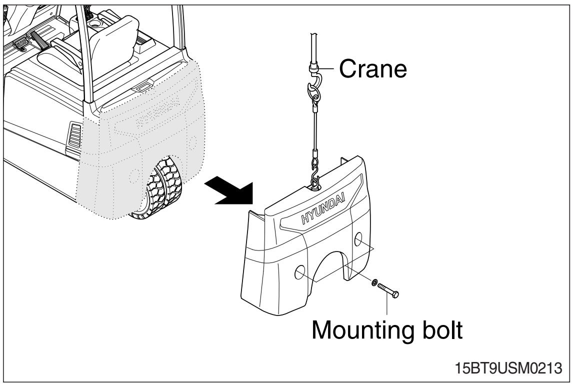
1) REMOVAL



(1) Mast and counterweight

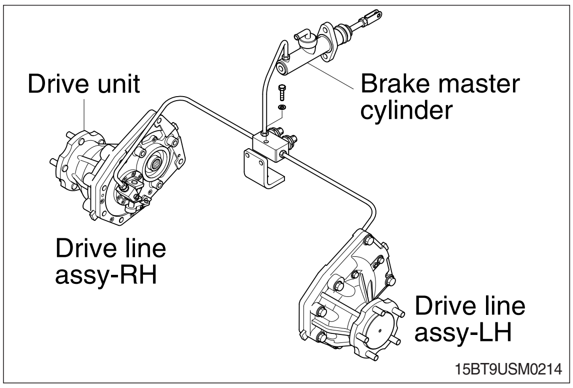
Refer to section on mast (Page 2-5)

After removing mast, remove the counterweight to prevent the truck from turning over.



(2) Brake piping

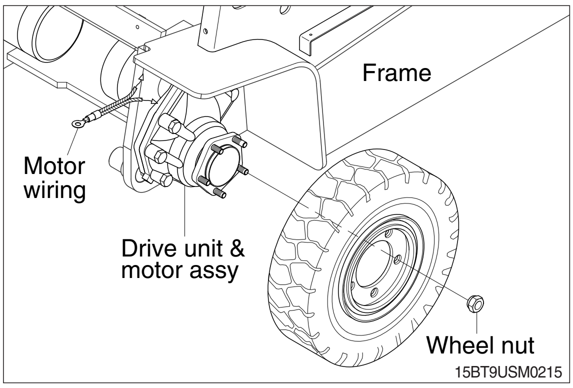
Disconnect the brake piping from the drive unit.



(3) Drive unit & motor assy

※ Drain the oil before disassembling the drive unit.

① Unscrew five wheel nuts and remove the wheel.



② Remove three hexagon bolts holding the drive motor in place.

③ Carefully remove the drive motor from the drive unit.
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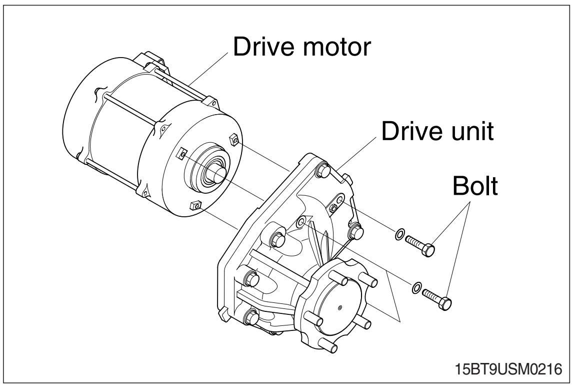
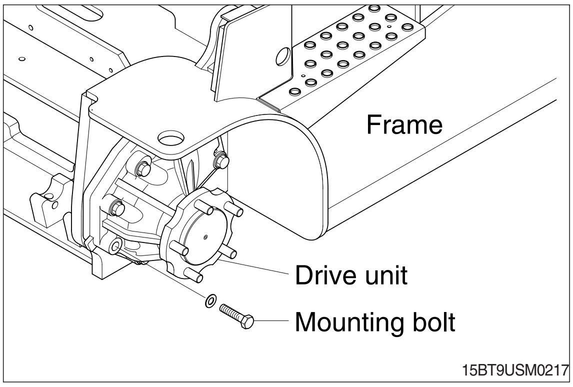


④ Loosen seven mounting bolts on the truck frame and carefully take out the drive unit.

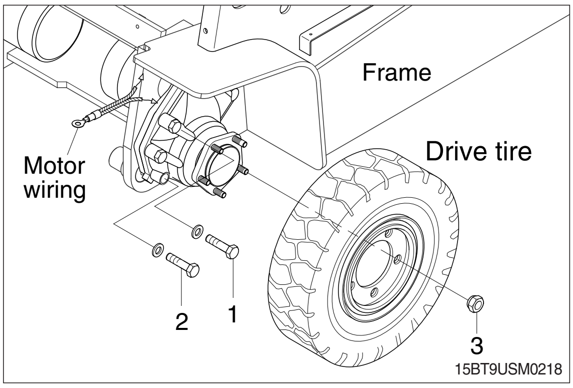


2) INSTALLATION

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

· Tightening torque

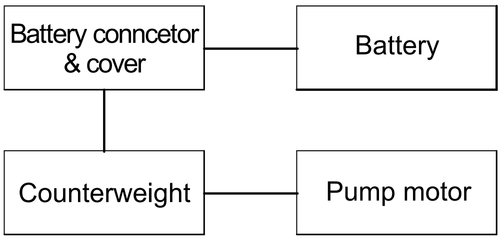
Item	kgf · m	lbf · ft
Drive motor (1)	5.6 ~ 8.2	40.5 ~ 59.3
Drive unit (2)	12.5 ~ 15	90.4 ~ 109
Wheel nut (3)	12.5 ~ 15.5	90.4 ~ 112



3. ELECTRICAL COMPONENTS

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

1) REMOVAL

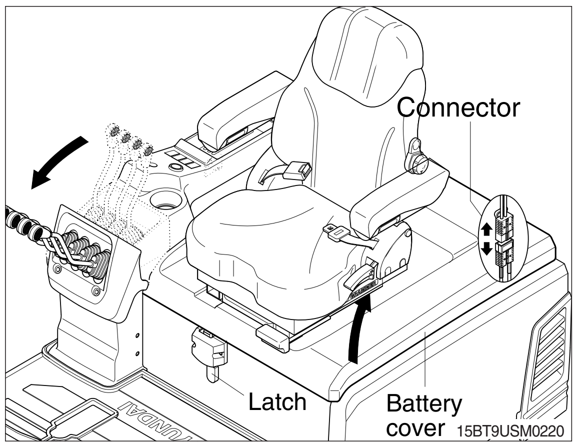


15BT9USM0219

(1) Battery

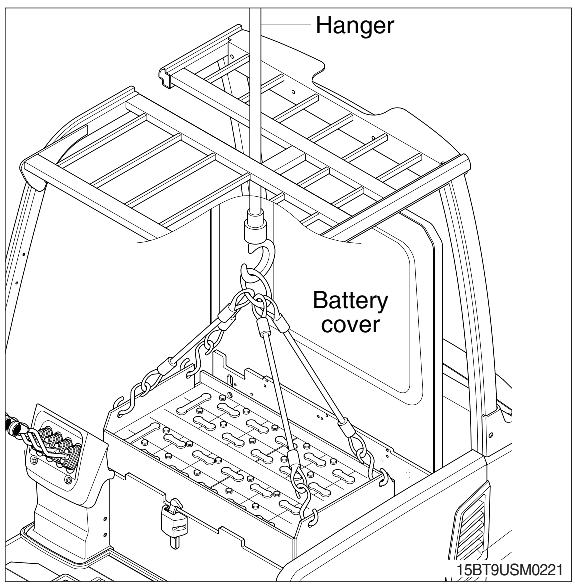
⚠ **Before pulling out the battery plug, tilt the mast forward a little, and lower the fork to the lowest position.**
The batteries weigh from around 780kg to 950 kg so the extreme care must be taken when handling them.

① Disconnect the battery connector.
Release the battery cover latch and open the battery cover.



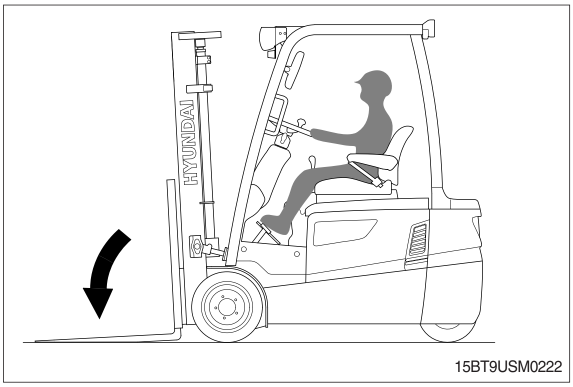
② Using a battery hanger, carefully raise the battery assembly.

※ Be careful not to damage overhead guard or control system.



(2) Pump motor

① Lower the fork to floor.



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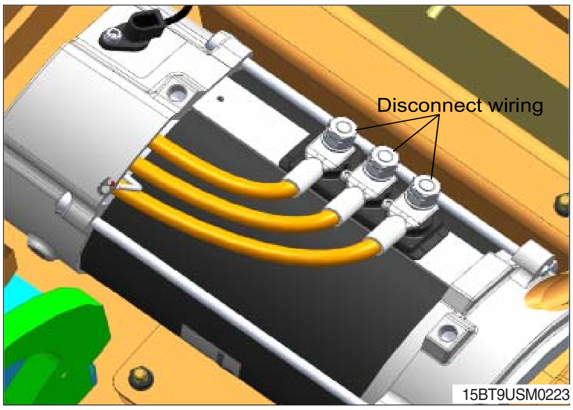
② Remove floor mat and rear floor plate.
Disconnect the wiring of pump motor.



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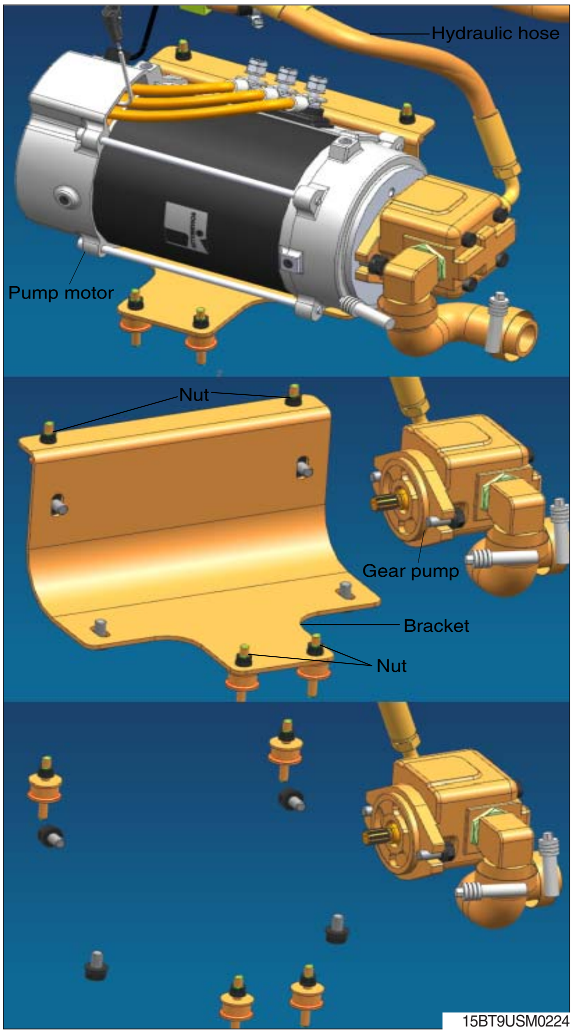
③ Empty all hydraulic oil in the hydraulic tank.

④ Disconnect the hydraulic hoses form the gear pump.

⑤ Remove the nuts of the motor mounting bracket.

⑥ Lift the motor & pump ass'y with a crane.

⑦ Remove the mounting bolts of the motor and remove the bracket.



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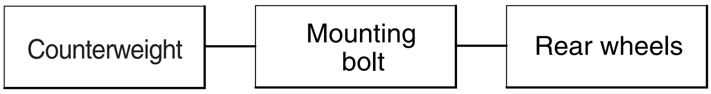
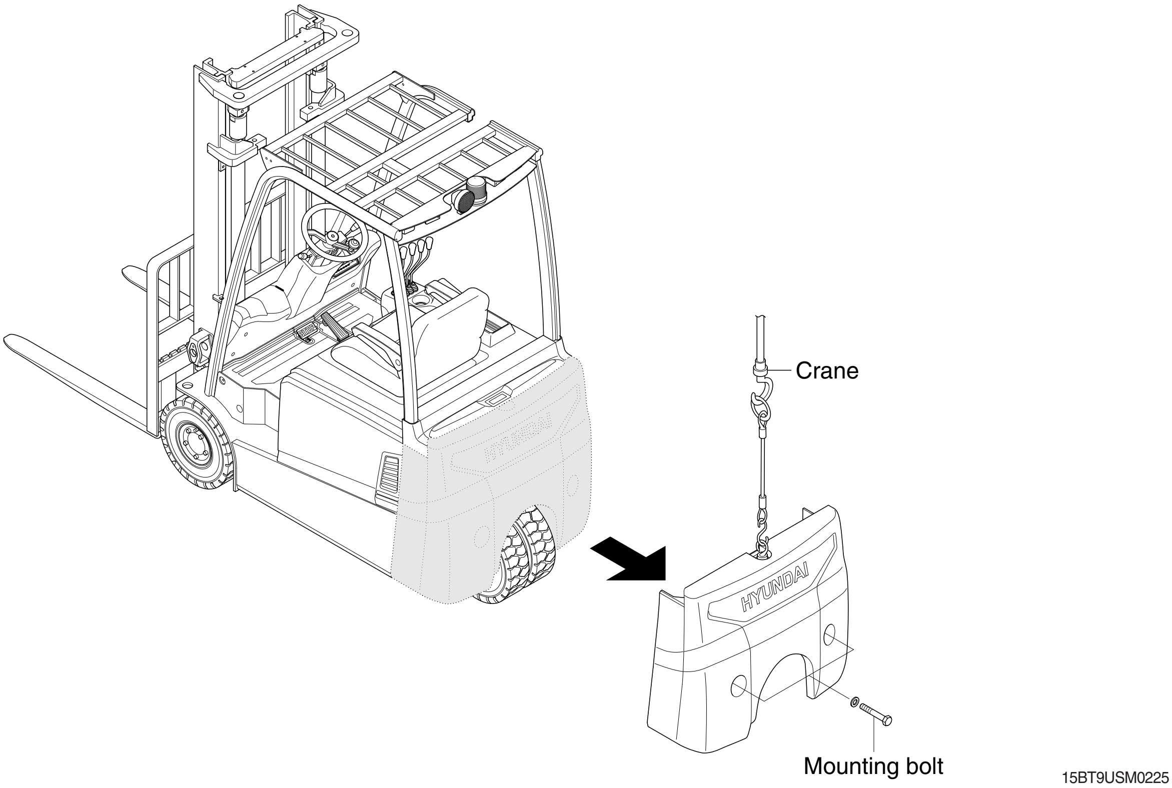
4. STEERING AXLE

1) 15/18/20BT-9U

(1) Removal





① **Counterweight**

Install a lifting tool in the counterweight, and raise with a crane.
Remove the mounting bolts, raise slightly and move to the rear.

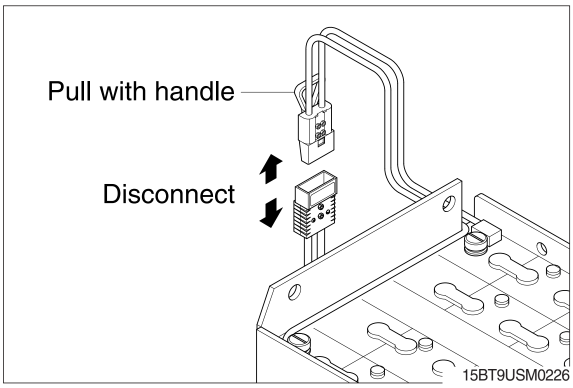
· Weight of counterweight(standard)

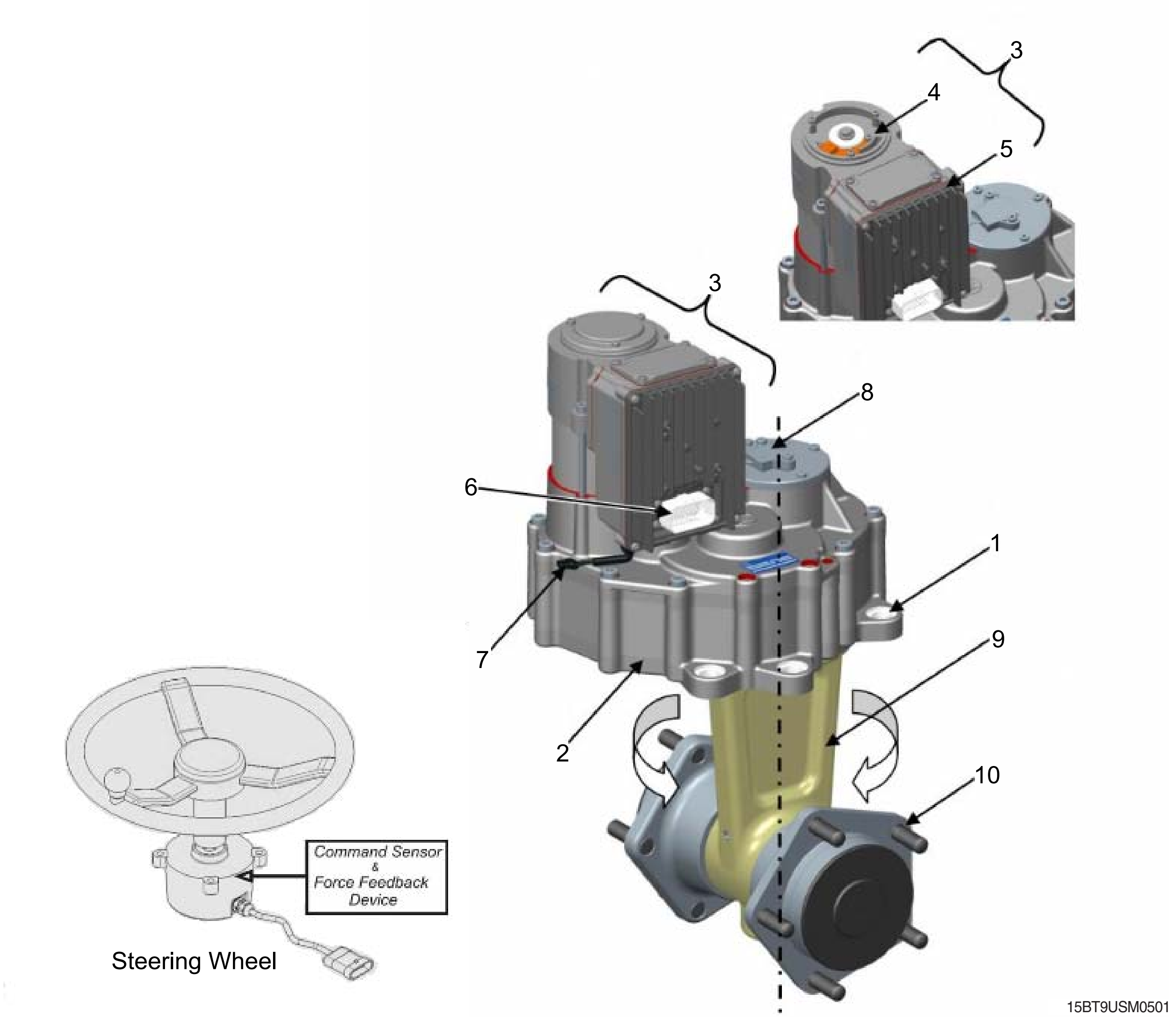
15BT-9U	575kg (1267lb)
18BT-9U	655kg (1444lb)
20BT-9U	790kg (1741lb)

· Tightening torque : 85~115 kgf · m (614~831lbf · ft)

② **Battery connector**

Disconnect the battery connector.





1	Hole (connection to Forklift chassis)	5	Steering controller	8	Angle sensor
2	Helical gear (3 stage)	6	Steering controller connection	9	Axle carrier
3	Motor controller unit	7	Connection for angles-of-rotation sensor	10	Output flange
4	AC Steering motor				

③ Cable
Disconnect the cable connection from steering wheel (TFD) to steering controller.

④ Loosen socket bolts and remove steering motor assy from steering axle bracket.

⑤ Jacking up the chassis of truck.
Loosen the hub nut and take off the steering wheel tire assembly.

⑥ Remove the hub cap. Pull out split pin and remove castle nut and washer.

⑦ Loosen bolts and remove steering axle assy from chassis.

※ Refer to Section 5. Steering System for more details.

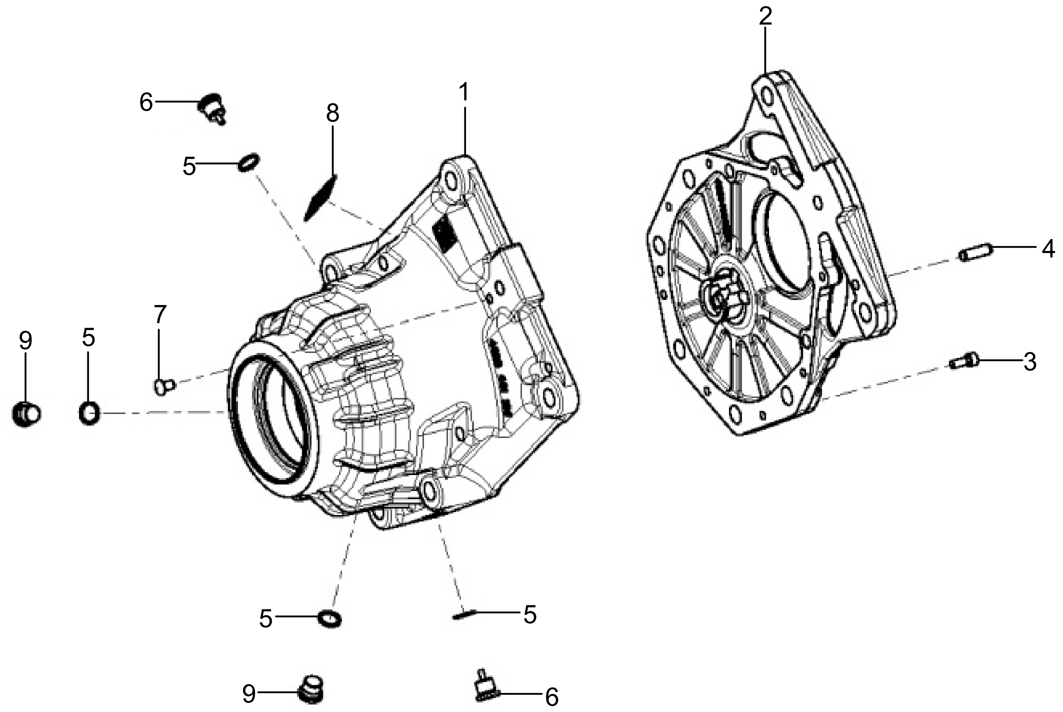
SECTION 3 POWER TRAIN SYSTEM

GROUP 1 STRUCTURE AND OPERATION

1. DRIVE UNIT

1) STRUCTURE

(1) Housing



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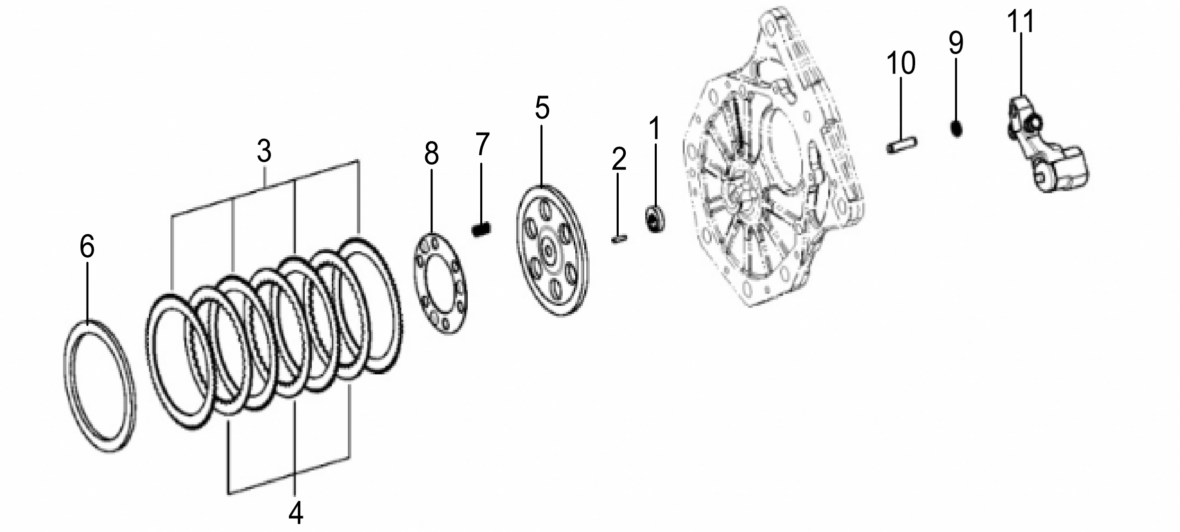
1	Housing	4	Cylinderical Pin	7	Breather
2	Housing Cover	5	Sealing Ring	8	Type Plate
3	Cap Screw	6	Screw Plug	9	Screw Plug

(2) Brake Parts



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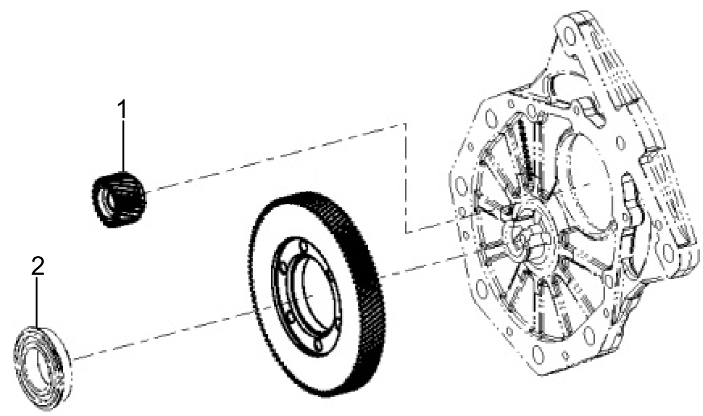
1	Axial Bearing	5	Pressure Disc	9	Sealing Ring
2	Cylindrical Pin	6	Pressure Disc	10	Pin
3	Outer Clutch Disc	7	Compression Spring	11	Brake Lever
4	Inner Clutch Disc	8	Fixing Plate		

(3) Input



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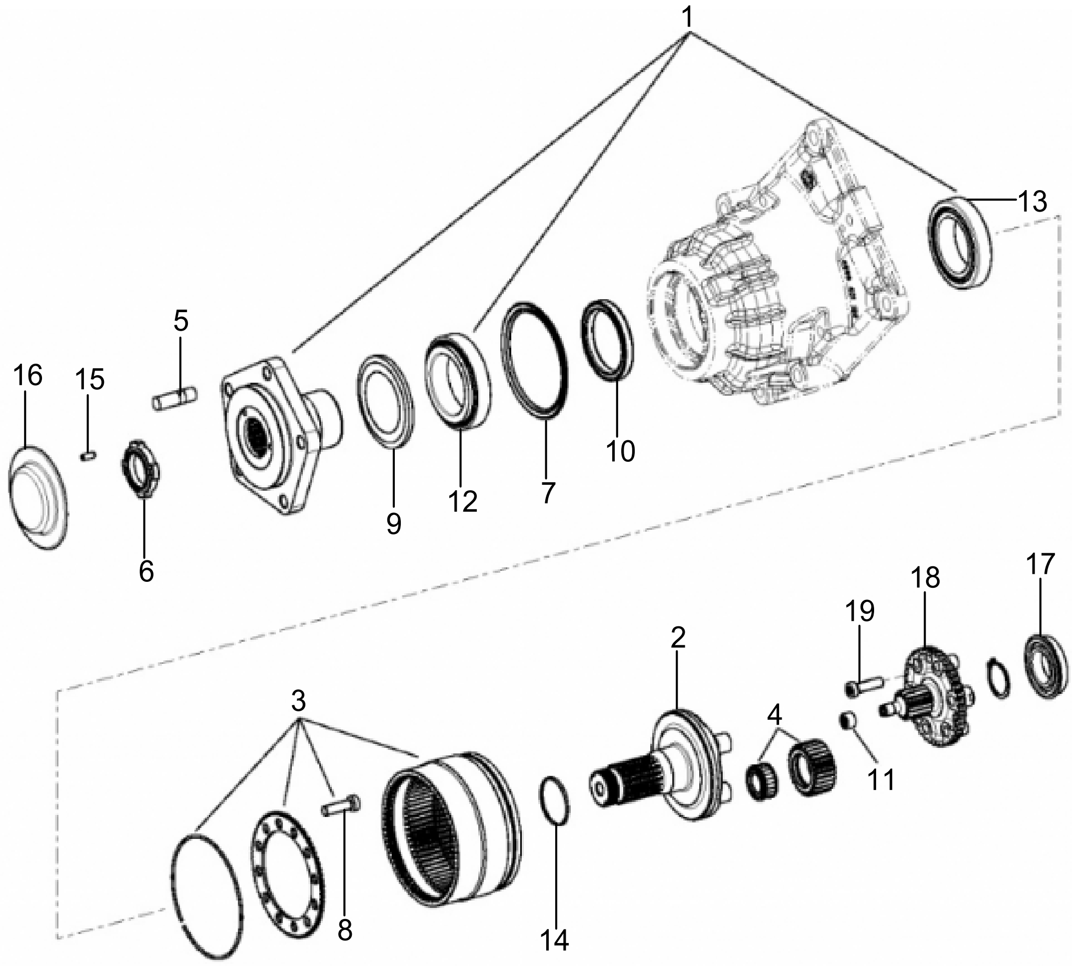
1	Drive Pinion	2	Spur Gear

(4) Output



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1	Wheel Shaft	8	Torx Screw	15	Ball bearing
2	Planet Carrier	9	Nilos Ring	16	Protection Cap
3	Ring Gear	10	Shaft Seal	17	Ball Bearing
4	Planetary Gear	11	Needle Sleeve	18	Inner Disc Carrier
5	Wheel Stud	12	Tapered Roller Bearing	19	Torx Screw
6	Slotted Nut	13	Tapered Roller Bearing		
7	Sealing Ring	14	O-Ring		

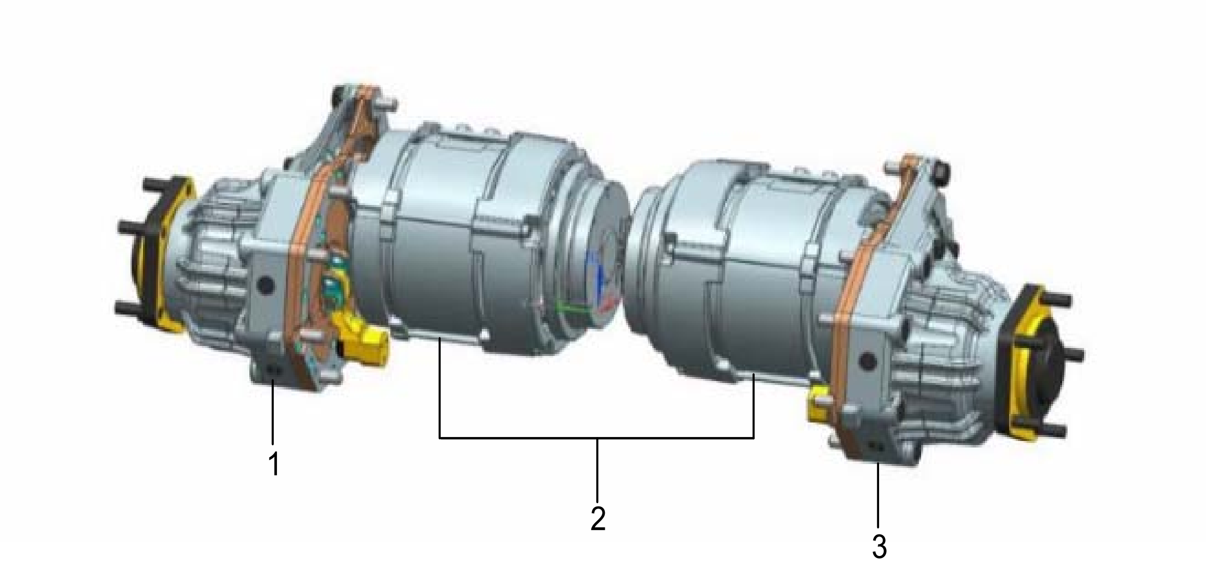
2) SPECIFICATION

Item	Unit	Specification
Max. output torque	N · m	1320
Max. static wheel load	kg/lb	2850/8818
Max. input speed	rpm	5000
Gear ratio available	-	14.0 to 26.6
Weight with oil	kg/lb	Up to 78/171
Oil quantity(ATF)	l /U.S. · qt	0.35/0.36

3) PRINCLPLE OF OPERATION

(1) Outline of the power transmission system

The drive units are composed of the drive unit (LH) and the drive unit (RH) which are connected with the motor as a power transmission system to assemble the drive wheel for the battery type fork lift.



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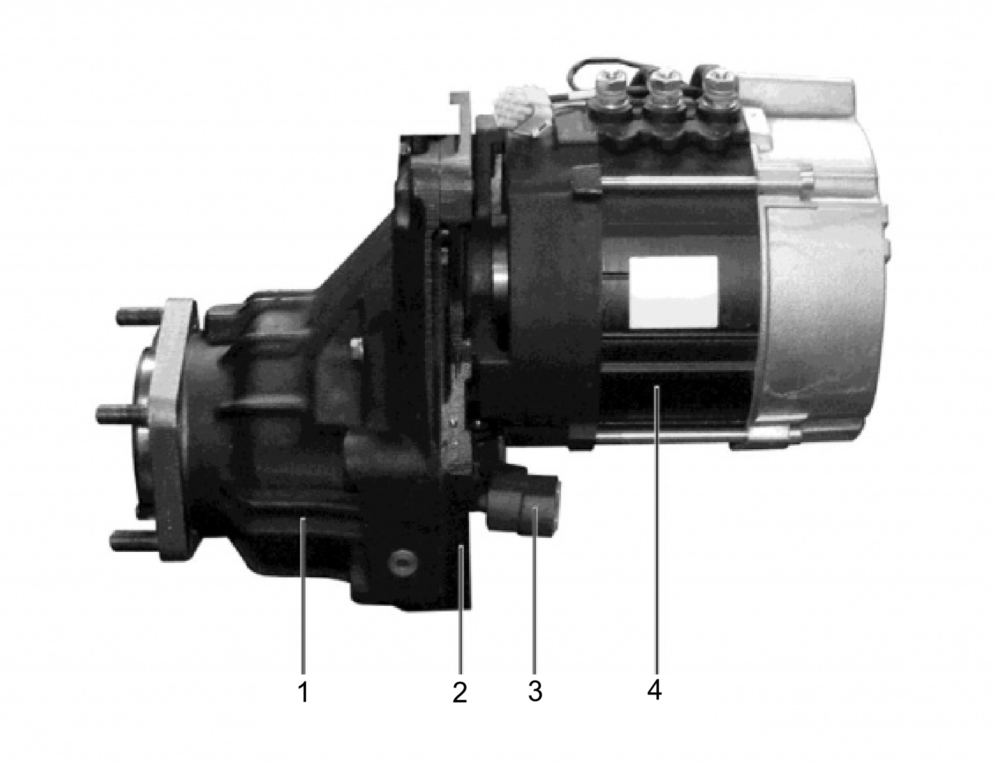
1	Drive unit (LH)	2	Motor	3	Drive unit (RH)

The power of the drive motor which is received from signal of the controller transmits to the dirve gear and the power transfered from the drive gear transmits to the drive wheel via the planetary gear and wheel hub. As a result, it is able to drive to forward and reverse of the fork lift.

(2) Principle of the operation

① Structure of the drive unit



1	Housing	3	Brake lever	4	Motor
2	Cover				

15BT9USM0306

② Technical description

The Drive Unit is only designed for use in fork-lift trucks (front-wheel drive concept for electric counter balanced lift trucks).

The Drive Unit is equipped with an integrated service and parking brake.

Depending on the application, The Drive Unit may be used in vehicles up to a maximum static wheel load of 2850 kg. The Drive Unit is attached to the vehicle chassis by fixtures mounted on the drive unit. The following optional accessories are always available to complete the Gearbox into a drive unit:

- Electric drive motor
- Wheel
- Fixing elements

GROUP 2 TROUBLESHOOTING

Problem	Cause	Remedy
1. High-pitch hitting noise(depending on rpm)	· Teeth of spur gear stage damaged when mounting motor	· Check gear teeth of input pinion and spur gear for damage (Replace a damaged input pinion; if the spur gear is damaged, you may carefully refile the gear teeth using a diamond file.)
2. High-pitch, singing noise	· Mechanical engine connection defective motor bearing defective	· Check motor dimensions and motor connection and if necessary retighten input pinion to hub. Inspect motor and replace if necessary
3. Dull, grinding noise	· Defective Wheel bearing	· Inspect wheel bearing, replace if necessaryl
	· Incorrect bearing pretension of wheel bearing	· Check bearing pretension, correct if necessary
	· Defective teeth in planetary gear	· Inspect planetary stage gear set and wheel bearing, replace if necessary
4. Bleeder	· Oil level too high	· Check oil level, correct if necessary
5. Housing cover	· Bolts not tightened to specified torque	· Check tightening torque, retighten bolts if necessary
6. Gear shaft	· Radial shaft sealing ring damaged or worn	· Check radial shaft sealing ring, replace if necessary
7. Brake Lever	· Defective sealing ring	· Check sealing ring, replace if necessary
8. Screw plugs	· Screw plugs not tightened to specified torque · Incorrect or defective sealing ring mounted	· Check tightening torque, if necessary retighten bolts · Remove screw plugs and use genuine sealing rings
9. Motor Connection	· Defective motor O-ring	· Remove motor and replce O-ring
10. Motor	· Worn radial shaft sealing ring on motor shaft · Defective connecting cable/loose · Carbon brushes(if fitted) fretted/worn · Insulation burned through	· If necessary replce motor · Replace/tighten connecting cable · Replace carbon brushes · Replace motor
11. Drive unit	· Blocked motor/gear box · Service brake blocked	· Replce motor/gear box · Carry out maintenance/repair to service brake

12. Foot brake	· Air in hydraulic system · Worn brake discs · Worn axial slide bearing · Ruptured brake cable	· Bleed or top up brake fluid · Replace brake discs · Replace axial slide bearing · Replace brake cable

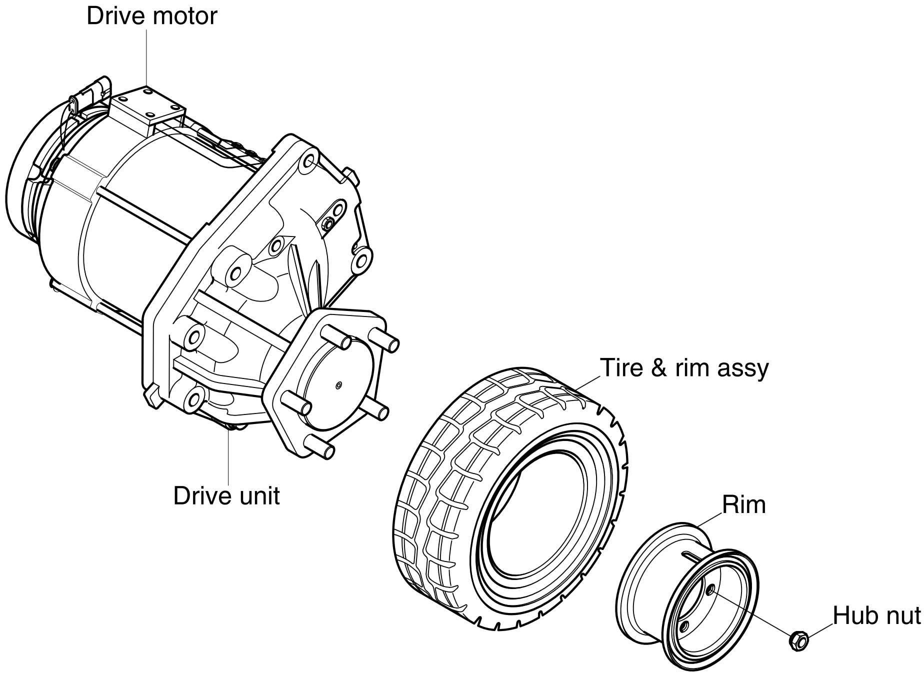
GROUP 3 DISASSEMBLY AND ASSEMBLY

1. Disassembly

Drain oil from transmission before removal of the drive unit. Loosen and remove the wheel nuts as well as take off the drive wheel. See the related chapter for further work on the drive motor of the drive unit.

1) REMOVAL OF THE DRIVE UNIT

(1) **Removal of Drive unit.** (refer to see page 2-8)



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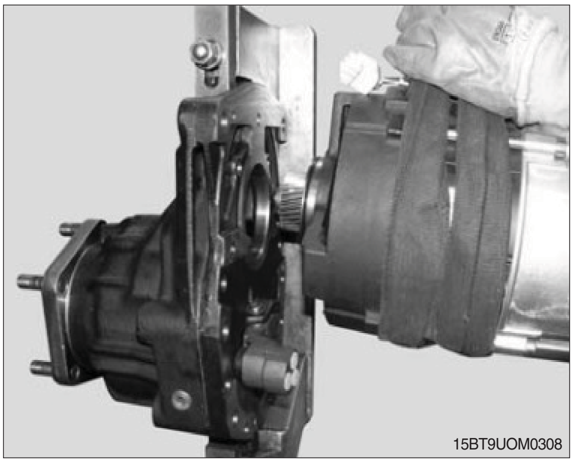
2) REMOVAL OF THE DRIVE MOTOR

(1) Drive motor and accessories mounted to the drive motor have to be disconnected.

(2) Take off cautiously the drive motor from the drive unit.

⚠ **Do not damage the teeth of the motor pinion and the spur gear.**
Damages can cause louder running noises.

※ In case of an inadequate removal of the drive motor from the drive unit there is danger to damage the sealing surface for the O-ring in the housing.
If only the drive motor is removed, the released drive unit opening is to be sealed in order to avoid that dirt can get inside the drive unit.



15BT9UOM0308

2. GENERAL INSTRUCTIONS FOR CORRECT DISASSEMBLY AND REASSEMBLY

Cleanliness is essential for a correct work.
Drive unit removed from the vehicle have to be cleaned prior to opening.
Special care and cleanliness are essential for a correct disassembly and reassembly of the unit as well as for the installation of each spare part. A fault during installation can result in an early wear and chips as well as foreign particles in the unit could cause fatal damage in the drive unit.
Prior to reassembly all parts must be cleaned and inspected for wear and other defects.
It would be a false economy to reinstall parts which are not in a perfect condition.
All parts have to be oiled carefully during reassembly. Apply a sealing compound onto housing-and cover faces, which must be tight towards the outside.

For heating of bearings etc. use heating plates, heating elements or heating furnaces.
Never heat directly with an open flame. This avoids damage to the bearings.

If not otherwise indicated heat ball bearings, gears, flanges etc. to approx. 90-100℃.

Parts which have been mounted in a warm condition must be subsequently installed after cooling down to ensure a perfect contact.
Lubricate both parts before shafts, bearings etc. are pressed into position.

For reassembly all of the indicated setting values, test data and tightening torques must be observed.
HYUNDAI-units will be filled with oil after repair work.

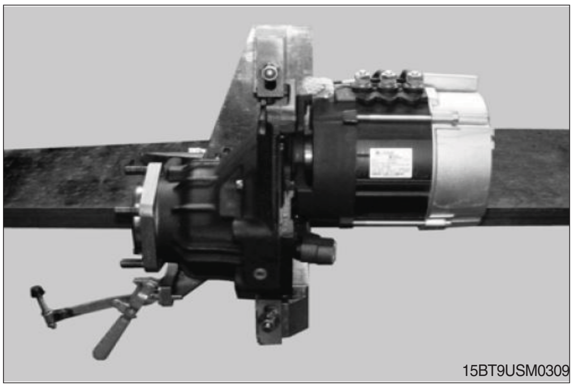
The following description of disassembly and reassembly serves to inform both the after-sales service.
※ Centers of HYUNDAI and of the vehicle manufacturer, where adequate workshop facilities and trained specialists are present.

3. DISASSEMBLY OF THE DRIVE UNIT

1) Motor Disassembly

※ Always keeps clean working area when disassebling the drive unit.

(1) Clamp the drive unit in the assembly fixture and turn the drive unit.



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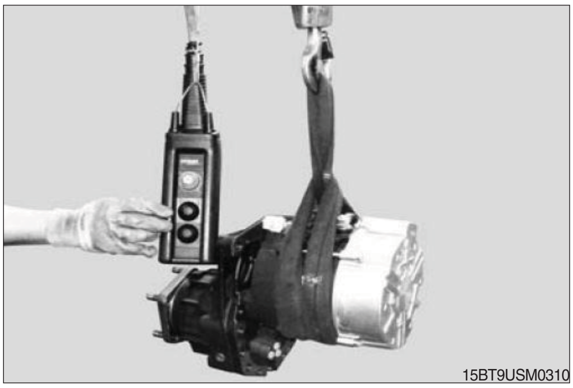
(2) Fasten the motor to suitable lifting gear using approved attachment equipment.



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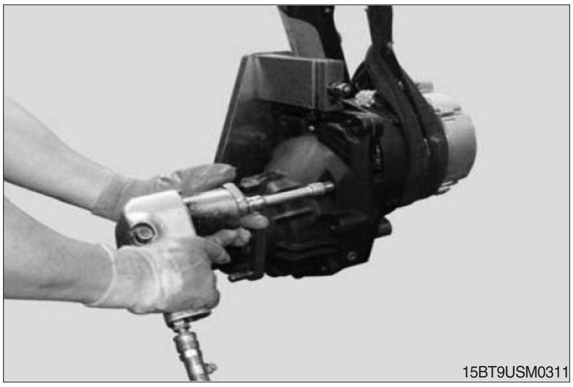
(3) Undo the 3 Allen bolts and remove.



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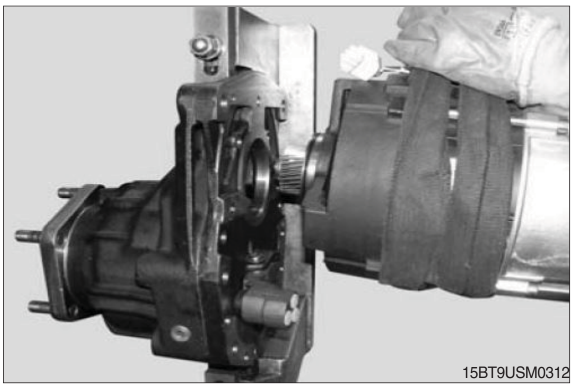
(4) Carefully remove the motor from the drive unit and set it down on a suitable support piece. Secure the motor against falling.



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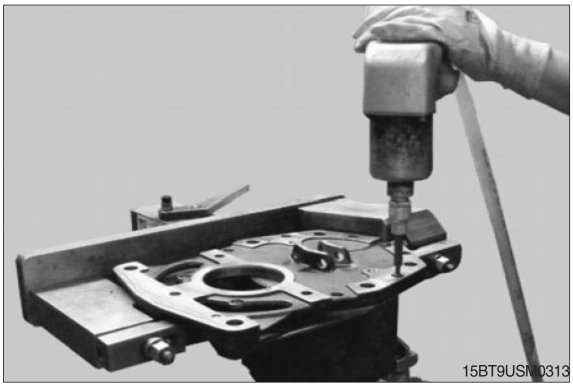
2) Removing the Housing cover

※ The brake lever shall be removed before removing the housing cover.

(1) Undo the 8 Allen bolts and remove from the housing cover.



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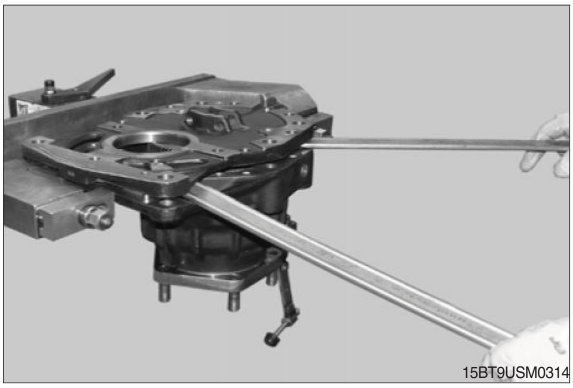
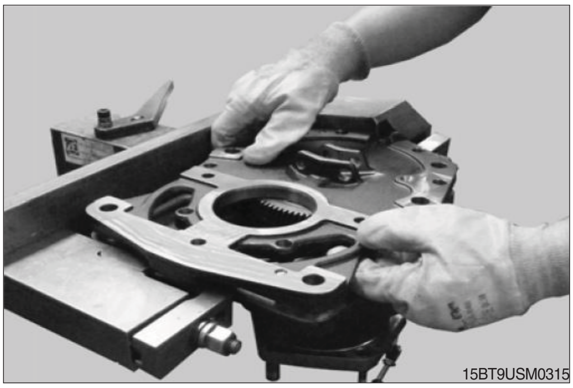
(2) Release the housing cover using assembly levers and raise slightly and evenly.



15BT9USM0314

(3) Remove the housing cover from housing.



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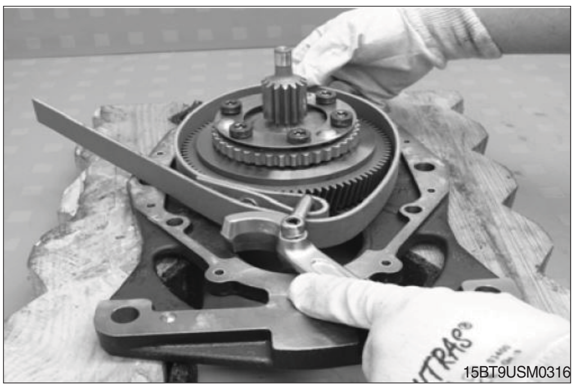
Inner disc carrier

(4) Place the cover assembly onto a suitable support and assure an even and stable rest. Place the strap around the spur gear and tighten it by using the wrench lever.



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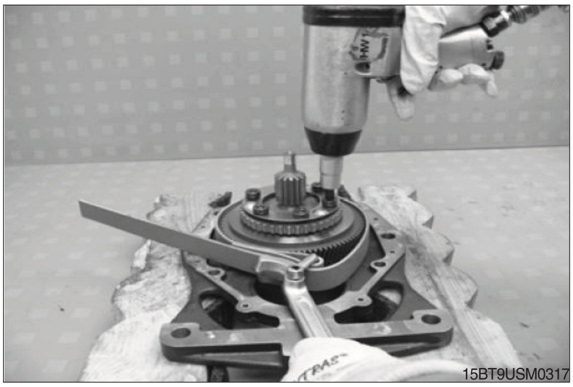
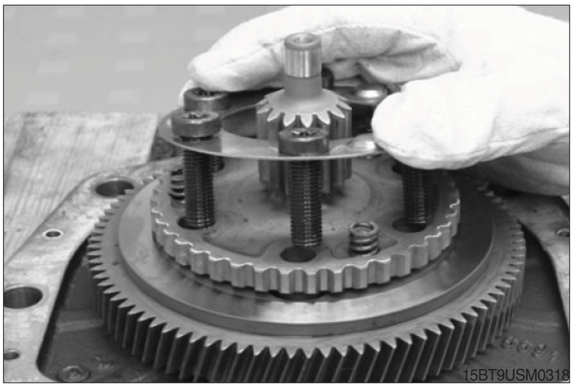
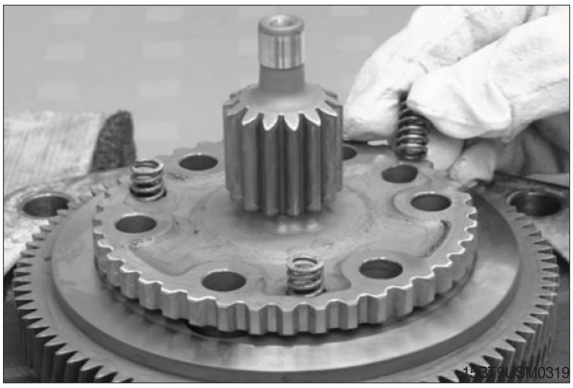
(5) Hold the spur gear tight using the strap wrench. Undo the 6 Torx bolts.



(6) Manually remove the retaining plate from the spur gear together with the 6 Torx bolts.

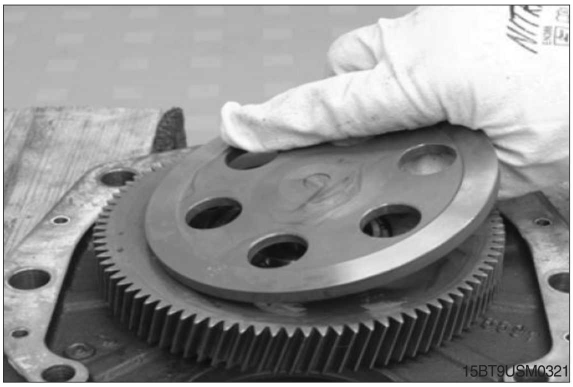


(7) Manually remove the 3 pressure springs 1.6x8.0x21.5 from the spur gear.



(8) Manually remove the inner disc carrier from the pressure disc.

(9) Manually remove the pressure disc from spur gear.



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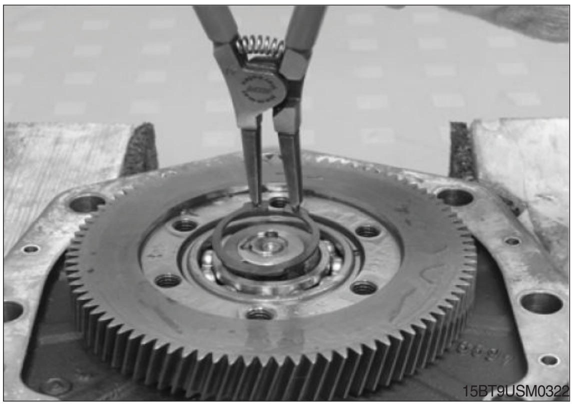
Spur gear
(10) Remove the spur gear retaining ring.



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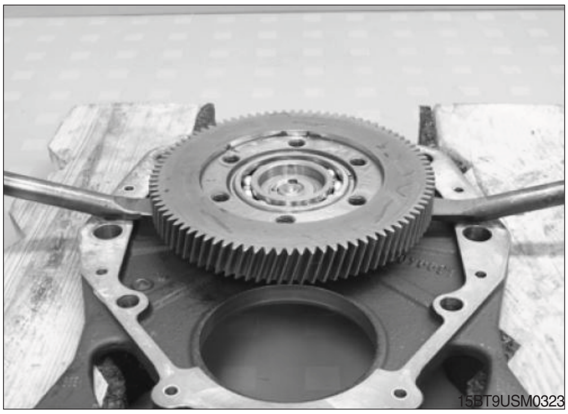
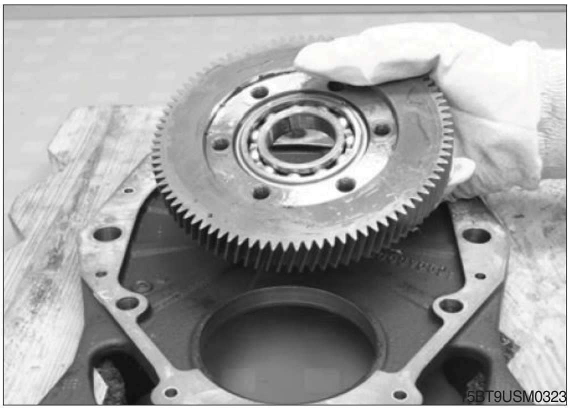
15BT9USM0322

(11) By levering the spur gear alternately on both sides, manually remove it from the housing cover.

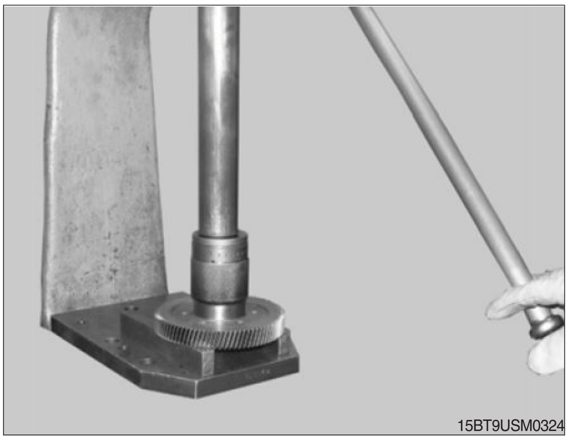
※ Be careful not to damage the toothing when levering.





(12) Remove the grooved ball roller bearing from the spur gear using tool and the hand lever press.

※ Risk of accident and injury from crushing. When pressing out the grooved ball roller bearing, do not place hands between the punch and the tool.



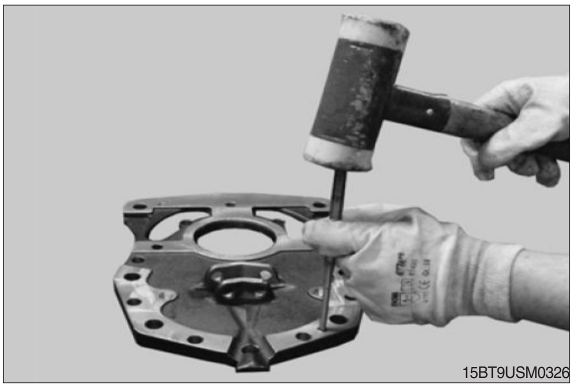
Axial bearing

(13) Lever the axial bearing out of the housing cover using a screw driver and remove.

15BT9USM0325

Cylinderical pin

(14) Remove the 2 cylindrical pins from the housing cover. If one or both of the cylindrical pins remain in the housing during disassembly, they shall be removed using pliers. The pins will be destroyed in the process and shall be replaced during reassembly.



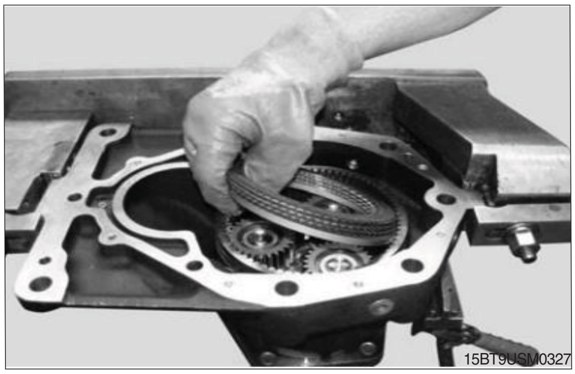
15BT9USM0326

3) Housing disassembly

※ When changing the disc set in one gearbox, the disc set of the gearbox on the other side of the vehicle shall also be changed. If this is disregarded, there may be a pronounced difference in braking effect between the left-hand and right-hand gearbox. The difference in braking effect may lead to longer braking distances or to the vehicle breaking out to the side. lways keeps clean working area when disassebling the drive unit.

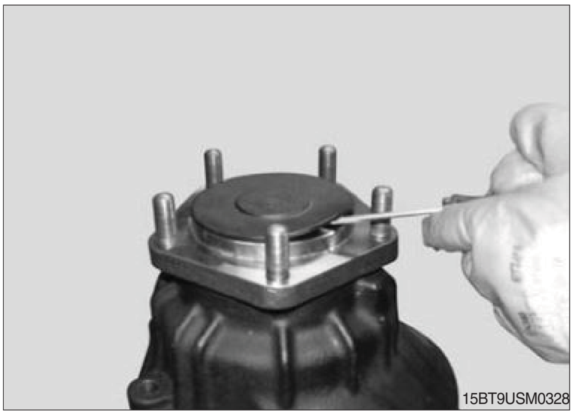
Brake disc set

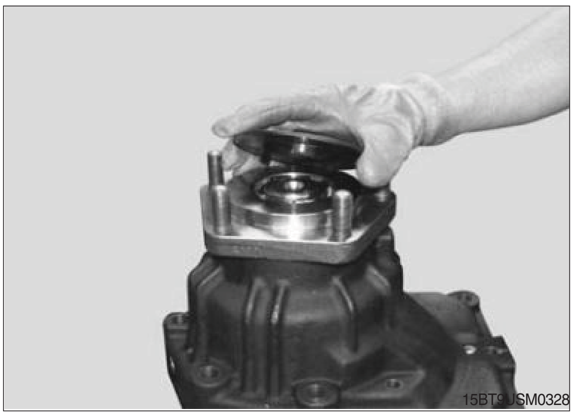
(1) Remove the brake disc from the internal gear.



Protective cap

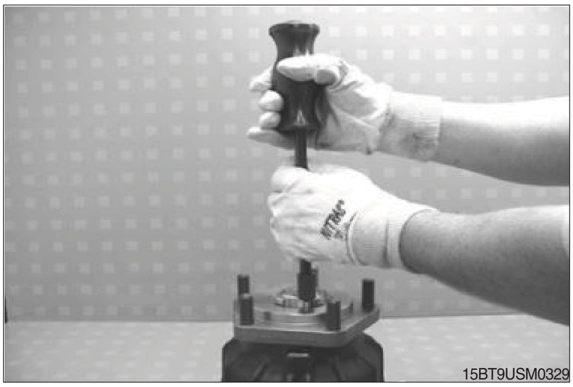
(2) Release the protective cap from the wheel shaft and remove manually.





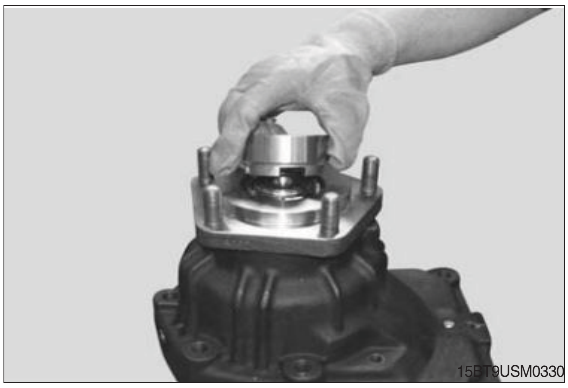
Cylindrical pin

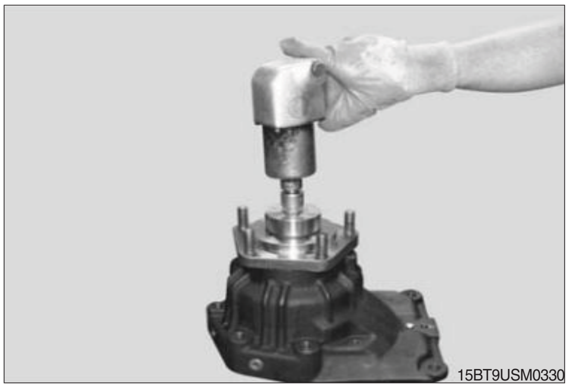
(3) Remove the cylindrical pin which secures the grooved nut from the wheel shaft.
To do this, screw the thread of Pinion extractor with hammer stroke fully into the cylindrical pin. Slide the hammer upwards several times with enough drive to pull out the cylindrical pin.



Grooved nut

(4) Undo the grooved nut from the wheel shaft and remove manually.





(5) Place the housing on the press table with the mating surface facing downwards.

15BT9USM0331

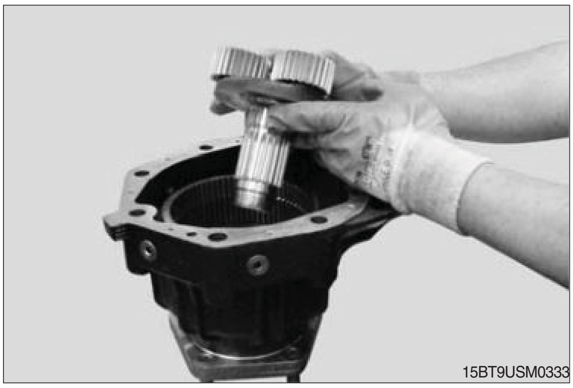
Planet carrier

(6) Press the planet carrier out of the housingousing sub assy.

※ Risk of accident and injury from crushing. When pressing out the planet carrier, do not place hands between the punch and the tool.

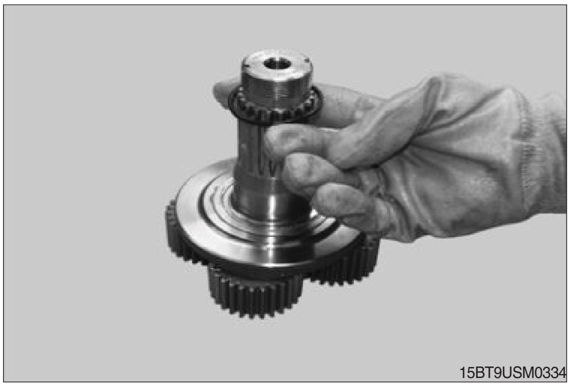
15BT9USM0332

(7) Remove the planet carrier from the housing.



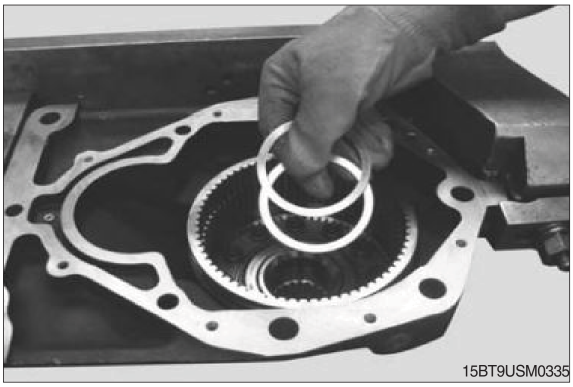
15BT9USM0333

(8) Remove O-ring from planet carrier by hand.



15BT9USM0334

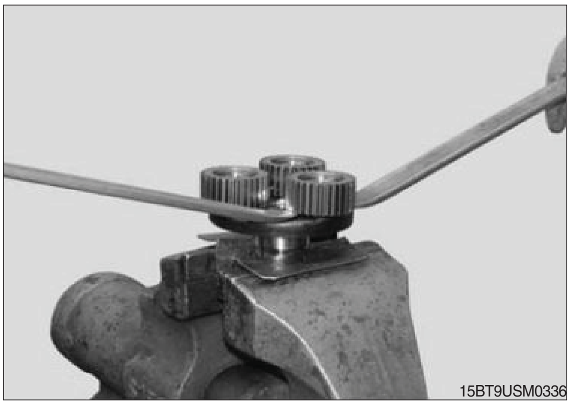
(9) Clamp the housing in the assembly fixtures. Remove the spacers from the housing.



15BT9USM0335

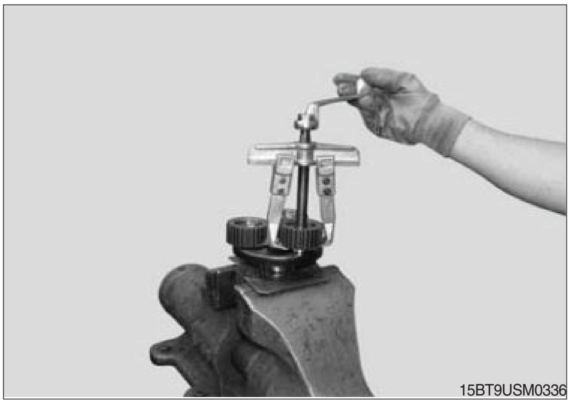
Planetary gears

(10) Version with 3 planet gears
Clamp the planet carrier in a vice.
Fit the jaws of the vice with protective jaws (e.g. copper, aluminium or brass) to prevent the surfaces from being damaged.



15BT9USM0336

Remove the 3 planetary gears from the planet gear.



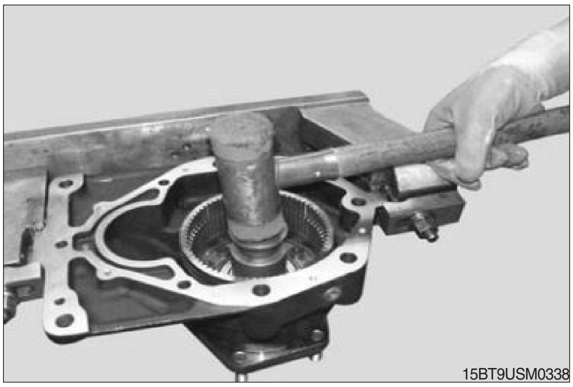
15BT9USM0336

(11) Version with 4 planet gears
Clamp the planet carrier in a vice.
Fit the jaws of the vice with protective jaws (e.g. copper, aluminium or brass) to prevent the surfaces from being damaged.

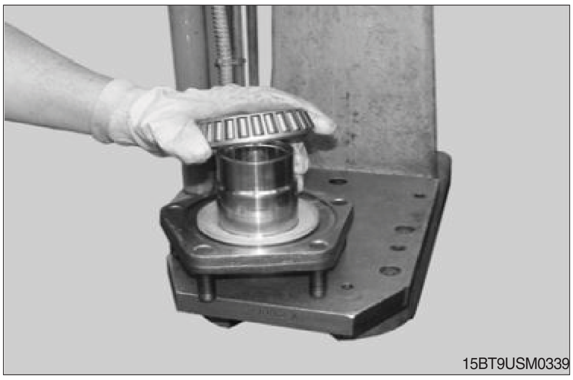
Remove the 4 planetary gears from the planet gear.

15BT9USM0337

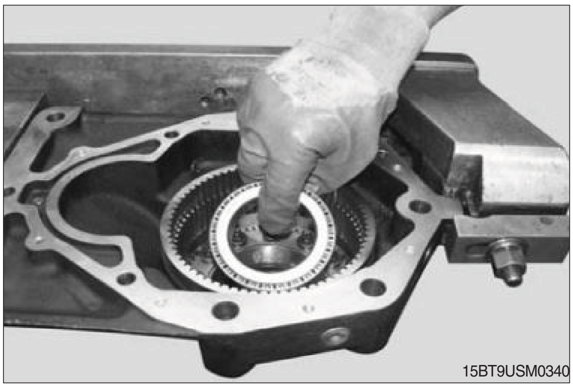
Gear shaft
(12) Drive the wheel shaft out of the housing. Secure the drive against falling from below with your hand.


15BT9USM0338

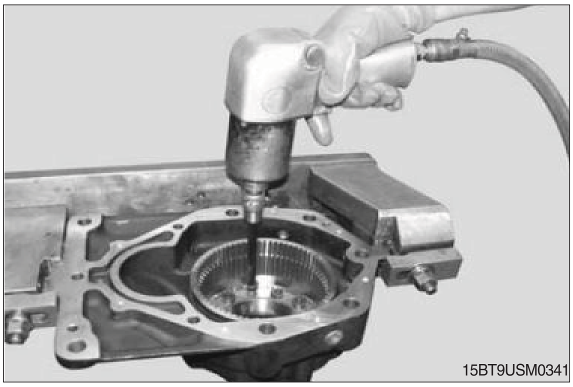
Wheel shaft taper roller bearing
(13) If necessary, heat the taper roller bearing to facilitate removal. Wear prescribed protective equipment and use appropriate tools.
Remove the wheel shaft side taper roller bearing from the wheel shaft. If necessary, heat the taper roller bearing.
※ Risk of accident and injury caused by hot surface.


15BT9USM0339

(14) Remove the planet carrier side taper roller bearing.


15BT9USM0340

Internal gear
(15) Remove the 12 Torx bolts from the internal gear.


15BT9USM0341

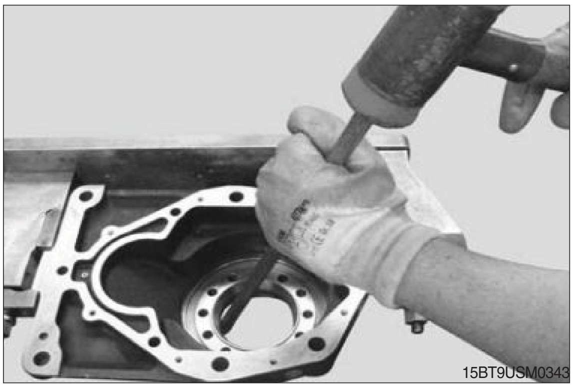
(16) Remove the internal gear from the housing.

If the internal gear is damaged, it shall be replaced as a complete unit.


15BT9USM0342

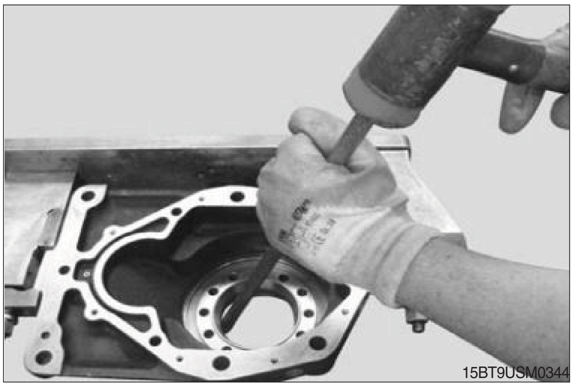
Wheel shaft sealing ring

(17) Drive the sealing ring downwards and out of the housing by impacting it alternately on opposite sides.
The shaft sealing ring is destroyed in the process. During reassembly, a new shaft sealing ring shall be used.


15BT9USM0343

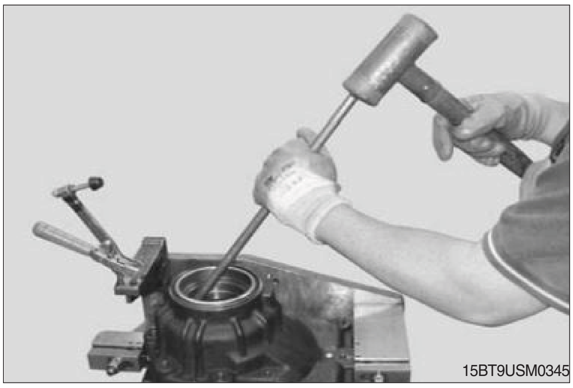
Wheel shaft side bearing cup

(18) Drive the wheel shaft side bearing cup of the taper roller bearing downwards and out of the housing by impacting it alternately on opposite sides.


15BT9USM0344

Planet carrier side wheel shaft

(19) Drive the planet carrier side bearing cup of the taper roller bearing downwards and out of the housing by impacting it alternately on opposite sides.


15BT9USM0345

\# Wheel shaft sided sealing

(20) Disassemble the sealing ring by using a chisel.
The sealing ring is destroyed in the process. During reassembly, a new sealing ring shall be used.

15BT9USM0346

3. ASSEMBLY OF THE DRIVE UNIT

1) Housing reassembly

※ Wheel shaft sided sealing ring

(1) Place the wheel shaft sided sealing ring onto the transmission housing
Make sure that the sealing lip is facing upwards.

15BT9USM0347

(2) Drive up the sealing ring into the transmission housing against the block.

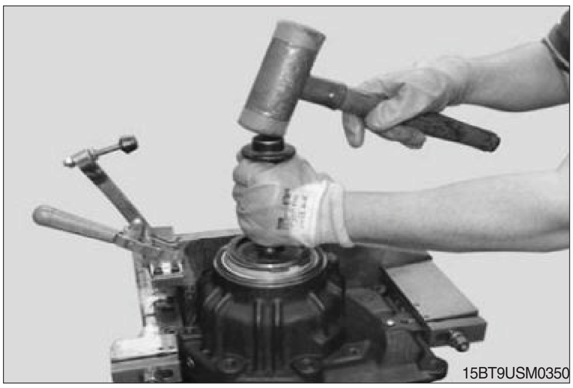
15BT9USM0348

Shaft sealing ring

(3) Place the shaft sealing ring into the tool (Assembly mandrel).
The closed side of the shaft sealing ring shall be facing the flange connection for the wheel.

15BT9USM0349

(4) Drive the shaft seal into the bore by using an assembly mandrel.
The shaft seal has reached its correct position as soon as its upper surface has reached at least the lower end of the bore's chamfer.



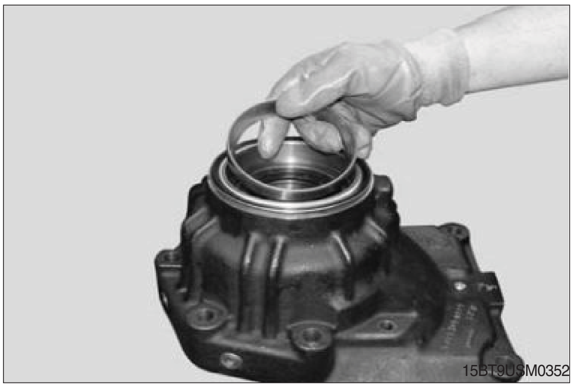
15BT9USM0350

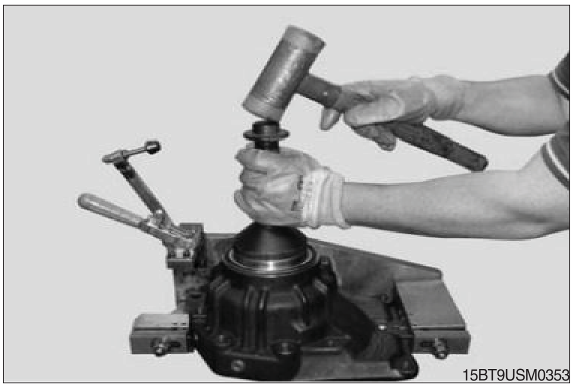
Wheel shaft side bearing seat

(5) Clean the wheel shaft side bearing seat of the taper roller bearing in the housing .


15BT9USM0351

(6) Drive the wheel shaft side bearing cup of the taper roller bearing into the bearing seat.
The inside of the bearing cup shall narrow to a taper towards the bearing seat and the wide edge of the bearing cup shall be positioned at the bottom.


15BT9USM0352

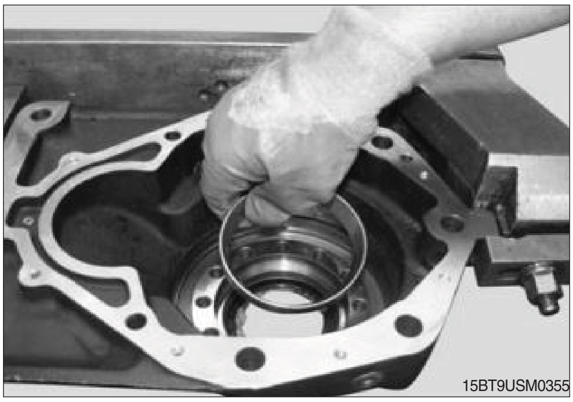

15BT9USM0353

(7) Coat the inner lip of the shaft sealing ring with multipurpose


15BT9USM0354

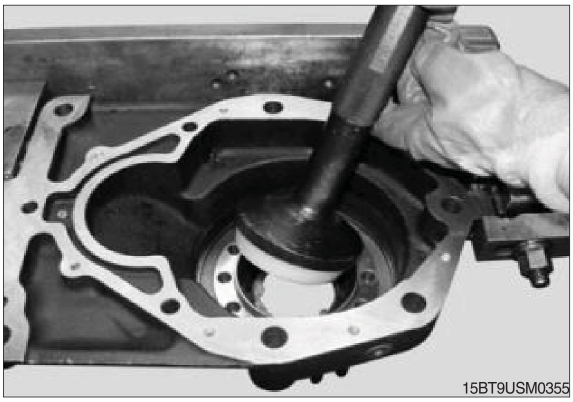
Planet carrier side bearing seat

(8) Drive the planet carrier side bearing cup of the taper roller bearing into the bearing seat.

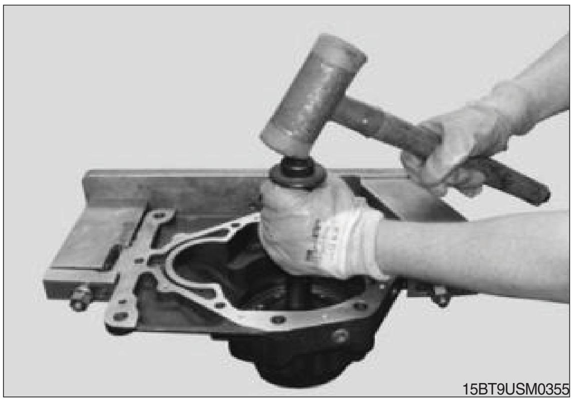


15BT9USM0355

The inside of the bearing cup shall narrow to a taper towards the bearing seat and the wide edge of the bearing cup shall be positioned at the bottom. Drive in the bearing cup until a dull metallic sound signals that the bearing cup is resting against the bearing seat.



15BT9USM0355



15BT9USM0355

\# Internal gear

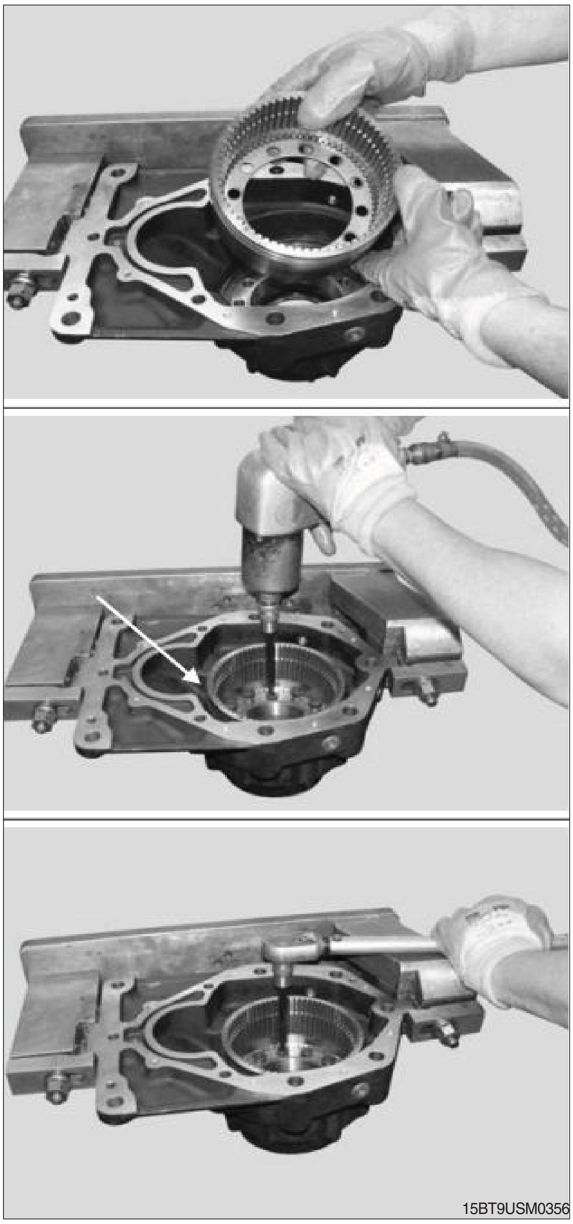
(9) Manually slot the toothed disc into the internal gear.
Lay the ring into the groove of the internal gear.
Place the internal gear into the housing by hand.

The opening of the ringshall be visible (see arrow). Bolt on the internal gear with 12 Torx bolts .

① Pretighten the bolts with a compressed-air screw driver in a cross wise pattern.
② Firmly tighten the bolts using a torque wrench.

When tightening the bolts, note the tightening torque of 79 Nm.

Check whether it is still possible to move the internal gear in a rocking motion after tightening the bolts. If it is possible, continue with work. If it is not: Remove the internal gear again and replace it.
Remove from the housing all the parts which have so far been installed and replace the housing.



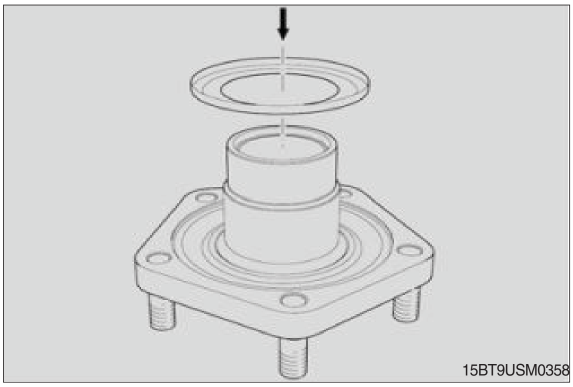
15BT9USM0356

\# Gear shaft

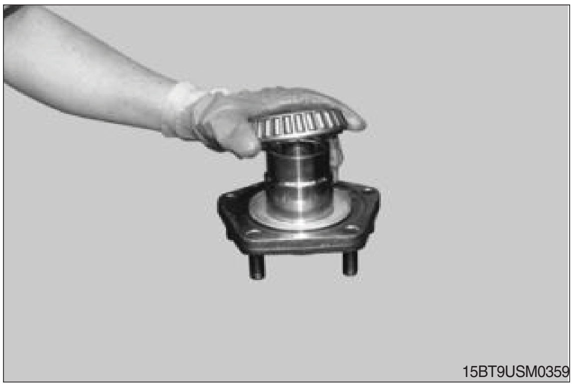
(10) Coat the Nilos ring with multipurpose grease.

15BT9USM0357

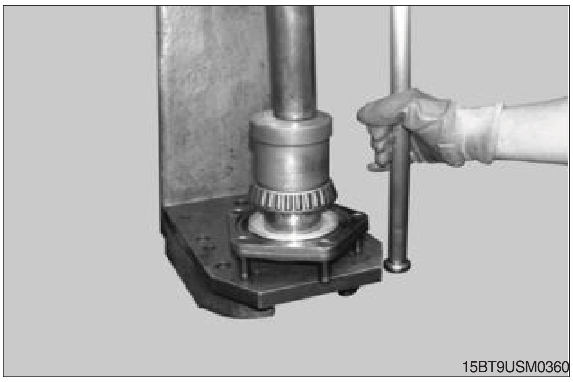
(11) Slide the Nilos ring onto the wheel shaft.



(12) Fit taper roller bearing on gear wheel side to gear shaft by hand.

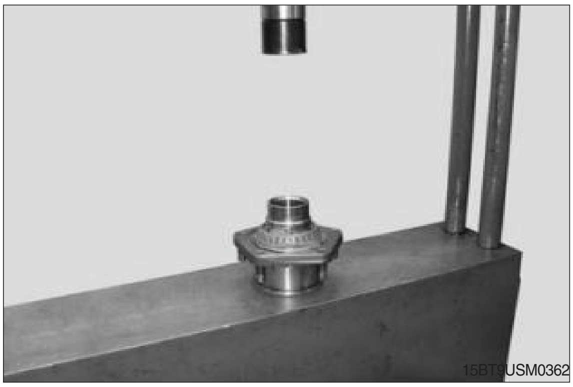


(13) Press taper roller bearing on gear wheel side onto gear shaft using lever press and tool.
Plunger of lever press, tool and gear shaft must align vertically with no offset.

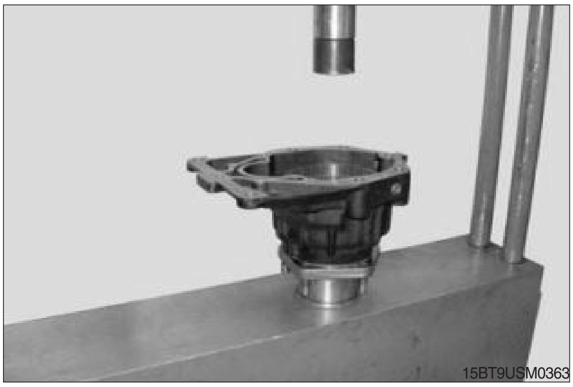


(14) Grease the taper roller bearing.

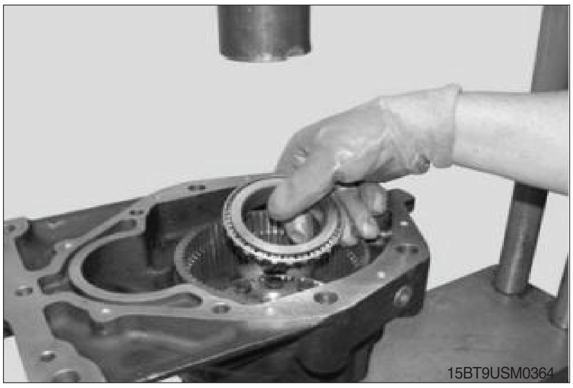
(15) Place the wheel shaft on the press table so that the wheel studs point downwards. The wheel shaft shall stand on a suitable sleeve and the wheel studs shall be clear of the table.



(16) Fit the housing perpendicularly onto the wheel shaft.
The mating surface of the housing shall face upwards.



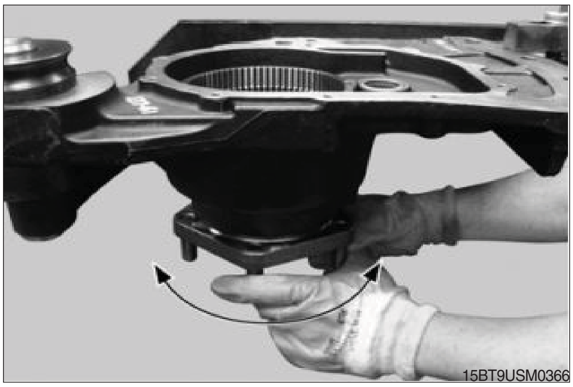
(17) Place the taper roller bearing onto the seat of the wheel shaft.



(18) Press the planet carrier side taper roller bearing onto the wheel shaft.

The punch of the hand lever press, tool and taper roller bearing shall be positioned vertically to each other without deflection.

(19) Check the wheel shaft for smooth running. It shall be possible to move the wheel shaft easily by hand. In order that the taper rollers can align themselves correctly in the bearing races, a soft head hammer should be used to tap at various points around the wheel shaft. If the taper rollers are correctly aligned, continue with the work. If they are not: Remove the wheel shaft again. Check both bearings (wheel shaft side and planet carrier side) for any damage which may have occurred during the press fitting procedure. If damage is found, remove the bearings and replace with new ones.



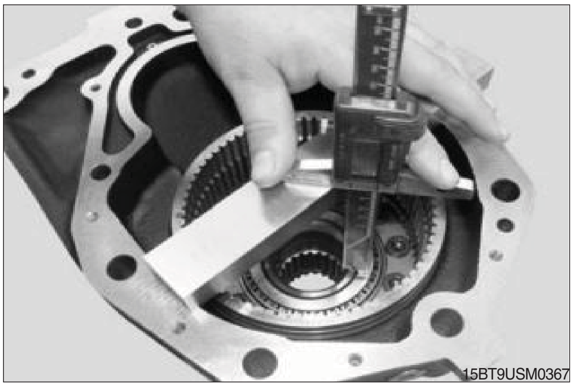
15BT9USM0366

Measuring and adjusting

(20) Measuring the distance between the bearing surface of the taper roller bearing and the surface of the wheel shaft.

① Rest spacer on the mating surface of the housing.

② Set the depth gauge onto spacer.



15BT9USM0367

It shall be ensured that the greatest possible contact area of the depth gauge is resting on spacer.

③ Adjust the depth gauge to the surface of the wheel shaft.

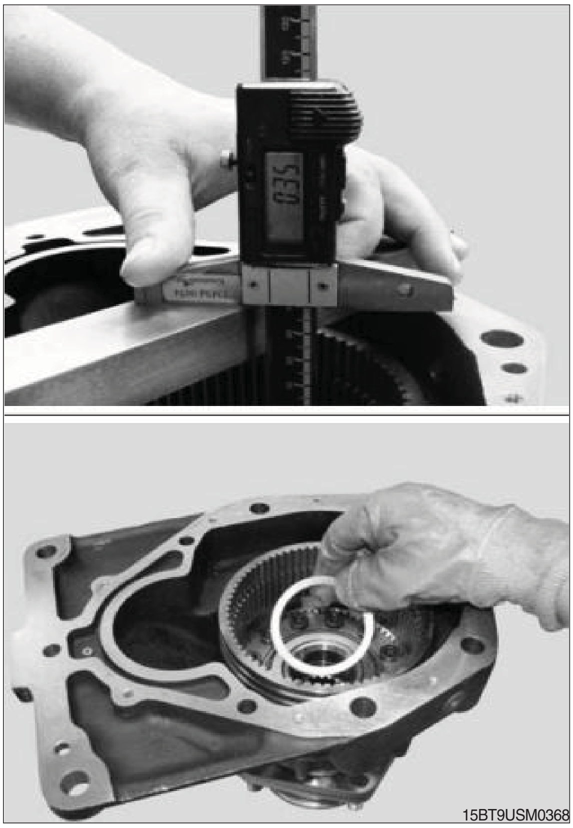
④ In the position, zero the depth gauge.

⑤ Adjust the depth gauge to the surface of the taper roller bearing

⑥ Read off the difference between the two settings.

⑦ Repeat the measurement on the opposite side. The difference in measurement may not exceed 0.5 mm.

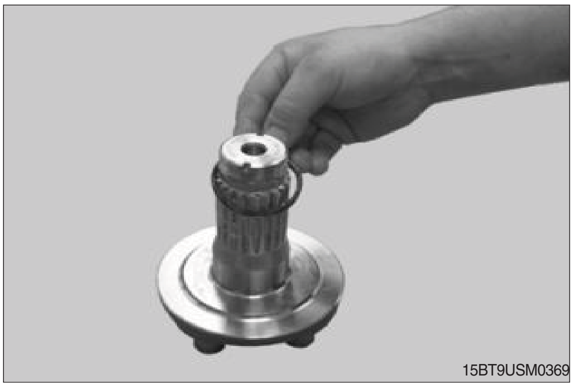
⑧ Select spacers. The thickness of the spacer set shall be the same as the difference between the measurements. A preloading on the wheel shaft is then achieved. The preloading on the wheel shaft shall be between 3 and 7 Nm.



15BT9USM0368

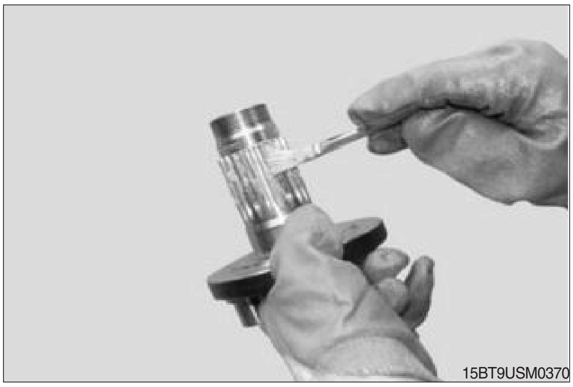
Planet carrier

(21) O-ring and press on planet carrier by hand.



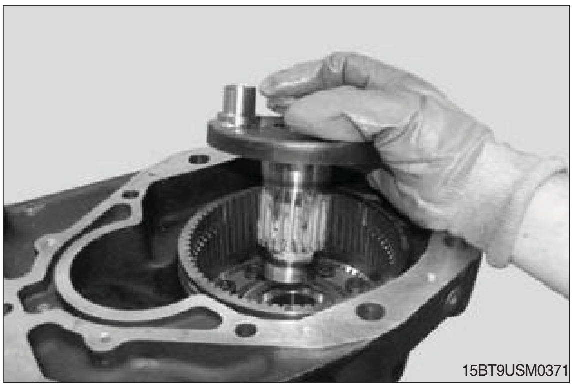
15BT9USM0369

(22) Coat the toothing of the planet carrier and the o-ring with Klüberplex BEM 34-132 (Klüber Lubrication) or Optimol White Paste T.



15BT9USM0370

(23) Blow out the seating of the planet carrier in the housing with compressed air and fit the planet carrier.

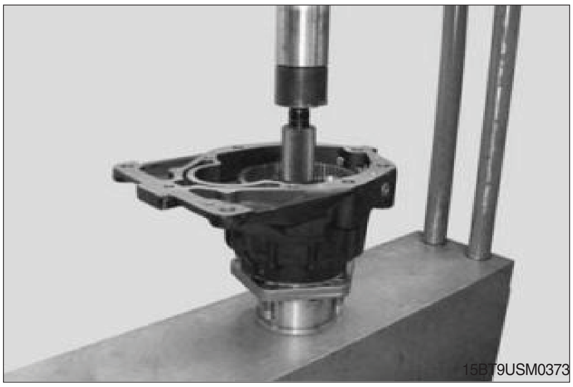


15BT9USM0371

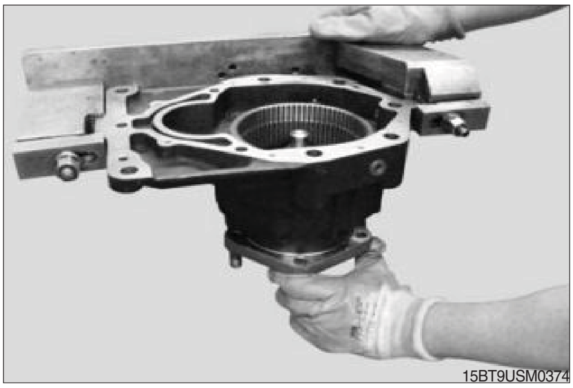
(24) Place the housing on the press table so that the wheel shaft is facing downwards. The wheel shaft shall stand on a suitable sleeve and the wheel studs shall be clear of the table.

15BT9USM0372

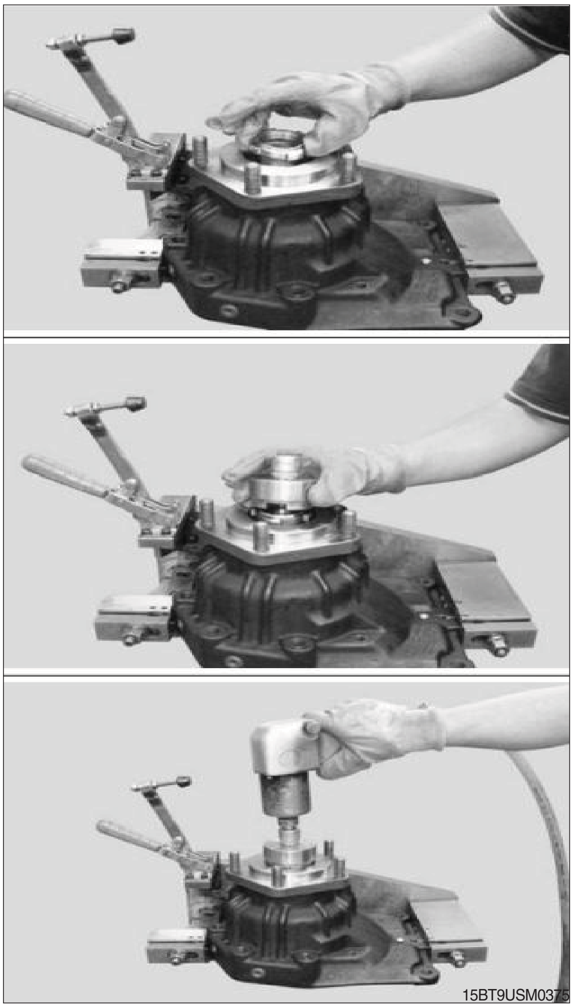
(25) Press the planet carrier into the wheel shaft.
Make sure that the outer toothing of the planet carrier and the inner toothing of the wheel shaft mesh together correctly.
The punch of the hand lever press, tool and wheel shaft shall be positioned vertically to each other without deflection.
※ Risk of accident and injury from crushing. When pressing in the planet carrier, do not place hands between the punch and the tool.


15BT9USM0373

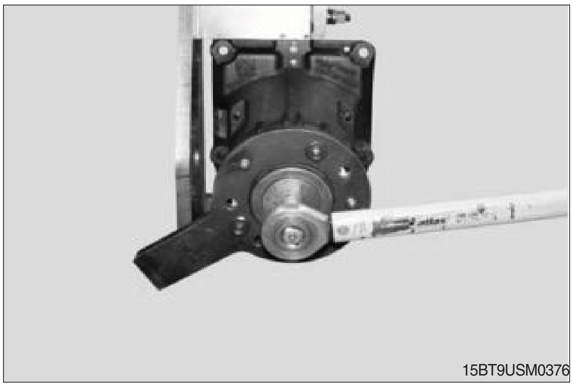
(26) Manually check the wheel shaft for ease of movement in the housing.
It shall be possible to turn the wheel shaft easily by hand.


15BT9USM0374

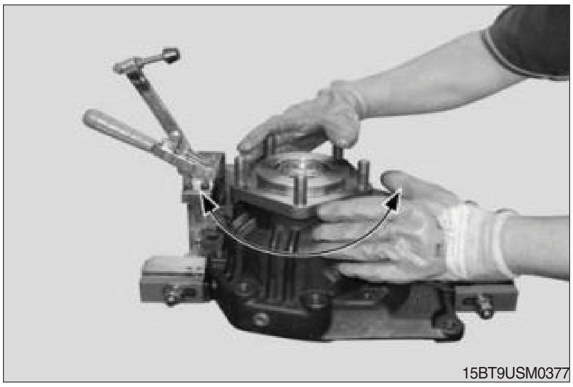
Grooved nut
(27) Fit the grooved nut to the wheel shaft.
Fit tool to the grooved nut.
Slightly tighten the grooved nut with compressed-air screwdriver.


15BT9USM0375

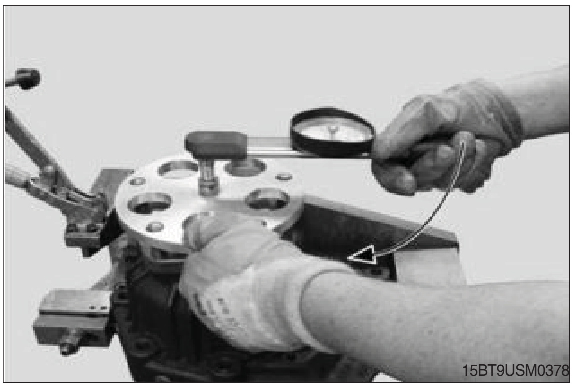
(28) Fit tool to the wheel shaft and lock in place with the screws Tighten the grooved nut to a tightening torque of 535 Nm.


15BT9USM0376

(29) Remove tool from the wheel shaft and check the wheel shaft for freedom of movement.
The wheel shaft shall be easy to turn in the housing.


15BT9USM0377

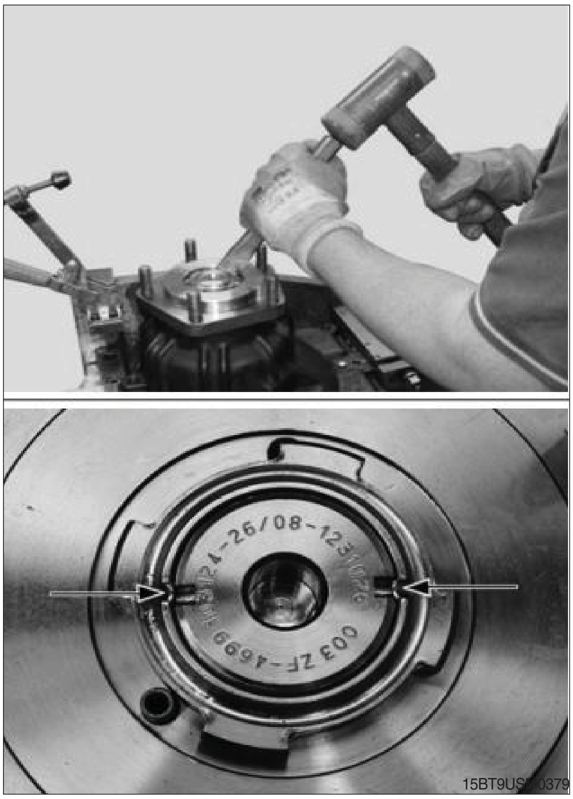
Wheel shaft drag torque
(30) Check the drag torque on the wheel shaft.
① Attach tool 11 to the wheel shaft.
② Attach the torque wrench with transition piece.
③ Turn the wheel shaft with the torque wrench.
④ Read off the drag torque from the torque wrench.


15BT9USM0378

The drag torque shall be between 3 and 7 Nm. If it is, continue with the work.
If it is not: Correct the spacers as follows:
Drag torque too high : The spacers chosen are too thick→Remove parts back to the work and redetermine the correct spacer thicknesses.
Drag torque too low : The spacers chosen are too thin → Remove parts back to work step 5 and redetermine the correct spacer thicknesses.

(31) Drive the collar of the grooved nut by means of a chisel (edge of the chisel must be a radius of approx. 2.0 mm) into the recesses of the planet carrier.

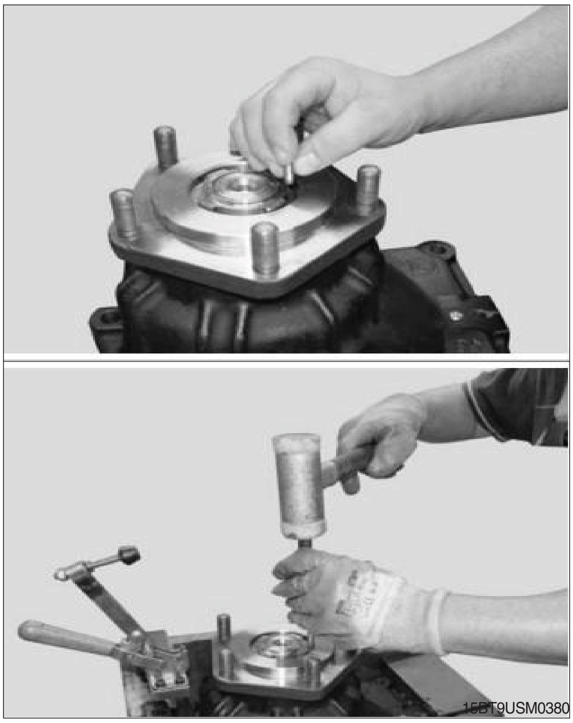
※ Use a chisel with a rounded edge only. A sharp edge may can damage the shoulder of the slotted nut.



15BT9USM0379

\# Cylinderical pin

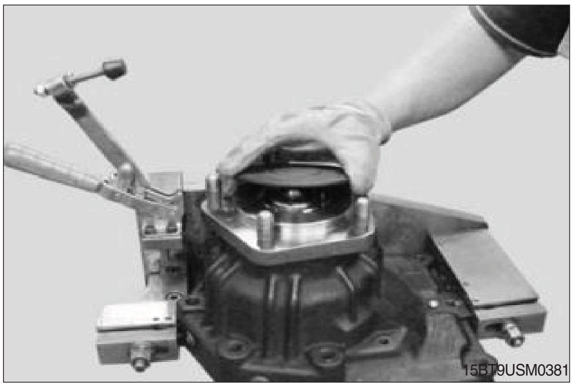
(32) Insert the cylindrical pin into the wheel shaft and drive it in.
The taper on the cylindrical pin shall point downwards.



15BT9USM0380

Protective cap

(33) Fit the protective cap to the wheel shaft and tap it lightly until it snaps into place.

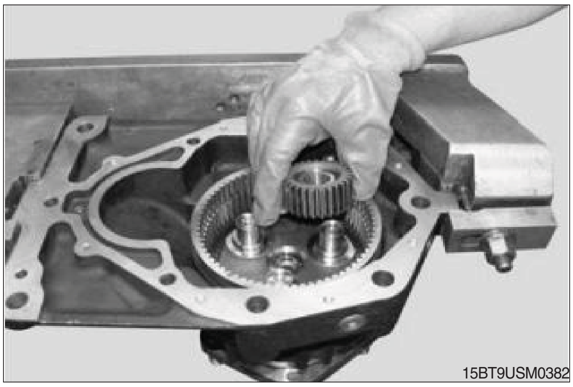


15BT9USM0381

Planetary gears

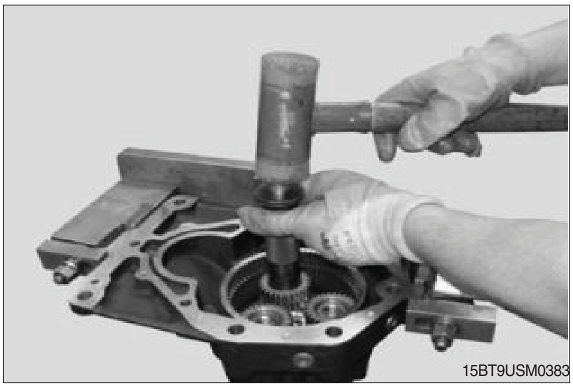
(34) Version with 3 planet gears
Place a planet gear with pre-assembled cylindrical roller bearing straight onto one of the pins of the planet carrier.

Do not tilt the planet gear. Face upwards the identification mark of the planet gear.



15BT9USM0382

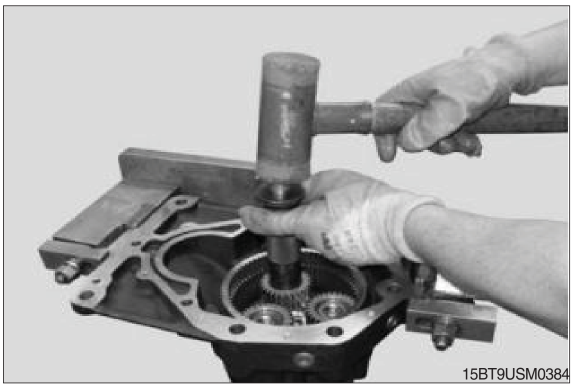
(35) Drive in the planet gear including the cylindrical roller bearing until reaching the limit stop. Use a hammer and a striking mandrel. Drive in the remaining two pre-assembled planet gears by using the same method. Note the correct meshing of the teeth of both planet gears and ring gear.



15BT9USM0383

(36) Apply a pining by using tool to lock the planet gears.

The pining is done correcly as soon as the axial play of the planet gear's cylindrical roller bearings on the bolts has dissappeared completely.



15BT9USM0384

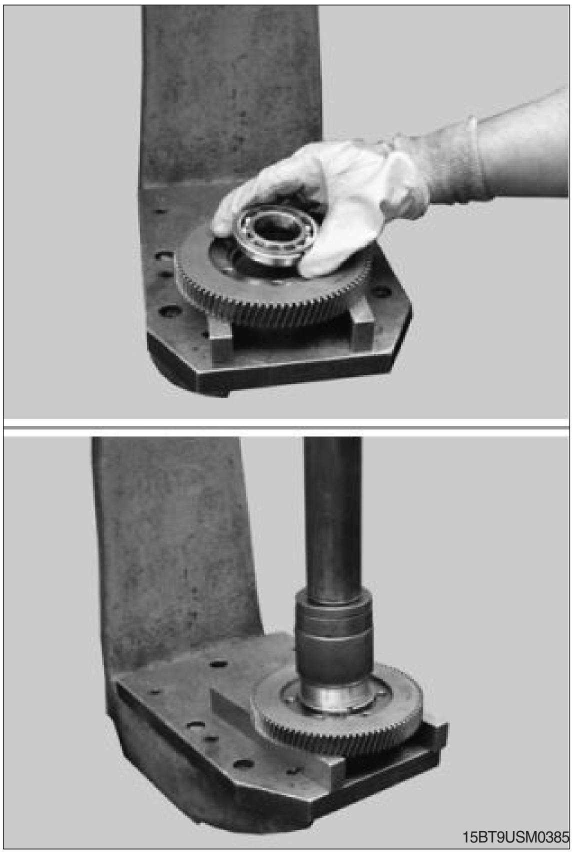
2) Housing cover reassembly

\# Grooved ball roller bearing

(1) Press the grooved ball roller bearing into the spur gear using the hand lever press.
The punch of the hand lever press, tool and brake piston shall be positioned vertically to each other without deflection.

Manually check the grooved ball roller bearing ment in the spur gear.
It shall be possible to turn the grooved ball roller bearing easily by hand.

if it is easy to turn, continue with the work.
If it is not: Check the bearing for any damage which may have occurred during the press fitting procedure. If damage is found, remove the bearing and replace with a new one.

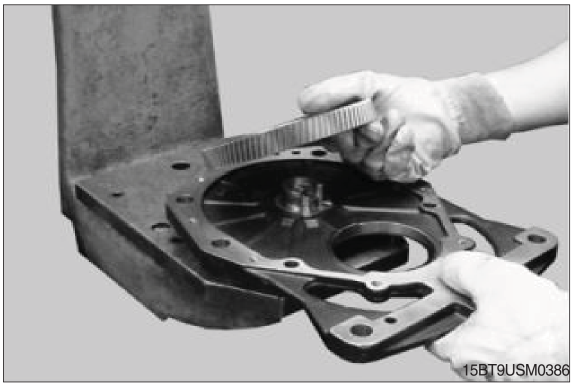


15BT9USM0385

\# Spur gear

(2) Place the housing cover on a suitable support piece on the hand lever press, with the mating surface facing upwards.

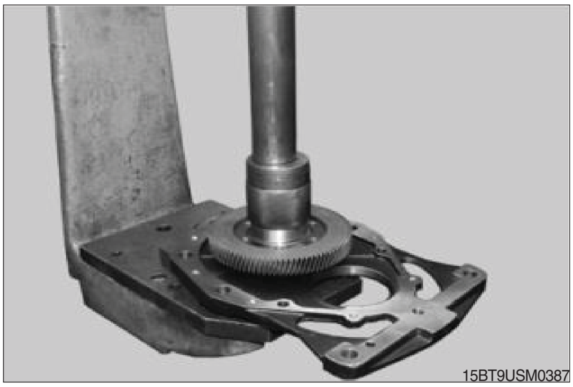
The housing cover shall be empty.



15BT9USM0386

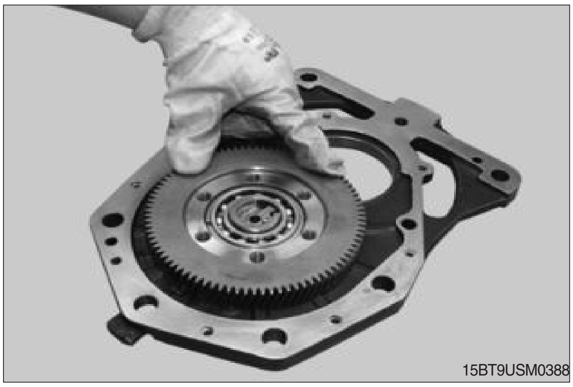
(3) Press the spur gear onto the housing cover.

The side of the spur being worked on shall face upwards.
The punch of the hand lever press and input pinion shall be positioned vertically to each other without deflection.



15BT9USM0387

(4) Manually check the spur gear for smooth running
The input pinion shall be easy to turn.
If it is, continue with the work.
If it is not : Check the bearing for any damage which may have occurred during the press fitting procedure.
If damage is found, remove the bearing and replace with a new one.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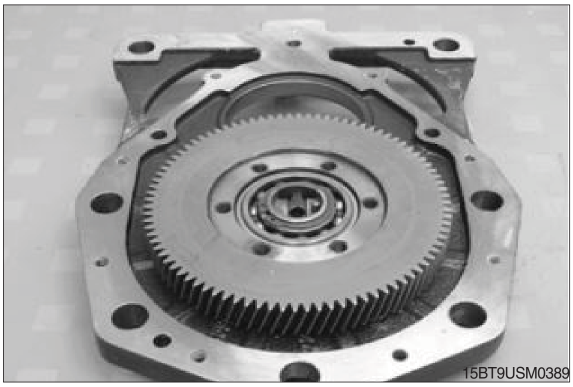
(5) Remove the housing cover from the hand lever press and place it in the assembly fixture with the mating surface facing upwards.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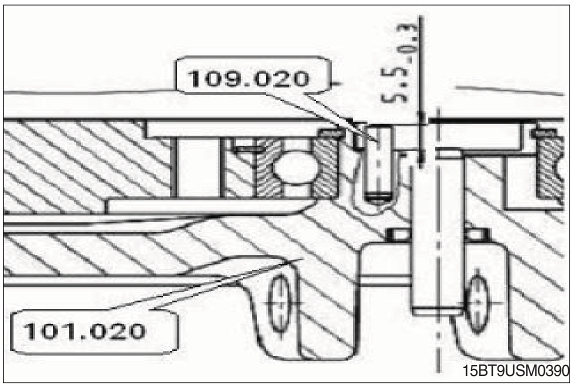
Axial bearing
(6) Check the heigh of the cylindrical pin (109.020) for a value of 5,5mm -0.3. If the measured value is found different from the given specification please remove the cylindrical pin (109.020) by using pliers and replace it by a new one installed at the correct mounting height.



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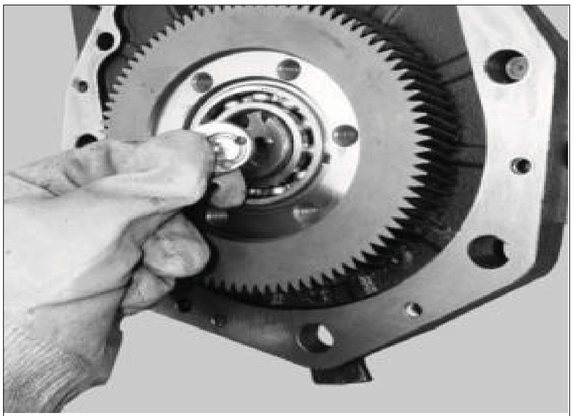
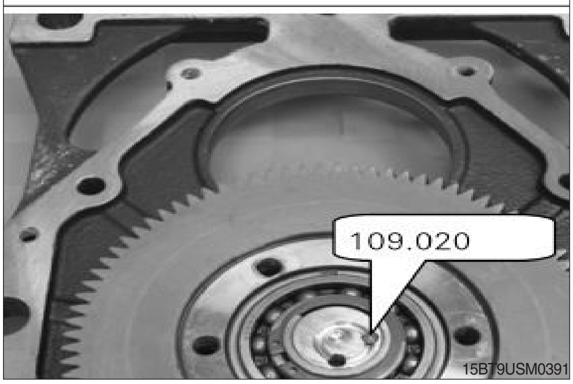
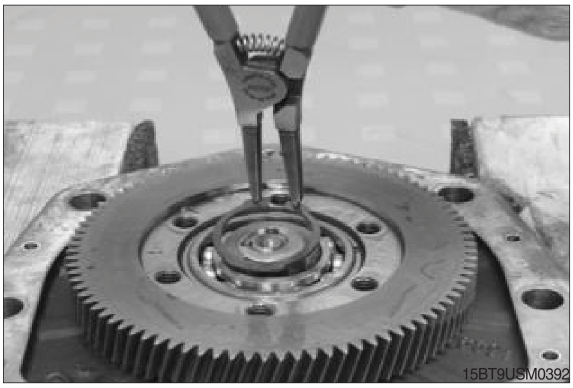
(7) Insert the axial bearing in the housing cover by hand.
The lubrication groove of the axial bearing shall face upwards.



Please assure proper position of the axial bearing related to the cylindrical pin.



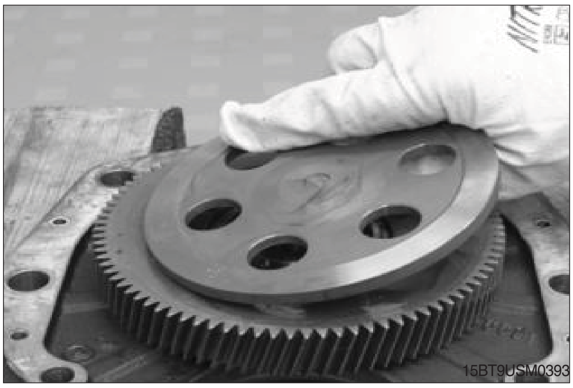
(8) Insert the spur gear retaining ring.



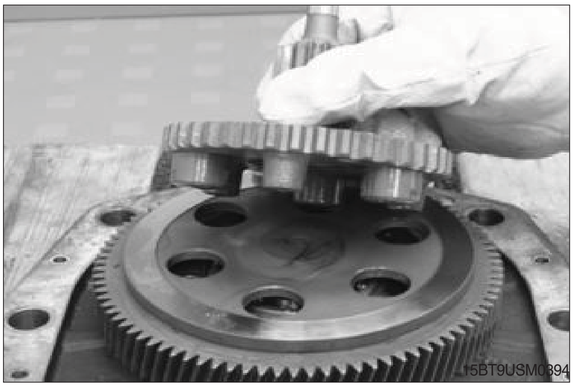
Inner disc carrier

(9) Place the pressure plate on the spur gear by hand.

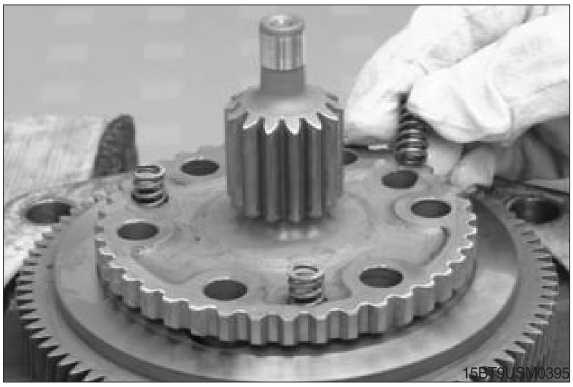
The bulge in the pressure plate shall be at the top. The holes in the pressure plate and the spur gear shall be positioned on top of each other.



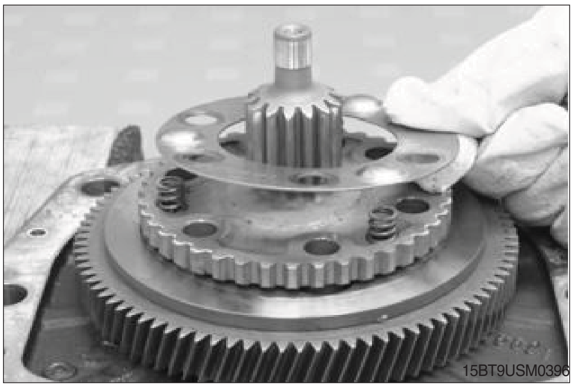
(10) Fit the inner disc carrier onto the spur gear) by hand.
The inner disc carrier fits onto the spur gear in one position only. Find out by trial and error the position in which the inner disc carrier needs to be set in relation to the spur gear.



(11) Insert the 3 pressure springs 1.6 x 8.0 x 21.5 into the inner disc carrier by hand.

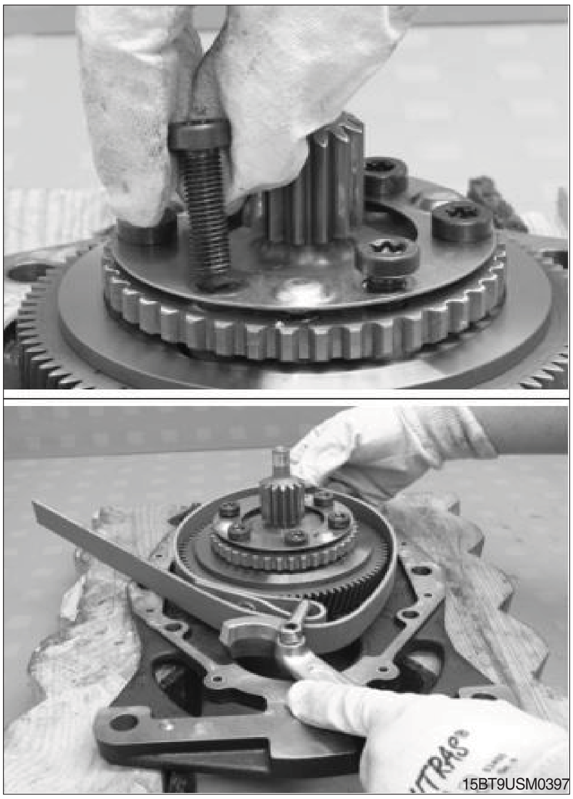


(12) Place the fixing plate over the pressure spring by hand. The springs shall be firmly seated in the recesses in the retaining ring.



(13) Insert the 6 Torx bolts into the fixing plate and screw them down into the spur gear tighten them by hand.

Place the cover assembly onto a suitable support (e.g. 2 pcs. of wooden strips) and assure an even and stable rest. Place the strap around the spur gear and tighten it by using the wrench lever. Spur gear must be free from grease and oil residue.



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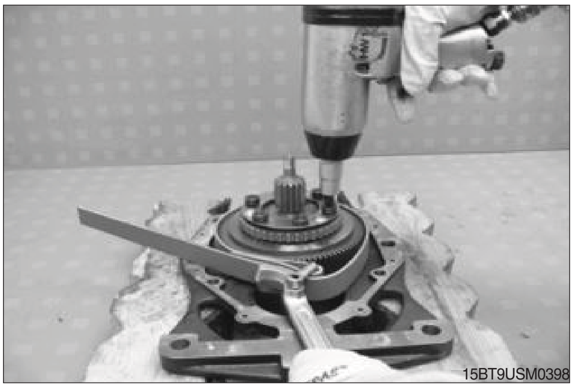
(14) Hold the spur gear tight using the strap wrench. Tighten the 6 Torx bolts to a tightening torque of 70Nm using an adjustable compressed-air screwdriver.

The bolts shall be tightened in a crosswise pattern.



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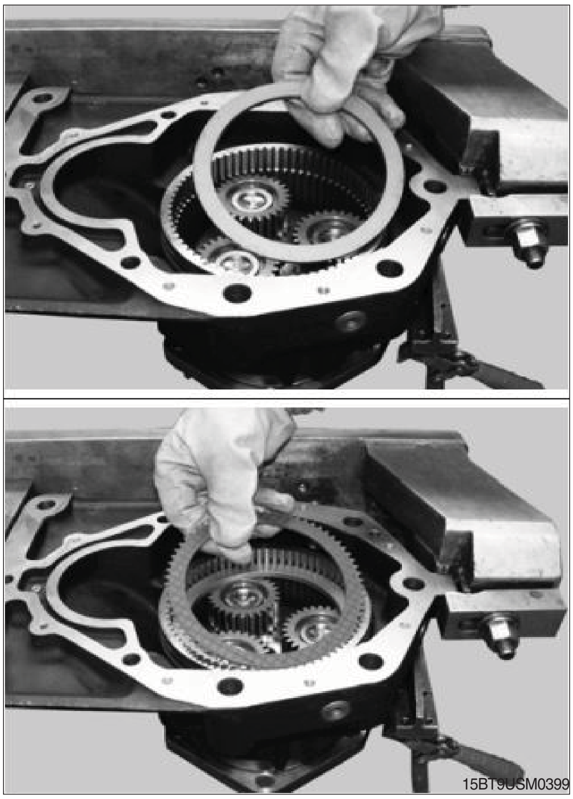
Disc set

(15) Place the disc set – consisting of 3 driven discs, 4 drive discs and 1 pressure disc– into the internal gear.

① Insert the pressure disc.
② Insert a drive disc.
③ Insert a driven disc.
④ Insert drive and driven discs alternately.

Insert the driven discs so that the side on which the teeth are rounded off faces upwards. The driven discs are completely even in circumference direction. They are non-sinusoidal. You do not need to bring them in a specific order prior installation.



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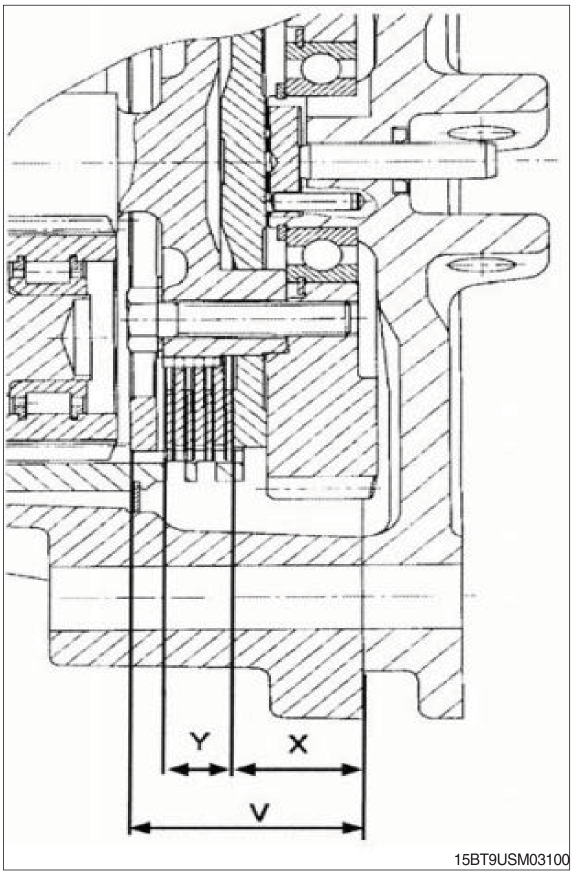
(16) Determining the thickness of the pressure disc
W=X+Y,   Z=V-W

Z [mm]	Pressure disc thickness
5.58 to 6.10	4.8 mm thick
6.11 to 6.70	5.3 mm thick
6.71 to 7.22	5.8 mm thick

"X" is the distance between the plane face of the cover and plane face of the pressure disc.
"Y" is the thickness of the disc set when it is compressed.
"W" is a reference dimension calculated by adding X and Y.
"V" is the distance between the plane face of the housing and the contact surface of the pressure disc in the internal gear.
"Z" is a reference dimension calculated by subtracting V and W.



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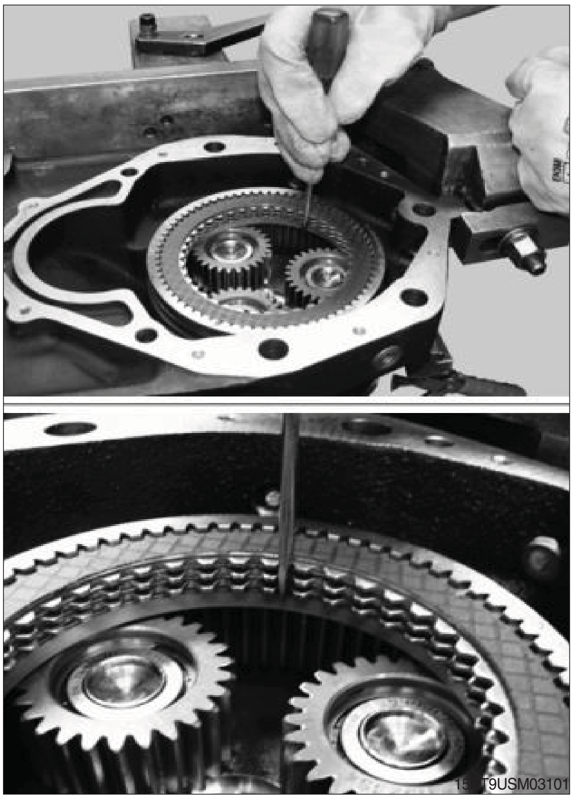
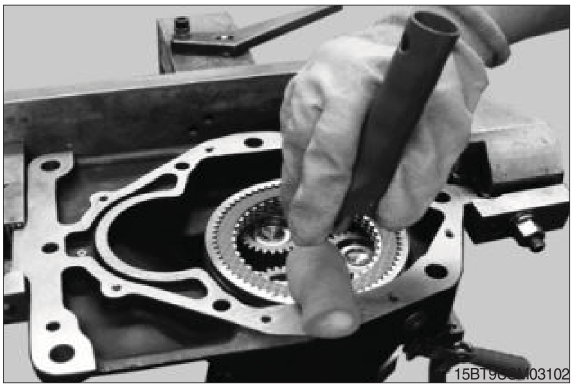
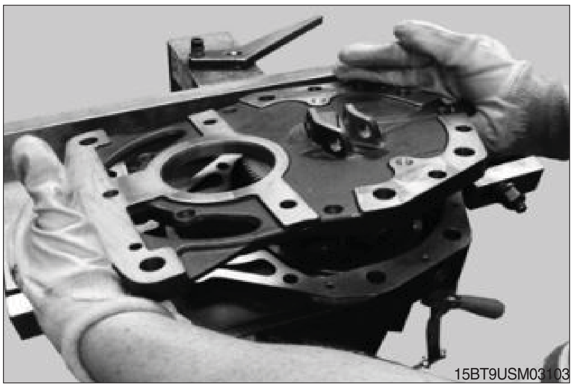
(17) Arrange the driven discs.
The teeth on all driven discs shall be positioned precisely in line with each other.



(18) Coat the mating surface of the housing and the housing cover with Loctite 574.



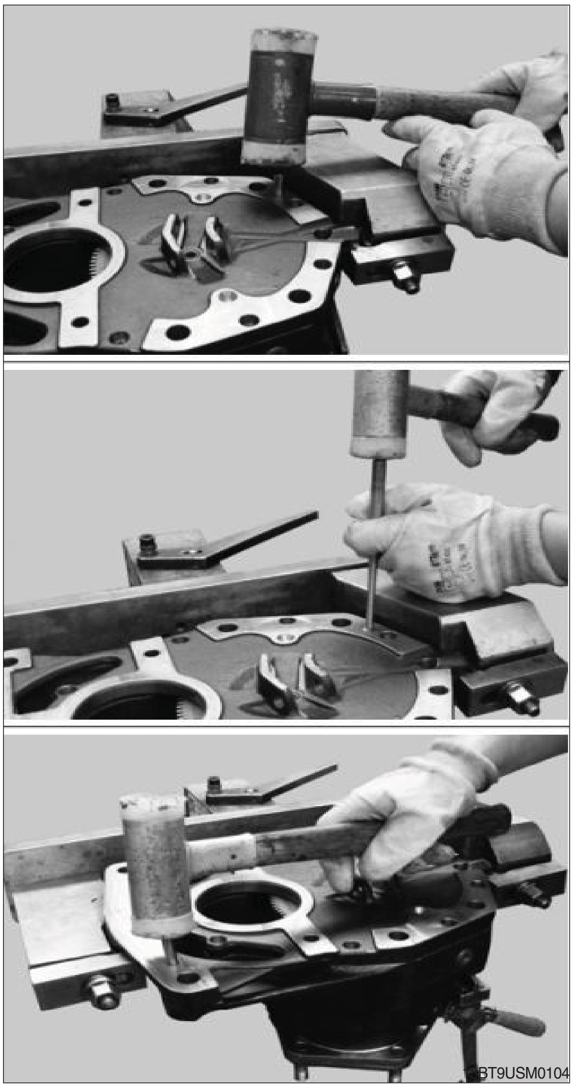
(19) Fit the housing cover to the housing by hand.
Care shall be taken to ensure that the guide of the inner disc carrier comes to rest in the needle sleeve.



Cylinder pin

(20) Drive the cylindrical pin into the housing.

The cylindrical pins shall be driven in so that they are flush with the surface.



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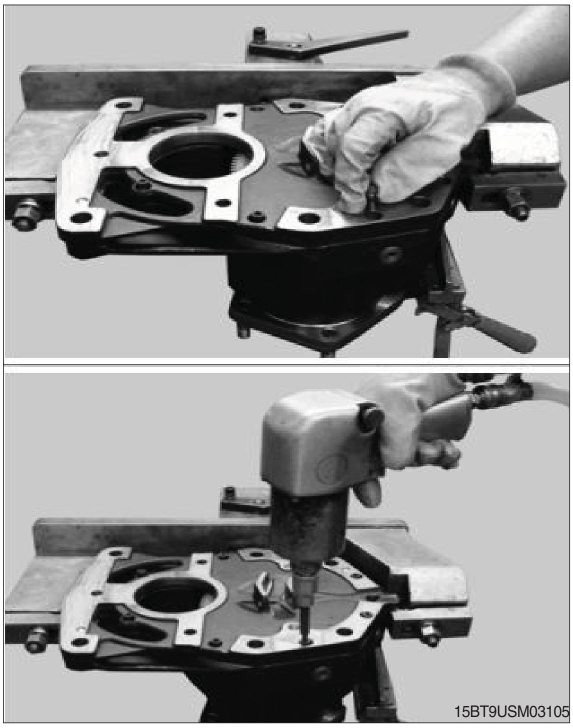
(21) Screw the 8 Allen bolts into the housing cover by hand and slightly tighten with a compressed air screwdriver.



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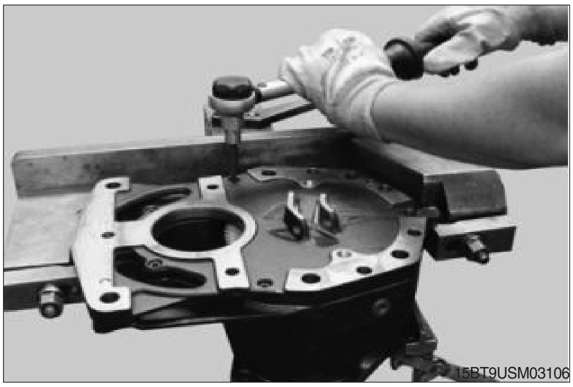
(22) Tighten the 8 Allen bolts to a tightening torque of 9.5 Nm.



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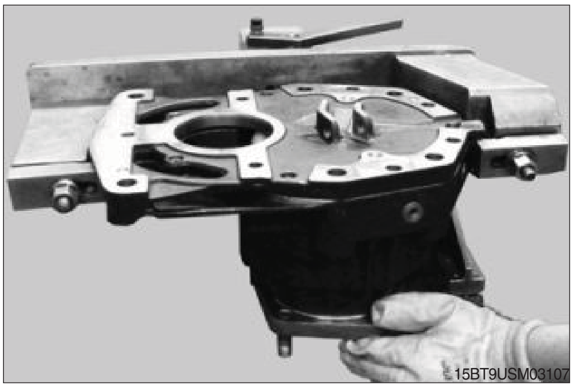
(23) Manually check the wheel shaft for smooth running.
It shall be possible to move the wheel shaft easily by hand.



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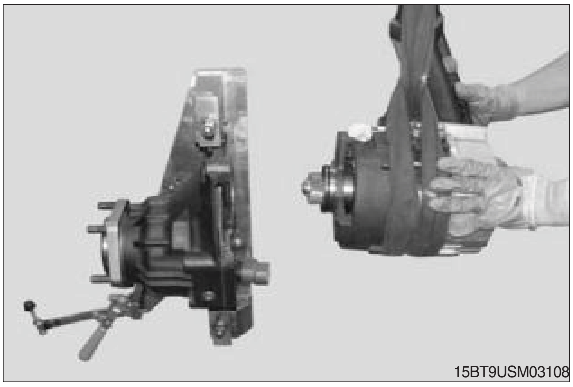
3) Motor reassembly

Motor

(1) Fasten the motor to suitable lifting gear using approved attachment equipment.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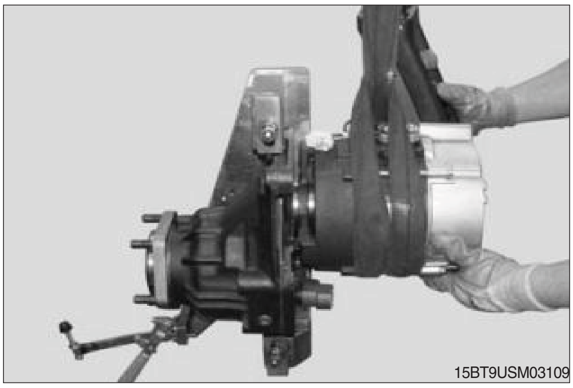
(2) Position the motor in front of the drive unit and manually mesh the motor pinion with the spur gear pinion.

When meshing the motor pinion with the spur gear, make sure that both sets of teeth are not tilted or damaged.
The motor connections shall be at the top in the installation position.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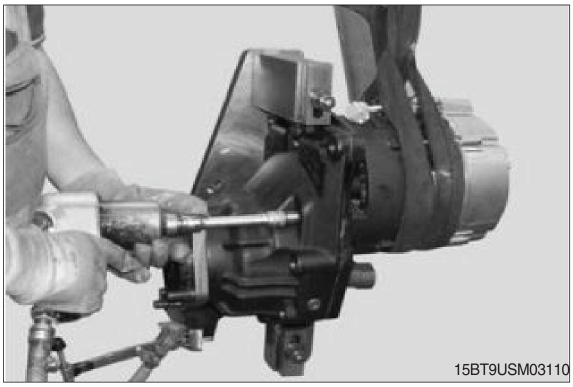
(3) Fasten the motor to the drive unit with the 3 Allen bolts.

Screw in the shorter Allen bolt at the top of the drive unit and each of the two other bolts into the right hand and left-hand side of the drive unit.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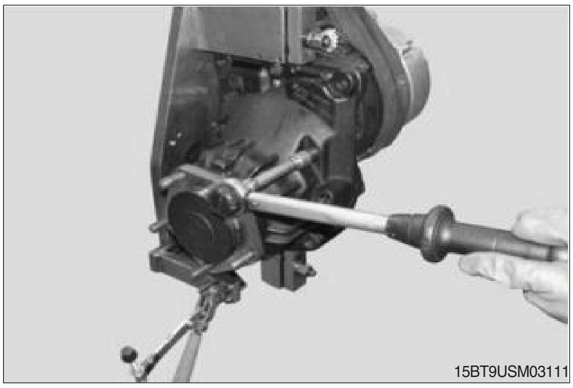
(4) Firmly tighten the 3 Allen bolts to a tightening torque of 23Nm.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SECTION 4 BRAKE SYSTEM

SECTION 4 BRAKE SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. OUTLINE

There are two brake systems, the service brake system and the parking brake system.

In the service brake system, oil pressure is generated in the master cylinder by treading on the brake pedal. This pressure causes the brake lever to press the pressure pin which gives braking pressure to the disk carrier.

In the parking brake system, the brake is operated automatically by electric control. This E-Brake is installed in the motor.

2. SPECIFICATION

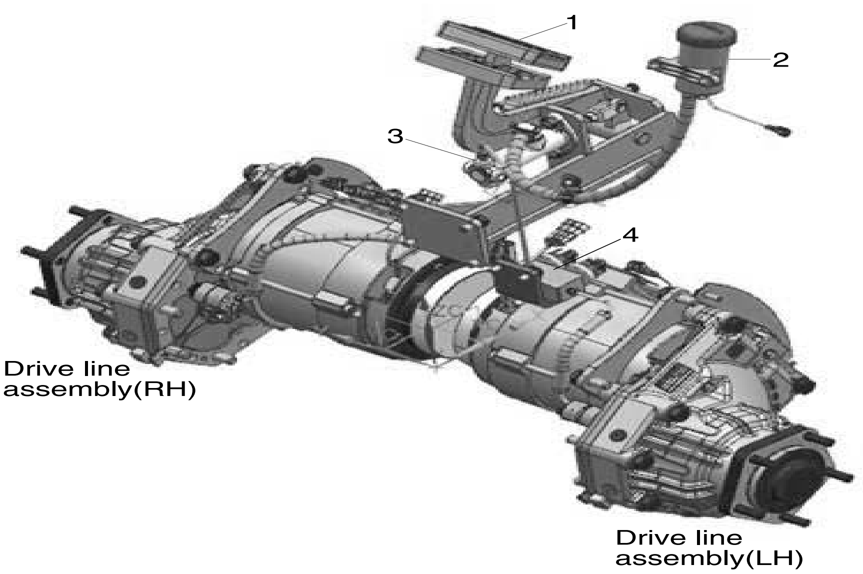
1) BRAKE

Item	Unit	Specification
Brake type	-	Front wheel, Wet disc brake
Brake fluid	-	Brake Fluid DOT 3
Max. brake torque	N · m (at 60bar)	2450
Max. braking pressure	bar	140
Oil volume	cc	500

2) PARKING BRAKE

Item	Specification
Type	Electric Auto parking (2EA)
Norminal Static Torque	60nm
Max. rotation speed	5500rpm

3. BRAKE PEDAL AND PIPING



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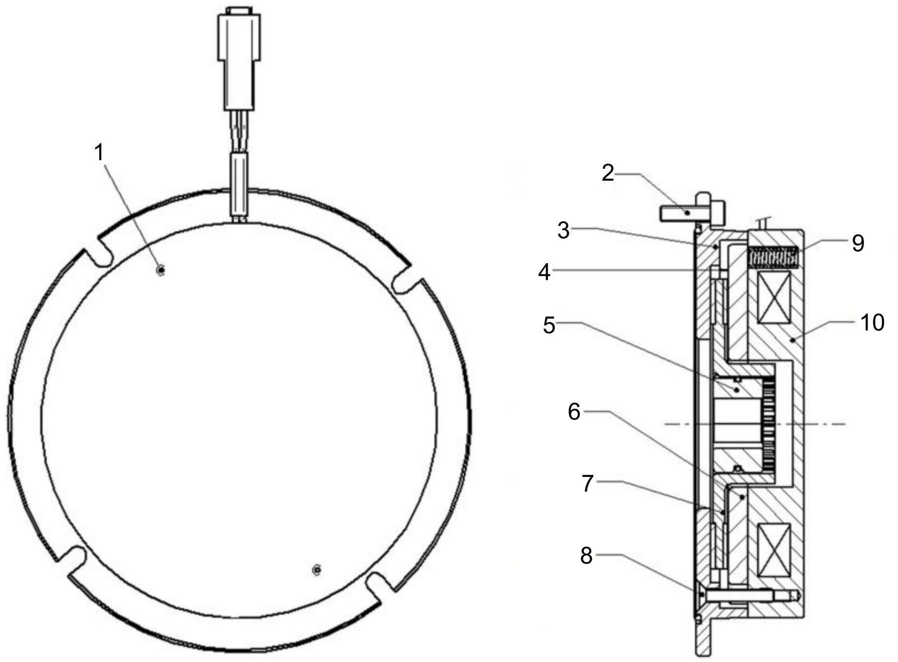
1 Brake pedal & bracket assy
2 Reservoir tank assy
3 Brake master cylinder
4 5 Way Block

4. PARKING BRAKE (E-BRAKE)



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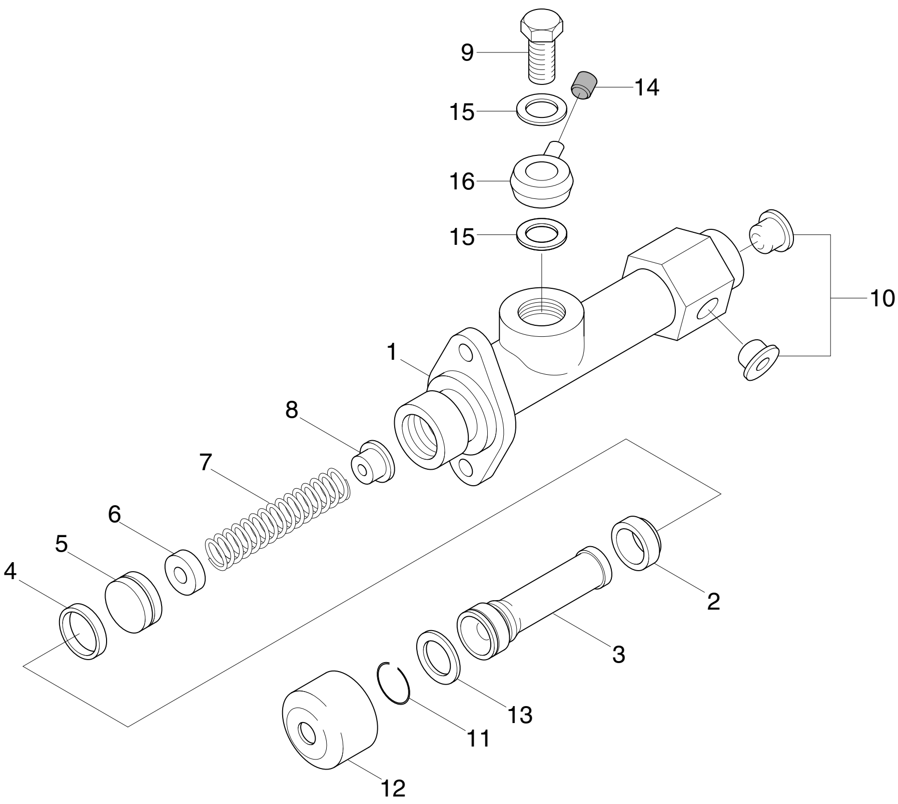
1 Screw cap
2 Fitting screw
3 Flange
4 Pin
5 Hub
6 Armature
7 Friction disc
8 Flange
9 Spring
10 Inductor

5. BRAKE MASTER CYLINDER

1) STRUCTURE



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1	Body	7	Spring	13	Plate
2	Secondary cup	8	Check valve assembly	14	Cap
3	Piston	9	Union bolt	15	Gasket
4	Spacer	10	Cap	16	Union
5	Primary cup	11	Retaining ring		
6	Spring seat	12	Boot		

2) DISASSEMBLY AND ASSEMBLY

(1) Remove the boot(12).
(2) Take out the retaining ring(11) and plate(13).
(3) Take out the piston(3), secondary cup(2), spacer(4), primary cup(5), spring seat(6), spring(7) and check valve assembly(8) from cylinder.
(4) Perform assembly in reverse order of disassembly and add special working.
 · Body and metallic parts should be washed and cleaned with petroleum solvents then dry the parts by air. Rubber parts should be washed with brake oil.
 · Coat the rubber grease inner surface of cylinder.

2) INSPECTION

(1) Cylinder

Check the corrosion and pitching of inner surface of cylinder.
If any defects are noted, replace the parts.

(2) Piston

Check for wear of piston, replace the piston if necessary.

Item	Standard gap	Allowable limit
Gap of cylinder and piston	0.020~0.080mm	0.2mm

(3) Rubber parts

Check for wear of secondary cup and primary cup and replace them with new ones if necessary.

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

1) BRAKE PIPING

(1) Check pipes, hoses and joints for damage, oil leakage or interference.

(2) Operate brake pedal and check operating force when pedal in depressed. Check also change in operating force, and change in position of pedal when pedal is kept depressed.

2) BRAKING FORCE

(1) Select a dry, flat, paved surface and, drive truck at maximum speed. When signal is given, stop truck immediately and measure distance from point where signal was given to point where truck stopped(unloaded)

· Stopping distance : Within 5m(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.

3) Trouble shooting

Problem	Cause	Remedy
Brakes do not work	· Oil leakage in the system or oil to low low in tank. · Air trapped in the system. · Worn out of deteriorated piston cup in master cylinder resulting in oil leakage	· Repair oil leakage. After bleeding fill fill oil tank of master cylinder to specified level with brake oil. · Bleed air completely from the brake lever. · Inspect cylinder and piston for degree of wear. On satisfactory, replace cup.
Brake pedal travel too large	· Air trapped in the system.	· Bleed air completely out. · Inspect oil tube joints & connections and replace leaking parts.
Wheel feel heavy	· Return port in master cylinder closed by piston cup.	· Inspect master cylinder. · Repair or replace pedal return spring.

2. PARKING BRAKE (E-BRAKE)

1. OPERATIONAL CHECKS

1) BRAKE CONNECTION

(1) E-brake has to be supplied with direct current. The polarity does not affect operation.
(2) Switch the equipment on and confirm that the friction disc rotates freely.

2) BRAKING FORCE

(1) Friction faces must kept completely clean of any oil, grease or abrasive dust to get the proper force. Nominal static torque is 60nm.

3) Trouble shooting

Problem	Cause	Remedy
Brakes do not release	· Power supply is too low. · Power supply is interrupted. · Worn disc. · Coil is damaged.	· Adjust power supply. · Reconnect power supply. · Replace the brake. · Replace the brake.
Brake does not brake	· Voltage present at switch off position. · Grease on friction faces. · Release screws are engaged.	· Check power supply. · Replace the brake · Remove release screws or screws caps are not too engaged.
Nuisance braking	· Power supply is too low.	· Adjust power supply.

GROUP 3 ADJUSTMENTS

1. ADJUSTMENT OF PEDAL

1) BRAKE PEDAL

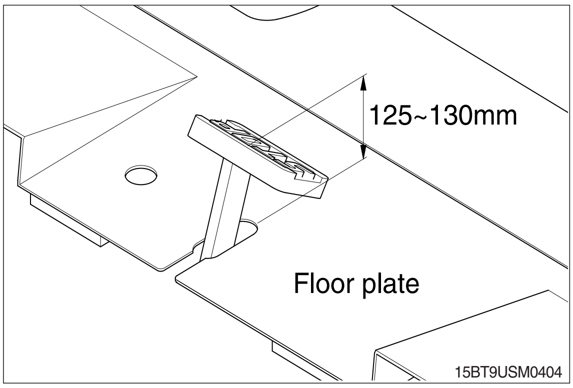
(1) Pedal height from floor plate adjust with stopper bolt.

· Pedal height : 125~130mm (4.9~5.1in)

(2) Play

Adjust with rod of mast cylinder.

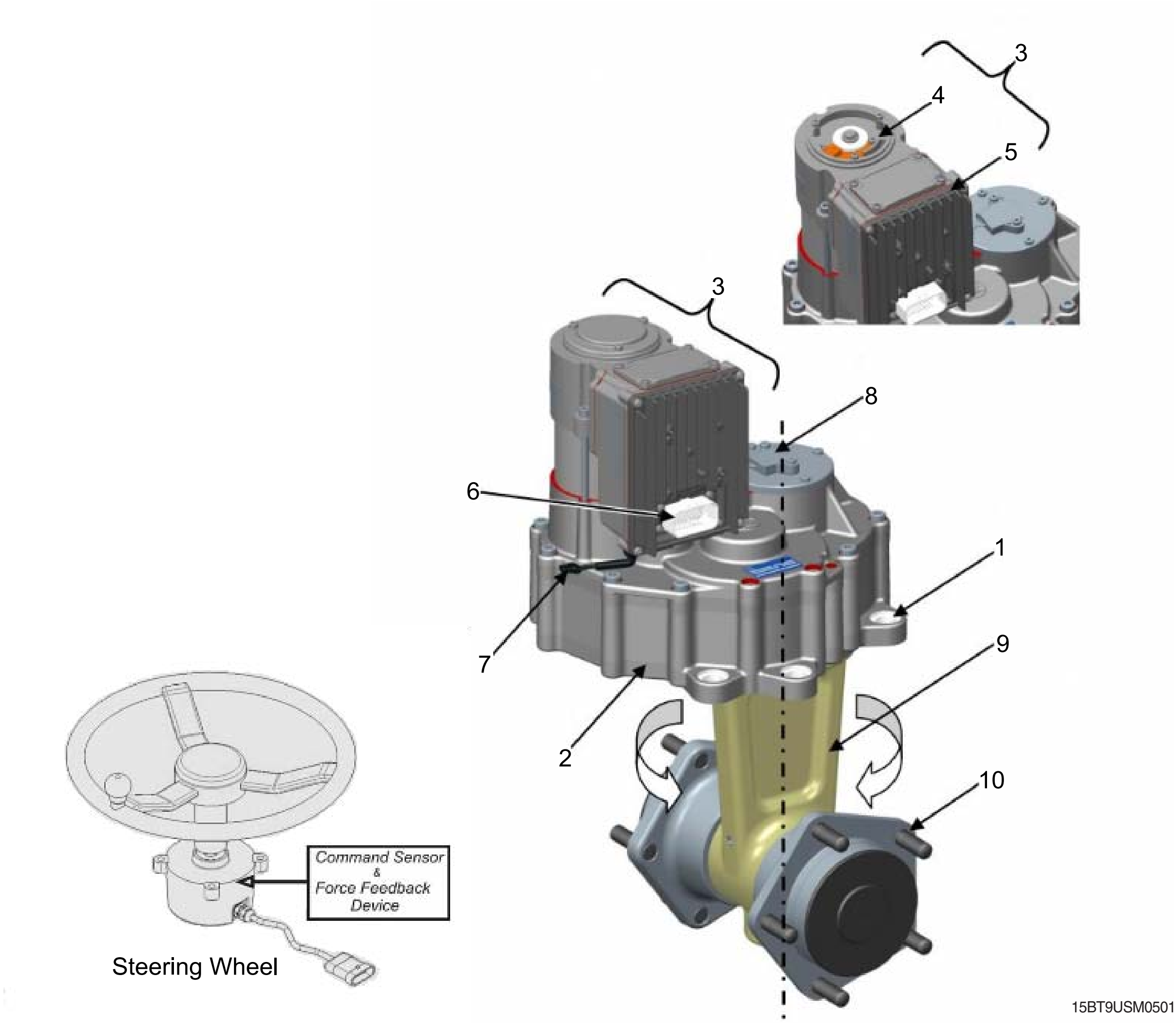
· Idle stroke : 4~6mm (0.16~0.23in)



SECTION 5 STEERING SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. LAYOUT

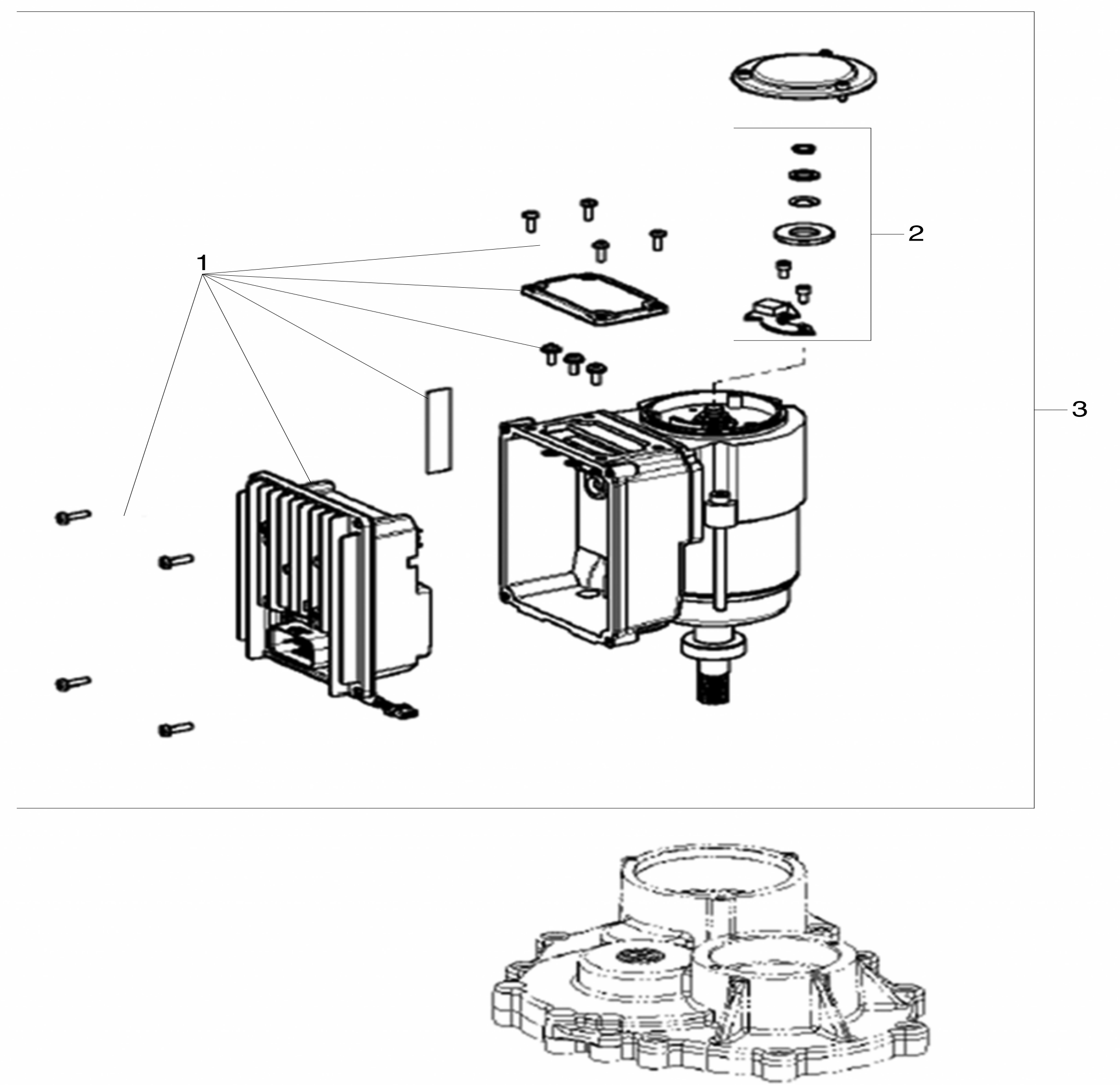


1	Hole (connection to Forklift chassis)	5	Steering controller	8	Angle sensor
2	Helical gear (3 stage)	6	Steering controller connection	9	Axle carrier
3	Motor controller unit	7	Connection for angles-of-rotation sensor	10	Output flange
4	AC Steering motor				

The steering operation by rotating the electric motor using the signal values from the steering sensor installed under the steering handle. EPS(Electronic Power Steering) system uses the electric motor for steering to achieve advanced functions such as operating force, lock to lock rev adjustment, and the correct system. Unlike traditional HPS(Hydraulic Power Steering) system, The electric motor only operates when the steering wheel is turned. And eliminating unnecessary energy consumption and noise. Without any hydraulic equipment, oil maintenance is unnecessary and environmentally friendly.

2. STEERING UNIT STRUCTURE

1) Control Engine Unit



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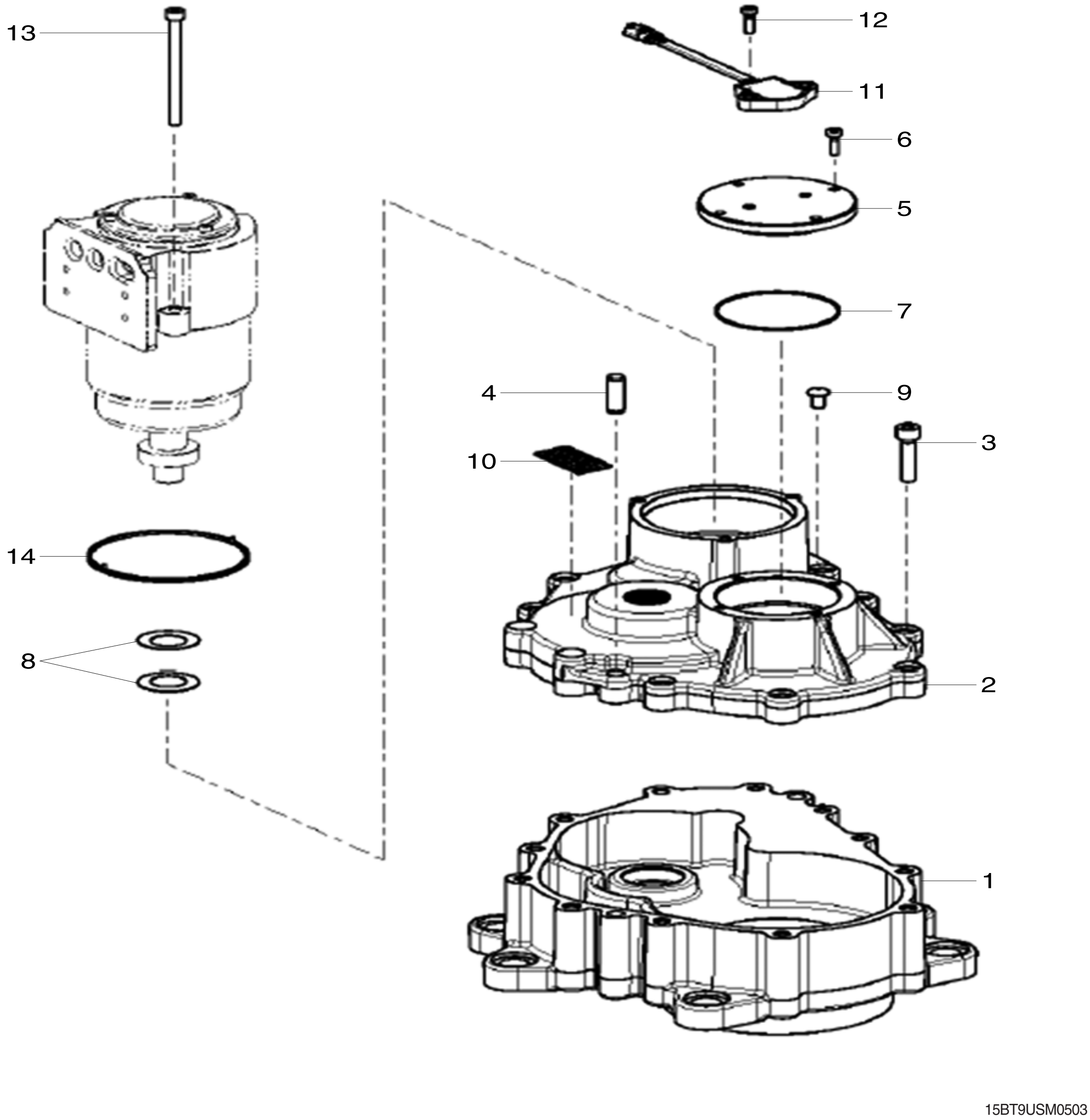
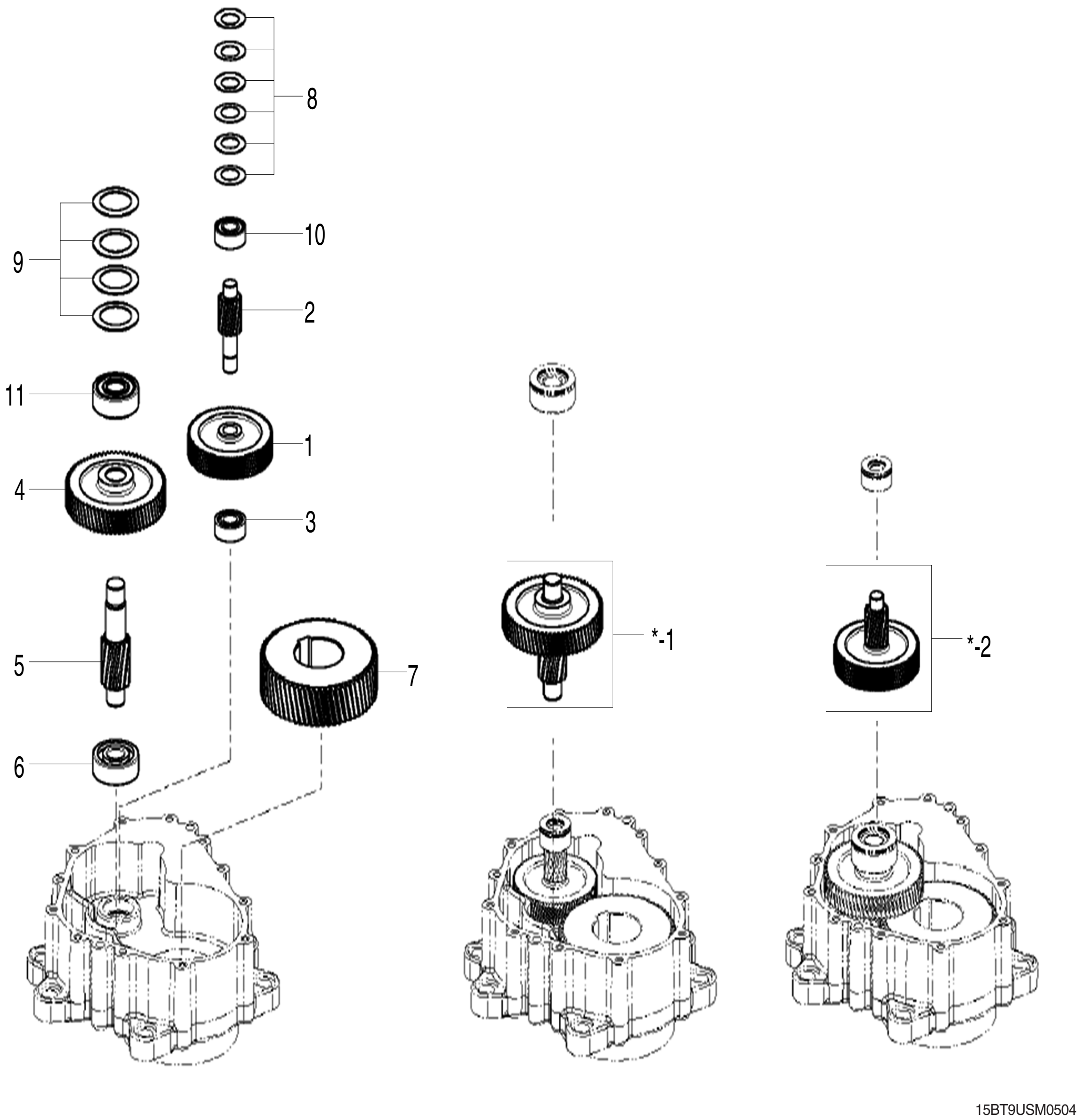
1 Control Unit　　2 Sensor Kit　　3 Control Engine Unit

2) Housing



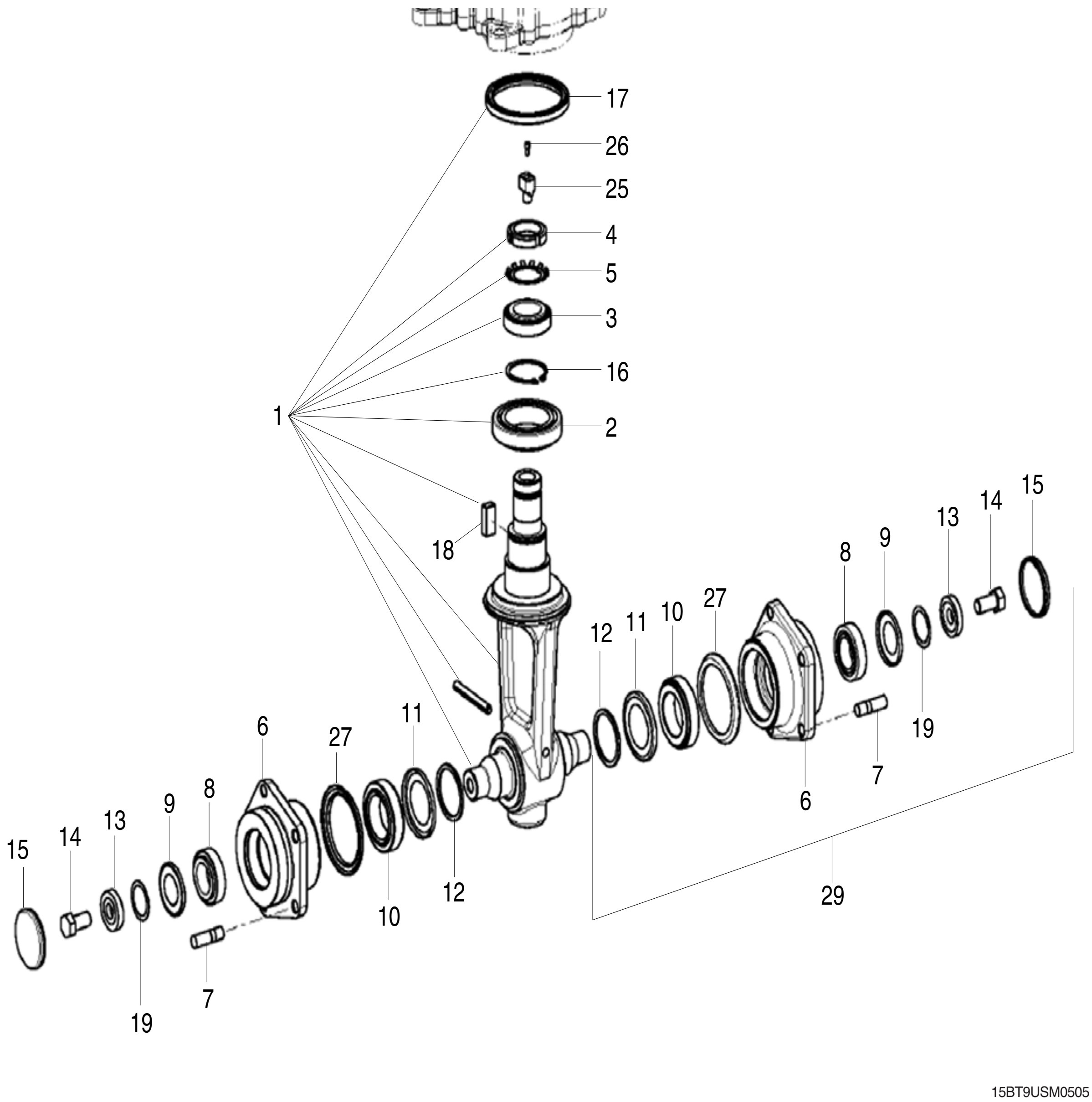
1	Housing	6	Cap screw	11	Sensor
2	Housing cover	7	O-Ring	12	Cap screw
3	Cap screw	8	Cup spring	13	Cap screw
4	Cylinder pin	9	Breather	14	V-ring
5	Cover	10	Type plate		

3) Input



1	Spur gear	6	Ball bearing	11	Ball bearing
2	Pinion shaft	7	Spur gear	*-1	Input (Z=72)
3	Ball bearing	8	Cup spring	*-2	Input (Z=92)
4	Spur gear	9	Cup spring		
5	Pinion shaft	10	Ball bearing		

4) Output



1	Output kit	9	Nilos ring	17	Shaft seal
2	Tapered roller bearing	10	Tapered roller bearing	18	Fitty key
3	Tapered roller bearing	11	Nilos ring	19	Shim ring
4	Slotted nut	12	Shim	25	Magnet
5	Locking nut	13	End shim	26	Cap screw
6	Output flange	14	Hexagone srew	27	Axial shaft seal
7	Wheel stud	15	Protection cap	29	Hub
8	Tapered roller bearing	16	Retaining ring		

5) OPERATION

The steering system for this forklift truck is EPS. It stands for Electronic Power Steering. The EPS with integrated helical gear transmission is used in front-wheel-driven 3-wheel counter-balance lift trucks up to 2 tons lifting capacity for the steering of the rear axle. The EPS is connected with the vehicle chassis via fixing holes which are cast on the helical gear transmission. The torque for the steering is generated by an AC motor, which is firmly installed to the helical gear transmission. The AC motor is an integral part of the motor controller unit. The input pinion is directly mounted on the motor shaft of the AC motor (in overhung position) and is therefore the 1 st stage of the helical gear transmission. It is no longer necessary to mount the input pinion separately on the motor shaft.

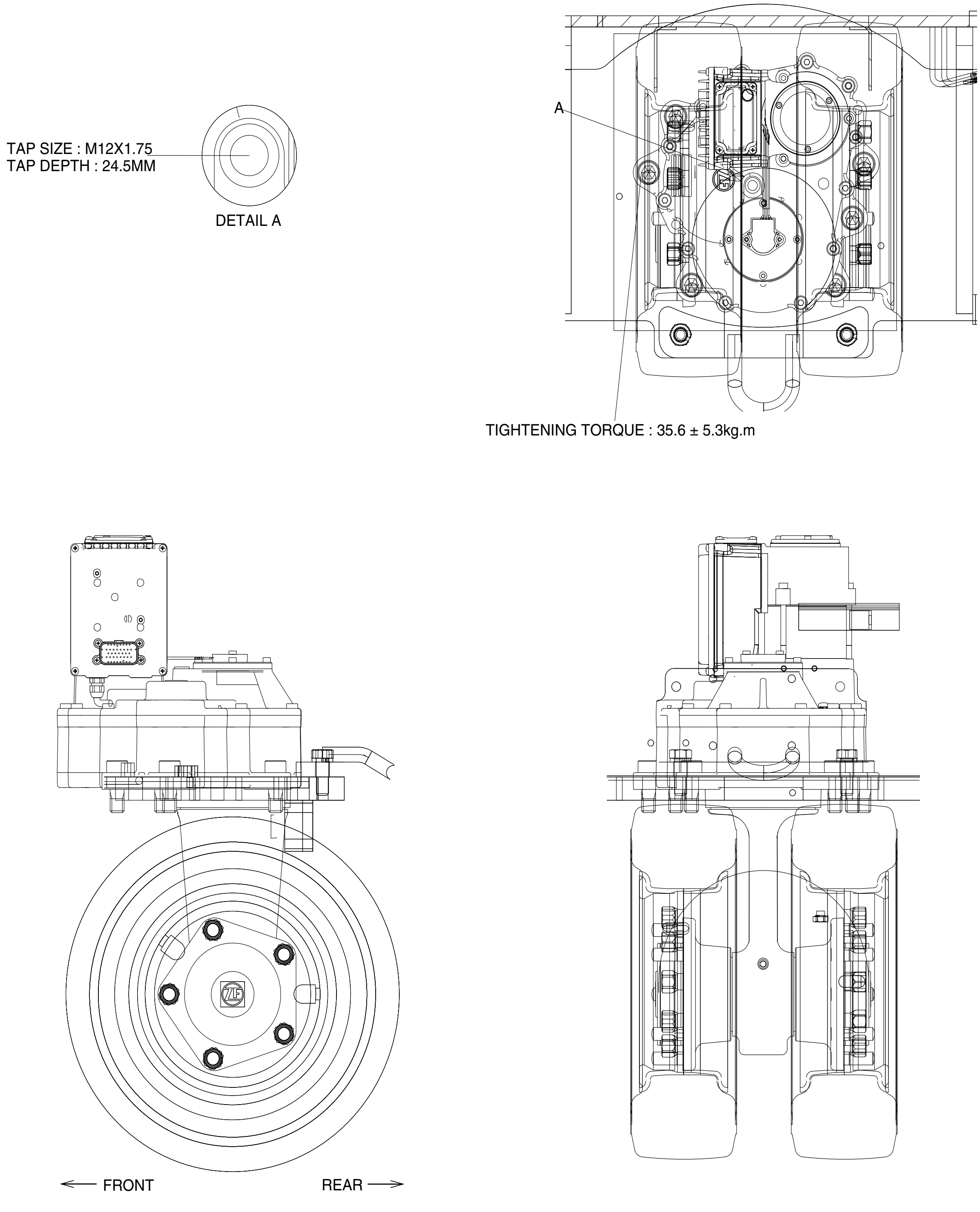
The three-stage helical gear transmission of the EPS has got a high overall ratio. Fluid grease is used for lubrication of the gears of the helical gear transmission. Tapered roller bearings are used as axle carrier and wheel bearings. Ball bearings and tapered roller bearings of the transmission and the wheel bearing are designed for lifetime lubrication with roller and sliding bearing grease. This multi-purpose grease is a high-quality lithium-calcium-saponified grease with optimum lubrication properties for roller bearings.

The EPS is a joint project with the market leader for electronic controllers, ZAPI who delivers the electric controller unit consisting of AC motor, steering controller and steering software for it.
The speed sensor for feedback of the speed to the steering controller is located directly under the cover of the AC motor. The angles-of-rotation sensor measures the actual value of the set steering angle or the angle position of the steering axle. It operates touchless in connection with a magnet located in the rotation axis of the axle carrier.

This steer-by-wire steering system, with the steering wheel motion being electrically transmitted to the steered axle, has the following advantages over the current hydrostatic steering system:

- Mechanical components are replaced by electrical ones. Advantages regarding space, significantly reduced installation effort during assembly.
- Low energy consumption compared with the hydrostatic steering system.
- It is no longer necessary that the hydraulic circuit for the steering is always active.
- Low-noise helical gear transmission by optimized gearing technology and excellent damping characteristics due to fluid grease lubrication.
- Wear-free helical gear transmission with high gear ratio.
- Variable adaptation of the steering ratio.
- Optimized sensor system.
- Plug & Play total system with mechanics, electrics, electronics and software functions from one source.

6) TIGHTENING TORQUE AND SPECIFICATION



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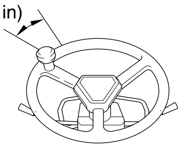
GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

Check item	Checking procedure
Steering wheel  	· Set rear wheels facing straight forward, then turn steering wheel to left and right. Measure range of steering wheel movement before rear wheel starts to move. Range should be 30~60mm at rim of steering wheel. If play is too large, adjust at gear box. Test steering wheel play with forklift stopped.
Knuckle	· Check knuckle visually or use crack detection method. If the knuckle is bent, the tire wear is uneven, so check tire wear.
Steering axle	· Ask assistant to drive machine at minimum turning radius. · Fit bar and a piece of chalk at outside edge of counterweight to mark line of turning radius. · Min turning radius(Outside) : Refer to page 1-5 (Specifications)

2. TROUBLESHOOTING

1) STEERING SYSTEM

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

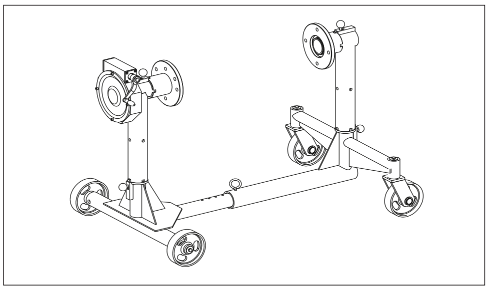
Problem	Cause	Remedy
Steering wheel turns unsteadily. Steering system makes abnormal sound or vibration.	· Lockout loosening. · Metal spring deteriorated. · Gear backlash out of adjustment. · Lockout loosening. · Air in oil circuit.	· Retighten. · Replace. · Adjust. · Retighten. · Bleed air.
Abnormal sound heard when steering wheel is turned fully	Valve · Faulty. (Valve fails to open.)	· Repair or replace.
Steering cylinder head leakage (Piston rod)	· Packing foreign material. · Piston rod damage. · Rod seal damage and distortion. · Chrome gilding damage.	· Replace · Grind surface with oil stone. · Replace · Grind
Steering cylinder head thread (A little bit leak is no problem)	· O-ring damage.	· Replace
Welding leakage	· Cylinder tube damage.	· Tube replace.
Rod	· Tube inside damage. · Piston seal damage and distortion	· Grind surface with oil store. · Replace
Piston rod bushing inner diameter excessive gap	· Bushing wear.	· Replace

GROUP 3 DISASSEMBLY AND ASSEMBLY

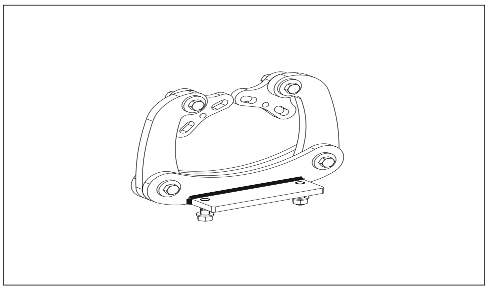
1. STEERING UNIT

1) TOOLS

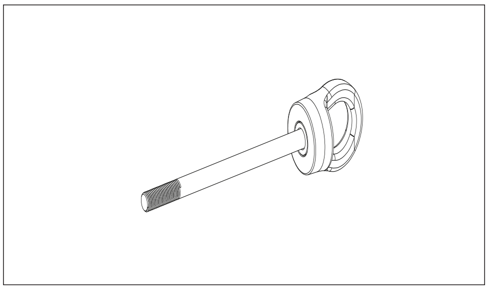
(1) Assembly truck assy



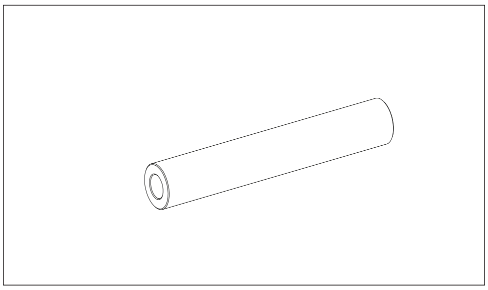
(2) Assembly fixture



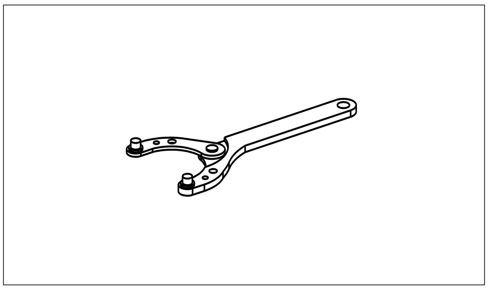
(3) Eye bolt



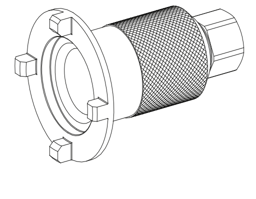
(4) Bushing



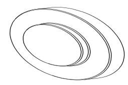
(5) Holding device



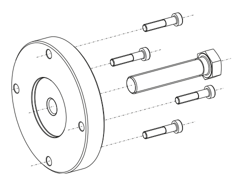
(6) Slotted nut wrench



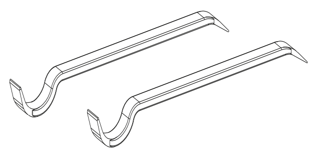
(7) Pressure piece



(8) Forcing device

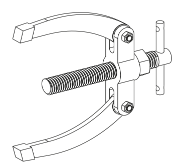


(9) Assembly lever set

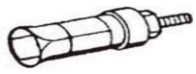


(10) Extrator

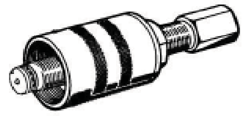
(11) Counter support



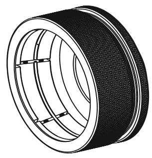
(12) Inner extrator



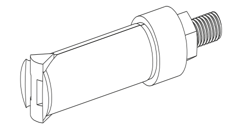
(13) Basic tool



(14) Grab sleeve

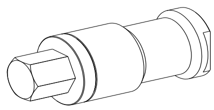


(15) Inner extrator

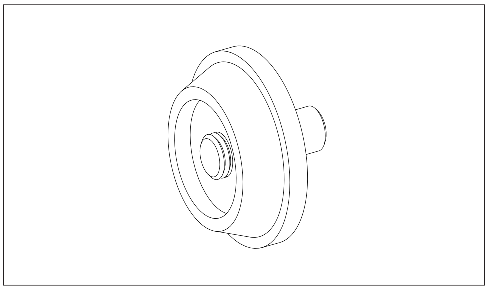


(16) Removing tool

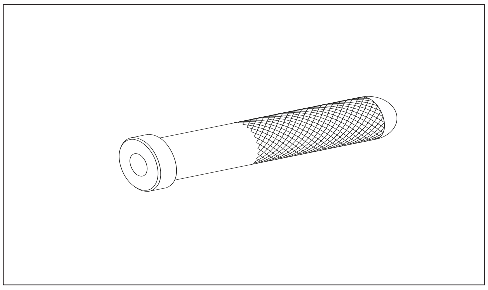
(17) Screwing device



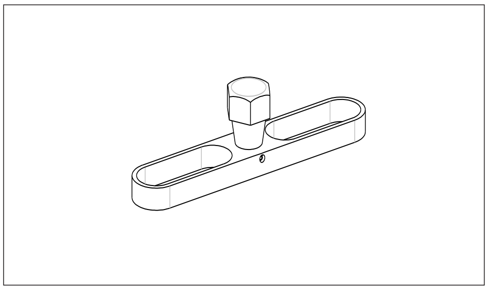
(18) Driver tool



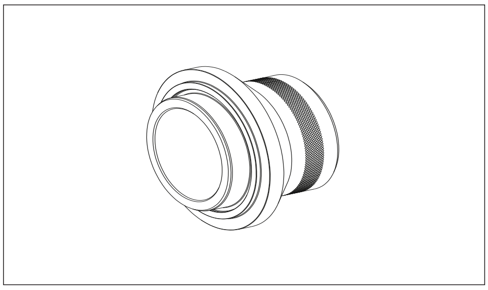
(19) Handle



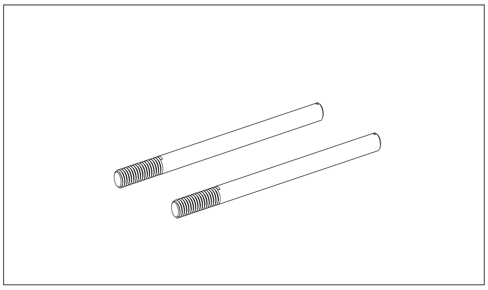
(20) Holding device



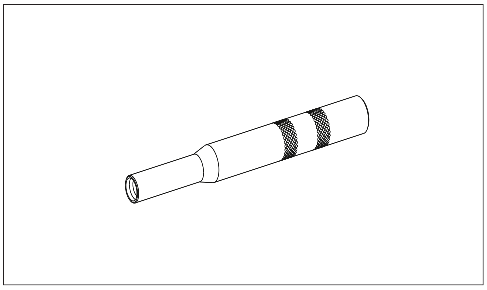
(21) Driver tool



(22) Locating pin



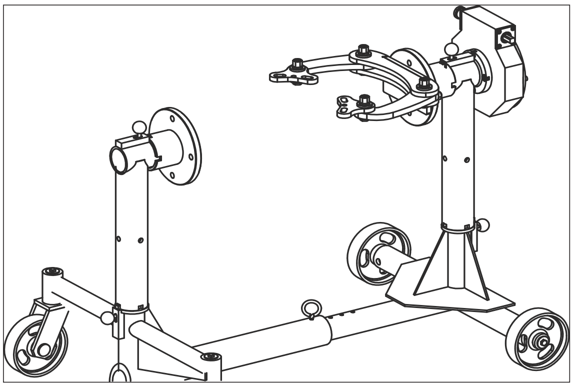
(23) Press-in manderl



2) DISASSEMBLY

(1) Clamping of transmission

① Attach assembly fixture to the assembly truck.

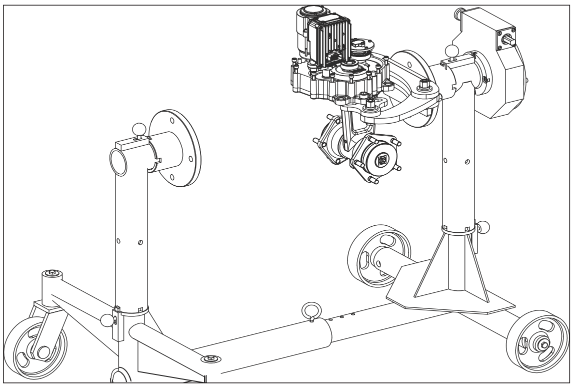


② Install lifting device, consisting of eyebolt with bushing on the transmission as shown.

③ Transport transmission and position it in the assembly fixture.

Fix the transmission to the assembly fixture.

Removing lifting device.



(2) Housing

\# Electric control unit motor

① Separate plug connection from sensor on the wiring harness.

② Loosen and remove cylindrical screw.

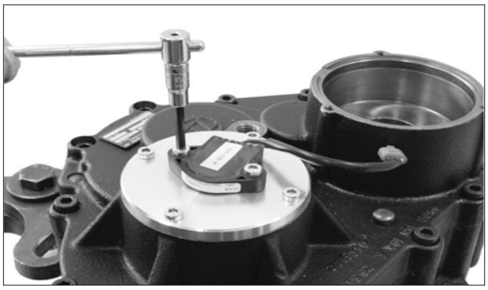
③ Remove electric control unit upwards.

④ Pay attention that the releasing V-ring does not drop.

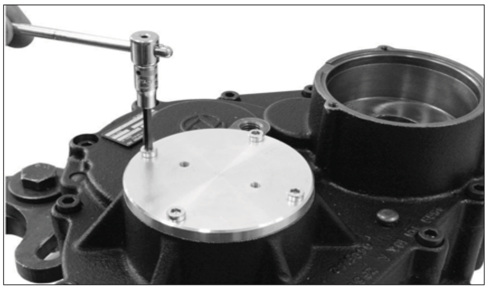
⑤ Remove cup springs from the hole of the motor connection.

\# Angles of rotation sensor

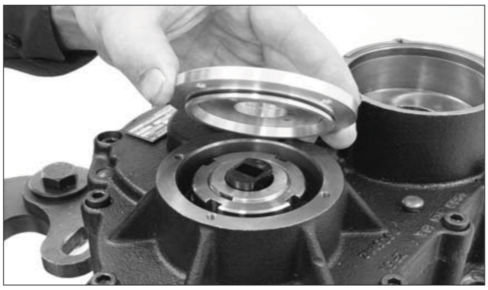
① Loosen cylindrical screws on the Angles-of-rotation sensor.



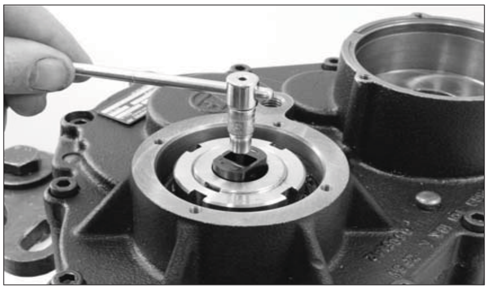
② Loosen cylindrical screws on the cover.



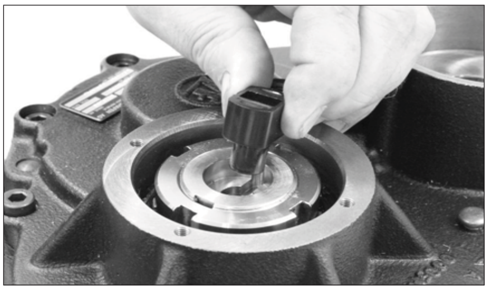
③ Remove cover. If required, remove O-ring.



④ Loosen cylindrical screw from solenoid.



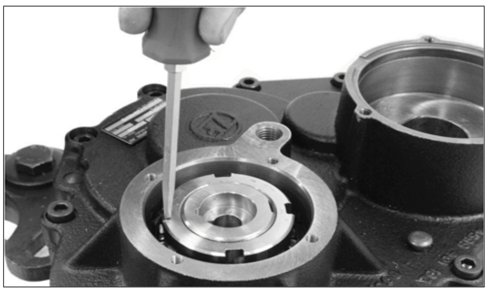
⑤ Remove solenoid.



(3) Input an output

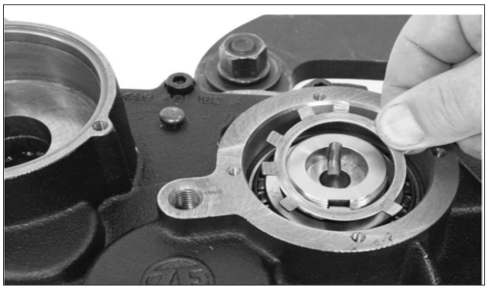
Axle carrier bearing

① Unlock slotted nut on the locking plate on the axle carrier bearing.

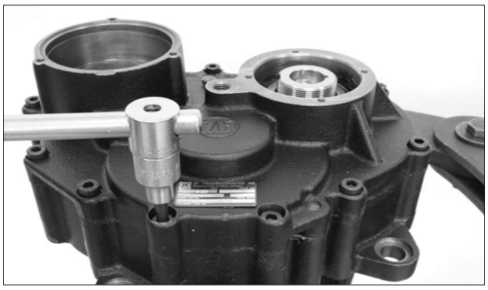


② Position holding device onto the output flange and bolt it to the wheel stud by two wheel nuts.
Loosen and remove slotted nut.

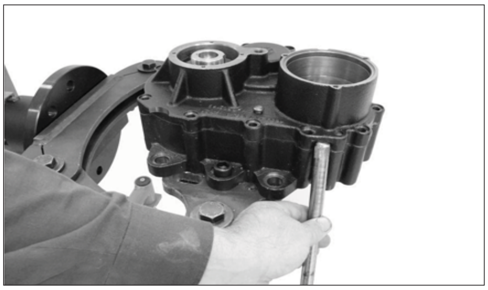
③ Remove locking plate.



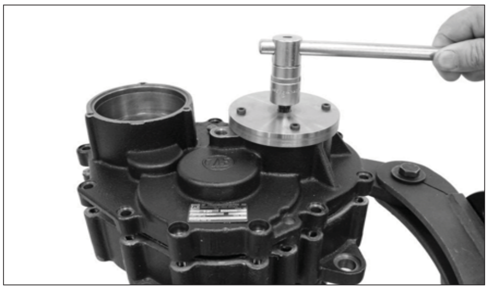
④ Loosen and remove cylindrical screws from housing.



⑤ Locate suitable assembly mandrel on the casting noses of cylindrical pin.
Loosen the housing cover by slightly hitting the two noses alternately.



⑥ Place pressure piece on axle carrier.
Locate forcing device and tighten it with screws.
Turn in screw and press off the housing cover.

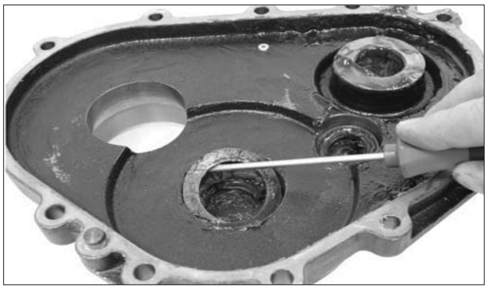


⑦ Remove bearing inner ring.

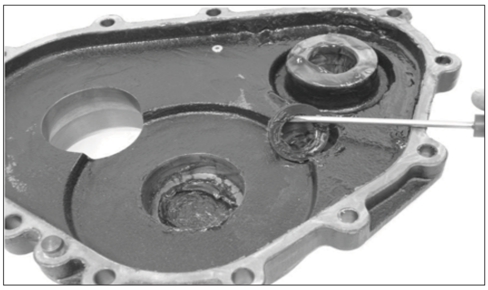
⑧ Remove bearing outer ring from the housing cover.

Helical gear transmission

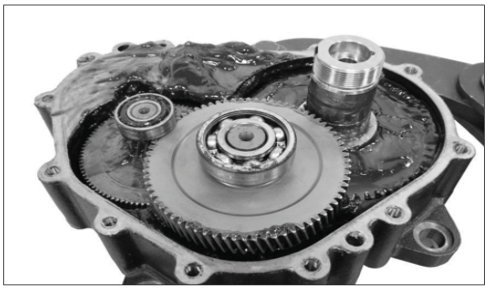
① Turn around housing cover.
Remove cup springs.



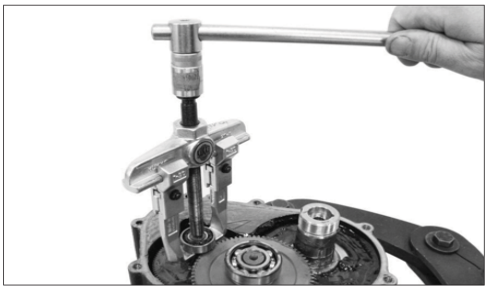
② Remove cup springs.



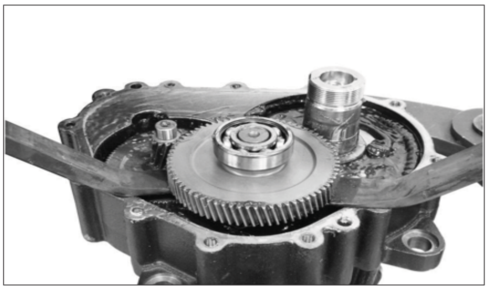
③ Remove grease from helical gear transmission.



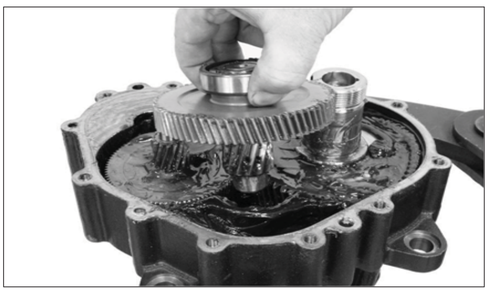
④ Pull ball bearing from the pinion shaft using a two-armed puller.



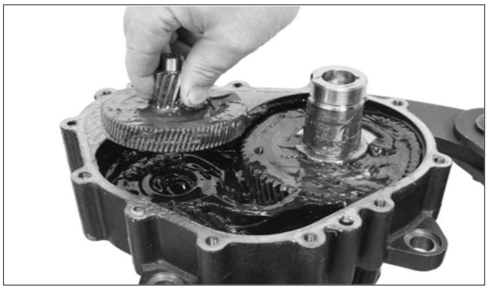
⑤ Unlock slotted nut on the locking plate on the axle carrier bearing.



⑥ Remove pinion shaft.



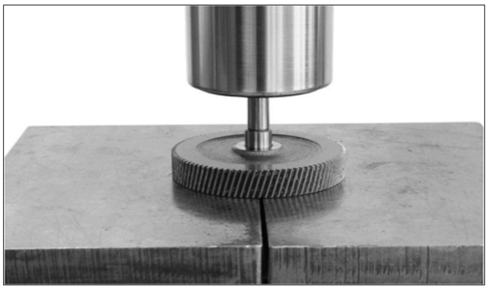
⑦ Remove pinion shaft by hand.



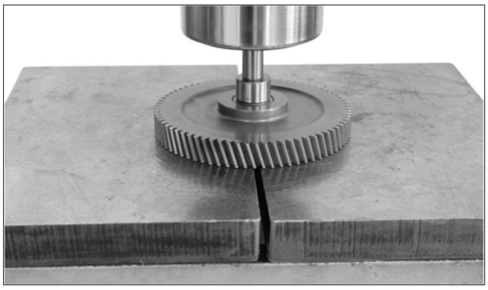
⑧ Pull ball bearing off the pinion shaft.

⑨ Pull ball bearing off the pinion shaft.

⑩ Use a suitable assembly mandrel to force pinion shaft out of the spur gear.

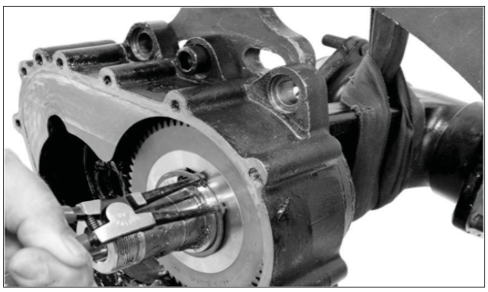


⑪ Use a suitable assembly mandrel to force pinion shaft out of the spur gear.



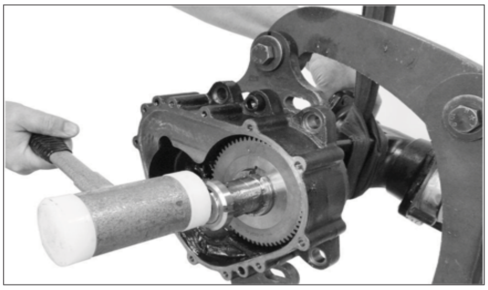
Axle carrier

① Turn transmission on the assembly truck (horizontal position).

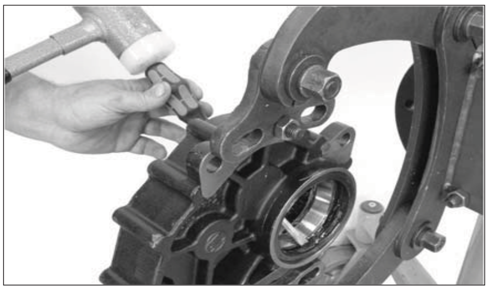


② Fit slotted nut.

Drive axle carrier out of the spur gear and remove it.



③ Force shaft seal out of the housing and remove it.



④ Rotate housing on the assembly truck by 90°. Remove bearing outer ring.

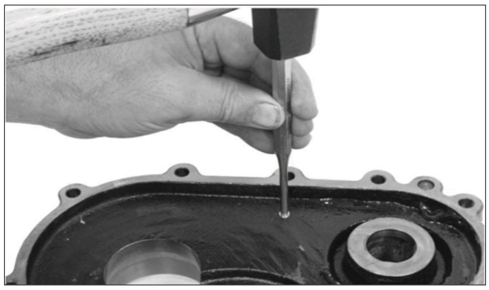
⑤ Rotate housing on the assembly truck by 180°. Pull ball bearing out of the hole of housing.

⑥ Place pressure piece upon axle carrier.

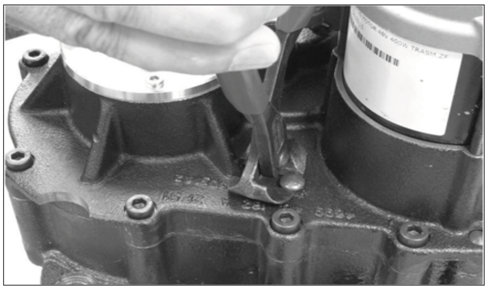
⑦ Pull bearing inner ring from axle carrier.

⑧ If required, remove fitting key.

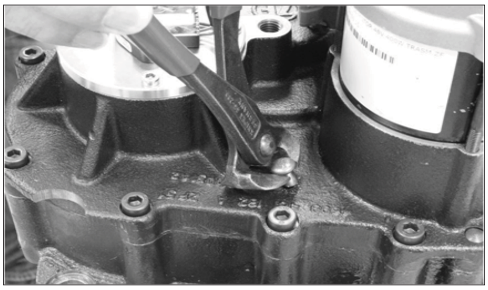
Breather
① For removal on detached housing cover, drive the breather out of the hole on the inner side of the housing cover using a pin punch and remove it.



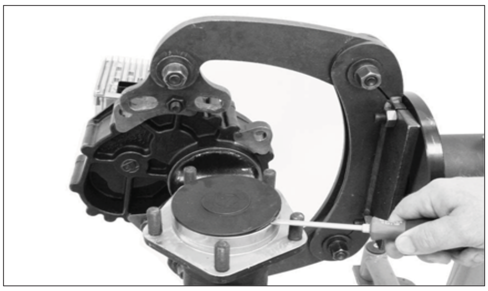
② For removal on mounted unit, locate pincer head of the end-cutting pliers beneath the breather cap.



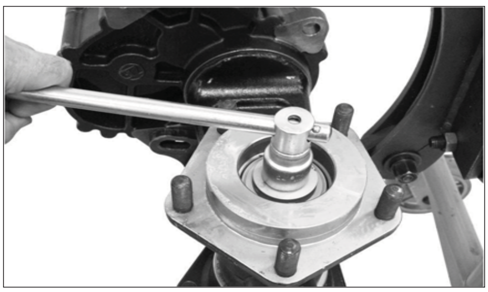
③ Pull the breather out of the housing cover.



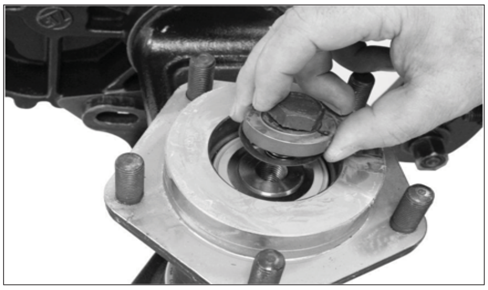
Wheel hub bearing
① Rotate transmission on the assembly truck (horizontal position).
Use screw driver to lever out protective cap and remove it from the output flange.



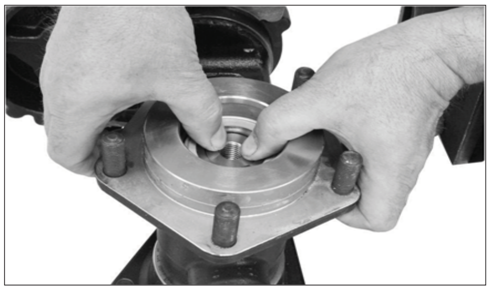
② Loosen hexagon screw.



③ Remove hexagon screw, end shim and the releasing adjusting washer.



④ Remove output flange.

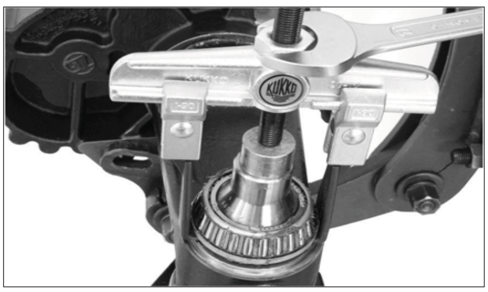


⑤ Take Nilos ring and bearing inner ring out of the output flange.

⑥ Pull bearing outer ring (internal side of output flange).

⑦ Pull bearing outer ring (outside of output flange).

⑧ Pull bearing inner ring together with the Nilos ring off the axle.

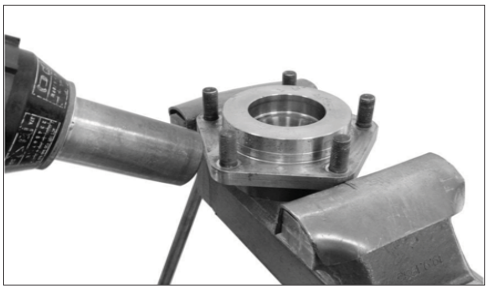


⑨ Take out shim (see arrow) by hand.

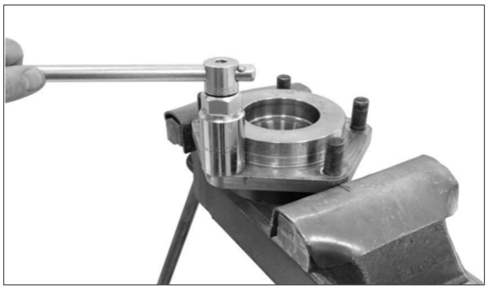
Change wheel stud

① Clamp output flange.

Heat up the wheel stud to be changed.

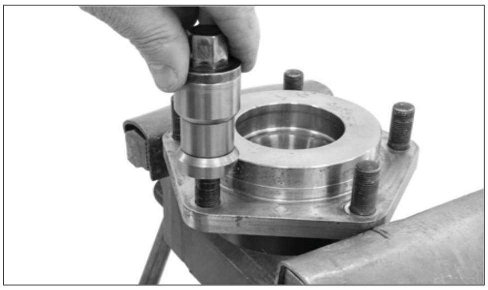


② Use removing tool to loosen wheel bolt and remove it.

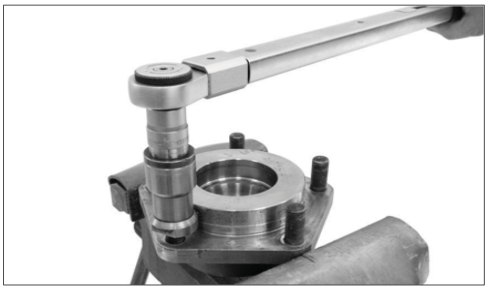


③ Turn new wheel stud with the long thread side into the screwing device.

Afterwards turn in the short thread side of the wheel stud on the output flange.



④ Tighten wheel stud using a screwing device.



2) REASSEMBLY

(1) Input and output
Wheel hub bearing

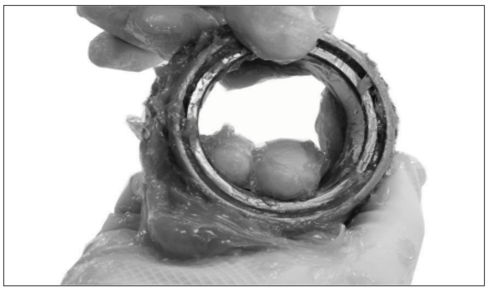
① Insert bearing outer ring (output flange outer face) until contact.

② Insert bearing outer ring (output flange internal side) until contact.

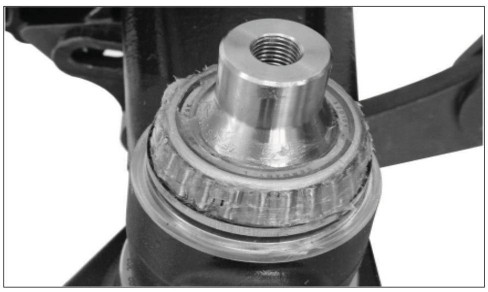
③ Place shim.

④ Mount Nilos ring.

⑤ Fill grease into bearing inner rings (each output side). Fill grease in the space between inner ring and bearing cage, until visible overflow. Do not rotate the cage for a complete filling, but slightly displace the bearing with the cage.

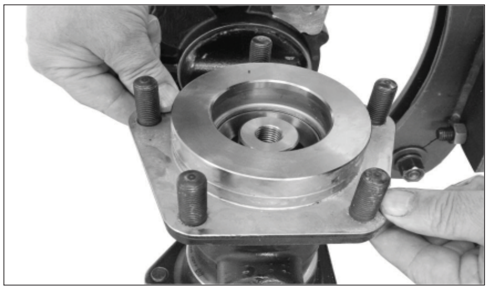


⑥ Install bearing inner ring which is filled with grease and bring it to contact position.

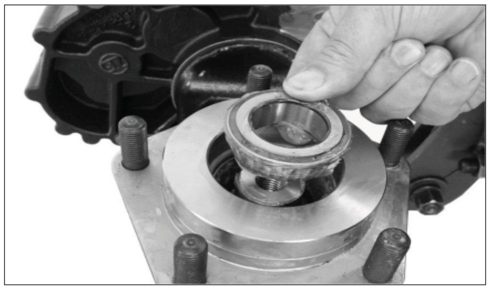


⑦ Slightly grease the track of the bearing outer ring.

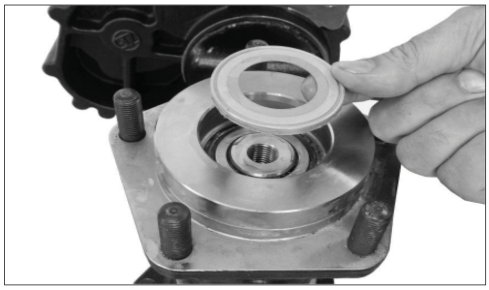
Place output flange (with bearing outer ring) onto the bearing inner ring.



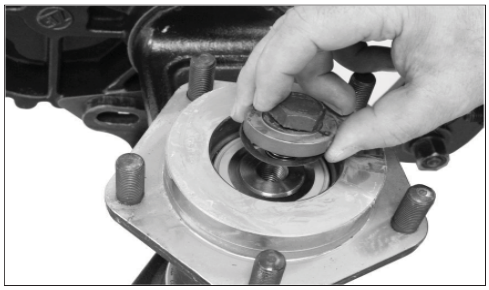
⑧ Fill bearing inner ring with grease. Proceed according to sequence of operation described in ⑤. Slightly grease the track of the bearing outer ring. Insert bearing inner ring into the bearing outer ring.



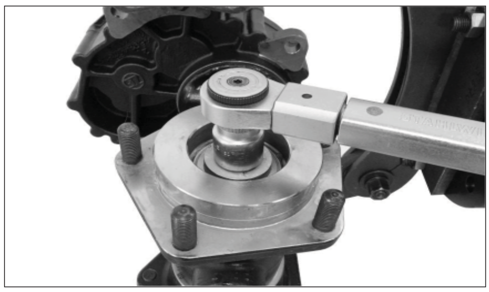
⑨ Insert Nilos ring.



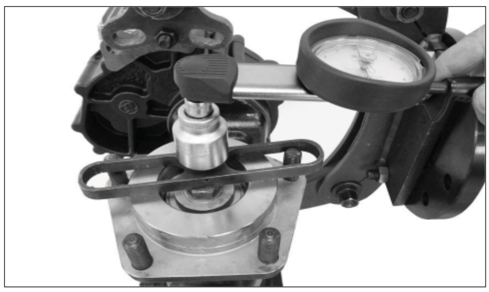
⑩ Install adjusting washer, end shim and hexagon screw.



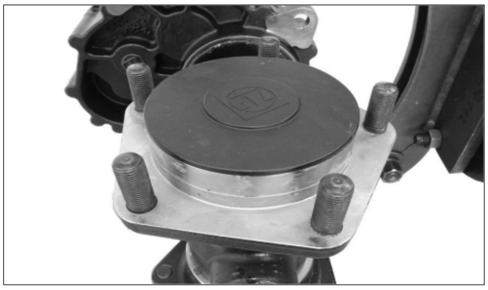
⑪ Tighten hexagon screw.
Tightening torque = 245 Nm.



⑫ Check rolling torque of wheel hub bearing 1.0 … 3.0 Nm. In case of deviations from the required rolling torque, correct with an appropriate adjusting washer. 1. Insufficient rolling torque – use thicker adjusting washer. 2. Excessive rolling torque – use thinner adjusting washer.



⑬ Press in protective cap until contact.



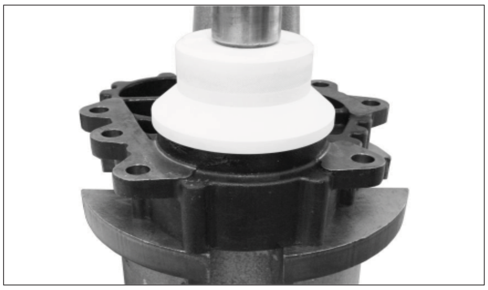
Axle carrier

① If removed or in case of a new part, mount fitting key.

② Install heated bearing inner ring (85 … 120°C) on the axle carrier until contact.

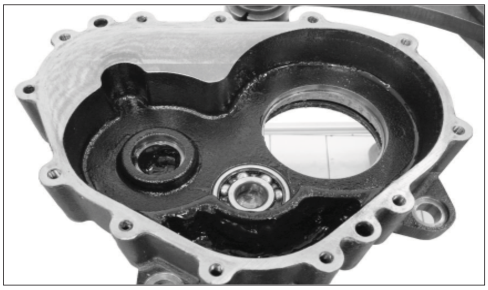
③ Insert bearing outer ring into the housing.

④ Press the shaft seal into the housing with the sealing lip facing the grease chamber.



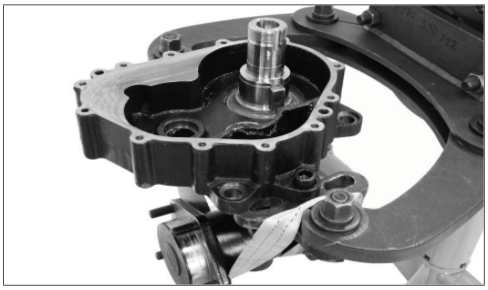
⑤ Richly grease the bearing rollers, inside and outside as well as front sides.

⑥ Install the ball bearing in the housing.

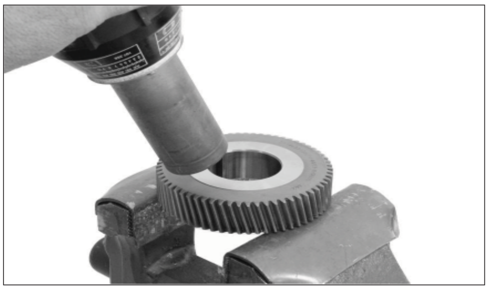


⑦ Rotate the housing by 180°.
Insert complete axle carrier from above until contact position.
Use a lashing strap to clamp the axle carrier tightly to the assembly fixture to secure it against falling out.

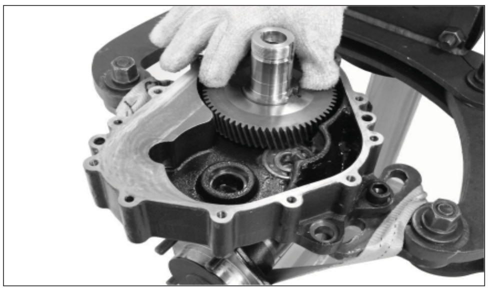
⑧ Rotate the housing back by 180°.
Apply some fluid grease around the tapered roller bearing area.



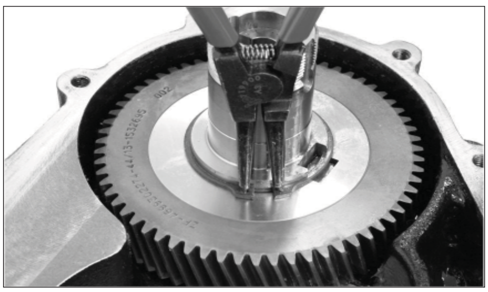
⑨ Heat spur gear.



⑩ Install heated spur gear until contact.

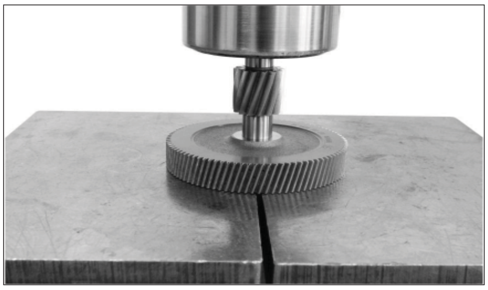


⑪ Snap in retaining ring.

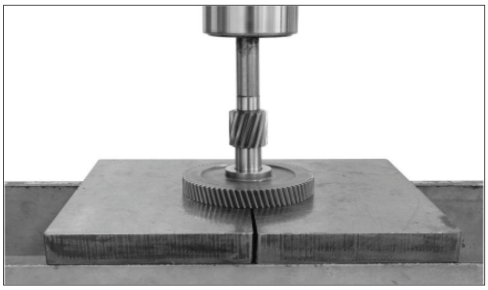


Helical gear transmission

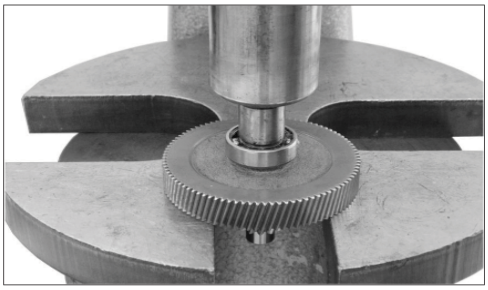
① Press in pinion shaft until contact on the spur gear.



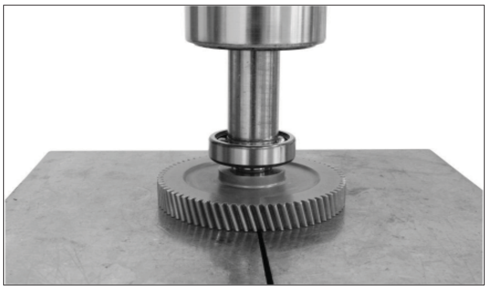
② Press in pinion shaft until contact on the spur gear.



③ Press ball bearing on the bearing inner ring onto the pinion shaft until contact position.

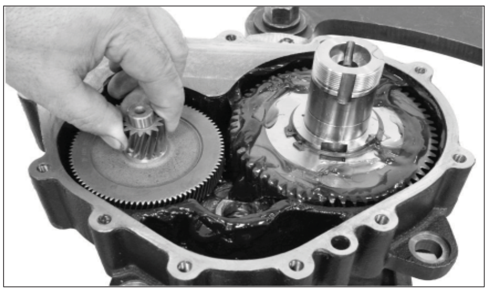


④ Press ball bearing on the bearing inner ring onto the pinion shaft until contact position.

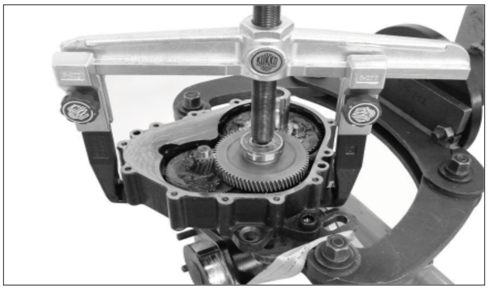


⑤ Fill transmission chamber with fluid grease.

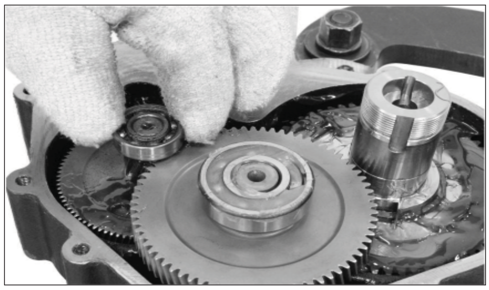
⑥ Insert preassembled pinion shaft with ball bearing.



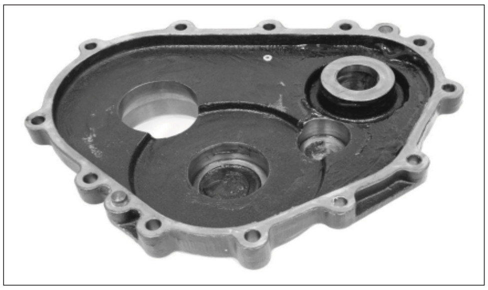
⑦ Press in the preassembled pinion shaft until contact.



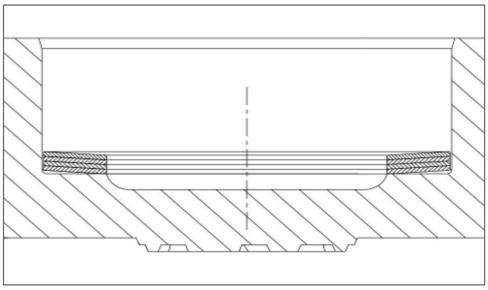
⑧ Install heated ball bearing (85~120°C) on the pinion shaft until contact.



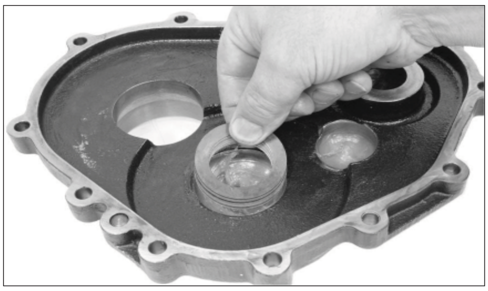
⑨ Reset cylindrical pins in the housing cover.



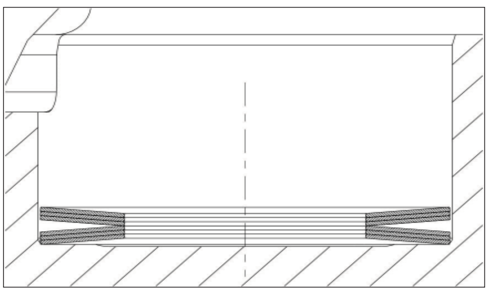
⑩ The opposite figure shows the installation position of cup springs, 4 pcs).



⑪ Use fluid grease to fix cup springs into the hole of the housing cover.



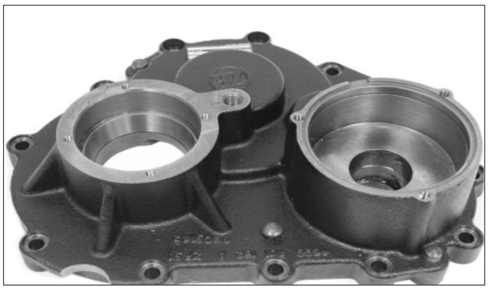
⑫ The opposite figure shows the installation position of cup springs, 6 pcs)



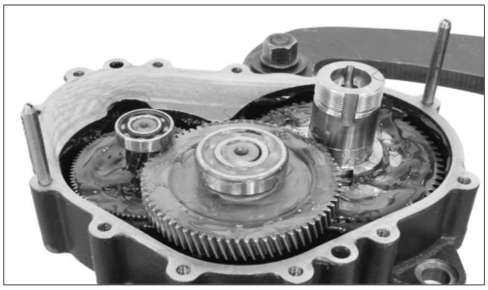
⑬ Use fluid grease to fix cup springs into the hole of the housing cover.

Axle carrier bearing

① Turn around the housing cover.
Install bearing outer ring (see arrow) and bring it into contact position.

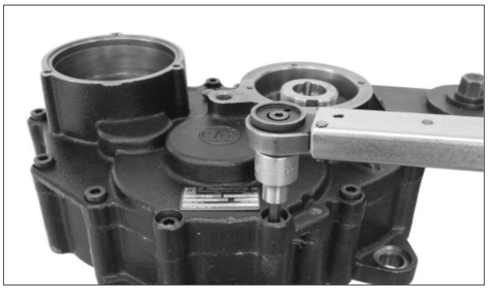


② Fill transmission chamber with fluid grease.
Install two locating pins.

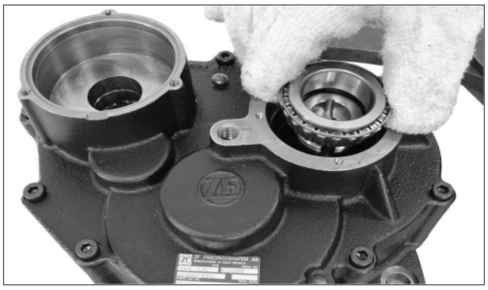


③ Clean sealing surfaces on the housing and housing cover.
Evenly wet sealing surface of the housing cover with Loctite 574. Install housing cover and bring it to contact position. Flush-drive cylindrical pins.

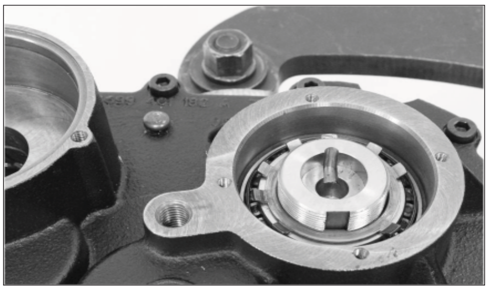
④ Remove locating pins.
Fix housing cover with cylindrical screws.
Tightening torque (M8/10.9) = 34 Nm.



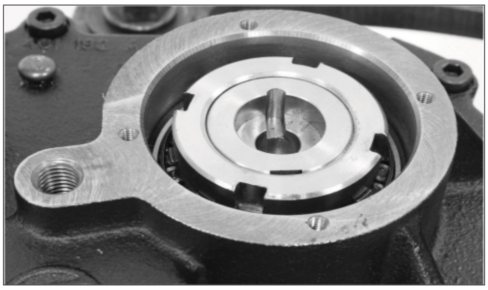
⑤ Fill bearing inner ring with grease, Proceed according to operation sequence.
Install heated bearing inner ring (85~120°C) on bearing outer ring until contact.



⑥ Insert locking plate.



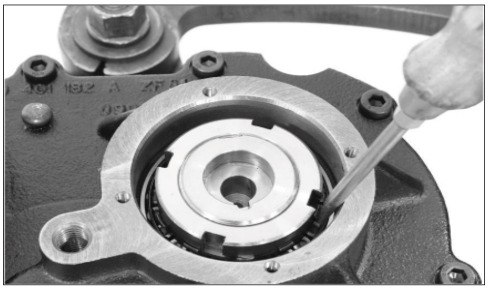
⑦ Hand-tighten slotted nut.
Remove lashing strap.



⑧ Position the holding device on the gear shaft and fix it on the wheel bolt using two wheel nuts. Tighten slotted nut until the required rolling torque is obtained. Then force out bearing by means of slight hits and roll it in.

⑨ Check rolling torque of axle carrier bearing 10~15 Nm.

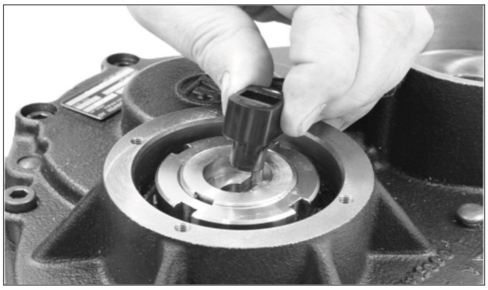
⑩ Secure slotted nut with locking plate.



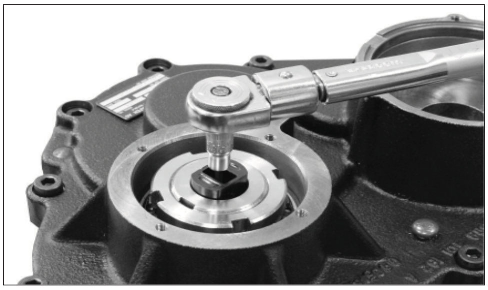
(2) Housing

Angles of rotation sensor

① Insert solenoid into the groove of the axle carrier.

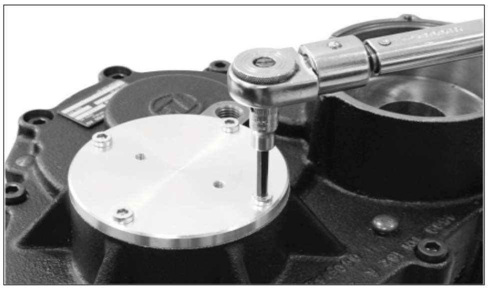


② Fix solenoid by means of cylindrical screw.
Tightening torque = 3 Nm.

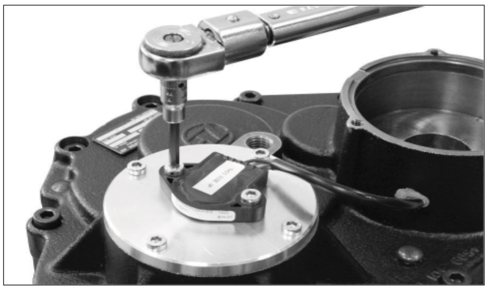


③ Grease O-ring and insert it into the annular groove of the cover.

④ Insert cover and bring it to contact position.
Fix cover with cylindrical screws.
Tightening torque = 5.5 Nm.

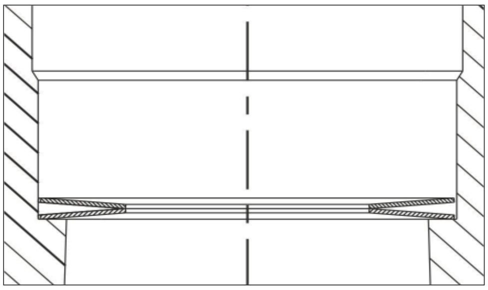


⑤ Place sensor observing the correct side.
Fix sensor by means of cylindrical screws.
Tightening torque = 4 Nm



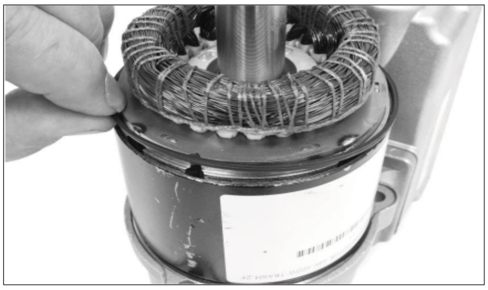
Electric control unit motor

① The opposite figure shows the installation position of cup springs.



② Insert cup springs into the hole of the motor connection

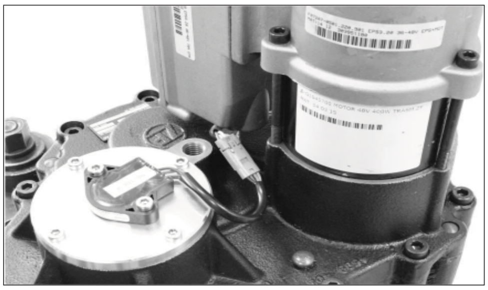
③ Install V ring on the motor.



④ Carefully mount control unit in the motor connection rotating it slightly.
Simultaneously lower it until contact, when tooth engagement is noticeable.

③ Fix control unit using cylindrical screws. Tightening torque = 9.5 Nm.

④ Connect wiring harness to the sensor.



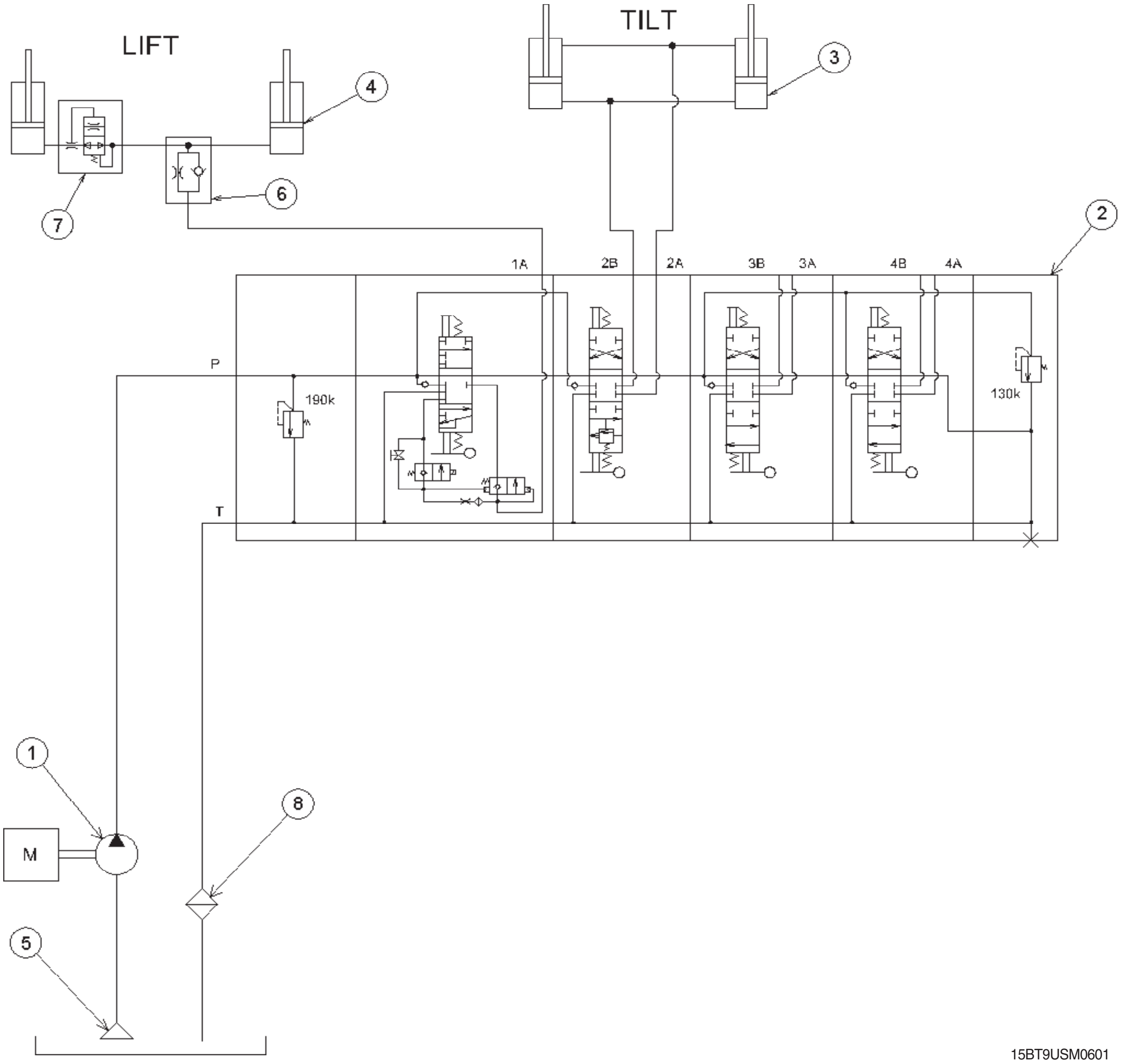
Breather

① If removed, or in case of a new part, use press-in mandrel to insert breather into the hole of the housing cover.

SECTION 6 HYDRAULIC SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

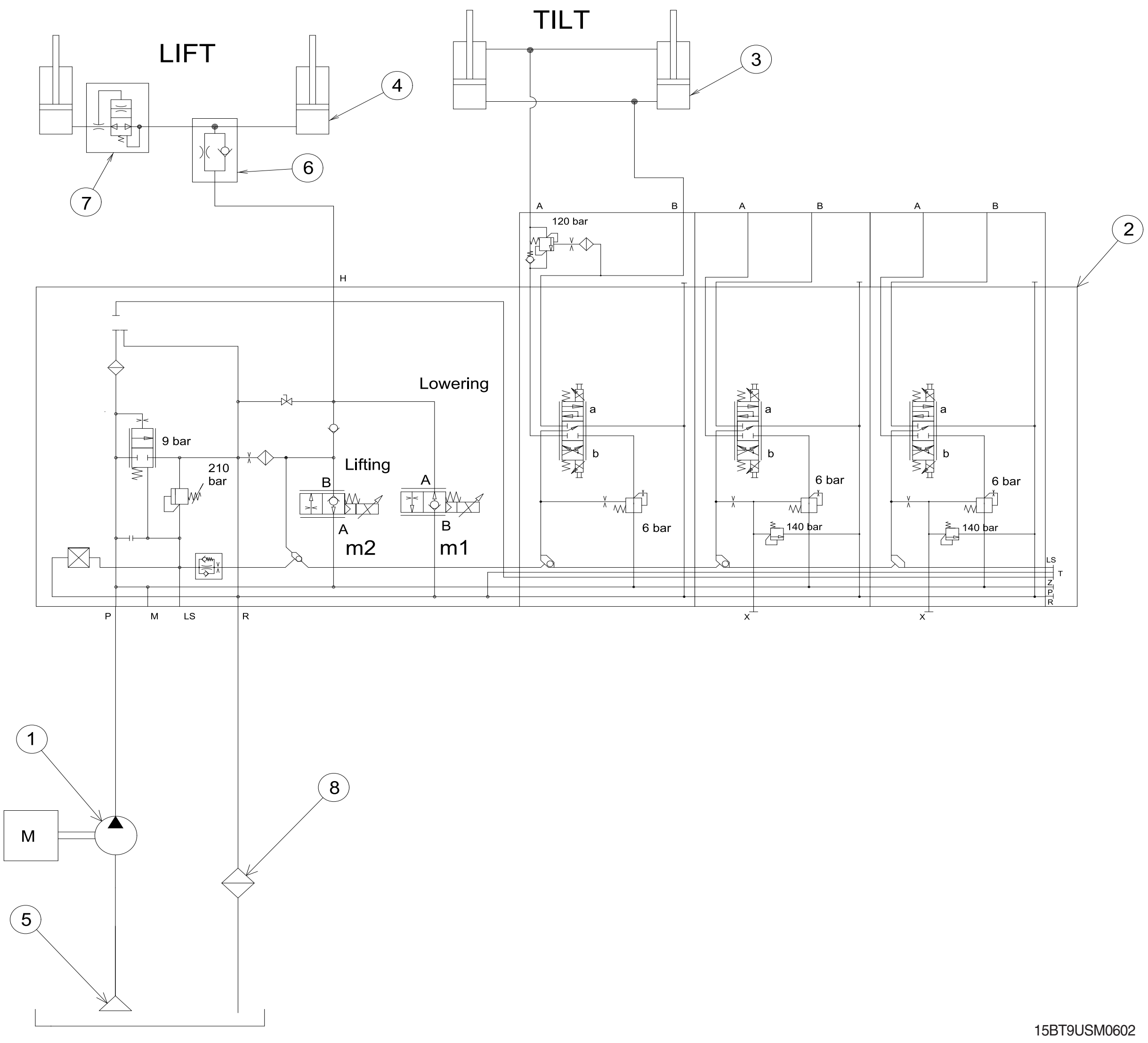
1. HYDRAULIC CIRCUIT



1	Gear pump	4	Lift cylinder	7	Down safety valve
2	Main control valve	5	Suction strainer	8	Return filter
3	Tilt cylinder	6	Down control valve		

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

1.1 HYDRAULIC CIRCUIT(FINGER-TIP)

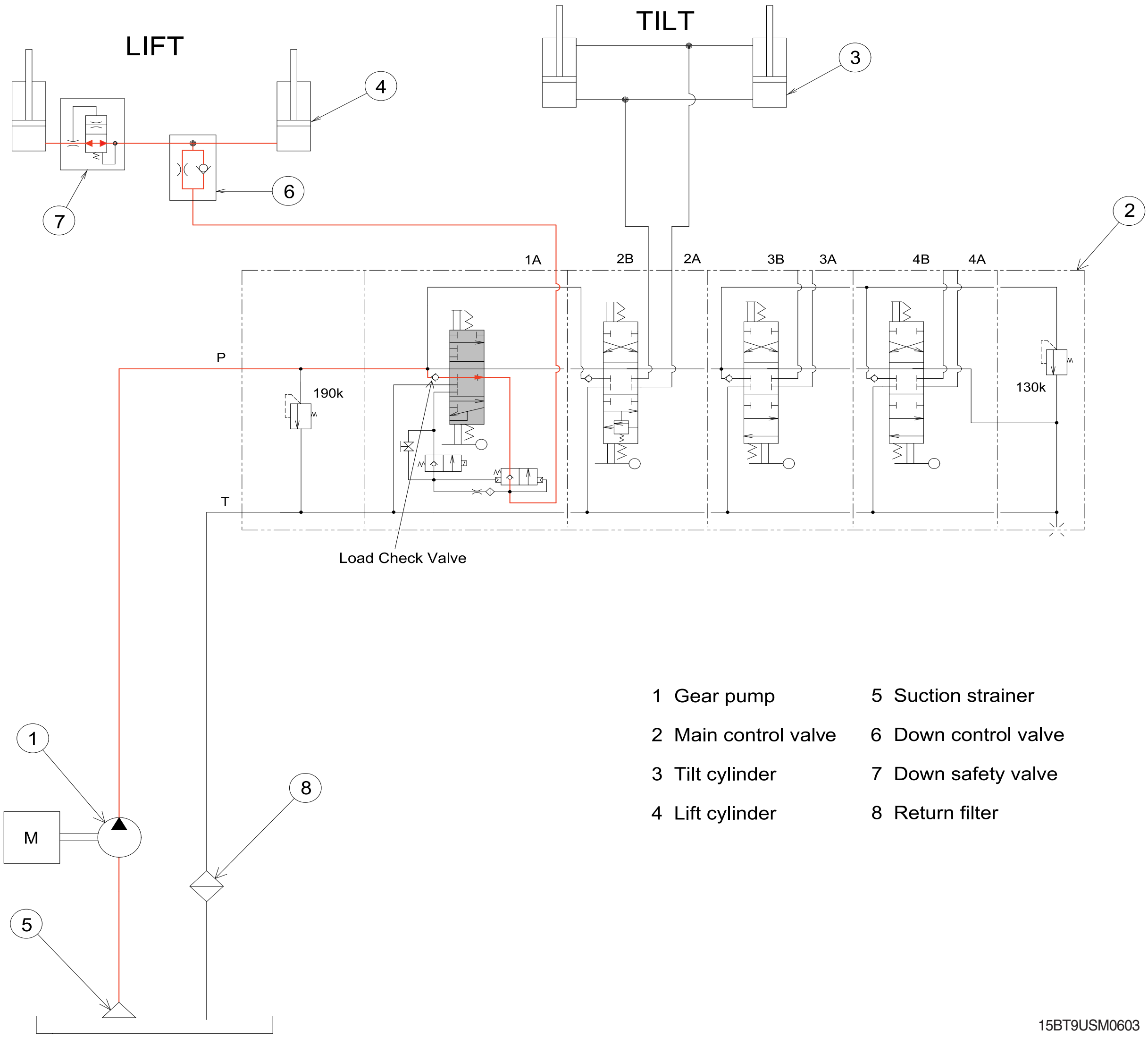


1	Gear pump	4	Lift cylinder	7	Down safety valve
2	Main control valve	5	Suction strainer	8	Return filter
3	Tilt cylinder	6	Down control valve		

※ 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

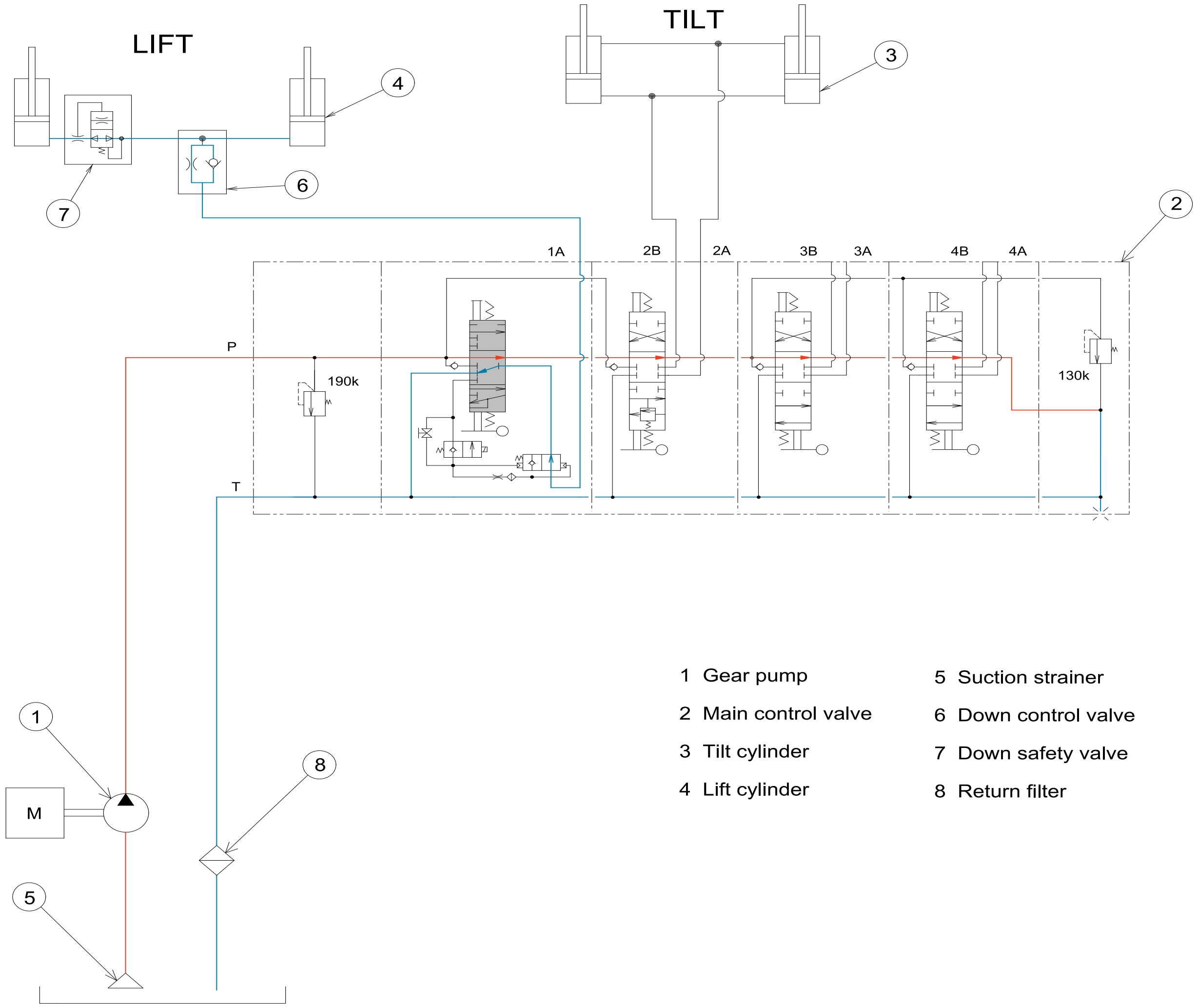
※ Descriptions are based on the manual type.



When the lift control lever is pulled back, the spool on the first block is moves to lift position.
The oil from hydraulic gear pump(1) flows into main control valve(2) and then goes to the large chamber of lift cylinder(4) by pushing the load check valve of the spool.
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



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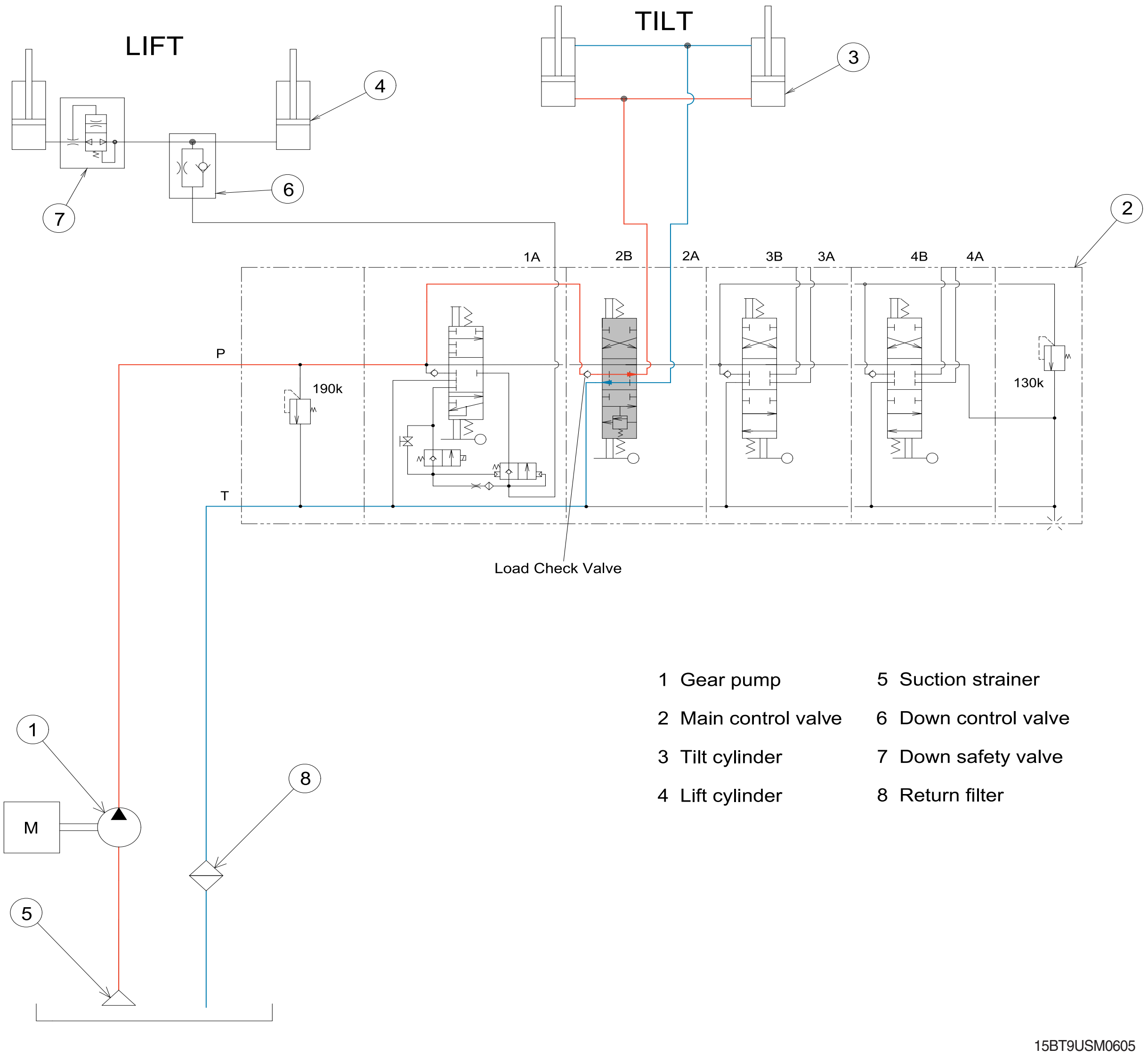
When the lift control lever is pushed forward, the spool on the first block is moved to lower position. The work port(1A) and the small chamber and the large chamber are connected to the return passage, so the forks will be lowered due to its own weight.

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

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



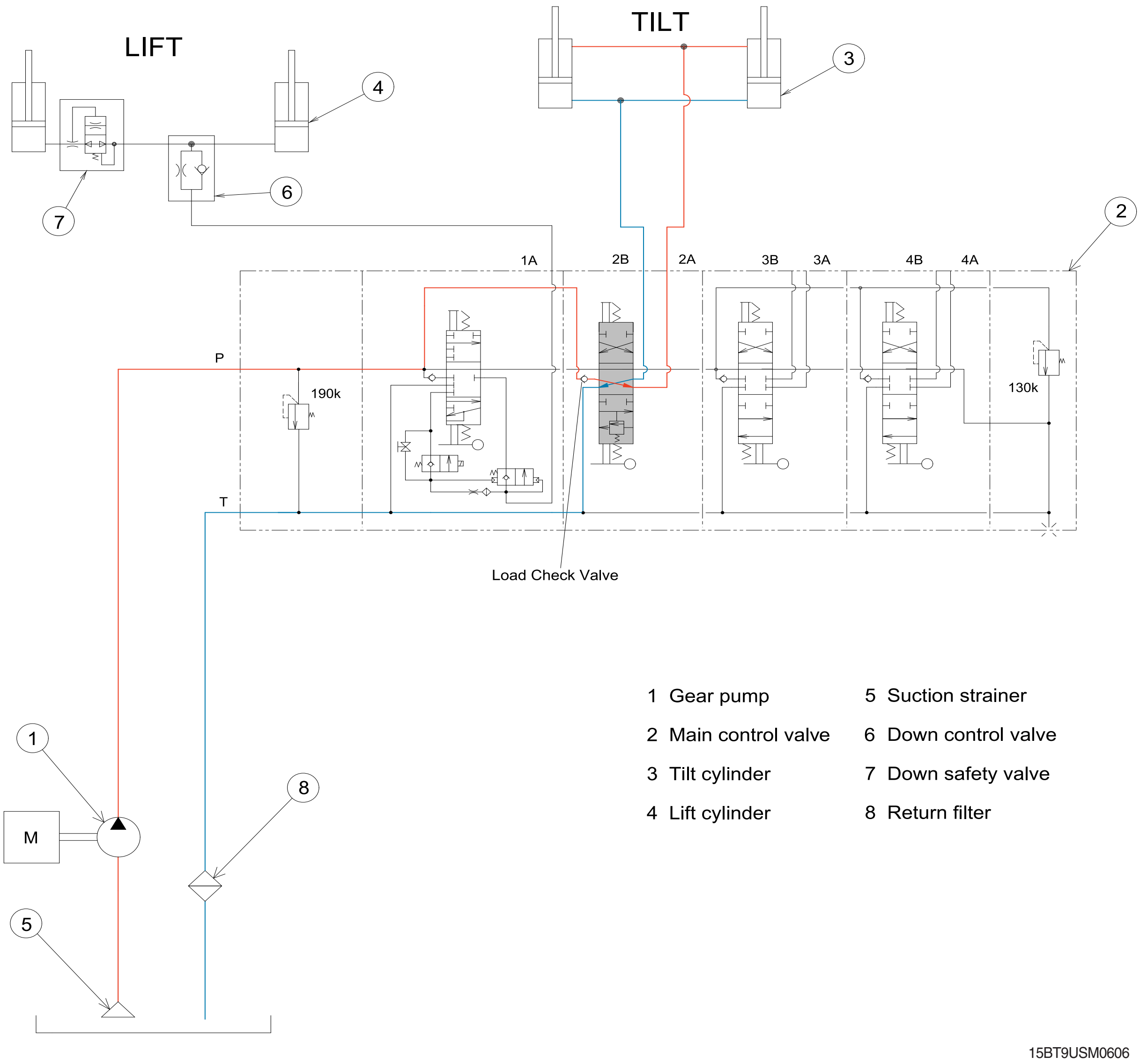
When the tilt control lever is pushed forward, the spool on the second block is moved to tilt forward position. The oil from hydraulic gear pump(1) flows into main control valve (2) and then goes to the large chamber of tilt cylinder(3) by pushing the load check valve of the spool.

The oil at the small chamber of tilt cylinder(3) returns to hydraulic tank 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.

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



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

The oil from hydraulic gear pump(1) flows into main control valve(2) and then goes to the small chamber of tilt cylinder(3) by pushing the load check valve of spool.

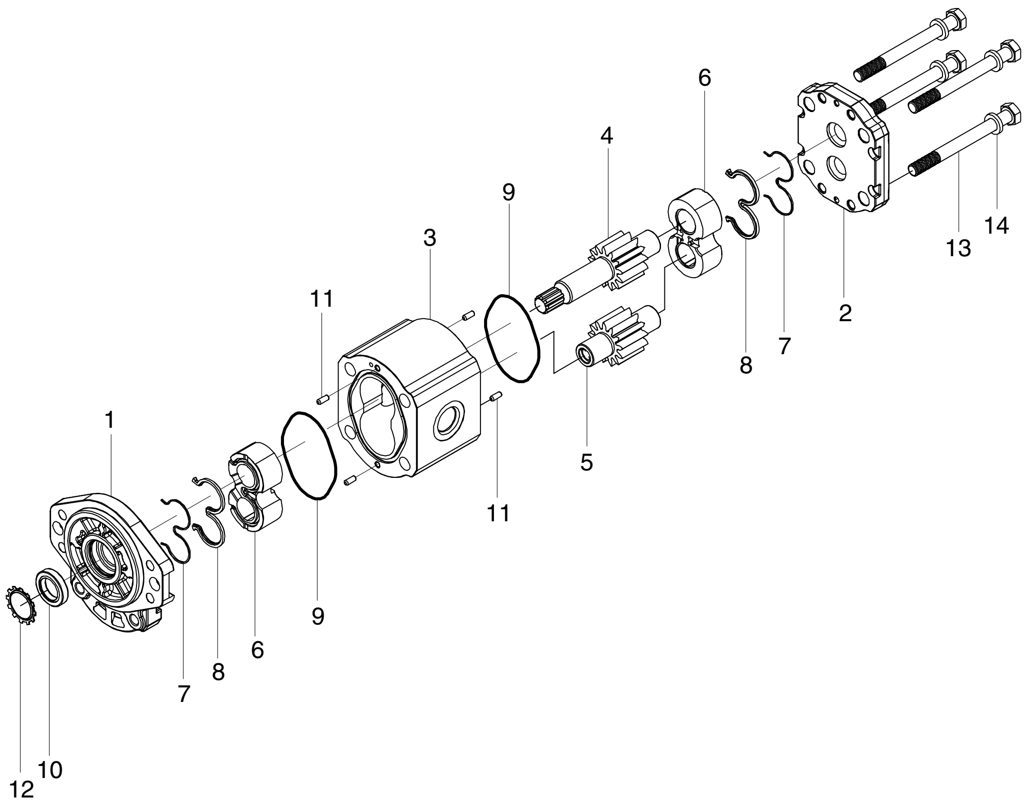
The oil at the large chamber of tilt cylinder(3) returns to hydraulic tank at the same time.

When this happens, the mast tilt backward.

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

2. HYDRAULIC GEAR PUMP

1) STRUCTURE



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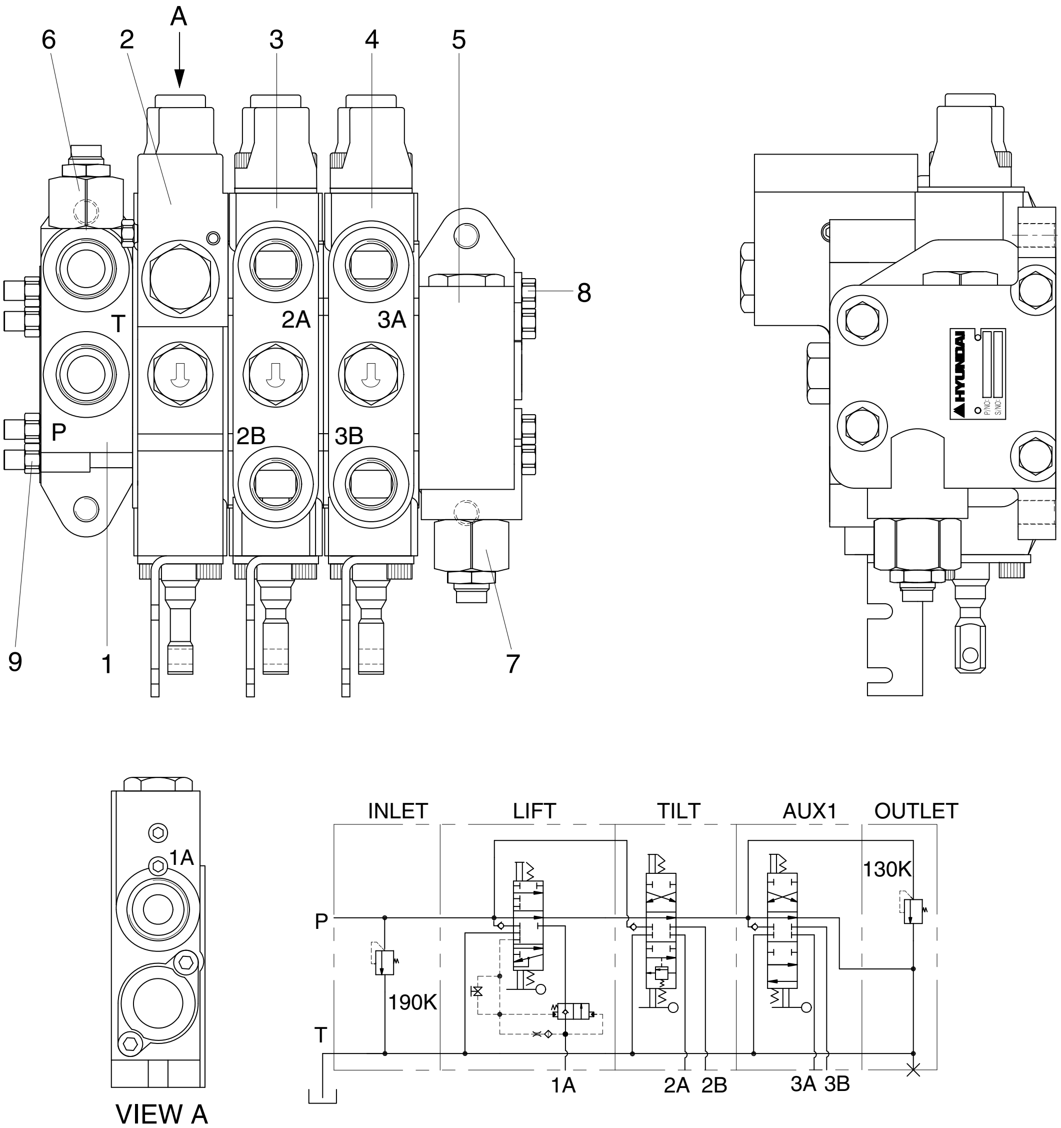
1	Mounting flange	6	Bearing block	11	Dowel pin
2	End cover	7	Backup ring	12	Start ring
3	Gear housing	8	Seal	13	Socket head bolt
4	Drive gear	9	O-ring	14	Spring washer
5	Idler shaft	10	Shaft seal		

2) OPERATION

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

3. MAIN CONTROL VALVE (without OPSS)

1) STRUCTURE (3 Spool)



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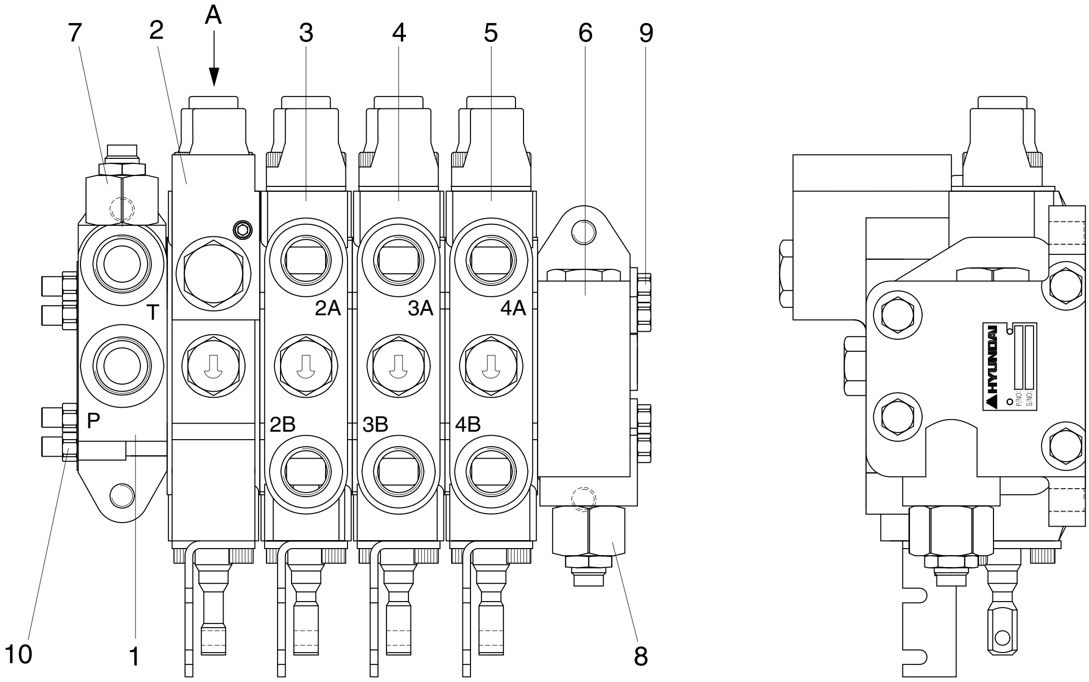
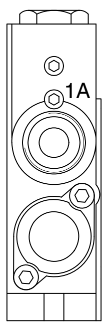
Port name	Size	Port
Inlet port	7/8-14UNF	P
Outlet port	7/8-14UNF	T
Work port	7/8-14UNF	1A
Work port	3/4-16UNF	2A, 2B, 3A, 3B

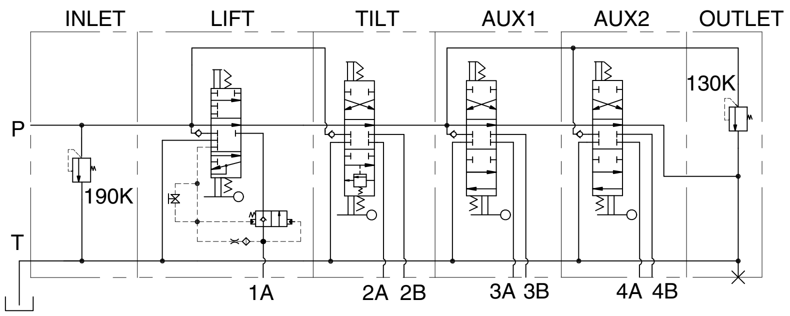
1 Inlet block assy
2 Lift block assy
3 Tilt block assy
4 Aux 1 block assy
5 Outlet block assy
6 Main relief valve assy
7 Auxiliary relief valve assy
8 Long bolt
9 Nut

2) 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

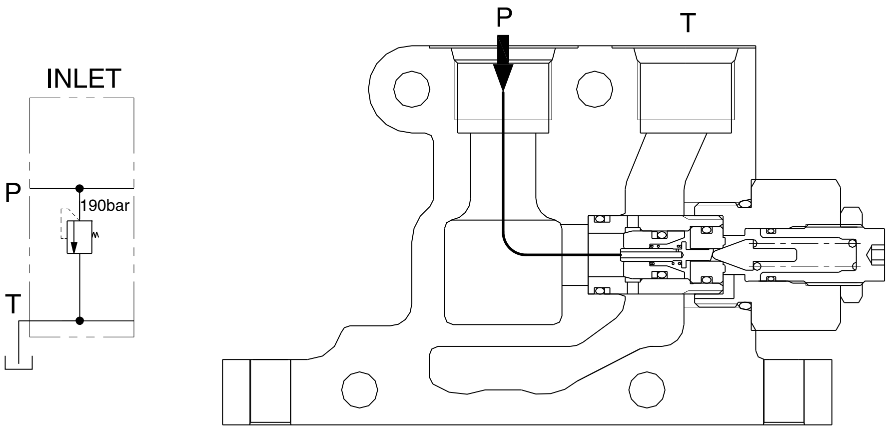
15BT9USM0609

1 Inlet block assy
2 Lift block assy
3 Tilt block assy
4 Aux 1 block assy
5 Aux 2 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.



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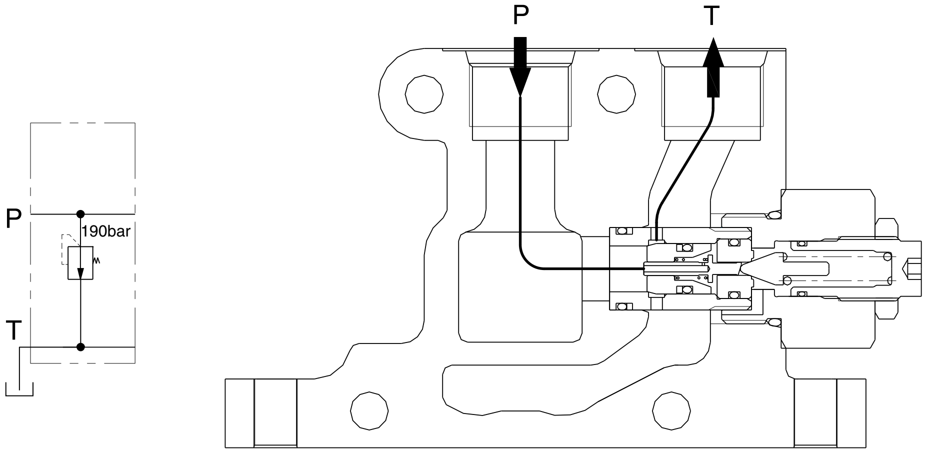
(2) Operation of relief valve at setting pressure

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.



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4) LIFT SECTION

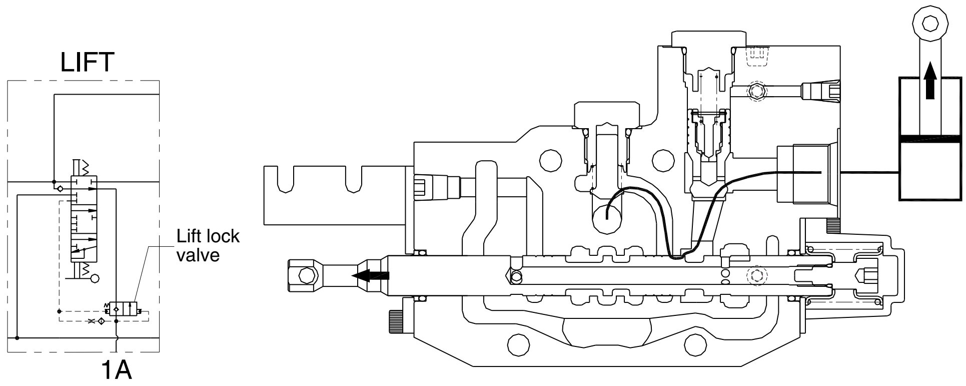
(1) Operation

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

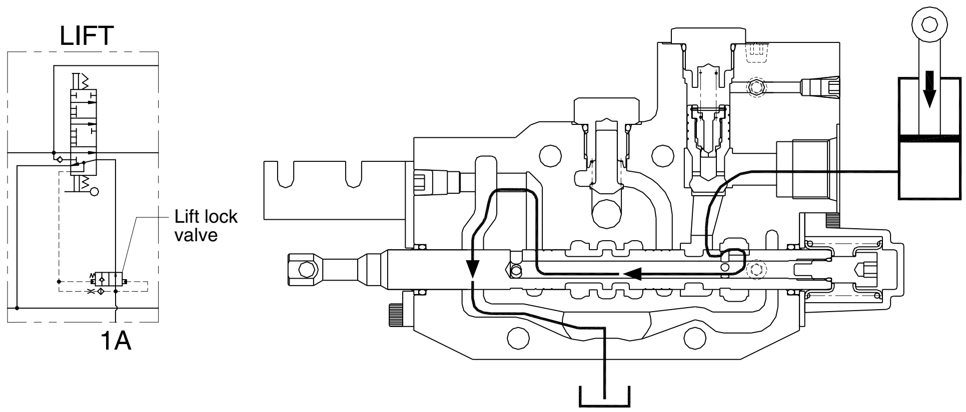
When the operator shifts the lever backwards, the spool is extended out of the valve, and this opens the internal fluid passages that lift the mast. Oil flows through the high pressure parallel cavity, past the load check valve, through the spool metering notches, past the lift lock check valve, and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



15BT9USM0612

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.



15BT9USM0613

Pressure is limited by the main relief valve.

5) TILT SECTION

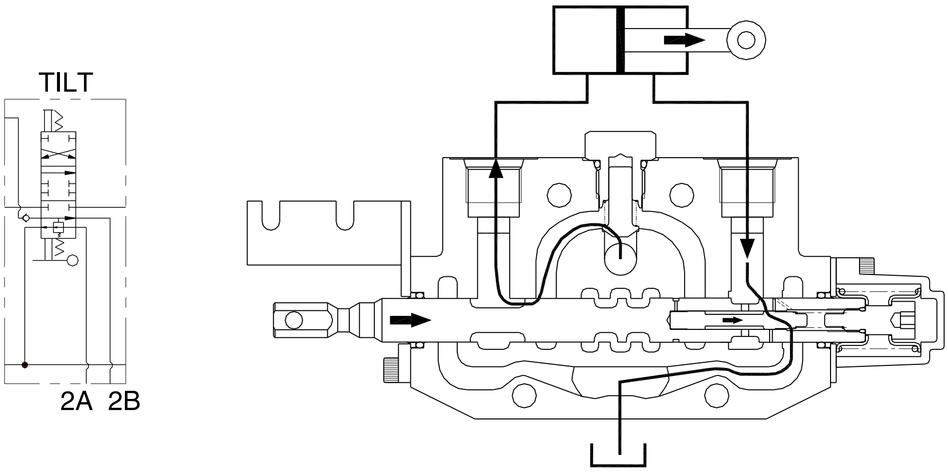
(1) Operation

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.

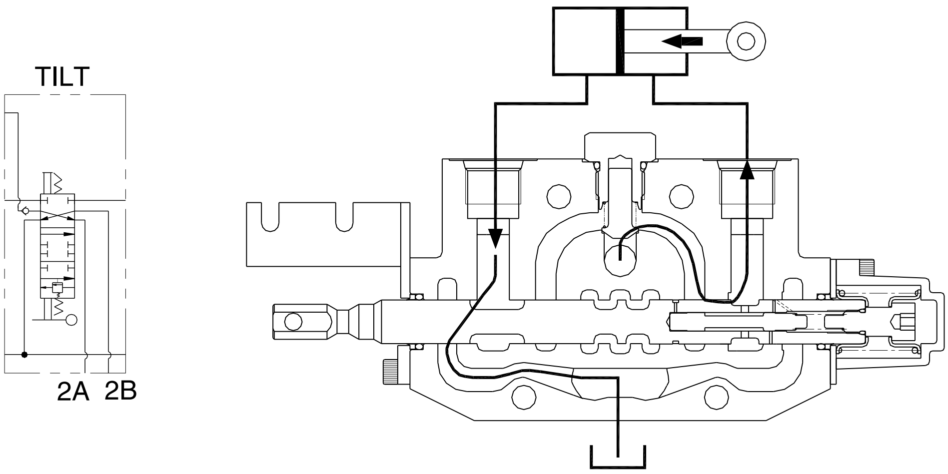
Simultaneously, the high pressure acts upon the end of the tilt lock plunger to move it towards the spring end of the spool. This plunger movement opens additional spool metering notches which control oil flow from the rod end of the cylinder to the tank return line.



15BT9USM0614

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.



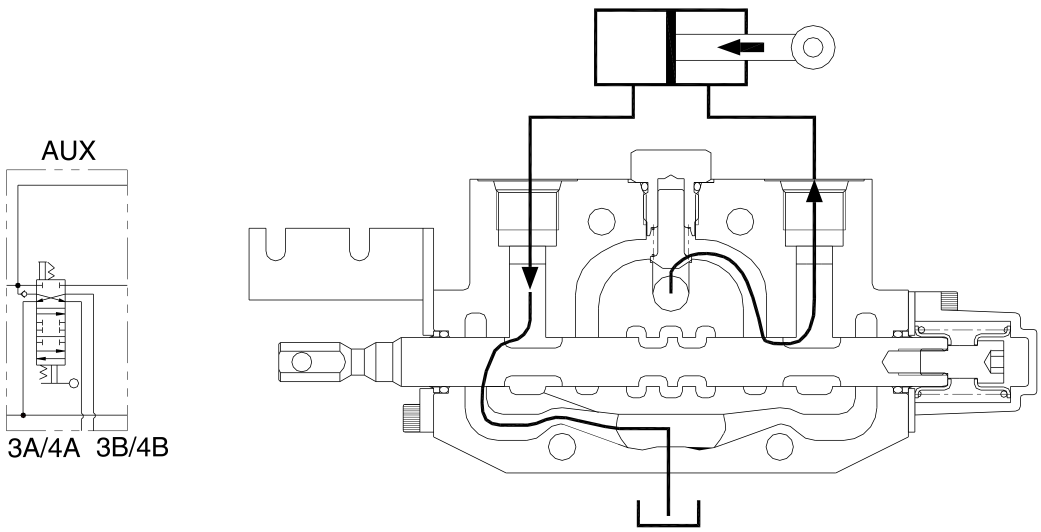
15BT9USM0615

Pressure is limited by the main relief valve.

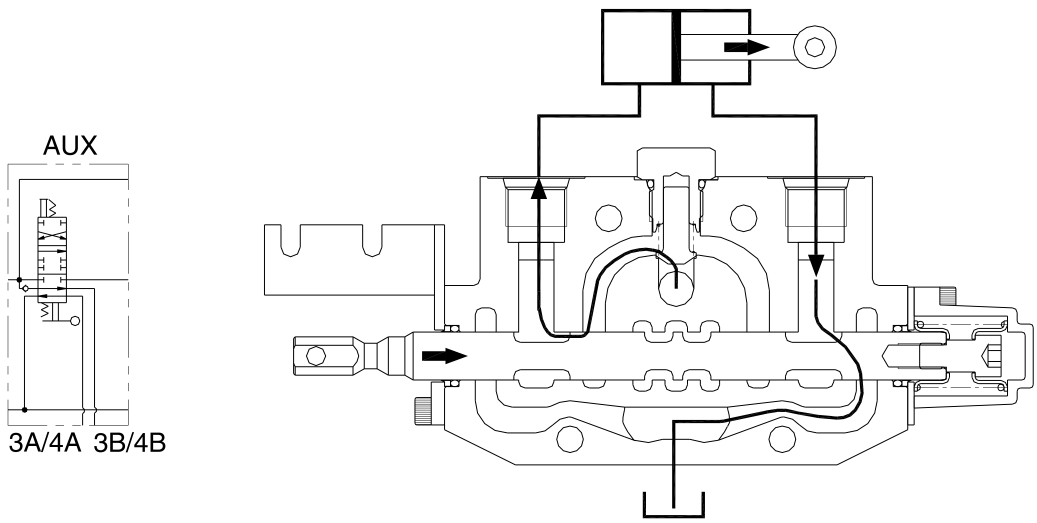
6) AUXILIARY SECTIONS

(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.



15BT9USM0616



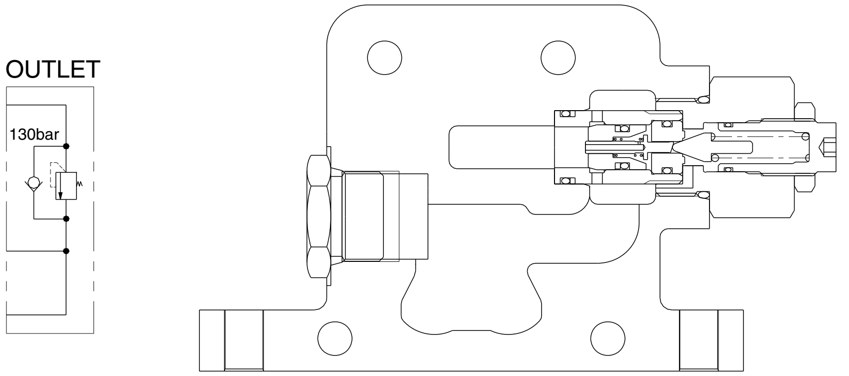
15BT9USM0617

Pressure is limited by the secondary main relief valve.

7) OUTLET SECTION

(1) Operation

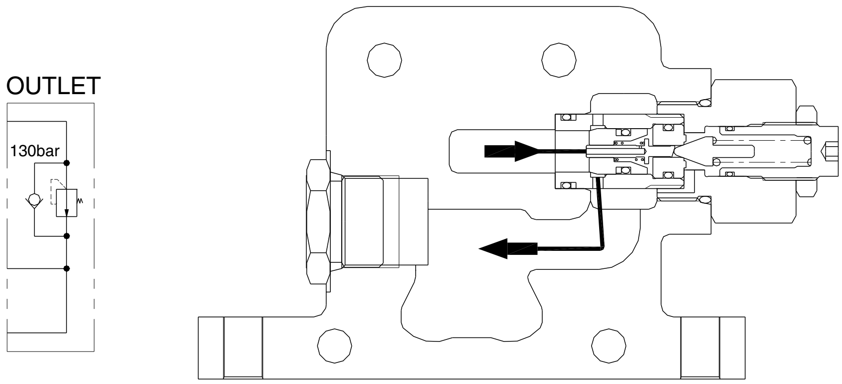
The outlet section contains the tank port and the secondary relief valve(with built-in anti-cavitation feature).



15BT9USM0618

(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.

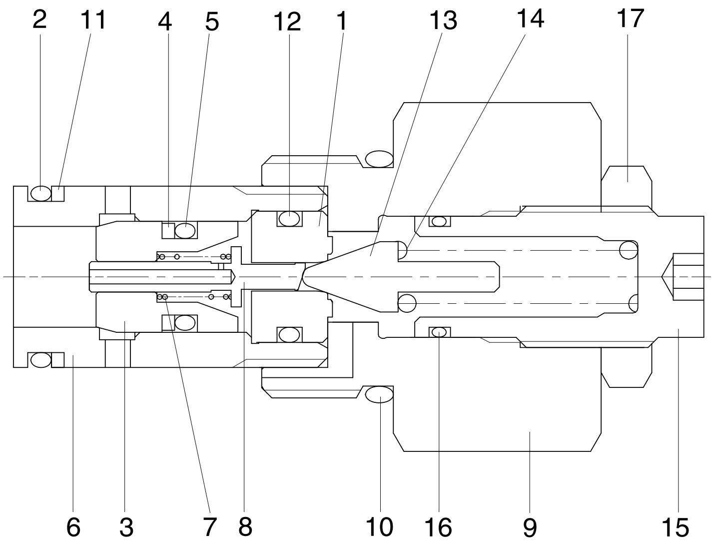


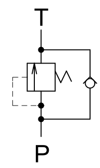
15BT9USM0619

8) 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 130kgf/cm^2 in accordance with 1 revolution of adjust bolt.





· Main relief valve : 190 kgf/cm^2

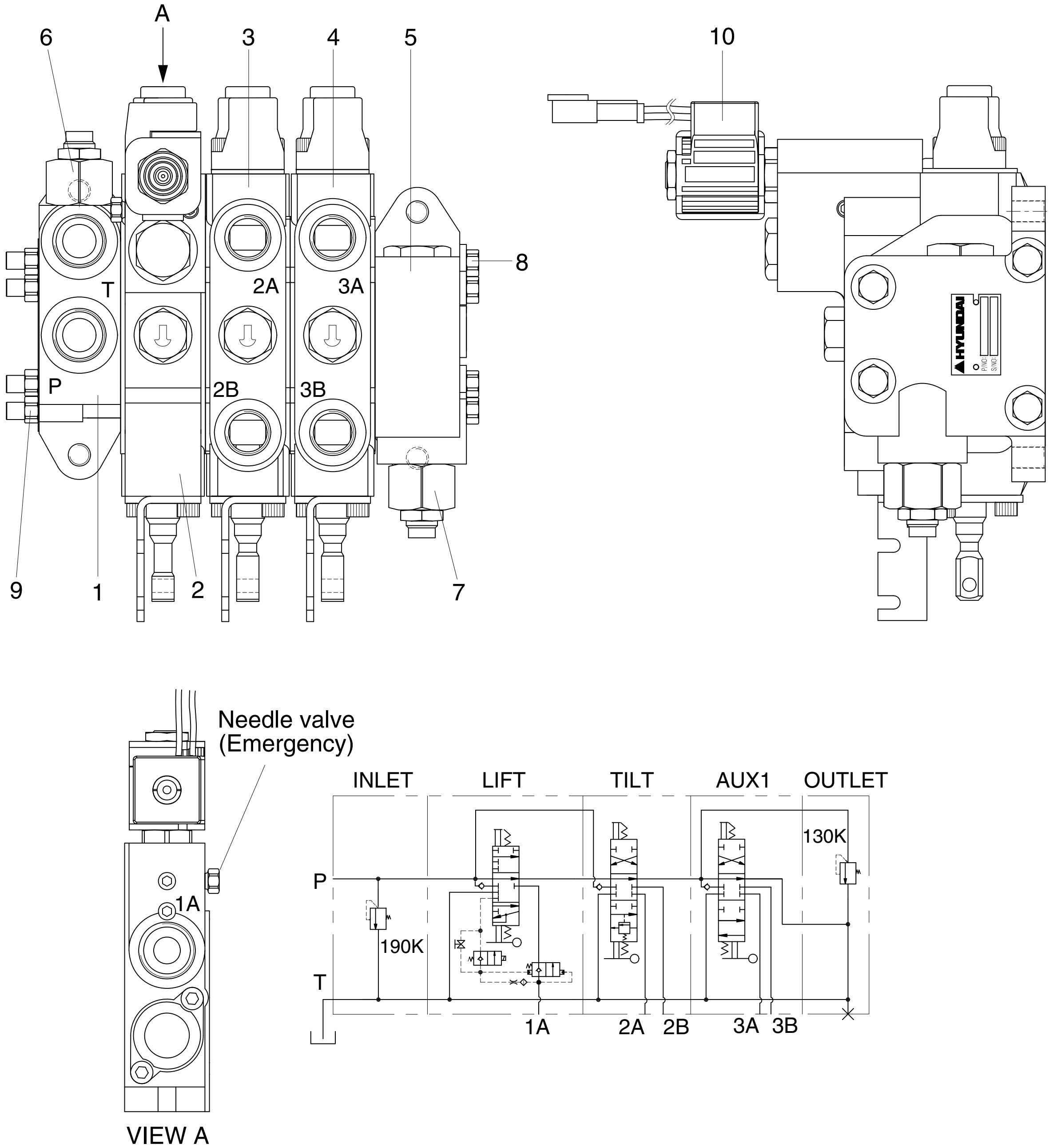
· Auxiliary relief valve : 130 kgf/cm^2
(For 3,4 spool only)

15BT9USM0620

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		

MAIN CONTROL VALVE (with OPSS)

1) STRUCTURE (3 Spool)

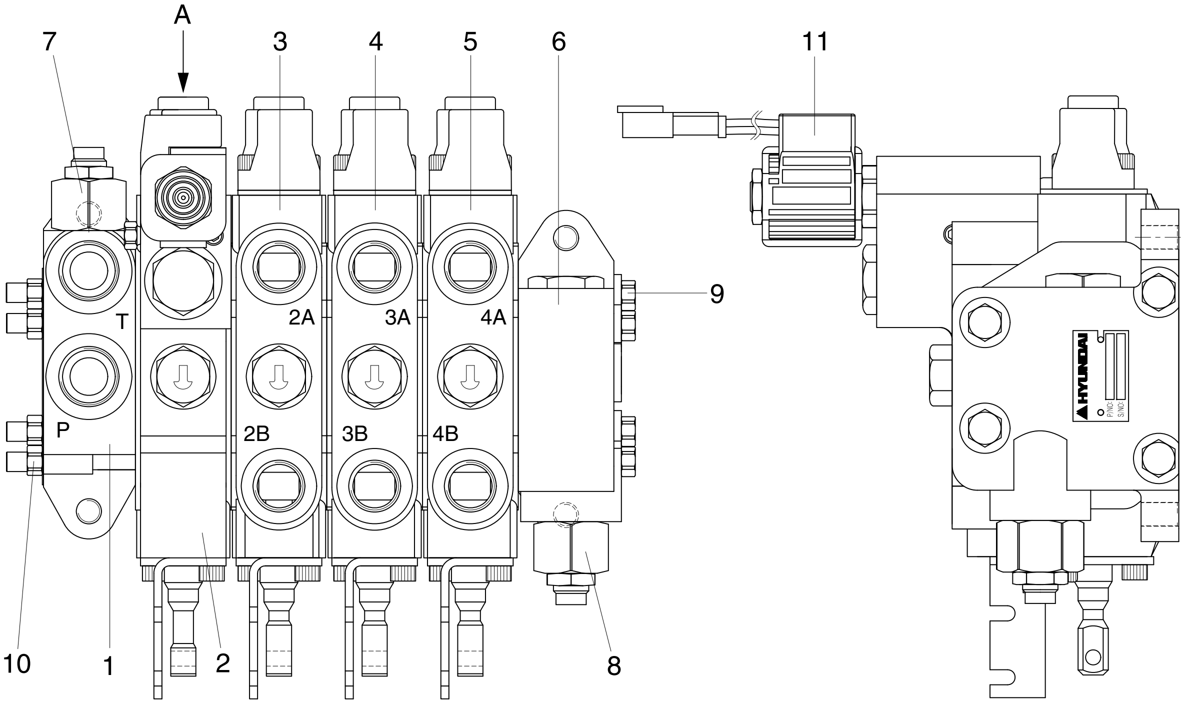


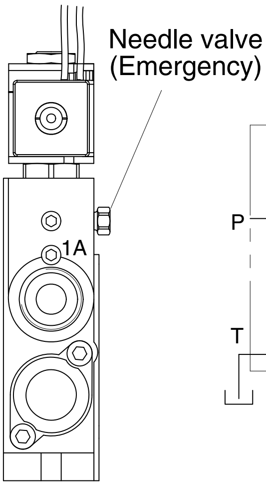
Port name	Size	Port
Inlet port	7/8-14UNF	P
Outlet port	7/8-14UNF	T
Work port	7/8-14UNF	1A
Work port	3/4-16UNF	2A, 2B, 3A, 3B

15BT9USM0621

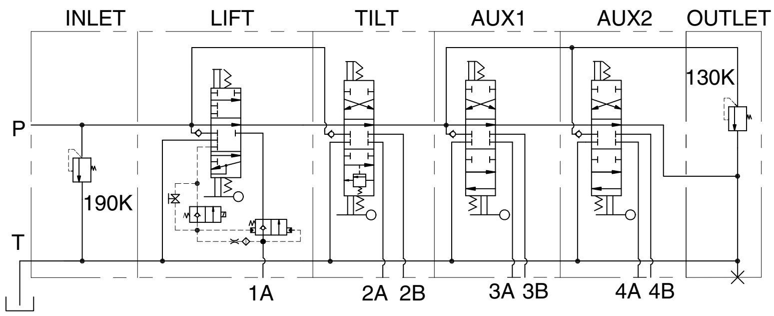
1 Inlet block assy
2 Lift block assy
3 Tilt block assy
4 Aux 1 block assy
5 Outlet block assy
6 Main relief valve assy
7 Auxiliary relief valve assy
8 Long bolt
9 Nut
10 Solenoid valve

2) 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

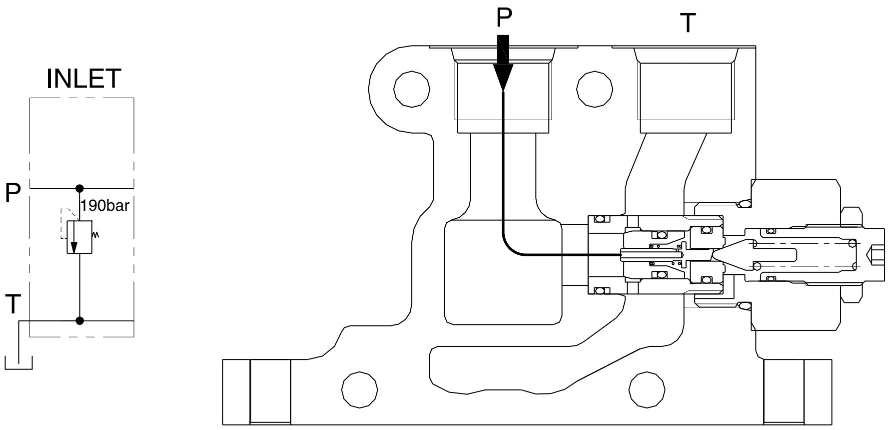
15BT9USM0622

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

3) INLET SECTION

(1) Operation

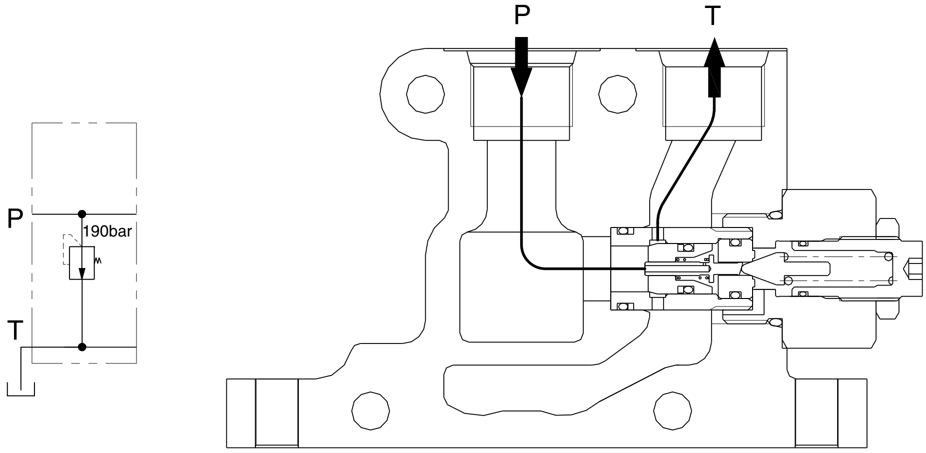
The inlet section contains the pump inlet connection and main relief valve.



15BT9USM0610

(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.



15BT9USM0611

4) LIFT SECTION

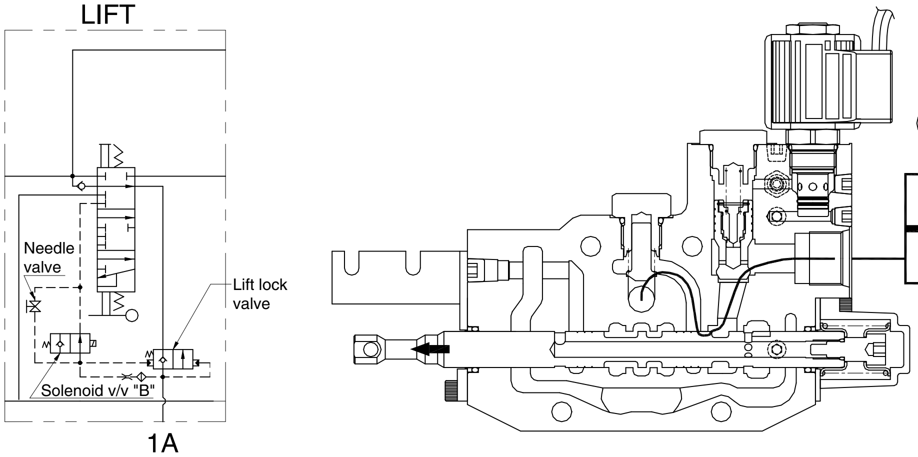
(1) Operation

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

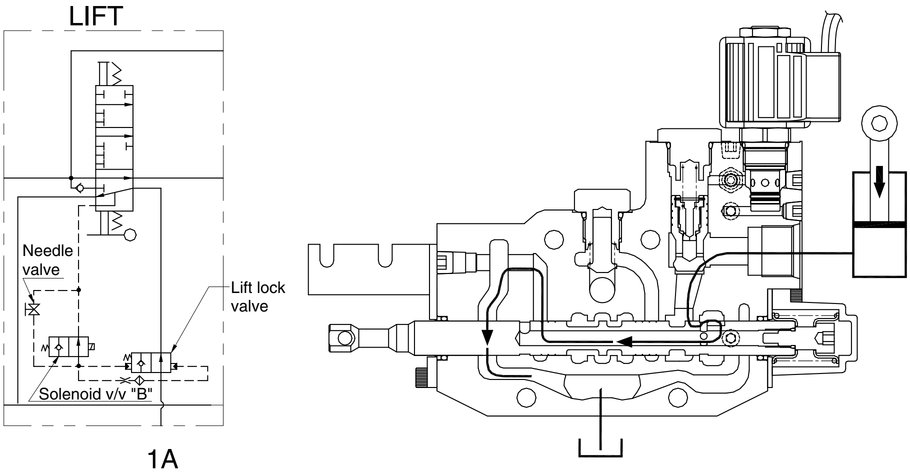
When the operator shifts the lever backwards, the spool is extended out of the valve, and this opens the internal fluid passages that lift the mast. Oil flows through the high pressure parallel cavity, past the load check valve, through the spool metering notches, past the lift lock check valve, and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



15BT9USM0623

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.



15BT9USM0624

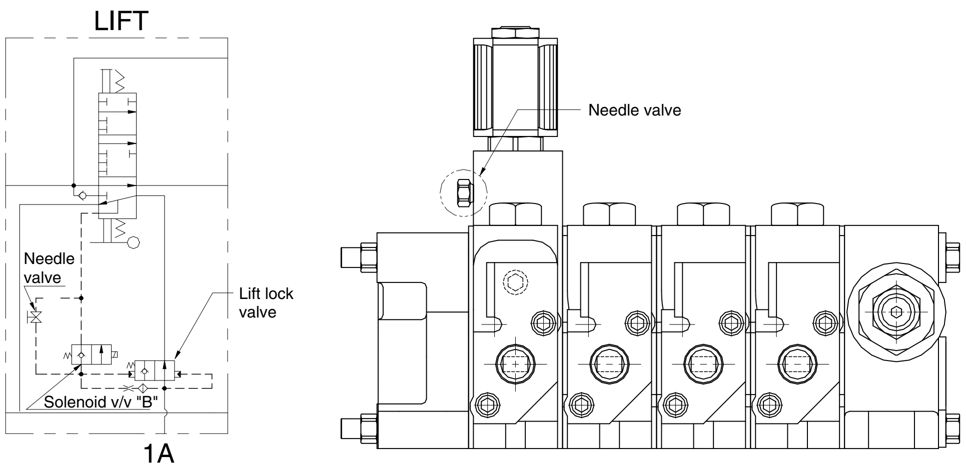
Pressure is limited by the main relief valve.

③ **Secondary lowering method** : A secondary lowering method is available in the event of the loss of battery power that is needed to energize the normally closed solenoid valve.

Important note : Before opening the secondary needle valve, make sure personnel and equipment are safely positioned to avoid accidents. Be careful to operate this secondary valve slowly, as heavy loads may be suspended.

A manual valve(needle valve) is located on the lift section, and it can be operated by opening the vehicle cowling and rotating the manual valve(needle valve) counterclockwise with a wrench.

Open the manual valve (needle valve) approximately 2 turn (do not rotate more than 3 turns). Then shift the lift spool slowly for controlled lowering. This should be just enough for slow, controlled movement of the mast.



15BT9USM0625

Pressure is limited by the main relief valve.

5) TILT SECTION

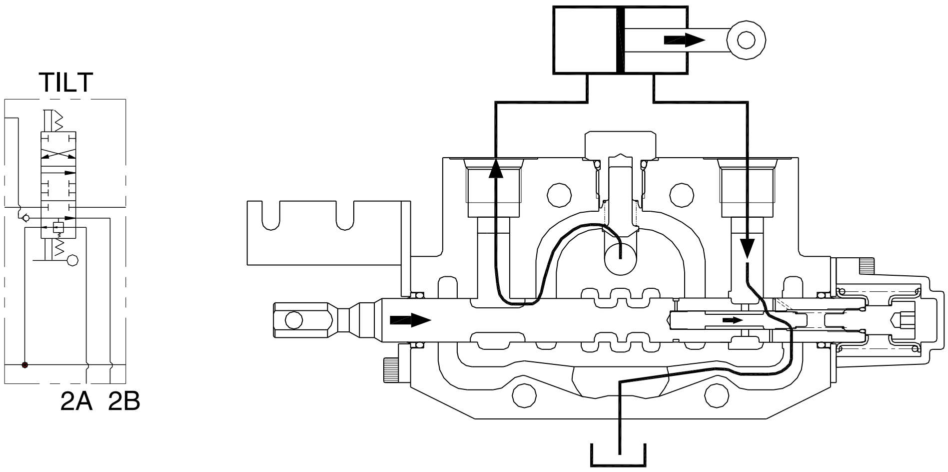
(1) Operation

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.

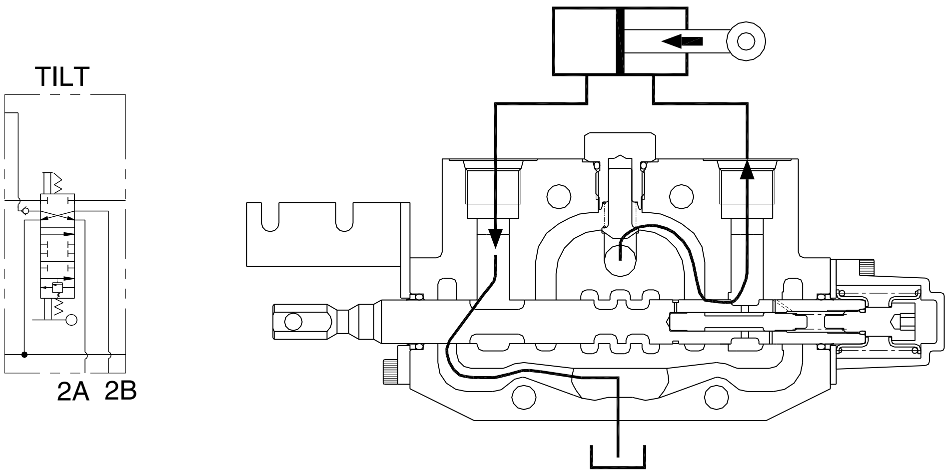
Simultaneously, the high pressure acts upon the end of the tilt lock plunger to move it towards the spring end of the spool. This plunger movement opens additional spool metering notches which control oil flow from the rod end of the cylinder to the tank return line.



15BT9USM0614

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.



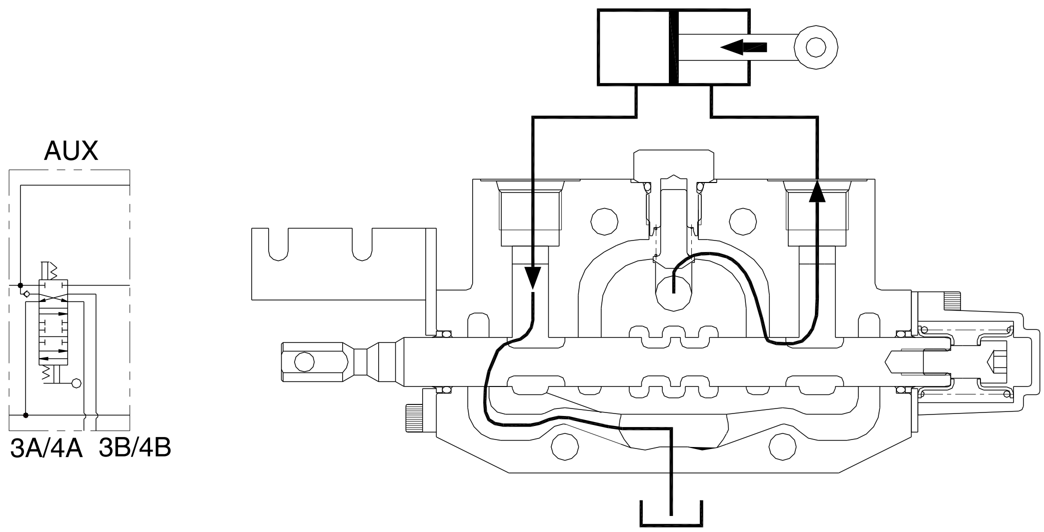
15BT9USM0615

Pressure is limited by the main relief valve.

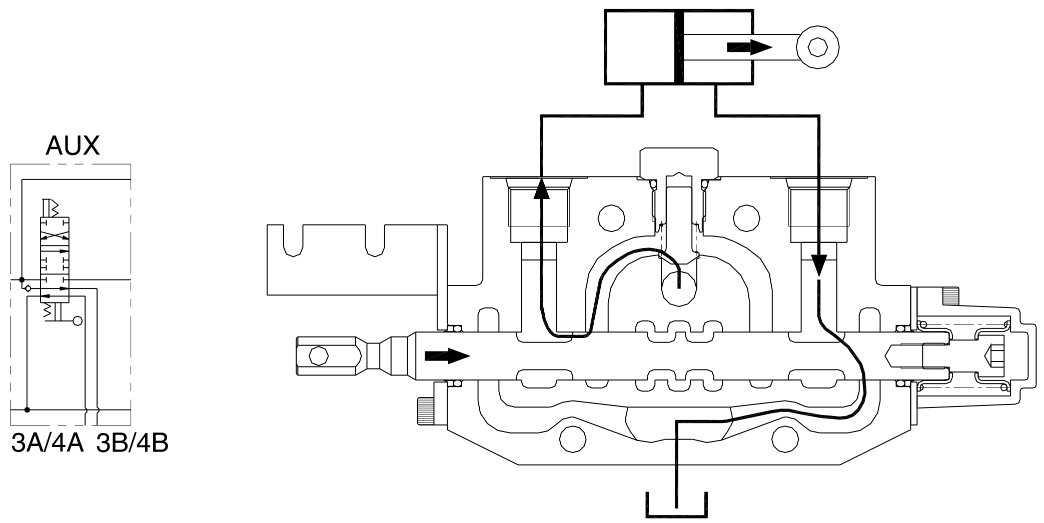
6) AUXILIARY SECTIONS

(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.



15BT9USM0616



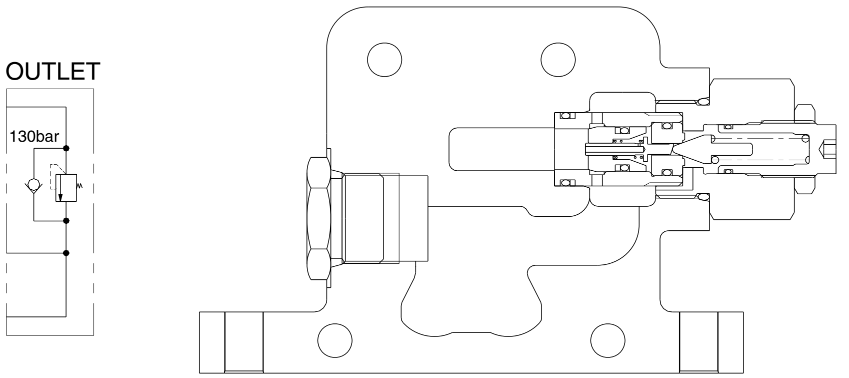
15BT9USM0617

Pressure is limited by the secondary main relief valve.

7) OUTLET SECTION

(1) Operation

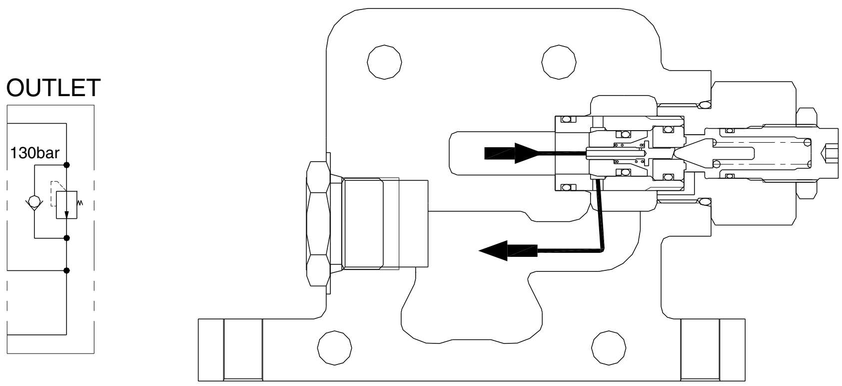
The outlet section contains the tank port and the secondary relief valve(with built-in anti-cavitation feature).



15BT9USM0618

(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.

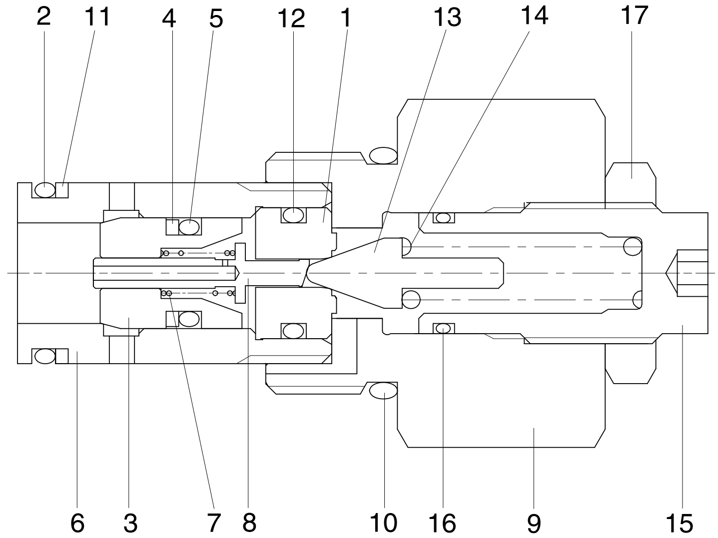


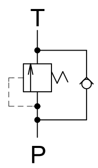
15BT9USM0619

8) 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 130kgf/cm^2 in accordance with 1 revolution of adjust bolt.





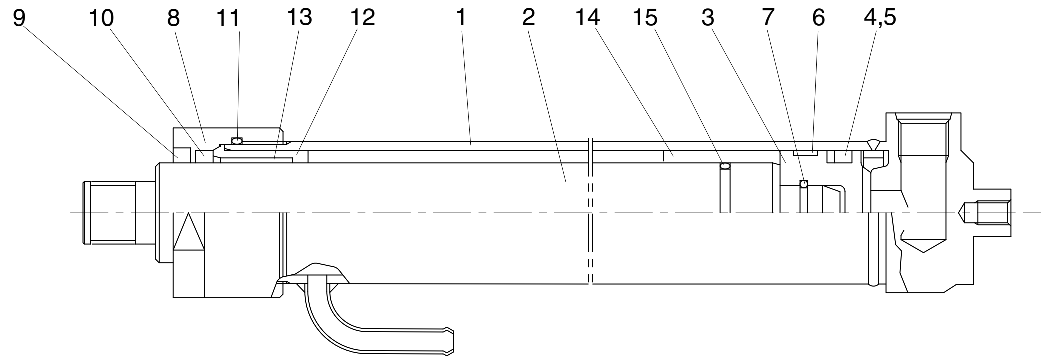
· Main relief valve : 190 kgf/cm^2

· Auxiliary relief valve : 130 kgf/cm^2
(For 3,4 spool only)

15BT9USM0620

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

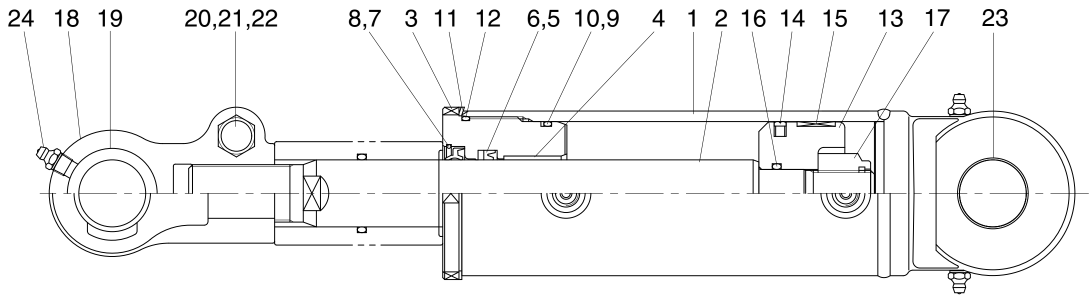
4. LIFT CYLINDER



15BT9USM0626

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

5. TILT CYLINDER



15BT9USM0627

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

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

1) CHECK ITEM

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

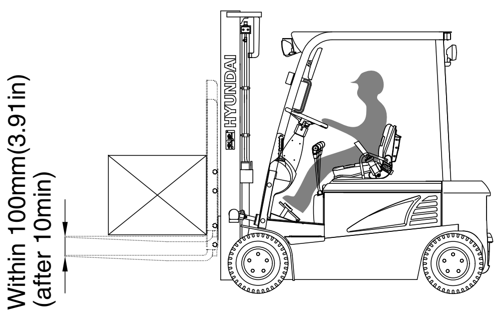
(2) Set mast vertical and raise 1m from ground. Wait for 10 minutes and measure hydraulic drift(amount forks move down and amount mast tilts forward).

· Check condition

- Hydraulic oil : Normal operating temp (50˚C)
- Mast substantially vertical.
- Rated capacity load.

· Hydraulic drift

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



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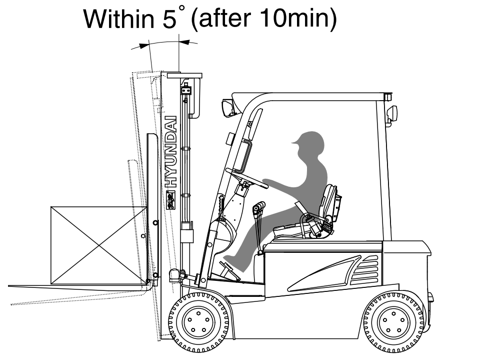


15BT9USM0629

(3) If the hydraulic drift is more than the specified value, replace the control valve or cylinder packing.
Check that clearance between tilt cylinder bushing and mounting pin is within standard range.

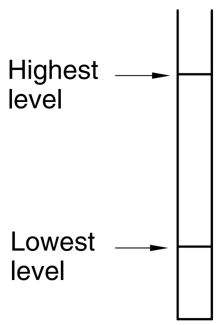
mm (in)

Standard	Under 0.6 (0.02)

2) HYDRAULIC OIL

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

(2) When changing hydraulic oil, clean suction strainer(screwed into outlet port pipe) and line filter(screwed into inlet pipe). Line filter uses paper element, so replace periodically(every 6 months or 1000 hours)



15BT9USM0630

3) CONTROL VALVE

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

2. TROUBLE SHOOTING

1) SYSTEM

Problem	Cause	Remedy
Large fork lowering speed	· Seal inside control valve defective. · Oil leaks from joint or hose. · Seal inside cylinder defective.	· Replace spool or valve body. · Replace. · Replace packing.
Large spontaneous tilt of mast	· Tilting backward : Check valve defective. · Tilting forward : tilt lock valve defective. · Oil leaks from joint or hose. · Seal inside cylinder defective.	· Clean or replace. · Clean or replace. · Replace. · Replace seal.
Slow fork lifting or slow mast tilting	· Lack of hydraulic oil. · Hydraulic oil mixed with air. · Oil leaks from joint or hose. · Excessive restriction of oil flow on pump suction side. · Relief valve fails to keep specified pressure. · Poor sealing inside cylinder. · High hydraulic oil viscosity. · Mast fails to move smoothly. · Oil leaks from lift control valve spool. · Oil leaks from tilt control valve spool.	· Add oil. · Bleed air. · Replace. · Clean filter. · Adjust relief valve. · Replace packing. · Change to ISO VG46. · 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 ISO VG46. · 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. (Refer to 6-14 page)
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

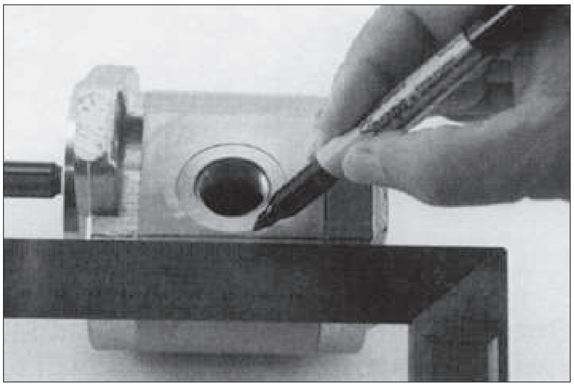
- · Metric socket set
- · Internal snap ring pliers
- · Shaft seal sleeve
- · Torque wrench

(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.

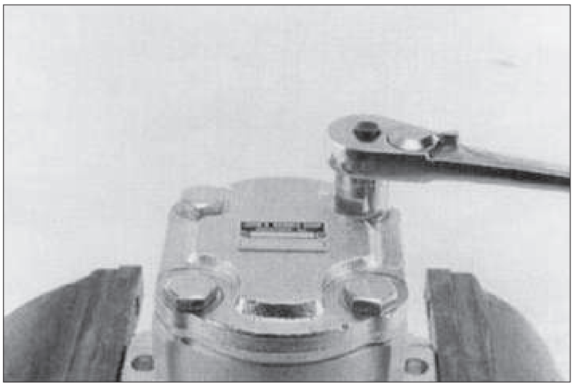


PUMP 01

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

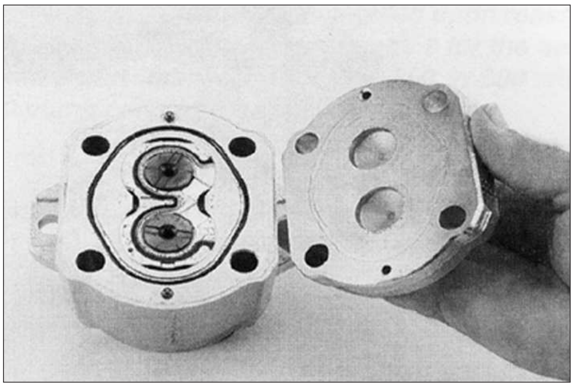
(6) Loosen the four metric hexagon head bolts.

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



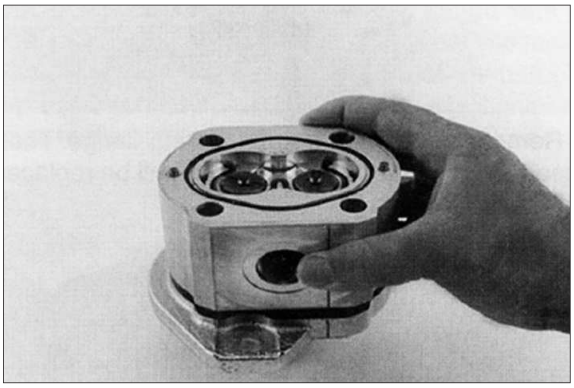
PUMP 02

(8) Lift and remove end cover.



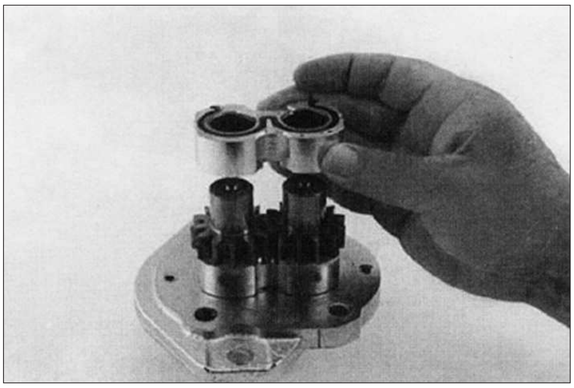
PUMP 03

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



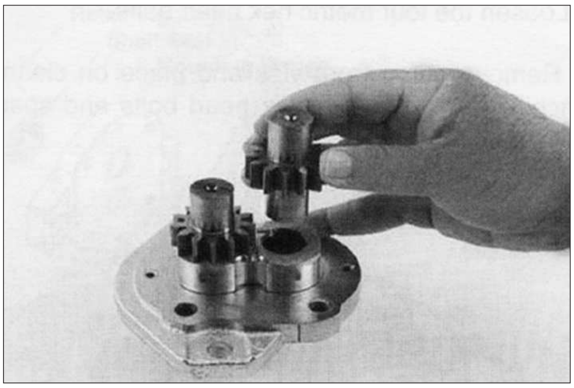
PUMP 04

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



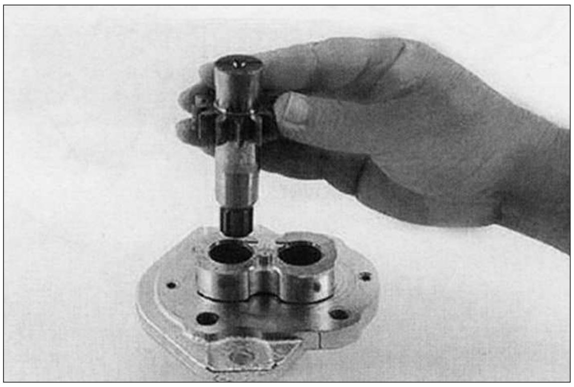
PUMP 05

(11) Remove idler shaft from bearing block.



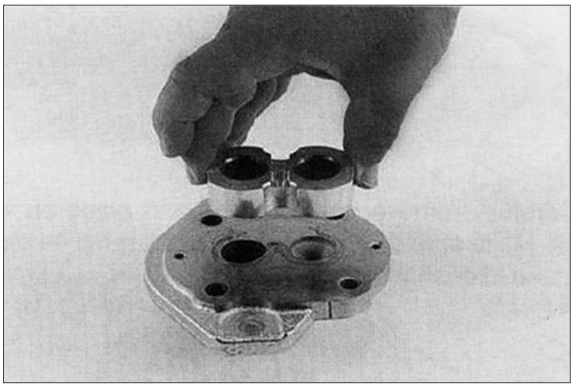
PUMP 06

(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.



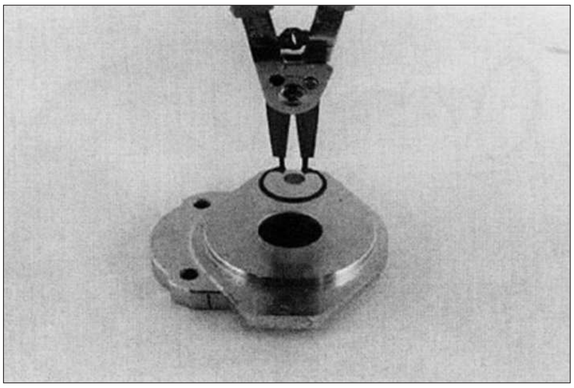
PUMP 07

(13) Remove the front bearing block.



PUMP 08

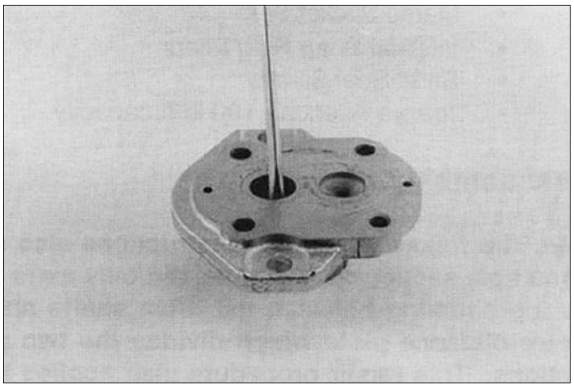
(14) Turn mounting flange over, with shaft seal up, and remove the retaining ring with proper snap ring pliers.



PUMP 09

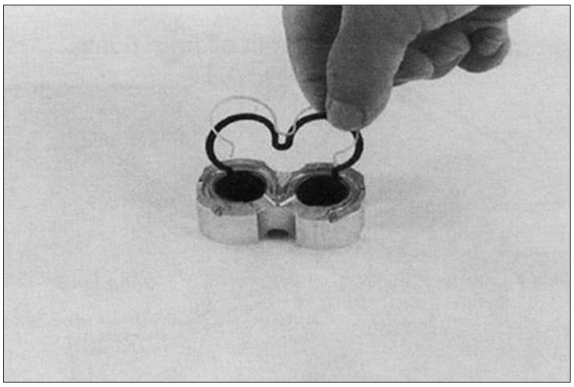
(15) Remove the oil seal from mounting flange, be careful not to mar or scratch the seal bore.

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



PUMP 10

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



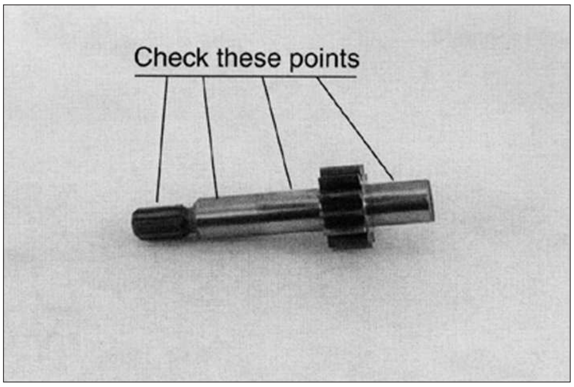
PUMP 11

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.

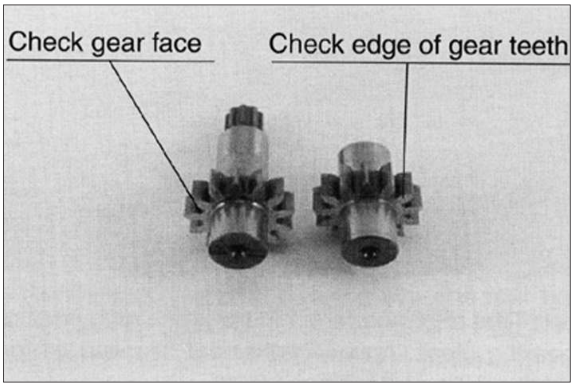
(2) Check drive shaft spline for twisted or broken teeth, check keyed drive shaft for broken or chipped keyway. No marks or grooves on shaft in seal area, some discoloration of shaft is allowable.

(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

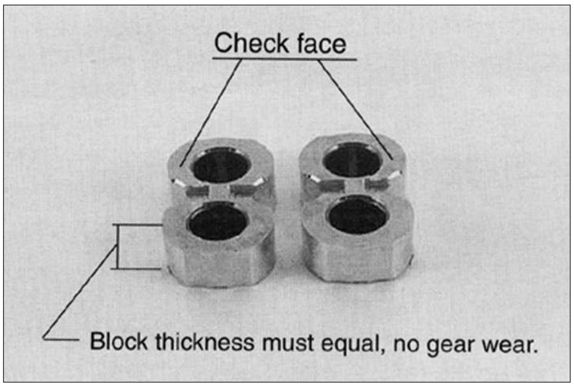
(5) Inspect bearing blocks for excessive wear or scoring on the surfaces which are in contact with the gears. Also inspect the bearings for excessive wear or scoring.

(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.

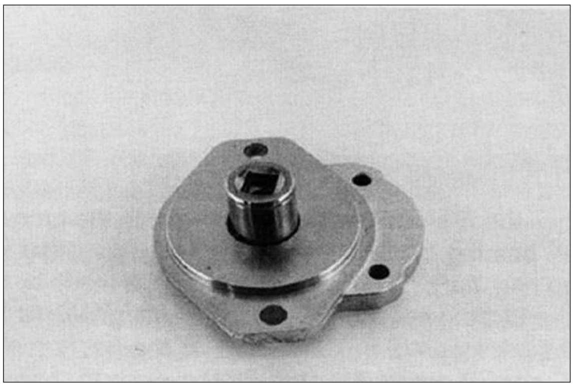


PUMP 14

3) ASSEMBLY

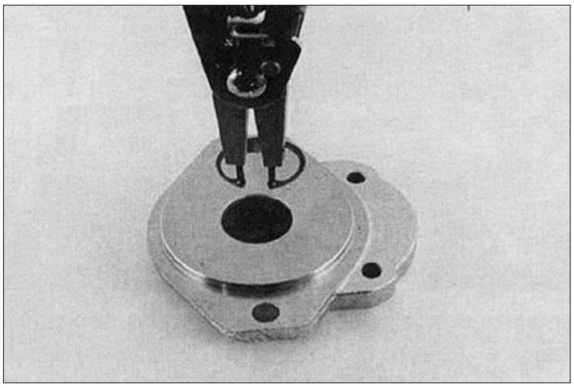
※ **New seals should be installed upon reassembly of pump.**

(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.



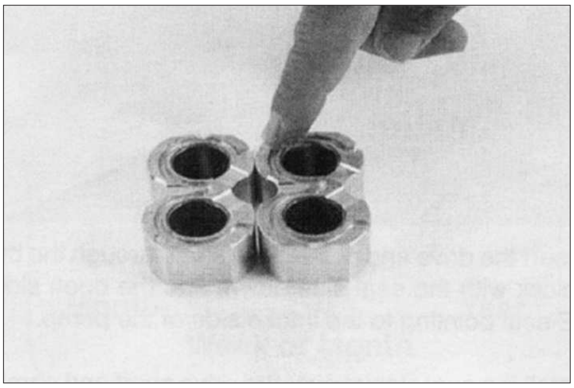
PUMP 15

(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.

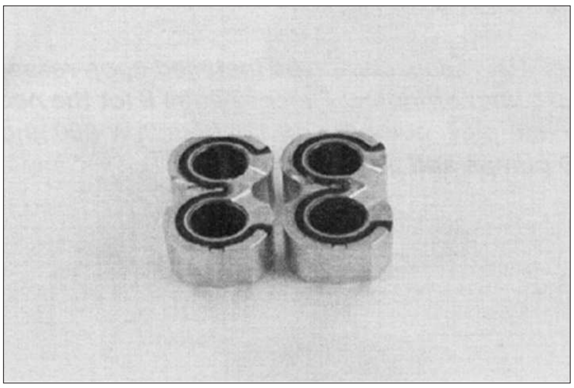


PUMP 17

(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.

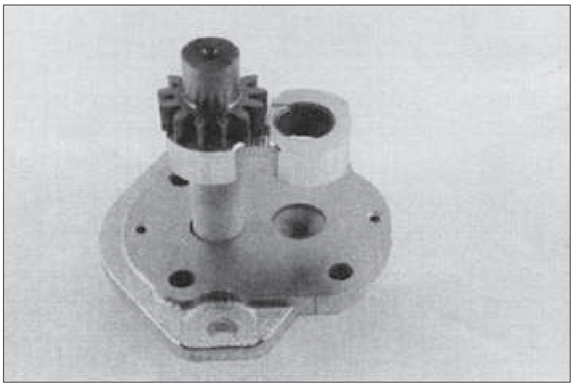
(6) Apply a light coating of petroleum jelly to the exposed face of the front bearing block.



PUMP 18

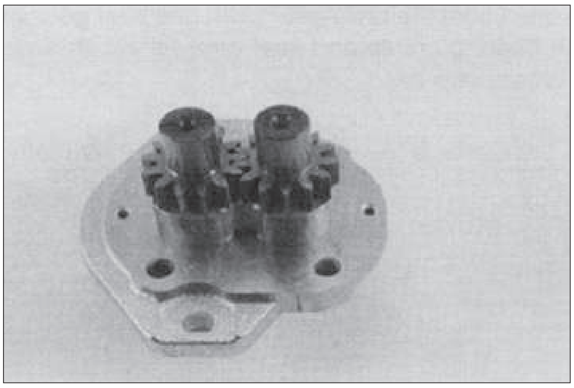
(7) Insert the drive end of the drive shaft through the bearing block with the seal side down, and the open side of the E-seal pointing to the intake side of the pump.

(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

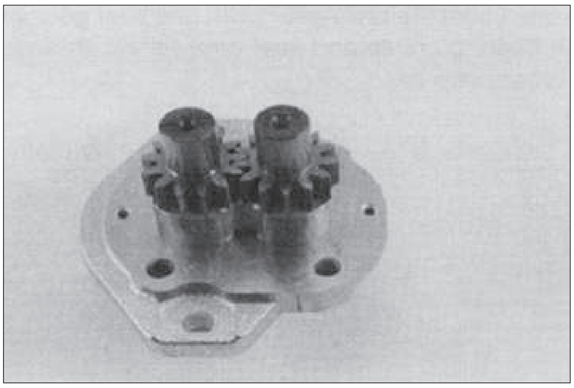
(9) Install the idler gear shaft in the remaining position in the bearing block. Apply a light coat of clean oil to the face of the drive and idler gears.



PUMP 20

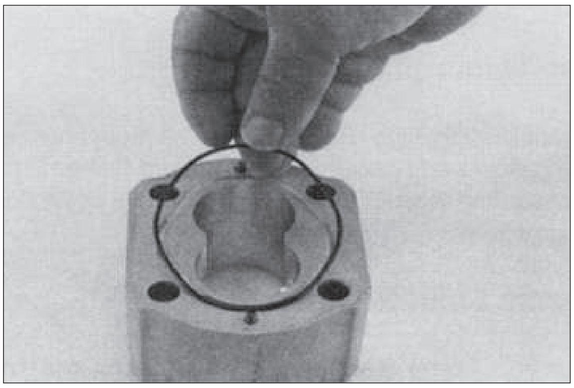
(10) Pick up the rear bearing block, with seal side up and with open end of the E-seal facing the intake side of the pump, place over the drive and idler gear shafts.

(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.



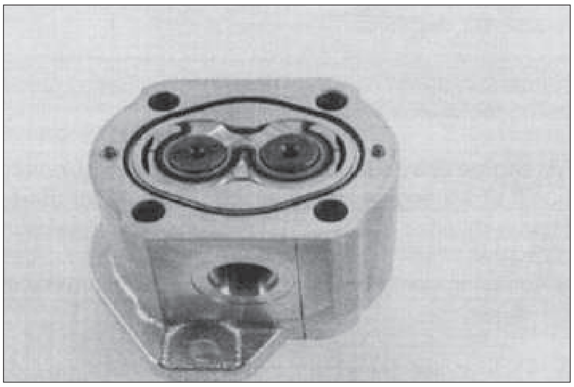
PUMP 21

(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

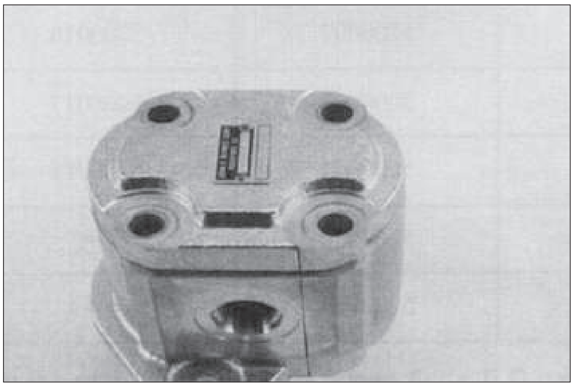
(13) Gently slide the gear housing over the rear bearing block assembly, slide housing down until the housing engages the dowel pins. Press firmly in place with hands, do not force or use any tool.
Check to make sure the intake port in the housing in on the same side as the open end of the E-seal and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



PUMP 23

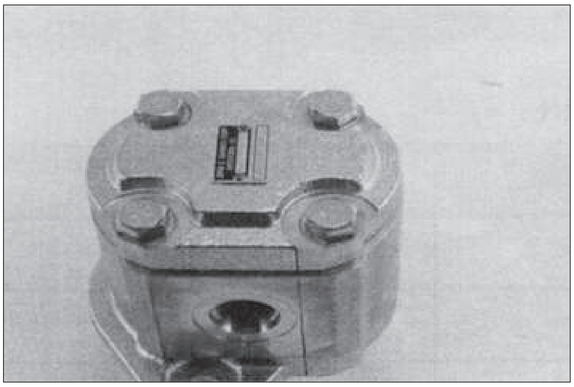
(14) The surface of the rear bearing block should be slightly below the face of the gear housing. If the bearing block sits higher then the rear face of the gear housing then the E-seal or O-ring have shifted out of the groove. If this is the case, remove the gear housing and check for proper seal installation.

(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.



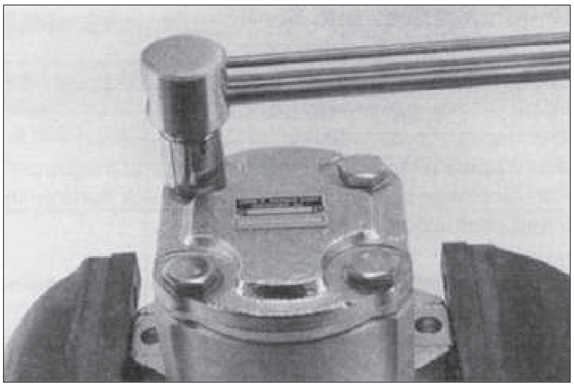
PUMP 25

(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

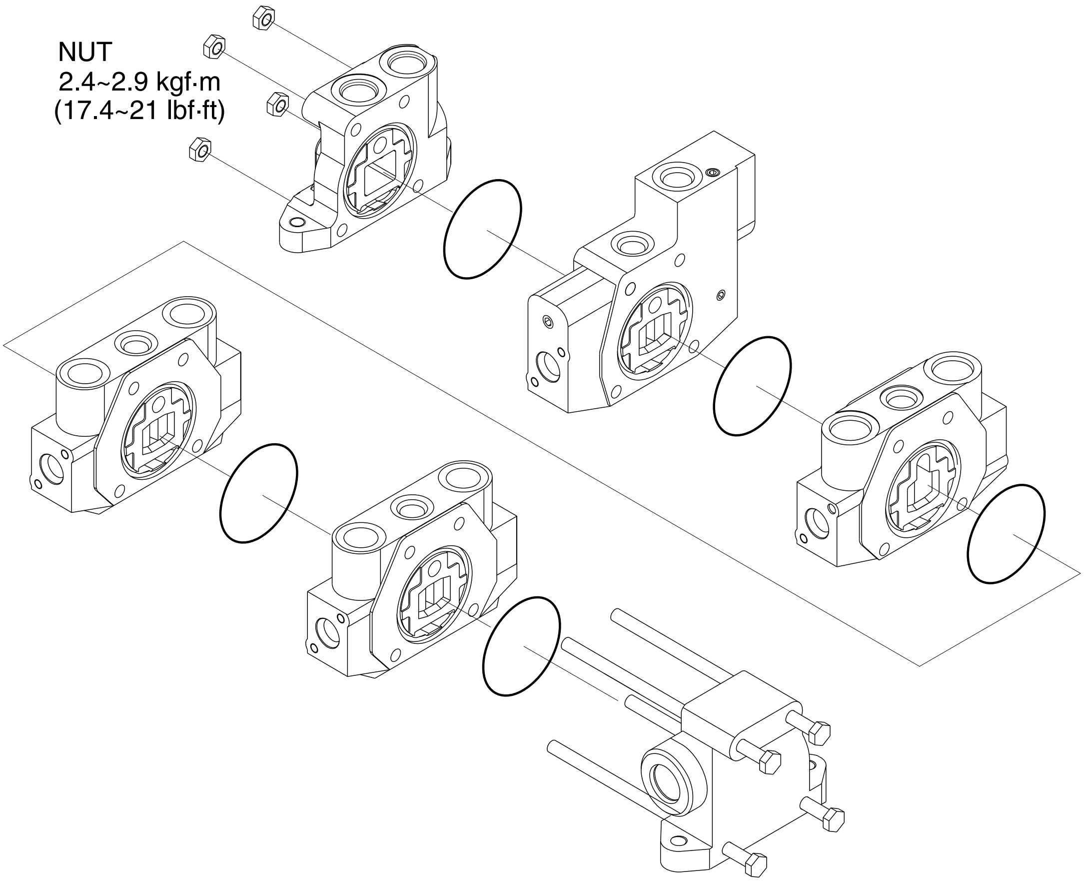
2. MAIN CONTROL VALVE (Manual type with OPSS)

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 Additional auxiliary valve sections may be added to the main control valve in a similar manner as indicated below.

(2) Block sub assembly



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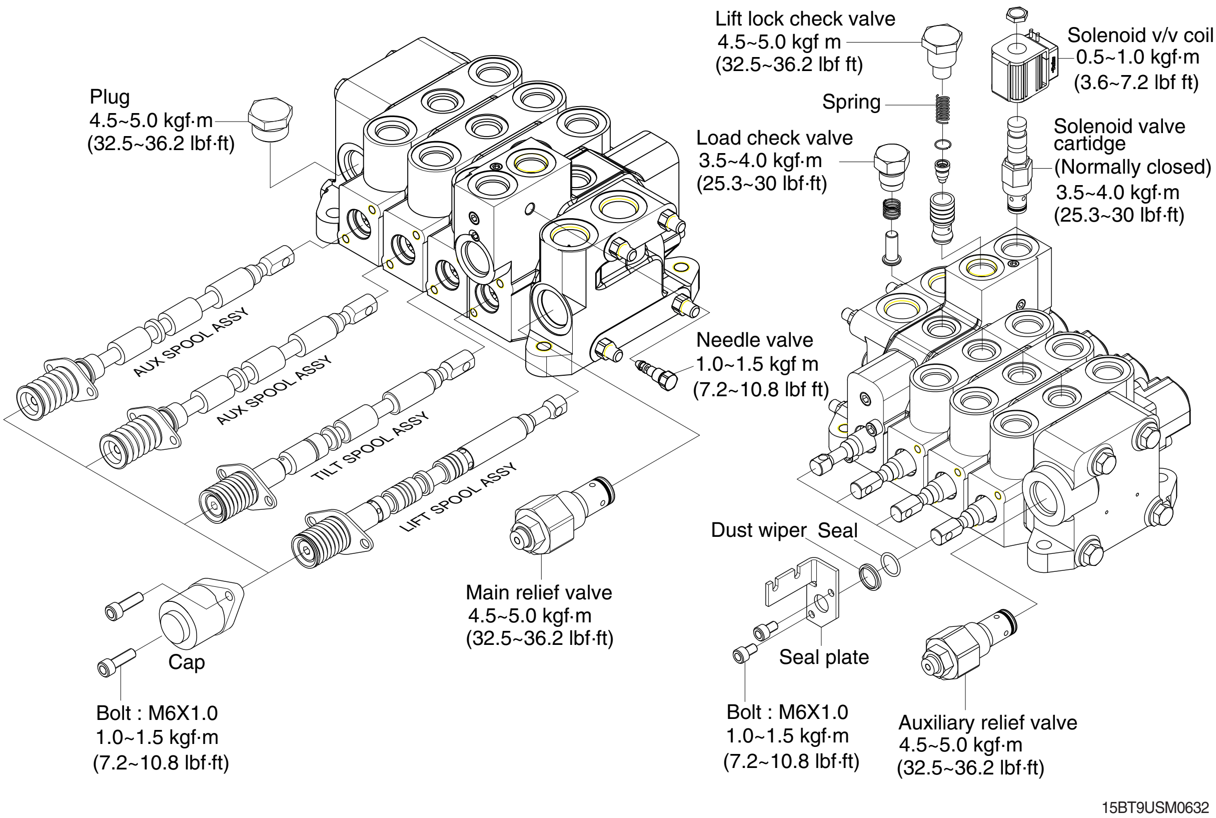
① Attach all the O-rings to the appropriate grooves between the spool sections.
② Stack the valve sections such that all the work ports are facing up, the spool ends are all in the same direction, and they are resting on a flat(within 0.2㎜), uniform surface.
③ Insert all the tie rods through the drilled 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 2.4~2.9kgf · m(17.4~21lbf · 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 4.5~5.0kgf · m(32.5~36.2lbf · ft).

② Install the plug assembly in the tank port of the inlet section. Torque to 4.5~5.0kgf · m (32.5~36.2lbf · 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 1.0~1.5kgf · m (7.2~10.8lbf · ft) is reached on both bolts.

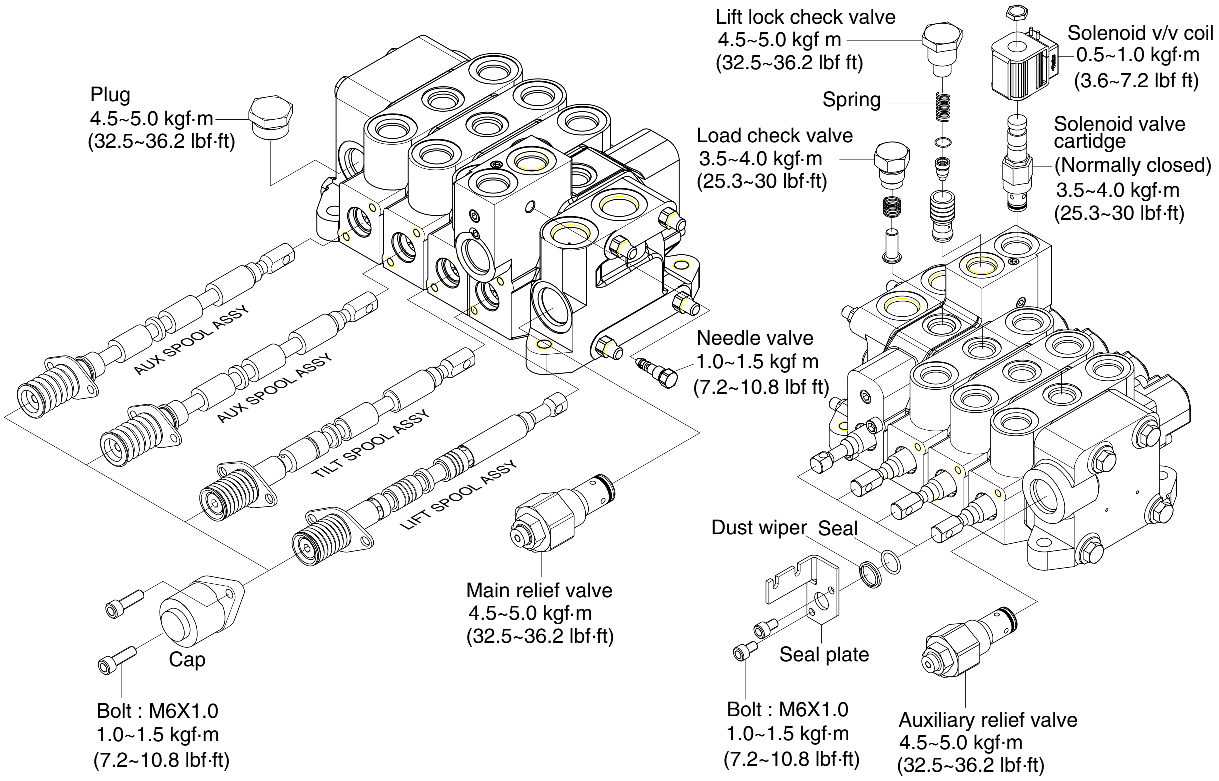
③ Install the second spool seal and dust wiper over the clevis end of the spool and retain with a seal plate and two bolts. Torque both bolts alternatively until a torque of 1.0~1.5kgf · m(7.2~10.8lbf · ft) is reached on both bolts.

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

⑤ The normally closed solenoid is installed in the rightmost cavity on the top of the section. Torque to 3.5~4.0kgf · m (25.3~30lbf · ft)

⑥ Install the lift lock check valve assembly in the remaining open cavity in the top of the housing. Torque to 4.5~5.0kgf · m(32.5~36.2lbf · ft)

⑦ Install the needle valve subassembly in the cavity on the inlet-facing surface of the housing. Torque to 1.0~1.5kgf · m (7.2~10.8lbf · 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.

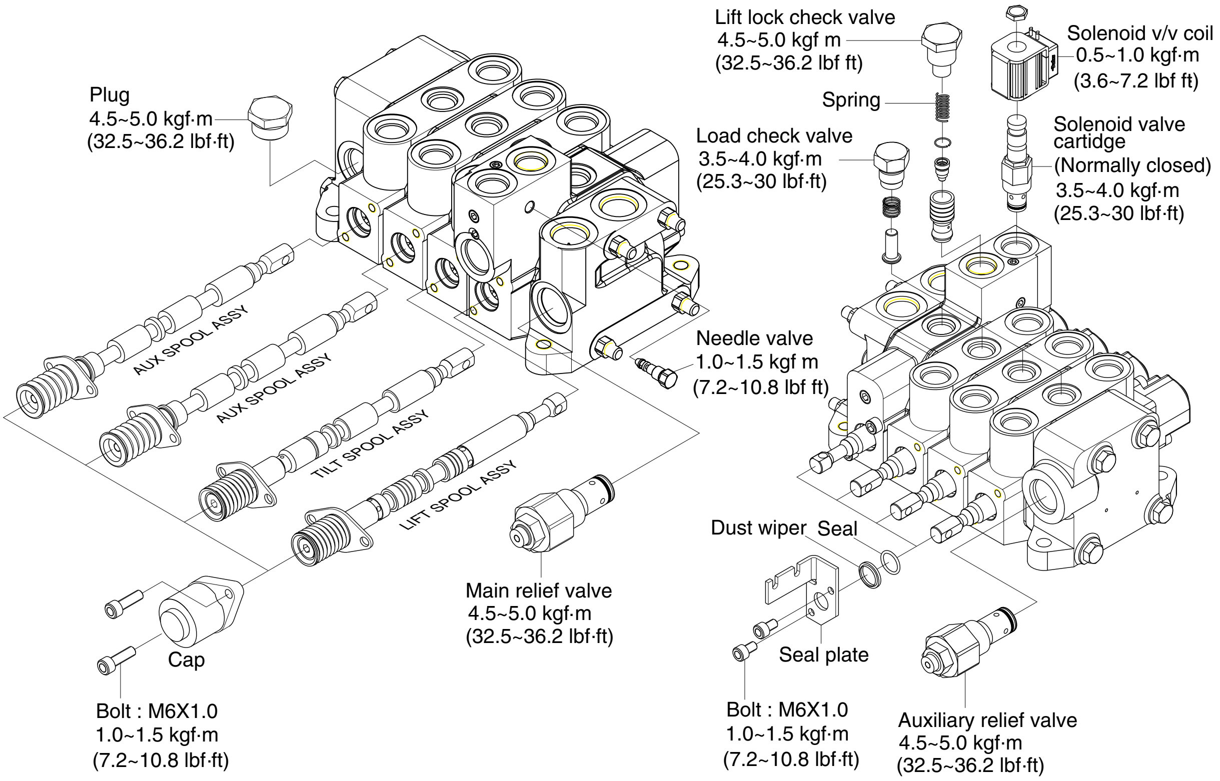
② Insert the clevis end of the spool into the right-hand side of the spool bore(the tallest end of the housing). Place the spool cap over the spool and spring assembly and connect the cap to the housing using two bolts. Torque both bolts alternatively until a torque of 1.0~1.5kgf · m (7.2~10.8lbf · ft)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

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

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



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(6) 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 1.0~1.5kgf · m (7.2~10.8lbf · 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 1.0~1.5kgf · m(7.2~10.8lbf · 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) Outlet section

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

2) DISASSEMBLY

(1) General

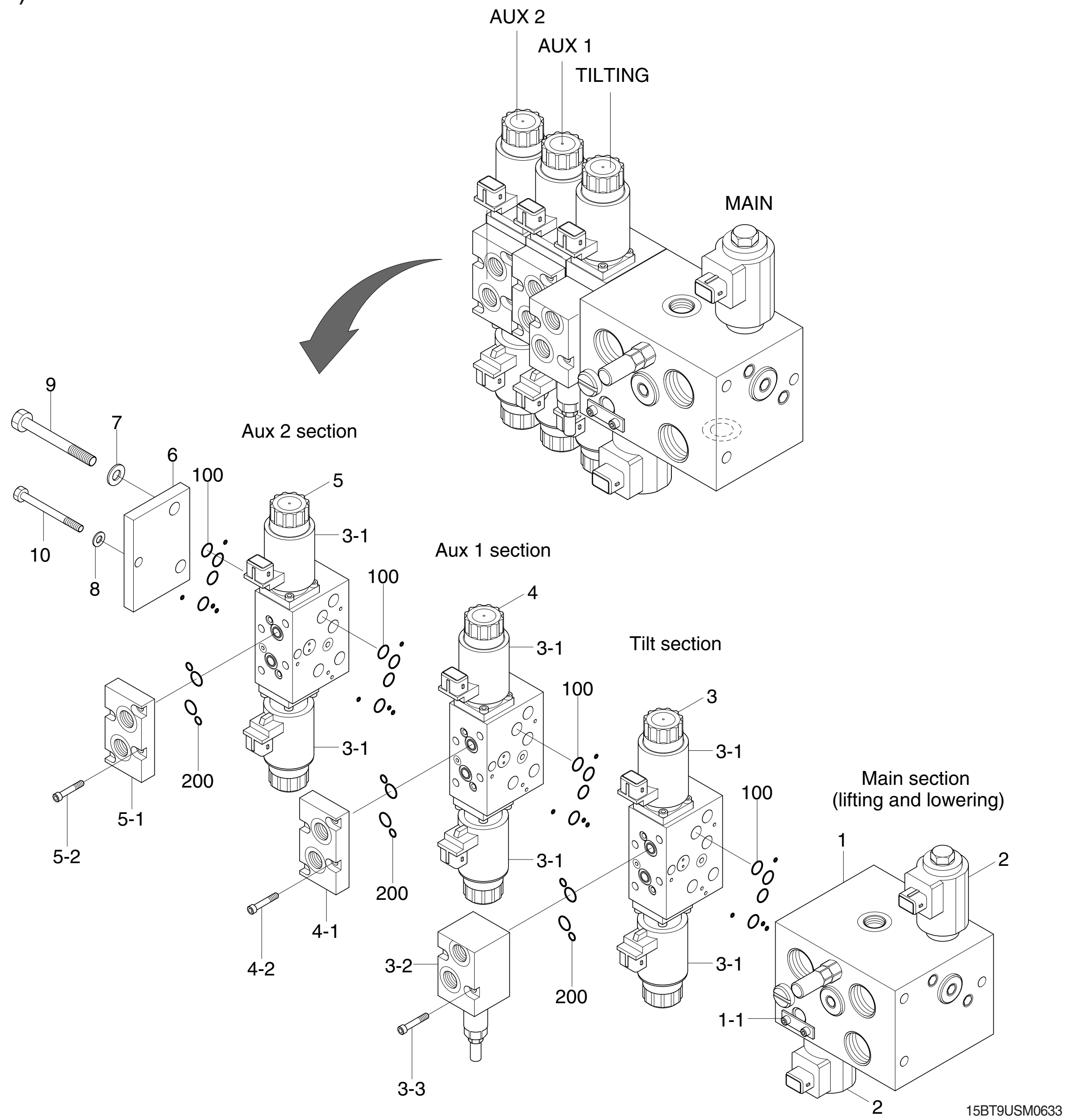
① Subassemblies (such as relief valves, check valves, and spools) may be removed without having to loosen the tie rods and disassembling the entire valve.
② Disassemble the valve sections on a flat working surface.
③ Ensure that the disassembly area will be clean and free of contamination.
④ Keep the 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. MAIN CONTROL VALVE (FINGERTIP, OPT)

1) STRUCTURE

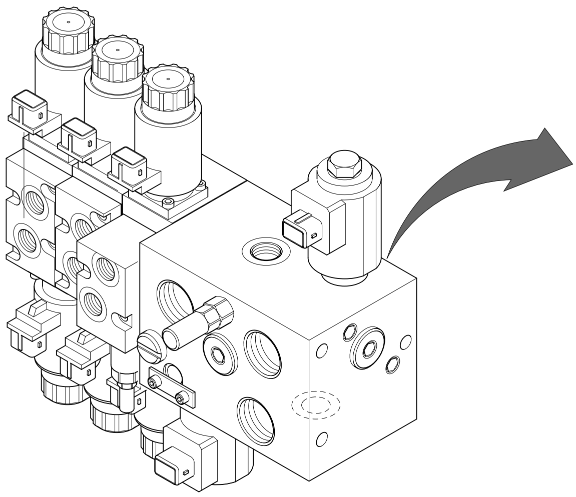


※ Tightening torque

- Item (3-3, 4-2, 5-2) : 0.61 kgf·m (4.4 lbf.ft)
- Item (9) : 2.3 kgf·m (17.0 lbf.ft)
- Item (10) : 0.97 kgf·m (7.0 lbf.ft)

1	Main block	4-1	Ancillary block	8	Washer
2	Solenoid valve (lift)	4-2	Socket head screw	9	Socket head screw
3	Solenoid valve (tilt)	5	Solenoid valve (auxiliary 2)	10	Socket head screw
3-1	Coil amp	5-1	Ancillary block	100	Section seal kit
3-2	Block	5-2	Socket head screw	200	Ancillary block
3-3	Socket head screw	6	End plate		
4	Solenoid valve (auxiliary 1)	7	Washer		

2) MAIN SECTION



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※ Flow rate : 80 lpm

※ Maximum pressure : 250 bar

※ Setting pressure : 190 bar

(1) Lifting and lowering valve

① Main section

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※ When it can't control lifting & lowering, need to check EMP valve. Because of contamination material EMP valve often can't operate properly that means valve poppet and seat opened.

② EMP solenoid valve

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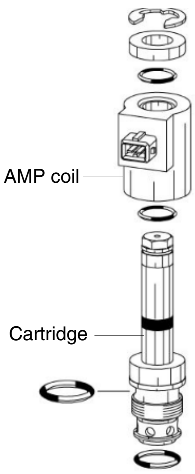
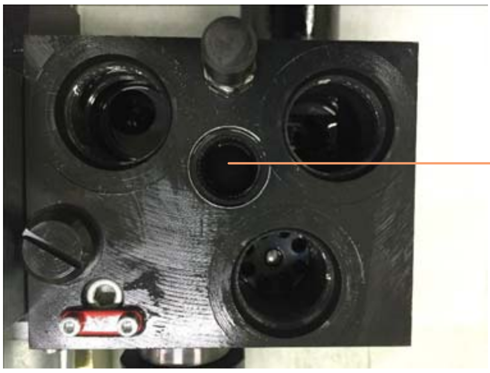
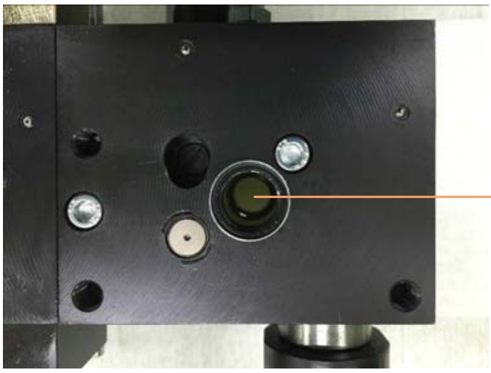
※ Tightening torque
6.1 kgf·m (44.3 lbf·ft)

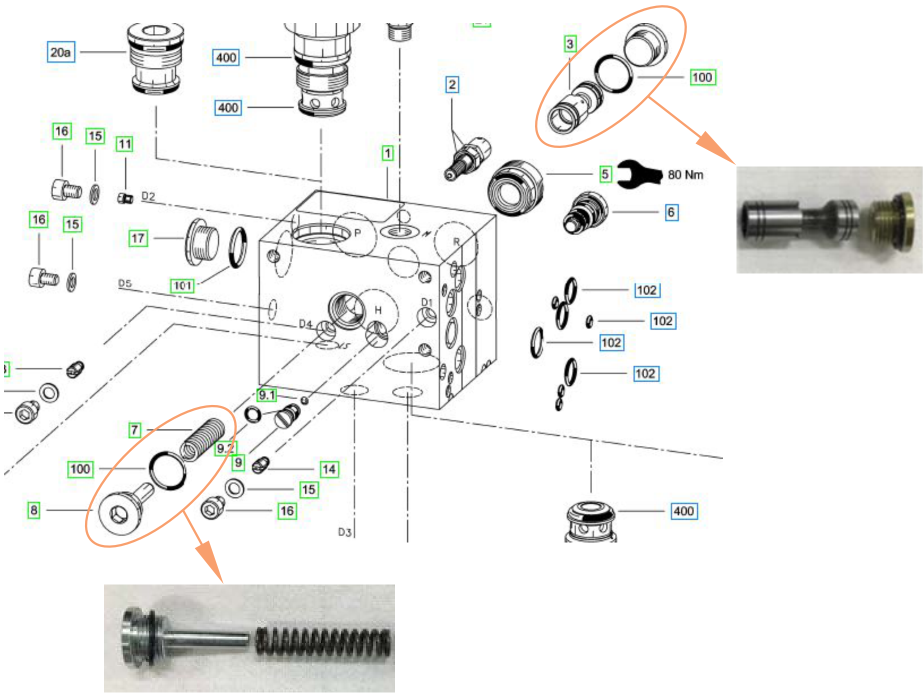


(2) 3-way controller





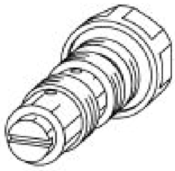
※ During unloading, supplied oil by the pump return to tank keeping 9 bar of system pressure.

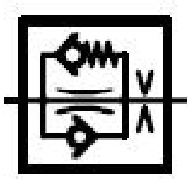


(3) S damping screw

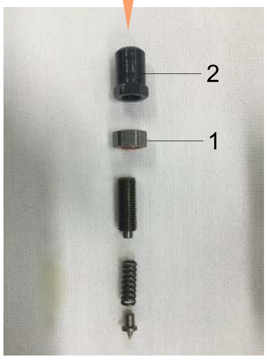
※ S damping
Integrated combination of orifice, check valve, pre-load valve (approx. 25 bar).

※ Tightening torque
1.02 kgf·m (7.4 lbf·ft)

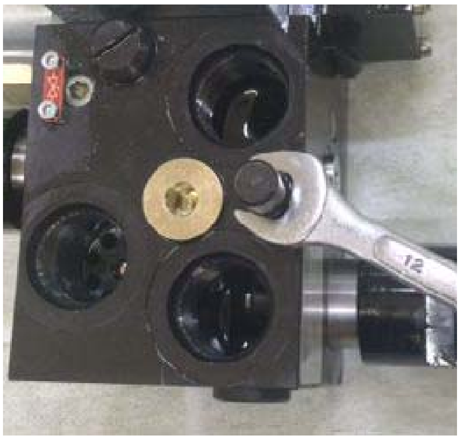




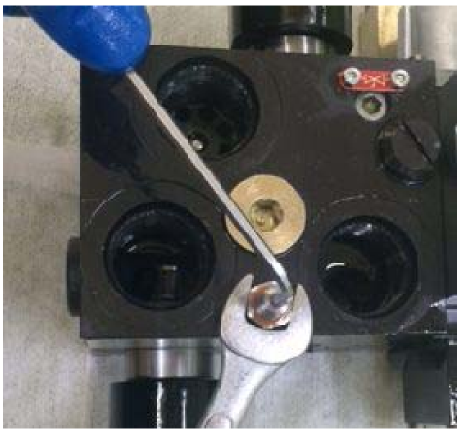
(4) Pressure relief valve



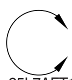
※ Relief valve
Control the main system pressure.



※ Use with a 12 mm spanner.
※ Tightening torque (1)
1.43 kgf·m (10.3 lbf·ft)



※ Use with a 3 mm wrench.
※ Tightening torque (2)
1.43 kgf·m (10.3 lbf·ft)

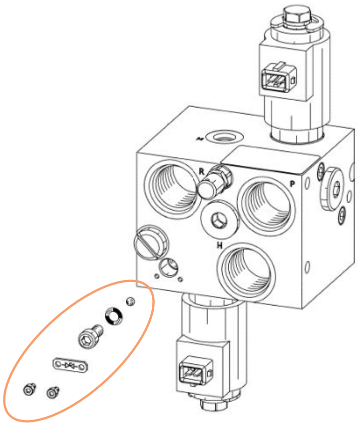

= Pressure increases
= Pressure decreases

25L7AFT13

※ Rotating clockwise to increase setting pressure with a wrench.
※ 80 bar increase and decrease per 1 turn.

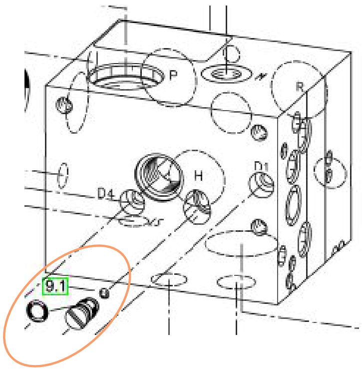
(5) Emergency lowering valve and shuttle valve

① Emergency lowering valve



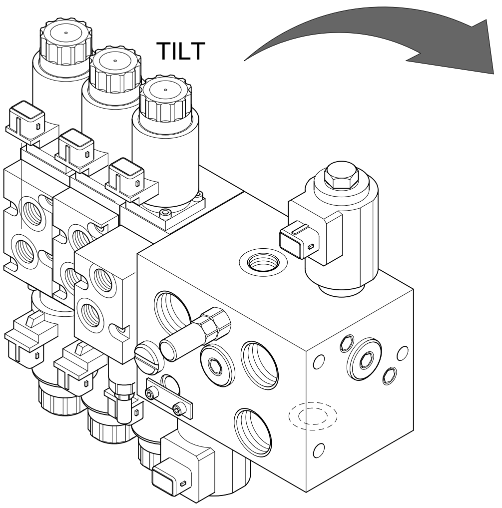
※ When need to force lowering, rotate counter clockwise increasingly with emergency lowering valve.

② Shuttle valve



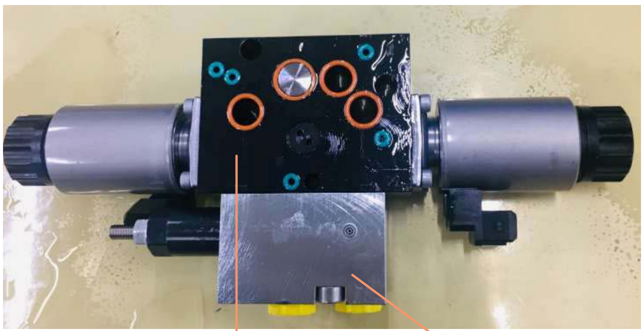
※ Transfer bigger load pressure through shuttle valve.
※ Use a flat screw driver.

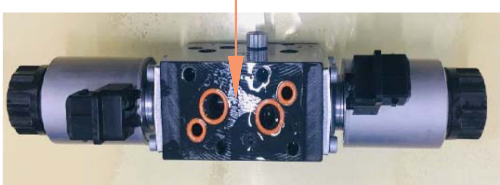
3) TILT SECTION



※ Flow rate : 16 lpm
※ Load holding pressure : 120 bar

(1) Proportional directional valve





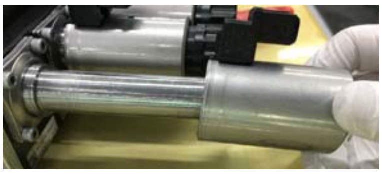
① Valve section block

② Counter balance valve block

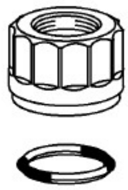
(2) Disassembly valve section

① Disassemble spool

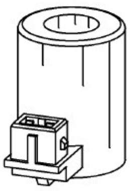
② Disassemble coil



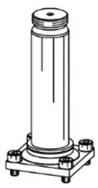
③ Disassembling process



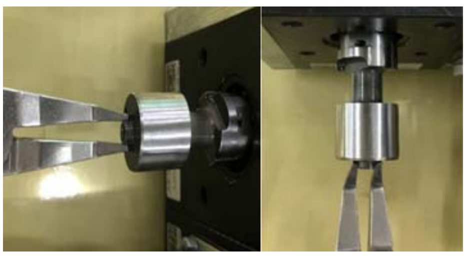
a. Release cap.

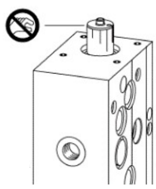


b. Release oil part.



c. Release actuation system.





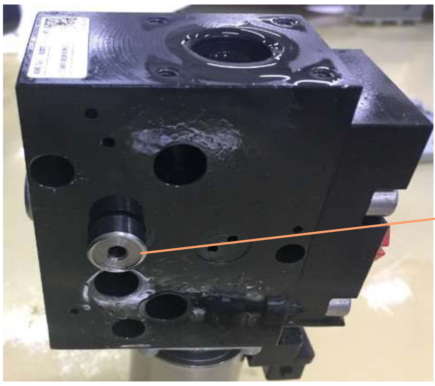
d. Pull out spool.

※ Do not use finger.

※ Use tool like picture (long nose plier).

(3) 2 way controller and shuttle valve

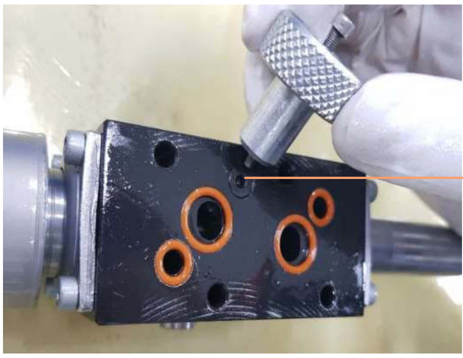
① 2 way controller (6 bar)

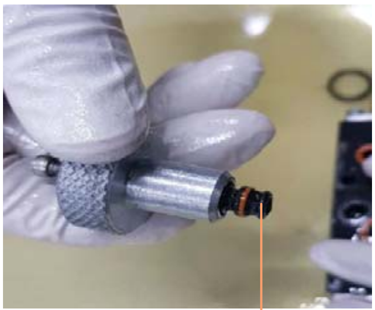


※ Pull out 2 way controller by fingers directly

※ 2 way controller make it keep 6 bar regardless of load change between in and out of spool.

② Shuttle valve



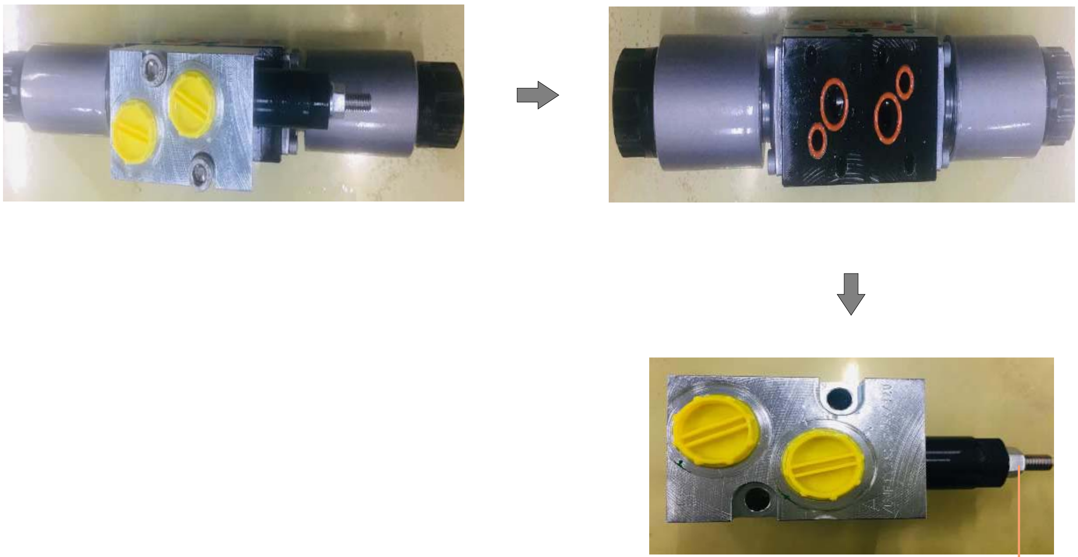


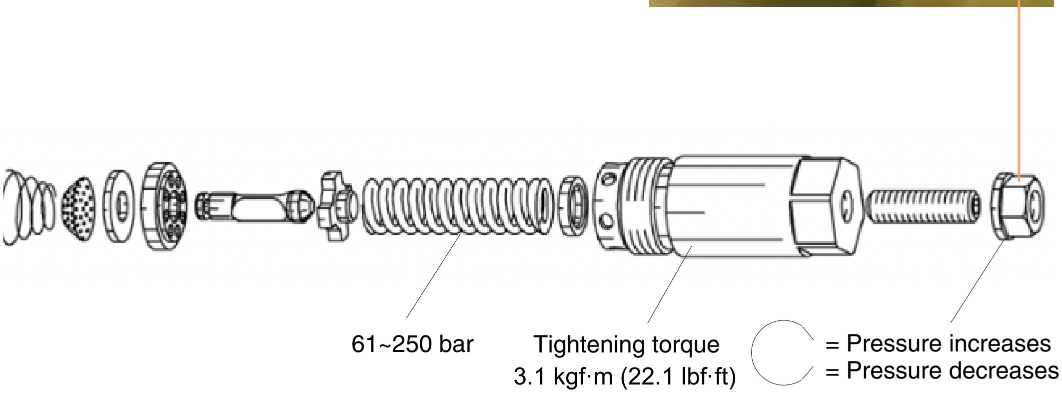
※ Transfer bigger load pressure through shuttle valve.

※ Fix 3 mm bolt and pull out.

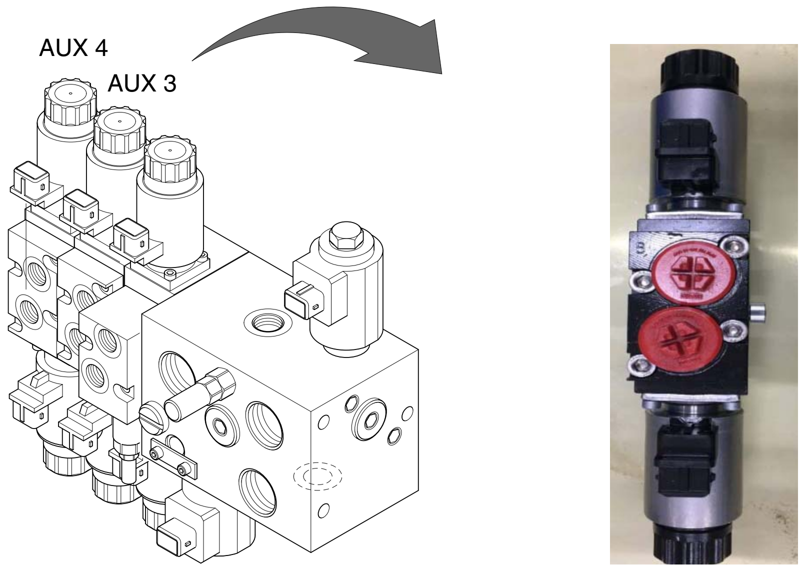
(4) Counter balance valve

※ Counter balance valve needs during tilting out operation.



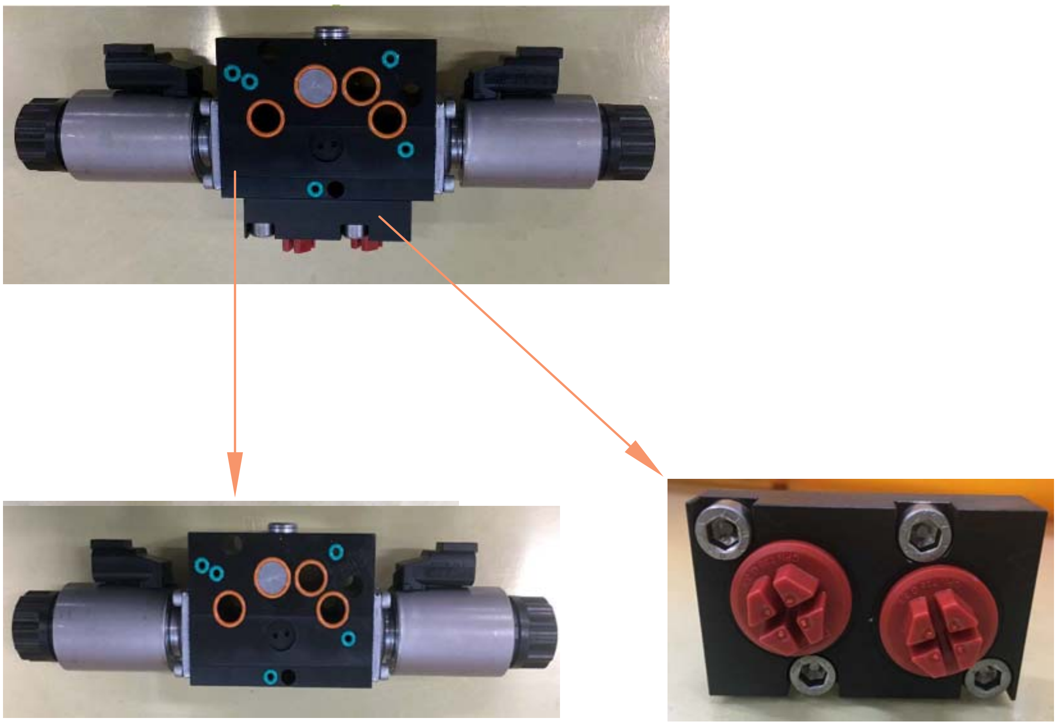


4) AUXILIARY SECTION



※ Flow rate
AUX 1 : 10 lpm, AUX 2 : 25 lpm
※ Pressure limit
AUX 1 : 140 bar, AUX 2 : 140 bar

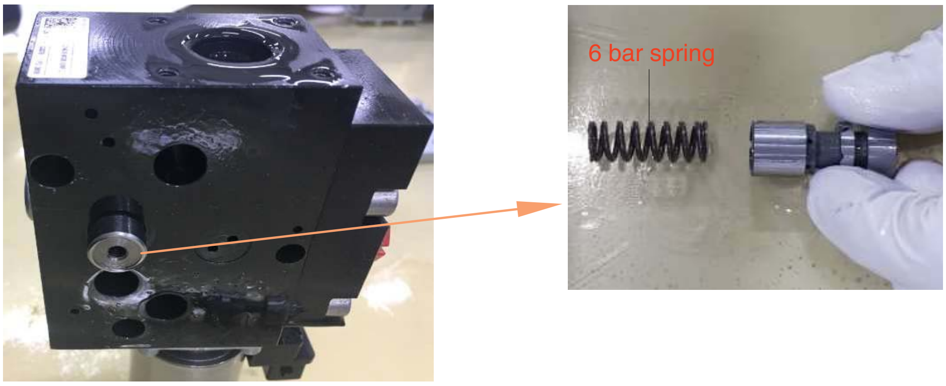
(1) Proportional directional valve



① Valve section block ② Ancillary block

(2) 2 way controller and shuttle valve

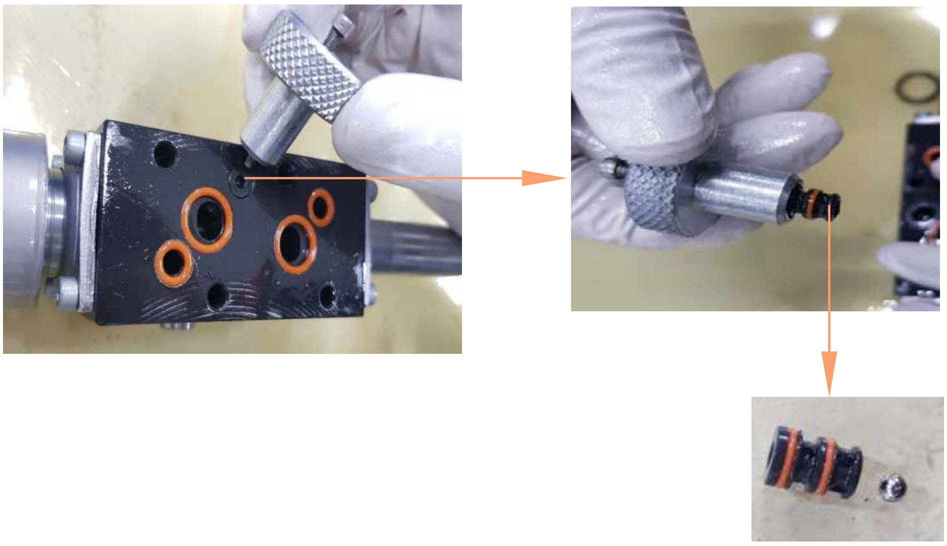
① 2 way controller (6 bar)



※Pull out 2 way controller by fingers directly.

※2 way controller make it keep 6 bar regardless of load change between in and out of spool.

② Shuttle valve

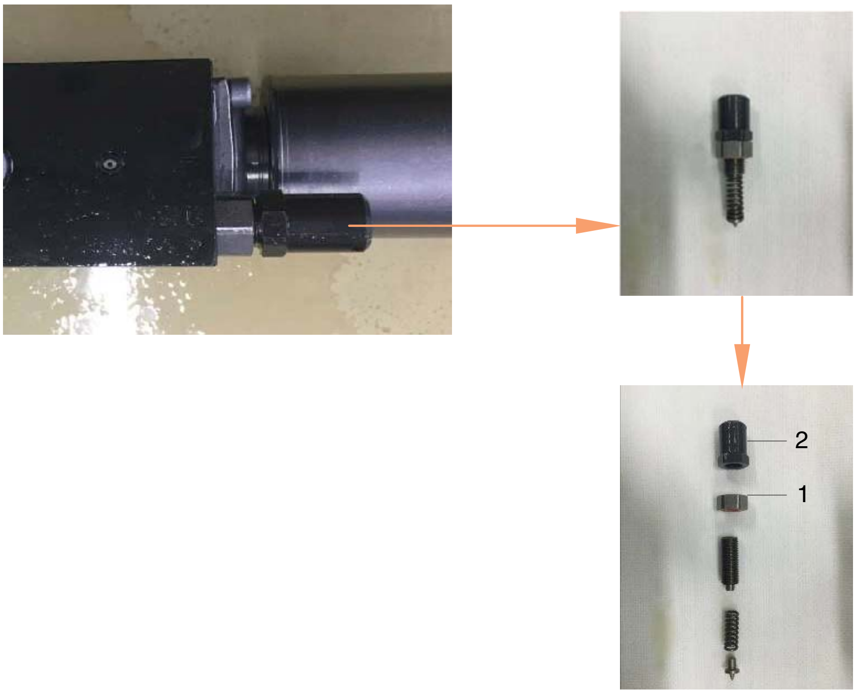


※ Transfer bigger load pressure through shuttle valve.

※ Fix 3 mm bolt and pull out.

(3) Second relief valve

※ Controlling individual section pressure, rotating clockwise to increase setting pressure with wrench.
※ 80 bar increase and decrease per 1 turn.



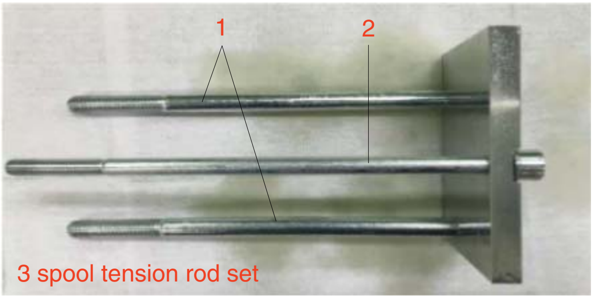
※ Use with a 12 mm spanner.
※ Tightening torque (1)
1.43 kgf·m (10.3 lbf·ft)

※ Use with a 3 mm wrench.
※ Tightening torque (2)
1.43 kgf·m (10.3 lbf·ft)

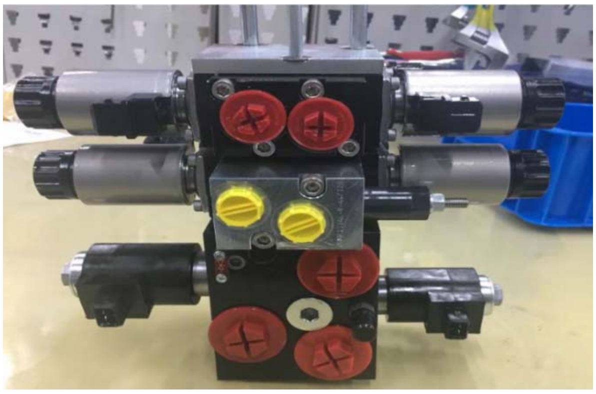
= Pressure increases
= Pressure decreases

5) ADD SECTION PART

(1) Disassembly



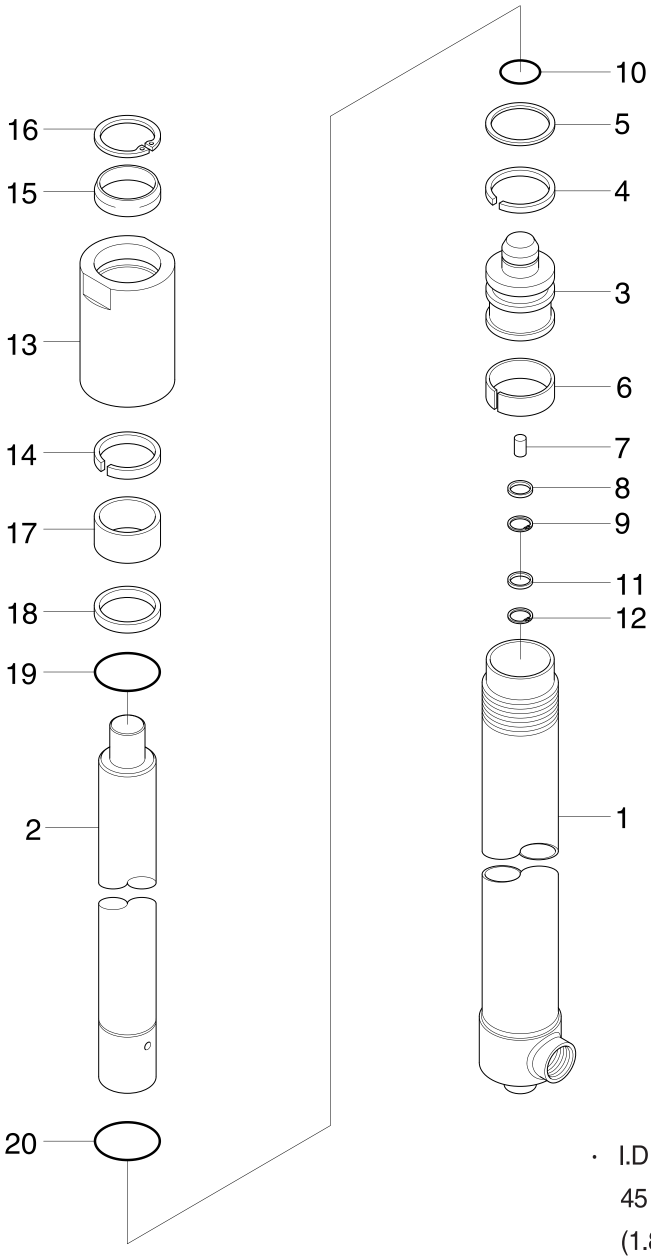
※ Tightening torque
- Item 1 (2 EA) : 2.3 kgf·m (17.0 lbf·ft)
- Item 2 (1 EA) : 0.97 kgf·m (7.0 lbf·ft)



※ From 4 spool to 3 spool.
※ When it needs to disassemble section valve, it's possible to release tension rod sets.

4. LIFT CYLINDER

1) STRUCTURE



· I.D × O.D × Stroke (standard)
45 × 55 × 1645mm
(1.8 × 2.2 × 65 in)

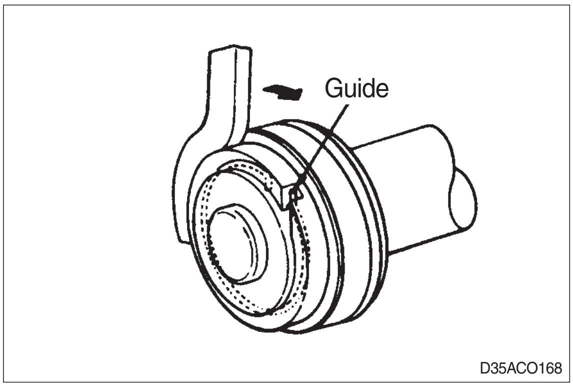
· Rod O.D : 35mm (1.4 in)

15BT9HS14

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.



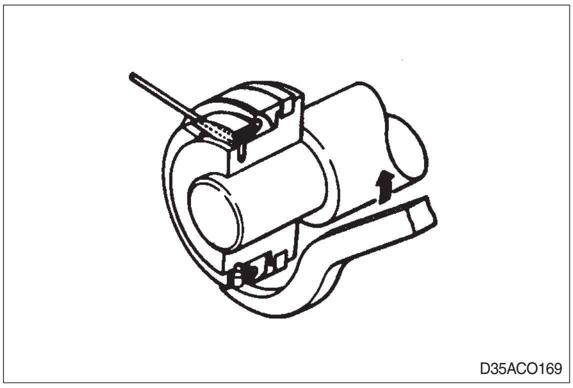
3) CHECK AND INSPECTION

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

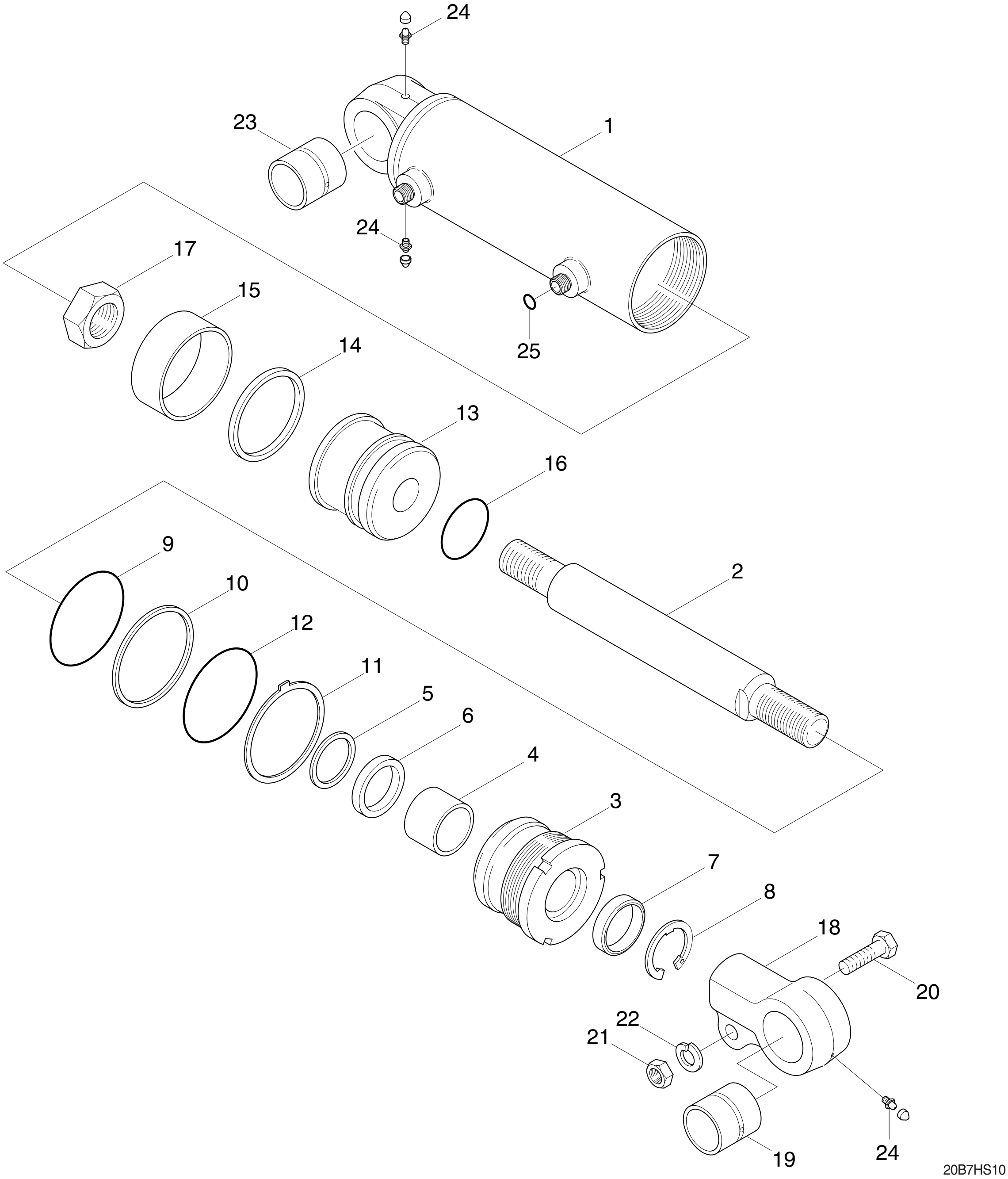
4) ASSEMBLY

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



5. TILT CYLINDER

1) STRUCTURE



1	Tube assy	10	Back up ring	18	Rod eye
2	Rod	11	Lock washer	19	Spherical bearing
3	Gland	12	O-ring	20	Hexagon bolt
4	Bushing	13	Piston	21	Hexagon nut
5	Rod seal	14	Piston seal	22	Spring washer
6	Back up ring	15	Wear ring	23	Bushing
7	Dust wiper	16	O-ring	24	Grease nipple
8	Snap ring	17	Nylon nut	25	O-ring
9	O-ring				

2) DISASSEMBLY

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

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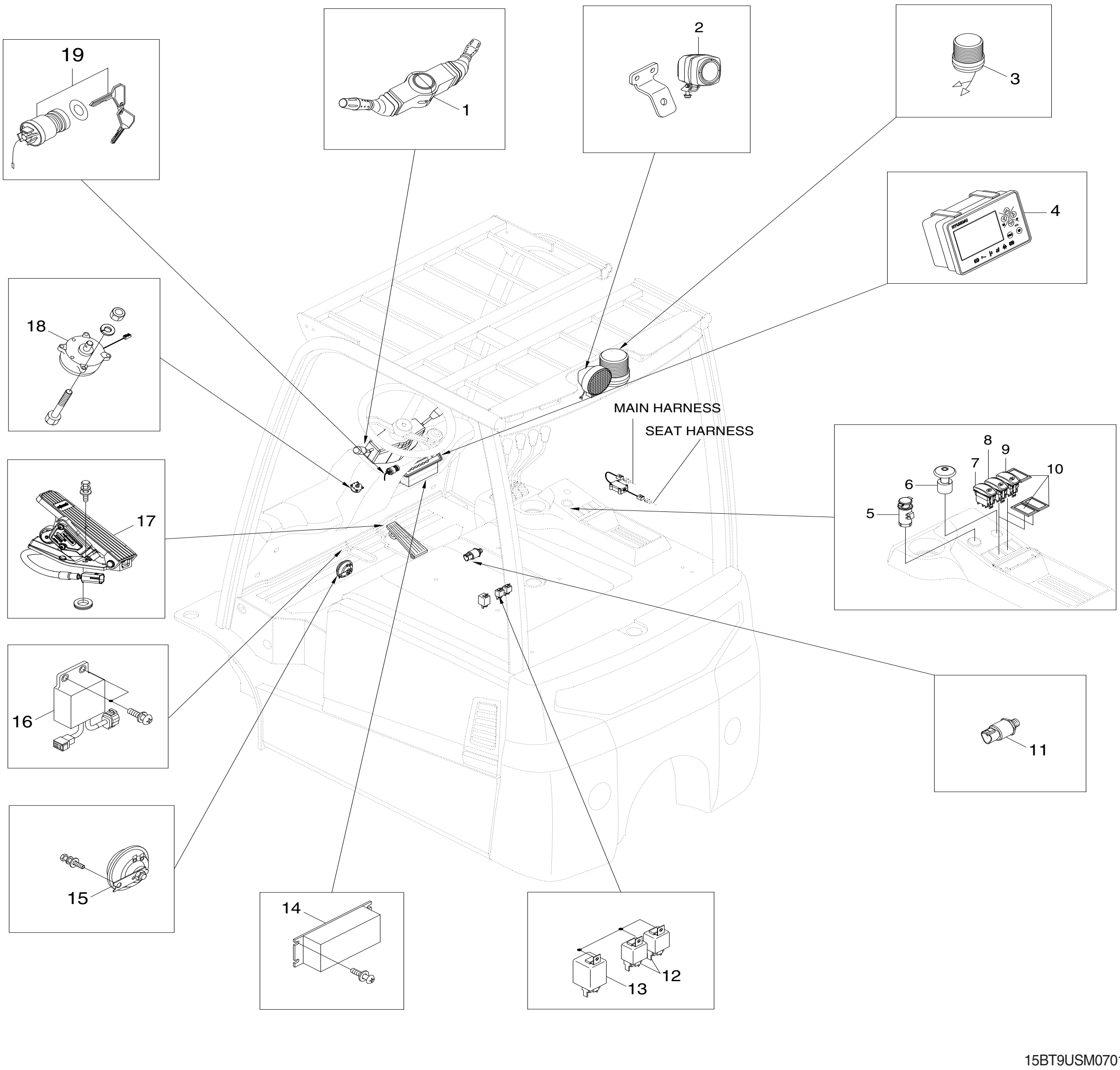
3) CHECK AND INSPECTION

mm(in)

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

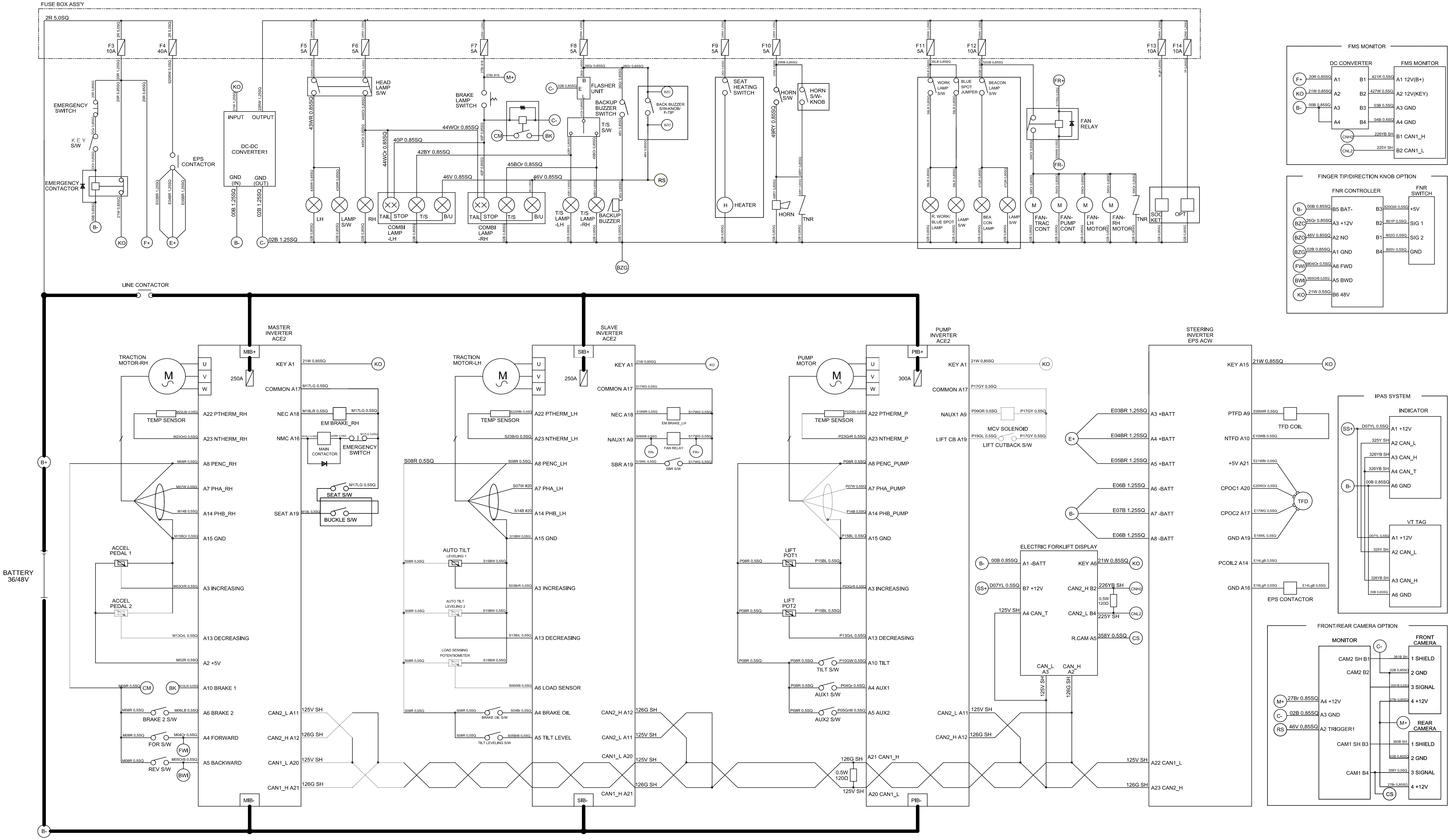
SECTION 7 ELECTRICAL SYSTEM

GROUP 1 COMPONENT LOCATION



1	Combination switch	8	Rear work lamp switch	14	Dc-Dc converter
2	Blue spot light	9	Beacon lamp switch	15	High horn
3	Beacon lamp	10	Panel plug	16	FNR controller
4	Display	11	Pressure sensor	17	Accelerator assy
5	Socket assy	12	Relay	18	TFD sensor
6	Emergency switch assy	13	Flasher unit assy	19	Key switch assy
7	Head lamp switch				

·NON-UL MANUAL TYPE (15BT-9U : ~#89, 18BT-9 : ~#145, 20BT-9U : ~#179)

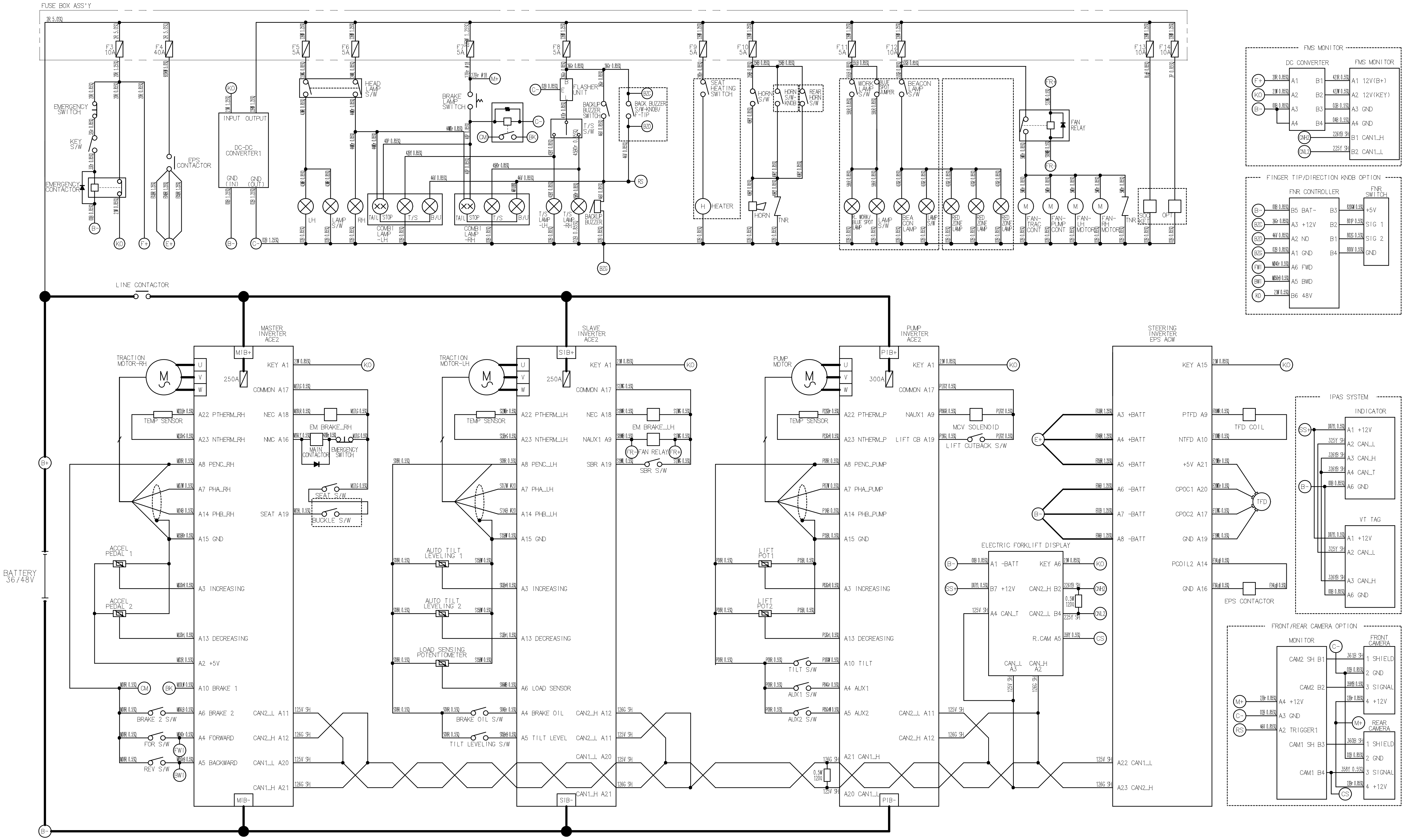


NOTE

1.B+ : BATTERY POSITIVE
B- : BATTERY NEGATIVE
C- : CONVERTER1 OUTPUT NEGATIVE
E+ : EPS CONTROLLER POSITIVE
KO : KEY SWITCH OUT
FR+: FAN RELAY POSITIVE
FR- : FAN RELAY NEGATIVE
M+ : MONITOR POSITIVE
F+ : FMS POSITIVE
CNH2: CAN HIGH_2
CNL2: CAN LOW_2
RS : REVERSE SIGNAL
BZC: BACK BUZZER COMMON
BZO: BACK BUZZER OUT
BZG: BACK BUZZER GROUND
FWI: FORWARD INPUT
BWI: BACKWARD INPUT
TDI: TRACTION DIGITAL INPUT COMMON
CS : CAMERA SIGNAL
SS+ : FINGERTIP SUB CONTROLLER POSITIVE
CM : CONTROLLER COMMON
BK : BRAKE SIGNAL
2. is optional item.
3. is shield wire type.

21FY-90712

·NON-UL MANUAL TYPE (15BT-9U : #90~#227, 18BT-9 : #146~#396, 20BT-9U : #180~660)



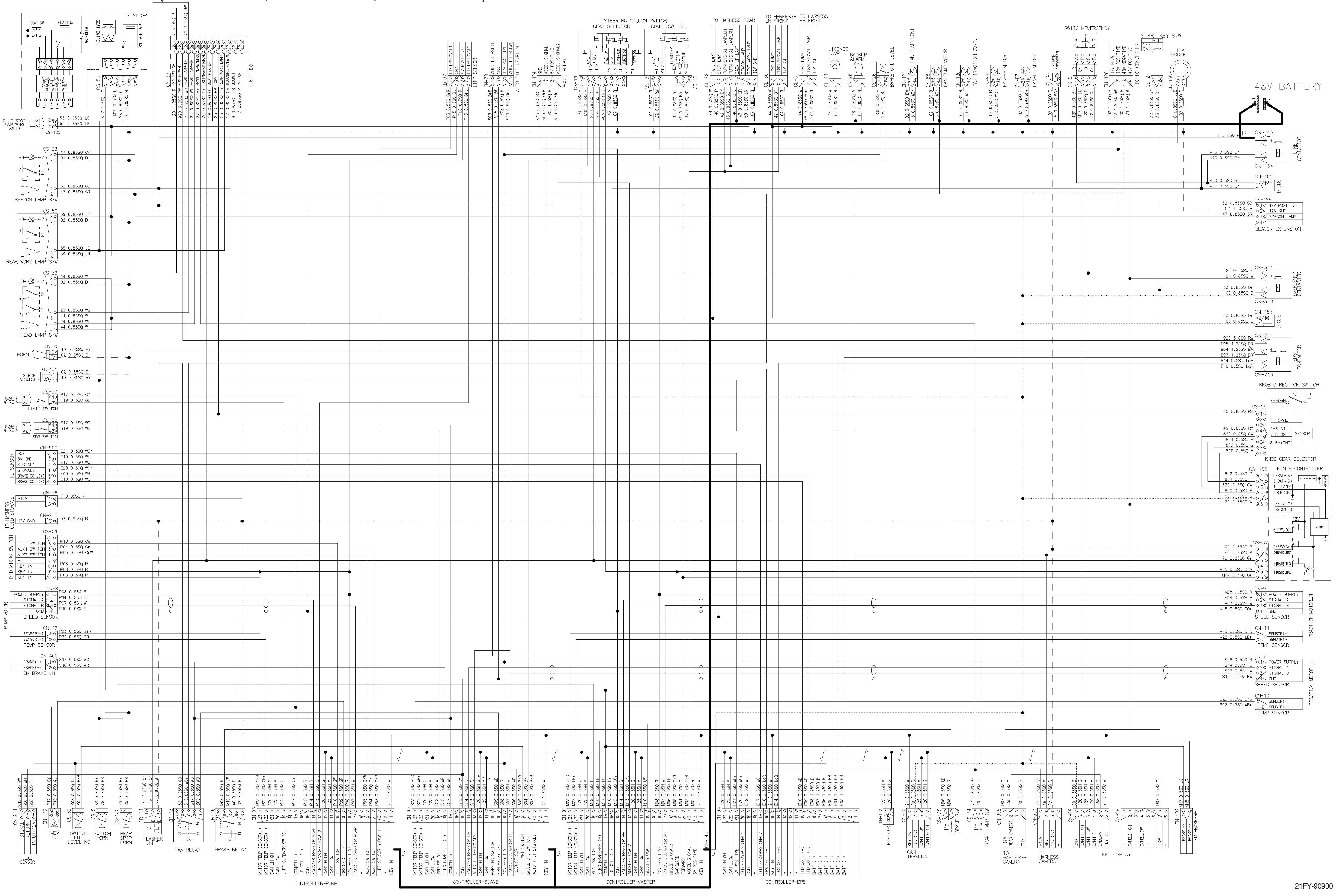
NOTE

1.B+ : BATTERY POSITIVE
B- : BATTERY NEGATIVE
C- : CONVERTER1 OUTPUT NEGATIVE
E+ : EPS CONTROLLER POSITIVE
KO : KEY SWITCH OUT
FR+: FAN RELAY POSITIVE
FR- : FAN RELAY NEGATIVE
M+ : MONITOR POSITIVE
F+ : FMS POSITIVE
CNH2: CAN HIGH_2
CNL2: CAN LOW_2
RS : REVERSE SIGNAL
BZC: BACK BUZZER COMMON
BZO: BACK BUZZER OUT
BZG: BACK BUZZER GROUND
FWI: FORWARD INPUT
BWI: BACKWARD INPUT
TDI: TRACTION DIGITAL INPUT COMMON
CS : CAMERA SIGNAL
SS+ : FINGERTIP SUB CONTROLLER POSITIVE
CM : CONTROLLER COMMON
BK : BRAKE SIGNAL

2. is optional item.
3. is shield wire type.

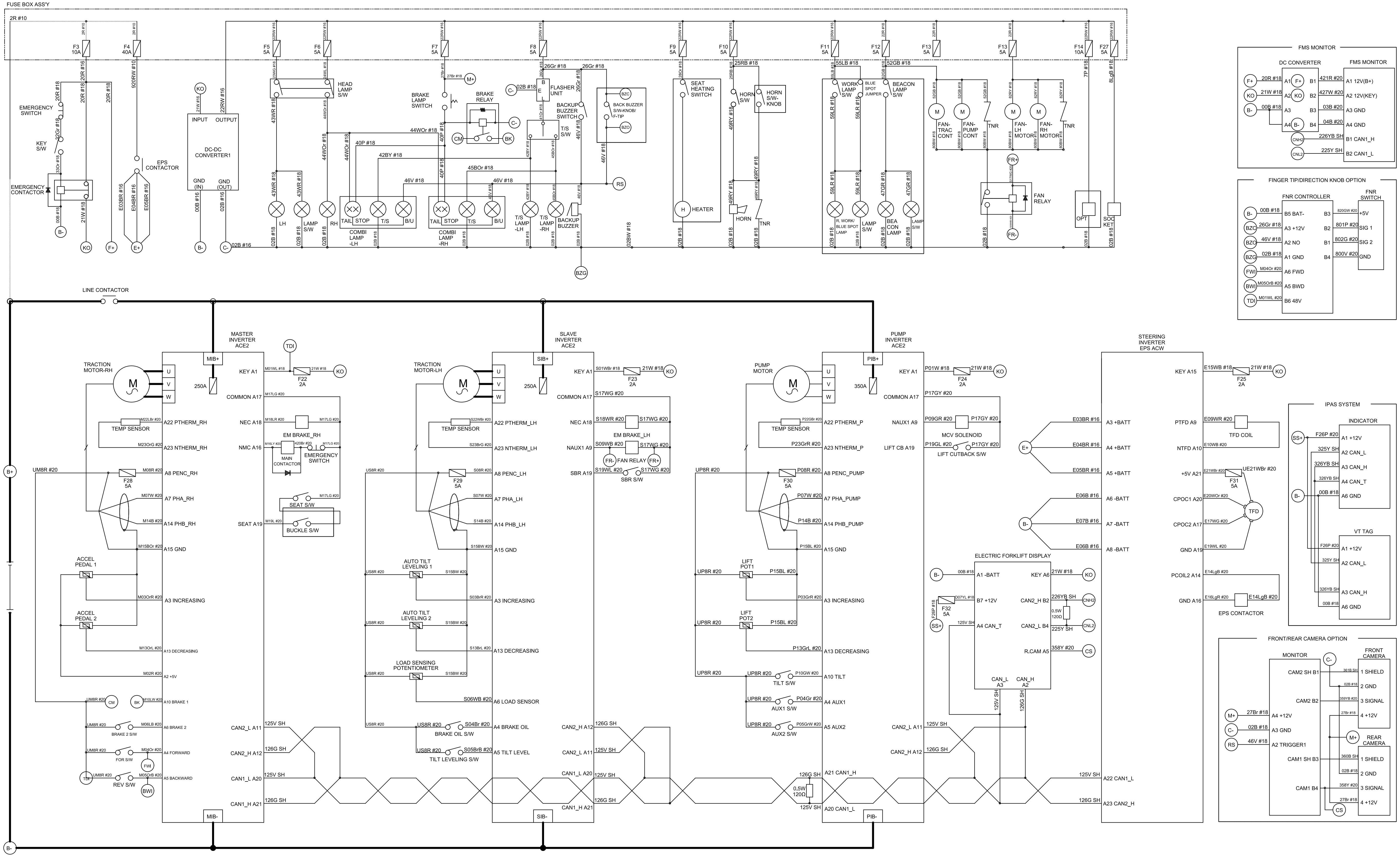
21FY-90714

·NON-UL MANUAL TYPE (15BT-9U : #278~, 18BT-9U : #397~, 20BT-9U : #661~)



21FY-90900

·UL MANUAL TYPE (15BT-9U : ~#89, 18BT-9 : ~#145, 20BT-9U : ~#179)

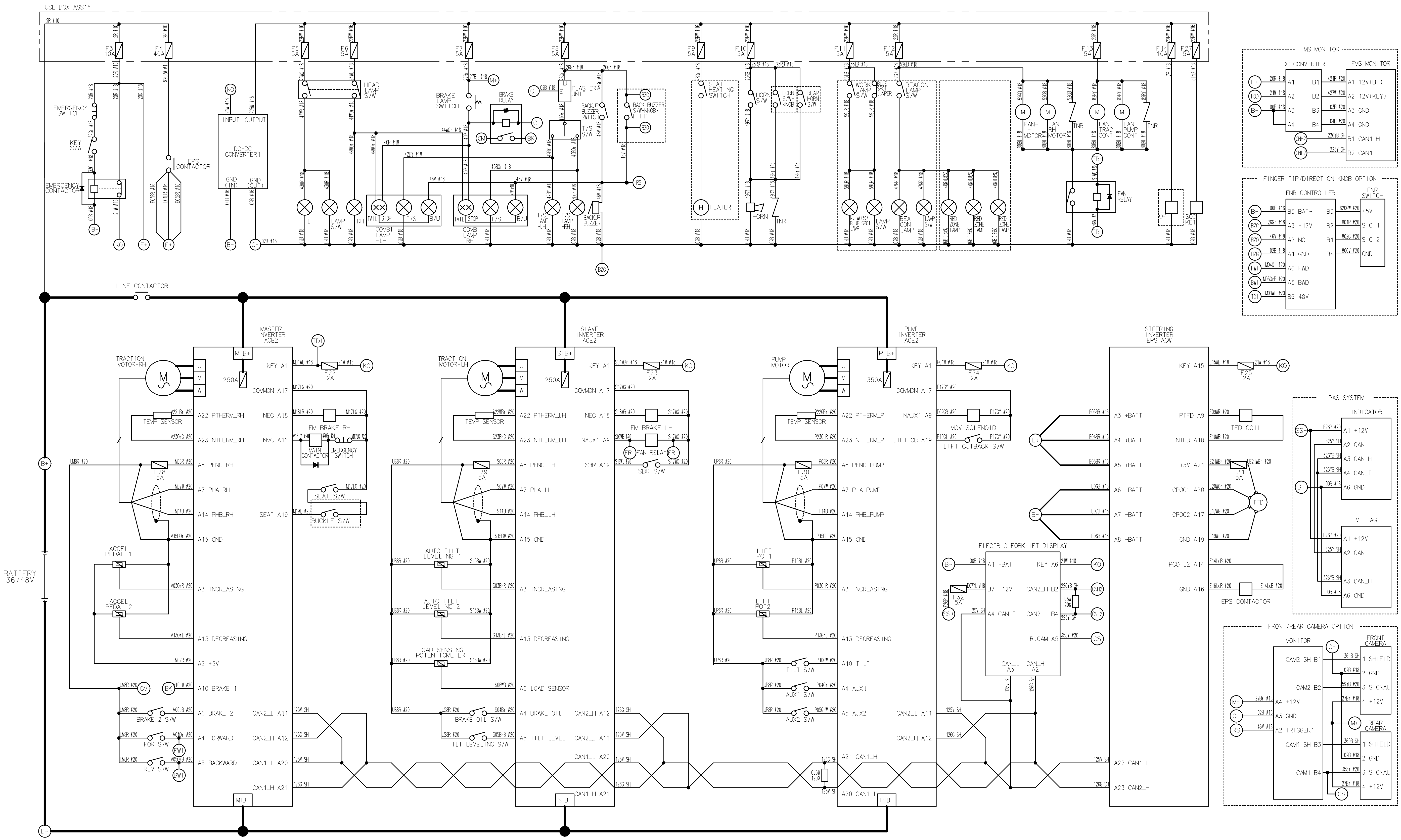


NOTE

1.B+ : BATTERY POSITIVE	FR- : FAN RELAY NEGATIVE	BZC: BACK BUZZER COMMON	CS : CAMERA SIGNAL
B- : BATTERY NEGATIVE	M+ : MONITOR POSITIVE	BZO: BACK BUZZER OUT	SS+ : FINGERTIP SUB CONTROLLER POSITIVE
C- : CONVERTER1 OUTPUT NEGATIVE	F+ : FMS POSITIVE	BZG: BACK BUZZER GROUND	CM : CONTROLLER COMMON
E+ : EPS CONTROLLER POSITIVE	CNH2: CAN HIGH_2	FWI: FORWARD INPUT	BK : BRAKE SIGNAL
KO : KEY SWITCH OUT	CNL2: CAN LOW_2	BWI: BACKWARD INPUT	2. is optional item.
FR+: FAN RELAY POSITIVE	RS : REVERSE SIGNAL	TDI: TRACTION DIGITAL INPUT COMMON	3. is shield wire.

21FY-90611

·UL MANUAL TYPE (15BT-9U : #90~#227, 18BT-9 : #146~#396, 20BT-9U : #180~660)

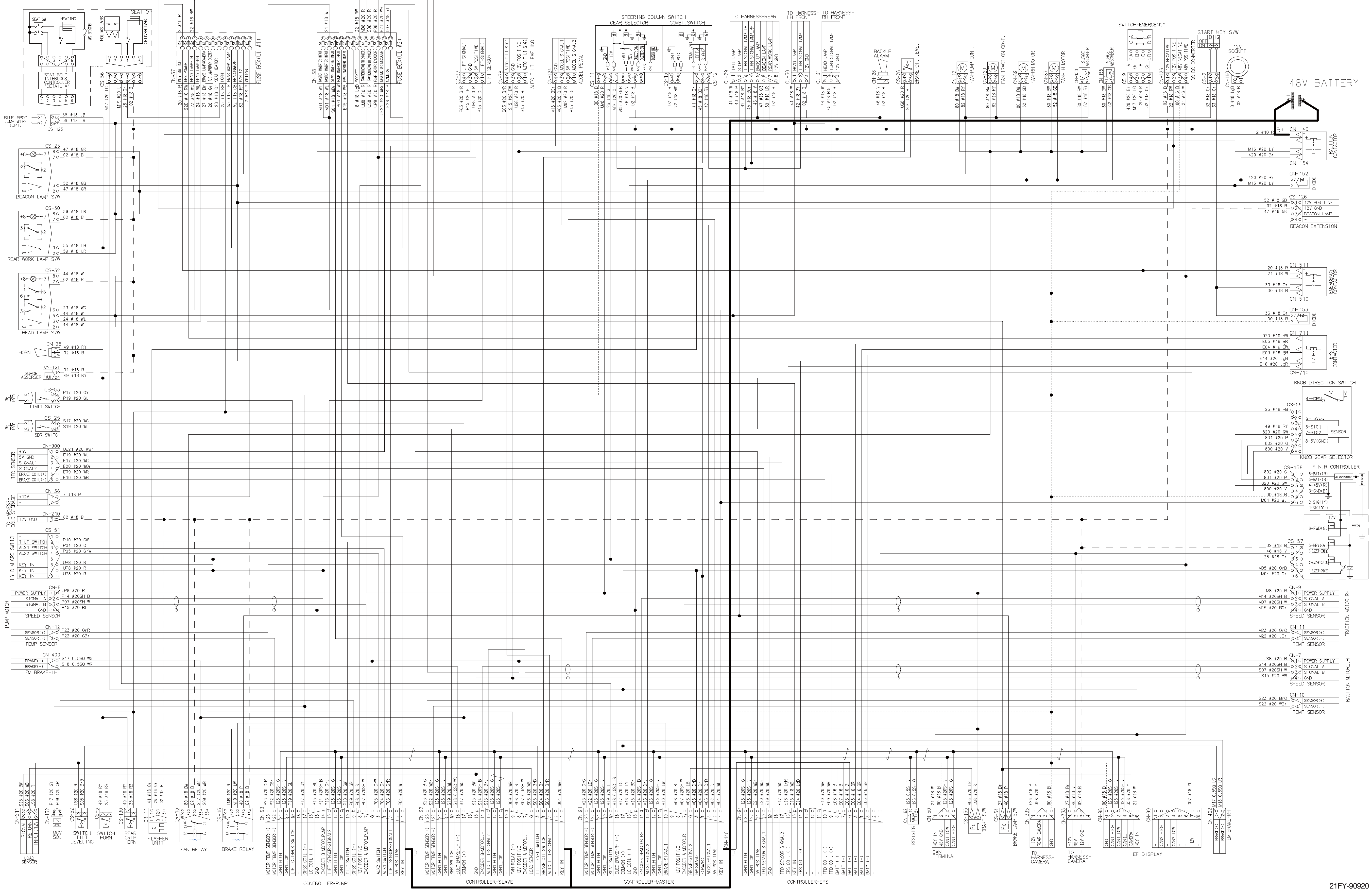


NOTE

1. B+ : BATTERY POSITIVE
   B- : BATTERY NEGATIVE
   C- : CONVERTER1 OUTPUT NEGATIVE
   E+ : EPS CONTROLLER POSITIVE
   KO : KEY SWITCH OUT
   FR+: FAN RELAY POSITIVE
   FR- : FAN RELAY NEGATIVE
   M+ : MONITOR POSITIVE
   F+ : FMS POSITIVE
   CNH2: CAN HIGH_2
   CNL2: CAN LOW_2
   RS : REVERSE SIGNAL
   BZC: BACK BUZZER COMMON
   BZO: BACK BUZZER OUT
   BZG: BACK BUZZER GROUND
   FWI: FORWARD INPUT
   BWI: BACKWARD INPUT
   TDI: TRACTION DIGITAL INPUT COMMON
   CS : CAMERA SIGNAL
   SS+ : FINGERTIP SUB CONTROLLER POSITIVE
   CM : CONTROLLER COMMON
   BK : BRAKE SIGNAL
2. is optional item.
3. is shield wire type.

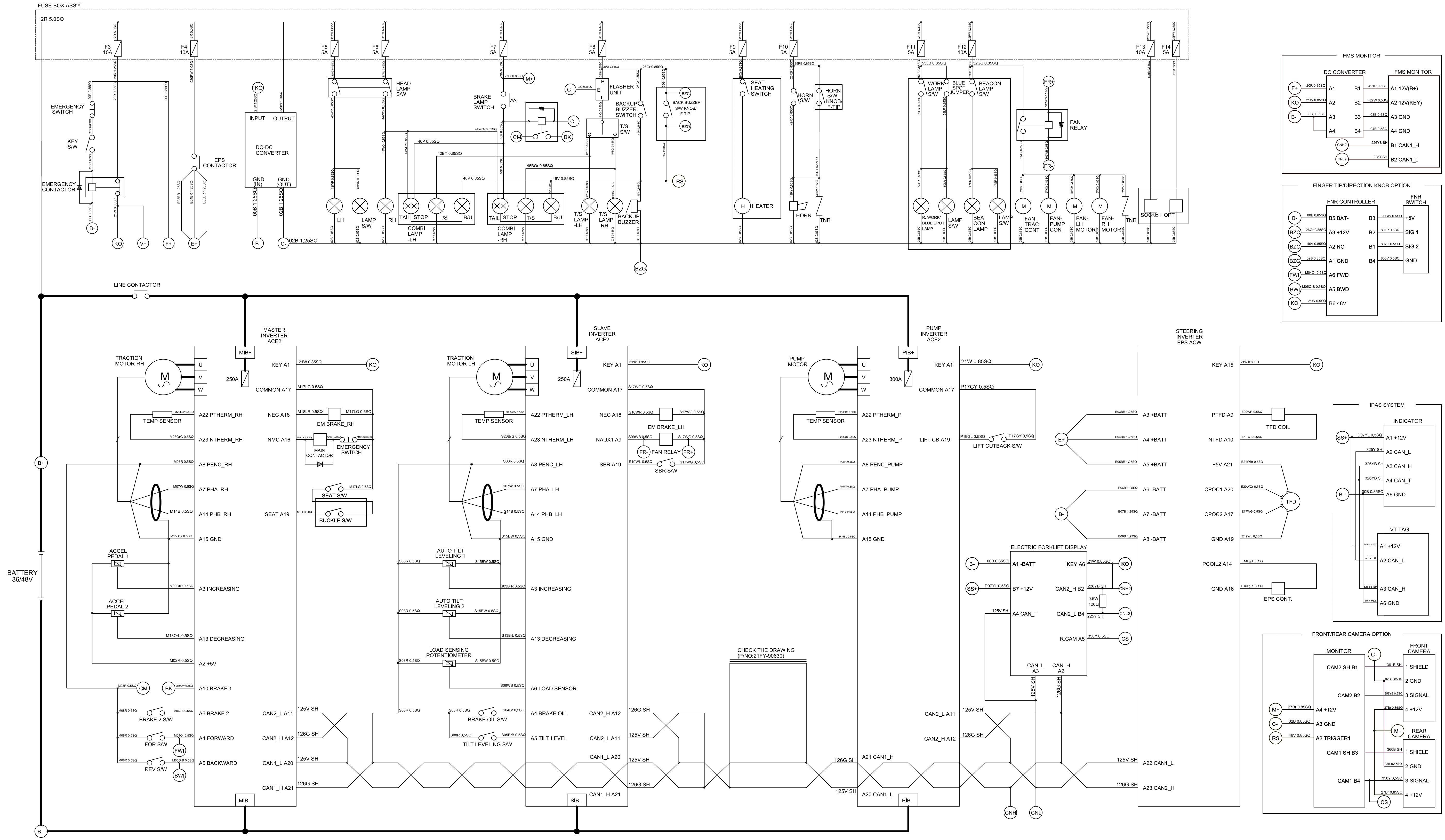
21FY-90613

·UL MANUAL TYPE (15BT-9U : #278~, 18BT-9U : #397~, 20BT-9U : #661~)



21FY-90920

·NON-UL FINGERTIP TYPE (15BT-9U : ~#89, 18BT-9 : ~#145, 20BT-9U : ~#179)

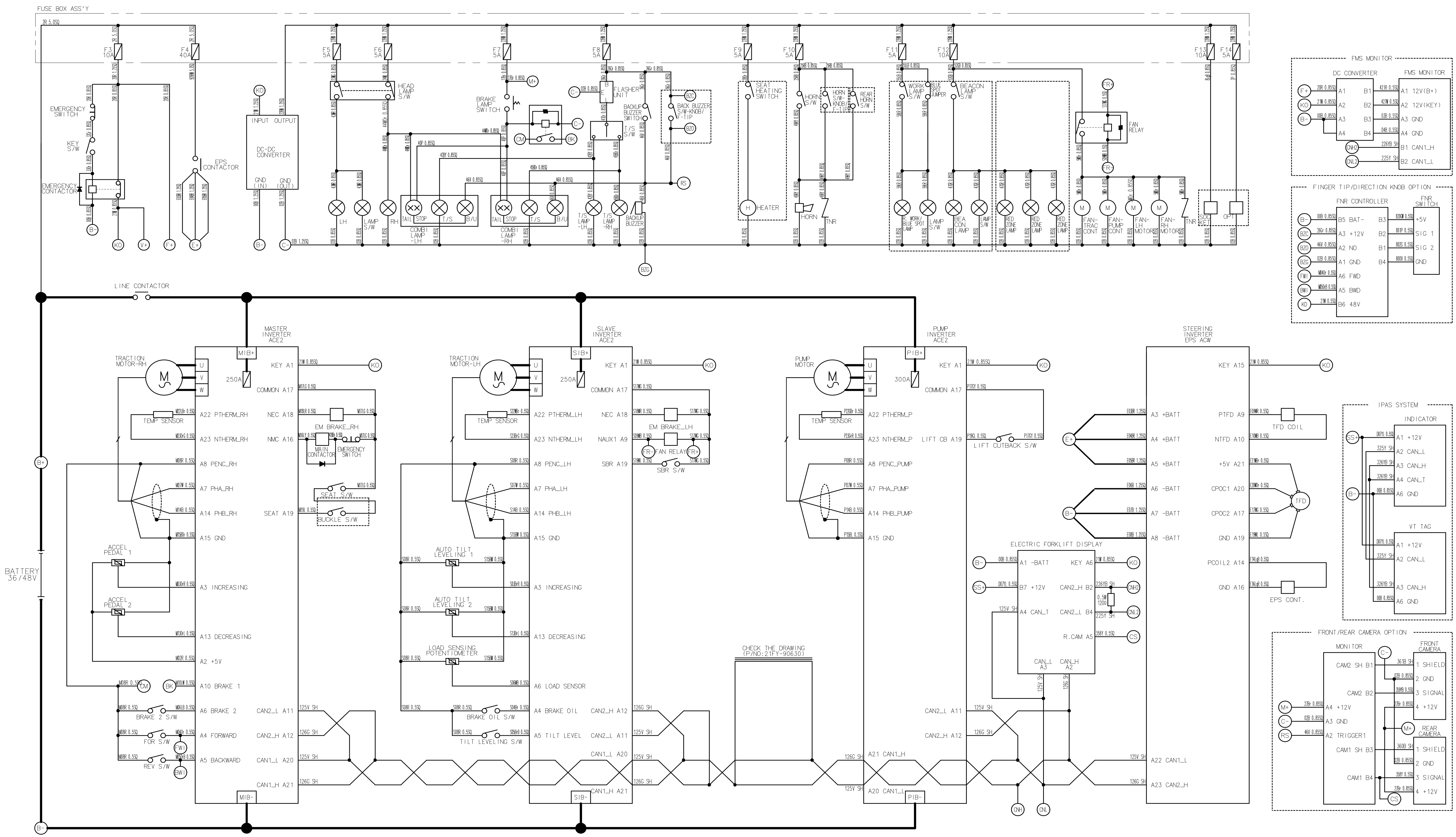


NOTE

1.B+ : BATTERY POSITIVE	FR- : FAN RELAY NEGATIVE	BZC: BACK BUZZER COMMON	CS : CAMERA SIGNAL
B- : BATTERY NEGATIVE	M+ : MONITOR POSITIVE	BZO: BACK BUZZER OUT	SS+: FINGERTIP SUB CONTROLLER POSITIVE
C- : CONVERTER1 OUTPUT NEGATIVE	F+ : FMS POSITIVE	BZG: BACK BUZZER GROUND	V+ : VCM VALVE POSITIVE
E+ : EPS CONTROLLER POSITIVE	CNH2: CAN HIGH_2	FWI: FORWARD INPUT	CM : CONTROLLER COMMON
KO : KEY SWITCH OUT	CNL2: CAN LOW_2	BWI: BACKWARD INPUT	BK : BRAKE SIGNAL
FR+: FAN RELAY POSITIVE	RS : REVERSE SIGNAL	TDI: TRACTION DIGITAL INPUT COMMON	2. ▭ is optional item.
			3. ⬭ is shield wire.

21FY-90722

·NON-UL FINGERTIP TYPE (15BT-9U : #90~#227, 18BT-9 : #146~#396, 20BT-9U : #180~660)

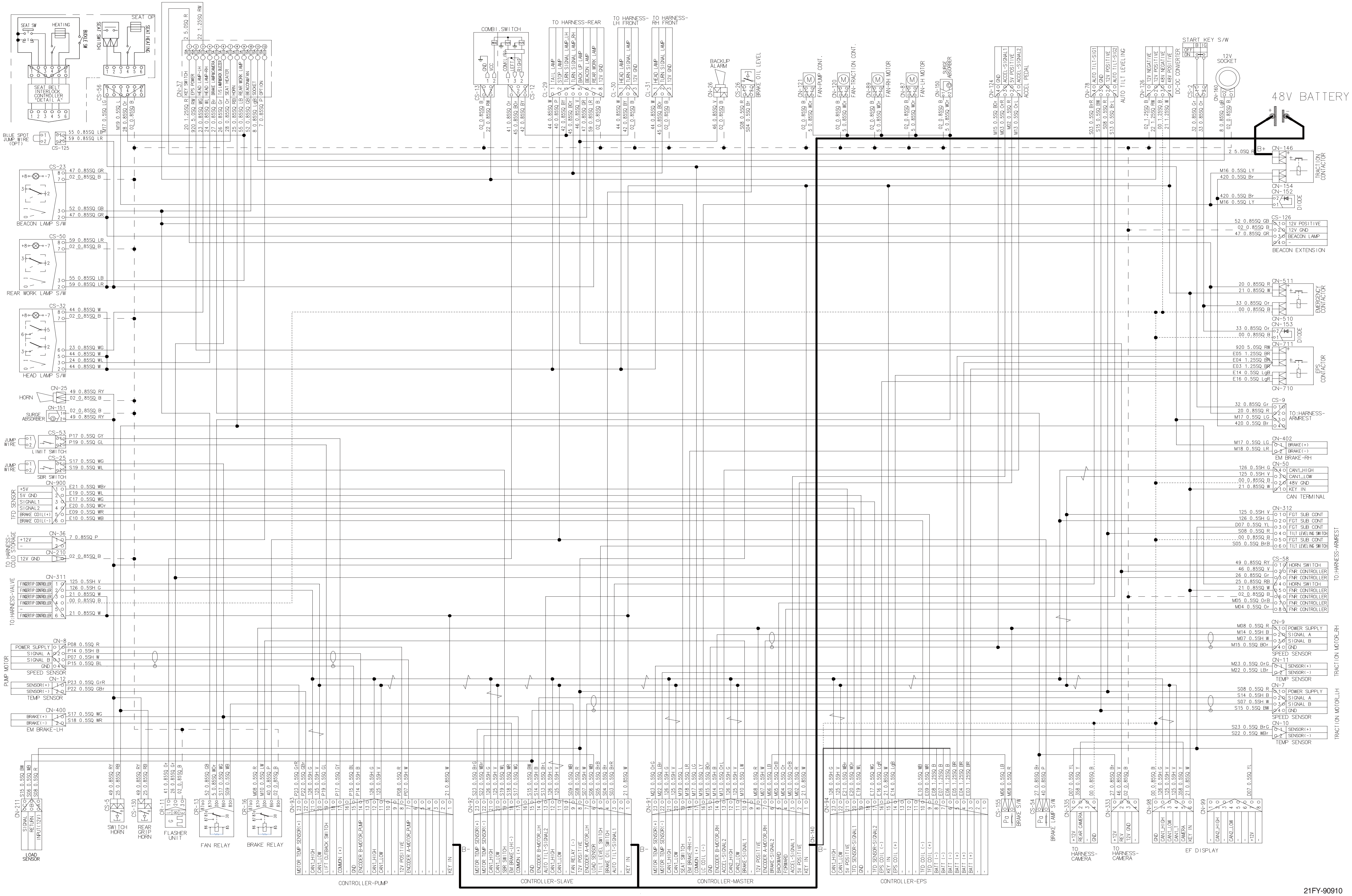


NOTE

1. B+ : BATTERY POSITIVE
   B- : BATTERY NEGATIVE
   C- : CONVERTER1 OUTPUT NEGATIVE
   E+ : EPS CONTROLLER POSITIVE
   KO : KEY SWITCH OUT
   FR+: FAN RELAY POSITIVE
   FR- : FAN RELAY NEGATIVE
   M+ : MONITOR POSITIVE
   F+ : FMS POSITIVE
   CNH2: CAN HIGH_2
   CNL2: CAN LOW_2
   RS : REVERSE SIGNAL
   BZC: BACK BUZZER COMMON
   BZO: BACK BUZZER OUT
   BZG: BACK BUZZER GROUND
   FWI: FORWARD INPUT
   BWI: BACKWARD INPUT
   TDI: TRACTION DIGITAL INPUT COMMON
   CS : CAMERA SIGNAL
   SS+: FINGERTIP SUB CONTROLLER POSITIVE
   V+ : VCM VALVE POSITIVE
   CM : CONTROLLER COMMON
   BK : BRAKE SIGNAL
2. is optional item.
3. is shield wire type.

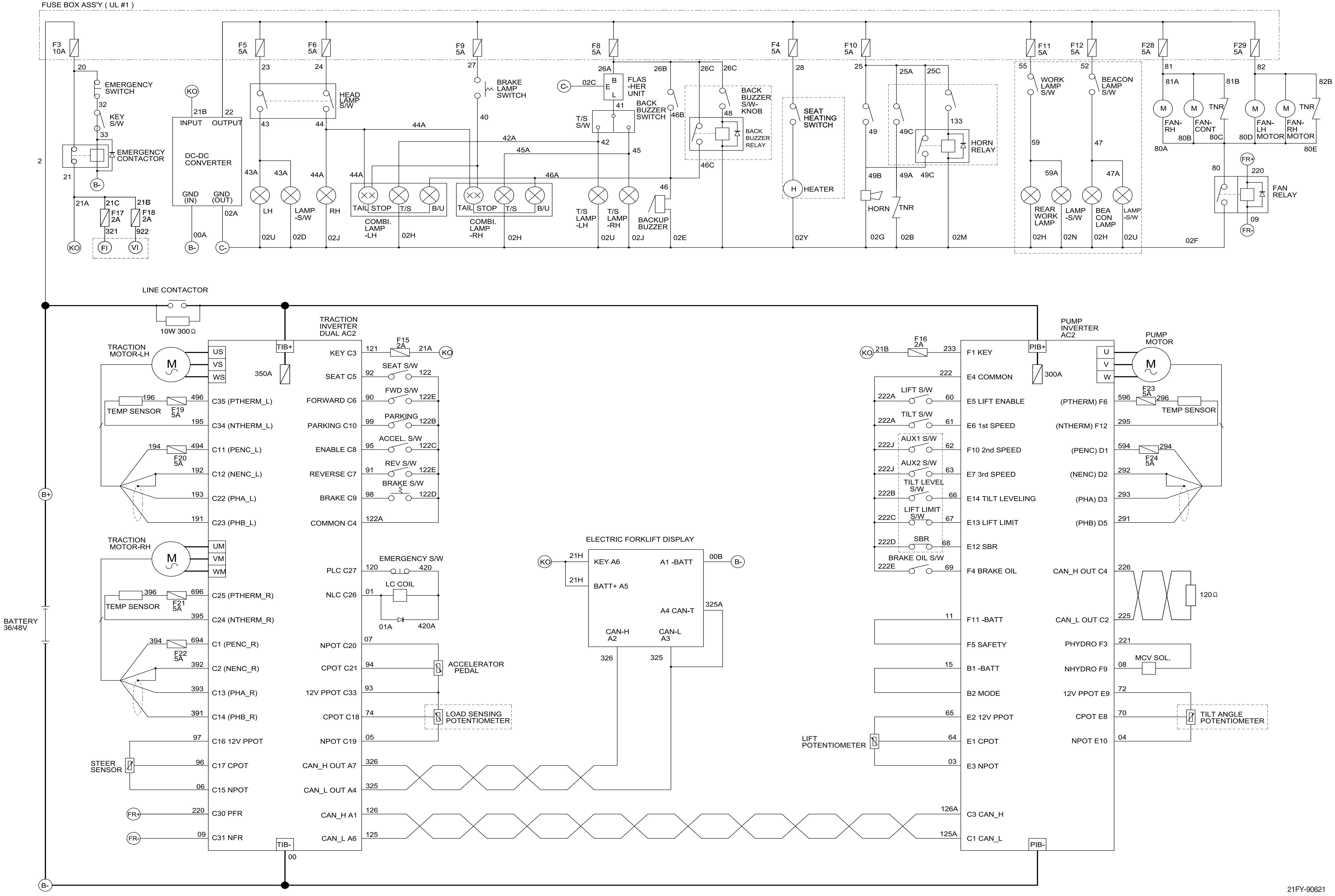
21FY-90724

·NON-UL FINGERTIP TYPE (15BT-9U : #278~, 18BT-9U : #397~, 20BT-9U : #661~)

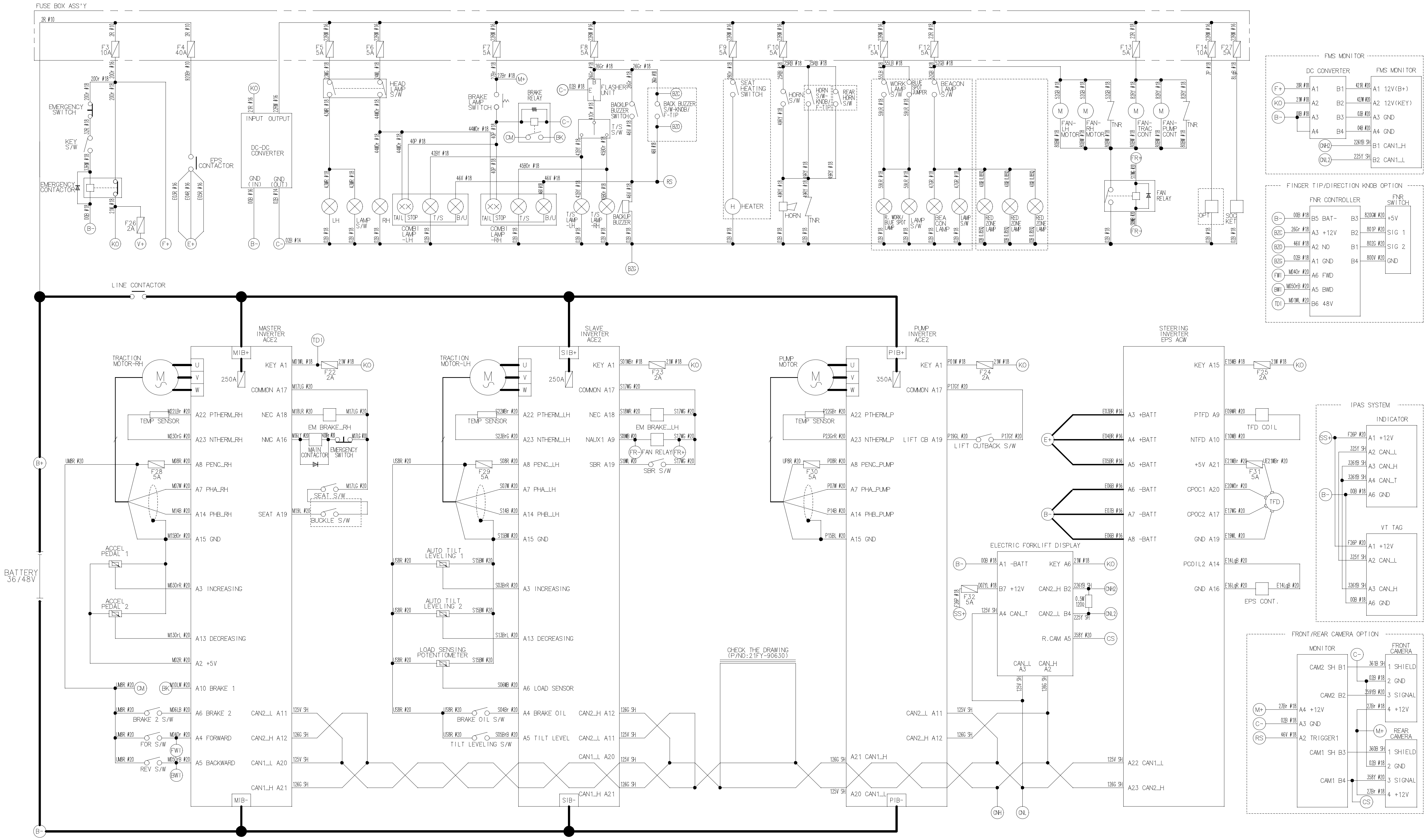


21FY-90910

·UL FINGERTIP TYPE (15BT-9U : ~#89, 18BT-9 : ~#145, 20BT-9U : ~#179)



·UL FINGERTIP TYPE (15BT-9U : #90~#227, 18BT-9 : #146~#396, 20BT-9U : #180~660)

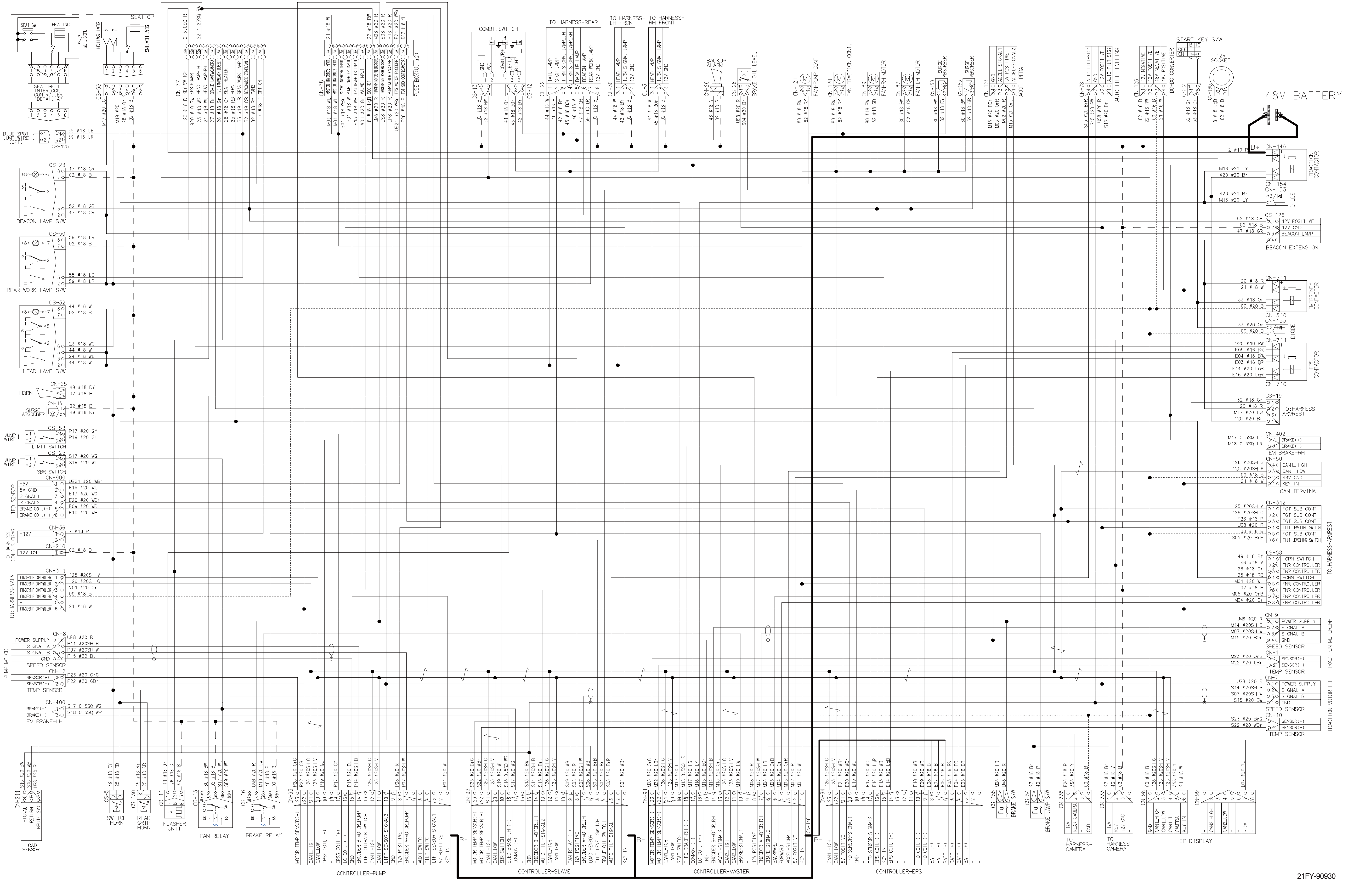


NOTE

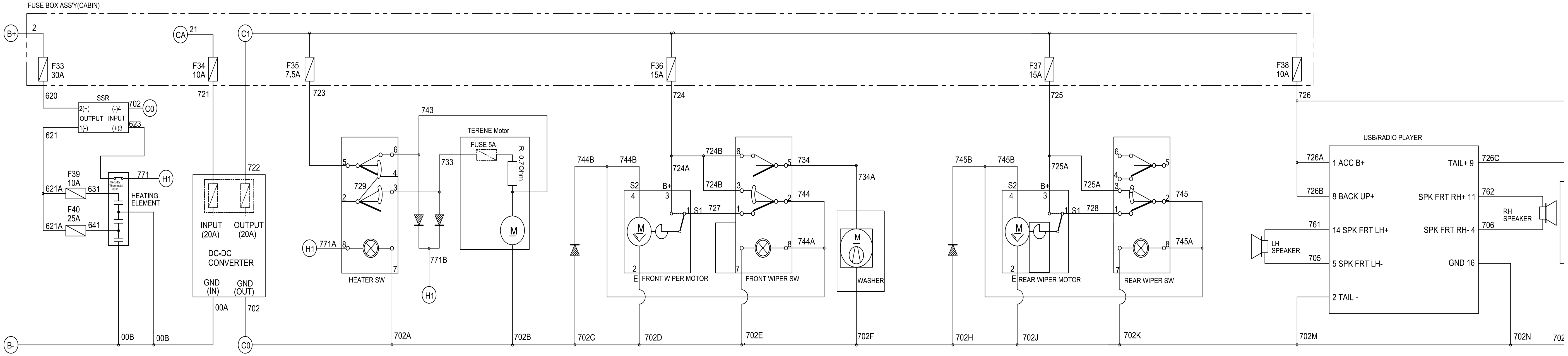
1. B+ : BATTERY POSITIVE
   B- : BATTERY NEGATIVE
   C- : CONVERTER1 OUTPUT NEGATIVE
   E+ : EPS CONTROLLER POSITIVE
   KO : KEY SWITCH OUT
   FR+: FAN RELAY POSITIVE
   FR- : FAN RELAY NEGATIVE
   M+ : MONITOR POSITIVE
   F+ : FMS POSITIVE
   CNH2: CAN HIGH_2
   CNL2: CAN LOW_2
   RS : REVERSE SIGNAL
   BZC: BACK BUZZER COMMON
   BZO: BACK BUZZER OUT
   BZG: BACK BUZZER GROUND
   FWI: FORWARD INPUT
   BWI: BACKWARD INPUT
   TDI: TRACTION DIGITAL INPUT COMMON
   CS : CAMERA SIGNAL
   SS+ : FINGERTIP SUB CONTROLLER POSITIVE
   V+ : VCM VALVE POSITIVE
   CM : CONTROLLER COMMON
   BK : BRAKE SIGNAL
2. (dotted box) is optional item.
3. (dashed ellipse) is shield wire type.

21FY-90623

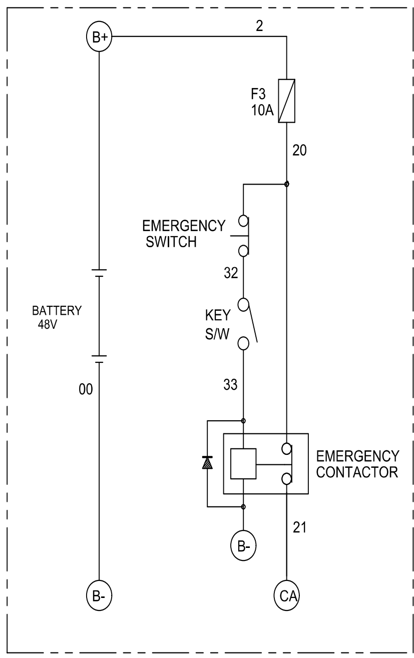
·UL FINGERTIP TYPE (15BT-9U : #278~, 18BT-9U : #397~, 20BT-9U : #661~)



·CABIN (15BT-9U : ~#277, 18BT-9U : ~#396, 20BT-9U : ~#660)



* MAIN WIRING DIAGRAM *



NOTE

1.B+ : BATTERY POSITIVE

B- : BATTERY NEGATIVE

CA : CABIN ACCESSORY INPUT

C1 : CABIN CONVERTER POSITIVE

C0 : CABIN CONVERTER NEGATIVE

H1 : HEATER INPUT

2.WIRE NO. & COLOR

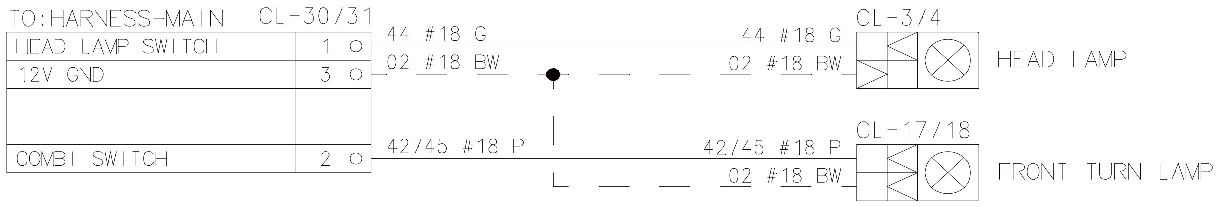
0:B 1:Br 2:R 3:Or 4:Y

5:G 6:L 7:Vi 8:Gr 9:W

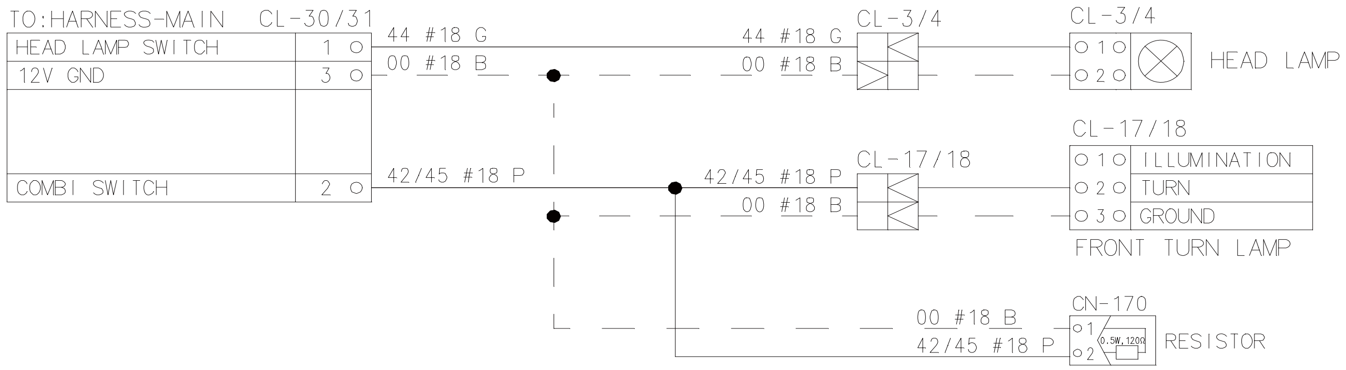
21FY-90770

·OHG (15BT-9U : #278~, 18BT-9U : #397~, 20BT-9U : #661~)

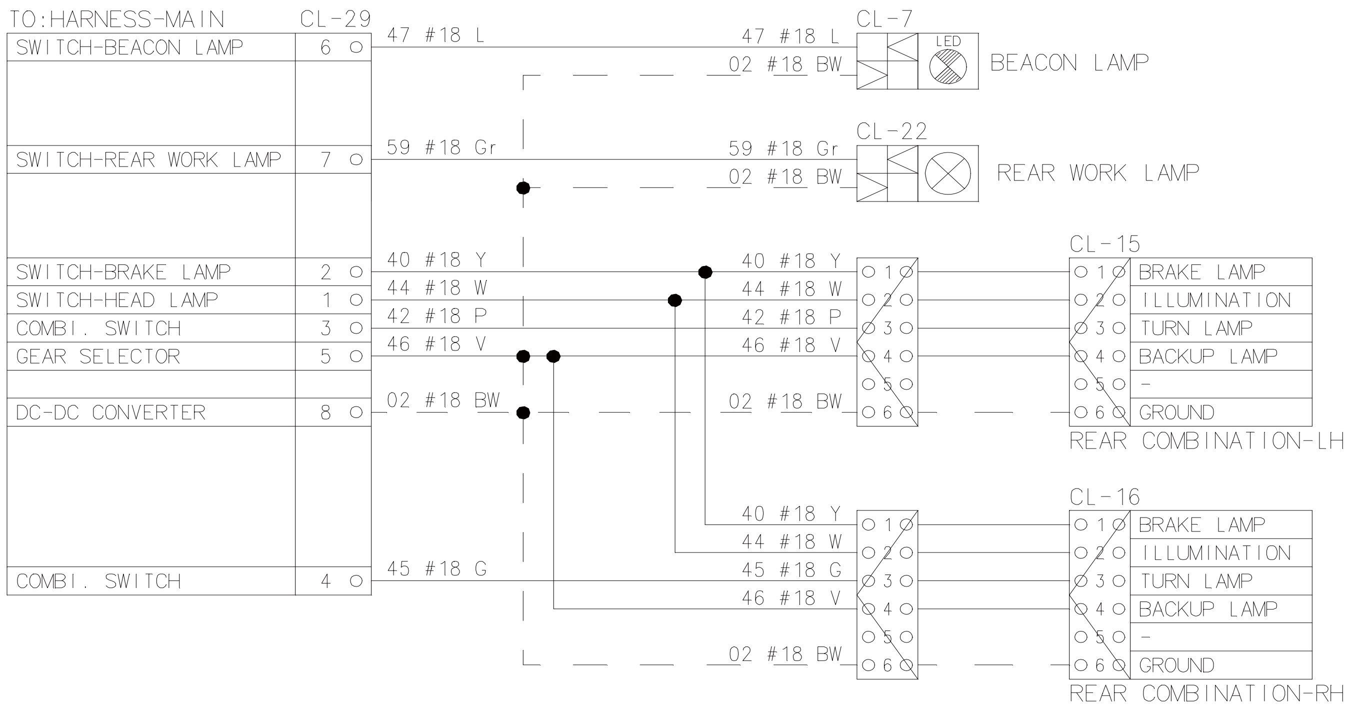
*ELEC.DIAGRAM OF HARNESS-FRONT LH/RH(HALLOGEN LAMP)

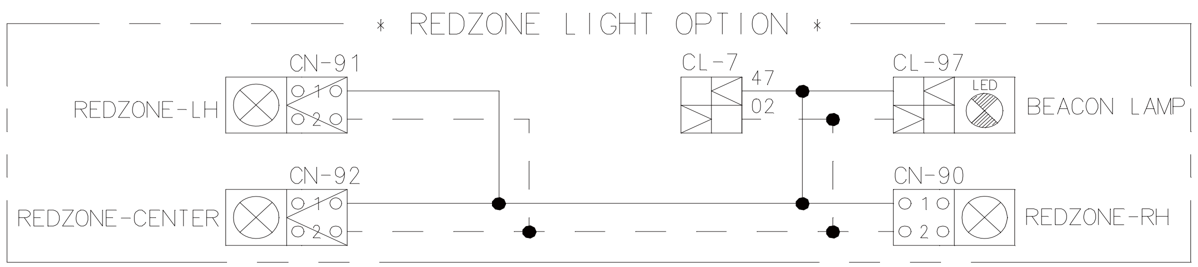


*ELEC.DIAGRAM OF HARNESS-FRONT LH/RH(LED LAMP)

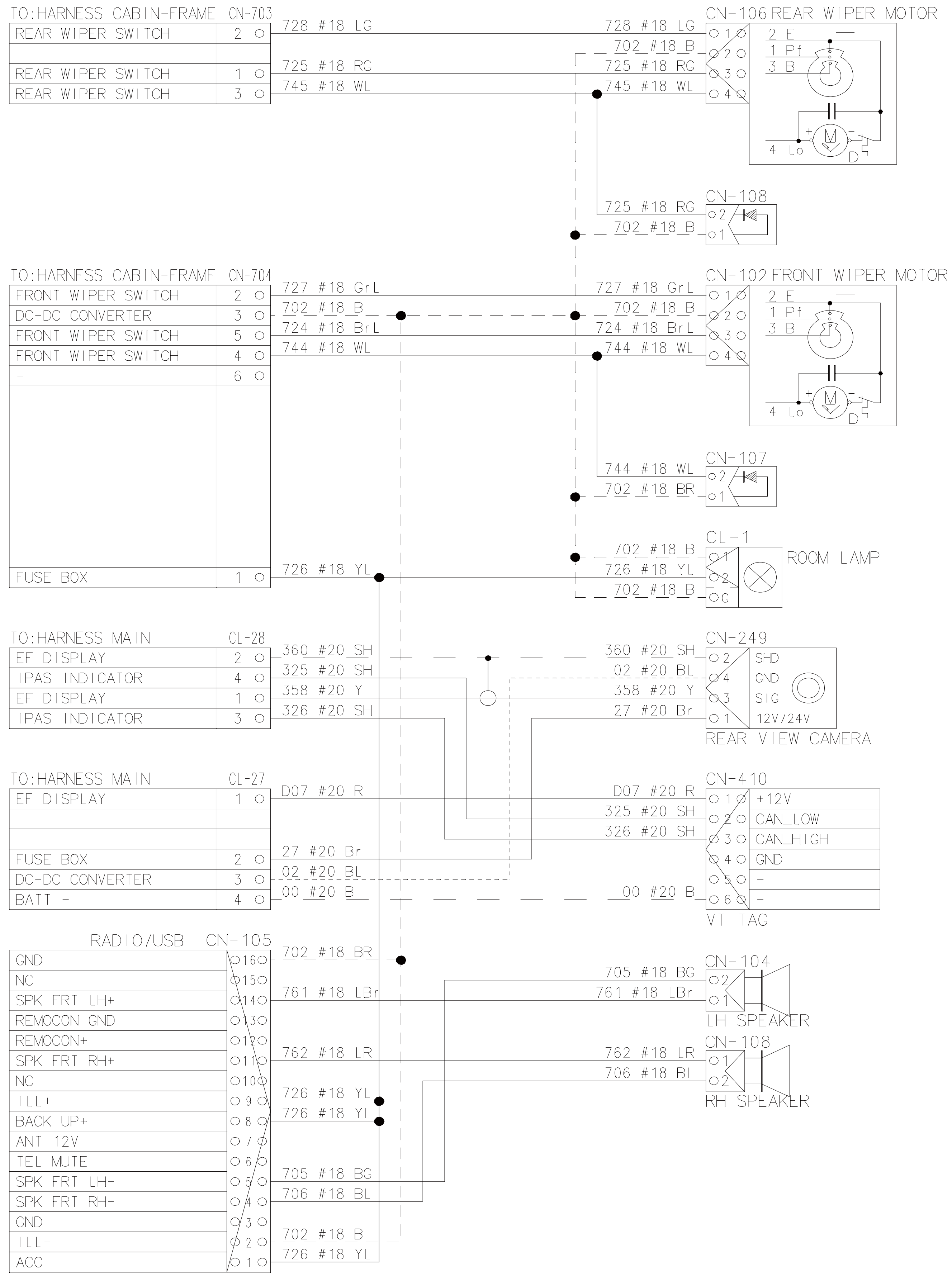


*ELEC.DIAGRAM OF HARNESS-REAR



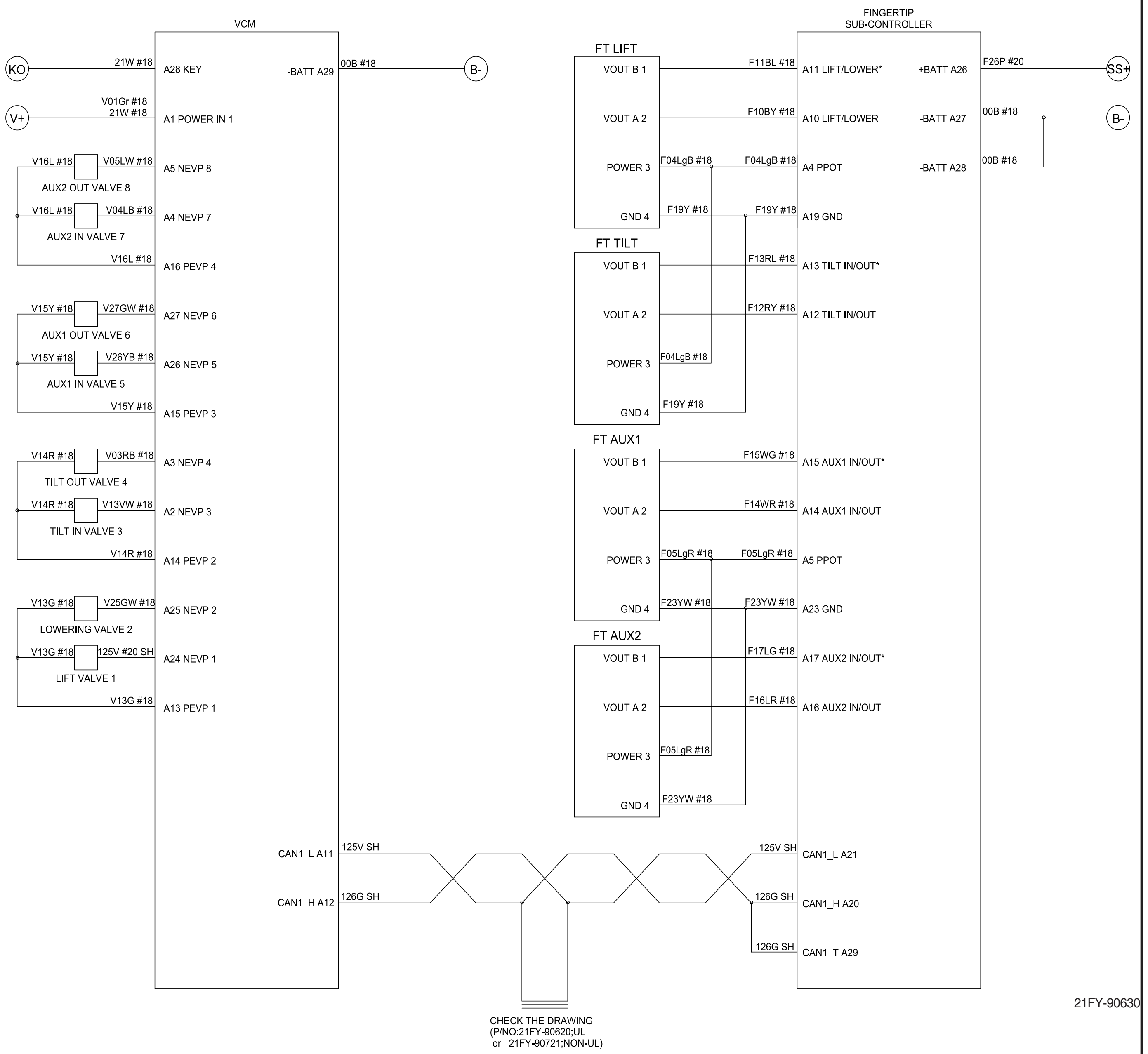


*ELEC.DIAGRAM OF HARNESS CABIN-OHG

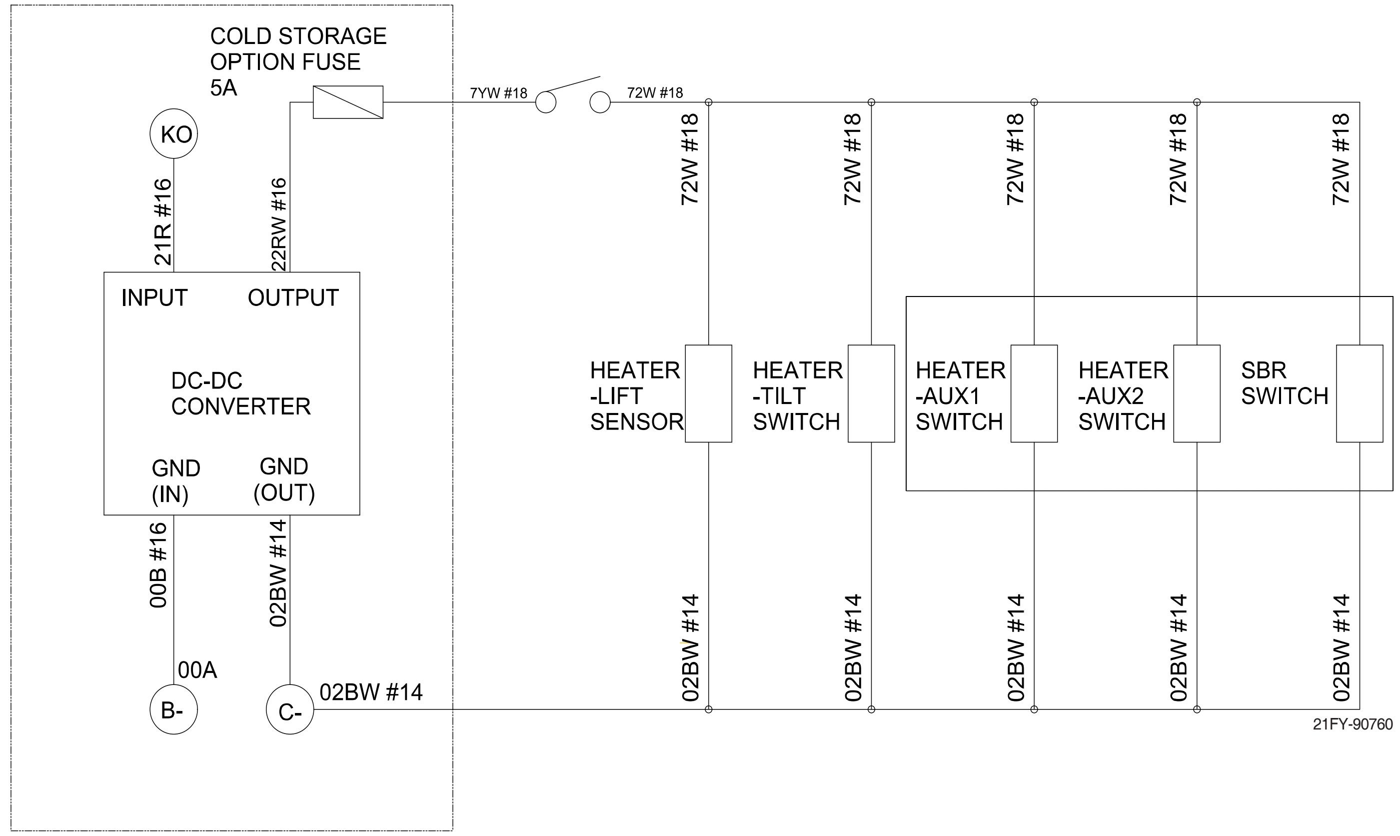


21FY-90960

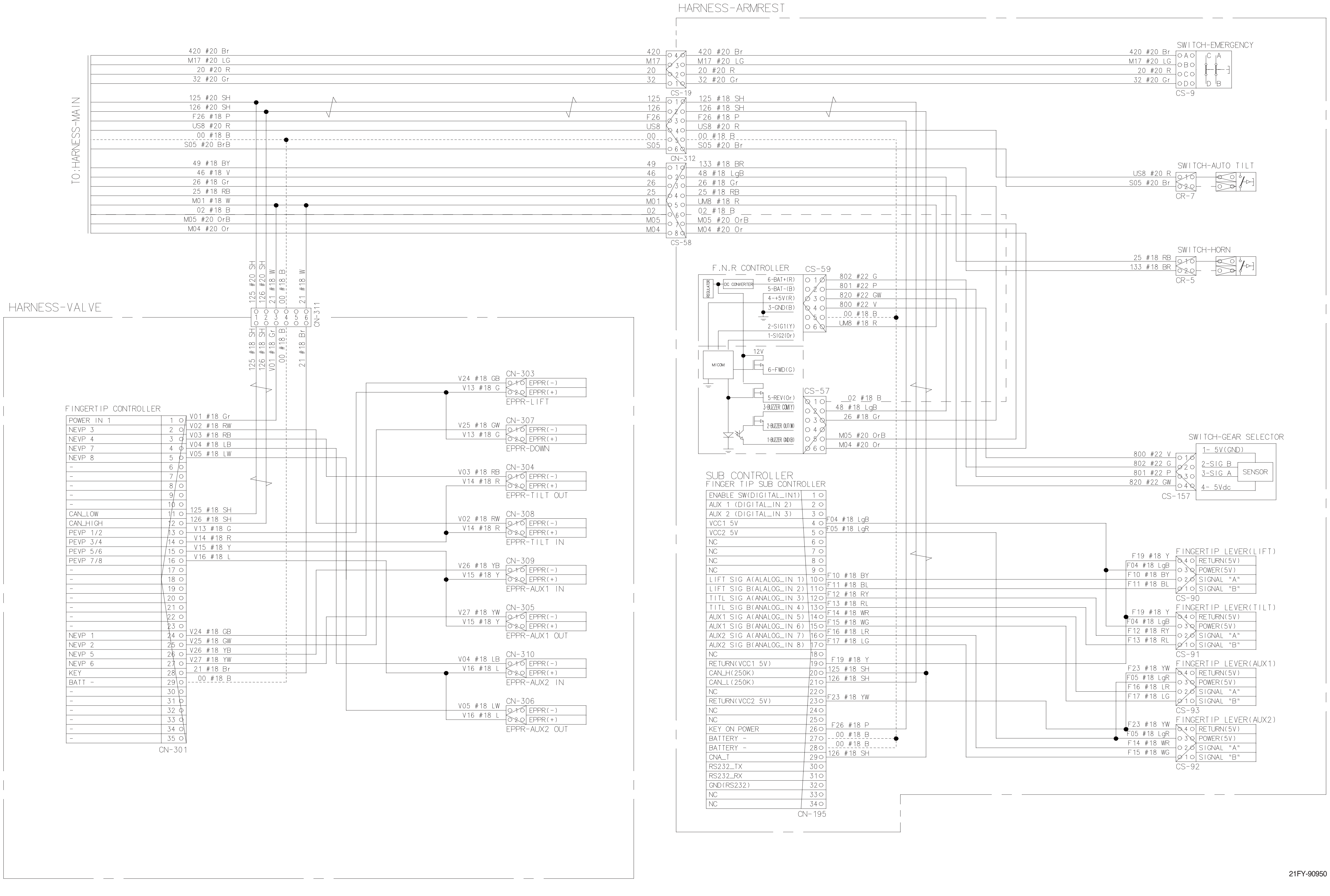
·FINGERTIP (15BT-9U : ~#277, 18BT-9U : ~#396, 20BT-9U : ~#660)



·COLD STORAGE (15BT-9U : ~#277, 18BT-9U : ~#396, 20BT-9U : ~#660)

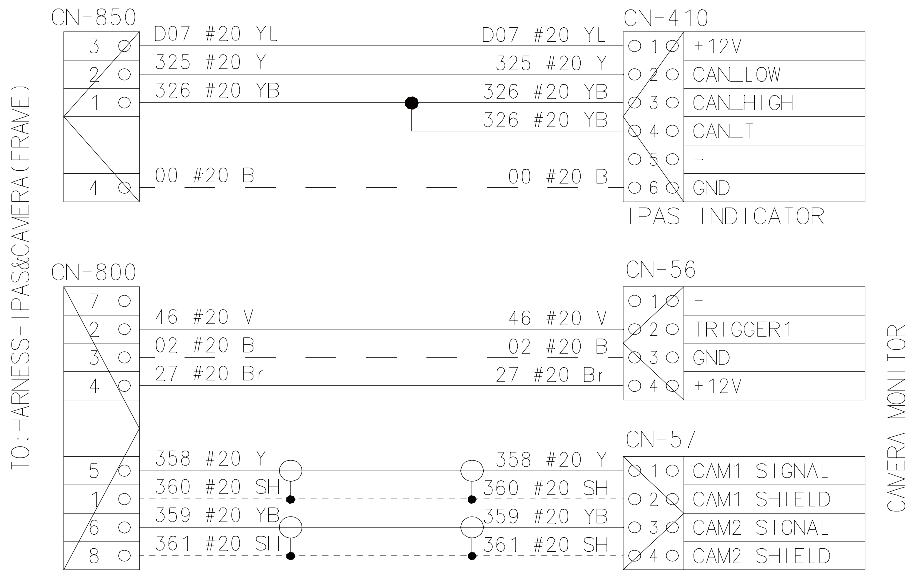


·FINGERTIP GROUP (15BT-9U : #278~, 18BT-9U : #397~, 20BT-9U : #661~)

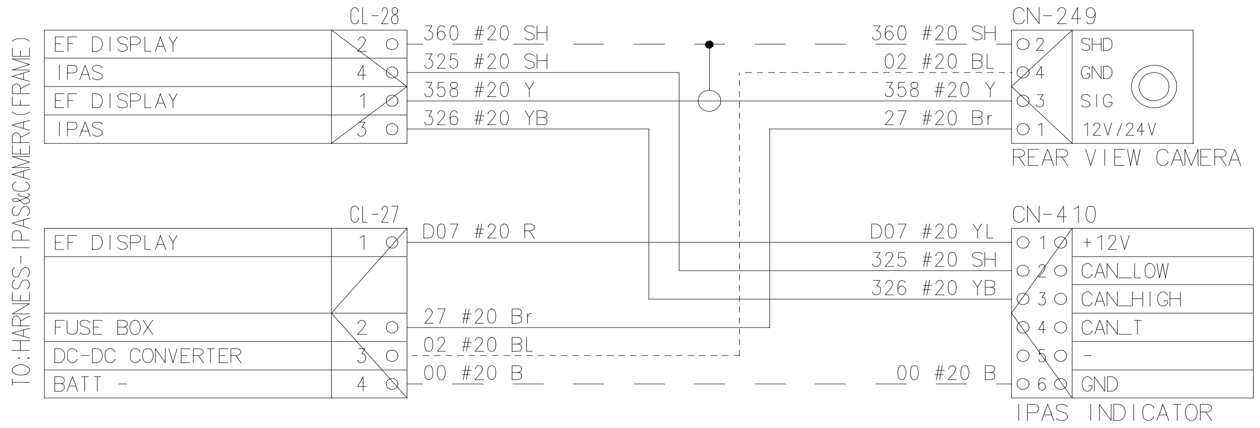


·OPTION (15BT-9U : #278~, 18BT-9U : #397~, 20BT-9U : #661~)

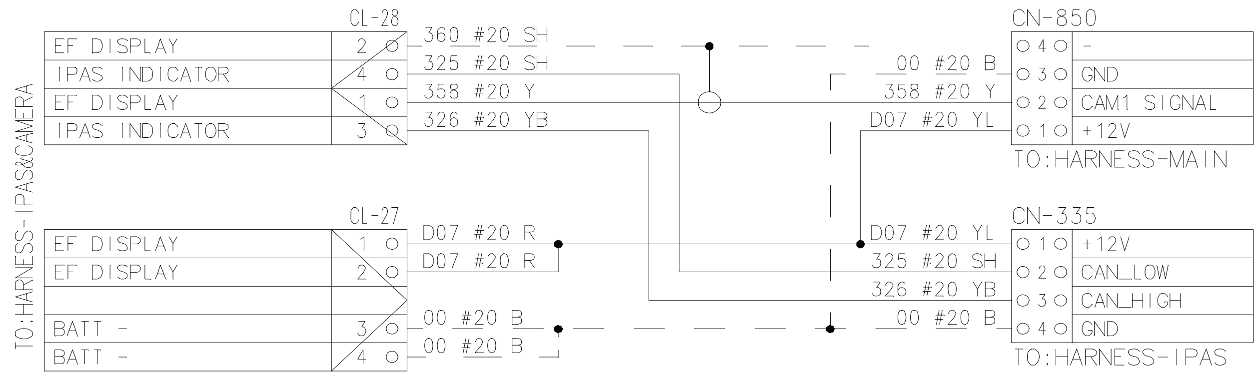
*ELEC.DIAGRAM OF HARNESS-MONITOR



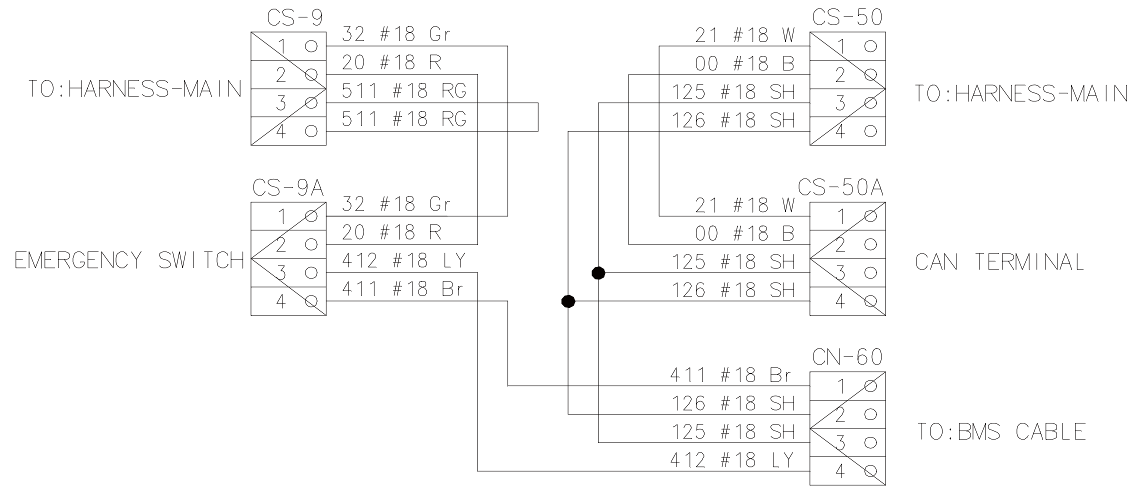
*ELEC.DIAGRAM OF HARNESS-IPAS&CAMERA



*ELEC.DIAGRAM OF HARNESS-IPAS&REAR CAMERA(FRAME)

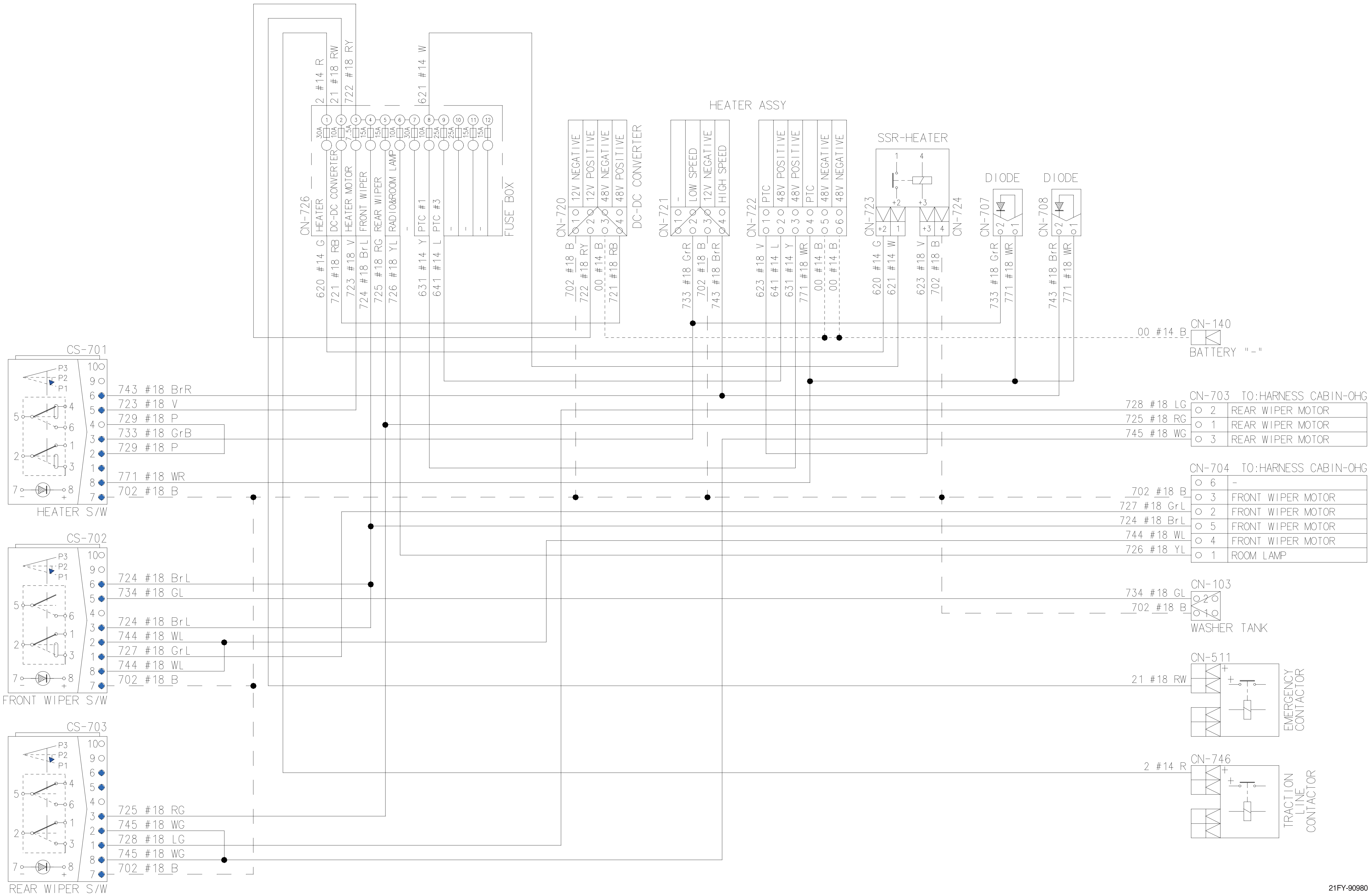


*ELEC.DIAGRAM OF HARNESS-BMS

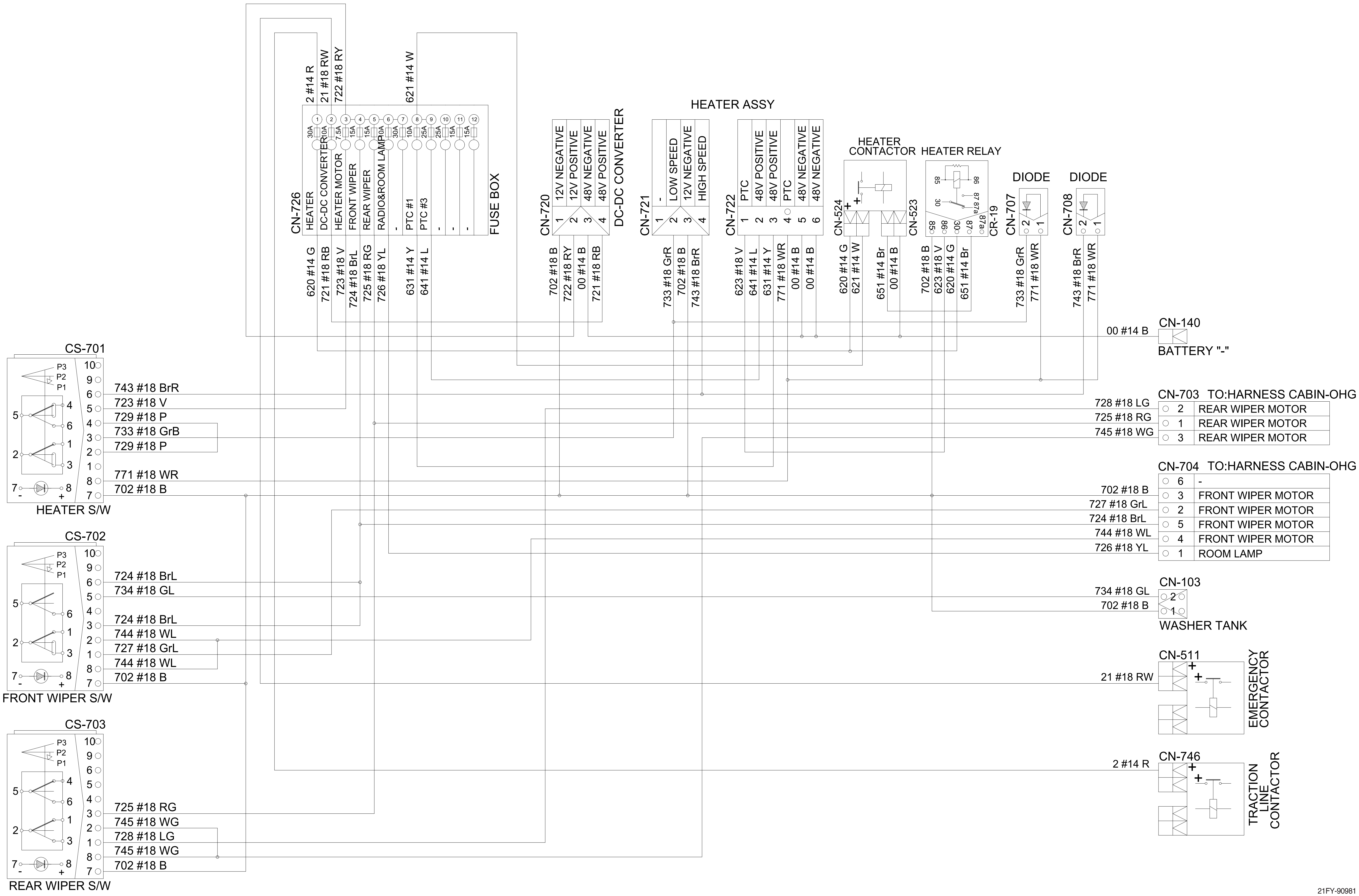


21FY-90970

·CABIN FRAME 1/2 (15BT-9U : #278~#408, 18BT-9U : #397~#602, 20BT-9U : #661~#1038)



·CABIN FRAME 2/2 (15BT-9U : #409~, 18BT-9U : #603~, 20BT-9U : #1039~)



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 and 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.

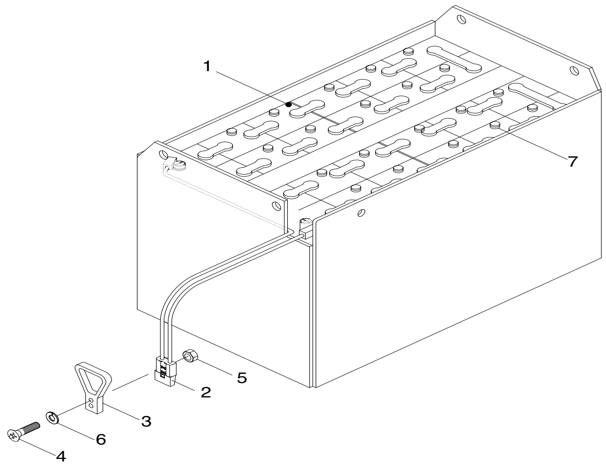
To drive the fork lift truck, a DRIVING CONTROL SYSTEM and some electric components such as direction change lever (forward/reverse section switch) and accelerator are required to select the driving direction and to control the speed of driving motor.

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, potentiometer 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

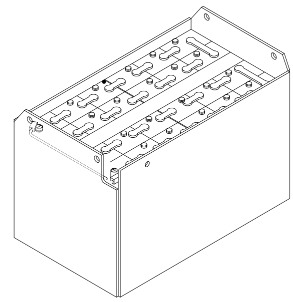


15BT9USM0702

1	Cells	4	Screw	6	Washer
2	Battery connector	5	Weld nut	7	Cap
3	Handle				

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.


15BT9USM0703

3) SPECIFICATION AND SERVICE DATA

Item	Unit	15TB-9	18/20BT-9
Type	-	Lead Acid	
Rated voltage	V	48	
Capacity(Option)	AH/hr	440(510)	510(585)
Electrolyte	-	WET	
Dimension (W×D×H)	mm	978×545×635	978×630×635
Connector	-	SB 350 or SR 350 (SBE 320)	
Weight	kg	850(STD)	1030(STD)

Fully charged specific gravity	1.280 (25°C)
End of discharge specific gravity	1.120 (25°C)
Discharge end voltage	48V
Electrolyte	Refined dilute sulfuric
Replenishment fluid	Refined (pure) water
Insulation resistance	1MΩ

4) SAFETY PRECAUTIONS

(1) When 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 an explosion.

(3) Never place metallic articles on the batteries

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

(4) Handling of charger

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

5) OPERATION PRECAUTIONS

(1) Avoid over-discharge

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

(2) Avoid over-charge

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

(3) Avoid excessive elevation of temperature

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

6) CHECKING

(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 decreases 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 (standard)

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 conditions 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 if it is 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 ×1.0~1.5" at the start of charging, and at the final stage it is "5 hour rate current ×0.15~0.25". Normally the charge is terminated within 8~12 hours automatically.

b. **Charging by constant current constant voltage automatic charger**

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

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

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

c. **Charging 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.

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.

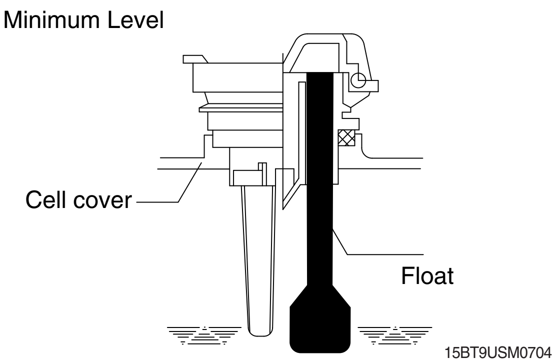
⑥ Replenishment of distilled water

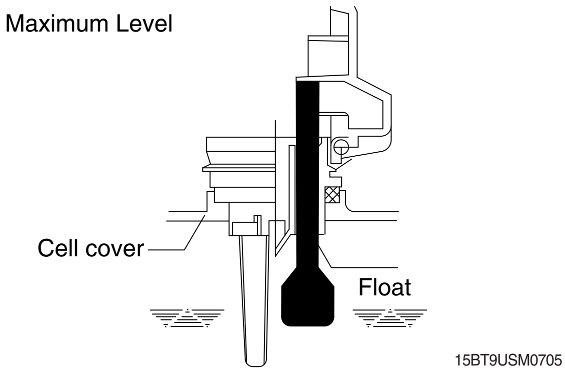
Only the water content of electrolyte is decreased due to electrolysis of distilled water during charge and natural evaporation. If a battery used with the electrolyte decreased excessively, plates will deteriorate resulting in markedly shortening of battery life. Be sure to check the electrolyte level 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 45 cc, 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 45 cc or less. Incidentally, distilled water replenishment should be made before charging to the content 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 distilled 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 from failure cell as well as all surrounding cells is with hand or electric drill (25 ㎜).

⚠ **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. Be sure to check the electrolyte level once every 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 away from room heaters or other heat generating sources. Clean, cool and dry place where no direct sunlight 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 0°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 distilled 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.

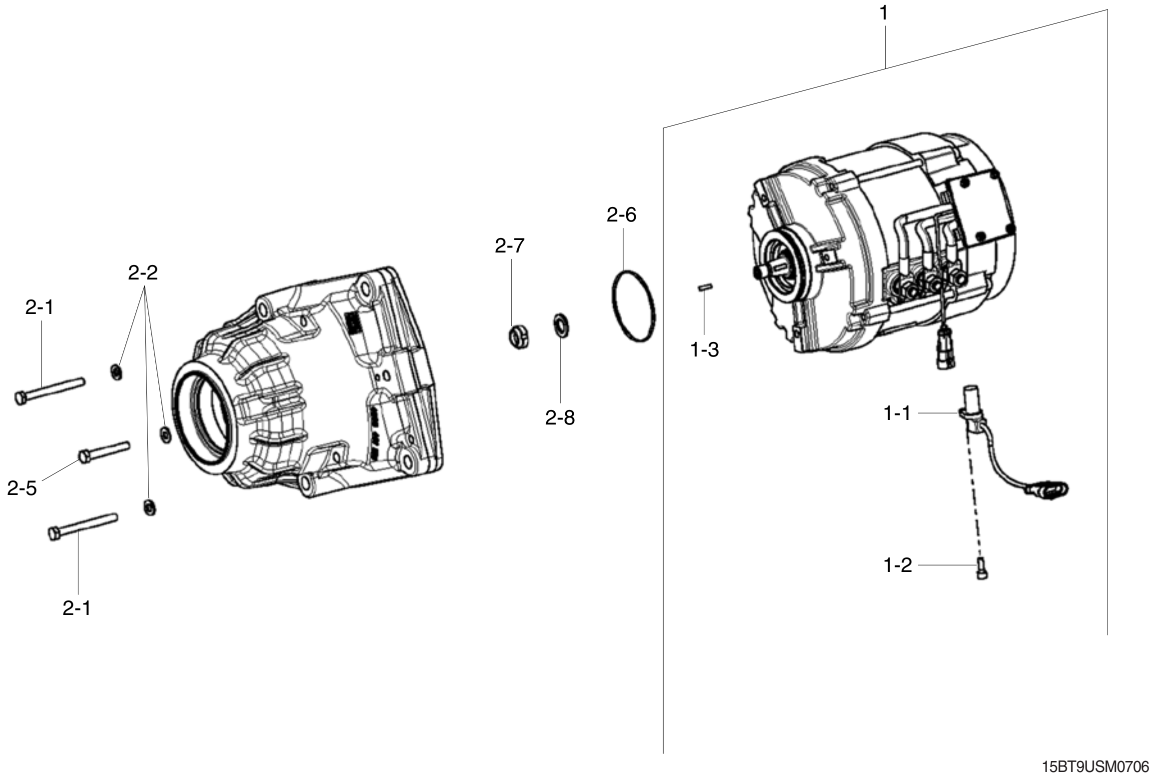
Contrarily if the temperature is high, especially if used at above 55°C, the battery life will be considerably shortened. Care must be taken so that the temperature during charge will be maintained at 55°C or lower. Even under unavoidable circumstances it should not exceed 55°C.

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 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



1	Motor	2	Assembly parts	2-6	O-ring
1-1	Sensor	2-1	Hexagon screw	2-7	Slotted nut
1-2	Cap screw	2-2	Washer	2-8	Washer
1-3	Woodruff Key	2-5	Hexagon screw		

2) SPECIFICATION

Item	Unit	Specification
Type	-	TSA200-100-269
Rated voltage	Vac	32
Rated output	kW	5.4×2
IP Grade	-	54

3) MAINTENANCE INSTRUCTION

※ Before starting the maintenance please disconnect the power supply.

(1) Ball bearing

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

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

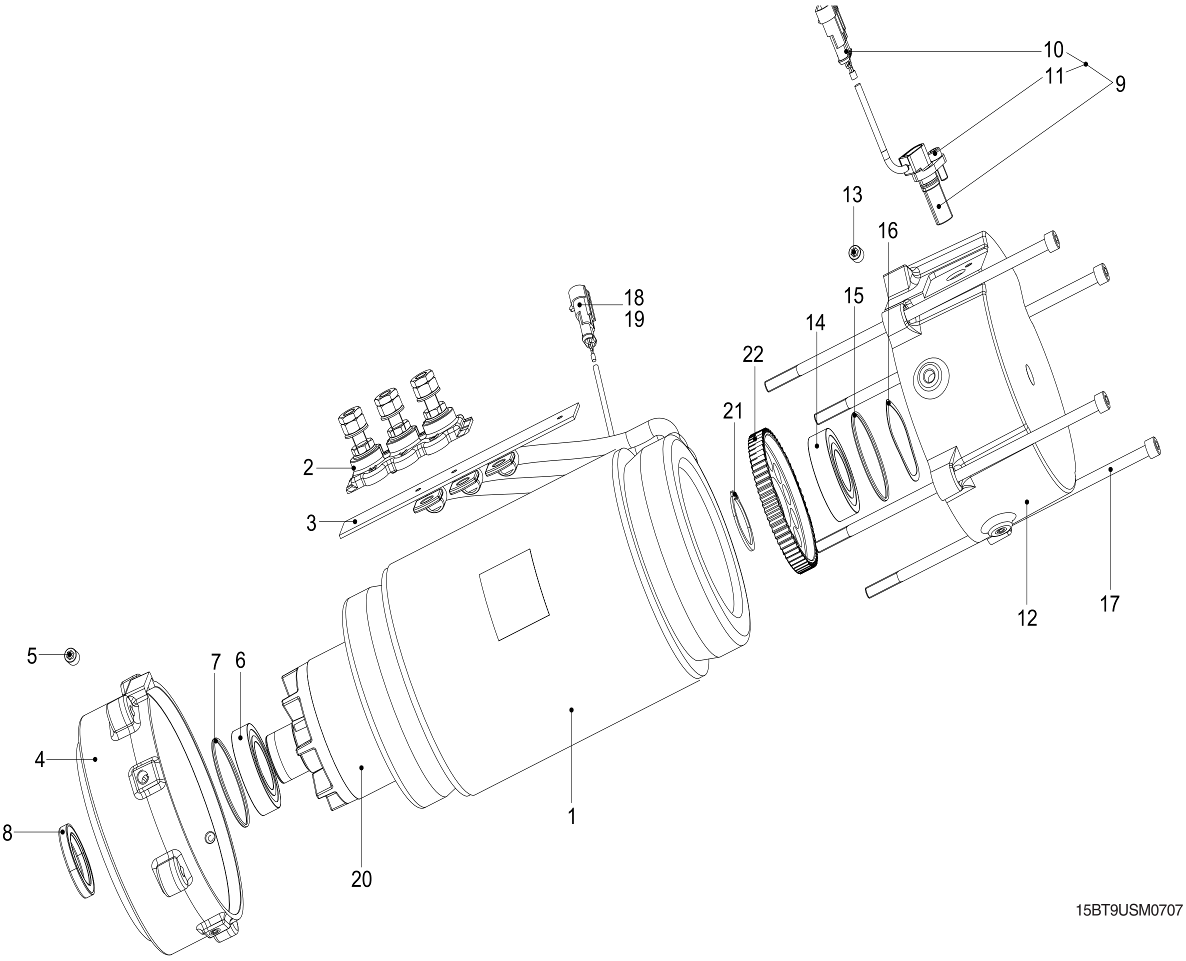
After approximately 10,000 operating hours the bearings have to be replaced.

(2) Disassembly and assembly

The motor is assembled and disassembled according to the relevant sectional drawing and part list. (See page 7-13)

4. PUMP MOTOR

1) STRUCTURE



1	Stator	9	KB sensor	16	Wavy-washer
2	Group terminal board	10	Group plug	17	Cyl. screw
3	Terminal base	11	Cyl. screw	18	Temp. sensor
4	Drive end shield	12	Commutator end plate	19	Group plug
5	Threaded pin	13	Threaded pin	20	Rotor
6	Ball bearing	14	Ball bearing	21	Circlip
7	O-ring	15	O-ring	22	Gear wheel sensor
8	Shaft seal				

2) SPECIFICATION

Item	Unit	Specification
Type	-	ABDD4002
Rated voltage	Vac	32
Rated output	kW	14.9
Insulation	-	Class F

3) INTERNAL INVOLUTE SPLINE DATA

Item	Unit	Specification
Flat root side fit	-	Class 7
No of teeth	EA	9
Spline pitch	mm	16/32
Pressure angle	Degree	30
Major diameter	mm	16.535
Form diameter	mm	15.977
Minor diameter	mm	12.9300
Pin diameter	mm	2.743

4) MAINTENANCE INSTRUCTION

※ Before starting the maintenance please disconnect the power supply.

(1) Ball bearing

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

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

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

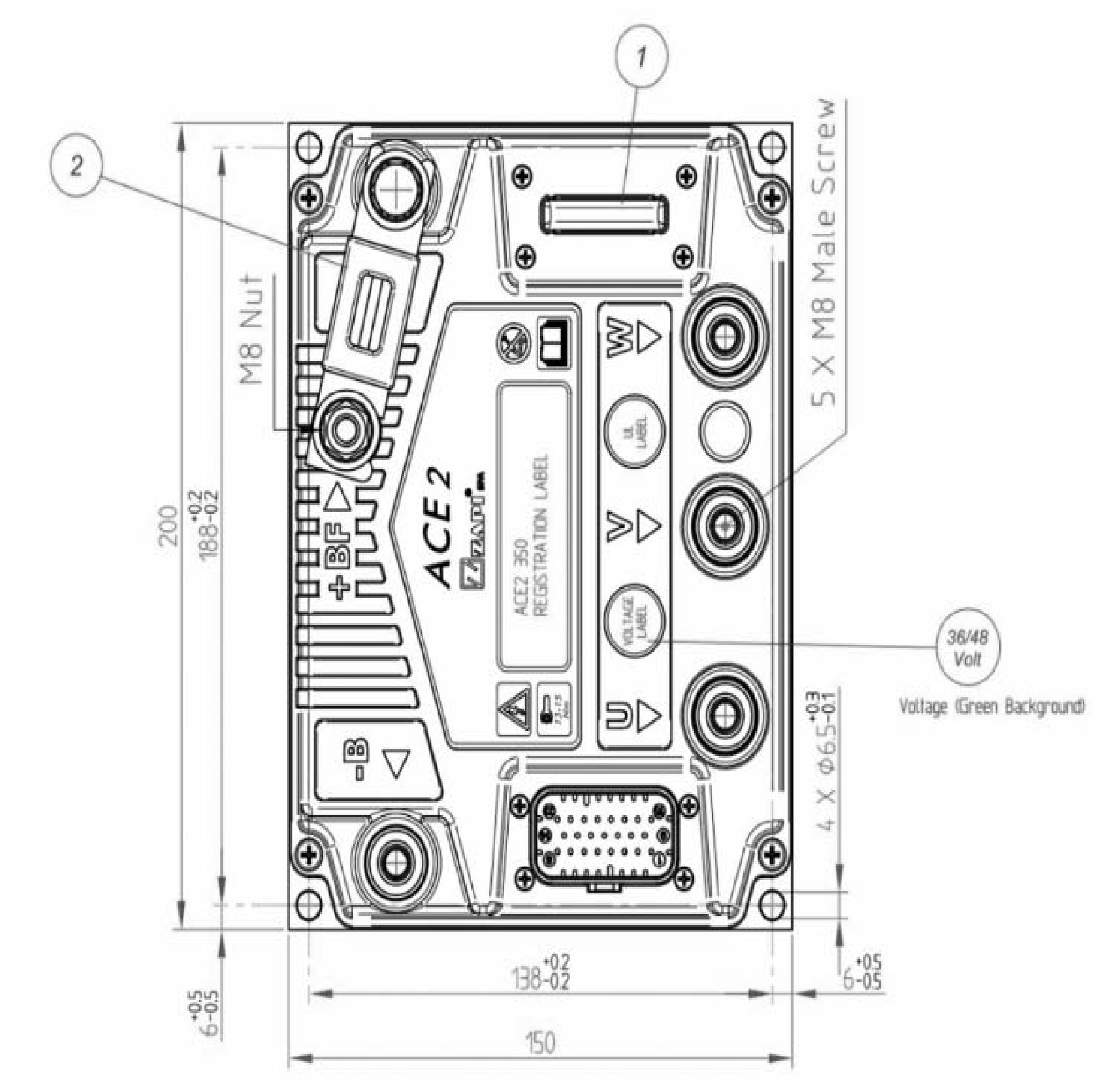
(2) Disassembly and assembly

The motor is assembled and disassembled according to the relevant sectional drawing and part list. (See page 7-15)

5. CONTROLLER SYSTEM

1) STRUCTURE

(1) Traction and Pump controller



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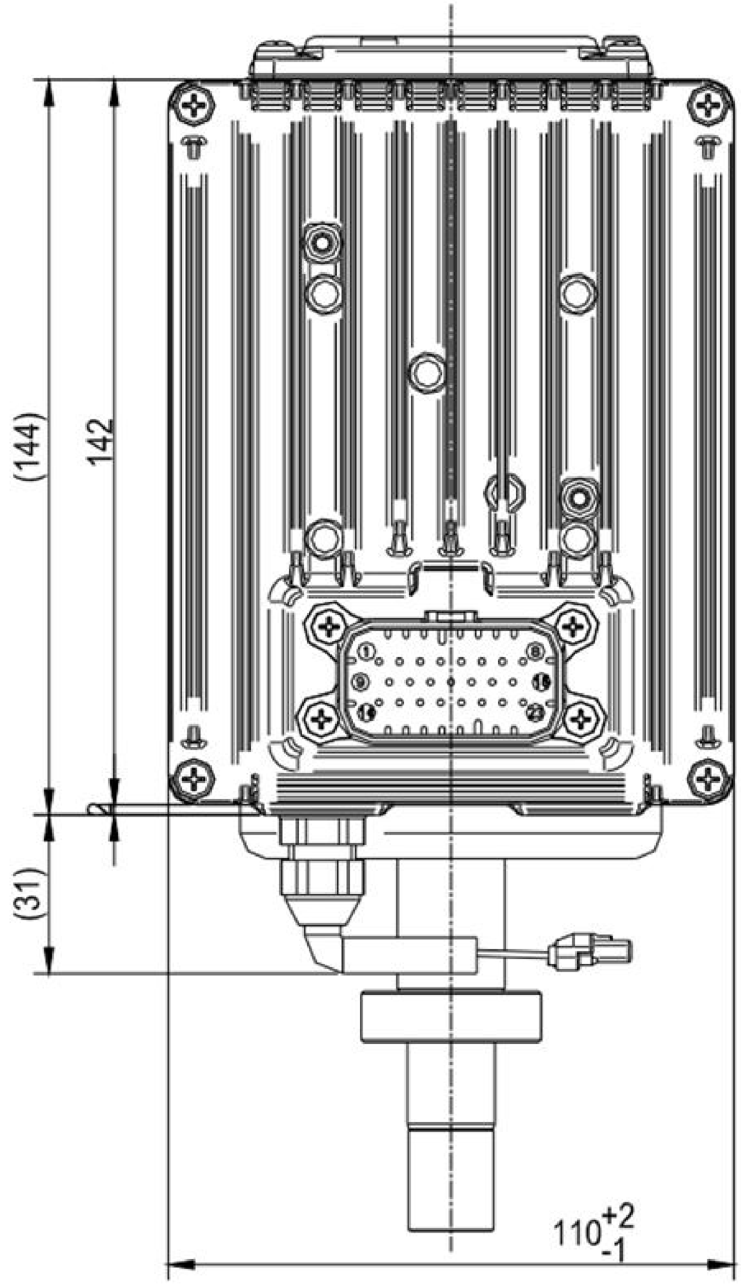
(2) EPS controller



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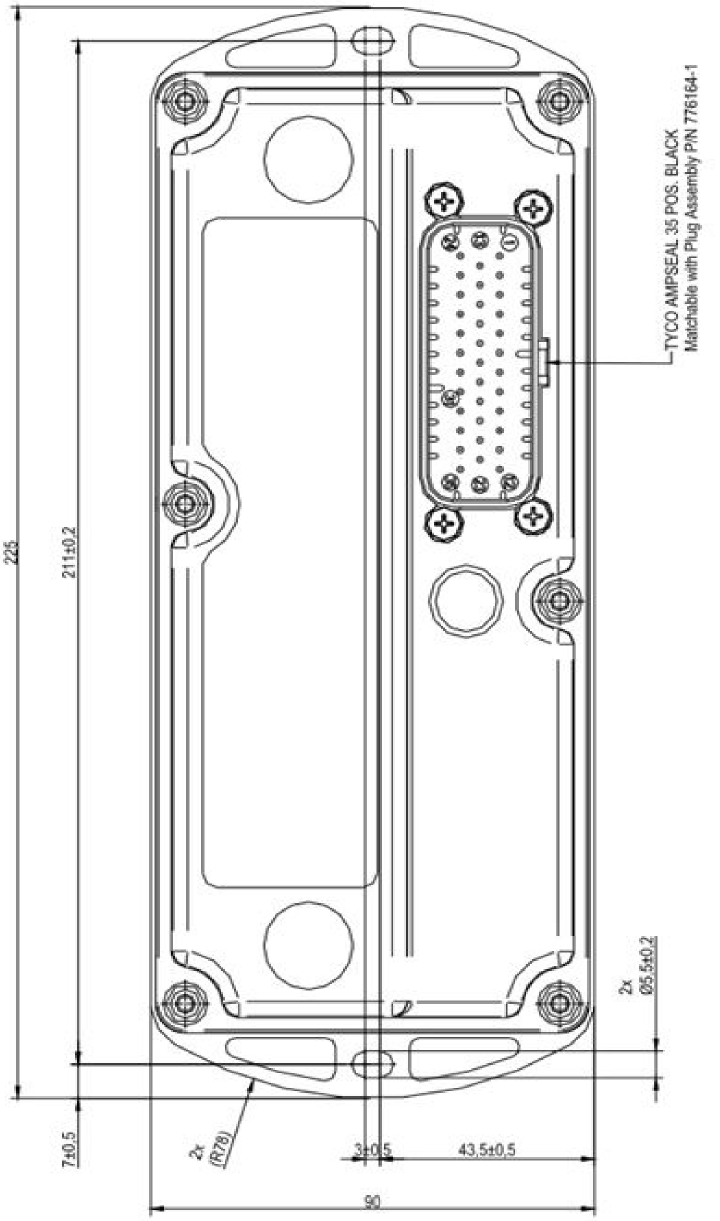
(3) VCM controller(option)



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※ Specifications

Model	Model	Application	Type	Power	Current limit
15/18/20BT-9U	ACE2 x 2	TRACTION	MOSFET	36-48V, 350A x2	350A/2min
	ACE2	PUMP	MOSFET	36-48V, 450A	450A/2min
	EPS ACW	EPS	MOSFET	36-48V, 70A	
	VCM RETAIL	FINGERTIP	MOSFET	36-48V	

2) OPERATIONAL FEATURES (Traction and Pump controller)

(1) Features

① Speed control

② Optimum behavior on a slope due to the speed feedback:
The motor speed follows the accelerator, starting a regenerative braking if the speed exceeds the set point.

③ Electrical stop on a ramp: the machine is electrically held on a slope for a programmable time.

④ Stable speed in every position of the accelerator.

⑤ Regenerative release braking based upon deceleration ramps.

⑥ Regenerative braking when the accelerator pedal is partially released (deceleration).

⑦ Direction inversion with regenerative braking based upon deceleration ramp.

⑧ Regenerative braking and direction inversion without contactors: only the main contactor is present.

⑨ The release braking ramp can be modulated by an analog input, so that a proportional brake feature is obtained.

⑩ Optimum sensitivity at low speeds.

⑪ Voltage boost at the start and with overload to obtain more torque (with current control).

⑫ The inverter settings can drive an electromechanical brake.

⑬ High efficiency of motor and battery due to high frequency commutations.

⑭ Double microcontroller for safety functions.

(2) Protection features

The ACE2 is protected against some controller injuries and malfunctions.

① Battery polarity inversion : It is necessary to fit a MAIN CONTACTOR to protect the inverter against reverse battery polarity and for safety reasons.

② Connection Errors : All inputs are protected against connection errors.

③ Voltage monitoring : Protected against battery undervoltage and overvoltage.

④ Thermal protection : If the controller temperature exceeds 85 °C, the maximum current is reduced in proportion to the thermal increase. The temperature can never exceed 105 °C.

⑤ External agents : The inverter is protected against dust and the spray of liquid to a degree of protection meeting IP65. Nevertheless, it is suggested to carefully study controller installation and position. With little simple shrewdness, the controller protection degree can be strongly increased.

⑥ Protection against uncontrolled movements :
The main contactor will not close if:
- The Power unit is not working.
- The Logic board doesn't work perfectly.
- The output voltage of the accelerator does not fall below the minimum voltage value stored, with 1 V added.
- Running microswitch in closed position.
- Low battery charge

When the battery charge is low, the maximum current is reduced to the half of the maximum current programmed.

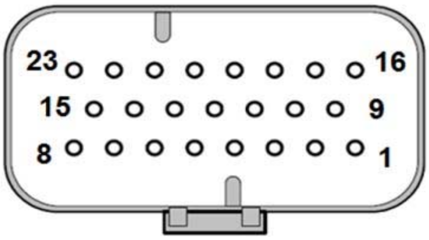
⑦ Protection against accidental start up : A precise sequence of operations are necessary before the machine will start. Operation cannot begin if these operations are not carried out correctly.

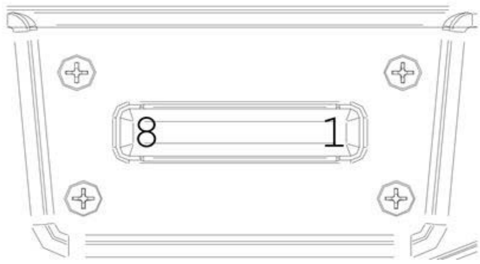
⑧ Requests for drive must be made after closing the key switch.

3) DESCRIPTION OF THE CONNECTORS

(1) Traction and pump controller

ACE2 is equipped with a 23-poles Ampseal connector like that of the figure. Each of the 23 pins is referred to as “A#”, where “A” denotes the connector name and “#” is the pin number, from 1 to 23.





15BT9USM0711

① Traction controller (Right)

Pin	Function	Description
A1	KEY	Input of the key switch signal.
A2	5V	Positive supply for the accelerator pedal. (+5V 100mA maximum).
A3	CPOT	Analog input of the accelerator pedal 1 signal. (0 – 5 V).
A4	FWD	Digital input, active when connected to +5V. The default function is as FORWARD request; closing this input the truck moves forward.
A5	BWD	Digital input, active when connected to +5V. The default function is as BACKWARD request; closing this input the truck moves backward.
A6	CPOT	Analog input. It is used for the brake pedal 2 request. (0 – 5 V).
A7	ENCA	Channel A of the incremental encoder of right traction motor.
A8	PENC	Positive supply for the encoder of right traction motor. (+5 V, 150 mA maximum)
A10	CPOT	Analog input. It is used for the brake pedal 1 request. (0 – 5 V).
A11	CANL	Low-level signal of CAN bus interface 2.
A12	CANH	High-level signal of CAN bus interface 2.
A13	CPOT	Analog input of the accelerator pedal 2 signal. (0 – 5 V).
A14	ENCB	Channel B of the incremental encoder of right traction motor.
A15	GND	Negative supply for the encoder and the accelerator pedal.
A16	NMC	Output of the main-contactor driver (driving to -B); PWM voltage controlled; 1.5A maximum continuous current.
A17	PCOM	Connect the positive supply of coils (MC, EB) to this pin.
A18	NEB	Output of the electromechanica brake driver(driving to -B). PWM voltage controlled. 1.5A maximum continuous current.

Pin	Function	Description
A19	SEAT	Digital input, active when connected to +B. It is used for SEAT input.
A20	CANL	Low-level signal of CAN bus interface 1.
A21	CANH	High-level signal of CAN bus interface 1.
A22	THMOT	Positive terminal for the right motor thermal sensor. The internal pull-up is a fixed 2 mA current source (max 5 V).
A23		Negative terminal for the right traction motor thermal sensor.
B1	PCLRXD	Positive serial reception.
B2	NCLRXD	Negative serial reception.
B3	PCLTXD	Positive serial transmission.
B4	NCLTXD	Negative serial transmission.
B5	GND	Negative console power supply.
B6	+12	Positive console power supply.
B7	FLASH	It must be connected to pin 8 for the Flash memory programming.
B8	FLASH	It must be connected to pin 7 for the Flash memory programming.

② Traction controller (Left)

Pin	Function	Description
A1	KEY	Input of the key switch signal.
A3	CPOT	Analog input of the auto tilt leveling sensor 1. (0 – 5 V).
A4	BRAKE OIL	Digital input, active when connected to +5V. The function is as BRAKE OIL request.
A5	TILT LEVEL	Digital input, active when connected to +5V. The function is as TILT LEVELING request.
A6	CPOT	Analog input of the load sensor signal. (0 – 5 V).
A7	ENCA	Channel A of the incremental encoder of left traction motor.
A8	PENC	Positive supply for the encoder of left traction motor. (+5 V, 150 mA maximum)
A9	NAUX	Output of fan relay-coil driver (driving to -B); PWM voltage controlled; 2 A maximum continuous current.
A11	CANL	Low-level signal of CAN bus interface 2.
A12	CANH	High-level signal of CAN bus interface 2.
A13	CPOT	Analog input of the auto tilt leveling sensor 2. (0 – 5 V).
A14	ENCB	Channel B of the incremental encoder of left traction motor.
A15	GND	Negative supply for the encoder and auto tilt leveling sensor.
A17	PCOM	Connect the positive supply of coils (EB, fan relay) to this pin.
A18	NEB	Output of the electromechanical-brake driver (driving to -B); PWM voltage controlled; 1.5A maximum continuous current.

Pin	Function	Description
A19	SBR	Digital input, active when connected to +B. It is used for SBR input.
A20	CANL	Low-level signal of CAN bus interface 1.
A21	CANH	High-level signal of CAN bus interface 1.
A22	THMOT	Positive terminal for the left traction motor thermal sensor. The internal pull-up is a fixed 2 mA current source (max 5 V).
A23		Negative terminal for the left traction motor thermal sensor.
B1	PCLRXD	Positive serial reception.
B2	NCLRXD	Negative serial reception.
B3	PCLTXD	Positive serial transmission.
B4	NCLTXD	Negative serial transmission.
B5	GND	Negative console power supply.
B6	+12	Positive console power supply.
B7	FLASH	It must be connected to pin 8 for the Flash memory programming.
B8	FLASH	It must be connected to pin 7 for the Flash memory programming.

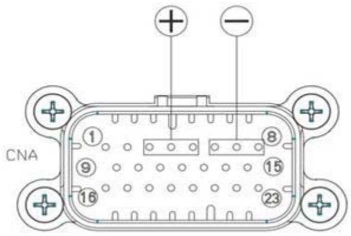
③ Pump controller

Pin	Function	Description
A1	KEY	Input of the key switch signal.
A3	CPOT	Analog input of the lift sensor. (0 – 5 V).
A4	AUX1	Digital input, active when connected to +5V. The function is as AUX1 request.
A5	AUX2	Digital input, active when connected to +5V. The function is as AUX2 request.
A7	ENCA	Channel A of the incremental encoder of pump motor.
A8	PENC	Positive supply for the encoder of pump motor. (+5 V, 150 mA maximum)
A9	NAUX	Output of MCV solenoid-coil driver (driving to -B); PWM voltage controlled; 2 A maximum continuous current.
A10	CPOT	Analog input. It is used for the tilt s/w request. (0 – 5 V).
A11	CANL	Low-level signal of CAN bus interface 2.
A12	CANH	High-level signal of CAN bus interface 2.
A14	ENCB	Channel B of the incremental encoder of pump motor.
A15	GND	Negative supply for the encoder and lift sensor.
A17	PCOM	Connect the positive supply of coils (MCV solenoid) to this pin.
A19	LIFT CB	Digital input, active when connected to +B. It is used for LIFT CBUTBACK input.
A20	CANL	Low-level signal of CAN bus interface 1.

Pin	Function	Description
A21	CANH	High-level signal of CAN bus interface 1.
A22	THMOT	Positive terminal for the right motor thermal sensor. The internal pull-up is a fixed 2 mA current source (max 5 V).
A23		Negative terminal for the right traction motor thermal sensor.
B1	PCLRXD	Positive serial reception.
B2	NCLRXD	Negative serial reception.
B3	PCLTXD	Positive serial transmission.
B4	NCLTXD	Negative serial transmission.
B5	GND	Negative console power supply.
B6	+12	Positive console power supply.
B7	FLASH	It must be connected to pin 8 for the Flash memory programming.
B8	FLASH	It must be connected to pin 7 for the Flash memory programming.

(2) EPS controller

23 poles AMPSEAL connector (CNA) assignment.



15BT9USM0712

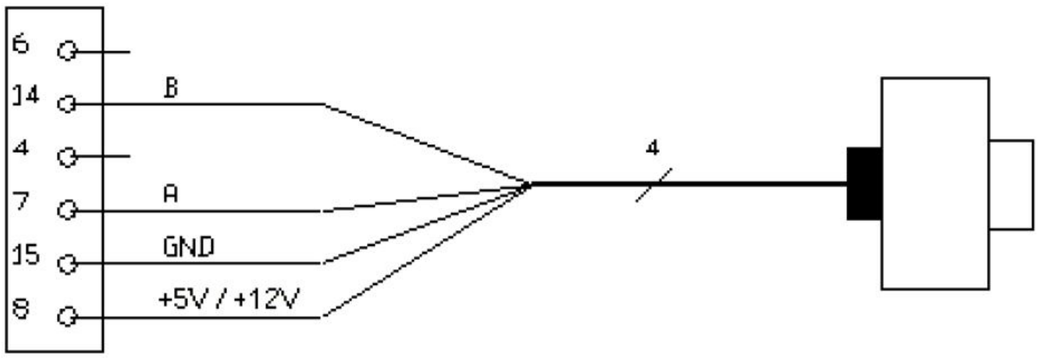
Pin	Function	Description
A3	PBATT	PBATT power connection
A4	PBATT	PBATT power connection
A5	PBATT	PBATT power connection
A6	NBATT	NBATT power connection
A7	NBATT	NBATT power connection
A8	NBATT	NBATT power connection
A9	PCOILS	Overload and short-circuit protected positive breaker for coils. A9 makes and takes Vbatt: 2Adc max @ Vbatt<=48V.
A10	NCOIL	Overload and short-circuit protected negative breaker for a proportional coil. A10 is a PWMout: 1.3Adc max @ Vbatt<=48V
A14	PCOIL2	Short-circuit protected positive breaker for a proportional coil. Cascaded with A9. A14 is a PWMout: 0.7Adc max @ Vbatt<=48V
A15	KEY IN	Key input (Logic Supply input)

Pin	Function	Description
A16	GND	GND. NBATT logic reference
A17	CPOC2	2nd triangle wave shape PWM 5% to 95% or analog signal in the range 0.5V to 4.5V
A19	GND	GND. NBATT logic reference
A20	CPOC1	1st triangle wave shape PWM 5% to 95% or analog signal in the range 0.5V to 4.5V
A21	VDD	5Vdc 50mA supply output (PPOC positive supply for CPOC1-2)
A22	CANL1	CAN Bus channel LOW (No 120 termination aboard)
A23	CANH1	CAN Bus channel HIGH (No 120 termination aboard)

(3) Connection of encoder(Traction and Pump)

ACE2 can handle different types of encoder. To control AC motor, it is necessary to install an incremental encoder with 2 phases shifted by 90°. The encoder supply can be 5 V or 12 V. For special applications it is possible to install incremental encoder with zero-position signal.

- A 8 : +5V/+12V : encoder positive power supply.
- A15 : GND : encoder negative supply.
- A 7 : ENC A : encoder phase A.
- A14 : ENC B : encoder phase B.



15BT9USM0713

4) Function configuration

Using the CONFIG MENU of the programming smart console, or using a display, the user can configure the following functions.

(1) Right traction inverter

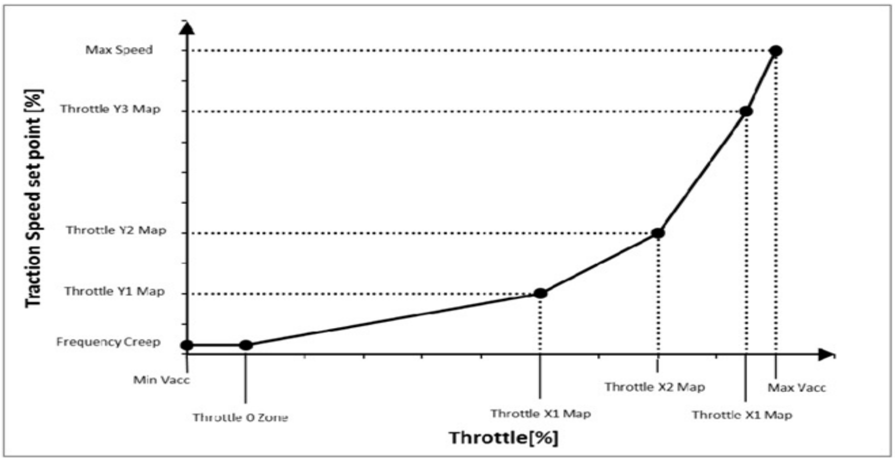
① Set option

SET OPTIONS	DESCRIPTION
HOUR COUNTER	This option specifies the hour counter mode. It can be set one of two: - RUNNING: The counter registers travel time only - KEY ON: The counter registers when the "key" switch is closed
BATTERY CHECK	This option specifies the management of the low battery charge situation. There are four levels of intervention: - 0 : nothing happens; the battery charge level is evaluated but ignored, meaning that no action is taken when the battery runs out. - 1 : The BATTERY LOW alarm occurs when the battery level is evaluated to be lower or equal to 10% of the full charge. With the BATTERY LOW alarm, the control reduces the maximum speed down and it also reduces the maximum current down to 50% of the full current. - 2 : The BATTERY LOW alarm occurs when the battery level is evaluated to be lower or equal to 10% of the full charge. - 3 : The BATTERY LOW alarm occurs when the battery level is evaluated to be lower or equal to 10% of the full charge. With the BATTERY LOW alarm, the control reduces the maximum speed down.

SET OPTIONS	DESCRIPTION
STOP ON RAMP	- ON : The stop on ramp feature (truck electrically hold on a ramp) is managed for a fixed time (6 sec.). - OFF : The stop on ramp feature is not performed.
SET MOT.TEMPERAT	This parameter defines the type of motor temperature sensor adopted. - NONE = no motor thermal sensor is connected. - DIGITAL : A digital (ON/OFF) motor thermal sensor is connected to A23. - OPTION#1 : An analog motor thermal sensor is connected to A23. The temperature sensor is a KTY 84-130 PTC (positive thermal coefficient resistance). - OPTION#2 : An analog motor thermal sensor is connected to A23. The temperature sensor is a KTY 83-130 PTC (positive thermal coefficient resistance). - OPTION#3 : An analog motor thermal sensor is connected to A23. The temperature sensor is a PT1000 PTC (positive thermal coefficient resistance).
EM.BRAKE FUNCT.	This parameter enables or disables the output NEB A18, dedicated to the electromechanical brake: NONE = diagnoses are masked and E.B. is not driven upon a traction request. BRAKE = E.B. is driven upon a traction request if all the related diagnoses pass. The behavior on a slope depends on the STOP ON RAMP setting. Do not use this setting if the electromechanical brake is not really present.
STEER TABLE	This parameter is used to set the correct steering table. - OPTION #1 : The steering table is the one for 3 wheels truck. - OPTION #2 : The steering table is the one for 4 wheels truck.
LOAD SENSOR	- OFF : Load Sensing Function is deactivated - ON : Load Sensing Function is activated.
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.
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.

SET OPTIONS	DESCRIPTION
BMS	This option set the communication check between traction and Li-ion Battery Management System. - ON : using BMS with Lithium Battery - OFF : not using BMS with Lithium Battery
RS232 CONSOLE	This parameter enables or disables the console to change settings.

② **Adjustments**

ADJUSTMENTS	DESCRIPTION
THROTTLE 0 ZONE	This parameter defines a dead band in the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE X1 MAP	This parameter defines the acclerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE Y1 MAP	This parameter defines the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE X2 MAP	This parameter defines the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE Y2 MAP	This parameter defines the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE X3 MAP	This parameter defines the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE Y3 MAP	This parameter defines the accelerator input curve. - Accelerator input curve  The speed remains at the FREQUENCY CREEP value as long as the voltage from the accelerator potentiometer is below THROTTLE 0 ZONE. Basically this defines a dead zone close to the neutral position.
BAT. MIN ADJ.	After key on, the controller uses the following parameters to detect the BDI%. BAT. MIN ADJ. : using after key on. (discharged battery level) BAT. MAX ADJ. : using after key on. (charged battery level)
BAT. MAX ADJ.	
BDI ADJ STUP MIN	At key on, the controller uses the following parameters to detect the new BDI%. BDI ADJ STUP MIN : using at key on. (discharged battery level) BDI ADJ STUP MAX : using at key on. (charged battery level)
BDI ADJ STUP MAX	
BDI RESET	If the difference between the old BDI% and new BDI% is less than BDI RESET, the BDI% is not changed to new BDI%. BDI RESET : using the old BDI% is over 30% before key off. BDI RESET 2 : using the old BDI% is less than 30%(from 29% to 0%) before key off.
BDI RESET 2	

ADJUSTMENTS	DESCRIPTION
MOTOR HIGH TEMP	This parameter defines the motor temperature above which a cutback is applied. Cutback is valid only during motoring, while during braking the 100% of the maximum current is always available independently by the temperature.
MOT.SHUTDOWN TEM	This parameter defines the maximum motor temperature permitted, above which the controller stops driving the motor.
REF. LOAD WEIGHT	(This parameter is used for that LOAD SENSOR is ON) This parameter is used to show and configurate the reference load weight.
OVERLOAD WEIGHT	(This parameter is used for that LOAD SENSOR is ON) 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 according to OVERLOAD TYPE paramter.
MAX LOAD WEIGHT	(This parameter is used for that LOAD SENSOR is ON) This parameter is used to show and configurate the maximum load weight.
LOAD SPEED UPD.	(This parameter is used for that LOAD SENSOR is ON) To increase accuracy, Load Sensor only works when the traction motor speed is lower than as set in this parameter.

③ Parameter

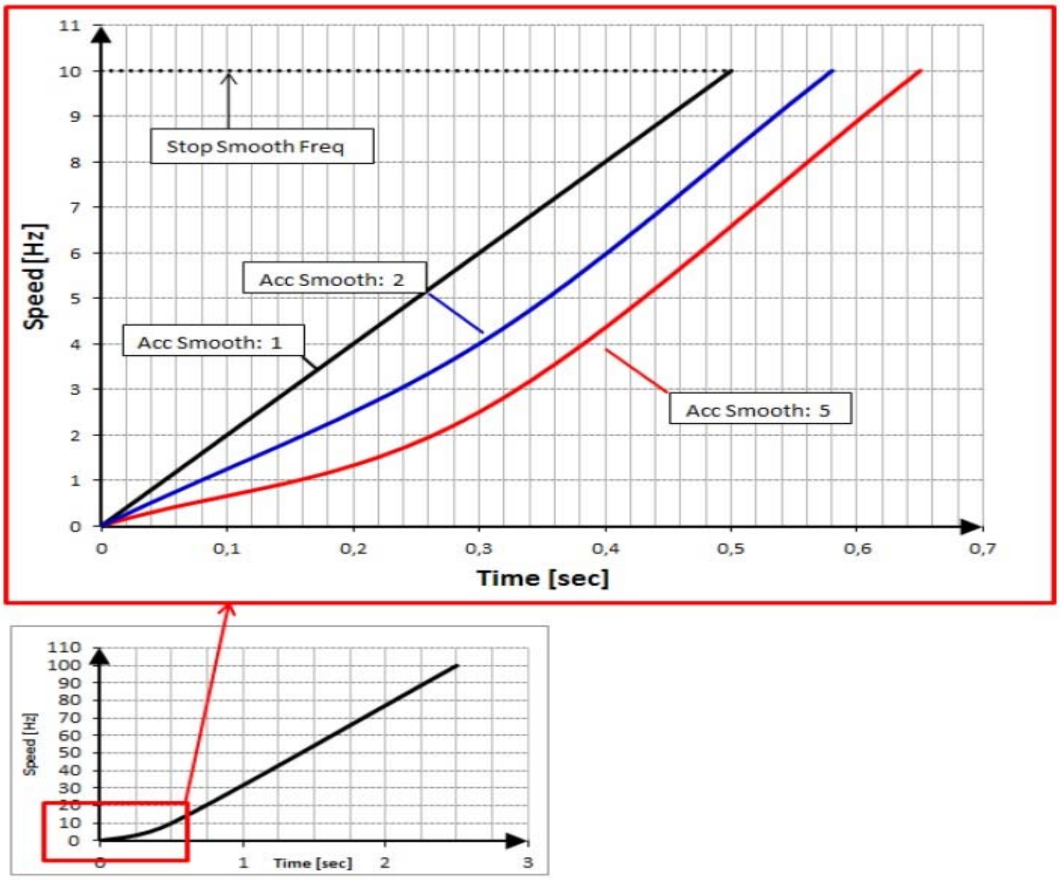
PARAMETER	DESCRIPTION
ACCELERATION 0	It specifies the motor acceleration at 0 Hz. At level 0 the acceleration is maximum. Increasing the parameter's level the acceleration decreases.
ACCELERATION 1	It specifies the motor acceleration at ACC PROF. FREQ 1[Hz]. At level 0 the acceleration is maximum. Increasing the parameter's level the acceleration decreases.
ACCELERATION 2	It specifies the motor acceleration at ACC PROF. FREQ 2[Hz]. At level 0 the acceleration is maximum. Increasing the parameter's level the acceleration decreases.
ACCELERATION 3	It specifies the motor acceleration at ACC PROF. FREQ 3[Hz]. At level 0 the acceleration is maximum. Increasing the parameter's level the acceleration decreases.
ACCELERATION 4	It specifies the motor acceleration at ACC PROF. FREQ 4[Hz]. At level 0 the acceleration is maximum. Increasing the parameter's level the acceleration decreases.
ACCELERATION 5	It specifies the motor acceleration at ACC PROF. FREQ 5[Hz]. At level 0 the acceleration is maximum. Increasing the parameter's level the acceleration decreases.
ACC PROF.FREQ 1	In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 1 parameter.

PARAMETER	DESCRIPTION
ACC PROF.FREQ 2	In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 2 parameter.
ACC PROF.FREQ 3	In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 3 parameter.
ACC PROF.FREQ 4	In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 4 parameter.
ACC PROF.FREQ 5	In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 5 parameter.
RELEASE BRAKING	This parameter defines the deceleration ramp performed after the running request is released.
INVERS. BRAKING	This parameter defines the deceleration ramp performed when the direction switch is toggled during drive.
DECEL. BRAKING	This parameter defines the deceleration ramp performed when the accelerator is released but not completely.
PEDAL BRAKING	This parameter defines the deceleration ramp performed when the braking pedal is pressed.
SPEED LIMIT BRK.	This parameter defines the deceleration ramp performed upon a speed-reduction request.
STEER BRAKING	This parameter defines the deceleration ramp related to the steering angle.
MAX SPEED FORW	This parameter defines the maximum speed in forward direction.
MAX SPEED BACK	This parameter defines the maximum speed in backward direction.
CUTBACK SPEED 1	This parameter defines the maximum speed performed when the cutback switch is active.
TURTLE SPEED	This parameter defines the maximum speed at turtle mode.
BMS WRN1 CUTBACK	This parameter defines the maximum speed performed when the BMS warning 1 is active.
MOT.HT MAX SPEED	The Maximum speed when the Motor Temperature is reached to the " MOTOR HIGH TEMP " Setting.
BATT. LOW SPEED	This parameter defines the maximum speed performed according to "BATTERY CHECK" parameter.
M.TRAC SPEED RED	Maximum speed when the MAINTENANCE is set to OPTOIN#2 or #3
CURVE SPEED 1	This parameter defines the maximum traction speed when the steering angle is equal to the STEER ANGLE 1 angle.
MAX ANGLE SPEED	This parameter defines the maximum traction speed when the steering angle is equal to the STEER ANGLE 1 angle.
OVERLOAD SPEED	This parameter defines the maximum traction speed according to the "OVERLOAD TYPE" parameter when the loaded weight exceeds the "OVERLOAD WEIGHT" parameter.
FREQUENCY CREEP	This parameter defines the minimum speed when the forward- or reverse-request switch is closed, but the accelerator is at its minimum.
BMS WRN0 CUTBACK	This parameter defines the maximum current performed when the BMS warning 0 is active.

PARAMETER	DESCRIPTION
MOT.HT MAX CURRE	The Maximum Current when the Motor Temperature is reached to the " MOTOR HIGH TEMP " Setting
BATT. LOW CURRENT	This parameter defines the maximum current performed according to "BATTERY CHECK" parameter.
ACC. SMOOTH	This parameter defines the acceleration profile: 1 results in a linear ramp, higher values result in smoother parabolic profiles.
INV. SMOOTH	This parameter defines the acceleration profile performed when the truck changes direction: 1 results in a linear ramp, higher values result in smoother parabolic profiles.
STOP SMOOTH	This parameter defines the frequency at which the smoothing effect of the acceleration profile ends.
BRK SMOOTH	This parameter defines the deceleration profile: 1 results in a linear ramp, higher values result in smoother parabolic profiles.
STOP BRK SMOOTH	This parameter defines the frequency at which the smoothing effect of the deceleration profile ends.

※ Acceleration smoothness

Smoothing-related parameters define a parabolic profile for the acceleration or deceleration ramps close to 0 rpm. Values have not a physical meaning: 1 means linear ramp, higher values (up to 5) result in smoother accelerations.



PARAMETER	DESCRIPTION
EB ENGAGE DELAY	This parameter defines the delay introduced between the traction request and the actual activation of the traction motor. This takes into account the delay occurring between the activation of the EB output (i.e. after a traction request) and the effective EB release, so to keep the motor stationary until the electromechanical brake is actually released. The releasing delay of the brake can be easured or it can be found in the datasheet.
SEAT DELAY TIME	This parameter defines the delay time after the seat switch is off.
CHAT TIME	In seconds. When truck is key on, if the operator doesn't use the truck for the time(CHAT TIME), main contactor is open to save energy.

(2) Left traction inverter

① Set option

SET OPTIONS	DESCRIPTION
EM.BRAKE FUNCT.	This parameter enables or disables the output NEB A18, dedicated to the electromechanical brake: NONE = diagnoses are masked and E.B. is not driven upon a traction request. BRAKE = E.B. is driven upon a traction request if all the related diagnoses pass. The behavior on a slope depends on the STOP ON RAMP setting. Do not use this setting if the electromechanical brake is not really present.
COOLING FAN	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 FAN WORKING TEMP and FAN WORKING MOTOR. - Option #3 : fans work when motors work.
FAN RELAY COIL	- ON : Using 12V Relay for cooling fan - OFF : not Using 12V Relay for cooling fan
RS232 CONSOLE	This parameter enables or disables the console to change settings.

② Adjustments

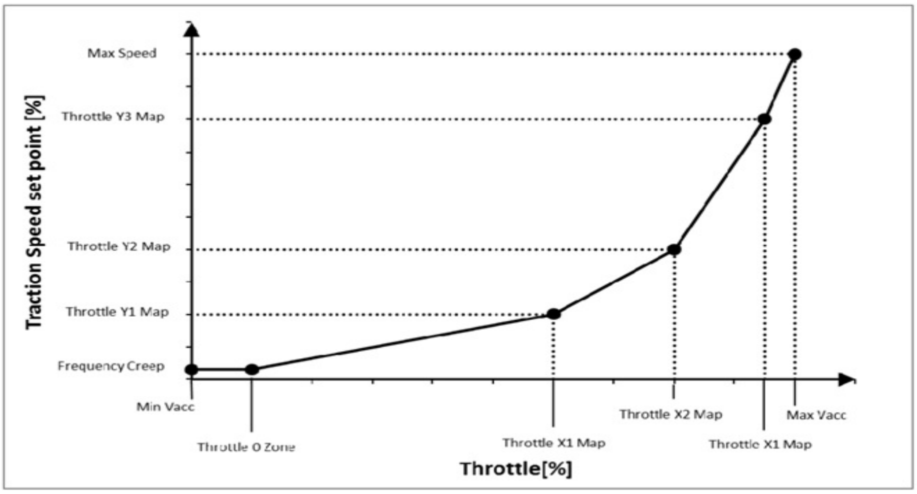
Adjustments	DESCRIPTION
FAN WORKING TEMP	(This parameter is used for that COOLING FAN is option #2) If the temperature of inverter exceeds the temperature indicated in this paramter.
FANWORKING MOTOR	(This parameter is used for that COOLING FAN is option #2) If the temperature of motor exceeds the temperature indicated in this paramter.

(3) Pump inverter

① Set option

SET OPTIONS	DESCRIPTION
SET MOT.TEMPERAT	This parameter defines the type of motor temperature sensor adopted. - NONE = no motor thermal sensor is connected. - DIGITAL : a digital (ON/OFF) motor thermal sensor is connected to A23. - OPTION#1 : an analog motor thermal sensor is connected to A23. The temperature sensor is a KTY 84-130 PTC (positive thermal coefficient resistance). - OPTION#2 : an analog motor thermal sensor is connected to A23. The temperature sensor is a KTY 83-130 PTC (positive thermal coefficient resistance). - OPTION#3 : an analog motor thermal sensor is connected to A23. The temperature sensor is a PT1000 PTC (positive thermal coefficient resistance).
OPSS	- ON : Present (Using OPSS Coil) - OFF : Absent (Not using OPSS Coil)
FINGERTIP	- ON : The truck model includes electro-hydraulic distributor and finger tips. Can communication with VCM and Hydro CB zapi modules is enabled. - OFF : The truck model includes mechanical lever distributor.
FINGERTIP MISM	- ON : trigger the alarm if the fingertip output values are not within the admissible range; - OFF : alarm is not occurred even if the fingertip output values are not within the admissible range.
LEVER FULL	(This parameter is used for that FINGERTIP is ON.) - ON : All combinations of hydraulic function are available. - OFF : The combination of hydraulic function is not available at special condition for the safety. (Lift + tilt down)
AUX 1 FUNCTION	(This parameter is used for that FINGERTIP is ON.) - OFF : The truck doesn't have the AUX 1 function (default) - ON : The truck has the side shift function (Option)
AUX 2 FUNCTION	(This parameter is used for that FINGERTIP is ON.) - OFF : The truck doesn't have the AUX 2 function (default) - ON : The truck has the side shift function (Option)
FORK LEVELING	- OFF : Auto fork leveling function is not activated. - ON : Auto fork leveling function is activated.
CUTBACK MODE	The Traction / Pump speed cutback when the A19(P) pin is Open
RS232 CONSOLE	This parameter enables or disables the console to change settings.

② Adjustments

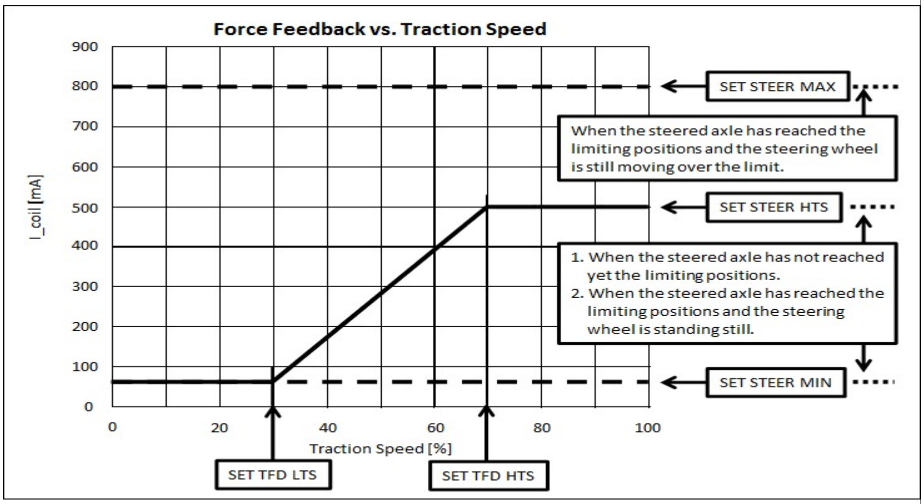
Adjustments	DESCRIPTION
THROTTLE 0 ZONE	This parameter defines a dead band in the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE X1 MAP	This parameter defines the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE Y1 MAP	This parameter defines the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE X2 MAP	This parameter defines the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE Y2 MAP	This parameter defines the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE X3 MAP	This parameter defines the accelerator input curve. (Please refer to the accelerator input curve in the description of THROTTLE Y3 MAP)
THROTTLE Y3 MAP	This parameter defines the acclerator input curve. - Accelerator input curve  The speed remains at the RREQUENCY CREEP value as long as the voltage from the acclerator potentiometer is below THROTTLE 0 ZONE. Basically this defines a dead zone close to the neutral position.
MOTOR HIGH TEMP	This parameter defines the motor temperature above which a cutback is applied. Cutback is valid only during motoring, while during braking the 100% of the maximum current is always available independently by the temperature.
MOT.SHUTDOWN TEM	This parameter defines the maximum motor temperature permitted, above which the controller stops driving the motor.
FORK CENTER DEAD	(This parameter is used for that FORK LEVELING is ON) It sets the pecentage of center dead zone from the center value , when fork leveling function is doing.
FORK APPR. RANGE	(This parameter is used for that FORK LEVELING is ON) It sets the approach range from the center value , when fork leveling function is doing.
FORK VALVE MIN	(This parameter is used for that FORK LEVELING and FINGERTIP are ON) It sets the pecentage of tilt valve current , when fork leveling function is doing.

③ Parameter

Parameter	DESCRIPTION
ACCELER. DELAY	This parameter defines the acceleration ramp.
RELEASE BRAKING	This parameter defines the deceleration ramp performed after the running request is released.
DECEL. BRAKING	This parameter defines the deceleration ramp performed when the accelerator is released but not completely.
MAX SPEED LIFT	This parameter defines the maximum speed of the pump motor during lift.
TILT SPEED	This parameter defines the maximum speed of the pump motor during tilt.
AUX1 SPEED	This parameter defines the maximum speed of the pump motor during AUX1.
AUX2 SPEED	This parameter defines the maximum speed of the pump motor during AUX2.
CUTBACK SPEED 1	This parameter defines the maximum speed performed when the cutback switch is active.
BMS WRN1 CUTBACK	This parameter defines the maximum speed performed when the BMS warning 1 is active.
MOT.HT MAX SPEED	The Maximum speed when the Motor Temperature is reached to the " MOTOR HIGH TEMP " Setting.
BATT. LOW SPEED	This parameter defines the maximum speed performed according to "BATTERY CHECK" parameter.
M.PUMP SPEED RED	Maximum speed when the MAINTENANCE is set to OPTOIN#2 or #3.
FREQUENCY CREEP	This parameter defines the minimum speed when the forward- or reverse-request switch is closed, but the accelerator is at its minimum.
BMS WRN0 CUTBACK	This parameter defines the maximum current performed when the BMS warning 0 is active.
MOT.HT MAX CURRE	The Maximum Current when the Motor Temperature is reached to the " MOTOR HIGH TEMP " Setting.
BATT. LOW CURRENT	This parameter defines the maximum current performed according to "BATTERY CHECK" parameter.
ACC. SMOOTH	This parameter defines the acceleration profile: 1 results in a linear ramp, higher values result in smoother parabolic profiles.
STOP SMOOTH	This parameter defines the frequency at which the smoothing effect of the acceleration profile ends.
SEAT DELAY TIME	This parameter defines the delay time after the seat switch is off.
AUTO FORK SPEED	Pump speed at the Automatic Fork Leveling function is performed
FORK MIN SPEED	The maximum Tilt speed while approaching dead zone.

(4) EPS inverter

① Parameter

Parameter	DESCRIPTION
POTI REVOLUTIONS	From 30 to 90. This setting specifies the number of revolutions of the steering wheel for a side to side rotation of the steered axle.
SET STEER MIN.	0 to 1000mA. The minimum Force Feedback value is set via SET STEER MIN. (Please refer to the Force Feedback vs. Traction Speed in the description of SET TFD HTS)
SET STEER MAN.	0 to 1000mA. The maximum Force Feedback value is set via SET STEER MAX. (Please refer to the Force Feedback vs. Traction Speed in the description of SET TFD HTS)
SET STEER HTS	0 to 1000mA. This parameter is used to handle the minimum Force Feedback value at HTS (High Traction Speed). (Please refer to the Force Feedback vs. Traction Speed in the description of SET TFD HTS)
PERCUSSION DUTY	The time delay before switching off the Force Feedback when the steered axle has reached the limiting position and the steering wheel has been released is set by this parameter. - LEVEL 0: 16 msec delay. - LEVEL 1: 32 msec delay. - LEVEL 2: 48 msec delay. - LEVEL 9: 160 msec delay.
1ST ANGLE GAIN	From 30 to 180 degrees. This parameter sets the maximum steered axle angle in the steering direction with FEEDBACK POT 1 value higher than 2.5V.
2ND ANGLE GAIN	From 30 to 180 degrees. This parameter sets the maximum steered axle angle in the steering direction with FEEDBACK POT 1 value lower than 2.5V.
SET TFD LTS	This parameter is used to handle the minimum Force Feedback value at LTS(Low Traction Speed). (Please refer to the Force Feedback vs. Traction Speed in the description of SET TFD HTS)
SET TFD HTS	This parameter is used to handle the minimum Force Feedback value at HTS(High Transation Speed). 

(5) VCM INVERTER

① Set option

SET OPTIONS	DESCRIPTION
TRUCK MODEL SEL.	There are 2 options, 15/18/20BT-9U, 25/30/32/35B-9U.
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.
OUT EV2 A7 DIAG	- ON : Diagnosis is ON - OFF : Diagnosis is OFF
OUT EV1 A6 DIAG	- PRESENT : Diagnosis is Present - ABSENT : Diagnosis is absent
PROPORTIO. VALVE	- ON : using Proportional valve - OFF : Not using proportional valve

② Parameter

PARAMETER	DESCRIPTION
I MIN EVP1	This parameter adjusts the minimum current of valve 1 (Lift).
I MAX EVP1	This parameter adjusts the maximum current of valve 1 (Lift).
I MIN EVP2	This parameter adjusts the minimum current of valve 2 (Lowering).
I MAX EVP2	This parameter adjusts the maximum current of valve 2 (Lowering).
I MIN EVP3	This parameter adjusts the minimum current of valve 3 (Tilt in).
I MAX EVP3	This parameter adjusts the maximum current of valve 3 (Tilt in).
I MIN EVP4	This parameter adjusts the minimum current of valve 4 (Tilt out).
I MAX EVP4	This parameter adjusts the maximum current of valve 4 (Tilt out).
I MIN EVP5	This parameter adjusts the minimum current of valve 5 (AUX1 in).
I MAX EVP5	This parameter adjusts the maximum current of valve 5 (AUX1 in).
I MIN EVP6	This parameter adjusts the minimum current of valve 6 (AUX1 out).
I MAX EVP6	This parameter adjusts the maximum current of valve 6 (AUX1 out).
I MIN EVP7	This parameter adjusts the minimum current of valve 7 (AUX2 in).
I MAX EVP7	This parameter adjusts the maximum current of valve 7 (AUX2 in).
I MIN EVP8	This parameter adjusts the minimum current of valve 8 (AUX2 out).
I MAX EVP8	This parameter adjusts the maximum current of valve 8 (AUX2 out).
VOLTAGE EV2	Supplying Voltage for EV2.
EVP1 OPEN DELAY	It determines the acceleration ramp on EVP1.
EVP1 CLOSE DELAY	It determines the deceleration ramp on EVP1.
EVP2 OPEN DELAY	It determines the acceleration ramp on EVP2.
EVP2 CLOSE DELAY	It determines the deceleration ramp on EVP2.
EVP3 OPEN DELAY	It determines the acceleration ramp on EVP3.

PARAMETER	DESCRIPTION
EVP3 CLOSE DELAY	It determines the deceleration ramp on EVP3.
EVP4 OPEN DELAY	It determines the acceleration ramp on EVP4.
EVP4 CLOSE DELAY	It determines the deceleration ramp on EVP4.
EVP5 OPEN DELAY	It determines the acceleration ramp on EVP5.
EVP5 CLOSE DELAY	It determines the deceleration ramp on EVP5.
EVP6 OPEN DELAY	It determines the acceleration ramp on EVP6.
EVP6 CLOSE DELAY	It determines the deceleration ramp on EVP6.
EVP7 OPEN DELAY	It determines the acceleration ramp on EVP7.
EVP7 CLOSE DELAY	It determines the deceleration ramp on EVP7.
EVP8 OPEN DELAY	It determines the acceleration ramp on EVP8.
EVP8 CLOSE DELAY	It determines the deceleration ramp on EVP8.

(6) DISPLAY

① Password

If determines to set the function of user password when key on.

- OFF : No use
- ON : Activate the user password (Default password is "00000" and it can be re-set at user menu)

② Maintenance

If determines to set the function of maintenance alarm when if come to service interval.

- OFF : No use
- ON : Activate the maintenance alarm function.

③ Hour counter

It indicates the machine operating hours.

- key ON : key on time
- Pump : Pump motor operating time.
- Traction : Traction motor operating time.

⑺ PROGRAMMING AND ADJUSTMENTS

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

※ Adjustments via buttons on a display, please refer to the display section. (page 7-6X)

ADJUSTMENTS VIA SMART CONSOLE(Option)

Adjustment of parameters and changes to the inverter's configuration are made using the smart console.

15BT9USM0718

※ Please connect and disconnect it from the inverter after a key switch off.

① Connected

If connection is successful, the display will show a page similar to the next one.

VMCM HY1.00
48v 0a 500H
NO CAN MSG N.05

This menu shows basic information about the controller.

- First line displays the controller firmware.
- Second line shows controller voltage, controller current and hour meter.
- Last line shows the current alarm code, if present.

Press OK to access the MAIN MENU.

MAIN MENU
PARAMETER CHANGE
TESTER
ALARMS

Use UP and DOWN keys to navigate the list: once you find the desired menu press OK to enter it.

② How to modify parameters

From MAIN MENU enter the desired menu (for example the PARAMETER CHANGE menu).

PARAMETER CHANGE	
ACCELER DELAY	1.0
E. ACCELER DELAY	1.5
SPEED LIMIT BRK	2.2
E.SPD. LIMIT BRK	2.2

With UP and DOWN keys you can scroll the list: once you have highlighted the parameter you want to modify, press either LEFT or RIGHT keys to decrease or increase the parameter value.

Keep LEFT/RIGHT button pressed to continuously repeat the value modification (“auto-repeat” function): this function will speed up the procedure in case many parameter values must be changed.

You can press ESC to exit the menu at any time. In case parameters have been modified, the console will prompt the request to confirm/discard changes.

```
PARAMETER CHANGE
AC
      APPLY CHANGES?
E.
   YES=OK      NO=ESC
SP
E.SPD. LIMIT BRK          2.2
```

Description above is valid for every menu which contains parameters and options like SET OPTIONS, ADJUSTMENT, HARDWARE SETTINGS, etc.

③ **Program Vacc**

PROGRAM VACC menu has been slightly modified from old consoles. Upon entering this menu the console shows the current programmed values.

```
PROGRAM VACC
CURRENT VALUES
MAX                 5.0
MIN                 0.3
PRESS OK FOR SETUP
```

When OK is pressed, PROGRAM VACC procedure starts. Console invites you:

· To select the enable switch, if any;
· To select the direction switch (either forward or backward);
· To depress the pedal to its maximum excursion.

Displayed values vary accordingly to operator inputs.

Sequence above can slightly vary depending on controller firmware. Anyway the logic remains the same: before programming the min/max values, execute any starting sequence which is necessary, then press the pedal or push the joystick.

```
PROGRAM VACC
FORWARD        0.0   4.5
BACKWARD       0.2   4.4
SEL. ENABLE AND DIRECTION
THEN PRESS PEDAL
(EXC TO ENTER)
```

When ESC is pressed, console asks if programmed values must be saved or discarded.

④ Tester

It shows four variables at once: use UP/DOWN keys to scroll the list.

TESTER	
MOTOR VALTAGE	0%
FREQUENCY	0
ENCODER	0
BATTERY VOLTAGE	24.5V

⑤ Alarms

It shows all controller alarms at once.

ALARMS	
NO CAN MESSAGE	10h
INCORRECT START	2h
NONE	0h
NONE	0h
NONE	0h
F1 TO CLEAR LOGBOOK	

Five is the maximum number of alarm codes which is stored inside the controller.

Colors are used to separate recurrent alarm codes from rare events. In order of increasing frequency, alarm names can be:

- White: up to 5 occurrences
- Yellow: up to 20,
- Orange: up to 40,
- Red: more than 40.

Use UP/DOWN to select a certain alarm in the list: if OK is pressed, additional pieces of information about that alarm are displayed. Press F1 to clear the alarm logbook of the controller: once F1 is pressed, the console asks for confirmation.

(8) MORNITORING MENU

In smart console, this menu appears as “TESTER” MENU.

① Right traction inverter - Master

Monitoring	Description
KEY VOLTAGE	Key voltage measured in real time.
BATTERY VOLTAGE	Battery voltage measured in real time (across the DC bus).
MOTOR VOLTAGE	Estimation of the DC current the inverter is drawing from the battery.
FREQUENCY	Frequency of the current sine-wave that the inverter is supplying to the motor.
MEASURED SPEED	Motor speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz). (measured value by master micom)
MEASURED SPD SLV	Motor speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).
SLIP VALUE	Motor slip, i.e. difference between the current frequency and the motor speed (in Hz).
CURRENT RMS	Root-mean-square value of the line current supplied to the motor. (measured value by master micom)
CURRENT RMS SLV	Root-mean-square value of the line current supplied to the motor. (measured value by slave micom)
IMAX LIM. TRA	Instantaneous value of the maximum current the inverter can apply to the motor to satisfy a traction request. The value is evaluated basing on actual conditions (inverter temperature, motor temperature, etc.).
IMAX LIM. BRK	Instantaneous value of the maximum current the inverter can apply to the motor to satisfy a braking request. The value is evaluated basing on actual conditions (inverter temperature, motor temperature, etc.).
MOT. POWER WATT	Estimation of the power supplied to the motor.
DC BUS CURRENT	Estimation of the DC current the inverter is drawing from the battery.
STEER ANGLE	Current steering-wheel angle. When the steering is straight ahead STEER ANGLE is zero.
BATTERY CHARGE	Estimation of the battery charge based on the battery voltage.
TEMPERATURE	Temperature measured on the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm.
MOTOR TEMPERAT.	Motor-windings temperature. This temperature is used for the MOTOR OVERTEMP alarm.
A19 SEAT SW	Status of the Seat Input on A19.
A6 BRAKE 2 SW	Status of the Pedal-Brake SW 2 input A6.
A4 FWD SWITCH	Status of the forward input A4.
A5 BWD SWITCH	Status of the backward inch input A5.
A13 ACC1	Voltage of the Accelerator-Pedal 1 (Increasing analog signal) on A13.
A3 ACC2	Voltage of the Accelerator-Pedal 2 (Decreasing analog signal) on A13.
A10 BRAKE 1 SW	Status of the Pedal-Brake SW 1 input A10.
A16 MAIN CONT.	Voltage applied over the main contactor coil. It corresponds to the duty cycle value of PWM applied and it is expressed in percentage.

Monitoring	Description
A18 ELEC. BRAKE	Voltage applied over the electro mechanic brake coil. It corresponds to the duty cycle value of PWM applied and it is expressed in percentage.
CTRAP HW	This is a counter and it is showing the number of occurrences of hardware- overcurrent occurrences detection.
TRUCK SPEED	Speed of the truck.
ODOMETER KM	Odometer: overall distance traveled by the truck.
WEIGHT	This shows the measured load weight.

② Right traction inverter- Slave

Monitoring	Description
MEASURED SPD SLV	Motor speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).
CNA4	Status of the forward input A4.
CNA5	Status of the backward inch input A5.
CNA6	Status of the Pedal-Brake SW 2 input A6.
CNA19	Status of the Seat Input on A19.
A13 ACC 1	Voltage of the Accelerator-Pedal 1 (Decreasing analog signal) on A13.

③ Left traction inverter - Master

Monitoring	Description
KEY VOLTAGE	Key voltage measured in real time.
BATTERY VOLTAGE	Battery voltage measured in real time (across the DC bus).
MOTOR VOLTAGE	Estimation of the DC current the inverter is drawing from the battery.
FREQUENCY	Frequency of the current sine-wave that the inverter is supplying to the motor.
MEASURED SPEED	Motor speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).
SLIP VALUE	Motor slip, i.e. difference between the current frequency and the motor speed (in Hz).
CURRENT RMS	Root-mean-square value of the line current supplied to the motor.
IMAX LIM. TRA	Instantaneous value of the maximum current the inverter can apply to the motor to satisfy a traction request. The value is evaluated basing on actual conditions (inverter temperature, motor temperature, etc.).
IMAX LIM. BRK	Instantaneous value of the maximum current the inverter can apply to the motor to satisfy a braking request. The value is evaluated basing on actual conditions (inverter temperature, motor temperature, etc.).
MOT. POWER WATT	Estimation of the power supplied to the motor.
DC BUS CURRENT	Estimation of the DC current the inverter is drawing from the battery.
TEMPERATURE	Temperature measured on the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm.
MOTOR TEMPERAT.	Motor-windings temperature. This temperature is used for the MOTOR OVERTEMP alarm.
A19 SBR	Status of the SBR SW Input on A19.
A4 BRAKE OIL	Status of the Brake oil SW Input on A4.
A5 LEVELING DIG	Status of the Tilt leveling SW input A5.
A13 TILT LEV1	Status of the Auto tilt leveling 1 (Increasing analog signal) input A13.
A6 LOAD SENSOR	Status of the Load sensor potentiometer (analog signal) input A6.
A3 TILT LEV2	Status of the Auto tilt leveling 2 (Decreasing analog signal) input A6.
A18 ELEC. BRAKE	Voltage applied over the electro mechanic brake coil. It corresponds to the duty cycle value of PWM applied and it is expressed in percentage.
CTRAP HW	This is a counter and it is showing the number of occurrences of hardware- overcurrent occurrences detection.

④ Left traction slave

Monitoring	Description
MEASURED SPEED	Motor speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).
CNA4	Status of the Brake oil SW Input on A4.
CNA5	Status of the Tilt leveling SW input A5.
CNA6	Status of the Load sensor potentiometer (analog signal) input A6.
CNA19	Status of the SBR SW Input on A19.
A13 TILT LEV 1	Status of the Auto tilt leveling 1 (Decreasing analog signal) input A13.

⑥ Pump inverter - Master

Monitoring	Description
KEY VOLTAGE	Key voltage measured in real time.
BATTERY VOLTAGE	Battery voltage measured in real time (across the DC bus).
MOTOR VOLTAGE	Estimation of the DC current the inverter is drawing from the battery.
FREQUENCY	Frequency of the current sine-wave that the inverter is supplying to the motor.
MEASURED SPEED	Motor speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).
SLIP VALUE	Motor slip, i.e. difference between the current frequency and the motor speed (in Hz).
CURRENT RMS	Root-mean-square value of the line current supplied to the motor.
IMAX LIM. TRA	Instantaneous value of the maximum current the inverter can apply to the motor to satisfy a traction request. The value is evaluated basing on actual conditions (inverter temperature, motor temperature, etc.)
IMAX LIM. BRK	Instantaneous value of the maximum current the inverter can apply to the motor to satisfy a braking request. The value is evaluated basing on actual conditions (inverter temperature, motor temperature, etc.)
MOT. POWER WATT	Estimation of the power supplied to the motor.
DC BUS CURRENT	Estimation of the DC current the inverter is drawing from the battery.
BATTERY CHARGE	Estimation of the battery charge based on the battery voltage.
TEMPERATURE	Temperature measured on the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm.
MOTOR TEMPERAT.	Motor-windings temperature. This temperature is used for the MOTOR OVERTEMP alarm.
A4 AUX1 SWITCH	Status of the AUX1 SW Input on A4.
A5 AUX2 SWITCH	Status of the AUX2 SW Input on A5.
A19 CUTBACK SW	Status of the LIFT CUTBACK SW Input on A19.
A10 TILT SWITCH	Status of the TILT SW Input on A10.
A13 LIFT POT 1	Status of the LIFT POT 2 (Increasing analog signal) input A13.
A3 LIFT POT 2	Status of the LIFT POT 1 (Decreasing analog signal) input A3.
A9 SET EVP	This value shows the setpoint of proportional elevtrovalve (OPSS) EVP.
CTRAP HW	This is a counter and it is showing the number of occurrences of hardware overcurrent occurrences detection.

⑦ Pump Inverter - Slave

Monitoring	Description
MEASURED SPEED	Motor speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).
CNA4	Status of the AUX1 SW Input on A4.
CNA5	Status of the AUX2 SW Input on A5.
CNA19	Status of the CUTBACK SW input A19.
A13 LIFT POT 1	Status of the LIFT POT 1 (Increasing analog signal) input A3.

⑧ EPS Inverter - Master

MONITORING	Description
FEEDBACK POT 1	Real time analog value of input CPOT1 (A1). (STEERING AXLE SENSOR)
FEEDBACK POT 2	Real time analog value of input CPOT2 (A2). (STEERING AXLE SENSOR)
FEEDBACK ENC.	Voltage 0 to 5000mV. This is the value of the encoder counting scaled in a range 2500mV +/- 2500mV corresponding to a 0+/-180 degrees in the steered axle. FEEDBACK ENC assumes 2500mV value when the encoder counting is null. A steered axle angle in the range 0+/-90degrees corresponds to a FEEDBACK ENC of 2500V+/-1250mV (i.e. from 1250mV to 3750mV). Adjustment SET STEER 0-POS must be set in order the encoder counting is null (and FEEDBACK ENC is 2500mV) when the steered axle is really straight ahead.
ENC COUNTING	Counts of the encoder vs. the straight ahead direction of the steered axle. Adjustment SET STEER 0-POS must be set in order the encoder counting is null (and FEEDBACK ENC is 2500mV) when the steered axle is really straight ahead.
ENC SPEED	This is the speed of the motor measured with the encoder on the motor shaft.
FREQUENCY	This is the frequency applied to the steering motor.
MOTOR VOLTAGE	It is a percentage. 100% means the sine waves in the motor have the maximum PWM amplitude.
MOTOR CURRENT	Root Mean Square value of the line current in the motor.
IQ RMS	Root Mean Square value of the quadrature current in the motor (torque component).
ID RMS	Root Mean Square value of the direct current in the motor (flux component).
TEMPERATURE	Temperature of the controller base plate.
MOTOR TEMPERAT.	Temperature of the motor windings measured with the thermal sensor inside the motor and connected to CNG #7.
CW LIMIT LEVEL	When the STEER ANGLE overtakes the superior limit for the steered wheel angle limitation, the steered wheel angle will be limited and CW LIMIT LEVEL turns ON (active).
ACW LIMIT LEVEL	When STEER ANGLE is lower than the inferior limit for the steered wheel angle limitation, the steered wheel angle will be limited and ACW LIMIT LEVEL turns ON (active).
TRUCK MOVING	This reading turns ON when the traction speed is not null.
I TFD	This is the real time measurement of the DC current [mA] in the load connected to CNA #10 (TFD COIL).
MOT POWER WATT	This is the real time measurement of the active power in Watts entering the motor.
STEER ANGLE	This reading supplies the angle of the steered axle in degrees with sign.
STATUS #9	STATUS #9 is used to support the embedded troubleshooting.
STATUS #8	STATUS #8 is used to support the embedded troubleshooting.
STATUS #7	STATUS #7 is used to support the embedded troubleshooting.
STATUS #6	STATUS #6 is used to support the embedded troubleshooting.
STATUS #5	STATUS #5 is used to support the embedded troubleshooting.
STATUS #2	STATUS #2 is used to support the embedded troubleshooting.
STATUS #1	STATUS #1 is used to support the embedded troubleshooting.

⑨ EPS Inverter - Slave

MONITORING	Description
FEEDBACK POT 1	Real time analog value of input CPOT 1 (A1). (STEERING AXLE SENSOR)
FEEDBACK POT 2	Real time analog value of input CPOT 2 (A2). (STEERING AXLE SENSOR)
FEEDBACK ENC.	Voltage 0 to 5000mV. This is the value of the encoder counting scaled in a range 2500mV +/- 2500mV corresponding to a 0+/-180 degrees in the steered axle. FEEDBACK ENC assumes 2500mV value when the encoder counting is null. A steered axle angle in the range 0+/-90degrees corresponds to a FEEDBACK ENC of 2500V+/-1250mV (i.e. from 1250mV to 3750mV). Adjustment SET STEER 0-POS must be set in order the encoder counting is null (and FEEDBACK ENC is 2500mV) when the steered axle is really straight ahead.
ENC COUNTING	Counts of the encoder vs. the straight ahead direction of the steered axle. Adjustment SET STEER 0-POS must be set in order the encoder counting is null (and FEEDBACK ENC is 2500mV) when the steered axle is really straight ahead.
ENC SPEED	This is the speed of the motor measured with the encoder on the motor shaft.
FREQUENCY	This is the frequency applied to the steering motor.
MOTOR CURRENT	Root Mean Square value of the line current in the motor.
IQ RMS	Root Mean Square value of the quadrature current in the motor (torque component).
ID RMS	Root Mean Square value of the direct current in the motor (flux component).
TEMPERATURE	Temperature of the controller base plate.
MOTOR TEMPERAT.	Temperature of the motor windings measured with the thermal sensor inside the motor and connected to CNG #7.
CW LIMIT LEVEL	When the STEER ANGLE overtakes the superior limit for the steered wheel angle limitation, the steered wheel angle will be limited and CW LIMIT LEVEL turns ON (active).
ACW LIMIT LEVEL	When STEER ANGLE is lower than the inferior limit for the steered wheel angle limitation, the steered wheel angle will be limited and ACW LIMIT LEVEL turns ON (active).
TRUCK MOVING	This reading turns ON when the traction speed is not null.
I TFD	This is the real time measurement of the DC current [mA] in the load connected to CNA #10 (TFD COIL).
MOT POWER WATT	This is the real time measurement of the active power in Watts entering the motor.
STEER ANGLE	This reading supplies the angle of the steered axle in degrees with sign.
STATUS #9	STATUS #9 is used to support the embedded troubleshooting.
STATUS #8	STATUS #8 is used to support the embedded troubleshooting.
STATUS #7	STATUS #7 is used to support the embedded troubleshooting.
STATUS #6	STATUS #6 is used to support the embedded troubleshooting.
STATUS #5	STATUS #5 is used to support the embedded troubleshooting.
STATUS #2	STATUS #2 is used to support the embedded troubleshooting.
STATUS #1	STATUS #1 is used to support the embedded troubleshooting.

⑩ VCM Inverter - Master

MONITORING	Description
BATTERY VOLTAGE	Battery voltage measured in real time (across the DC bus).
OUTPUT GROUP #1	% value. Percentage of the maximum current applied on the output group #1 (EVP 1 and EVP 2).
OUTPUT GROUP #2	% value. Percentage of the maximum current applied on the output group #2 (EVP 3 and EVP 4).
OUTPUT GROUP #3	% value. Percentage of the maximum current applied on the output group #3 (EVP 5 and EVP 6).
OUTPUT GROUP #4	% value. Percentage of the maximum current applied on the output group #4 (EVP 7 and EVP 8)
NEV2 OUTPUT	% value. Percentage of the battery voltage applied on the EV 2
NEV1 OUTPUT	% value. Percentage of the battery voltage applied on the EV 1

5) GENERAL SUGGESTION FOR SAFETY

(1) Before doing any operation, ensure that the battery is disconnected.

(2) For traction applications, raise up or otherwise disable driving wheels to prevent the possibility of unexpected vehicle motion or motion in the wrong direction during initial commissioning. For hydraulic applications, open the valve to prevent the possibility of excessive pressure (in the event of a malfunction of the relief valve pressure).

(3) Take necessary precautions to not compromise safety in order to prevent injuries to personnel and damages to equipment.

(4) After operation, even with the key switch open, the internal capacitors may remain charged for some time. For safe operation onto the setup, it is recommended to disconnect the battery and to discharge the capacitors by means of a resistor of about 10~100 Ohm between +B and -B terminals of the inverter.

※ The method of discharging internal capacitor.
Bofore checking controllers, motors, cables and etc., discharge the internal capacitor in controllers by following below steps ;

① Disconnect the battery cable.

② Emergency contactor on and key on.

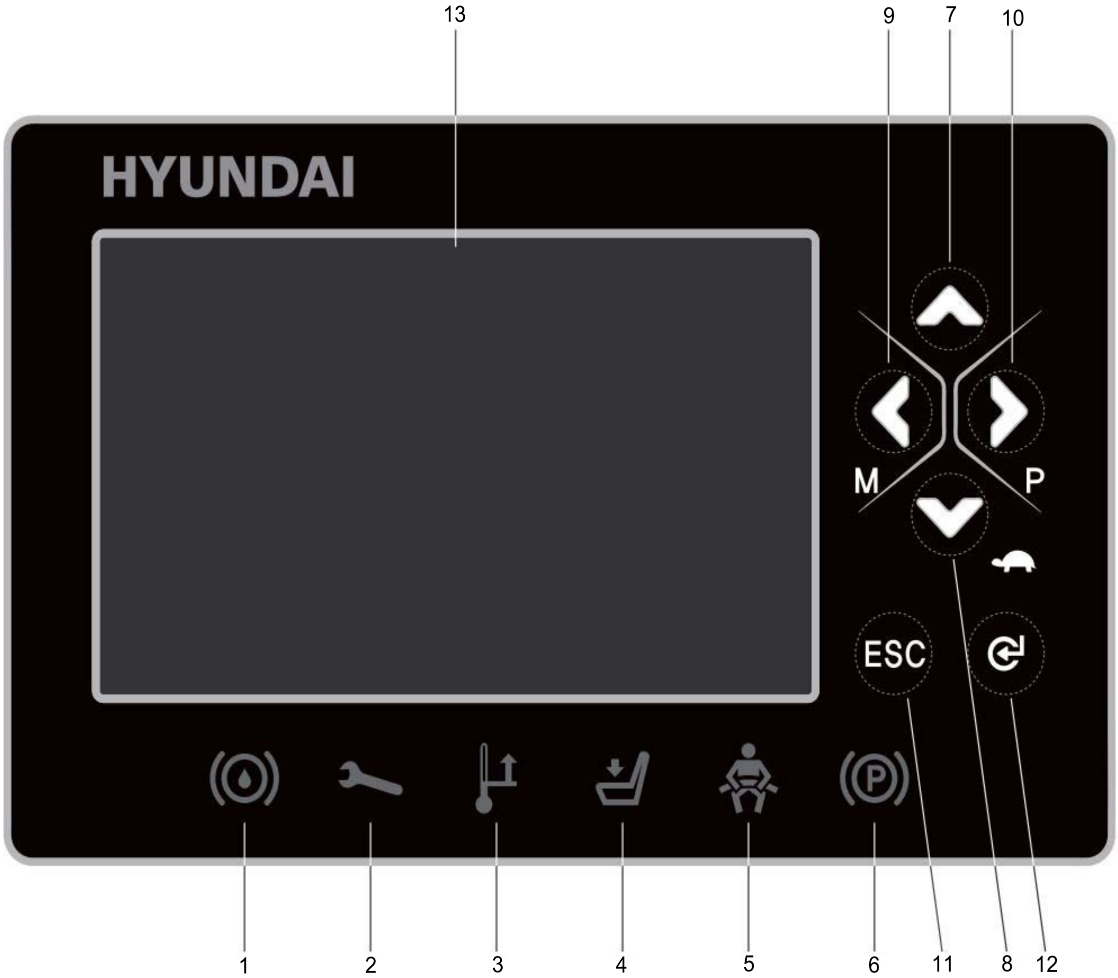
③ Wait until all warning lamps (red LED) on display become off.

④ Discharging process is finished.

6. INSTRUMENT PANEL : DISPLAY (15BT-9U : ~#303, 18BT-9U : ~#449, 20BT-9U : ~#782)

1) STRUCTURE

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



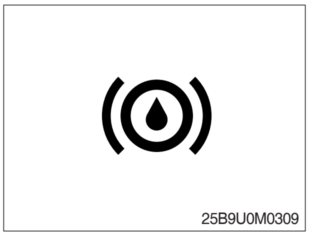
· LCD : TFT 4.3 inch IPS

25B9U0M0308

1	Oil level warning lamp	6	Parking brake warning lamp	11	ESC button
2	Wrench warning lamp	7	Up button	12	Enter button
3	Thermometer warning lamp	8	Down/turtle button	13	LCD function
4	Seat warning lamp	9	Left/menu button		
5	Seat belt warning lamp	10	Right/performance button		

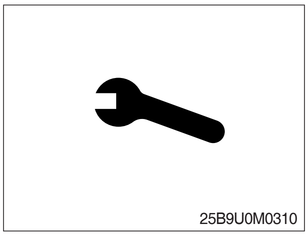
2) WARNING LAMP

(1) Brake oil level warning lamp



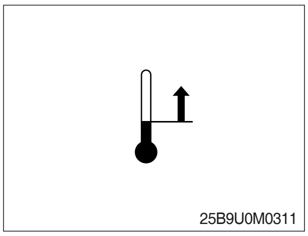
This LED lights when measured level of brake oil stored in reservoir tank is below the minimum acceptable mark.

(2) Wrench warning lamp



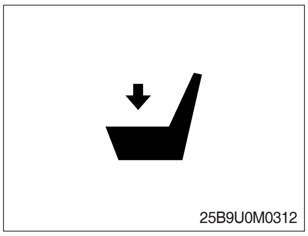
This LED lights when an electric device (controller, motor, cable, etc.) is in abnormal condition.

(3) Thermometer warning lamp



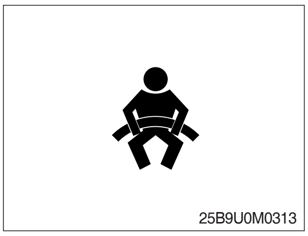
This LED lights when the controller or motor temperature is high.

(4) Seat warning lamp



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

(5) Seat belt warning lamp

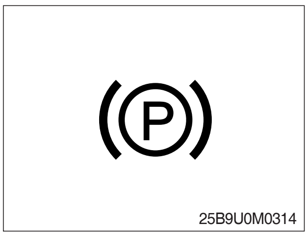


(1) This LED blinks in following 2 cases.

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) Parking brake warning lamp



(1) This LED lights when the parking brake is activated.

3) BUTTON

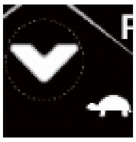
These buttons are used to select or change the menu and input value of the LCD function and display menu.

(1) Up button

25B9U0M0315

Press to select upward move.

(2) DOWN/TURTLE button



25B9U0M0316

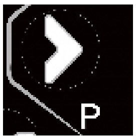
Press to select downward move.
TURTLE MODE ON/OFF

(3) LEFT/MENU button

25B9U0M0317

Press to select leftward move.
Go into the menu.

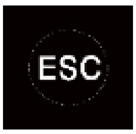
(4) RIGHT/PERFORMANCE button



25B9U0M0318

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

(5) Cancel (ESC) button



25B9U0M0319

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

(6) ENTER button

25B9U0M0320

Press to select Enter.

4) LCD FUNCTION

25B9U0M0321

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 at page 7-58.

(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 set-point. 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

It indicates the speed level by 2 km.

(5) Truck speed

The truck speed is shown in number. The unit can be ㎞/h or mph according to the display setting (see 7-66 page).

(6) Hour meter

The number shows the hours worked. The letter present beside the hour meter number 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 points 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's state of charge)

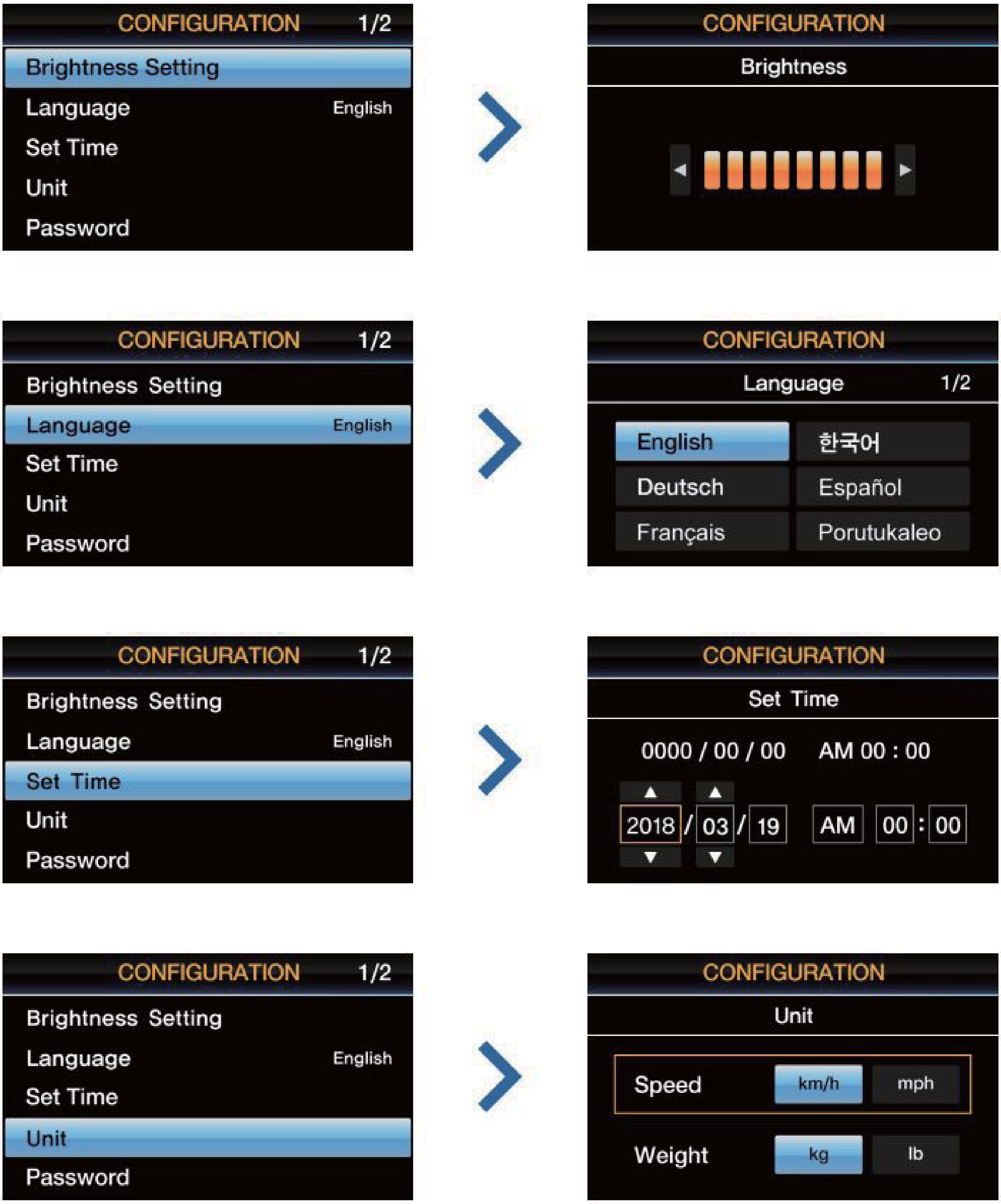
The battery's state of charge is shown by ten bars. Each bar represents the 10% of the battery charge. As the battery becomes discharged, the bars turn off progressively, one after another, in proportion to the value of the residual battery charge. When the residual battery charge is 20% or under, the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

(10) Load weight (option)

The indicator shows the weight the machine carrying at load.

- Indicator range : 0~6375 ㎏

5) HOW TO SET THE DISPLAY MENU



25B9UOM0322

25B9UOM0323

6) DESCRIPTION OF THE TRUCK MENU

(1) Access to truck menu

Step	Display	Description
1		1. When the vehicle key turns on, the initial screen as shown on the left appears. 2. Press "ESC" button for more than 1 second in the initial screen.
2		1. The password input screen appears as shown on the left. 2. Enter the password using the "UP", "DOWN", "LEFT/MENU", "RIGHT/PERFORMANCE" buttons and press the "ENTER" button.
3		1. After inputting the password, the initial screen appears as shown on the left. 2. Press the "LEFT / MENU" button.
4		1. TRUCK MENU appears as shown on the left. 2. Use the "UP" and "DOWN/TURTLE" buttons to select the desired menu (HIGH-LIGHT in blue) and press the "ENTER" button to enter the menu. 3. To move to the upper menu, press "ESC" button to move.

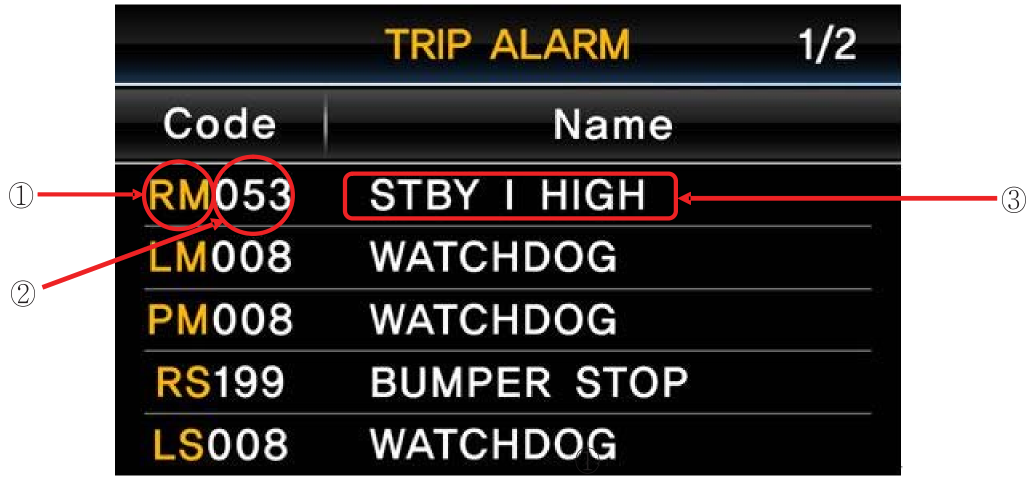
7) ALARM & ALARM HISTORY

(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  ,  buttons as follows :

15BT9USM07CL1

(2) Detail description of ALARM SCREEN



15BT9USM07CL04

①First orange capital letter shows in which controller the alarm happens as below;

RM : Right Traction - Master	PS : Pump - Slave
RS : Right Traction - Slave	EPSM : EPS - Master
LM : Left Traction - Master	EPSS : EPS - Slave
LS : Left Traction - Slave	VCMM : VCM - Master
PM : Pump - Master	VCMS : VCM - Slave

②Following three letters or digits show alarm code. Please refer to 10. ALARM CODE (Page 7-69).

③This shows a name of ALARM. Please refer to 10. ALARM CODE (page 7-69).

(3) Alatm history

Alarm History can be looked up as follows ;

15BT9USM07CL5

①Step 1 : Service man can check the alarm history on ALARM HISTORY menu
②Step 2 : When service man enter the ALARM HISTORY menu, display read entire alarm records of all controller.
③Step 3 : When display finish to read alarm records, service man can choose each controller to read the alarm history.
④Step 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.
⑤Step 5-1 : When service man press button at Step 4, operator can see a detail alarm information of chosen alarm. Please refer to (4) DETAIL ALARM INFORMATION (see below).
Step 5-2 : When service man press button at Step 4, service man can see a alarm clear
⑥menu. 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 button, just escape to step 3 without clearing

(4) Detail alarm information

15BT9USM07CL6

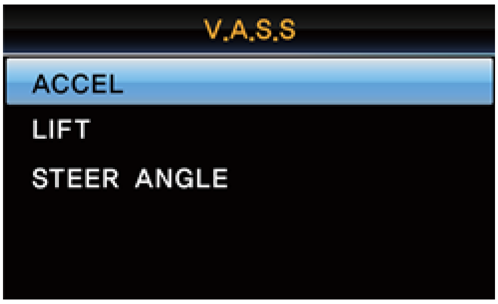
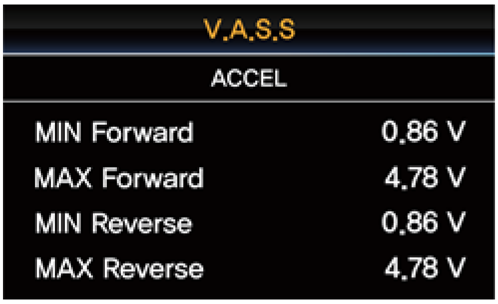
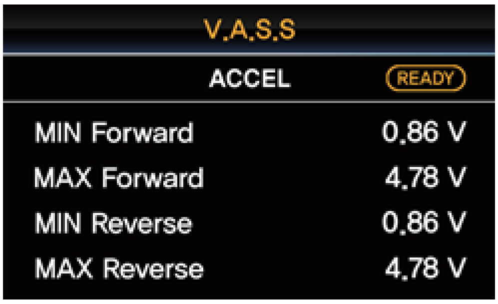
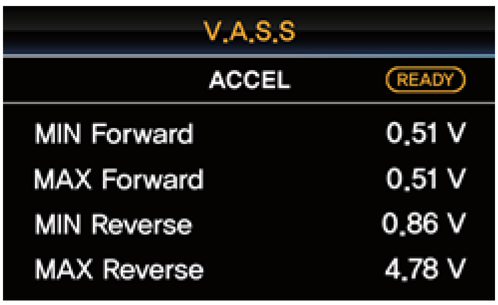
①Code of alarm
②Name of alarm
③Count of alarm
④Temperature of controller as alarm occurs.
⑤Hourmeter of controller as alarm occurs.

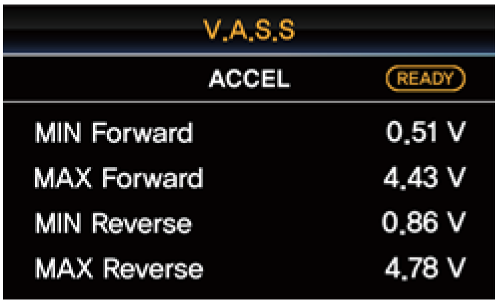
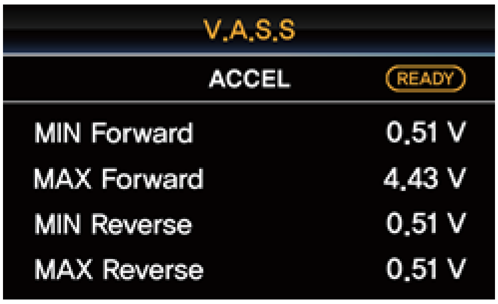
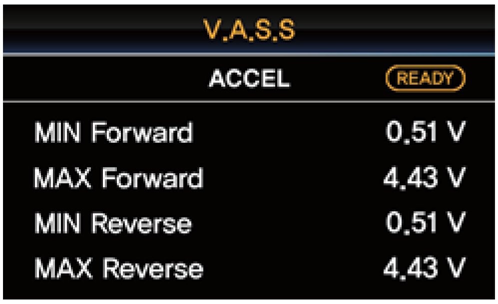
8) VASS SETUP USING DISPLAY MENU

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.)

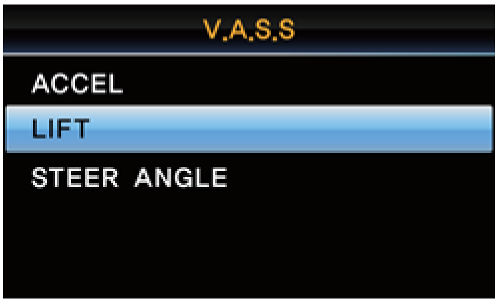
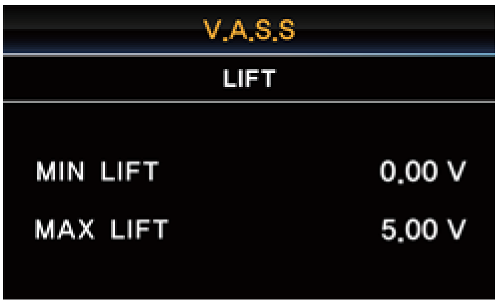
While even a motor is running, VASS can not be configurated properly, so please be sure that all motors are not running before entering configuration process & saving.

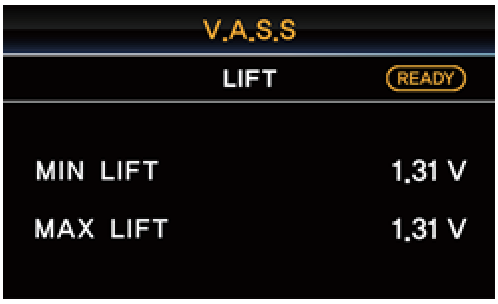
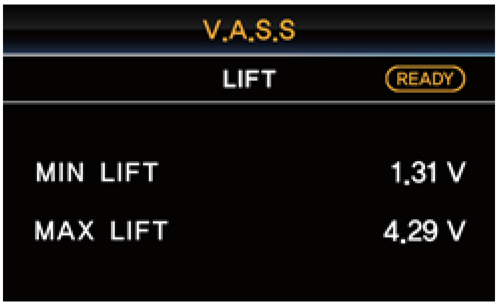
(1) ACCEL VASS setting method

<table>
<tr><th>Step</th><th>Display</th><th>Description</th></tr>
<tr><td>1</td><td>
</td><td>1. Access the accelerator pedal setup screen via "TRUCK MENU → SETTING → V .A.S.S → ACCEL".</td></tr>
<tr><td>2</td><td>
</td><td>1. As shown on the left screen, the accelerator pedal setting screen appears.
※ Confirm that the forward / reverse gear is neutral and both the traveling and hydraulic motor are stopped.
2. Press the "ENTER" button to start the setting.</td></tr>
<tr><td>3</td><td>
</td><td>1. When the ready indicator appears in the upper right corner of the screen, start setting.
2. Place the forward / reverse gear in forward position.</td></tr>
<tr><td>4</td><td>
</td><td>1. Press the accelerator pedal all the way down and release it again</td></tr>
</table>

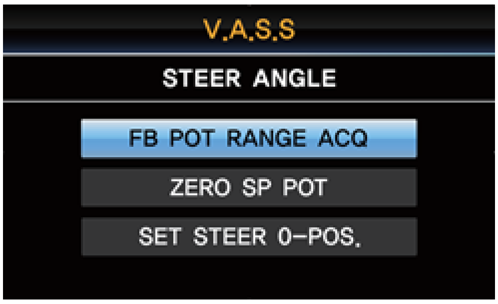
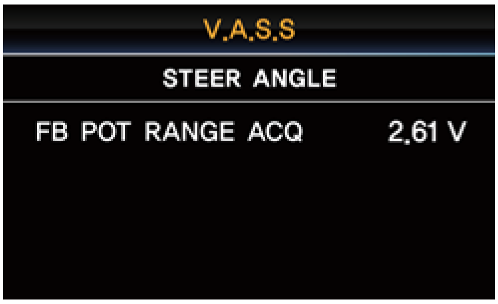
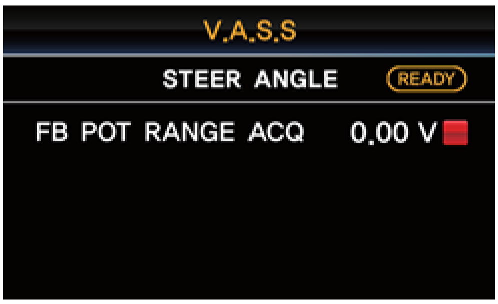
Step	Display	Description
5		1. You can see that MAX FORWARD has been changed. 2. Change the forward / reverse gear from forward to reverse.
6		1. MIN REVERSE (minimum value at backward) and MAX REVERSE (maximum value at backward) are changed to 0V ~ 0.9V state. 2. Place the forward / reverse gear in forward position.
7		1. You can see that MAX REVERSE has been changed. ※ Set the forward / reverse gear to neutral and check that all motors are stopped. 2. Press the "ENTER" button to save.

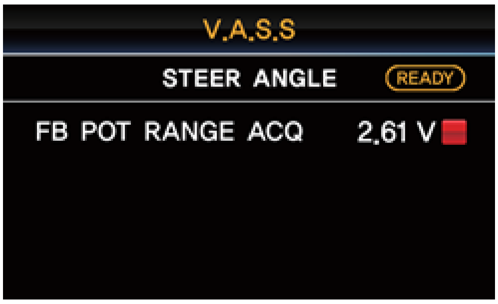
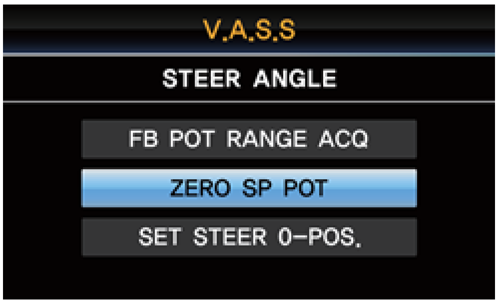
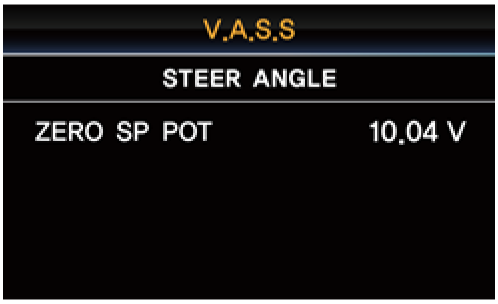
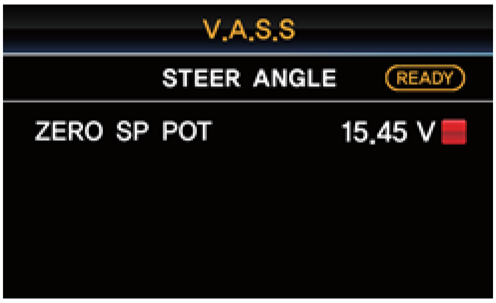
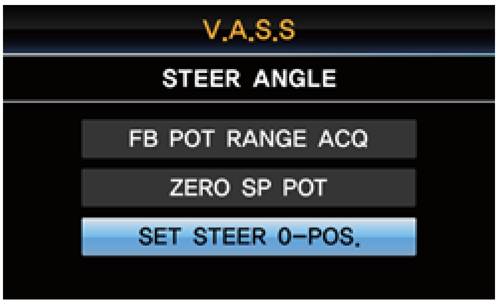
(2) LIFT VASS setting method

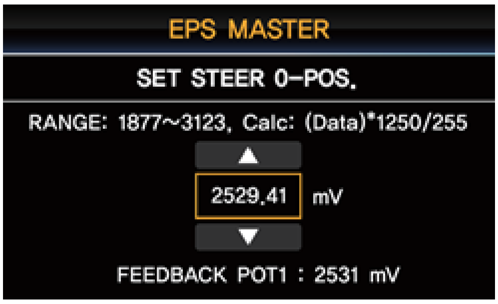
Step	Display	Description
1		1. Access the lift sensor setting screen via "TRUCK MENU → SETTING → V.A.S.S. → LIFT".
2		1. As shown on the left screen, the accelerator setting screen appears. ※ Confirm that the forward / reverse gear is neutral and both the traveling / hydraulic motor is stopped. 2. Press the "ENTER" button to start the setting.

Step	Display	Description
3		1. The READY indicator appears in the upper right corner of the screen, and the MIN LIFT and MAX LIFT values are aligned to the current minimum value. 2. Pull up the lift lever until it stops.
4		1. Pulling the LIFT LEVER all the way down will change the value when the MAX LIFT value is pulled to its maximum. ※ Set the forward / reverse gear to neutral and check that all motors are stopped. 2. Press the "ENTER" button to save.

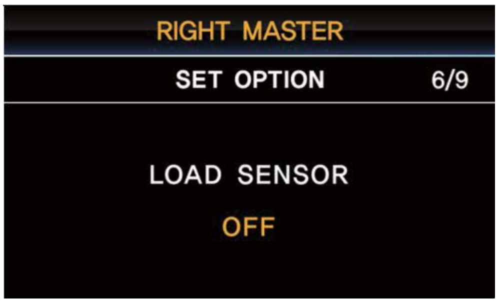
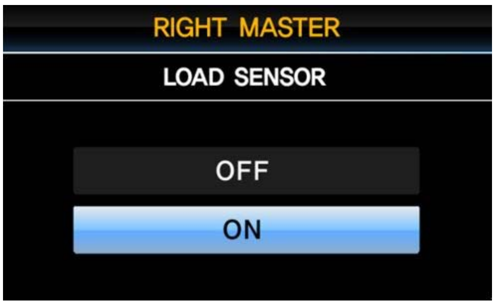
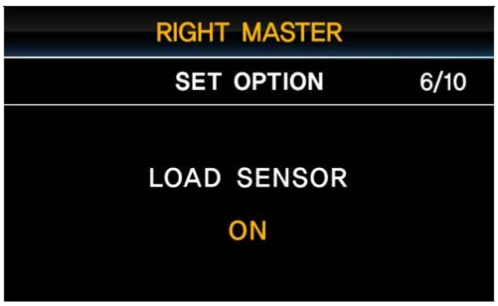
(3) STEER ANGLE VASS setting method

Step	Display	Description
1		1. Access the lift sensor setting screen via "TRUCK M ENU → S ETTING → V.A.S.S. → STEER ANGLE". 2. Enter the "FB POT RANGE ACQ" menu.
2		1. Press the "ENTER" button on the left screen to start the setting.
3		1. Turn the steering wheel repeatedly 3 to 4 times to the left and right. (Repeat as close as possible to the left / right maximum steering angle.)

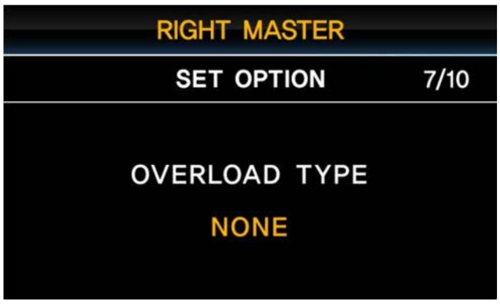
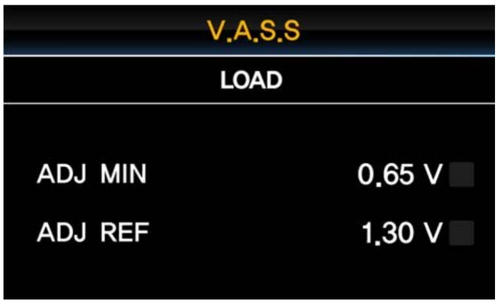
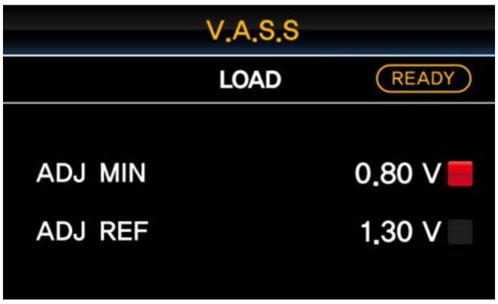
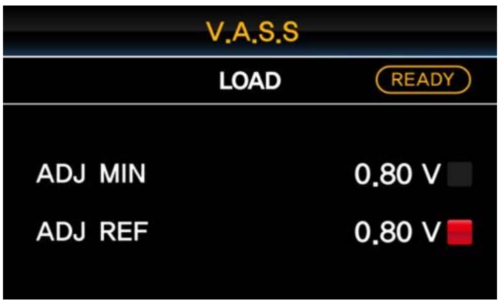
Step	Display	Description
4		1. If the voltage change no longer appears, press "ENTER" to save.
5		1. Access the lift sensor setting screen via "TRUCK M ENU → SETTING → V.A.S.S. → STEER ANGLE". 2. Enter the "ZERO SP POT" menu.
6		1. Press the "ENTER" button on the left screen to start the setting.
7		1. Position the steering wheel in the forward direction (steering knob at 8 o'clock) and press "ENTER" to save. 
8		1. Access the lift sensor setting screen via "TRUCK M ENU → S ETTING → V.A.S.S. → STEER ANGLE". 2. Enter the "SET STEER 0-POS." menu.

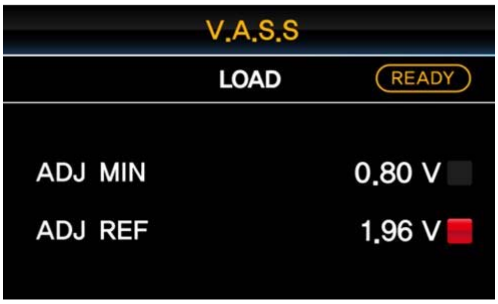
Step	Display	Description
9		※ Make sure that the angle of the steering wheel (rear wheel) is in the complete forward direction (0.) before starting the setting. 1. Press the "ENTER" button on the left screen to start the setting.
10		1. Press the "UP" and "DOWN / TURTLE" buttons to adjust the value to match the "FEEDBACK POT 1" value at the bottom of the screen and press "ENTER" to save.

(4) LOAD SENSOR setting method(Option)

Step	Display	Description
1		1. In the TRUCK MENU, find the LOAD SENSOR parameter via “SETTING ▯ RIGHT MASTER ▯ SET OPTION”
2		1. Change it to “ON” by using "UP" button and "DOWN / TURTLE" button and press "ENTER" button to save.
3		1. You can see that LOAD SENSOR has been changed to “ON”.

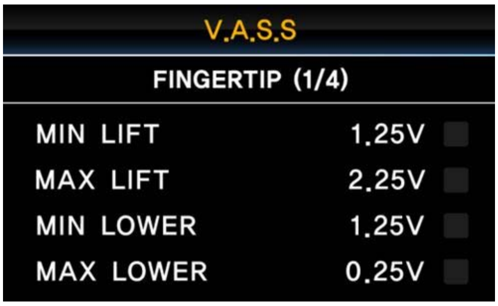
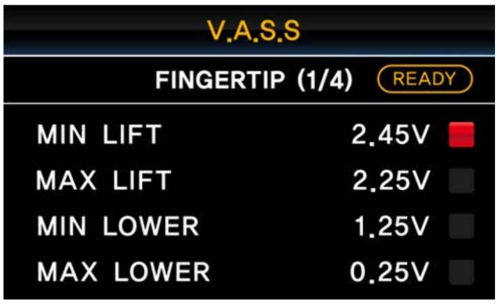
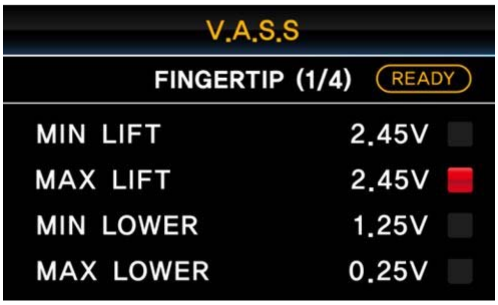
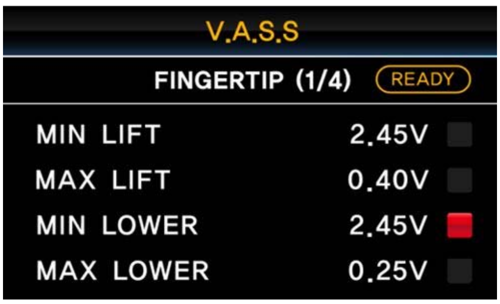
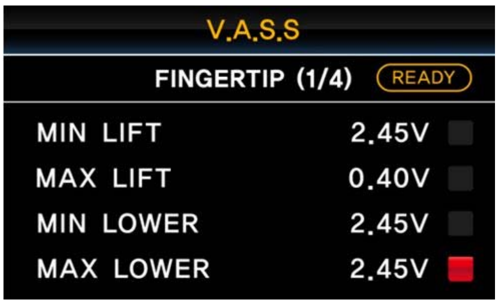
Step	Display	Description
4		1. In the TRUCK MENU, find the REF.LOAD WEIGHT parameter via “TRUCK MENU ▯ RIGHT MASTER ▯ ADJUSTMENTS” 2. REF LOAD WEIGHT is a parameter that adjusts the weight of the setting load. Press the "ENTER" button to set.
5		1. Use the "UP" button and the "DOWN / TURTLE" button to set the load weight for the setup (assuming 2800KG) and press the "ENTER" button.
6		1. Press the "ENTER" button to save.
7		1. You can see that the REF LOAD WEIGHT parameter value has changed. 2. Use the "UP" and "DOWN / TURTLE" buttons to find the OVER LOAD WEIGHT parameter.
8		1. The OVER LOAD WEIGHT parameter sets the weight at which the overload warning occurs, and the value differs for each model / mast. Refer to "OVERLOAD WEIGHT” for each model / mast. 2. Refer to steps 5 and 6 to set the specified weight. 3. Open TRUCK MENU ▯ RIGHT MASTER ▯ SET OPTION ▯ OVERLOAD TYPE setting screen.

Step	Display	Description
9		1. The OVER LOAD TYPE parameter has three options as shown below. 1) NONE: No warning even if the load weight exceeds the OVER LOAD WEIGHT setting. 2) OPTION # 1: OVER LOAD WEARING occurs when the load weight exceeds the OVER LOAD WEIGHT setting value, and stops the vehicle operation except LIFT DOWN and steering function. 3) OPTION # 2: OVER LOAD WARNING occurs only when the load weight exceeds the OVER LOAD WEIGHT setting. 2. OVER LOAD TYPE must be set to NONE for LOAD SENSOR setting. If set to OPTION # 1 or OPTION # 2, change to "NONE" using "ENTER" button and "UP" or "DOWN / TURTLE" After that, LOAD SENSOR must be set.
10		1. Access the LOAD SENSOR setting screen via “TRUCK MENU ▯ SETTING ▯ V.A.S.S ▯ LOAD SENSOR”. (Only when the LOAD SENSOR parameter in step 1 is set to ON.) 2. After confirming that the forward / reverse gear is neutral and both the drive and hydraulic motor are stopped, press the "ENTER" button in no-load state to start the setting.
11		1. At the top right of the screen, "READY" appears, "ADJ MIN" displays a red mark, and the "ADJ MIN LOAD" setting starts. The value of "ADJ MIN" indicates the no-load LOAD SENSOR input, and the setup proceeds. 2. Press Enter button to move on to the "ADJ REF".
12		1. "ADF REF" displays a red mark and the "ADJ REF" setting starts. 2. "ADJ REF" is the input value of the load sensor when the load for setting is lifted. When setting, lift the load to a height of about 50 cm from the ground. ※Before lifting the load, slightly lower and lift the load to operate normally. 3. You can see that the "ADF REF" value changes every time you lift the load.

Step	Display	Description
13		1. After waiting for 5 ~ 10 seconds after lifting the load(REF. LOAD WEIGHT), make sure that the ADJ REF value stabilizes, then press the ENTER button.
14		1. Press the "ENTER" button to save and exit. 2. Set the OVERLOAD TYPE in Step 9 as desired. (Default value is NONE) ▯ Note: For accuracy of LOAD SENSOR, the reference load for setting should be as large as possible within the range of not exceeding OVERLOAD WEIGHT.

(5) FINGERTIP setting method(OPTION)

Step	Display	Description
1		1. In the TRUCK MENU, find the TRUCK MODEL SEL. parameter via “TRUCK MENU ▯ SETTING ▯ PUMP MASTER ▯ SET OPTION”
2		1. Use the "UP" button and the "DOWN / TURTLE" button to find each of the following parameters and change them to the corresponding settings. 1) EVP TYPE: NONE (Not applicable for 15/18/20BT-9U) 2) OPSS: OFF 3) FINGERTIP: ON 4) FINGERTIP MISM: ON 5) AUX 1 FUNCTION: ON (when the lever specification is 3-spool or more) 6) AUX 2 FUNCTION: ON (when the lever specification is 4-spool or more)

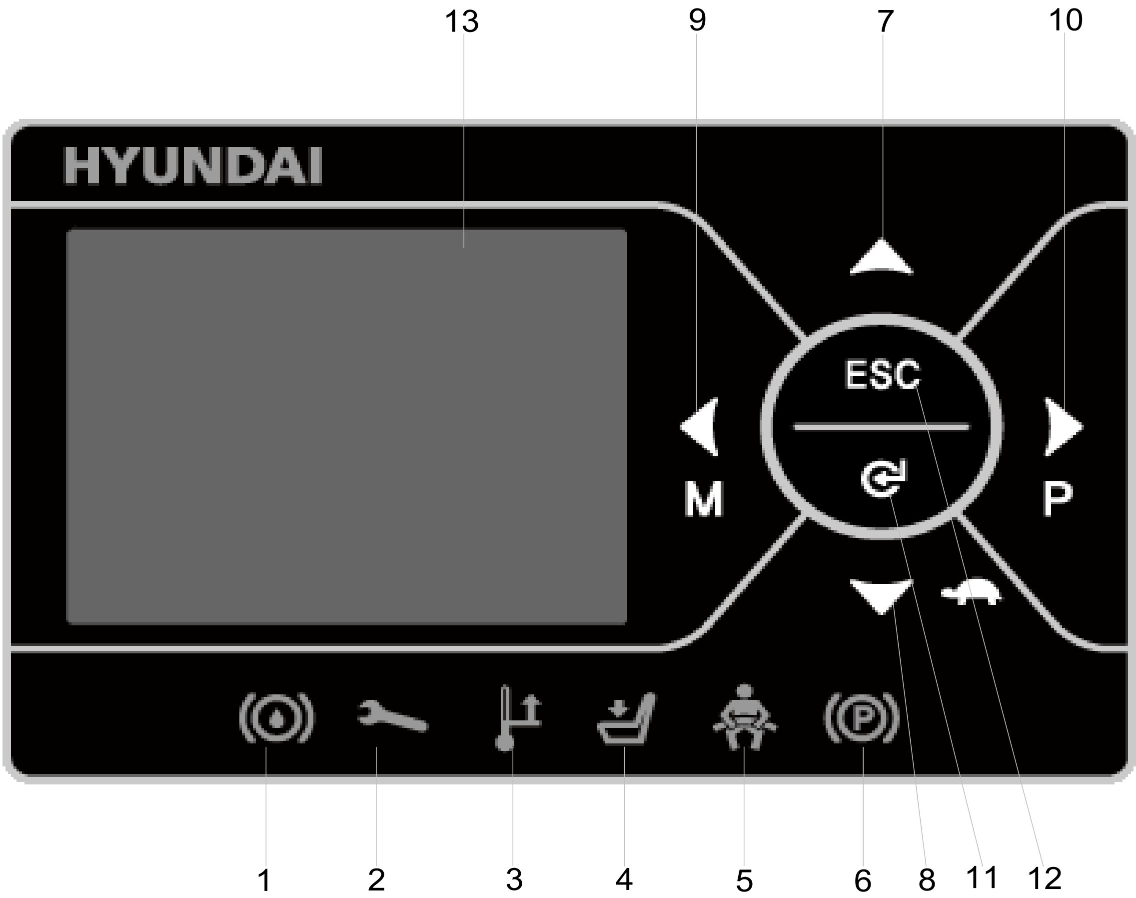
Step	Display	Description
3		1. Access the FINGERTIP setting screen via “TRUCK MENU ▯ SETTING ▯ V.A.S.S ▯ FINGERTIP”. (Only when the FINGERTIP parameter in step 1 is set to ON.) 2. Press the ENTER button to set the LEVER as shown below. 1) 2-SPOOL : LIFT, TILT 2) 3-SPOOL : LIFT, TILT, AUX1 3) 4-SPOOL : LIFT, TILT, AUX1, AUX2 3. For illustrative purposes, Below will set the LIFT LEVER by pressing the "ENTER" button.
4		1. The READY indicator appears in the upper right corner of the screen, a red indicator appears on the right of the MIN LIFT and MIN LIFT (LIFT UP MIN value) setting starts. 2. Set MIN LIFT (LIFT UP MIN value). While pulling the LEVER a little bit (about 10˚) from the center, press the "ENTER" button to set the MIN LIFT value.
5		1. It switches to MAX LIFT (LIFT UP MAX value) setting and displays real time LEVER voltage value. 2. Set MAX LIFT (LIFT UP MAX value). While pulling the lever all the way down, press the "ENTER" button to set the MIN LOWER value.
6		1. It switches to MIN LOWER (LOWER MIN value) setting and displays real time LEVER voltage value. 2. Set MIN LOWER (LOWER MIN value). While pushing the LEVER a little bit (about 10˚) from the center, press the "ENTER" button to set the MAX LOWER value.
7		1. It switches to MAX LOWER (LOWER MAX value) setting and displays real time LEVER voltage value. 2. Set MAX LOWER (LOWER MAX value). While pulling the lever all the way down, press the "ENTER" button.

Step	Display	Description
8		1. After completing all lever settings, press "ENTER" button. 2. Press the "ENTER" button to exit.

6. INSTRUMENT PANEL : DISPLAY (15BT-9U : #304~, 18BT-9U : #450~, 20BT-9U : #783~)

1) STRUCTURE

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



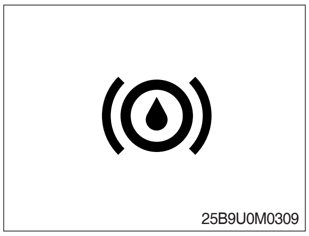
25B9U0M0308-1

· LCD : TFT 3.5 inch IPS

1	Oil level warning lamp	6	Parking brake warning lamp	11	Enterbutton
2	Wrench warning lamp	7	Up button	12	ESC button
3	Thermometer warning lamp	8	Down/turtle button	13	LCD function
4	Seat warning lamp	9	Left/menu button		
5	Seat belt warning lamp	10	Right/performance button		

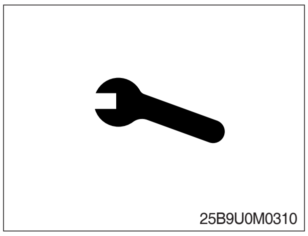
2) WARNING LAMP

(1) Brake oil level warning lamp



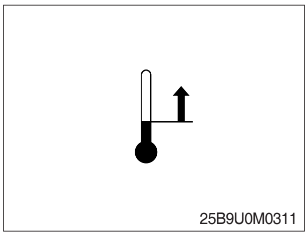
This LED lights when measured level of brake oil stored in reservoir tank is below the minimum acceptable mark.

(2) Wrench warning lamp



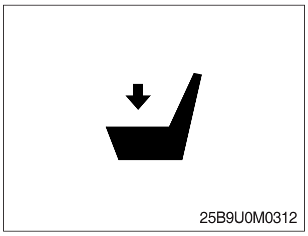
This LED lights when an electric device (controller, motor, cable, etc.) is in abnormal condition.

(3) Thermometer warning lamp



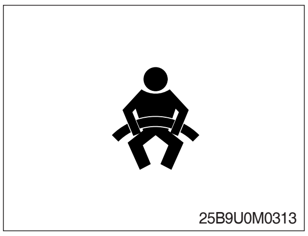
This LED lights when the controller or motor temperature is high.

(4) Seat warning lamp



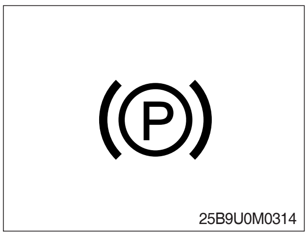
This LED lights when the operator is not on the seat.

(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) Parking brake warning lamp



(1) This LED lights when the parking brake is activated.

3) BUTTON

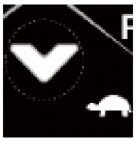
These buttons are used to select or change the menu and input value of the LCD function and display menu.

(1) Up button

25B9U0M0315

Press to select upward move.

(2) DOWN/TURTLE button



25B9U0M0316

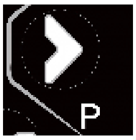
Press to select downward move.
TURTLE MODE ON/OFF

(3) LEFT/MENU button

25B9U0M0317

Press to select leftward move.
Go into the menu.

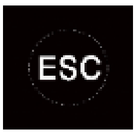
(4) RIGHT/PERFORMANCE button



25B9U0M0318

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

(5) Cancel (ESC) button



25B9U0M0319

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

(6) ENTER button

25B9U0M0320

Press to select Enter.

4) LCD FUNCTION

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

(1) Current time

The number shows the current time according to the setting, which can be changed by display setting at page 7-58.

(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 set-point. 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

It indicates the speed level by 2 km.

(5) Truck speed

The truck speed is shown in number. The unit can be km/h or mph according to the display setting (see 7-66 page).

(6) Hour meter

The number shows the hours worked. The letter present beside the hour meter number 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 points 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's state of charge)

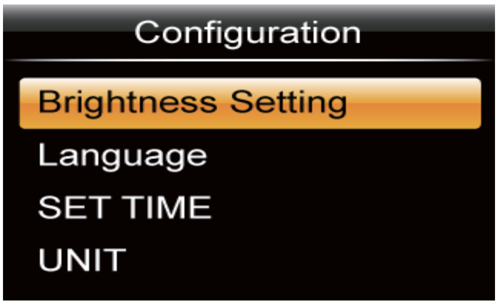
The battery's state of charge is shown by ten bars. Each bar represents the 10% of the battery charge. As the battery becomes discharged, the bars turn off progressively, one after another, in proportion to the value of the residual battery charge. When the residual battery charge is 20% or under, the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

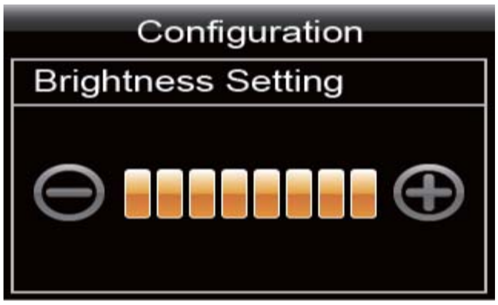
(10) Load weight (option)

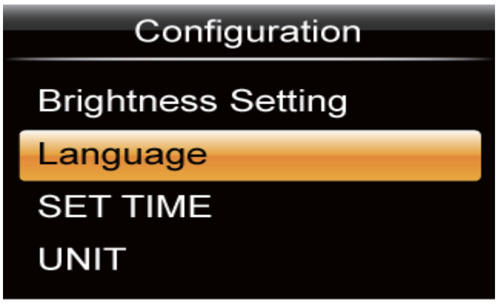
The indicator shows the weight the machine carrying at load.

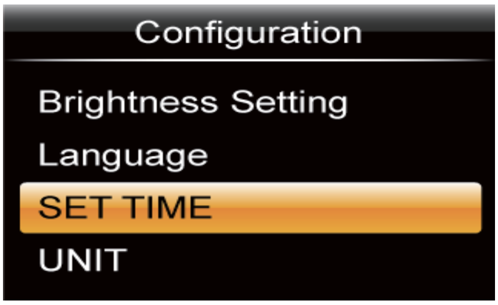
- Indicator range : 0~6375 kg

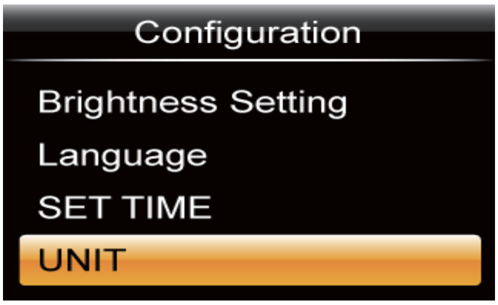
5) HOW TO SET THE DISPLAY MENU

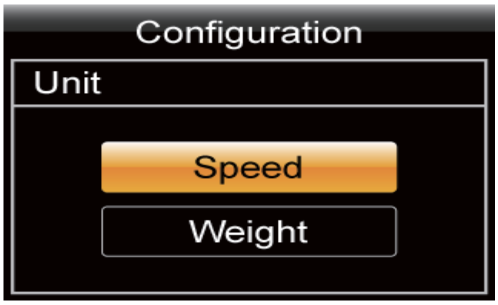


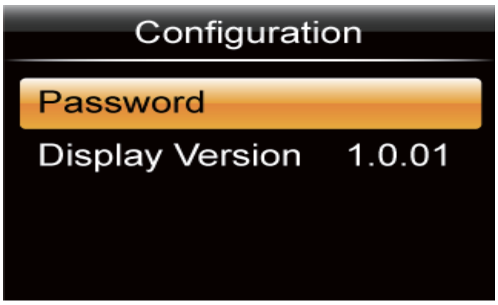


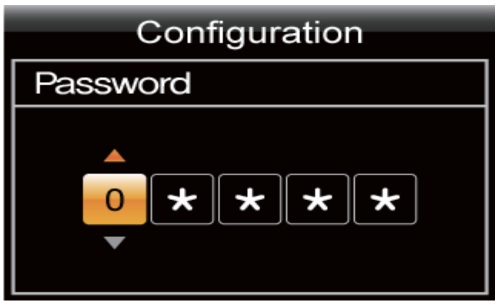






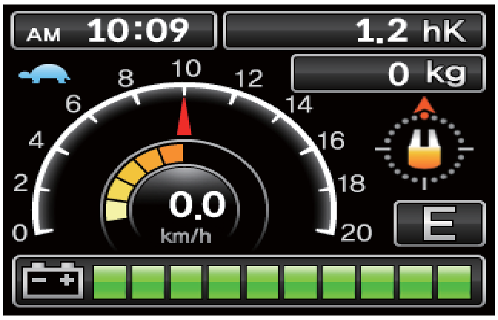
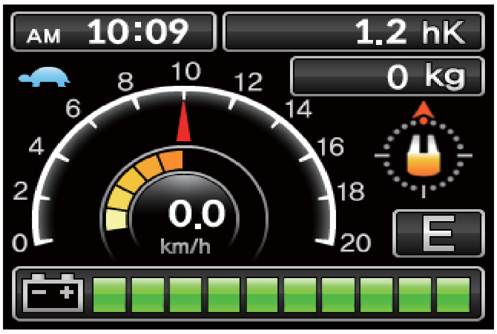
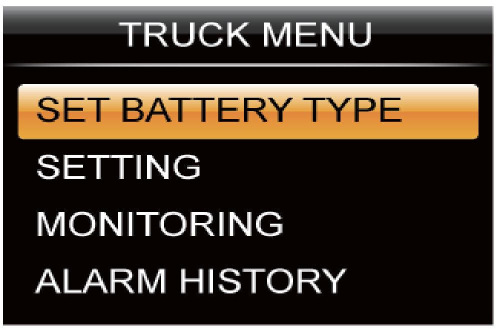






6) DESCRIPTION OF THE TRUCK MENU

(1) Access to truck menu

Step	Display	Description
1		1. When the vehicle key turns on, the initial screen as shown on the left appears. 2. Press "ESC" button for more than 1 second in the initial screen.
2		1. The password input screen appears as shown on the left. 2. Enter the password using the "UP", "DOWN", "LEFT/MENU", "RIGHT/PERFORMANCE" buttons and press the "ENTER" button.
3		1. After inputting the password, the initial screen appears as shown on the left. 2. Press the "LEFT / MENU" button.
4		1. TRUCK MENU appears as shown on the left. 2. Use the "UP" and "DOWN/TURTLE" buttons to select the desired menu (HIGH-LIGHT in orange) and press the "ENTER" button to enter the menu. 3. To move to the upper menu, press "ESC" button to move.

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 :

(2) Detail description of ALARM SCREEN

①First orange capital letter shows in which controller the alarm happens as below;

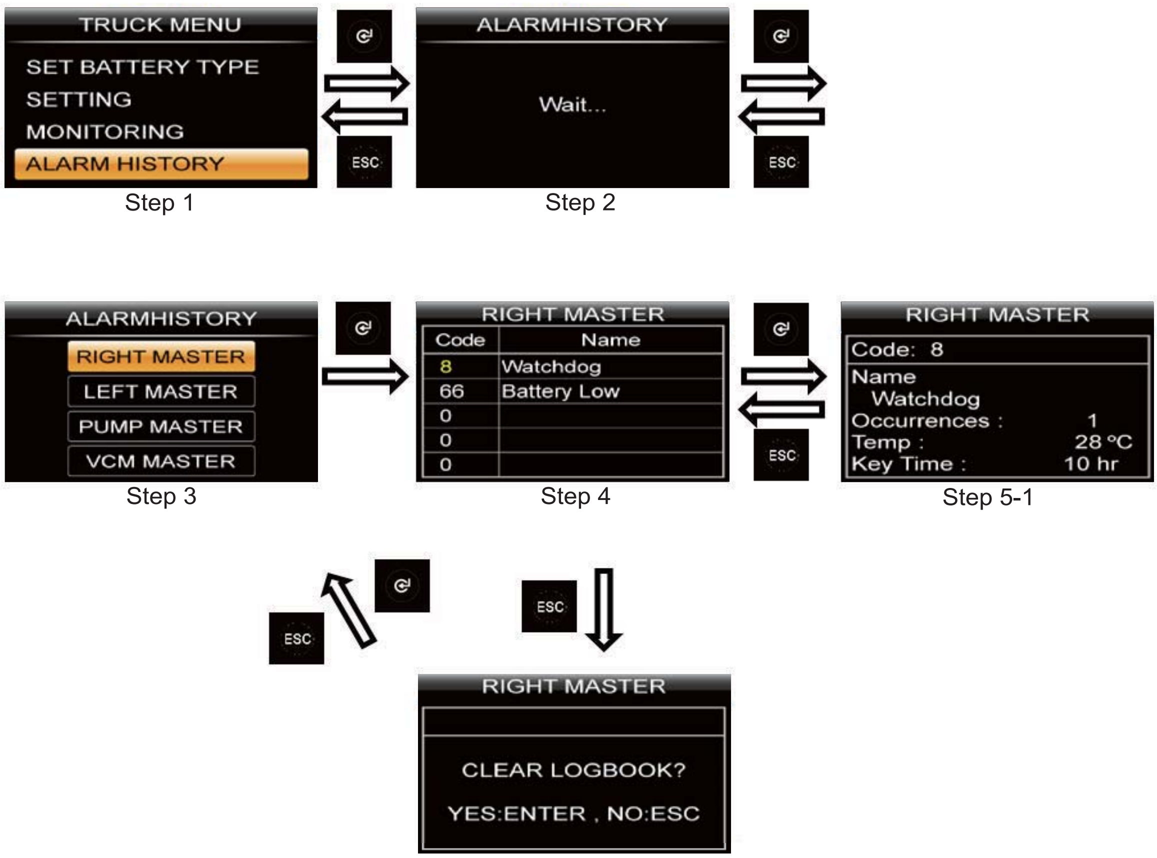
RM : Right Traction - Master
RS : Right Traction - Slave
LM : Left Traction - Master
LS : Left Traction - Slave
PM : Pump - Master
PS : Pump - Slave
EPSM : EPS - Master
EPSS : EPS - Slave
VCMM : VCM - Master
VCMS : VCM - Slave

②Following three letters or digits show alarm code. Please refer to 10. ALARM CODE (Page 7-69).

③This shows a name of ALARM. Please refer to 10. ALARM CODE (page 7-69).

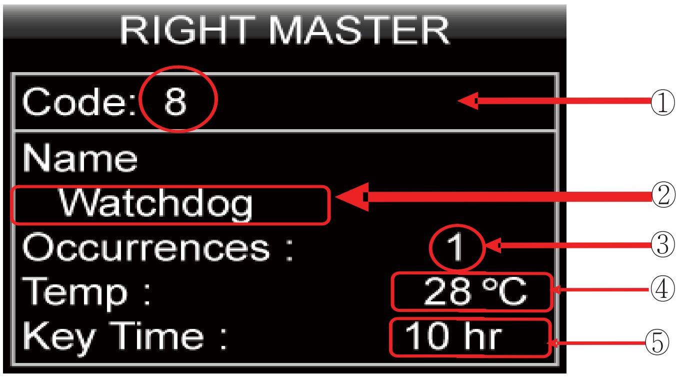
(3) Alatm history

Alarm History can be looked up as follows ;



①Step 1 : Service man can check the alarm history on ALARM HISTORY menu
②Step 2 : When service man enter the ALARM HISTORY menu, display read entire alarm records of all controller.
③Step 3 : When display finish to read alarm records, service man can choose each controller to read the alarm history.
④Step 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.
⑤Step 5-1 : When service man press button at Step 4, operator can see a detail alarm information of chosen alarm. Please refer to (4) DETAIL ALARM INFORMATION (see below).
Step 5-2 : When service man press ESC button at Step 4, service man can see a alarm clear
⑥menu. 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



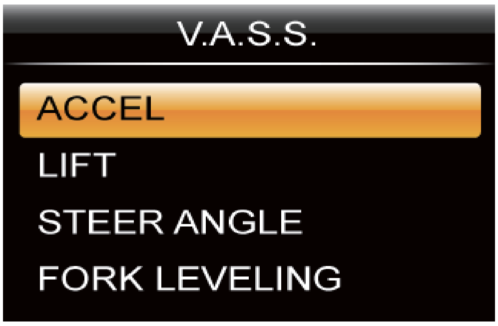
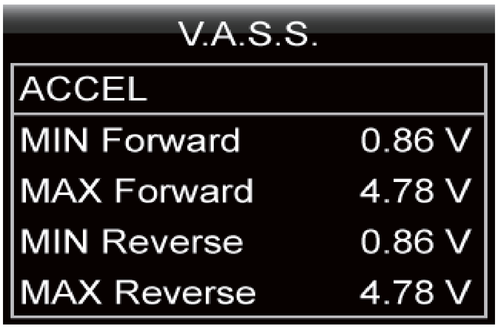
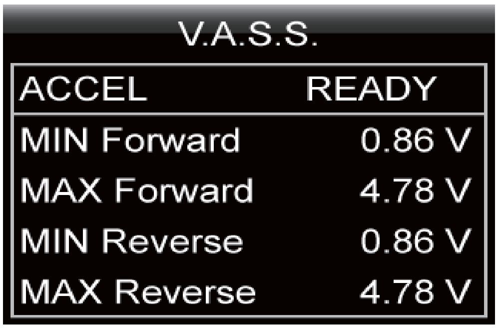
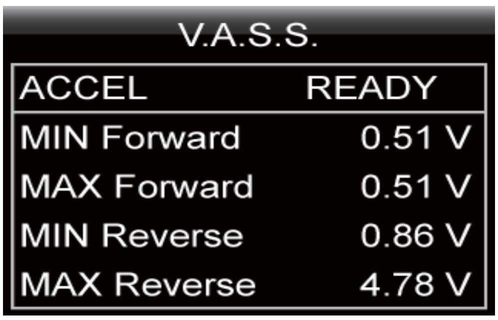
①Code of alarm
②Name of alarm
③Count of alarm
④Temperature of controller as alarm occurs.
⑤Hourmeter of controller as alarm occurs.

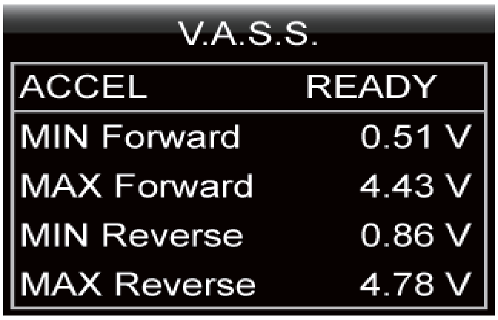
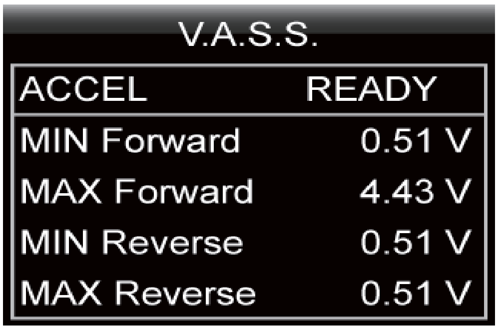
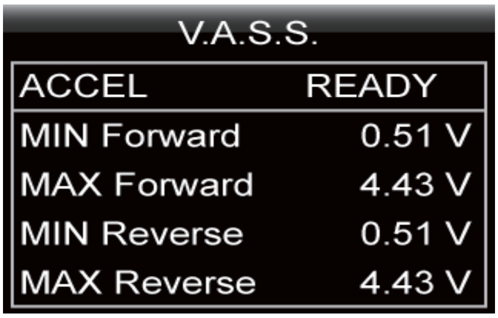
8) VASS SETUP USING DISPLAY MENU

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.)

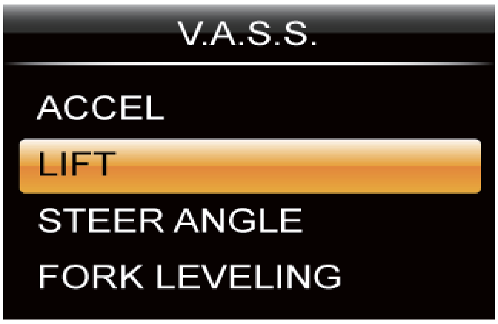
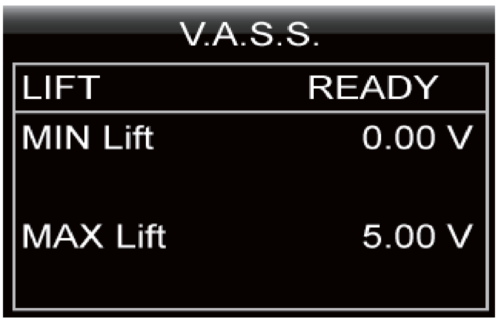
While even a motor is running, VASS can not be configurated properly, so please be sure that all motors are not running before entering configuration process & saving.

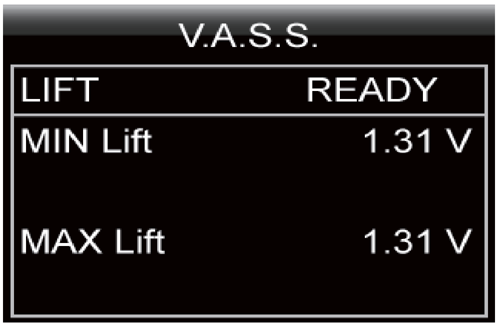
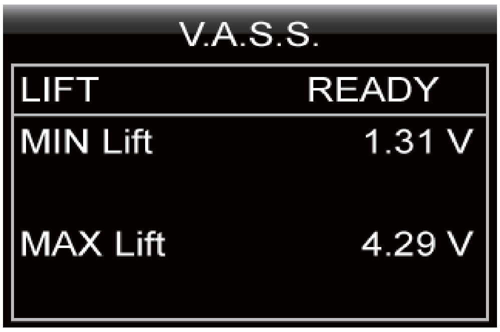
(1) ACCEL VASS setting method

Step	Display	Description
1		1. Access the accelerator pedal setup screen via "TRUCK MENU → SETTING → V .A.S.S → ACCEL".
2		1. As shown on the left screen, the accelerator pedal setting screen appears. ※ Confirm that the forward / reverse gear is neutral and both the traveling and hydraulic motor are stopped. 2. Press the "ENTER" button to start the setting.
3		1. When the ready indicator appears in the upper right corner of the screen, start setting. 2. Place the forward / reverse gear in forward position.
4		1. Press the accelerator pedal all the way down and release it again

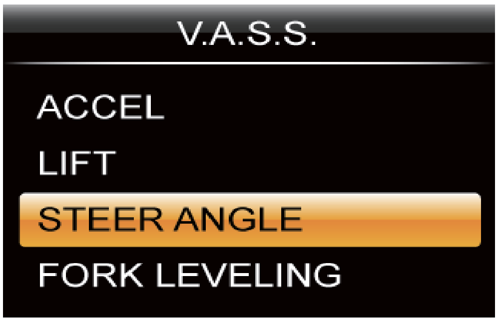
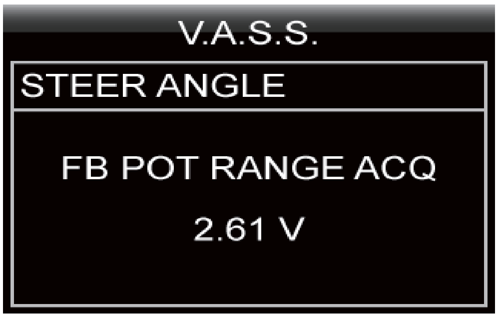
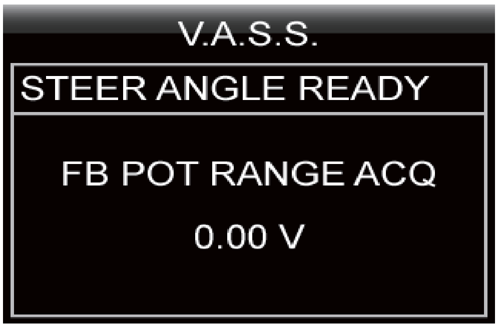
Step	Display	Description
5		1. You can see that MAX FORWARD has been changed. 2. Change the forward / reverse gear from forward to reverse.
6		1. MIN REVERSE (minimum value at backward) and MAX REVERSE (maximum value at backward) are changed to 0V ~ 0.9V state. 2. Place the forward / reverse gear in forward position.
7		1. You can see that MAX REVERSE has been changed. ※ Set the forward / reverse gear to neutral and check that all motors are stopped. 2. Press the "ENTER" button to save.

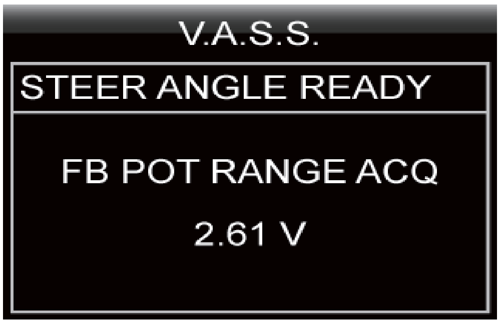
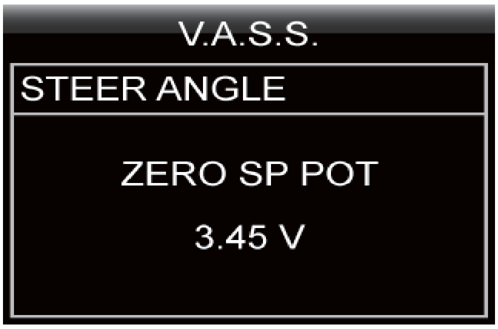
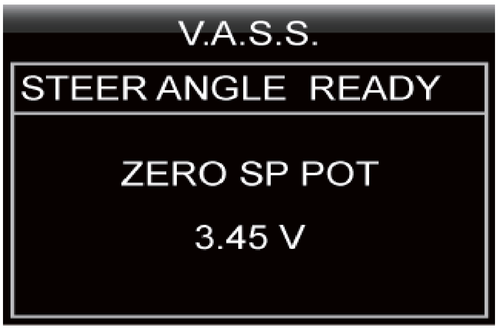
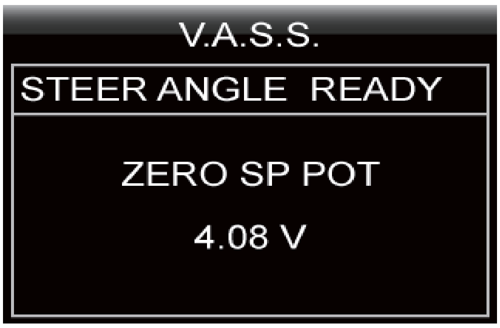
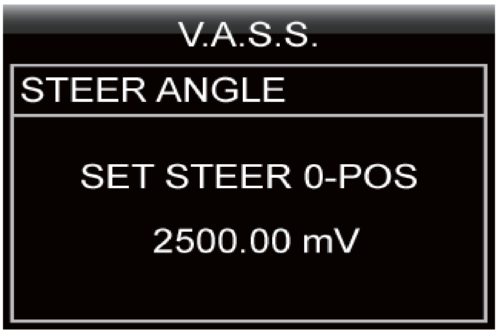
(2) LIFT VASS setting method

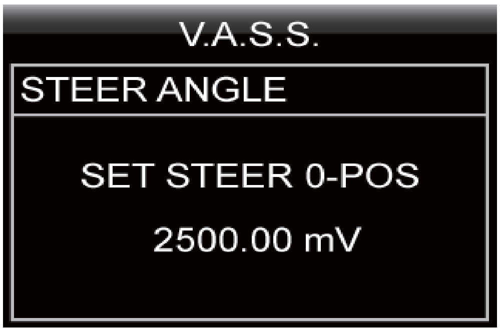
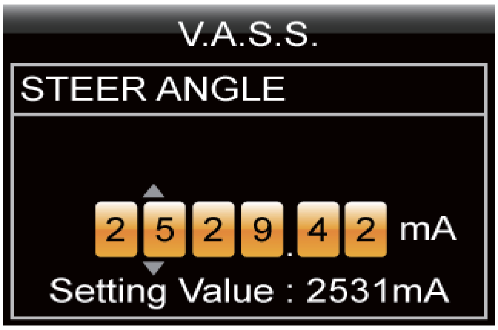
Step	Display	Description
1		1. Access the lift sensor setting screen via "TRUCK MENU → SETTING → V.A.S.S. → LIFT".
2		1. As shown on the left screen, the accelerator setting screen appears. ※ Confirm that the forward / reverse gear is neutral and both the traveling / hydraulic motor is stopped. 2. Press the "ENTER" button to start the setting.

Step	Display	Description
3		1. The READY indicator appears in the upper right corner of the screen, and the MIN LIFT and MAX LIFT values are aligned to the current minimum value. 2. Pull up the lift lever until it stops.
4		1. Pulling the LIFT LEVER all the way down will change the value when the MAX LIFT value is pulled to its maximum. ※ Set the forward / reverse gear to neutral and check that all motors are stopped. 2. Press the "ENTER" button to save.

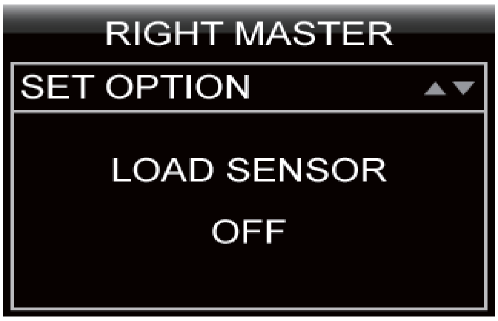
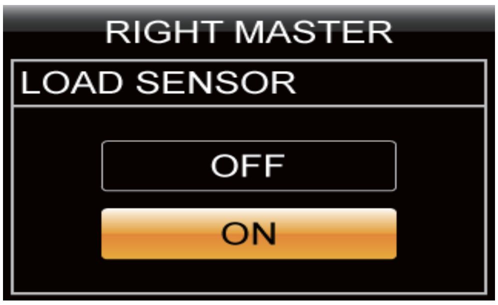
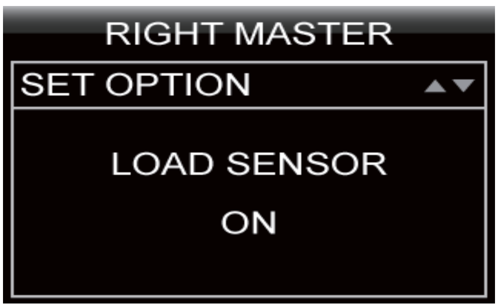
(3) STEER ANGLE VASS setting method

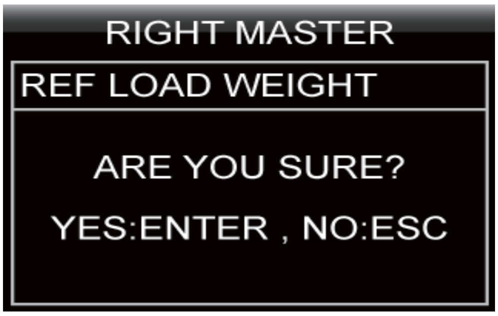
Step	Display	Description
1		1. Access the steer angle sensor setting screen via "TRUCK M ENU → S ETTING → V.A.S.S. → STEER ANGLE".
2		1. You can see the "FB POT RANGE ACQ" screen. 2. Press the "Enter" button on the left screen to start the setting.
3		1. Turn the steering wheel repeatedly 3 to 4 times to the left and right. (Repeat as close as possible to the left / right maximum steering angle.)

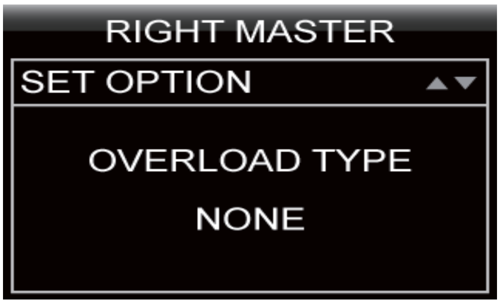
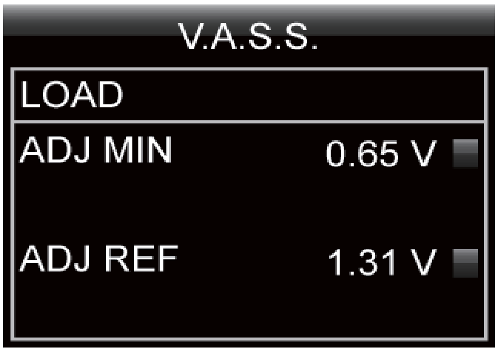
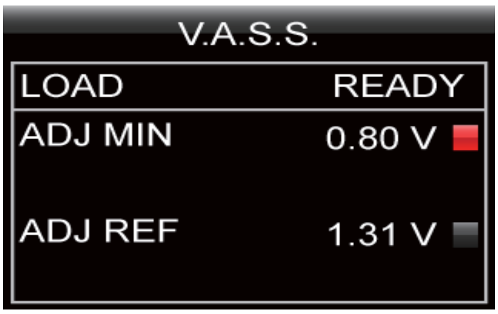
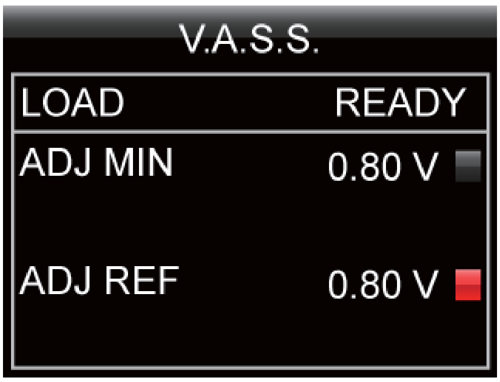
Step	Display	Description
4		1. If the voltage change no longer appears, press "ENTER" to save. 2. You have to key-off and key-on the forklift after the save.
5		1. Access the steer angle sensor setting screen via "TRUCK M ENU → SETTING → V.A.S.S. → STEER ANGLE". 2. Press the "▼" DOWN button. 3. You can see the "ZERO SP POT" screen.
6		1. Press the "ENTER" button on the left screen to start the setting.
7		1. Position the steering wheel in the forward direction (steering knob at 8 o'clock) and press "ENTER" to save.  2. You have to key-off and key-on the forklift after the save.
8		1. Access the lsteer angle sensor setting screen via "TRUCK M ENU → S ETTING → V.A.S.S. → STEER ANGLE". 2. Press the "▼" DOWN button twice. 3. You can see the "SET STEER 0-POS" screen.

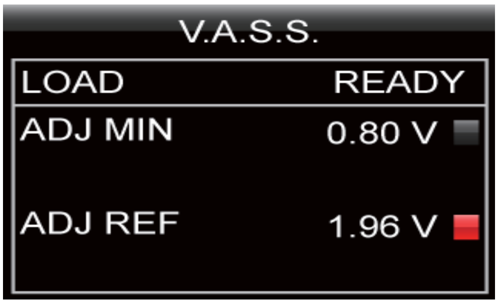
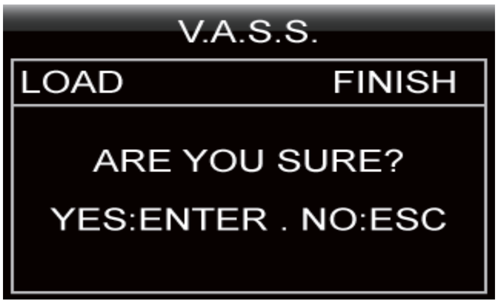
Step	Display	Description
9		※ Make sure that the angle of the steering wheel (rear wheel) is in the complete forward direction (0.) before starting the setting. 1. Press the "ENTER" button on the left screen to start the setting.
10		1. Press the "UP" and "DOWN / TURTLE" buttons to adjust the value to match the "Setting value" at the bottom of the screen and press "ENTER" to save.

(4) LOAD SENSOR setting method(Option)

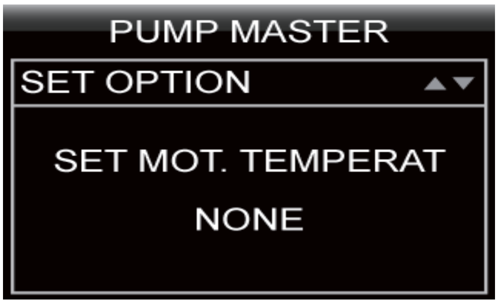
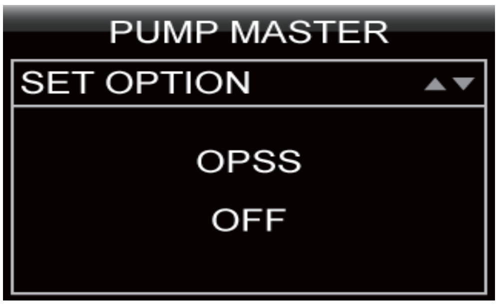
Step	Display	Description
1		1. In the TRUCK MENU, find the LOAD SENSOR parameter via “SETTING → RIGHT MASTER → SET OPTION”
2		1. Change it to “ON” by using "UP" button and "DOWN / TURTLE" button and press "ENTER" button to save.
3		1. You can see that LOAD SENSOR has been changed to “ON”.

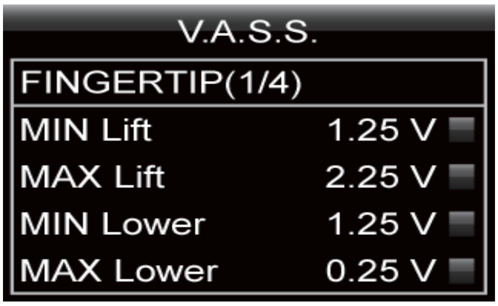
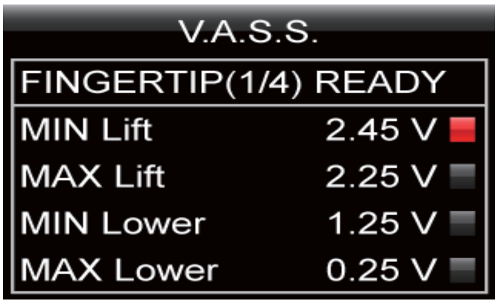
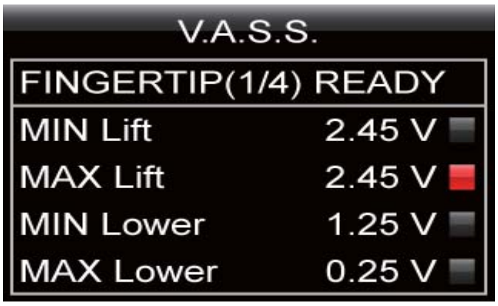
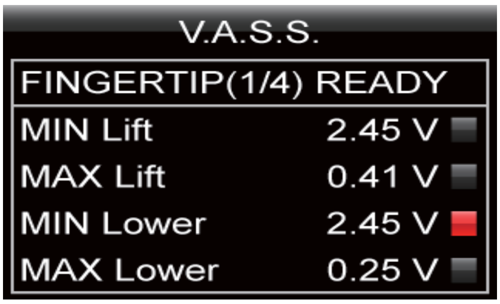
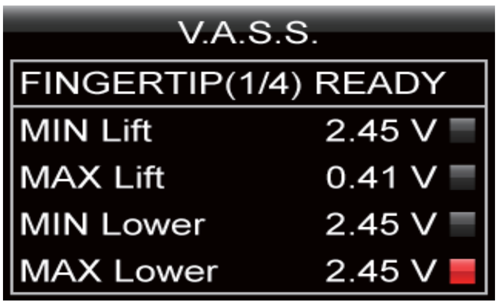
Step	Display	Description
4		1. In the TRUCK MENU, find the REF.LOAD WEIGHT parameter via “TRUCK MENU → RIGHT MASTER → ADJUSTMENTS” 2. REF LOAD WEIGHT is a parameter that adjusts the weight of the setting load. Press the "ENTER" button to set.
5		1. Use the "UP" button and the "DOWN / TURTLE" button to set the load weight for the setup (assuming 2800KG) and press the "ENTER" button.
6		1. Press the "ENTER" button to save.
7		1. You can see that the REF LOAD WEIGHT parameter value has changed. 2. Use the "UP" and "DOWN / TURTLE" buttons to find the OVER LOAD WEIGHT parameter.
8		1. The OVER LOAD WEIGHT parameter sets the weight at which the overload warning occurs, and the value differs for each model / mast. Refer to "OVERLOAD WEIGHT” for each model / mast. 2. Refer to steps 5 and 6 to set the specified weight. 3. Open TRUCK MENU → RIGHT MASTER → SET OPTION → OVERLOAD TYPE setting screen.

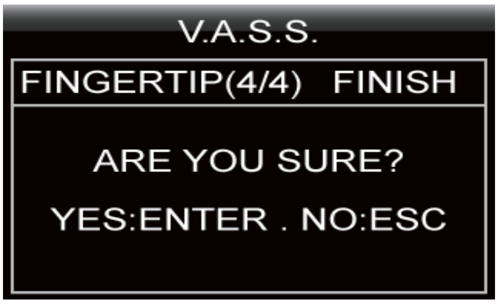
Step	Display	Description
9		1. The OVER LOAD TYPE parameter has three options as shown below. 1) NONE: No warning even if the load weight exceeds the OVER LOAD WEIGHT setting. 2) OPTION # 1: OVER LOAD WEARING occurs when the load weight exceeds the OVER LOAD WEIGHT setting value, and stops the vehicle operation except LIFT DOWN and steering function. 3) OPTION # 2: OVER LOAD WARNING occurs only when the load weight exceeds the OVER LOAD WEIGHT setting. 2. OVER LOAD TYPE must be set to NONE for LOAD SENSOR setting. If set to OPTION # 1 or OPTION # 2, change to "NONE" using "ENTER" button and "UP" or "DOWN / TURTLE" After that, LOAD SENSOR must be set.
10		1. Access the LOAD SENSOR setting screen via "TRUCK MENU → SETTING → V.A.S.S → LOAD SENSOR". (Only when the LOAD SENSOR parameter in step 1 is set to ON.) 2. After confirming that the forward / reverse gear is neutral and both the drive and hydraulic motor are stopped, press the "ENTER" button in no-load state to start the setting.
11		1. At the top right of the screen, "READY" appears, "ADJ MIN" displays a red mark, and the "ADJ MIN LOAD" setting starts. The value of "ADJ MIN" indicates the no-load LOAD SENSOR input, and the setup proceeds. 2. Press Enter button to move on to the "ADJ REF".
12		1. "ADF REF" displays a red mark and the "ADJ REF" setting starts. 2. "ADJ REF" is the input value of the load sensor when the load for setting is lifted. When setting, lift the load to a height of about 50 cm from the ground. ※Before lifting the load, slightly lower and lift the load to operate normally. 3. You can see that the "ADF REF" value changes every time you lift the load.

Step	Display	Description
13		1. After waiting for 5 ~ 10 seconds after lifting the load(REF. LOAD WEIGHT), make sure that the ADJ REF value stabilizes, then press the ENTER button.
14		1. Press the "ENTER" button to save and exit. 2. Set the OVERLOAD TYPE in Step 9 as desired. (Default value is NONE) ▯ Note: For accuracy of LOAD SENSOR, the reference load for setting should be as large as possible within the range of not exceeding OVERLOAD WEIGHT.

(5) FINGERTIP setting method(OPTION)

Step	Display	Description
1		1.Acess the PUMP SET OPTION setting screen via "TRUCK MENU → SETTING → PUMP MASTER → SET OPTION
2		1. Use the "UP" button and the "DOWN / TURTLE" button to find each of the following parameters and change them to the corresponding settings. 1) EVP TYPE: NONE (Not applicable for 15/18/20BT-9U) 2) OPSS: OFF 3) FINGERTIP: ON 4) FINGERTIP MISM: ON 5) AUX 1 FUNCTION: ON (when the lever specification is 3-spool or more) 6) AUX 2 FUNCTION: ON (when the lever specification is 4-spool or more)

Step	Display	Description
3		1. Access the FINGERTIP setting screen via "TRUCK MENU → SETTING → V.A.S.S → FINGERTIP". (Only when the FINGERTIP parameter in step 1 is set to ON.) 2. Press the ENTER button to set the LEVER as shown below. 1) 2-SPOOL : LIFT, TILT 2) 3-SPOOL : LIFT, TILT, AUX1 3) 4-SPOOL : LIFT, TILT, AUX1, AUX2 3. For illustrative purposes, Below will set the LIFT LEVER by pressing the "ENTER" button.
4		1. The READY indicator appears in the upper right corner of the screen, a red indicator appears on the right of the MIN LIFT and MIN LIFT (LIFT UP MIN value) setting starts. 2. Set MIN LIFT (LIFT UP MIN value). While pulling the LEVER a little bit (about 10˚) from the center, press the "ENTER" button to set the MIN LIFT value.
5		1. It switches to MAX LIFT (LIFT UP MAX value) setting and displays real time LEVER voltage value. 2. Set MAX LIFT (LIFT UP MAX value). While pulling the lever all the way down, press the "ENTER" button to set the MIN LOWER value.
6		1. It switches to MIN LOWER (LOWER MIN value) setting and displays real time LEVER voltage value. 2. Set MIN LOWER (LOWER MIN value). While pushing the LEVER a little bit (about 10˚) from the center, press the "ENTER" button to set the MAX LOWER value.
7		1. It switches to MAX LOWER (LOWER MAX value) setting and displays real time LEVER voltage value. 2. Set MAX LOWER (LOWER MAX value). While pulling the lever all the way down, press the "ENTER" button.

Step	Display	Description
8		1. After completing all lever settings, press "ENTER" button. 2. Press the "ENTER" button to exit.

7. ALARM CODE

1) TRACTION AND PUMP CONTROLLER

Code	Alarm	Master	Slave	Description
8	WATCHDOG	O	O	Cause: This is a safety related test. It is a self-diagnosis test that involves the logic between master and supervisor microcontrollers. Troubleshooting: This alarm could be caused by a CANbus malfunctioning, which blinds master-supervisor communication.
17	LOGIC FAILURE #3	O	O	Cause: A hardware problem in the logic board due to high currents (overload). An overcurrent condition is triggered even if the power bridge is not driven. Troubleshooting: The failure lies in the controller hardware. Replace the controller.
18	LOGIC FAILURE #2	O		Cause: Fault in the hardware section of the logic board which deals with voltage feedbacks of motor phases. Troubleshooting: The failure lies in the controller hardware. Replace the controller.
19	LOGIC FAILURE #1	O	O	Cause: This fault is displayed when the controller detects an undervoltage condition at the KEY input (A1). Undervoltage threshold depends on the nominal voltage of the controller. - Nominal voltage : 36/48V - Undervoltage threshold : 10V Troubleshooting (fault at startup or in standby): - Fault can be caused by a key input signal characterized by pulses below the undervoltage threshold, possibly due to external loads like DC/DC converters starting-up, relays or contactors during switching periods, solenoids energizing or de-energizing. Consider to remove such loads. - If no voltage transient is detected on the supply line and the alarm is present every time the key switches on, the failure probably lies in the controller hardware. Replace the logic board. Troubleshooting (fault displayed during motor driving): - If the alarm occurs during motor acceleration or when there is a hydraulic-related request, check the battery charge, the battery health and power-cable connections.

Code	Alarm	Master	Slave	Description
30	VMN LOW	O		Cause 1: Start-up test. Before switching the LC on, the software checks the power bridge: it turns on alternatively the high-side power MOSFETs and expects the phase voltages increase toward the positive rail value. If one phase voltage is lower than a certain percentage of the rail voltage, this alarm occurs. Cause 2: Motor running test. When the motor is running, the power bridge is on and the motor voltage feedback tested; if it is lower than expected value (a range of values is considered), the controller enters in fault state. Troubleshooting: - 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 connections are OK, the problem is inside the controller; Replace it. - If the alarm occurs while the motor is running, check: - Motor connections; - That the LC power contact closes properly, with a good contact; - If no problem is found, the problem is inside the controller. Replace it.

Code	Alarm	Master	Slave	Description
31	VMN HIGH	O		Cause 1: Before switching the LC on, the software checks the power bridge: it turns on alternatively the low-side power MOSFETs and expects the phase voltages decrease down to -B. If the phase voltages are higher than a certain percentage of the nominal battery voltage, this alarm occurs. Cause 2: This alarm may also occur when the start-up diagnosis has succeeded and so the LC has been closed. In this condition, the phase voltages are expected to be lower than half the battery voltage. If one of them is higher than that value, this alarm occurs. Troubleshooting: - If the problem occurs at start-up (the LC does not close), check: - Motor internal connections (ohmic continuity); - Motor power cables connections; - If the motor connections are OK, the problem is inside the controller. Replace it. - If the alarm occurs while the motor is running, check: - Motor connections; - That the LC power contact closes properly, with a good contact; - If no problem is found, the problem is inside the controller. Replace it.
37	CONTACTOR CLOSED	O		Cause: Before driving the LC coil, the controller checks if the contactor is stuck. The controller drives the power bridge for several dozens of milliseconds, trying to discharge the capacitors bank. If the capacitor voltage does not decrease by more than a certain percentage of the key voltage, the alarm is raised. Troubleshooting: It is suggested to verify the power contacts of LC; if they are stuck, is necessary to replace the LC.
38	CONTACTOR OPEN	O		Cause: The LC coil is driven by the controller, but it seems that the power contacts do not close. In order to detect this condition the controller injects a DC current into the motor and checks the voltage on power capacitor. If the power capacitors get discharged it means that the main contactor is open. Troubleshooting: - LC contacts are not working. Replace the LC. - If LC contacts are working correctly, contact a Hyundai dealer.

Code	Alarm	Master	Slave	Description
52	PUMP I=0 EVER	O		Cause: While truck is running, current value is 0 for more than 1 sec. Remedy: - Check the Main contactor - Check the controller
53	STBY I HIGH	O		Cause: In standby, the sensor detects a current value different from zero. Troubleshooting: The current sensor or the current feedback circuit is damaged. Replace the controller.
60	CAPACITOR CHARGE	O		Cause: When the key is switched on, the inverter tries to charge the power capacitors through the series of a PTC and a power resistance, checking if the capacitors are charged within a certain timeout. If the capacitor voltage results less than a certain percentage of the nominal battery voltage, the alarm is raised and the main contactor is not closed. Troubleshooting: - Check if an external load in parallel to the capacitor bank, which sinks current from the capacitors-charging circuit, thus preventing the caps from charging well. Check if a lamp or a dc/dc converter or an auxiliary load is placed in parallel to the capacitor bank. - The charging resistance or PTC may be broken. Insert a power resistance across line-contactor power terminals; if the alarm disappears, it means that the charging resistance is damaged. - The charging circuit has a failure or there is a problem in the power section. Replace the controller.
62	TH. PROTECTION	O		Cause: The temperature of the controller base plate is above 85 °C. The maximum current is proportionally decreased with the temperature excess from 85 °C up to 105 °C. At 105 °C the current is limited to 0 A. Troubleshooting: It is necessary to improve the controller cooling. To realize an adequate cooling in case of finned heat sink important factors are the air flux and the cooling-air temperature. If the thermal dissipation is realized by applying the controller base plate onto the truck frame, the important factors are the thickness of the frame and the planarity and roughness of its surface. If the alarm occurs when the controller is cold, the possible reasons are a thermal-sensor failure or a failure in the logic board. In the last case, it is necessary to replace the controller.

Code	Alarm	Master	Slave	Description
66	BATTERY LOW	O		Cause: Parameter BATTERY CHECK is other than 0 (SET OPTION list, at page 7-34) and battery charge is evaluated to be lower than BATT.LOW TRESHLD. Troubleshooting: - Check the battery charge and charge it if necessary. - If the battery is actually charged, measure the battery voltage through a voltmeter and compare it with the BATTERY VOLTAGE reading in the TESTER function. If they are different, adjust the ADJUST BATTERY parameter with the value measured through the voltmeter. - If the problem is not solved, replace the logic board.
74	DRIVER SHORTED	O		Cause: The driver of the LC coil is shorted. Troubleshooting: - Check if there is a short or a low impedance pull-down between NLC (A16) and -B. - The driver circuit is damaged; replace the logic board.
75	CONTACTOR DRIVER	O		Cause: The LC coil driver is not able to drive the load. The device itself or its driver circuit is damaged. Troubleshooting: This type of fault is not related to external components; replace the logic board.
78	VACC NOT OK	O		Cause: At key-on and immediately after that, the travel demands have been turned off. This alarm occurs if the ACCELERATOR reading (in TESTER function) is above the minimum value acquired during the PROGRAM VACC procedure. Troubleshooting: - Check the wirings. - Check the mechanical calibration and the functionality of the accelerator potentiometer. - Acquire the maximum and minimum potentiometer value through the PROGRAM VACC function. - If the problem is not solved, replace the logic board.

Code	Alarm	Master	Slave	Description
79	INCORRECT START	O		Cause: Incorrect starting sequence. Possible reasons for this alarm are: - A travel demand active at key-on. - Man-presence sensor active at key on. Troubleshooting: - Check wirings. - Check microswitches for failures. - Through the TESTER function, check the states of the inputs are coherent with microswitches states. - If the problem is not solved, replace the logic board.
80	FORW + BACK	O		Cause: This alarm occurs when both the travel requests (FW and BW) are active at the same time. Troubleshooting: - Check that travel requests are not active at the same time. - Check the FW and BW input states through the TESTER function. - Check the wirings relative to the FW and BW inputs. - Check if there are failures in the microswitches. - If the problem is not solved, replace the logic board.
82	ENCODER ERROR	O		Cause: This fault occurs when the frequency supplied to the motor is higher than 30 Hz and the signal feedback from the encoder has a too high jump in few tens of milliseconds. This condition is related to an encoder failure. Troubleshooting: - Check the electrical and the mechanical functionality of the encoder and the wires crimping. - Check the mechanical installation of the encoder, if the encoder slips inside its housing it will raise this alarm. - Also the electromagnetic noise on the sensor can be the 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.
86	PEDAL WIRE KO	O		Cause: Fault in accelerator negative (NPOT) input circuit Troubleshooting: -
134	PEDAL BRAKE MISM	O		Cause: BRAKE 1 and BRAKE 2 inputs have a different value. Troubleshooting: - Check the wirings.

Code	Alarm	Master	Slave	Description
135	DISPLAY ENABLE	O		Cause: The display enable signal has not been received to operate the truck. Troubleshooting: -
136	FORK POT MISM.	O		Cause: The sum of TILT LEVELING 1 and TILT LEVELING 2 input voltages do not match the supply voltage of the sensor. Troubleshooting: - Check the wirings. - Check the tilt leveling sensor output voltages.
137	FORK S.WRONG DIR	O		Cause: Direction of “AUTO TILT LEVELING” movement is not correct. Troubleshooting: - Check if operator operates truck correctly. - Check the Tilt Sensor of Fork leveling Option. - Re-configurate Tilt Sensor of Fork leveling Option.
138	FORK S. OUT RNG.	O		Cause: Value of tilt sensor (AUTO TILT LEVELING) is out of range. Troubleshooting: - Check the Tilt Sensor of AUTO TILT LEVELING Option. - Re-configurate Tilt Sensor of AUTO TILT LEVELING Option
139	FORK SENS LOCK	O		Cause: Value of tilt sensor (AUTO TILT LEVELING) is fixed even tilt request is activated. Troubleshooting: - Check the Tilt Sensor of AUTO TILT LEVELING Option. - Re-configurate Tilt Sensor of AUTO TILT LEVELING Option.
140	FINGERTIPS ACQ	O		Cause: Fingertip calibration is not correct. Troubleshooting: - Acquire the correct value of parameters LIFT MAX, LIFT MIN, LOWER MAX, LOWER MIN, TILT UP MAX, TILT UP MIN, TILT DOWN MAX, TILT DOWN MIN, AUX1 UP MAX, AUX1 UP MIN, AUX1 DOWN MAX, AUX1 DOWN MIN, AUX2 UP MAX, AUX2 UP MIN, AUX2 DOWN MAX, AUX2 DOWN MIN
141	LOAD SENS. ERROR	O		Cause: The signal of LOAD SENSOR input is not valid. Troubleshooting: - Acquire the correct value of parameters ADJ MIN LOAD, ADJ REF LOAD - Check the wirings.

Code	Alarm	Master	Slave	Description
142	OVERLOADED	O		Cause: The signal of LOAD SENSOR indicates a weight greater than parameter OVER LOAD WEIGHT. Troubleshooting: - Check if the operator operates truck correctly. - Acquire the correct value of parameters ADJ MIN LOAD, ADJ REF LOAD. - Verify the value of parameter OVERLOAD WEIGHT. - Check the wirings.
143	FINGERTIP MISM	O		Cause: The sum of input voltages from one of the fingertip sensors do not match the supply voltage of the sensor. Troubleshooting: - Check the wirings. - Check the fingertip sensor output voltages.
144	CAN REC VMC ERR	O		Cause: CAN communication problem with the VCM. Troubleshooting: - Check the CAN wirings. - Verify if the VCM is off or damaged.
145	SBR S/W OPEN	O		Cause: SBR (Side Battery Removal) sensor is open. Troubleshooting: - To remove warning cause. - Check the sensor.
146	BRAKE OIL	O		Cause: Lack of brake oil. Troubleshooting: Check the brake oil tank & sensor.
147	MAINT PRE WARN	O		Cause: The truck hours reached MAINT PRE WARN parameter value. Troubleshooting: Perform the truck maintainance and reset the alarm using MAINTEN. RESET parameter.
148	MOTOR HIGH TEMP	O		Cause: The temperature of left or right or both motors is high. Troubleshooting: - To remove warning cause. - Check the motor temp-sensor.
150	BMS WARNING 1	O		Cause: The battery monitoring system is in WARNING 1 status.

Code	Alarm	Master	Slave	Description
151	BMS WARNING 0	O		Cause: The battery monitoring system is in WARNING 0 status.
152	BMS FAULT	O		Cause: The battery monitoring system is in FAULT status.
153	BMS NOT READY	O		Cause: The battery monitoring system is in BMS NOT READY status.
154	POT MISMATCH	O		Cause: The sum of LIFT POT 1 and LIFT POT 2 input voltages do not match the supply voltage of the sensor. Troubleshooting: - Check the wirings. - Check the lift sensor output voltages.
155	WAIT MOTOR STILL	O		Cause: The controller is waiting for the motor to stop rotating. This warning can only appear in ACE 2 for brushless motors.
161	RPM HIGH	O		Cause: This alarm occurs in Gen. Set versions when the speed exceeds the threshold speed.
162	BUMPER STOP	O		Cause: The two digital inputs dedicated to the bumper functionality are high at the same time. The alarm can occur only if parameter BUMPER STOP = ON and only if ACE 2 is in CAN OPEN configuration. Troubleshooting: - Turn off one or both inputs dedicated to the bumper functionality. - If the alarm occurs even if the inputs are in the rest position, check if the microswitches are stuck. - In case the problem is not solved, replace the logic board.
163	ED SLIP MISMATCH	O		Cause: The control detects a mismatch between the expected slip and the evaluated one. This diagnostic occurs only if ED COMPENSATION = TRUE.
164	PWM ACQ. ERROR	O		Cause: This alarm occurs only when the controller is configured to drive a PMSM and the feedback sensor selected in the HARDWARE SETTINGS list is ENCODER ABI + PWM. The controller does not detect correct information on PWM input at start-up. Troubleshooting: - Re-cycle the key. - Check the sensor in order to verify that it works properly. - Check the wiring. - If the problem occurs permanently it is necessary to substitute logic board.

Code	Alarm	Master	Slave	Description
168	SIN/COS D.ERR XX	O		Cause: This alarm occurs only when the controller is configured as PMSM and the feedback sensor selected is sin/cos. The signal coming from sin/cos sensor has a wrong direction. The hexadecimal value "XX" facilitates Hyundai dealer debugging the problem. Troubleshooting: - Check the wirings. - If the motor direction is correct, swap the sin and cos signals. - If the motor direction is not correct, swap two of the motor cables. - If the problem is not solved, contact a Hyundai dealer.
169	ENCODER D.ERR XX	O		Cause: This alarm occurs only when the controller is configured as PMSM and the feedback sensor selected is the encoder. The A and B pulse sequence is not correct. The hexadecimal value "XX" facilitates Hyundai dealer debugging the problem. Troubleshooting: - Check the wirings. - If the motor direction is correct, swap A and B signals. - If the motor direction is not correct, swap two of the motor cables. - If the problem is not solved, contact a Hyundai dealer.
170	WRONG KEY VOLT.	O		Cause: The measured key voltage is not the right one for the inverter. Troubleshooting: - Check if the SET KEY VOLTAGE parameter in the ADJUSTMENTS list is set in accordance with the key voltage. - Check if the key voltage is ok using a voltmeter, if not check the wiring. - In case the problem is not solved, replace the logic board.
171	ACQUIRING A.S.	O		Cause: Controller is acquiring data from the absolute feedback sensor. Troubleshooting: The alarm ends when the acquisition is done.
172	ACQUIRE ABORT	O		Cause: The acquiring procedure relative to the absolute feedback sensor aborted.
173	ACQUIRE END	O		Cause: Absolute feedback sensor acquired.

Code	Alarm	Master	Slave	Description
175	SPEED FB. ERROR	O		Cause: This alarm occurs if the absolute position sensor is used also for speed estimation. If signaled, it means that the controller measured that the motor was moving too quick. Troubleshooting: - Check that the sensor used is compatible with the software release. - Check the sensor mechanical installation and if it works properly. - Also the electromagnetic noise on the sensor can be a cause for the alarm. - If no problem is found on the motor or on the speed sensor, the problem is inside the controller, it is necessary to replace the logic board.
176	HOME SENS.ERR XX	O		Cause: The controller detected a difference between the estimated absolute orientation of the rotor and the position of the index signal (ABI encoder). It is caused by a wrong acquisition of the angle offset between the orientation of the rotor and the index signal. The hexadecimal value “XX” facilitates Hyundai dealer debugging the problem. Troubleshooting: Repeat the auto-teaching procedure.
177	COIL SHOR. EB.	O		Cause: This alarm occurs when an overload of the EB driver (output NEB A18) occurs. Troubleshooting: - Check the connections between the controller outputs and the loads. - Collect information about characteristics of the coil connected to the driver and ask for assistance to a Hyundai dealer in order to verify that the maximum current that can be supplied by the hardware is not exceeded. - In case no failures/problems have been found, the problem is in the controller, which has to be replaced.

Code	Alarm	Master	Slave	Description
178	MOTOR SHUTDOWN	O		Cause: The temperature sensor has overtaken the threshold defined by MOT.SHUTDOWN TEM. Troubleshooting: - Check the temperature read by the thermal sensor inside the motor through the MOTOR TEMPERATURE reading in the TESTER function. - 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, replace the controller.
179	STEER SENSOR KO	O		Cause: The voltage read by the microcontroller at the steering-sensor input is not within the STEER RIGHT VOLT ÷ STEER LEFT VOLT range, programmed through the STEER ACQUIRING function. Troubleshooting: - Acquire the maximum and minimum values coming from the steering potentiometer through the STEER ACQUIRING function. If the alarm is still present, check the mechanical calibration and the functionality of the potentiometer. - If the problem is not solved, replace the logic board.
180	OVERLOAD	O		Cause: The motor current has overcome the limit fixed by hardware. Troubleshooting: If the alarm condition occurs again, ask for assistance to a Hyundai dealer. The fault condition could be affected by wrong adjustments of motor parameters.
181	WRONG ENC SET	O		Cause: Mismatch between “ENCODER PULSES 1” parameter and “ENCODER PULSES 2” parameter. Troubleshooting: Set the two parameters with the same value, according to the adopted encoder.
186	WAIT MOT.P STILL	O		The controller is waiting for the motor to stop rotating. This warning can only appear in ACE 2 or ACE 3 for brushless motors.

Code	Alarm	Master	Slave	Description
187	LIFT+LOWER	O		Cause: Both the pump requests (LIFT and LOWER) are active at the same time. Troubleshooting: - Check that LIFT and LOWER requests are not active at the same time. - Check the LIFT and LOWER input states through the TESTER function. - Check the wirings.
188	PUMP VACC NOT OK	O		Cause: At key-on and immediately after that, the travel demands have been turned off. This alarm occurs if the ACCELERATOR reading (in TESTER function) is above the minimum value acquired during the PROGRAM VACC procedure. Troubleshooting: - Check the wirings. - Check the mechanical calibration and the functionality of the accelerator potentiometer. - Acquire the maximum and minimum potentiometer value through the PROGRAM VACC function. - If the problem is not solved, replace the logic board.
189	PUMP INC START	O		Cause: Man-presence switch is not enabled at pump request. Troubleshooting: - Check wirings. - Check microswitches for failures. - Through the TESTER function, check the states of the inputs are coherent with microswitches states. - If the problem is not solved, replace the logic board.
192	FORK S.WRONG DIR		O	Cause: TILT LEVELING input is ON and the TILT LEVELING analog sensor output is not moving to the center values direction. Troubleshooting: - Release TILT LEVEL command. - Check wirings and TILT LEVELING sensor.
193	FORK S. OUT RNG.		O	Cause: TILT LEVELING input is outside admitted range. Troubleshooting: - Acquire the correct value of parameters FORK LEVEL MIN, FORK LVL CENTER, FORK LEVEL MAX. - Check wirings and TILT LEVELING sensor.

Code	Alarm	Master	Slave	Description
194	FORK SENS LOCK		O	Cause: TILT LEVELING sensor is frozen (stuck) more than 1.5sec at the correct direction movement. Troubleshooting: - Release the tilt leveling command. - Check if the tilt function is working correctly or if it is mechanically locked. - Check wirings and TILT LEVELING sensor.
195	FINGERTIPS ACQ		O	Cause: Fingertip calibration is not correct. Troubleshooting: - Acquire the correct value of parameters LIFT MAX, LIFT MIN, LOWER MAX, LOWER MIN, TILT UP MAX, TILT UP MIN, TILT DOWN MAX, TILT DOWN MIN, AUX1 UP MAX, AUX1 UP MIN, AUX1 DOWN MAX, AUX1 DOWN MIN, AUX2 UP MAX, AUX2 UP MIN, AUX2 DOWN MAX, AUX2 DOWN MIN
196	MOT.PHASE SH.	O		Cause: Short circuit between two motor phases. The hexadecimal value "XX" identifies the shorted phases: 36: U – V short circuit 37: U – W short circuit 38: V – W short circuit Troubleshooting: - Verify the motor phases connection on the motor side. - Verify the motor phases connection on the inverter side. - Check the motor power cables. - Replace the controller. - If the alarm does not disappear, the problem is in the motor. Replace it.
	LOAD SENS. ERROR		O	Cause: The signal of LOAD SENSOR input is not valid. Troubleshooting: - Acquire the correct value of parameters ADJ MIN LOAD, ADJ REF LOAD - Check the wirings.

Code	Alarm	Master	Slave	Description
197	WRONG SLAVE VER.	O		Cause: Wrong software version on supervisor uC. Troubleshooting: Upload the correct software version or ask for assistance to a Hyundai dealer.
	OVERLOADED		O	Cause: The signal of LOAD SENSOR indicates a weight greater than parameter OVER LOAD WEIGHT. Troubleshooting: - Check if the operator operates truck correctly. - Acquire the correct value of parameters ADJ MIN LOAD, ADJ REF LOAD. - Verify the value of parameter OVERLOAD WEIGHT. - Check the wirings.
198	M/S PAR CHK MISM	O		Cause: At start-up there is a mismatch in the parameter checksum between the master and the supervisor microcontrollers. Troubleshooting: Restore and save again the parameters list.
199	PARAM TRANSFER	O		Cause: Master uC is transferring parameters to the supervisor. Troubleshooting: Wait until the end of the procedure. If the alarm remains longer, re-cycle the key.
	BUMPER STOP		O	Cause The two digital inputs dedicated to the bumper functionality are high at the same time. The alarm can occur only if parameter BUMPER STOP = ON and only if ACE 2 is in CAN OPEN configuration. Troubleshooting - Turn off one or both inputs dedicated to the bumper functionality. - If the alarm occurs even if the inputs are in the rest position, check if the microswitches are stuck. - In case the problem is not solved, replace the logic board.

Code	Alarm	Master	Slave	Description
200	VDC OFF SHORTED	O		Cause: The logic board measures a voltage value across the DC-link that is constantly out of range, above the maximum allowed value. Troubleshooting: - Check that the battery has the same nominal voltage of the inverter. - Check the battery voltage, if it is out of range replace the battery. - If the battery voltage is ok, replace the logic board.
	STEER SENSOR KO		O	Cause: The voltage read by the microcontroller at the steering-sensor input is not within the STEER RIGHT VOLT ÷ STEER LEFT VOLT range, programmed through the STEER ACQUIRING function. Troubleshooting: - Acquire the maximum and minimum values coming from the steering potentiometer through the STEER ACQUIRING function. If the alarm is still present, check the mechanical calibration and the functionality of the potentiometer. - If the problem is not solved, replace the logic board.
201	TORQUE PROFILE	O		Cause: There is an error in the choice of the torque profile parameters. Troubleshooting: Check in the HARDWARE SETTINGS list the value of those parameters.
	WRONG ENC SET		O	Cause: Mismatch between “ENCODER PULSES 1” parameter and “ENCODER PULSES 2” parameter. Troubleshooting: Set the two parameters with the same value, according to the adopted encoder.

<table>
<tr><th>Code</th><th>Alarm</th><th>Master</th><th>Slave</th><th>Description</th></tr>
<tr><td>202</td><td>VDC LINK OVERV.</td><td>O</td><td>O</td><td>Cause:
This fault is displayed when the controller detects an overvoltage condition.
Overvoltage threshold depends on the nominal voltage of the controller.
<table><tr><th>Nominal voltage</th><th>24V</th><th>36/48V</th><th>72/80V</th><th>96V</th></tr><tr><td>Overvoltage threshold</td><td>35V</td><td>65V</td><td>115V</td><td>130V</td></tr></table>As soon as the fault occurs, power bridge and MC are opened.
The condition is triggered using the same HW interrupt used for undervoltage detection, uC discerns between the two evaluating the voltage present across DC-link capacitors:
- High voltage Overvoltage condition
- Low/normal voltage Undervoltage condition
Troubleshooting:
If the alarm happens during the brake release, check the line contactor contact and the battery power-cable connection.</td></tr>
<tr><td>204</td><td>BRAKE RUN OUT</td><td>O</td><td></td><td>Cause:
The CPOT BRAKE input read by the microcontroller is out of the range defined by parameters SET PBRK. MIN and SET PBRK. MAX.
Troubleshooting:
- Check the mechanical calibration and the functionality of the brake potentiometer.
- Acquire the minimum and maximum potentiometer values.
- If the alarm is still present, replace the logic board.</td></tr>
<tr><td>205</td><td>EPS RELAY OPEN</td><td>O</td><td></td><td>Cause:
The controller receives from EPS information about the safety contacts being open.
Troubleshooting:
Verify the EPS functionality.</td></tr>
</table>

Code	Alarm	Master	Slave	Description
206	INIT VMN HIGH	O		Cause: Before closing the LC, the software checks the power-bridge voltage without driving it. The software expects the voltage to be in a “steady state” value. If it is too high, this alarm occurs. The hexadecimal value “XX” identifies the faulty phase: 81: phase U 82: phase V 83: phase W Troubleshooting: - Check the motor power cables. - Check the impedance between U, V and W terminals and -B terminal of the controller. - Check the motor leakage to truck frame. - If the motor connections are OK and there are no external low impedance paths, the problem is inside the controller. Replace it.
207	INIT VMN LOW	O		Cause: Before closing the LC, the software checks the power-bridge voltage without driving it. The software expects the voltage to be in a “steady state” value. If it is too low, this alarm occurs. The hexadecimal value “XX” identifies the faulty phase: 01: phase U 02: phase V 03: phase W Troubleshooting: - Check the motor power cables. - Check the impedance between U, V and W terminals and -B terminal of the controller. - Check the motor leakage to truck frame. - If the motor connections are OK and there are no external low impedance paths, the problem is inside the controller. Replace it.
208	EEPROM KO	O	O	Cause: A HW or SW defect of the non-volatile embedded memory storing the controller parameters. This alarm does not inhibit the machine operations, but it makes the truck to work with the default values. Troubleshooting: Execute a CLEAR EEPROM procedure (refer to the Console manual). Switch the key off and on to check the result. If the alarm occurs permanently, it is necessary to replace the controller. If the alarm disappears, the previously stored parameters will be replaced by the default parameters.

Code	Alarm	Master	Slave	Description
209	PARAM RESTORE	O	O	Cause: This is a confirmation that a clear eeprom parameter was correctly performed. Troubleshooting: Recycle the key.
210	WRONG RAM MEM.	O	O	Cause: Deterministic Finite Automaton (DFA) is characterized by state transitions. As a protective measure any state transition is commanded by assigning two variables (state label and its complement). These two variables identify the new state (redundancy in the state label). This redundancy has been thought in order to avoid that a failure in the RAM memory leads to a wrong destination state for the DFAs. In case the two state labels are inconsistent or not complemented in between, this alarm occurs. Troubleshooting: If it is repetitive, it reports a problem in the controller.
211	STALL ROTOR	O		Cause: The traction rotor is stuck or the encoder signal is not correctly received by the controller. Troubleshooting: - Check the encoder condition. - Check the wiring. - Through the TESTER function, check if the sign of REQUENCY and ENCODER are the same and if they are different from zero during a traction request. - If the problem is not solved, replace the logic board.
	BMS NOT READY		O	Cause: The battery monitoring system is in BMS NOT READY status.
212	POWER MISMATCH	O		Cause : The error between the power setpoint and the estimated power is out of range. Troubleshooting : Ask for assistance to a Hyundai dealer about the correct adjustment of the motor parameters.
	W.SET. TG-EB XX		O	Cause: Supervisor microcontroller has detected that the master microcontroller has imposed a wrong setpoint for TG or EB output. Troubleshooting: - Check the matching of the parameters between master and supervisor. - Ask for the assistance of a Hyundai dealer. - If the problem is not solved, replace the logic board.

Code	Alarm	Master	Slave	Description
213	POSITIVE LC OPEN	O		Cause The positive voltage of LC is different from expected. Troubleshooting - Verify LC coil is properly connected. - Verify CONF. POSITIVE LC parameter is set in accordance with the actual coil positive supply. Software, depending on the parameter value, makes a proper diagnosis; a mismatch between the hardware and the parameter configuration could generate a false fault. - In case no failures/problems have been found, the problem is in the controller, which has to be replaced.
	INPUT MISMATCH		O	Cause: The supervisor microcontroller records different input values with respect to the master microcontroller. Troubleshooting: - Compare the values read by master and slave through the TESTER function. - Ask for the assistance to a Hyundai dealer. - If the problem is not solved, replace the logic board.
214	EVP COIL OPEN	O		Cause: No load is connected between the NEVP output (A19) and the electrovalve positive terminal. Troubleshooting: - Check the EVP condition. - Check the EVP wiring. - If the problem is not solved, replace the logic board.
215	EVP DRIV. SHORT.	O		Cause: - The EVP driver (output A19) is shorted. - The microcontroller detects a mismatch between the valve set-point and the feedback of the EVP output. Troubleshooting: - Check if there is a short circuit or a low-impedance conduction path between the negative of the coil and -B. - Collect information about: · The voltage applied across the EVP coil. · The current in the coil. · Features of the coil. Ask for assistance to Zapi in order to verify that the software diagnoses are in accordance with the type of coil employed. - If the problem is not solved, it could be necessary to replace the controller.

Code	Alarm	Master	Slave	Description
216	EB. COIL OPEN	O		Cause: This fault appears when no load is connected between the NEB output (A18) and the EB positive terminal PCOM (A17). Troubleshooting: - Check the EB coil. - Check the wiring. - If the problem is not solved, replace the logic board.
217	PEV NOT OK	O		Cause: Terminal PCOM is not connected to the battery or the voltage is different from that defined by parameter SET POSITIVE PEB. This alarm can occur if output NAUX 1 is present (and the related setting is active) or the AUX OUT function is active. Troubleshooting: - Check PCOM terminal: it must be connected to the battery voltage (after the main contactor). - Set the nominal PCOM voltage in parameter SET POSITIVE PEB in ADJUSTMENTS list.
	BMS FAULT		O	Cause: The battery monitoring system is in FAULT status.
218	SENS MOT TEMP KO	O		Cause: The output of the motor thermal sensor is out of range. Troubleshooting: - Check if the resistance of the sensor is what expected measuring its resistance. - Check the wiring. - If the problem is not solved, replace the logic board.
220	VKEY OFF SHORTED	O		Cause: At key-on, the logic board measures a voltage value of the KEY input that is constantly out of range, above the maximum allowed value. Troubleshooting: - Check that the battery has the same nominal voltage of the inverter. - Check the battery voltage, if it is out of range replace the battery. - In case the problem is not solved, replace the logic board.
221	EPS OPEN		O	Cause: The EPS is in alarm state.

Code	Alarm	Master	Slave	Description
222	SEAT MISMATCH	O		Cause: This alarm can appear only in a Traction + Pump configuration or in a multi-motor one. There is an input mismatch between the traction controller and the pump controller relatively to the TILLER/SEAT input (A6): the two values recorded by the two controllers are different. Troubleshooting: - Check if there are wrong connections in the external wiring. - Using the TESTER function, verify that the seat inputs are in accordance with the actual state of the external switch. - In case no failures/problems have been found, the problem is in the controller, which has to be replaced.
223	COIL SHOR. MC	O		Cause: This alarm occurs when an overload of the MC driver (output NMC A16) occurs. Troubleshooting: - Check the connections between the controller outputs and the loads. - Collect information about characteristics of the coil connected to the driver and ask for assistance to a Hyundai dealer in order to verify that the maximum current that can be supplied by the hardware is not exceeded. - In case no failures/problems have been found, the problem is in the controller, which has to be replaced.
224	WAITING FOR NODE	O		Cause: The controller receives from the CANbus the message that another controller in the net is in fault condition; as a consequence the controller itself cannot enter into an operative status, but it has to wait until the other node comes out from the fault status. Troubleshooting: Check if any other device on the CANbus is in fault condition.

Code	Alarm	Master	Slave	Description
226	VACC OUT RANGE	O		Cause: - The CPOT input read by the microcontroller is not within the MIN VACC ÷ MAX VACC range, programmed through the PROGRAMM VACC function. - The acquired values MIN VACC and MAX VACC are inconsistent. Troubleshooting: - Acquire the maximum and minimum potentiometer values through the PROGRAM VACC function. If the alarm is still present, check the mechanical calibration and the functionality of the accelerator potentiometer. - If the problem is not solved, replace the logic board.
227	HW FAULT	O		Cause: At start-up, some hardware circuit intended to enable and disable the power bridge or the LC driver (output A16) is found to be faulty. The hexadecimal value “XX” facilitates Hyundai dealer debugging the problem. Troubleshooting: This type of fault is related to internal components. Replace the logic board.
	OUT MISMATCH XX		O	Cause: This is a safety related test. Supervisor μC has detected that master μC is driving traction motor in a wrong way (not corresponding to the operator request). The hexadecimal value “XX” facilitates Hyundai dealer debugging the problem. Troubleshooting: - Checks the matching of the parameters between Master and Supervisor. - Ask for assistance to a Hyundai dealer. - If the problem is not solved, replace the logic board.
228	CHAT TIME	O		Cause: The chat time has expired. Troubleshooting: To activate traction or pump request

Code	Alarm	Master	Slave	Description
229	HW FAULT EB.	O		Cause: At start-up, the hardware circuit dedicated to enable and disable the EB driver (output A18) is found to be faulty. The hexadecimal value “XX” facilitates Hyundai dealer debugging the problem. Troubleshooting: This type of fault is not related to external components. Replace the logic board.
	NO CAN WR MSG. XX		O	Cause CANbus communication does not work properly. The hexadecimal value “XX” identifies the faulty node. Troubleshooting - Verify the CANbus network (external issue). - Replace the logic board (internal issue).
230	LC COIL OPEN	O		Cause: This fault appears when no load is connected between the NLC output A16 and the positive voltage (for example +KEY). Troubleshooting: - Check the wiring, in order to verify if LC coil is connected to the right connector pin and if it is not interrupted. - If the alarm is still present, than the problem is inside the logic board; replace it.
	SOFTWARE ERROR		O	Cause: A software issue has been detected. This alarm code is reserved for factory tests during the development of the application.
232	CONT. DRV. EV	O		Cause: AUX valve driver is not able to drive the load. Troubleshooting: The device or its driving circuit is damaged. Replace the controller.
233	POWERMOS SHORTED	O		Cause: The DC-link voltage drops to zero when a high-side or low-side MOSFET is turned on. Troubleshooting: - Check that motor phases are correctly connected. - Check that there is no dispersion to ground for every motor phases. - In case the problem is not solved, replace the controller.
234	DRV. SHOR. EV	O		Cause: AUX valve driver is shorted. Troubleshooting: Check if there is a short circuit or a low impedance path between the negative terminal of the coils and -B.

Code	Alarm	Master	Slave	Description
236	CURRENT GAIN	O		Cause: The maximum current gain parameters are at the default values, which means that the maximum current adjustment procedure has not been carried out yet. Troubleshooting: Ask for assistance to a Hyundai dealer in order to do the adjustment procedure of the current gain parameters.
237	ANALOG INPUT	O	O	Cause: This alarm occurs when the A/D conversion of the analog inputs returns frozen values, on all the converted signals, for more than 400 ms. The goal of this diagnosis is to detect a failure in the A/D converter or a problem in the code flow that skips the refresh of the analog signal conversion. Troubleshooting If the problem occurs permanently it is necessary to replace the logic board.
238	HW FAULT EV.	O		Cause: At start-up, the hardware circuit dedicated to enable and disable the EV driver (output A9) is found to be faulty. Troubleshooting: This type of fault is not related to external components. Replace the logic board.
239	CONTROLLER MISM.	O	O	Cause: The software is not compatible with the hardware. Each controller produced is “signed” at the end of line test with a specific code mark saved in EEPROM according to the customized Part Number. According with this “sign”, only the customized firmware can be uploaded. Troubleshooting: - Upload the correct firmware. - Ask for assistance to a Hyundai dealer in order to verify that the firmware is correct.

Code	Alarm	Master	Slave	Description
240	EVP DRIVER OPEN	O		Cause: The EVP driver (output NEVP) is not able to drive the EVP coil. The device itself or its driving circuit is damaged. Troubleshooting: This fault is not related to external components. Replace the logic board.
	OUT MISMATCH PU		O	Cause: This is a safety related test. Supervisor μC has detected that master μC is driving traction motor in a wrong way (not corresponding to the operator request). The hexadecimal value "XX" facilitates Hyundai dealer debugging the problem. Troubleshooting: - Checks the matching of the parameters between Master and Supervisor. - Ask for assistance to a Hyundai dealer. - If the problem is not solved, replace the logic board.
241	SP MISMATCH PUMP		O	Cause: This is a safety related test. The master μC has detected a supervisor μC wrong set point. The hexadecimal value "XX" facilitates Hyundai dealer debugging the problem. Troubleshooting: - Check the matching of the parameters between master and supervisor. - Ask for assistance to a Hyundai dealer. - If the problem is not solved, replace the logic board.

Code	Alarm	Master	Slave	Description
242	OPEN COIL EV.	O		Cause: This fault appears when no load is connected between the NAUX 1 output (A9) and the positive terminal PCOM (A17). Troubleshooting: - Check the EB coil. - Check the wiring. - If the problem is not solved, replace the logic board.
	SP MISMATCH XX		O	Cause: This is a safety related test. The master μC has detected a supervisor μC wrong set point. The hexadecimal value “XX” facilitates Hyundai dealer debugging the problem. Troubleshooting: - Check the matching of the parameters between master and supervisor. - Ask for assistance to a Hyundai dealer. - If the problem is not solved, replace the logic board.
243	THROTTLE PROG.	O		Cause: A wrong profile has been set in the throttle profile. Troubleshooting: Set properly the throttle-related parameters.
244	WARNING SLAVE	O		Cause: Warning on supervisor uC. Troubleshooting: Connect the Console to the supervisor uC and check which alarm is present.
245	IQ MISMATCHED	O		Cause: The error between the Iq (q-axis current) setpoint and the estimated Iq is out of range. Troubleshooting: Ask for assistance to a Hyundai dealer in order to do the correct adjustment of the motor parameters.
246	EB. DRIV.OPEN	O		Cause: The EB coil driver is not able to drive the load. The device itself or its driving circuit is damaged. Troubleshooting: This type of fault is not related to external components. Replace the logic board.
247	DATA ACQUISITION	O		Cause: Controller in calibration state. Troubleshooting: The alarm ends when the acquisition is done.

Code	Alarm	Master	Slave	Description
248	NO CAN MSG.	O	O	Cause CANbus communication does not work properly. The hexadecimal value "XX" identifies the faulty node. Troubleshooting - Verify the CANbus network (external issue). - Replace the logic board (internal issue).
249	MAINTENANCE HOUR	O		Cause: The truck hours reached MAINTEINANCE HOUR parameter value. Troubleshooting: Perform the truck maintainance and reset the alarm using MAINTEN. RESET parameter.
250	THERMIC SENS. KO	O		Cause: The output of the controller thermal sensor is out of range. Troubleshooting: This kind of fault is not related to external components. Replace the controller.
251	WRONG SET BAT.	O		Cause: At start-up, the controller checks the battery voltage (measured at key input) and it verifies that it is within a range of ±20% around the nominal value. Troubleshooting: - Check that the SET BATTERY parameter inside the ADJUSTMENTS list matches with the battery nominal voltage. - If the battery nominal voltage is not available for the SET BATTERY parameter inside the ADJUSTMENTS list, record the value stored as HARDWARE BATTERY RANGE parameter in the SPECIAL ADJUST. list and contact a Hyundai dealer. - Through the TESTER function, check that the KEY VOLTAGE reading shows the same value as the key voltage measured with a voltmeter on pin A1. If it does not match, then modify the ADJUST BATTERY parameter according to the value read by the voltmeter. - Replace the battery.
252	WRONG ZERO	O		Cause: At start-up, the amplifiers used to measure the motor voltage sense voltages outside a fixed range. Troubleshooting: This fault is related to internal components. Replace the logic board.

Code	Alarm	Master	Slave	Description
253	FIELD ORIENT. KO	O		Cause: The error between the Id (d-axis current) setpoint and the estimated Id is out of range. Troubleshooting: Ask for assistance to a Hyundai dealer in order to do the correct adjustment of the motor parameters.
254	EB. DRIV.SHRT.	O		Cause: - The EB driver is shorted. - The microcontroller detects a mismatch between the valve setpoint and the feedback at the EB output. Troubleshooting: - Check if there is a short or a low impedance path between the negative coil terminal and -B. - Check if the voltage applied is in accordance with the parameters settings. - If the problem is not solved, replace the controller.

2) EPS CONTROLLER

Code	Alarm	Master	Slave	Description
8	WATCHDOG	O	O	Cause: MuC and SuC communicate on a local CANbus communication system. Communication between them requires a stuffing bit (stuffing bit must be reversed at any new frame). In case the stuffing bit is frozen longer than 100msec this alarm occurs. Troubleshooting: If it is repetitive, it reports a problem in the controller.
13	EEPROM KO	O	O	Cause: Every microcontroller has its own Eeprom with two parameters lists (to have a local back up copy). Each list has its own checksum. When both checksums are wrong, this alarm occurs. In case a parameter list has a wrong checksum it will be repaired using the second list (back up copy with a correct checksum). Troubleshooting: Make a Clear EEPROM. If the problem persists replace controller.
16	LOGIC FAILURE #4	O	O	Cause: This alarm occurs in the rest state if the output of the voltage amplifier on the linked voltage Vu-Vw have a drift larger than +/- 0.25V (vs. the rest value it had at key-on). Troubleshooting: It is necessary to replace the controller.
17	LOGIC FAILURE #3	O	O	Cause: This alarm occurs in the rest state if the output of the voltage amplifier on the linked voltage Vv-Vu have a drift larger than +/- 0.25V (vs. the rest value it had at key-on). Troubleshooting: It is necessary to replace the controller.
32	VMN NOT OK	O	O	Cause: This alarm occurs at key on, in case at least one amplifiers on linked voltage Vv-Vu and Vu-Vw is not in a narrow window of +/- 300mV around 2.4Vdc 10msec long (sampling time 2msec for 5 consecutive samples). (Admitted outputs at rest are from 2.1V to 2.7V). Troubleshooting: If it is repetitive, it is necessary to replace the controller.

Code	Alarm	Master	Slave	Description
48	MAIN CONT. OPEN	O	O	Cause: This warning is active when the steering controller is receiving via CANbus the information that the power line contactor is open. Troubleshooting: This is not a problem in the E-steering motor controller. When this warning is raised up it means the VCM has open (or not closed yet) the line contactor.
53	STBY I HIGH	O	O	Cause: This alarm occurs when the eps E-steering motor controller is at rest, in case at least one current amplifiers on phases U and W is not in a narrow window of +/- 300mV around 2.5Vdc 10msec long (sampling time 2msec for 5 consecutive samples). (Admitted outputs at rest are from 2.2V to 2.8V). Troubleshooting: If it is repetitive, it is necessary to replace the controller.
60	CAPACITOR CHARGE	O	O	Cause: This alarm occurs at key on in case the DC Bus (rail capacitors) doesn't reach a minimum value of 14Vdc within 3.2secs despite it is expected to do. STATUS #5 supplies the real time value of the battery link (+B) in its short duration instance. Troubleshooting: Some cases: - if this alarm is only reported in the steering controller, check the continuity of cables to CNA#3-4-5 from battery source and E-steering motor controller. - if the cables to CNA #3-4-5 are OK, measure the voltage between CNA#3-4-5 and –B within 3 sec after key-on. Only in case the voltage measured is higher than 14Vdc (and short duration instance on STATUS#5 is lower instead) replace the controller. - In case the voltage measured between CNA#3-4-5 and –B is close to 0 there are two possibilities: · Short circuit on the DC rail and –B inside the E-steering motor controller (disconnect CNA#3-4-5 and measure the voltage in the traction controller DC bus (+B to –B posts): replace E-steering motor controller in case DC bus voltage of the traction controller raises up to higher than 14Vdc. · Short circuit on the DC rail and –B on another unit in the truck.

Code	Alarm	Master	Slave	Description
61	HIGH TEMPERATURE	O	O	Cause: This alarm occurs when the temperature in the power mosfets is higher than 80 degrees. Troubleshooting: Improve the cooling of the controller; otherwise it is necessary to replace the controller.
65	MOTOR TEMPERAT.	O	O	Cause: This alarm occurs only when DIAG MOTOR TEMP is analog and the thermal sensor inside the motor measures a temperature higher than 120 degrees. It occurs also when trying to acquire the motor resistance with a temperature in the motor higher than 120 degrees. Troubleshooting: Check the thermal sensor in the motor is right working. If it is, improve the cooling of the motor.
70	HIGH CURRENT	O	O	Cause: This alarm occurs two ways: - At key on, in case the circuit for limiting the max current via Hardware is always active (can be due to a failure of a current amplifier). - After key on, in case the circuit for limiting the max current via Hardware acts frequently. Troubleshooting: If it is repetitive, it is necessary to replace the controller.
71	POWER FAILURE #3	O	O	Cause: Current in phase W of the motor very low 100msec long even if it is commanded higher than 14% Imax. Troubleshooting: If it is repetitive, check if the battery is connected to the controller. Otherwise the problem can be a failure in the power three phase bridge or in the motor.

Code	Alarm	Master	Slave	Description
72	POWER FAILURE #2	O	O	Cause: This alarm is raised by the MuC when the current in phase V of the motor very low 100msec long even if it is commanded higher than 14% Imax. Zapi Universal 2.0: this alarm is raised by the SuC at key on, in case the contactor on the DC-rail to the E-steering controller is welded in its closed position (MAIN CONTACTOR to OPTION #1 only). Troubleshooting: MuC: If it is repetitive, check if the battery is connected to the controller. Otherwise the problem can be a failure in the power three phase bridge or in the motor. SuC: if the contactor on the DC-rail to the E-steering controller is welded in its closed position, replace it.
73	POWER FAILURE #1	O	O	Cause: This alarm is raised by the MuC when the current in phase U of the motor is very low 100msec long even if it is commanded higher than 14% Imax. Zapi Standard 1ST Gen and Universal 2.0: this alarm is raised by the SuC in case the I^2t of the current in the battery overtakes the admitted limit of 22000A^2s (i.e. overload protection of the battery connections). Troubleshooting: MuC: if it is repetitive, check if the battery is connected to the controller. Otherwise the problem can be a failure in the power three phase bridge or in terminal U motor connection. SuC: an overload is occurred in the steering controller. One possibility is too much friction in the transmission. Launch selfcheck #2 with the steered wheel lifted up (and then on the floor) to measure the current in the motor when turning the steered axle. Check the diagnostic response (STATUS #2 and alarm message).
91	DRIVER 2 KO	O	O	Cause: This alarm occurs in case the safety switch between CNA #9 and CNA #14 is detected short circuited at key-on and option AUX OUTPUT #1 is set to PRESENT. Troubleshooting: It reports either a short circuit to GND of the load connected to CNA #14 or a problem in the controller.

Code	Alarm	Master	Slave	Description
98	INPUT ERROR #2	O	O	Cause: The revolution of the sensor at the steering wheel is split in 4 quadrants: 1ST: 0 to 90 degrees 2ND: 90 to 180 degrees 3RD: 180 to 270 degrees 4TH: 270 to 360 degrees This alarm occurs in case the configuration of the two outputs jumps to a NOT ADIACENT quadrant. In practice, when the configuration of the two outputs: - Is in the 1ST quadrant, shift to 3RD quadrant is not admitted - Is in the 2ND quadrant, shift to 4TH quadrant is not admitted - Is in the 3RD quadrant, shift to 1ST quadrant is not admitted - Is in the 4TH quadrant, shift to 2ND quadrant is not admitted Single event raises the alarm. Troubleshooting: Check the connections of the analog sensor at the steering wheel (CNA #20 and CNA #17). Disturb or interference on the sensor.
205	SELF CHECK #2	O	O	Cause: This warning occurs when the SELFCHECKING routine #2 is in progress and the check result has not been determined yet. This selfchecking routine carries out an embedded monitoring of the encoder and of the current in the motor when commanded to move at a fixed speed of 25Hz. We suggest to launch SELFCHECK #2 with the steered wheel lifted up. The goal of this selftest is to check the functionality of encoder and mechanical components (transmission, sensor bearings, gears, pinion). After the gathered data have been processed and an unexpected result occurred, this warning message will turn in an alarm information. Troubleshooting: Recycle the key to exit the SELFCHECK #2 warning.
206	SELF CHECK #1	O	O	Cause: This warning occurs when the SELFCHECKING routine #1 is in progress and the check result has not been determined yet. This selfchecking routine carries out a voltammeter measure of the motor resistances between phase V and W (Rvw) and between phase W and U (Rwu) by injecting a fixed 14.7Adc current (sqrt(3/2) * ID RMS MAX). The goal of this selftest is to check the functionality of motor and three phase power bridge. After the gathered data have been processed and an unexpected result occurred, this warning message will turn in an alarm information. Troubleshooting: Recycle the key to exit the SELFCHECK #1 warning.

Code	Alarm	Master	Slave	Description
207	WRONG HW SET	O		Cause: A Zapi adjusted hardware setting, called HW TYPE, specifies the hardware characteristics of the controller where the SW has been downloaded (absolute max current and battery voltage). In case HW TYPE has an inconsistent value (i.e. specifies a not foreseen pair, battery voltage and absolute max current) this alarm occurs. Troubleshooting: Call Hyundai dealer or replace the controller.
	SP MISMATCH		O	Cause: MuC and SuC calculate independently each other the set point for speed in the motor and position at the wheel. This alarm is raised by the SuC in case it calculates different set points than the MuC. Troubleshooting: If it is repetitive, it reports a problem in the controller.
208	OUTPUT MISMATCH		O	Cause: SuC compares the set points of motor current, motor speed and position at the wheel with the actual values. If there is a mismatch SuC raises this alarm. Imax in the motor with the correct sign is an exception: no alarm in this case. Troubleshooting: If it is repetitive, it it reports a problem in the controller.
209	W.D. SYNCRO	O	O	Cause: SuC doesn’t receive synchronization signal frpm MuC longer than 90msec. Troubleshooting: Recycle the key. If the problem remains replace the controller.
210	WRONG SLAVE VER.	O	O	Cause: This alarm is raised by MuC in case the Software release in MuC and SuC are not matched (different release). Troubleshooting: Download the same software release (same number) on both microcontrollers.
211	TFD FEEDB. ERROR	O	O	Cause: MuC raises this alarm in case the actual current and the set point current in the TFD (to friction the steering wheel) stays unmatched more than 150mA 120msec long. Troubleshooting: Problem can be the resistance of the TFD coil is too high (coil broken) or the wires to the TFD coil broken or a problem in the controller.

Code	Alarm	Master	Slave	Description
212	WRONG RAM MEM.	O	O	Cause: Deterministic Finite Automaton (DFA) is characterized by state transitions. As a protective measure any state transition is commanded by assigning two variables (state label and its complement). These two variables identify the new state (redundancy in the state label). This redundancy has been thought in order to avoid that a failure in the RAM memory leads to a wrong destination state for the DFAs. In case the two state labels are inconsistent or not complemented in between, this alarm occurs. Troubleshooting: If it is repetitive, it reports a problem in the controller.
213	PARAM RESTORE	O	O	Cause: This is a confirmation that a clear eeprom parameter was correctly performed. Troubleshooting: Recycle the key.
214	SP JERK	O	O	Cause: This alarm occurs if an output of the sensor at the steering wheel has a step wider than 586mV between two consecutive samples and confirmed for further ten samples (all the samples are picked up with a sampling delay is 4msec). Troubleshooting: Read STATUS #9 when the alarm occurs to find the output between CNA #20 and CNA #17 had the widest step. Check the continuity of the cables from sensor to controller. Check for a disturb, noise, interference between sensor in the steering wheel and controller. Check the cable between steering wheel and controller is shorter than 2meters.
215	CAN BUS KO M/S	O	O	Cause: MuC and SuC communicate via a local (embedded) CanBus communication system. If a node does not receive any response from the other node longer than 100msec, this alarm occurs. Troubleshooting: If it is repetitive, it is a problem in the steering controller.

Code	Alarm	Master	Slave	Description
216	TFD WRONG RESIST	O	O	Cause: Parameter TFD OHM IMPED. sets the expected resistance of the TFD coil @ 25°C. This parameter is used for a coarse check of the integrity of the TFD coil. E-steering motor controller measures the TFD coil resistance with a voltammeter test (V_in_the_coil/ Current_in_the_coil). When the measured resistance is outside the range from 1/3 to 3 times TFD OHM IMPED 180msec long, MuC raises this alarm. V_in_the_coil is calculate using VCNA#9 –VCNA#10, if V in_the_ coil expected is lower than 2.3V diagnosis is not done due to a too low precision in value V_in_the_coil. Troubleshooting: Problem can be the resistance of the TFD coil is too high (coil broken) or too low (a short circuit inside the TFD) or the wires to the TFD are broken or the parameter called TFD OHM IMPED has been wrong set or a problem in the controller.
218	CONTROLLER MISM.	O	O	Cause: This alarm occurs when the embedded SW is not compatible with Hardware. Troubleshooting: Update the embedded SW.
220	MOTOR LOCKED	O	O	Cause: This alarm occurs when the current in the motor stays higher than 90% Imax longer than 1 secs when the traction speed is higher than 15% (delay becomes 5 secs when the traction speed is lower than 5%). Troubleshooting: Too much torque required to steer or problem in the encoder (launch selfcheck #2).
221	M/S PAR CHK MISM	O	O	Cause: MuC compares its checksum for the parameters list with the checksum of the parameters list in the SuC. In case they are mismatched, MuC raises this alarm. Troubleshooting: Check which parameter(s) is different between MuC and SuC and update (write) the unmatched parameter(s). To easily fix the problem make a Clear Eeprom.

Code	Alarm	Master	Slave	Description
223	FB JERK	O	O	Cause: This alarm occurs if the encoder counting has a step wider than 21° between two consecutive samples and confirmed for further thirteen samples (all the samples are picked up with a sampling delay is 16msec). The diagnostic routine uses an encoder counting scaled in the range 2048ud+/-2048ud (corresponding to a steered axle angle of 0+/-180˚) and the threshold for the alarm is +/-244ud corresponding to an angle of 244/2048*180˚=21˚. Troubleshooting: See reading SLOPE PEAK of the tester menu (with DEBUG OUTPUT temporary set to Level 13) to have a real time monitoring of the max step detected by the diagnostic routine. Check the encoder is right working. Use also STATUS # 2 to have a feedback on the encoder functionality (see topic 16: TROUBLESHOOTING).
225	CURRENT GAIN	O	O	Cause: This alarm occurs when the gains of the current amplifiers (ADJUSTMENT #03 and ADJUSTMENT #04) are set to their default values (Imax has not been regulated yet). Troubleshooting: Call Hyundai dealer.
226	STOP TRAC WR.	O	O	Cause: The eps is inhibiting the traction movement due to a wrong parameter configuration or calibration of the eps controller.
227	OUTRNG-TURN ST01	O	O	Cause: The wheel performed a rotation of 180 degrees.
228	POSITION ERR	O	O	Cause: This alarm occurs when the displacement between position of the steered wheel measured with the encoder (FEEDBACK ENC) and with the first output of the analog sensor (FBPOT1 AT ENC) is wider than 173mV (for six subsequent samples picked up with a sampling delay is 16msec). STATUS #7 can be used to detect real time the peak value of the displacement (to be compared with the alarm threshold of 175mV) and the values of the variables involved when that peak of the displacement has been recorded. Troubleshooting: Check STATUS #7 when alarm occurred. Check the analog value of the sensor on CND #2 (FEEDBACK POT 1). Verify also the encoder works correctly.

Code	Alarm	Master	Slave	Description
230	PARAM CONFIGURAT	O	O	Cause: 1 SYSYEM CONFIG not admitted or not available in this software 2 Not possible for this hardware has 2 feedback encoder and analog setpoints 3 EPS SYNC TYPE not admitted for this software 4 Command input not admitted for this software 5 Torque assist not available for this software 6 software end limit are not setted (360°) in position control 8 FEEDBACK DEVICE not admitted or not available in this software 9 key-on 0 alignement request without feedback switch (sw version <=7.01) 0A analog feedback without feedback switch and key-on syncronization not manual (sw version <=7.01) 0B In a single feedback encoder , parameter 1ST ENCODER RES 1= 2ND ENCODER RES 0C Analog feedback with no end limit setted 0D FEEDBACK DEVICE set to 7 (only encoder) in position control is not admitted 0E position or speed can command with no caniopen protocoll 0F 2nd home switch activated with AUX FUNCTION#11 set to 2 or 3 or4 or5 10 analog setpoint parallel trace not jet available 11 manaul startup syncronization in position control with feedback switch 12 2 encoder and analog feedback not possible 13 zero_sp1 + zero_sp2 out of range 20 Wrong teaching in potentiometer analog command (for example maximul lower then 0) 22 reserved for input_analog && sp_sawtooth
235	TFD SHRT/VOLT KO	O	O	Cause: This diagnosis is processed only at key on the Circuit in. Two tests: Q3 is initially off: CNA #9 is expected to be lower than 5Vdc. In case it isn't this alarm occurs; otherwise Q3 is switched on. Q3 is on: CNA #9 is expected to be higher than 60% of the DC bus. In case it isn't this alarm occurs. This alarm (with alarm number 40h) is raised also by the SuC in case the key input stays lower than 12.5V longer than 200msec. Troubleshooting: It reports either a short circuit to GND of the load connected to CNA #9 or a problem in the controller (on safety switch Q3).

Code	Alarm	Master	Slave	Description
236	TFD STB I HIGH	O	O	Cause: If the output of the amplifier to measure the current in the TFD is not Zero at rest, this alarm occurs. Zero for MuC is 0.5V (alarm when it is higher than 1V). (For MuC output increases when the current is not null). Zero for SuC is 4.5V (alarm when it is lower than 4V). For SuC output decreases when the current is not null. Troubleshooting: It reports a problem in the controller.
237	SLAVE ALARM	O		Cause: When SuC raises an alarm, steering motor cannot be actuated and the MuC informs the SuC has cut off the power stage by raising this warning. In the Zapi console, MuC specifies the LSByte of the SuC alarm code. For instance, in case of SuC alarm code FFD0 (OUTPUT MISMATCH), MuC raises SLAVE ALARM D0. (i.e. XX assumes the two last nibbles of the SuC alarm code.) Troubleshooting: If it is repetitive, it reports a problem in the controller.
	WAITING MASTER		O	Cause: When MuC raises an alarm, steering motor cannot be actuated and the SuC informs the MuC has cut off the power stage by raising this warning. In the Zapi console, SuC specifies the LSByte of the MuC alarm code. (i.e. XX assumes the two last nibbles of the MuC alarm code.) Troubleshooting: If it is repetitive, it reports a problem in the controller.
240	LOGIC SUPPLY ERR	O	O	Cause: This alarm occurs in case the 13.5V logic supply voltage to drive the three phase power bridge is detected lower than 11Vdc. Troubleshooting: Recycle the key. If it is repetitive, it reports a problem in the controller.

Code	Alarm	Master	Slave	Description
241	FB SENSOR LOCKED	O	O	Cause: This alarm occurs if the actual position (steered wheel angle measured via the encoder counting) does not pursuit the commanded position (steering wheel) longer than 500msec @ traction speed higher than 15% (at lower traction speed, time delay increases up to 2.5secs when traction speed is lower than 5%). If the displacement between commanded position and the encoder counting (i.e. steered wheel angle) is higher than 10degrees and the encoder counting increases less than 2degrees within the time delay of 500msec, this alarm occurs. Troubleshooting: STATUS #2 Selfchecking routine helps to found the root of the problem. This alarm can be due to: - At least one encoder channel broken. - Too much friction in the transmission/gears. - A failure in the power controller. - A failure in the motor (e.g. a sensor bearing locked or a motor phase broken).
244	PARAM TRANSFER	O	O	Cause: Master uC and Slave uC has its own parameter list (with its local back up copy). Change of a parameter is handled by the MuC only. MuC writes its own parameter and commands the SuC to do the same for its parameter list. Execution of the write command in the SuC is protected by a password. This alarm is raised up by the MuC in case SuC refuses to do the write command. Troubleshooting: Try to change one more time a parameter. If problem persists replace controller.
245	DATA ACQUISITION	O	O	Cause: This alarm occurs during max current regulation (factory adjusted) and when a procedure to acquire the motor resistance is launched. Troubleshooting: Recycle the key.
247	CAN BUS KO	O	O	Cause: If a node does not receive its dedicated CANbus message longer than 100msec, this alarm occurs. Troubleshooting: Problem can be in the CANbus wires, or in the CANbus transceiver inside VCM, E-steering motor controller or another unit in the truck. Identification of the root of the problem needs a CANbus analyzer.

Code	Alarm	Master	Slave	Description
248	S.P OUT OF RANGE	O	O	Cause: If occurs when the displacement between actual and expected conditions of the analog sensor at the steering wheel is wider than a threshold (16 subsequent samples picked up with a sampling delay is 4msec). PWM sensor: this threshold is a displacement of +/-5.5% of duty cycle when the speed of the steering wheel is null; linearly increasing up to 11% when the speed of the steering wheel is 5rev/sec. Analog sensor: this threshold is +/-250mV for the SuC and +/-400mV for the MuC. In case it gets higher than 250mVdc (or 400mVdc) or lower than -250mVdc (or 400mVdc) this alarm occurs. Diagnosis is split into 4 quadrants (0 to 90, 90 to 180, 180 to 270, 270 to 360 degrees). STATUS #8 can be used to detect real time the peak value of the displacement (to be compared with the alarm threshold of 250mV) and the values of the outputs when that peak of the displacement has been recorded). Troubleshooting: Check STATUS #8 when alarm occurred. Check the connections of the analog sensor at the steering wheel (CNA #20 and CNA #17). Disturb or interference on the sensor.
250	INPUT MISMATCH		O	Cause: MuC and SuC read the inputs independently each other. SuC takes care the values that it is reading are matched real time with the values the MuC is reading. The inputs are: - Steering Wheel sensor (CNA #20 and CNA #17) - Steered Wheel analog sensor - Encoder in the motor SuC raises this alarm in case they are mismatched Troubleshooting: If it is repetitive, it reports a problem in the controller.

Code	Alarm	Master	Slave	Description
251	INIT VMN NOT OK	O	O	Cause: After key-on, with the three phase power bridge off, the DC bus voltage is expected to raises up to 14Vdc within 3.2secs (alarm CAPACITOR CHARGE below if it isn't). In the same time, steering controller monitors the common voltage at the motor terminals (see STATUS #5 (MONITORING list)) and raises this alarm when the 3.2secs time-out is expired and: - The common voltage is lower than 7Vdc (bottom power mosfet shortcircuited to –B). OR - The common voltage is stuck to the DC Bus (top power mosfet shorcircuited to +B). (It is considered stuck in case it is in a window of +/- 1Vdc around the DC Bus). STATUS #5 in the TESTER menu, supplies the real time value of this common voltage on its long duration instance. Troubleshooting: Try to disconnect all the motor terminals from the controller, recycle the key and read STATUS #5. If the long duration instance (i.e. 1ST value) is in a window 8 to 13.5Vdc, the problem is a dispersion (lost of insulation of the motor). Otherwise replace the controller.
252	TWIN POT MISMAT.	O	O	Cause: it occurs when the displacement between actual and expected conditions (FEEBACK POT 1 + FEEDBACK POT 2=5Vdc) of the analog sensor at the steered wheel (tire) is wider than 490mVdc six subsequent samples picked up with a sampling delay is 16msec. STATUS #6 can be used to detect real time the peak value of the displacement (to be compared with the alarm threshold of 490mV) and the values of the outputs when the peak of the displacement has been recorded. Troubleshooting: Check STATUS #6 when alarm occurred. Check the connections (mechanical and electrical) of the analog sensor at the steered axle. Replace the sensor if nothing is found.
253	ANALOG	O	O	Cause: At key on, the A/D converter is switched on and it is expected to complete a conversion of the analog inputs within 16msec. In case it isn't, this alarm occurs. Troubleshooting: Recycle the key. If problem persists replace the controller.

Code	Alarm	Master	Slave	Description
254	NO SP REFRESH	O	O	Cause: This alarm is alive only when the sensor at the steering wheel is of PWM type (not analog). Then, in case at least one output between CPOC 1 and CPOC 2 (CNA #20 and CNA #17) has a PWM period shorter than 4msec or longer than 6msec confirmed for 92msec long, this alarm occurs (NO SP REFRES 02 and NO SP REFRES 04). It occurs also when at least one between CPOC 1 and CPOC 2 does not switch longer than 12msec (2 period lost) with alarm NO SP REFRES20 (i.e. 20h=32dec). Troubleshooting: Check the sensor at the steering wheel and the wiring from the steering wheel to the controller.

3) VCM CONTROLLER

Code	Alarm	Master	Slave	Description
8	WATCHDOG	O	O	Cause: A software watchdog is programmed inside each microcontroller. Its role is to check the correct operation of the software. All functions are blocked. Troubleshooting: it is an internal error, the module must be replaced.
19	LOGIC FAILURE #1	O	O	This alarm signals that an undervoltage at the key input has been detected. All functions are blocked. Troubleshooting depends on which is the reason of the alarm: - A real undervoltage situation happened. The alarm should disappear by simply switching off and on again the key. The cause of the undervoltage event has to be found on the application. For example: a truck function requesting a very large battery current may decrease too much the battery voltage. - Fault in the circuit which detects the undervoltage condition. The board must be replaced.
199	OUT1/2 COIL SH.		O	Cause: This alarm occurs when there is a short circuit of the EVP 1 or EVP 2 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: - 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.
200	WRONG PARAMETER	O		Cause: This is an alarm related to the throttle configuration. Troubleshooting: Check the parameters.
	OUT3/4 COIL SH.		O	Cause: This alarm occurs when there is a short circuit of the EVP 3 or EVP 4 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: - 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.

Code	Alarm	Master	Slave	Description
201	WRONG SLAVE VER.	O		Cause: Wrong software version on supervisor uC. Troubleshooting: Install the correct software version in the supervisor uC.
	OUT5/6 COIL SH.		O	Cause: This alarm occurs when there is a short circuit of the EVP 5 or EVP 6 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: - 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.
202	HM MISMATCH	O		Cause: Mismatch between VCM and traction regarding the Hour Meter. Troubleshooting: Check the parameter setting concerning the HM.
	OUT7/8 COIL SH.		O	Cause: This alarm occurs when there is a short circuit of the EVP7 or EVP8 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: - 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.
203	TILLER MISMATCH	O		-
	LASER COIL SH.		O	-

Code	Alarm	Master	Slave	Description
204	BATTERY LOW	O		Cause: It occurs when the battery charge is calculated being less than or equal to 10% of the full charge and the BATTERY CHECK setting is other than 0 (refer to SET OPTION menu). Troubleshooting: Get the battery charged. If it doesn't work, measure with a voltmeter the battery voltage and compare it with the value in the BATTERY VOLTAGE parameter. If they are different adjust the value of the ADJUST BATTERY function.
	BAT OUT COIL SH.		O	Cause: This alarm occurs when there is a short circuit of the EV 1 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: - 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.
205	LOAD BRK COIL SH		O	Cause: This alarm occurs when there is a short circuit of the EVP 9 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: - 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.
206	ALARM COIL SH.		O	Cause: This alarm occurs when there is a short circuit of the EV 2 coil. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand. Troubleshooting: - 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.
207	WATCH DOG MASTER		O	Cause: An Hardware watchdog is present inside to synchronize the microcontrollers. All functions are blocked. Troubleshooting: It is an internal error, the module must be replaced.

Code	Alarm	Master	Slave	Description
208	EEPROM KO	O	O	Cause: Fault in the area of memory where the parameters are stored or problems during the read/write operations of this memory. This alarm does not inhibit machine operation but default parameters are used. Troubleshooting: If the fault continues when the key switch is re-cycled, replace the board. If the fault disappears, the previously stored parameters will have been replaced by the default parameters.
209	PARAM RESTORE	O	O	Cause: This warning appears when the controller restored the default values. Troubleshooting: If a CLEAR EEPROM was mode before the last keyon-recycle, this warning just means that the EEPROM was correctly cleared. A travel demand or a pump request cancel the alarm. If this alarm appears at keyon without any CLEAR EEPROM request by the operator, there could be a problem inside.
210	WRONG RAM MEM.	O	O	Cause: The algorithm implemented to check the main RAM registers finds a wrong contents: the register is “dirty”. This alarm inhibit the machine operations. Troubleshooting: Try to switch the key off and then on, if the alarm is still present replace the logic board.
211	PUMP INC. START	O		Cause: This is a warning for an incorrect starting sequence. Troubleshooting: The possible reasons for this alarm is (use the readings in the TESTER to facilitate the troubleshooting) pump demand active at key on or a pump demand is present without the seat input active. Check the wirings. Check the micro-switches. It could be also an error sequence made by the operator. A failure in the logic is possible too; so when all of the above conditions were checked and nothing was found, replace the controller.
	PEV DRV. OPEN		O	Cause: VCM is not able to drive the high side driver of output PEVP 1. Troubleshooting: This type of fault is not related to external components; replace the logic board.
212	PEV DRV. SHORT.		O	Cause: The high side driver of output PEVP 1 is shorted. Troubleshooting: - Check if there is a short or a low impedance pull-up between pin A13 and +BATT. - The driver circuit is damaged in the logic board, which has to be replaced.

Code	Alarm	Master	Slave	Description
213	ENCODER LOCKED 1	O		Cause: The encoder n°1 is stuck or the encoder signals are not correctly received by the controller. Troubleshooting: Please check if the ENCODER 1 on the tester menu is different than zero during a lifting request. Check the wirings and check that the sensor works correctly. A failure in the logic is possible too; so when all of the above conditions were checked and nothing was found, replace the controller.
	VALVE MISM. OUT		O	Cause: Mismatch between uC Master and uC slave for output set point calculation. Troubleshooting: The logic board has to be replaced.
214	ENCODER LOCKED 2	O		Cause: The encoder n°2 is stuck or the encoder signals are not correctly received by the controller. Troubleshooting: Please check if the ENCODER 2 on the tester menu is different than zero during a lifting request. Check the wirings and check that the sensor works correctly. A failure in the logic is possible too; so when all of the above conditions were checked and nothing was found, replace the controller.
215	OUT PORT PULL-UP	O	O	Cause: This is an alarm related to the hardware configuration. Troubleshooting: The problem is on the logic board, which must be replaced.
217	ANALOG INPUT	O	O	Cause: There is a problem in the analog-to-digital module of the microcontroller. All functions are stopped. Troubleshooting: This a failure internal to the microcontroller, replace the
218	IN. MISM. D		O	Cause: Mismatch on digital input between Master and Slave. Troubleshooting: Compare the values read by Master and Slave by tester menu of console. Ask the assistance of a Hyundai dealer.

Code	Alarm	Master	Slave	Description
219	VALVE ENABLE	O		Cause: It occurs when the uC master try to activate an output but the supervisor uC doesn’t activate the enable. Troubleshooting: Check if some alarm is present on supervisor uC. Otherwise a fault in the hardware is present, the board must be replaced.
	IN. MISM. A/E		O	Cause: Mismatch on analog inputs or encoder inputs between Master and Slave. Troubleshooting: Compare the values read by Master and Slave by tester menu of console. Ask the assistance of a Hyundai dealer.
223	NO CAN MSG. 5	O		Cause: Timeout on the local CANbus. Troubleshooting: Switch OFF and ON. If the alarm is still present replace the board.
	NO CAN MSG. C		O	Cause: No CAN message from traction controller. Troubleshooting: Check the CAN connection on traction controller side. Verify that the traction communicates on CANbus.
224	WAITING FOR NODE	O		Cause: The controller receives from the CAN the message that another controller in the net is in fault condition; as a consequence the VCM controller itself cannot enter an operative status, but has to WAIT for the other controller coming out from the fault status.
	NO CAN MSG. 4		O	Cause: Timeout on the local CANbus. Troubleshooting: Switch OFF and ON. If the alarm is still present replace the board.
225	CONTROLLER MISM.	O	O	Cause: Wrong customer ID code found in the protected area of memory where this parameter are stored. Troubleshooting: Replaced the controller.
226	PUMP IN ALARM	O		Cause: Alarm on pump controller. Troubleshooting: Check the alarm on pump controller.
227	NO CAN MSG. 14	O	O	Cause: No CAN message from pump controller. Troubleshooting: Check the CAN connection on pump controller side. Verify that the pump communicates on CANbus.

Code	Alarm	Master	Slave	Description
228	NO CAN MSG. A	O	O	Cause: No CAN message from the Mini Lever or Joystick. Troubleshooting: Check the CAN connection on Mini Lever or Joystick side. Verify that the Mini Lever or Joystick communicate on CAN bus.
229	SDO TRAC.	O		Cause: There is a problem in the communication of HM between VCM and traction. Troubleshooting: Verify the communication between the two controllers. If all is ok try to replace the board.
231	DRV. SHRT A		O	Cause: VCM is not able to drive one of the first eight outputs. Troubleshooting: - Check if there is a short or a low impedance pull-down between one of the output and –BATT. - The driver circuit is damaged in the logic board, which has to be replaced.
232	DRV. OPEN A		O	Cause: The driver of one of the first eight outputs is shorted. Troubleshooting: This type of fault is not related to external components; replace the logic board.
233	DRV. SHRT B		O	Cause: The driver of one of the outputs NEV 1,.., NEV 3 is shorted. Troubleshooting: - Check if there is a short or a low impedance pull-down between one of the outputs and –BATT. - The driver circuit is damaged in the logic board, which has to be replaced.
234	DRV. OPEN B		O	Cause: VCM is not able to drive one of the outputs NEV 1,.., NEV 3. Troubleshooting: This type of fault is not related to external components; replace the logic board.
241	M/S PAR CHK MISM	O		Cause: Parameters are saved both in the master Eeprom and in the slave Eeprom. The two non-volatile memories must contains the same parameter values and they are compared periodically. If a difference is found, this alarm is raised. This alarm does not inhibit machine operation but default parameters are used. Troubleshooting: Try to save again the parameters. If the fault continues when the key switch is re-cycled, replace the board.

Code	Alarm	Master	Slave	Description
242	PARAM TRANSFER	O		Cause: Parameters are saved both in the master Eeprom and in the slave Eeprom. The two non-volatile memories must contains the same parameter values and they are compared periodically. If the master is not able to transfer the parameters to the slave, this alarm is raised. Troubleshooting: Try to save again the parameters. If the fault continues when the key switch is re-cycled, replace the board.
243	COIL OPEN A		O	Cause: This fault appears when the no load is connected between one of the outputs NEVP 1, NEVP 2….NEVP 8 and the positive terminal. Troubleshooting: - It is suggested to check the harness, in order to verify if some coil is connected to the right connector pin and if it is not interrupted. - If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic board, replace it.
244	CHECK UP	O		Cause: This is just a warning to call for the time programmed maintenance. Troubleshooting: It is just enough to turn the CHECK UP DONE option to level ON after the maintenance is executed.
	COIL OPEN B		O	Cause: This fault appears when no load is connected between one of the outputs NEV 1….NEV 3 and the positive terminal. Troubleshooting: - It is suggested to check the harness, in order to verify if some coil is connected to the right connector pin and if it is not interrupted. - If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic board, replace it.
245	COIL OPEN BRAKE		O	Cause: This fault appears when no load is connected between the output NEVP9 and the positive terminal. Troubleshooting: - It is suggested to check the harness, in order to verify if some coil is connected to the right connector pin and if it is not interrupted. - If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic board, replace it.
246	NO CAN MSG. C	O		Cause: No CAN message from traction controller. Troubleshooting: Check the CAN connection on traction controller side. Verify that the traction communicates on CANbus.

Code	Alarm	Master	Slave	Description
247	NO CAN MSG. 6	O		Cause: No CAN message from EPS. Troubleshooting: Check the CAN connection on steering controller side. Verify that the steering module communicates on CANbus.
248	NO CAN MSG. 10	O		Cause: No CAN message from DISPLAY. Troubleshooting: Check the CAN connection on display side. Verify that the display communicates on CANbus.
249	CAN BUS DISPLAY	O		Cause: The key relay driven by display is open. Troubleshooting: Check the relay.

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)

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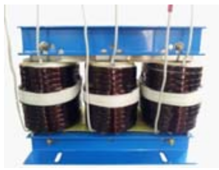

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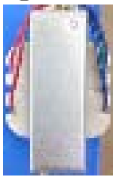

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1 Main PCB board
2 Main trans (Class H)
3 Cooling fan
4 SCR module
5 Monitor PCB
6 Overload
7 MG S/W
8 Assistant trans
9 Resistance (RD)
10 Resistance (DR)

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 3Ø380 V 3Ø440 V	For 3Ø220V, one step higher capacity cable should be used. (2.5 mm^2 → 4mm^2)
400-80 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.

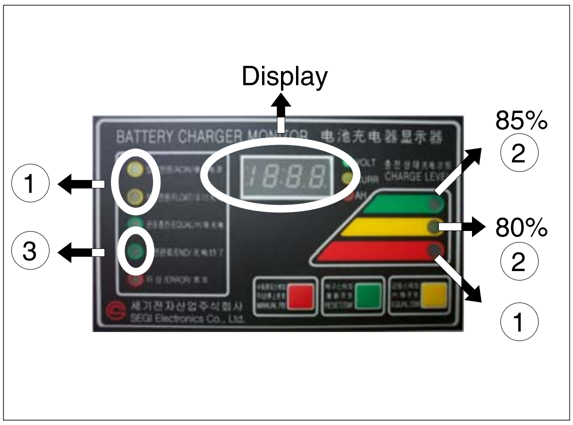
· According to charging condition

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.



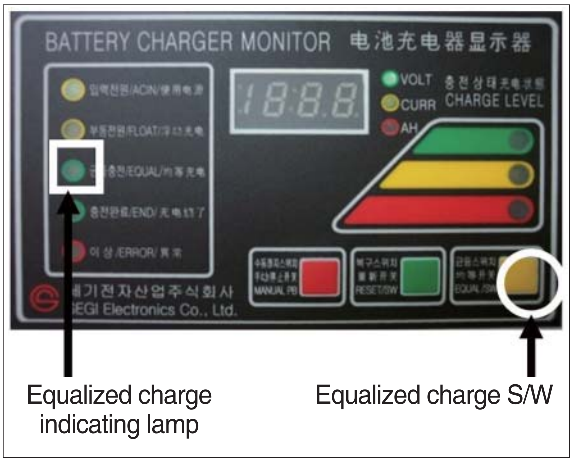
(2) Equalized charging

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.

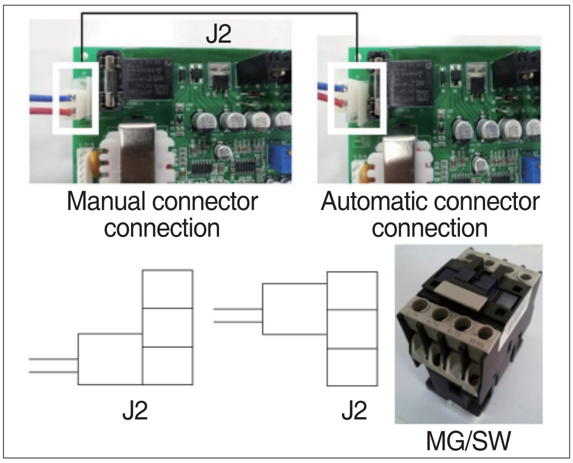
※ **When the green charging condition lamp is on (over 85% charged), the equalized charging switch is locked that it does not operate even pushing the button.**



(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)



(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 Iulua63V ~ Iula64V 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.

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.**

No	Code	Description of error
1	E.F	EPROM fail
2	O.V	Over voltage - Refer to page 7-86
3	O.C	Over current - Refer to page 7-85, 7-87.
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 7-84.
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.

Error indication

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

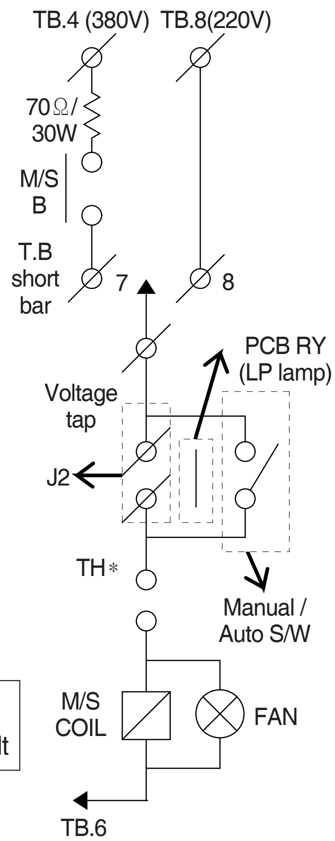
(2) Troubleshooting

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

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

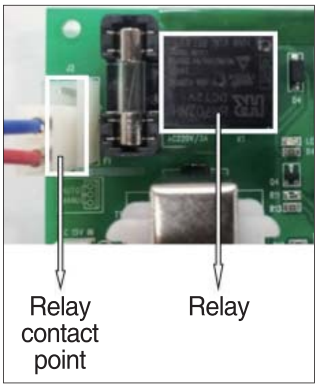
MS electric socket

Manual/Auto TAP (J2)

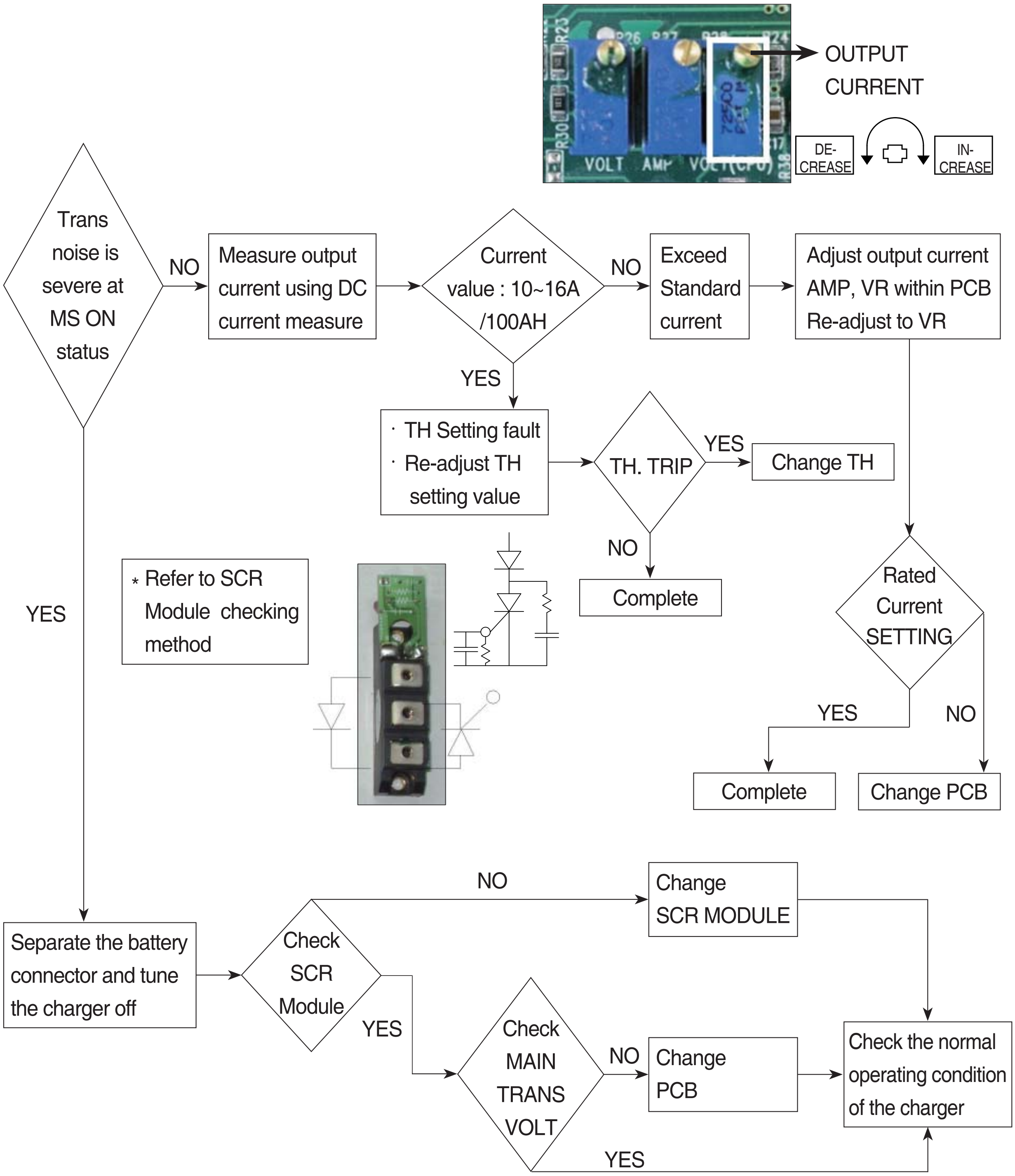


M/S electrical circuit

Check the rated voltage
- YES → Insert automatic/manual connector (J2) at the upper part of PCB to manual, after separating battery connector. → **AC INPUT MS switch ON**
  - YES → **PCB LP lamp lights up**
    - YES → CN4 contact fault / PCB RY contact fault
    - NO → Change PCB
  - NO → Put a black lead of multi-tester to input voltage switch No. 6 and measure voltage between tab No.8,PCB CN4,TH contact points with a red lead. → **Voltage 220V**
    - NO → TH contact fault / CN4 contact fault / PCB RELAY fault / TH manual restoration release
    - YES → MS COIL fault
- NO → Input power supply is not supplied.
  - · Check external lead cable.
  - · Check the connection of external input connecter
  - · Check external NFB TRIP



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

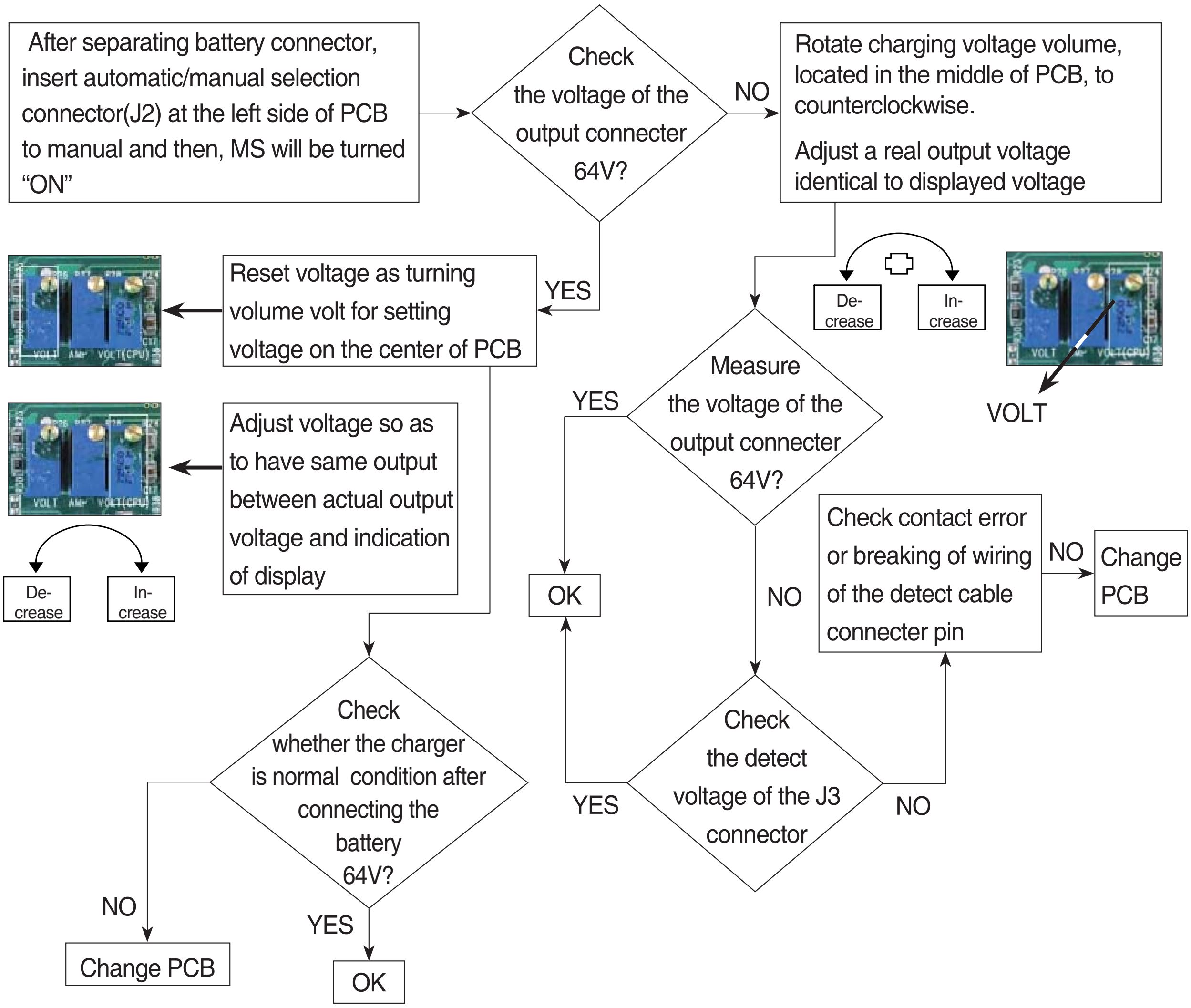


③ Charger TRIP is occurred after abnormality lamp is on.

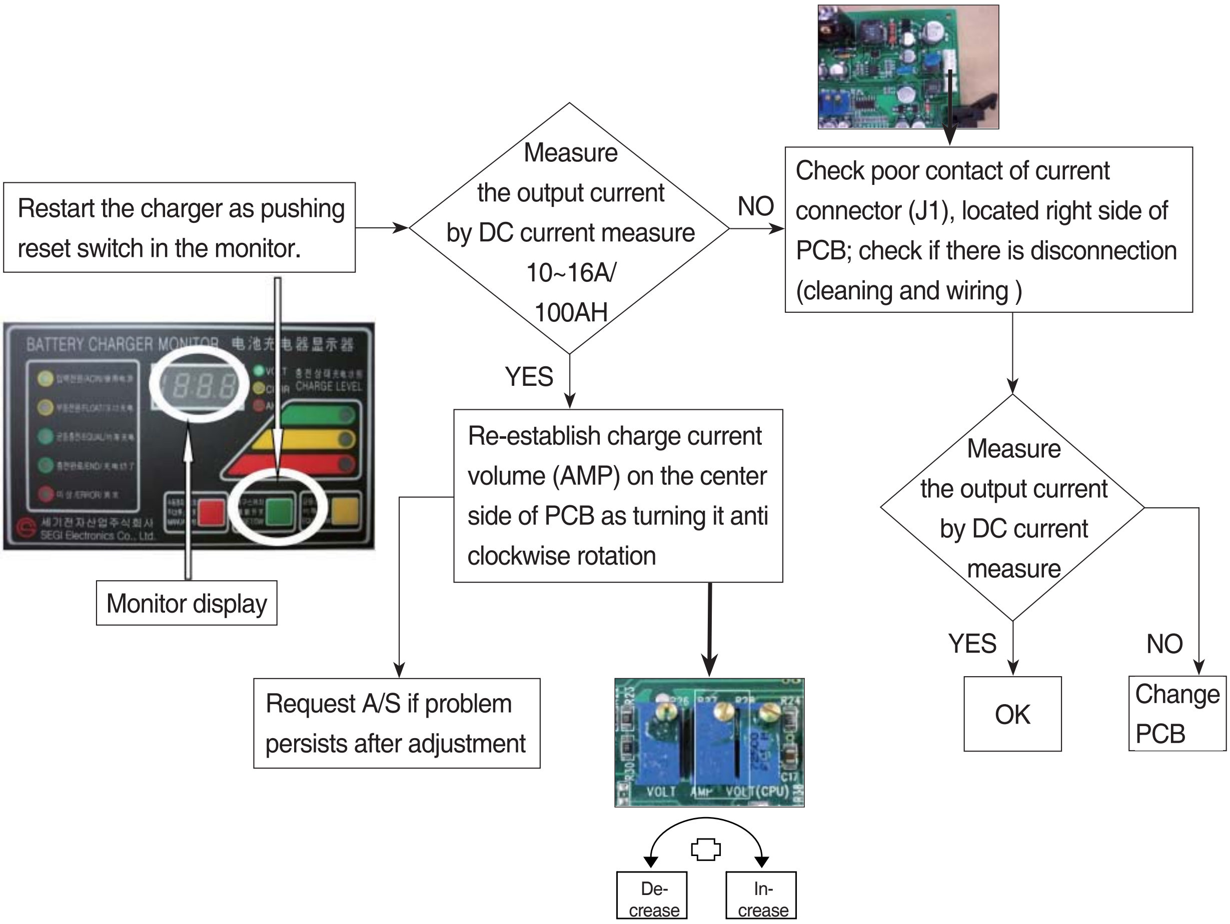
In case error code is "O.V" → Over-voltage output / Set at 66V (In case of BATT 48V)

34V (In case of BATT 24V)

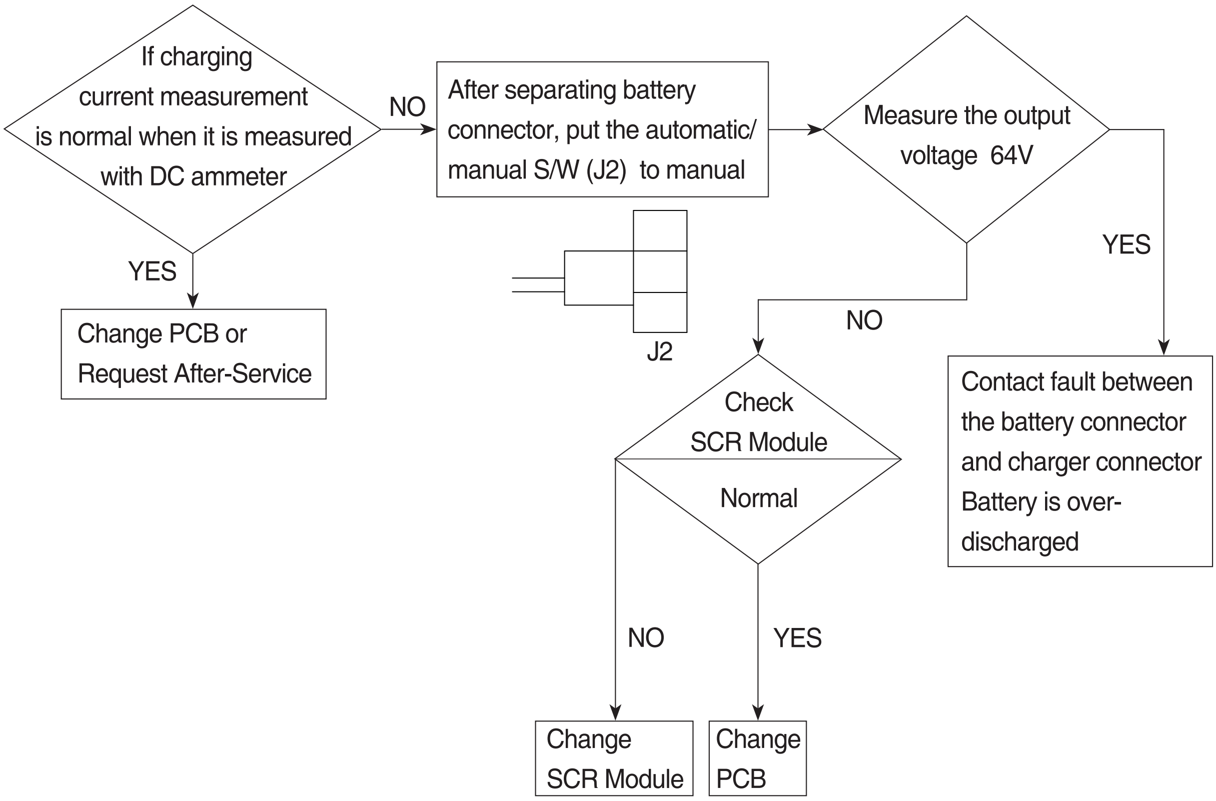
108V (In case of BATT 80V)



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.

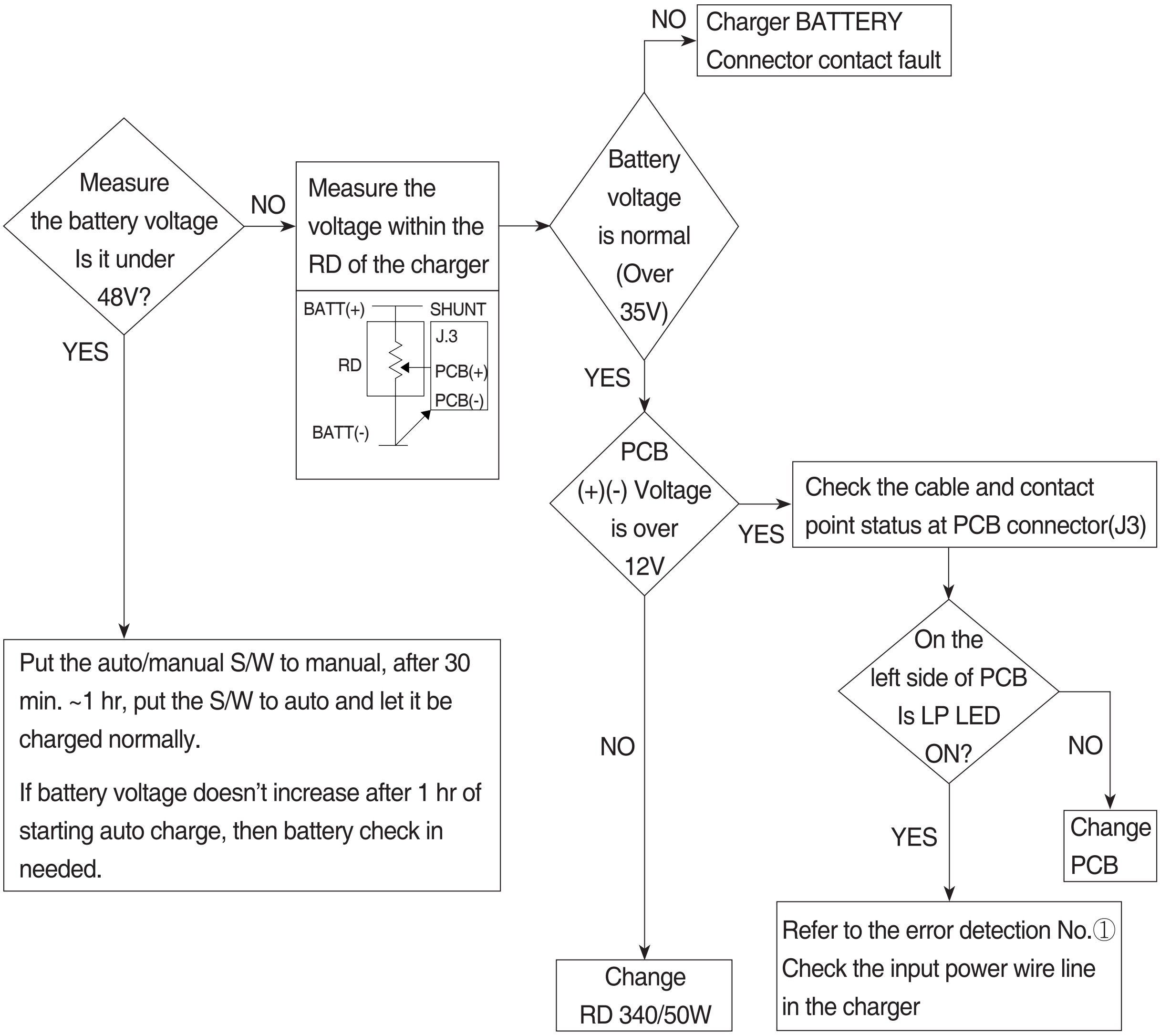


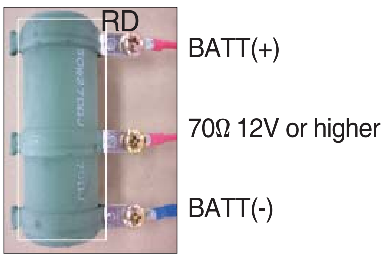
⑤ Charger TRIP is occurred after it started charging and charging completion lamp is on.
(In case input voltage is normal - Refer to the error detection No. 1)
Restore the charger as pushing reset switch.



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)

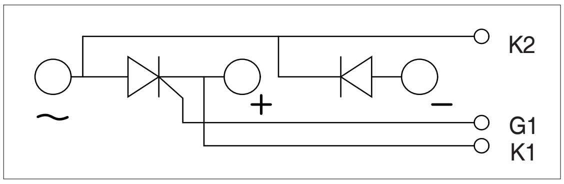




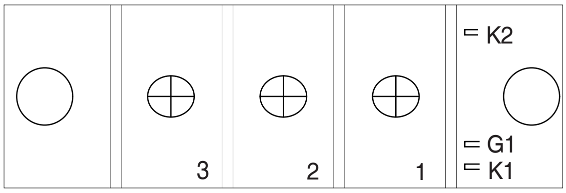
(based on 48V)

7) HOW TO CHECK THE SCR MODULE

Circuit

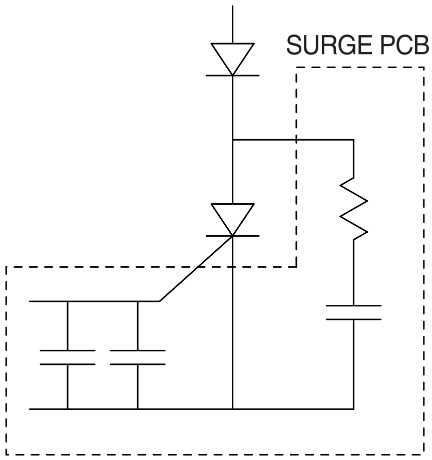


Real diagram

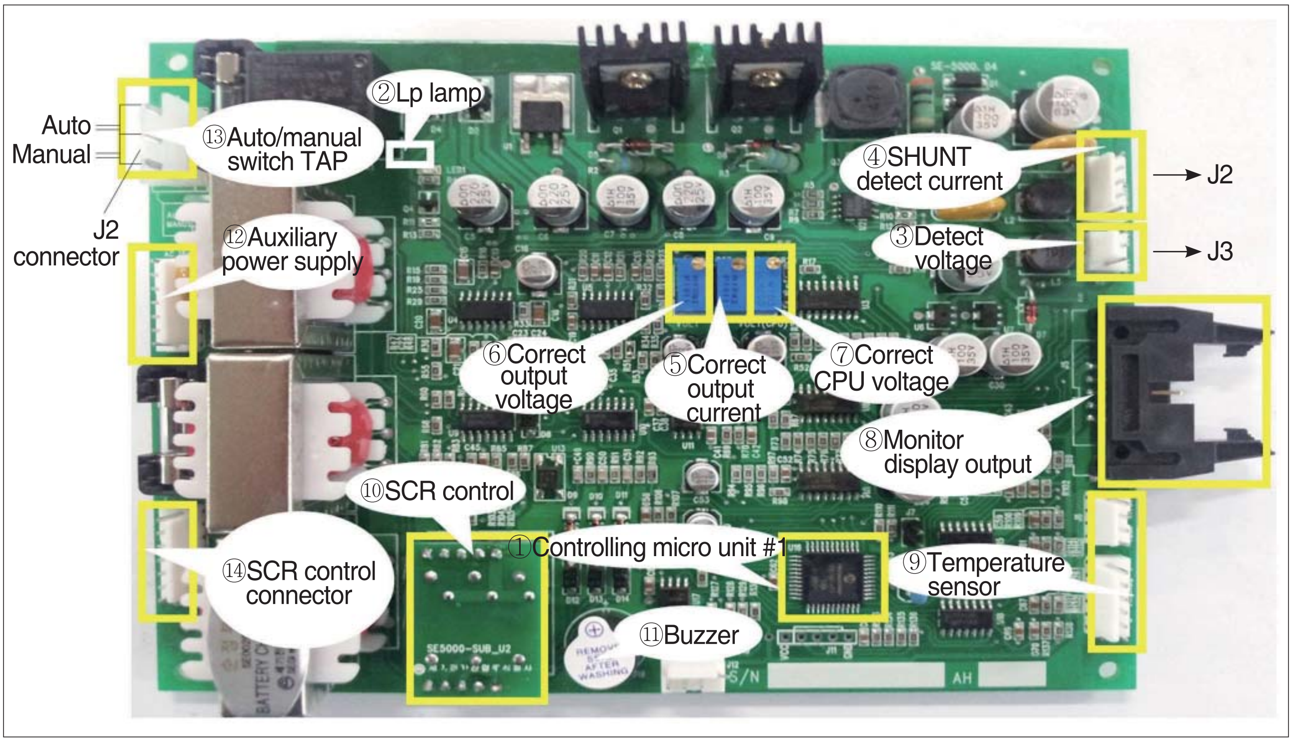


* Before checking SCR MODULE, be sure to disconnect bus bar and wire on the terminal.

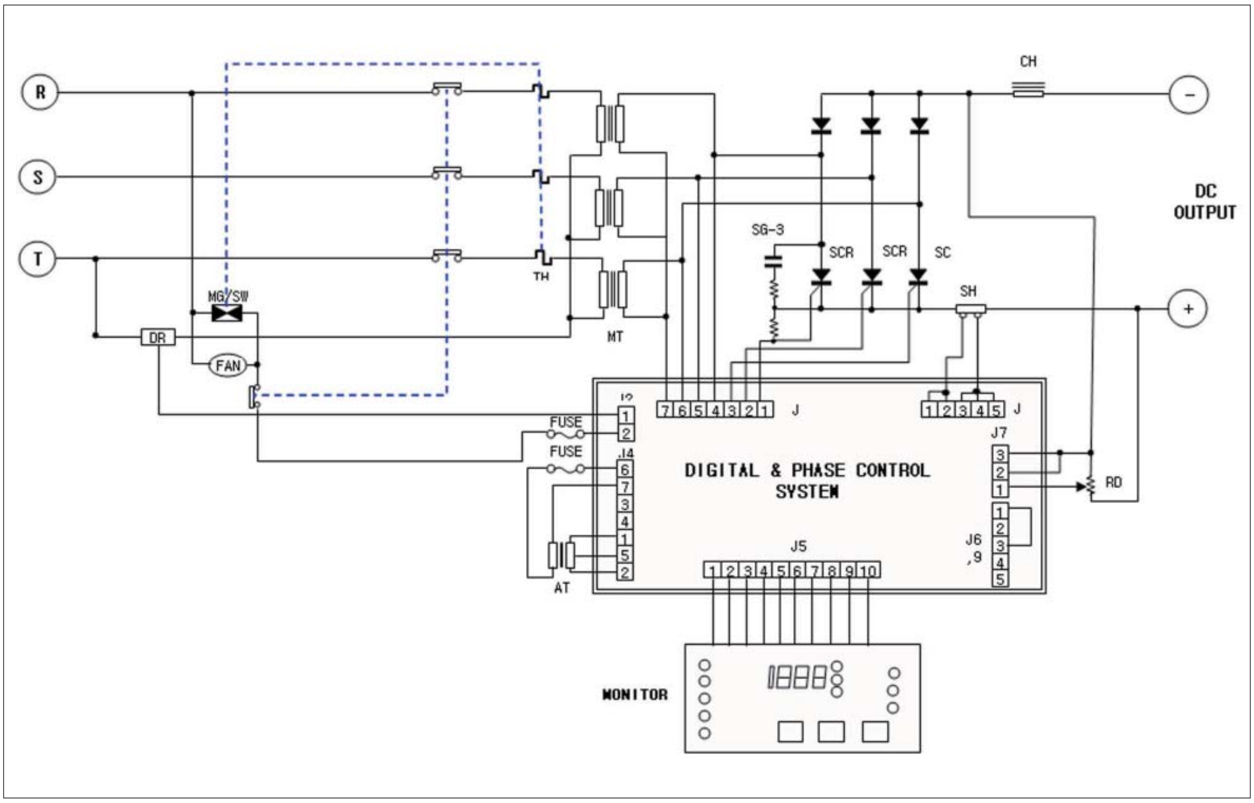
No.	Measuring point (Real diagram)	Measure value (Measurement of digital tester)
1	No.1 ~ No.3	Forward : Under 100 k ohm Reverse : Infinity (∞)
2	No.2 ~ No.3	Forward : Infinity (∞) Reverse : Infinity (∞)
3	G1 ~ K1	Forward : Under 100 ohm Reverse : Under 100 ohm But It depends on the module. If it is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



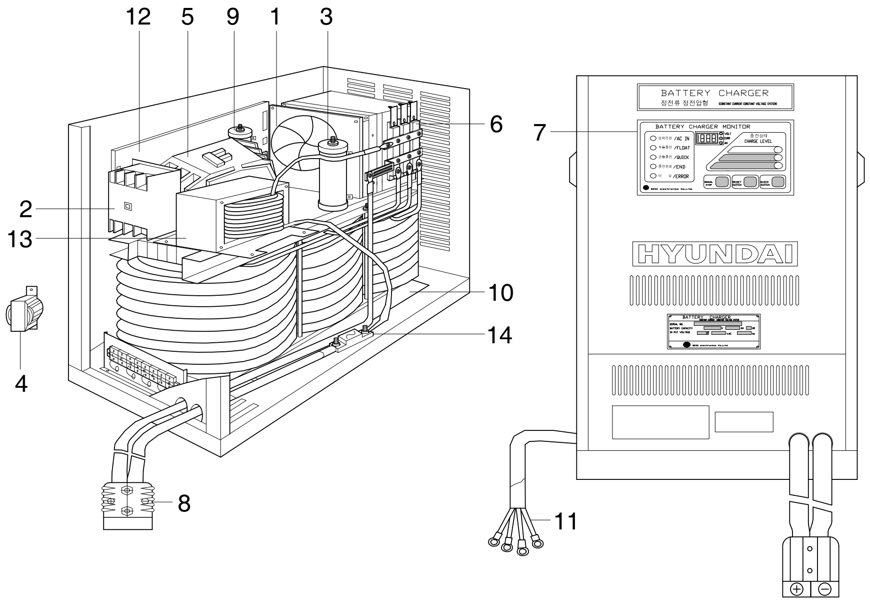
8) PCB MAJOR PARTS (NAME AND LOCATION)



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
CH
DC OUTPUT
SG-3
SCR
SCR
SC
TH
MG/SW
DR
FAN
MT
SH
J
J2
FUSE
FUSE
J4
DIGITAL & PHASE CONTROL SYSTEM
J7
RD
J6 ,9
J5
AT
MONITOR

CHARGER INTERIOR PARTS



1	AC fan	6	SCR module	11	AC input cable
2	Over load	7	Monitor board assy	12	Main board assy
3	Resistor assy - RD	8	DC output cable	13	Choke filter
4	Auxiliary trans	9	DR resistor	14	Fuse
5	Magnet switch	10	Main transformer		

※ LITHIUM ION BATTERY (OPTION)

1) Characteristics and Information

(1) This Lithium-Ion battery is a designed for the power supply of electric forklifts.

(2) It can be used on the charger or forklift when the battery pack is active.

(3) For recharging batteries, proper management may have a long useful life, but not in use for long periods of time may reduce capacity.

(4) Do not expose the battery to extremely high or low temperatures above 55°C and below -25°C. Use within -25 ~ 55°C to maintain maximum capacity.

(5) When the battery is used at low temperatures, the battery capacity is reduced.

(6) Battery charger is used at temperatures between 0 and 45°C.

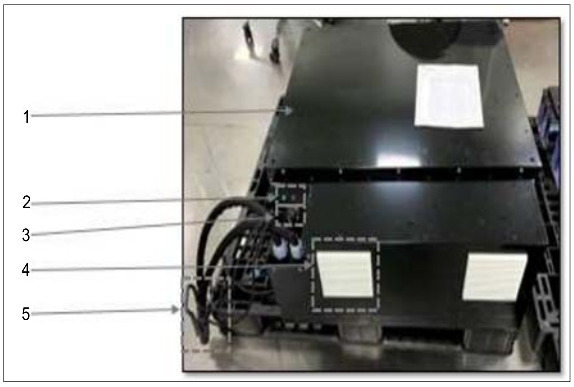
(7) Battery Management System(BMS) within the battery pack maintains a constant voltage difference between cell voltages and safely controls current and voltage.

(8) If the temperature rises above 60°C, the charging/discharge function will automatically stop.

(9) When Battery pack voltage falls below 37.8v, the protection function is activated and automatically shuts down the discharge.

※ The explanation of lithium batteries described in this manual, read carefully and understand . Refer to this manual at all times properly.

※ If you have any questions or technical problems, contact HYUNDAI dealer.

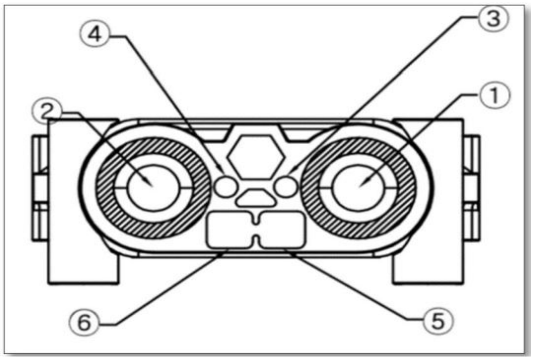


① Battery pack ② Status indicator
③ Monitoring connector ④ Cooling fan
⑤ Battery pack connector

COLOR	FUNCTION	OFF	FLICKERING	ON
GREEN	CHARGING/ DISCHARGING STATUS	STANDBY	CHARGING	DISCHARGING
RED	BATTERY STATUS	NORMAL	CAUTION	PROTECTION MODE

* Meaning of status indicator *

PIN No	Pin Name
1	Battery +
2	Battery -
3	CAN H
4	CAN L
5	Wake-Up
6	Wake-Up



* Structure & function
of battery pack connector*

2) Lithium Ion Battery Safety Matters

※ Proper handling and inspection are required for safe use of lithium-ion batteries.

※ Follow the instrustions to avoid accident. The explanations are in threee steps as below.
◈ Danger, ◆ Warning, ◇ Caution. Read the contents carefully and check the risk factors to prevent safety accidents.

(1) Electric shock caused by contact with conducting agent (◈ Danger - Electric shock)

① The lithium battery pack has high voltage, so if the body contacts the conducting agent during installation, repair, and inspection, it will be electrocuted.

② Maintenance and inspection shall be carried out by qualified professional personnel.

③ Wear protective gear such as rubber gloves and rubber boots for inspection and use insulated tools.

(2) Damage caused by organic solvent electrolyte (◈ Danger - electrolyte)

① Damages or incorrect use of the battery pack may result in excessive pressure in the internal cells.

② Each cell in the battery pack has a Vent that can't be reset. When the increases pressure of the battery cell, it is dangerous as the Vent may release flammable electrolytes.

③ Avoid smoking and stay away from sources of ignition, such as sparks.

④ Do not incinerate the battery pack. Do not drill or shock.

⑤ Do not solder or weld the battery pack..

(3) Safe handling of lithium battery packs (◈ Danger - Explosion, Electric shock)

① Do not throw the cell into fire. Do not heat the cell. It causes leakage, fever and rupture.

② If the battery smells strange, temperature is high, connection with the wire is damaged, terminals of the part are corroded, plug is deformed and finds trace of heating, Do not use it as it is due to may cause ignition, heat and flammable explosions. Ask your dealer or specialist for diagnosis.

③ Do not attach contaminants and foreign substances to the surface and connections of the battery. It may cause explosions and fires.

④ Clean contaminants and foreign substances with a wet cloth and keep them dry.

⑤ Be careful not to touch the battery by children.

⑥ The battery packs that has been in use for a long time are exchanged with new battery packs according to inspection result. If the exchange is delayed, internal aging can cause the explosion.

⑦ Do not arbitrarily disassemble or repair battery packs. It causes fever and ignition.

⑧ Do not overcharge or discharge when charging.

⑨ Do not allow lithium battery pack temperature to exceed 55℃.

⑩ Keep the lithium battery pack surface clean and dry always.

(4) Precautions prior to commencement of use (◆ Warning - Unpackage, Check / ◇ Caution - Installation, Connection)

① Check that the battery is free from leakage, heat, etc. when receiving. This will result in corrosion, fire and short circuit.

② Check the plug, cable for damage. This causes the fire.

③ Ensure that the actual battery type matches the specified battery in the forklift.
If the unsuitable battery is used, it can cause poor performance or damage to the truck during operation.

④ The battery pack is shipped with a charge of 30% to 50%, so charge it fully before use.

⑤ Do not install or connect except for professional technicians who have been sufficiently trained in handling methods and risks.

⑥ Please contact your dealer for battery module replacement. Incorrect replacement operation may cause battery damage.

⑦ Do not reverse or drop the battery pack.

⑸ **Maintenance (◆ Warning - Discharge, Charge)**

① Do not use the battery current that exceeds twice the rated capacity.
The battery Internal damage caused by abnormal use may cause an explosion.

② Charge the battery pack with a charger dedicated to the lithium-ion battery. If use different type charger will not charge enough, Battery may leak, short circuit.

③ Make sure that the lithium battery pack temperature is not above 55℃ during charging. A rise in temperature causes fire and explosion. Take extra care when charging during the summer and under the direct sunlight.

④ Do not change the maximum voltage of the charger without consulting the battery manufacturer. An excessive high input voltage will overcharge the battery, increasing the temperature and shortening battery life.

⑤ Don't charge in areas with poor ventilation, high temperature and high humidity, rainy areas, and corrosive gases.

⑥ Do not use firearm (lighter, cigarette, grinder, welding flame, etc.) during charging. It causes an explosion.

⑦ Do not overcharge. The battery can overheat. It can be dangerous and shorten its life.

⑧ Keep the battery below 55℃. It will shorten the life cycle when used at high temperatures. If the battery exceeds 55℃ during charging, the charge must be stopped.

⑨ Make sure that there is sufficient ventilation when charging indoors. Even if Battery is stored indoors, enough ventilation is needed.

⑩ Do not charge the battery below -25℃. Because it can be increased battery internal resistance at low temperature. Low temperature will reduce the efficiency of the charge and require adjustment of the charge volume. Therefore, a charging room with a temperature of 5 to 10℃ required at low temperatures.

⑹ **Environment of use (◇ Caution - Cleaning, ◆ Warning - Organic solvent)**

① Contaminants and debris on the top or connections of the battery may cause a short circuit and fire. Clean with a wet cloth and keep the area clean and dry.

② Do not use organic solvents or chemicals such as benzene, thinner and gasoline for battery cleaning. It may cause damage to the battery.

③ Do not flush the battery. It may causes damage.

④ If it is not used for a long time, keep it in a well ventilated and fire-free place to prevent explosion.

⑤ To prevent deformation and damage caused by freezing and overheating, the recommended use temperature is -25 ~ 55℃. Avoid contact with rainwater or sea water to prevent damage and fire.

(7) **Handling method (◈ Danger - Explosion, ◇ Caution - Others)**

① Turn off both key switch and charger switch when unplugging. When the key is removed from the ON state, sparks are generated and cause fire and explosion.

② Check + and - thoroughly when connecting cables. Causes damage to electronic parts. If cables and plugs are open due to corrosion or heat, contact your HYUNDAI dealer to replace them.

③ Do not modify the plug or connector arbitrarily. It may cause heat and explosion.

④ When connecting the plug, make sure it is in full contact and remove any foreign substances to prevent heating.

⑤ To prevent short circuit, do not place tools, such as spanners, on top of the battery.
Secure cables and battery terminals properly to prevent short circuit and performance degradation.

⑥ Do not use it for purposes other than forklift power sources. It may cause damage to the battery.

⑦ Do not spray water in case of fire. It may cause an explosion. Use a special powder fire extinguisher.

⑧ Follow the battery manufacturer's instructions on how to dispose of the battery at the end of its life.

3) Battery pack replacement

※ This guide explains how to repair when a problem occurs for lithium battery pack.

① Before replacing, read this instruction carefully .

② Use insulated tools and suitable clothing.

③ Before replacing the parts, remove the main plugs.

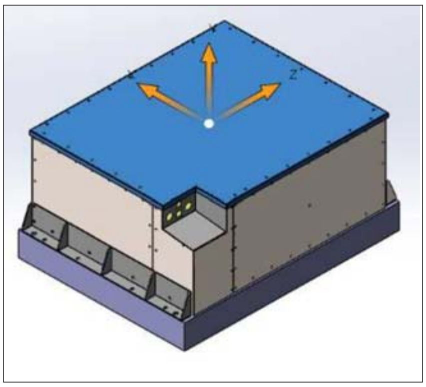
④ Check whether the contactor is disconnected. (Measured Voltage : 0V)

⑤ Electrical shock hazard. Do not touch uninsulated wires when the parts are repaired.

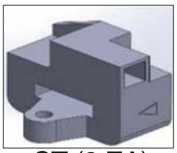
(1) Master BMS & Electronic parts replcement

① Remove the cover

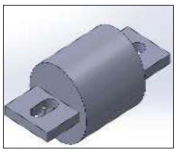
- Disassemble the 15 screw on cover.
- Remove the cover.
  * Tool : Screwdriver



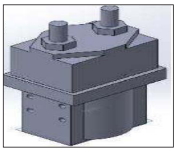
② Check the parts.



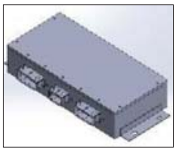
CT (2 EA)



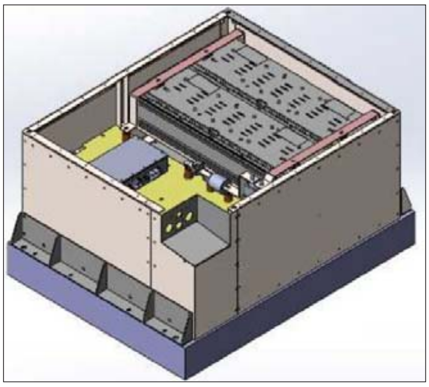
FUSE



CONTACTOR



MASTER BMS



③ CT Replacement

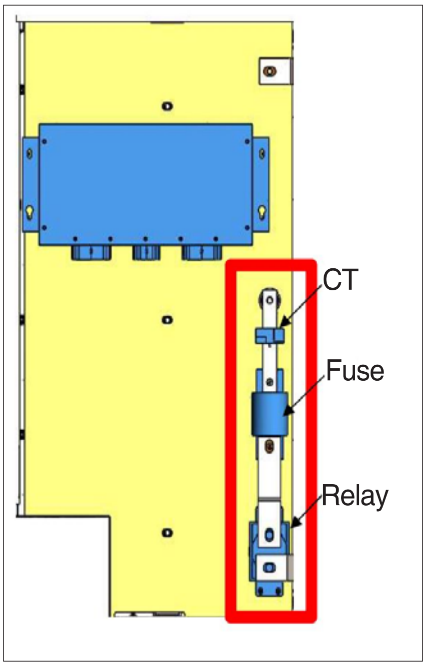
- Disassemble 2 M8 screws.
- Remove the CT.
- Set the new CT.
- Fasten the 2 M8 screws to fit it.

④ Fuse Replacement

- Disassemble M8 screws.
- Remove the Fuse.
- Set the new Fuse.
- Fasten the M8 screws to fit it.

⑤ Relay Replacement

- Disassemble 2 M10 screws.
- Remove the Relay.
- Set the new Relay.
- Fasten the 2 M10 screws to fit it.

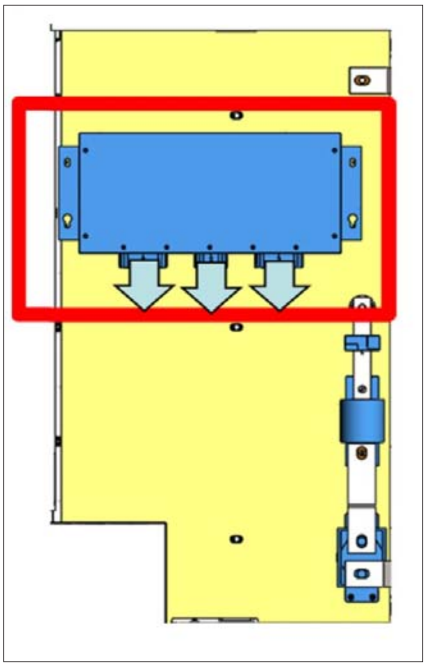


* Tool : Torque wrench 13mm & 17mm. Torque pressure when reassembling - M8 : above 122kgf·cm, M10 : 136 ~ 143kgf·cm.

⑥ Master BMS Replacement

- Disassemble cables that connect the slave BMS.
- Disassemble 4-point screw.
- Remove the Master BMS.
- Set the new Master BMS.
- Fasten the 4-point screw to fit it.

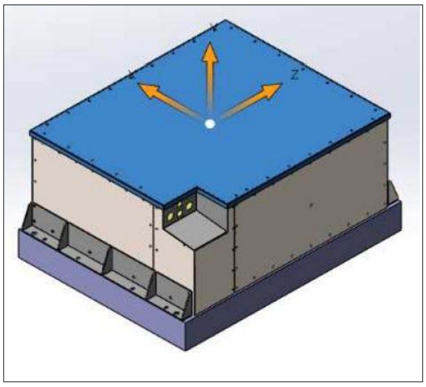
* Tool : Screwdriver. Torque pressure when reassembling - M4 : 14kgf·cm.



⑦ Assemble the cover

- Fasten the 15 screws on cover.
- Fit the cover.

* Tool : Screwdriver.

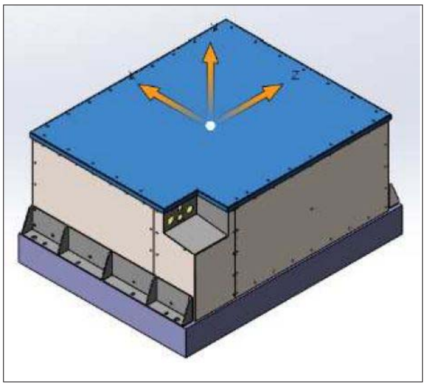


⑵ Module & Slave BMS replcement.

① Remove the top cover

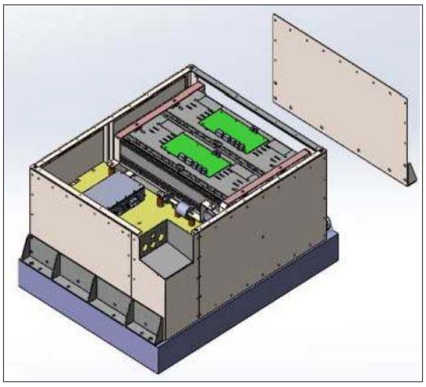
- Disassemble the 15 screw on cover.
- Remove the cover.

* Tool : Screwdriver



② Remove the right cover

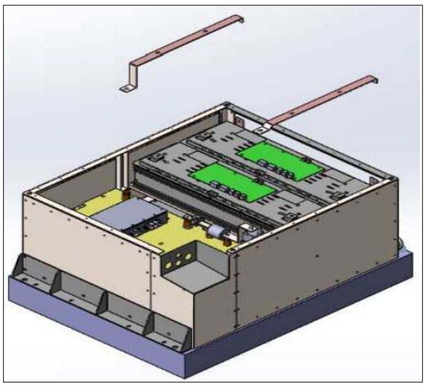
- Disassemble the 18 screw on the right cover.
- Remove the right cover.
  * Tool : Screwdriver



③ Remove +/- bus bars.

- Disassemble the 5 M8 screws & 1 M10 nut on the module.
- Remove the +/- bus bars.
  * Tool : Torque wrench 13mm & 17mm

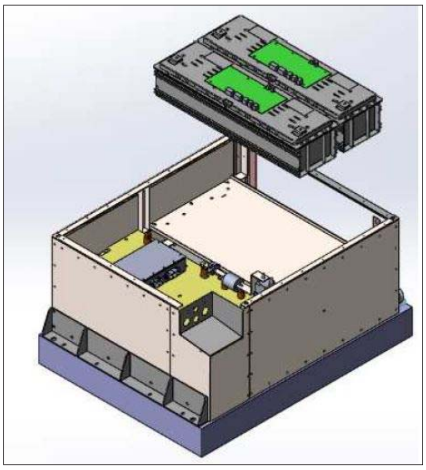
※ When removing bus-bars, make sure not to touch other component. Electrical shock hazard.



④ Module replacement

- Disassemble 4 screws on the floor.
- Remove the module.
- Set the new module.
- Fasten 4 screws to fit it.
  * Tool : Torque wrench 13mm

※ The entire weight amounts over 38kg by unit. Serious injury may occur due to the heavy weight of the product. Therefore, special care must be taken when handling. Make sure to have at least two people to deliver and remove the package. There is a risk of electric shock. So do not remove the cover.



⑤ Slave BMS replacement

- Disassemble sensor cable that connects the lithium cell.

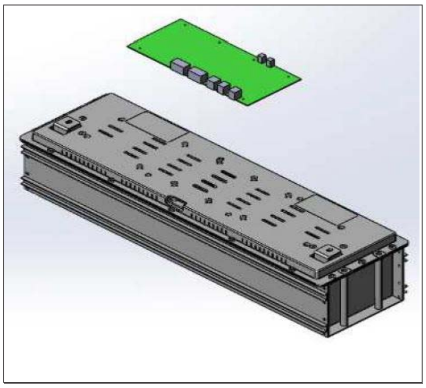
▯ - Disassemble the M3 screws on the module.

- Remove the slave BMS

▯ - Set the new slave BMS

- Fasten the M3 screws to fit it
  * Tool : Screwdriver, Wear rubber gloves.

※ There is a risk of electric shock. So do not remove the cover.



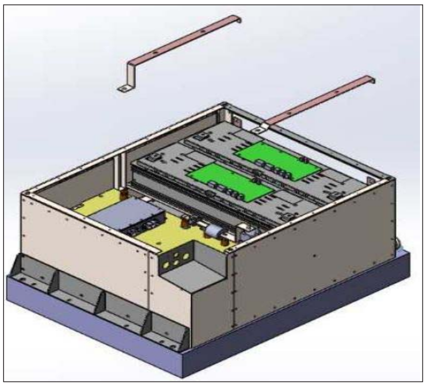
⑥ Assemble +/- bus-bars

 - Fasten 5 M8 screws & 1 M10 nut on the module.

 - Fit + / - bus-bars.

 * Tool : Torque wrench 13mm & 17m

※ **When removing bus-bars, make sure not to touch other component. Electrical shock hazard.**

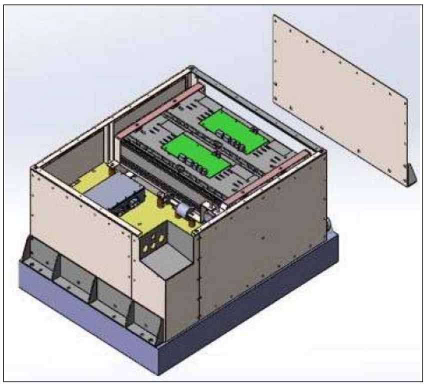


⑦ Assemble the right cover

 - Fasten 18 screws on the right cover.

 - Fit the right cover .

 * Tool : Screwdriver

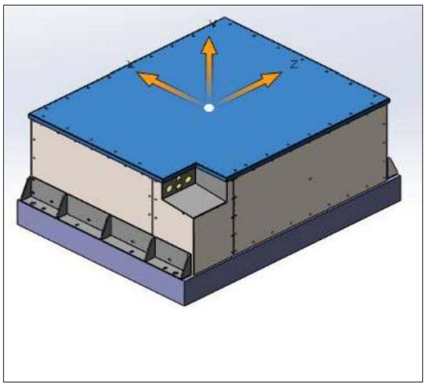


⑧ Assemble the cover

 - Fasten 15 screws on the cover.

 - Fit the cover.

 * Tool : Screwdriver



※ LITHIUM ION BATTERY CHARGER (OPTION)

※ Before connecting the battery charger to the power supply and the battery, carefully read the instructions below.

1) Use and Operation

(1) To use this battery charger you must comply with safety requirements contained in laws and regulations and in the provisions set out by the local authorities.

(2) The user should make sure that the use of charging equipment complies with current regulations and that any action that may endanger the life and health of the user or any third party is avoided, as well as avoiding any damage to property.

2) Installation and Safety warnings

(1) Before connecting the battery charger to the power supply and the battery, carefully read the instructions below.

① For correct functioning and improved yield, the battery charger must be positioned on the wall in the correct direction and fixed with plugs through the relative slots; Pay attention not to obstruct the ventilation slots holes.

② Only specialised and authorised staff can carry out jobs that require the battery charger to be opened.

③ Before operating the battery charger, the insulation of mains connection cables and of the battery connectors must be verified

④ It is necessary to intervene on electrical equipment, thoroughly trained personnel only.

⑤ Disconnect the mains connection before connecting or disconnecting the battery.

⑥ The battery being charged generates explosive gases, therefore it is prohibited to smoke in proximity of the machinery; avoid naked flames and or sparks and proximity with other machinery that lead to hazardous circumstances for people or property.

⑦ This battery charger contains electrical components which can generate electric arcs and sparks, so if used in enclosed areas it must be positioned in a site suitable to its function; anyhow the standard battery charger must be used in enclosed and well ventilated areas and not exposed to rain and/or splashing water, placed on sound, levels floors. Dusty areas or areas with water sources, sources of heat and humidity should be particularly avoided. DO NOT place the battery charger on surfaces and/or shelves made with wood or other flammable materials or accumulate various materials near the battery charger and place any items or containers with liquids on the lid.

⑧ To prevent dangers of electrocution, the battery charger must be connected to a current socket connected to earth. Moreover, the current socket to which the battery charger will be connected must be proportionate to the power of the same and must be protected by appropriate electric equipment in compliance with Standards (fuses automatic switch). For sufficient selectivity, the protection must have calibration of at least 10 % over the equipment current absorption.

⑨ Always use special bipolar connectors (DIN 320 REMA).
⑩ DO NOT use additional cables to extend the existing electrical connections.
⑪ The charging appliance is maintenance-free, except for routine cleaning that must be performed regularly and periodically according to the type of work environment. Before starting to clean the appliance, disconnect the power supply cable from the mains and the connection cables to the battery.

3) Connection to power supply

It is essential to connect to a current socket proportioned to the power of the installed battery charger. Ensure to also correctly connect the earth conductor. It is good practice during installation (or successively if the battery charger is moved), to check the mains voltage and the presence of all 3 phases present on the position where the battery charger works.

Battery Voltage	Charger Current	Module Power	Active Input Power	INPUT Iac Nom	FuseAC	DC Fuse
V	A	KW	kW	A	A	Code
48	250	16	15, 32	24, 97	32	LMT315

4) Battery connection

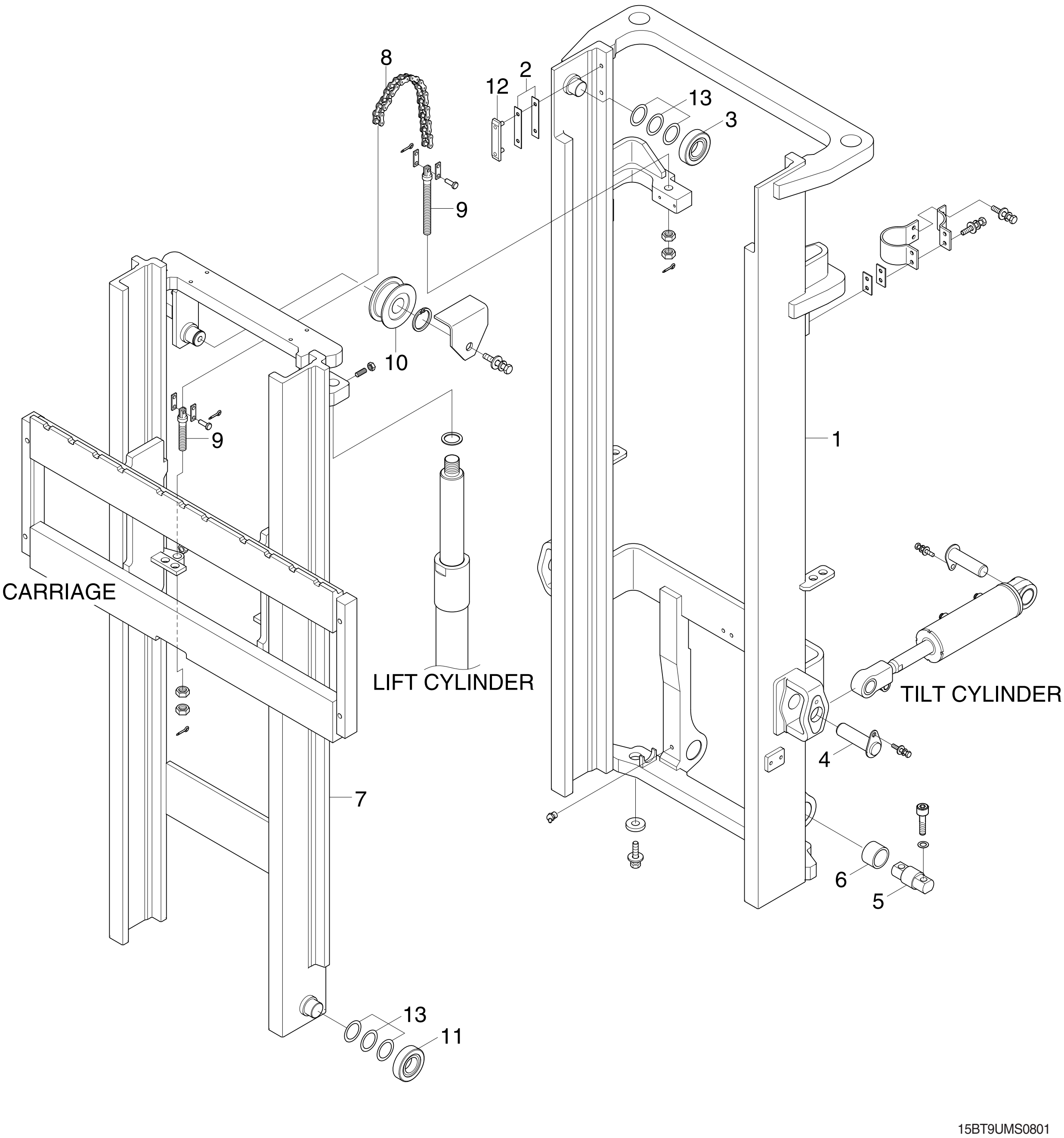
It is recommended to use relevant bi-polar connectors in compliance with Standards without the possibility of inversion of the polarity on the battery. Also check the current connection of the cables in the connector contacts. This operation has to be performed by skilled personnel only.

※ **The USB port is a service port to be used only for programming the charging parameters and downloading of historical data and graphs. You must disconnect the charger from USB cable during charging, to prevent EMI noise from interference with the charging process with unpredictable consequences for the battery charger and battery.**

SECTION 8 MAST

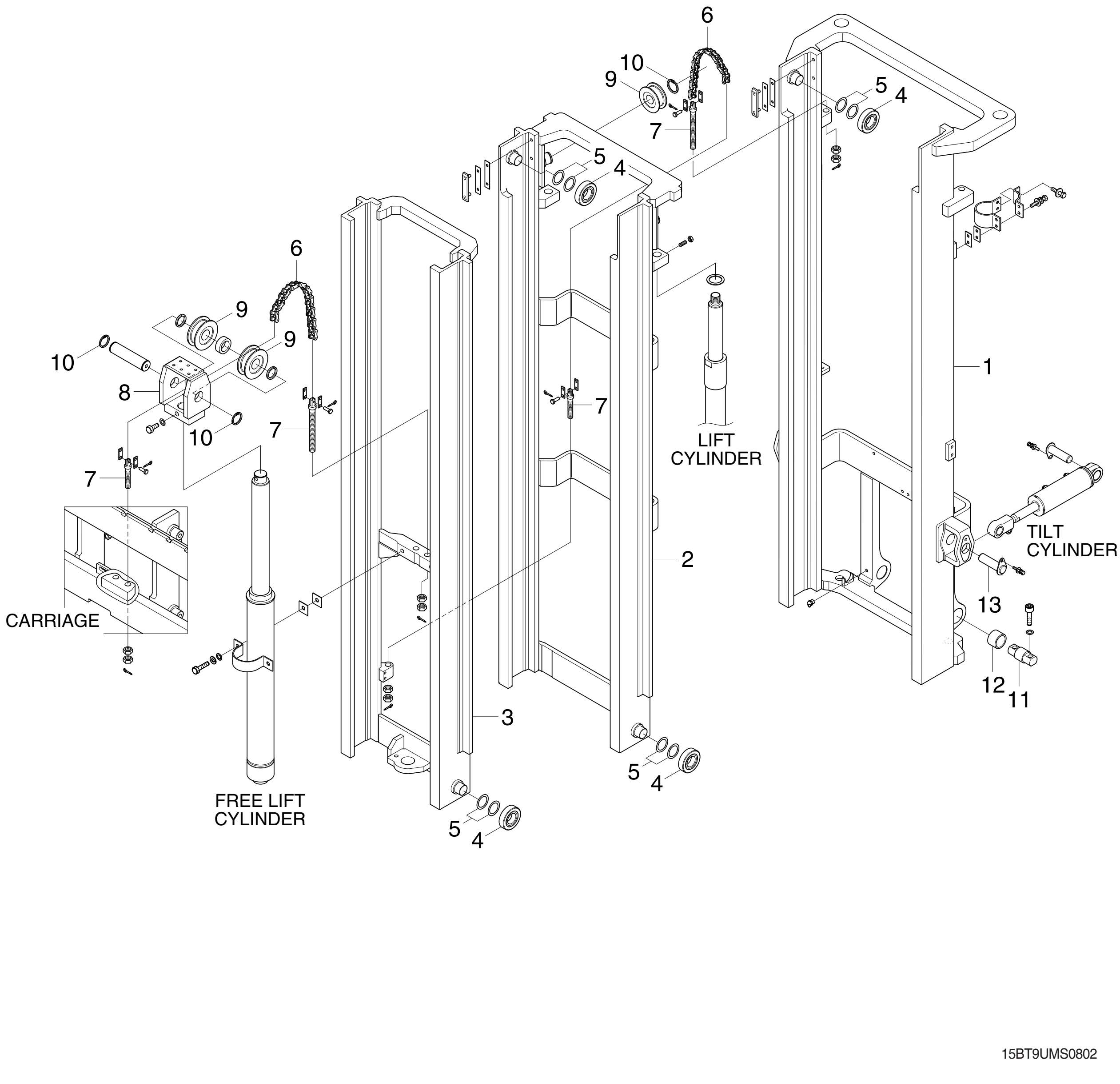
GROUP 1 STRUCTURE

1. 2 STAGE MAST(V MAST)



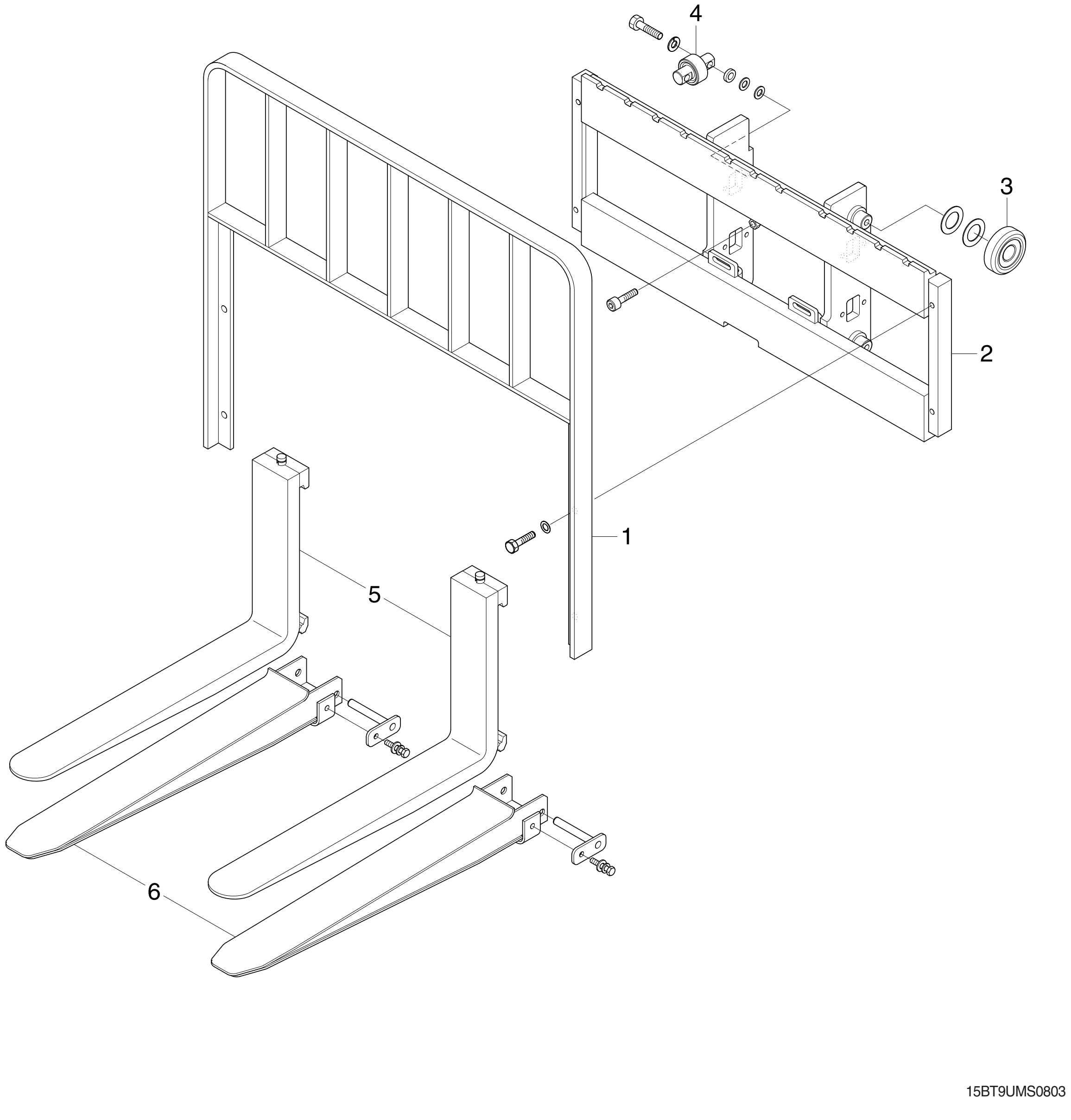
1	Outer mast	6	Bushing	10	Chain wheel bearing
2	Shim (0.5, 1.0t)	7	Inner mast	11	Roller
3	Roller	8	Lift chain	12	Back up liner
4	Tilt cylinder pin	9	Anchor bolt	13	Shim(0.5, 1.0t)
5	Mast mounting pin				

2. 3 STAGE MAST(TF MAST)



1	Outer mast	6	Lift chain	11	Mast mounting pin
2	Middle mast	7	Anchor bolt	12	Bushing
3	Inner mast	8	Sheave bracket	13	Pin
4	Roller	9	Sheave		
5	Shim (0.5, 1.0t)	10	Retaining ring		

3. CARRIAGE, BACKREST AND FORK



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

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

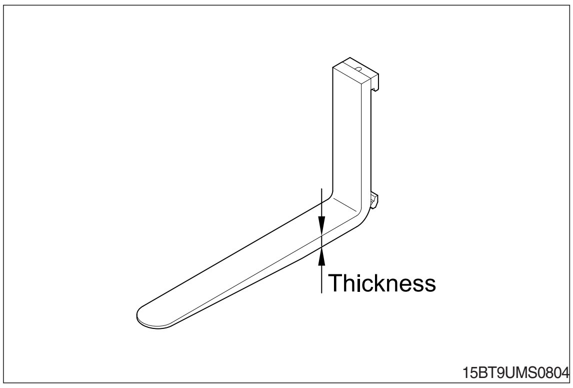
1. OPERATIONAL CHECKS

1) FORKS

(1) Measure thickness of root of forks and check that it is more than specified value.
EX : l = 900mm (35.4in)

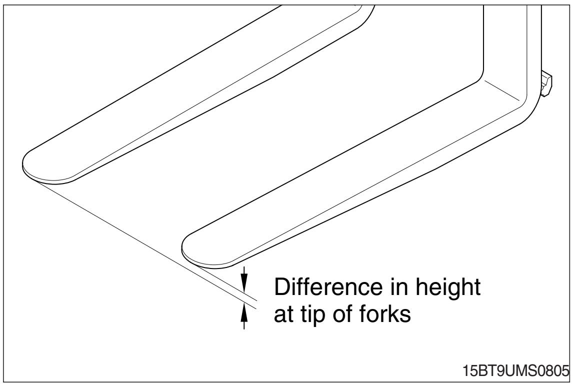
mm(in)

STD Fork assy	Applicable model	Standard	Limit
64FD-11010	15/18BT-9U	40(1.6)	37(1.5)
64HM-11010	20BT-9U	40(1.6)	37(1.5)



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

Model	Fork length (mm)	Height difference (mm)
15/18/20BT-9U	equal or below 1200	3
	above 1200	6



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

2. MAST

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

2. TROUBLESHOOTING

1) MAST

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

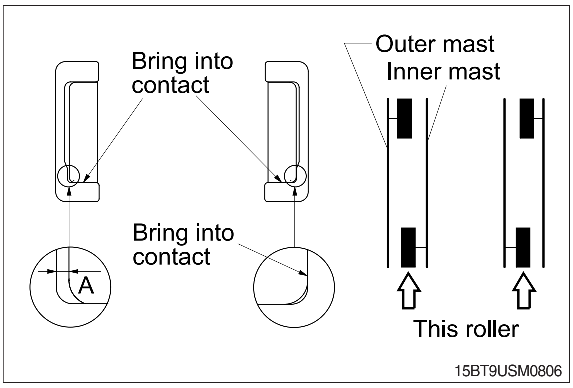
2) FORKS

<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 1200</td><td>3</td></tr><tr><td>above 1200</td><td>6</td></tr></table></td><td>If the measured value exceeds the allowance, replace fork.</td></tr>
<tr><td>Fatigue</td><td>Fatigue failure may result from the fatigue crack even though the stress to fork is below the static strength of the fork. Therefore, a daily inspection should be done.
· Crack on the fork heel.
· Crack on the fork weldments.</td><td>Repair fork by expert.
In case of excessive distortion, replace fork.</td></tr>
</table>

GROUP 3 ADJUSTMENT

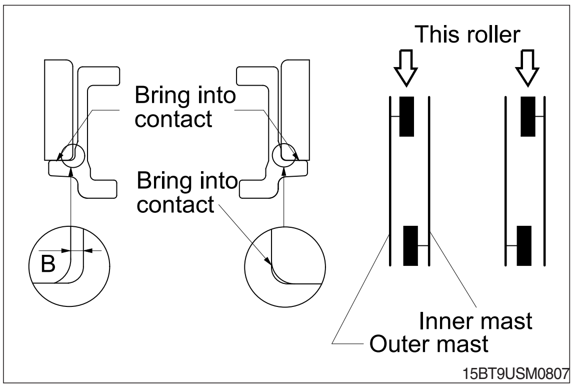
1. MAST LOAD ROLLER(V MAST)

1) INNER/OUTER MAST ROLLER CLEARANCE ADJUSTMENT



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

(2) Shift the inner mast to one side to bring the roller into contact with the outer mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner/outer mast roller shim.
- · Standard clearance A, B = 0.3 ~ 0.6mm
- · Shim thickness 0.5, 1.0mm

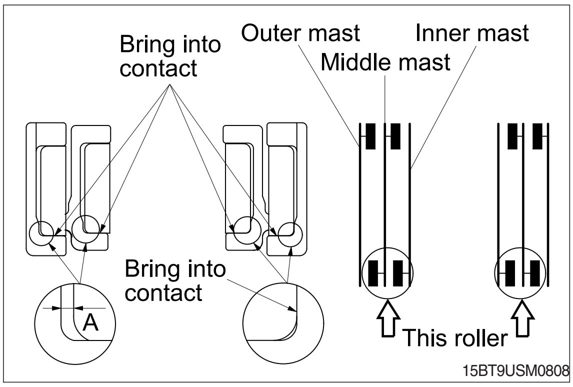


(3) Distribute the shim thickness equally to the left and right roller. Refer to Mast load roller and back up liner, removal and Installation.

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

2. MAST LOAD ROLLER(TF MAST)

1) INNER AND MIDDLE MAST ROLLER CLEARANCE ADJUSTMENT



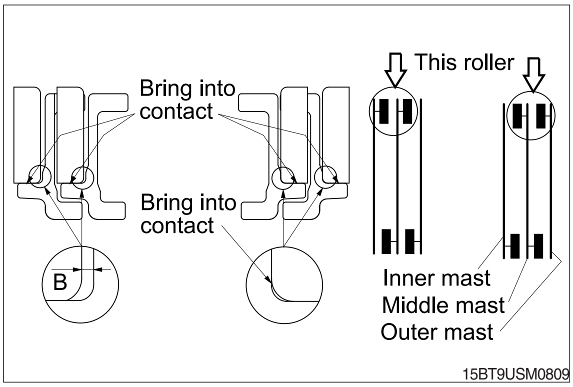
(1) Measure the clearance with the mast overlap at near 480mm.

(2) Shift the inner mast to one side to bring the roller into contact with the outer mast and the middle mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner and middle mast roller shim, respectively.
- · Standard clearance A = 0.3~0.6mm
- · Shim thickness 0.5, 1.0mm

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

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

2) OUTER AND MIDDLE MAST UPPER ROLLER CLEARANCE ADJUSTMENT.



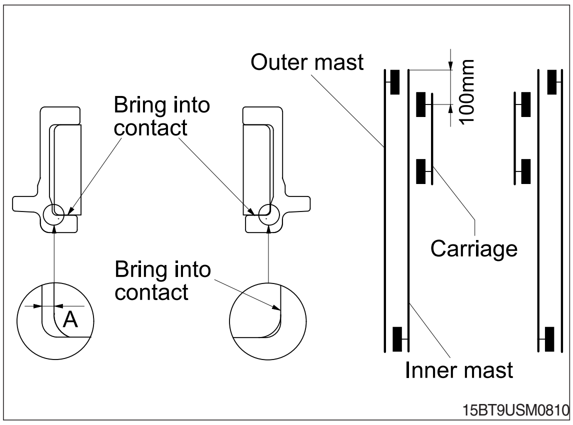
(1) Measure the clearance with the mast overlap at near 480mm.

(2) Shift the inner mast to one side to bring the roller into contact with the outer mast and the middle mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the outer and middle mast roller shim, respectively.
- · Standard clearance B = 0.3~0.6mm
- · Shim thickness 0.5, 1.0mm

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

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

3) CARRIAGE LOAD ROLLER



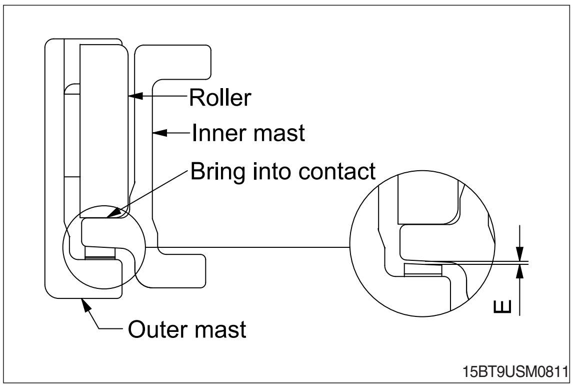
(1) Measure the clearance when the center of the carriage upper roller is 100mm from the top of the inner mast.

(2) Measure the clearance at upper, middle and lower rollers after loosen the adjust screws from the side rollers. Shift the carriage to one side to bring the roller into contact with the inner mast, and measure the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the carriage roller shim.
- · Standard clearance C = 0.3~0.6mm
- · Shim thickness = 0.5, 1.0mm

(3) Distribute the shim thickness equally to the left and right roller. Refer to Carriage assembly.

(4) After the adjustment, the carriage should move smoothly along the overall mast length.

4) MAST BACK UP LINER



(1) Measure the clearance with the middle mast at the bottom position.

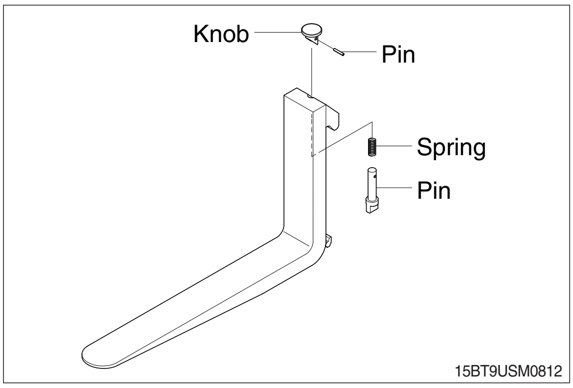
(2) With the middle mast in contact with the outer mast roller, adjust the clearance between the mast back up liner and middle mast to the following value by inserting the back up liner shim.
- · Standard clearance E = 0.2 ~ 0.6mm
- · Shim thickness = 0.5, 1.0mm

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

GROUP 4 REMOVAL AND INSTALLATION

1. FORKS

1) Lower the fork carriage until the forks are approximately 25mm(1inch) from the floor.
2) Turn the knob up 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.



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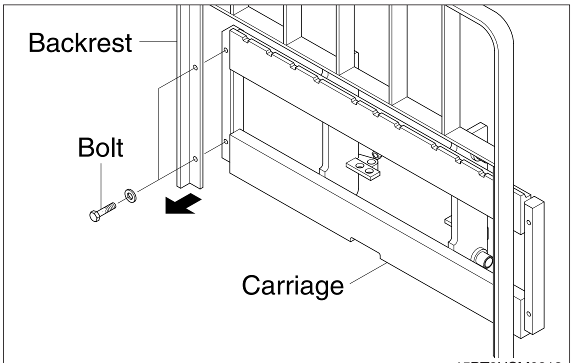
2. BACKREST

1) Remove bolts securing backrest to fork carriage. Disassemble the backrest from the carriage.
2) Position backrest on carriage and lower in place. Install and tighten bolts.



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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.

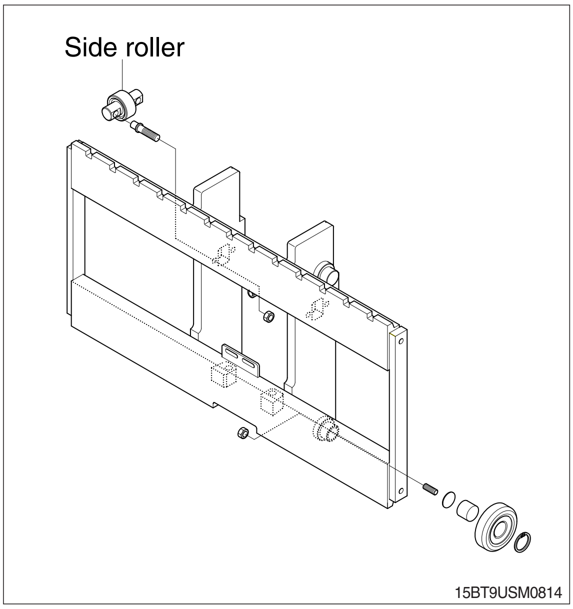
⚠ **Replace the split pin of chain anchor with new one.**

2) SIDE ROLLER

(1) Remove carriage as outlined in the carriage assembly and removal paragraph.
(2) Loosen and remove nuts, adjust screws 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.

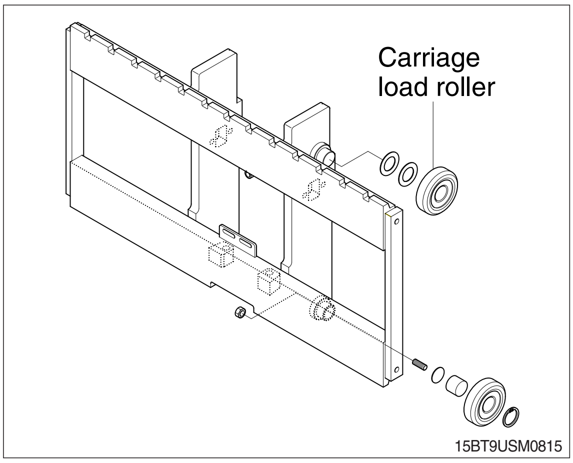
※ Adjustment

- Once carriage is properly installed, loosen nuts and adjust screws, (if not already done) allowing carriage to be centered in the inner mast.
- Adjust side roller by tightening screw until side roller just makes contact with mast. Back off approximately 1/10 turn on screw and tighten nut to lock screw in place.
- Run carriage up and down for the inner mast to be sure the carriage has free movement and does not stick. Also, make sure chains are properly adjusted. Refer to chain adjustment paragraph. Make adjustment when necessary and recheck operation of carriage.



3) CARRIAGE LOAD ROLLER

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



4) MAST LOAD ROLLER AND BACK UP LINER

(1) 2 stage mast(V mast)

① Remove the carriage assembly and move them to one side.

② Loosen and remove hexagon bolts and 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.

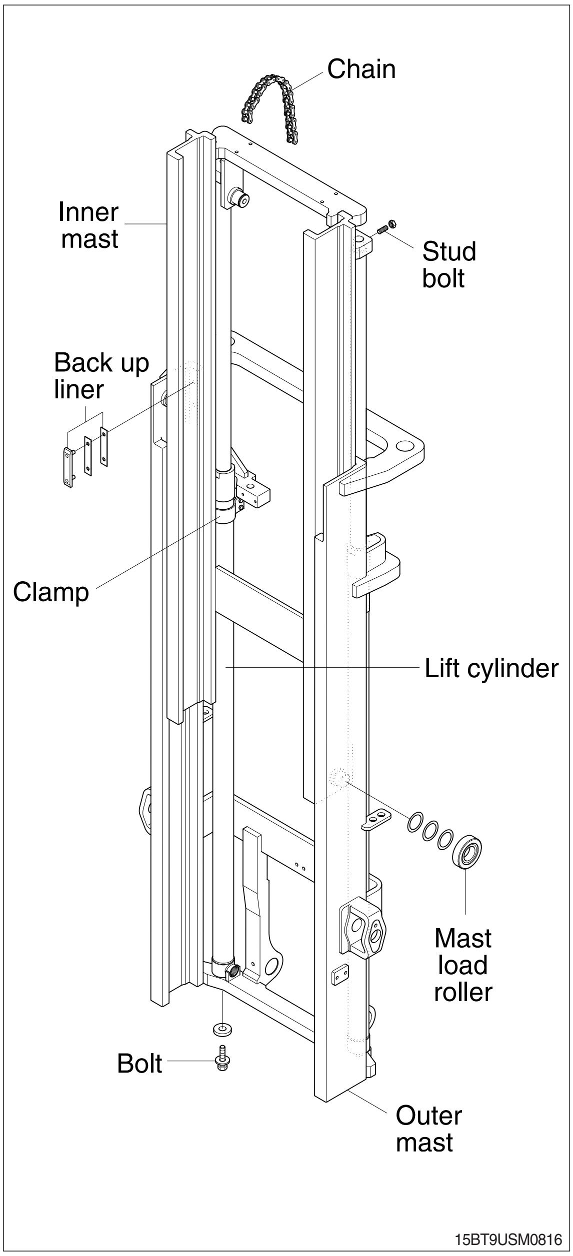
⑤ After lowering the lift cylinder rods, and disconnecting lift cylinder hose, tilt the lift cylinders LH and RH and them with ropes to the outer mast.

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.



(2) 3 stage mast(TF mast)

① Remove the carriage assembly and move it to one side.

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

③ Loosen and remove band and special washers securing lift cylinders to middle mast. Remove the spring pin.

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

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

⑥ Using the overhead hoist raise inner and middle masts. Place 4 inch block of wood under the free lift cylinder bracket of the inner mast then lower mast sections (this will create slack in the chains).

⑦ Remove retaining rings securing chain sheaves to sheave support brackets. While support chains, remove chain sheaves and let chains hang free. The upper outer and lower middle mast rollers and back up liners are now exposed.

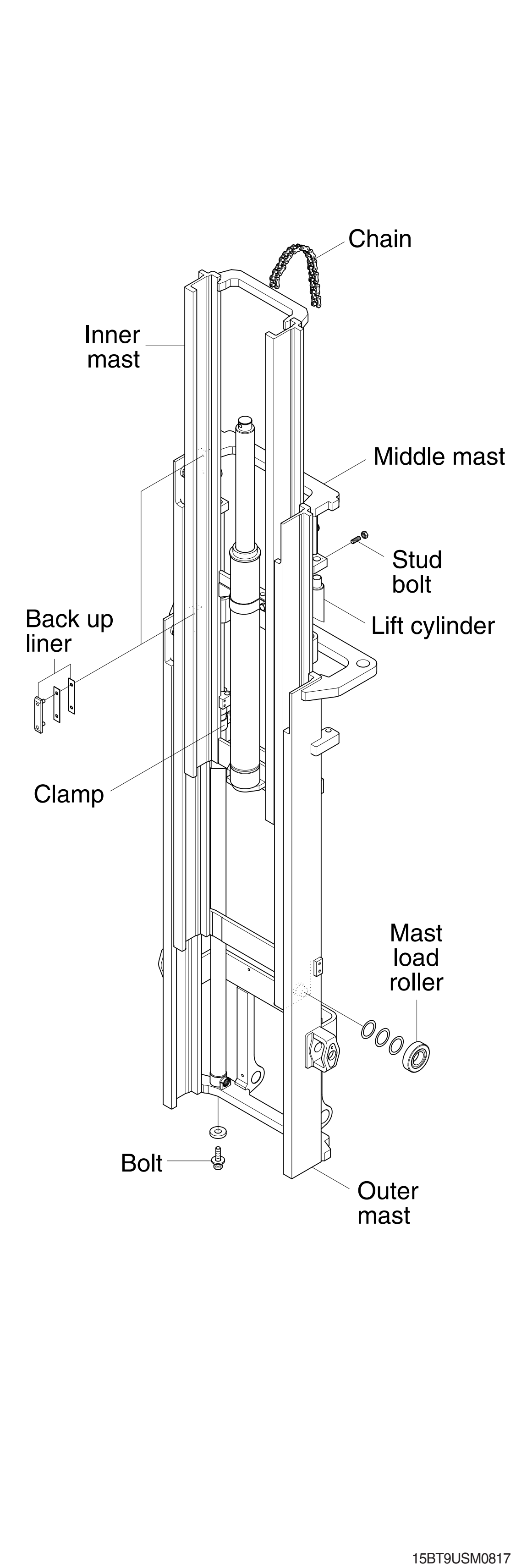
⑧ Using a player, remove load rollers from load bracket. Remove back up liners and shims.

⑨ Attach chains or sling to the middle mast section at top crossmember. Using an overhead hoist, slowly raise the middle mast until top and bottom rollers are exposed.

⑩ Using a pryer, remove load rollers from load roller bracket.

⑪ Thoroughly clean, inspect and replace all worn or damaged parts.

⑫ Reverse the above procedure to assemble. Refer to MAST LOAD ROLLER ADJUSTMENT paragraph.



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.

(2) Inner and middle mast(TF mast)

① After completing all necessary steps for load rollers and back up liner removal. Remove rear chains and sheave support if not already done.
② Disconnect free lift cylinder hose. Drain hose into a suitable pan or container and cap hose.
③ While supporting free lift cylinder assembly, remove bolts and washers securing cylinder to mast crossmember.
④ Place a sling around free lift cylinder and attach to an overhead hoist. Slowly raise and move cylinder to one side.
⑤ Attach chains or sling to the inner mast section at top crossmember. Using an overhead hoist slowly raise the upright straight up and out of middle mast section.
⑥ Attach chains or sling to the middle mast section at top crossmember. Using an overhead hoist slowly raise the upright straight up and out of outer mast section.
⑦ Replace upright and reverse above procedure to install. Make all necessary measurements and adjustments.

6) CHAIN

(1) Chain sheave(V 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.

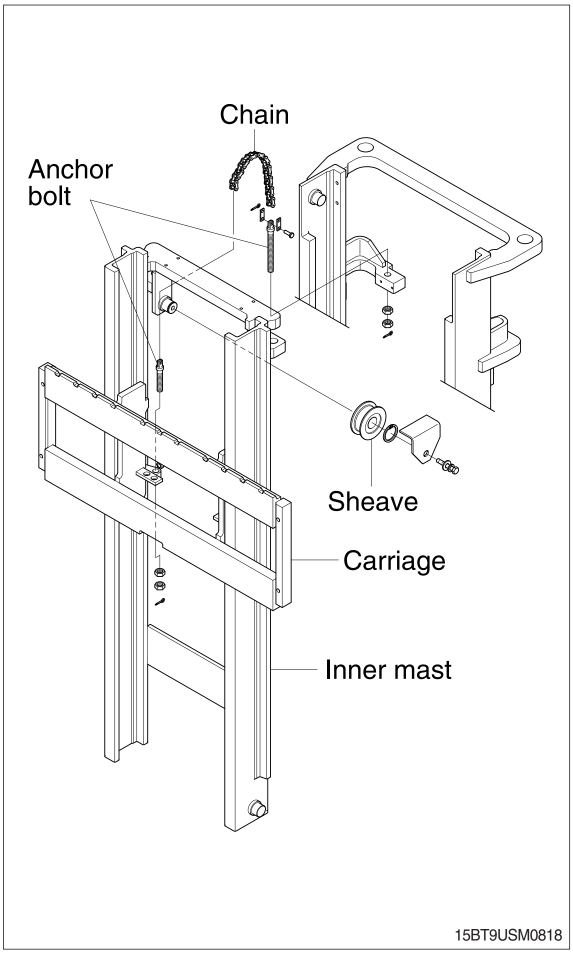
② Remove the split pin securing the chain anchor pins and discard.
While supporting the chains, remove the chain anchor pins and drape the chains over the carriage.

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) Rear chain sheave(TF mast)

① Raise and securely block carriage and inner mast section.

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

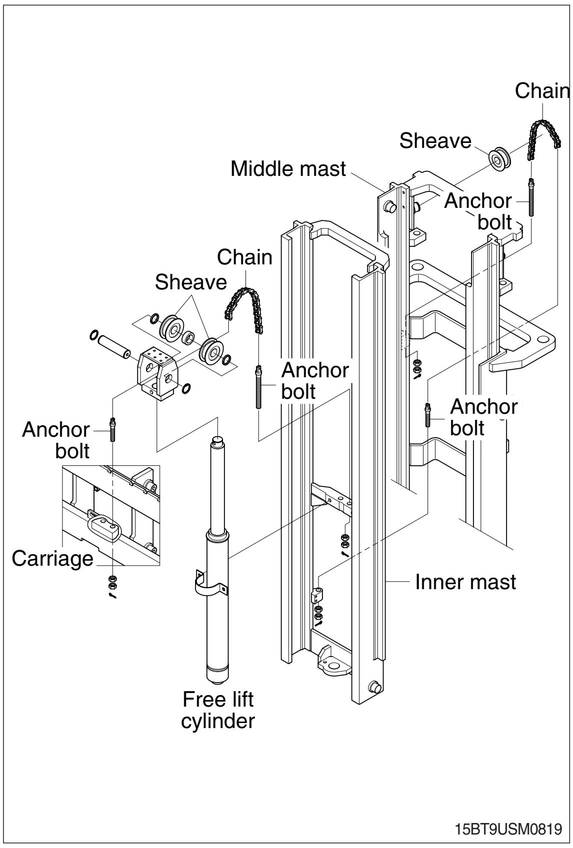
③ Remove chains.

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

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

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

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



(3) Chain wheel bearing support(TF mast)

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

(4) Rear chain(TF mast)

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

(5) Carriage chain

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

(6) Load chain inspection and maintenance

After every 200 hours of truck operation, lift chains should be inspected and lubricated inspect for the following chain conditions :

① Wear

As the chain flexes on and off the chain wheel bearings, the joints very gradually wear. The stretch a chain 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(12.7mm), 3/4(19.05mm), 1(25.4mm), 1-1/2(38.1mm), 2(50.8mm), use side A of scale.
· If pitch is 5/8(15.875mm), 1-1/4(31.75mm) or 2(50.8mm), use side B.
· Align point A or B to center of a pin and note position of the opposite A or B point.
· If other point also lines up with a pin, the chain is worn and should be replaced.

If any of the above conditions exists(cracked plates, turned pins, stretching etc), the chains should be replaced in pairs as a complete assembly. Order chains by part number to insure the correct chain length, pitch and material specifications.

(7) Load chain lubrication and adjustment

① Lubrication

The most important consideration in field maintenance of lift chains is lubrication. Hard working, heavily loaded chains cannot be expected to give satisfactory wear life without scheduled periodic re-lubrication. Like all bearing surfaces, the precision manufactured, hardened steel, joint-wearing surfaces require a film of oil between mating parts to prevent rapid wear. Oil must penetrate the chain joint to prevent wear. Applying oil to external surfaces will prevent rust, but oil must flow into the live bearing surfaces for maximum wear life. Frequency of re-lube will vary with operating conditions and environment, the best estimate of lube period is 200 hours. Trucks parked outdoors or trucks in extremely severe service, may require more frequent re-lube to maintain an oil film on all chain surface.

· Wipe off the old oil with a clean cloth and blow out the remaining dirt with compressed air.

⚠ Wear eye protection.

· With a clean brush, apply EP-140 extreme pressure lubricant or heavy motor oil(40W).

② Replacement

Replace chains as a pair. It will be virtually impossible to maintain uniform loading between the strands if a new chain is put into service opposite an old chain. The joints in the old chain will be greater than that on the new chain, greatly complicating the problem of maintaining equal chain tension. The new chain will wear more slowly causing it to bear the major portion of the load resulting in premature wear and fatigue failure. Don't steam clean or decrease new chains.

The manufacturer's grease is effective in reducing wear and corrosion. If the original factory lube is dried out or wiped off, soak the new chain in heavy engine oil for at 1/2 hour prior to installing on truck. After the old chains have been stripped from the mast, very carefully inspect chain anchors and chain wheel bearing. Broken, cracked or worn anchor must be replaced using the new anchor pin and split pin. Do not paint newly replaced chain after it has been installed.

③ Adjustment

Chain adjustments are important for the following reasons :

- · Equal loading of chain.
- · Proper sequencing of mast.
- · Prevent over-stretching of chains.
- · Prevent chains from jumping off sheaves if they are too loose.

④ Adjustment procedure

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