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1. STRUCTURE

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

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

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

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

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

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

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

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

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

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

2. HOW TO READ THE SERVICE MANUAL

Distribution and updating

Any additions, amendments or other changes will be sent to HYUNDAI distributors.

Get the most up-to-date information before you start any work.

Filing method

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

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

Revised edition mark(①②③···)

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

Revisions

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

Symbols

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

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

3. CONVERSION TABLE

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

Example

1. **Method of using the Conversion Table to convert from millimeters to inches**
   Convert 55mm into inches.
   (1) Locate the number 50 in the vertical column at the left side, take this as ⓐ, then draw a horizontal line from ⓐ.
   (2) Locate the number 5 in 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

1mm = 0.03937in

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

Kilogram to Pound

1kg = 2.2046lb

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

Liter to U.S. Gallon

1 ℓ = 0.2642 U.S.Gal

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

Liter to U.K. Gallon

1 ℓ = 0.21997 U.K.Gal

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

kgf · m to lbf · ft

1kgf · m = 7.233lbf · ft

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

kgf/cm² to lbf/in²

1kgf / cm² = 14.2233lbf / in²

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

TEMPERATURE

Fahrenheit-Centigrade Conversion.
A simple way to convert a fahrenheit temperature reading into a centigrade temperature reading or vice verse is to enter the accompanying table in the center or boldface column of figures.
These figures refer to the temperature in either Fahrenheit or Centigrade degrees.
If it is desired to convert from Fahrenheit to Centigrade degrees, consider the center column as a table of Fahrenheit temperatures and read the corresponding Centigrade temperature in the column at the left.
If it is desired to convert from Centigrade to Fahrenheit degrees, consider the center column as a table of Centigrade values, and read the corresponding Fahrenheit temperature on the right.

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

SECTION 1 GENERAL

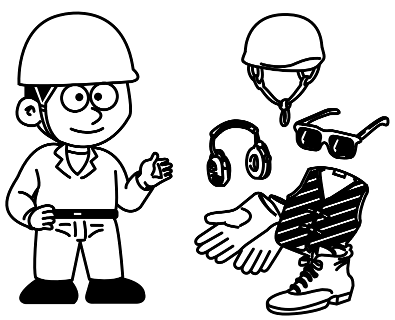
GROUP 1 SAFETY HINTS

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

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

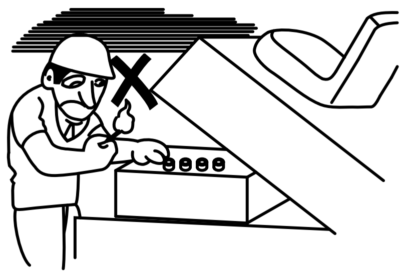
D50ASF01

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



D50ASF02

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

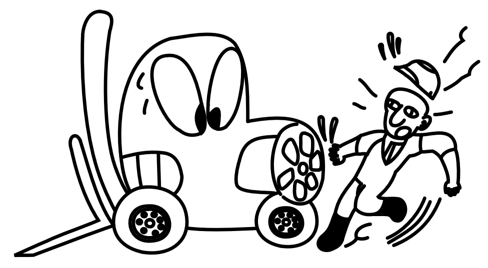


D50ASF03

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

D50ASF06

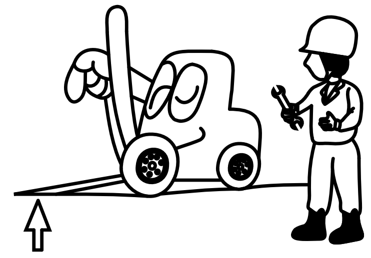
· Hand a caution sign in the operator's compartment (For example **Do not start** or **Maintenance** in progress).
  This will prevent anyone from starting or moving the machine by mistake.



D50ASF07

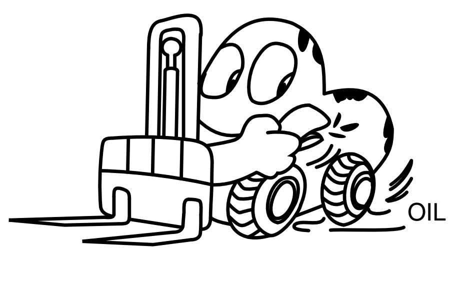
When inspecting running parts or near such parts, always stop the machine first.
Before checking or servicing accumulator or piping, depress brake pedal repeatedly to release pressure.

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



D50ASF08

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

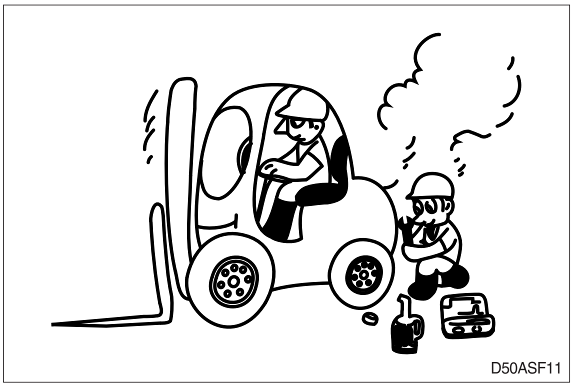


D50ASF09

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

D50ASF10

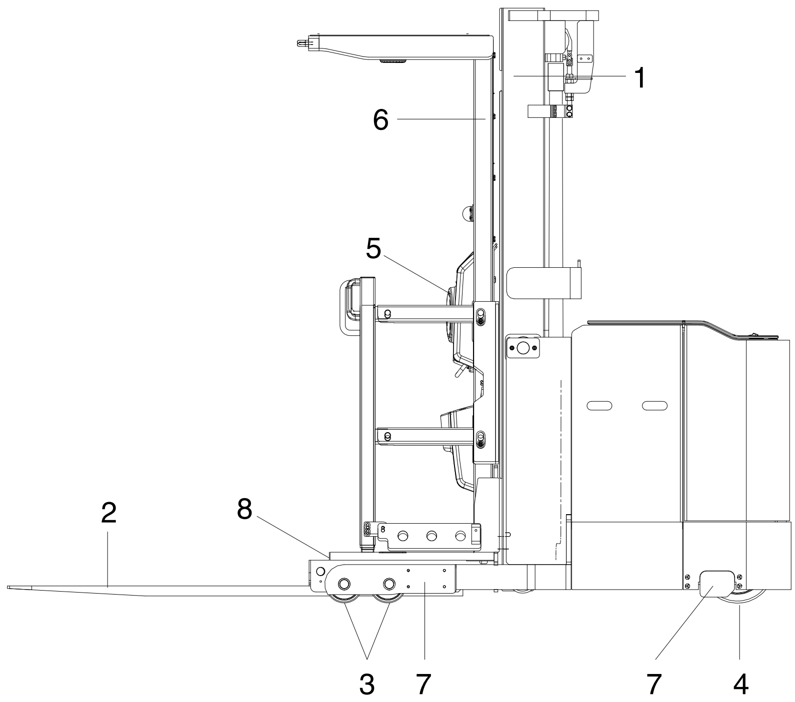
· Always remember that the hydraulic oil circuit is under pressure. When feeding or draining the oil or carrying out inspection and maintenance, release the pressure first.



· 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 40℃.
· 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

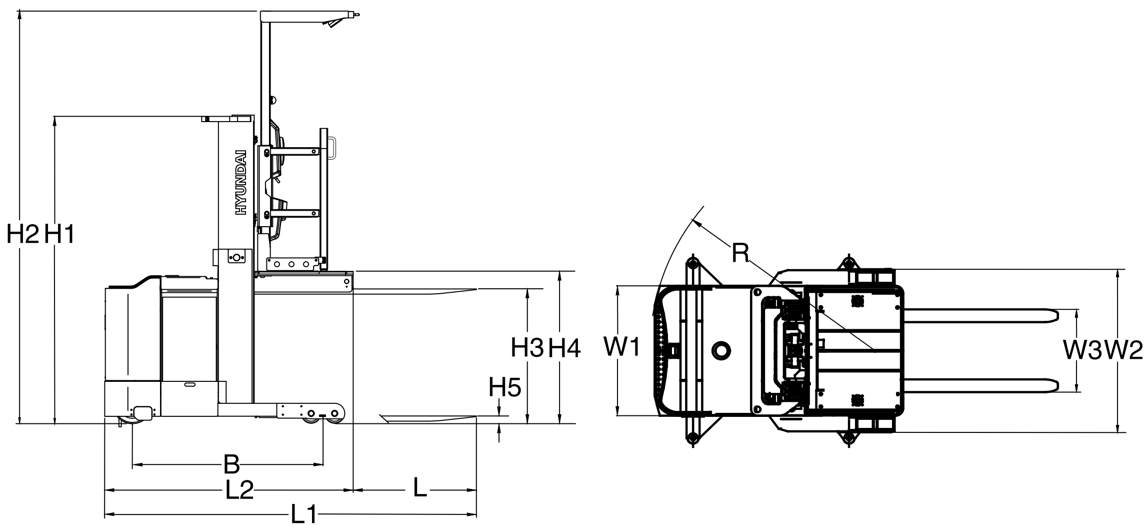


13BOP93KY01

1	Mast	4	Drive unit and tire	7	Guide roller
2	Fork	5	Steering wheel	8	Platform
3	Load tire	6	Overhead guard		

2. SPECIFICATIONS

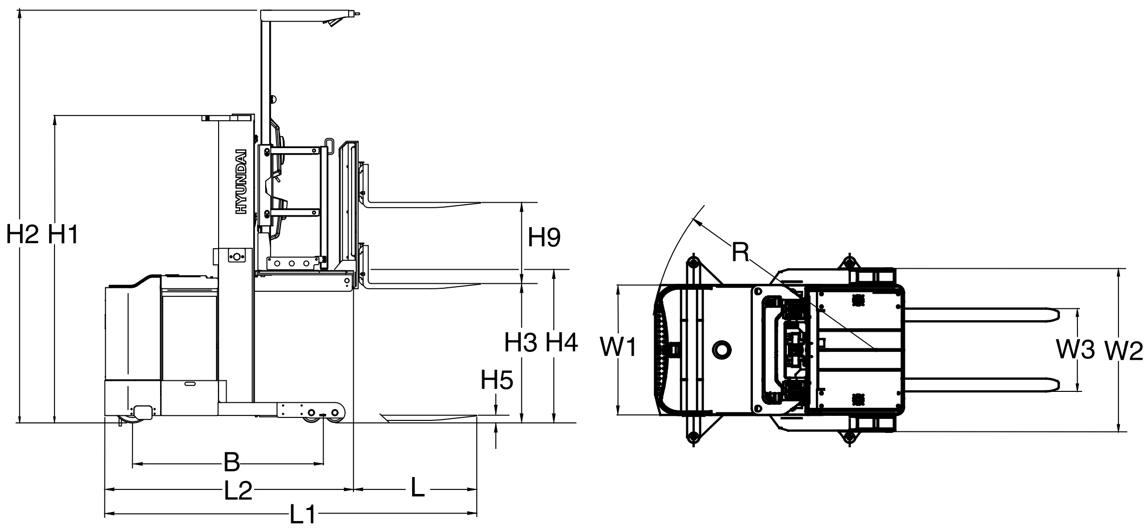
1) PLATFORM



13BOP98SP01

Description			Unit	Specification
Capacity			kg (lb)	1,306 (2,998.3)
Load center			mm (in)	600 (23.6)
Weight (with battery)			kg (lb)	2,934.5 (6,469.5)
Fork	Max lifting height	H3	mm (in)	3,275 (128.9)
	Min lifting height	H5	mm (in)	65 (2.6)
	Max spread width	W3	mm (in)	650 (25.6)
	Dimensions (T×W×L)		mm (in)	40×100×1,050 (1.6×3.9×41.3)
Platform	Max lifting height	H4	mm (in)	3,410 (134.3)
Mast	Max height	H2	mm (in)	5,470 (215.4)
	Closed mast height	H1	mm (in)	2,220 (87.4)
Picking height			mm (in)	5,010 (197.22)
Overall width of chassis		W1/W2	mm (in)	1,020/1,050 (40.2/49.2)
Overall length (without load)		L1	mm (in)	2,980 (117.3)
Travel speed (Load/unload)			km/h (mph)	12/12 (7.5/7.5)
Lifting speed (Load/unload), 36 V			mm/sec (ft/min)	320/430 (62.9/84.6)
Lifting speed (Load/unload), 24 V, option			mm/sec (ft/min)	240/370 (47.2/72.8)
Lowering speed (Load/unload)			mm/sec (ft/min)	430/400 (84.6/78.4)
Length to fork face		L2	mm (in)	1,930 (76)
Wheel base		B	mm (in)	1,480 (58.3)
Min turning radius		R	mm (in)	1,818 (71.6)

2) ADDITIONAL LIFT (OPT)



13BOP98SP02

Description			Unit	Specification
Capacity			kg (lb)	1,000 (2,204.6)
Load center			mm (in)	600 (23.6)
Weight (with battery)			kg (lb)	1,480 (58.3)
Fork	Max lifting height	H3	mm (in)	3,275 (128.9)
	Min lifting height	H5	mm (in)	65 (2.6)
	Additional lift	H9	mm (in)	760 (29.9)
	Max spread width	W3	mm (in)	840 (33.1)
	Dimensions (T×W×L)		mm (in)	40×100×1,050 (1.6×3.9×41.3)
Platform	Max lifting height	H4	mm (in)	3,410 (134.3)
Mast	Max height	H2	mm (in)	5,470 (215.4)
	Closed mast height	H1	mm (in)	2,220 (87.4)
Picking height			mm (in)	5,010 (197.22)
Overall width of chassis		W1/W2	mm (in)	1,020/1,050 (40.2/41.3)
Overall length (without load)		L1	mm (in)	3,130 (123.2)
Travel speed (Load/unload)			km/h (mph)	12/12 (7.5/7.5)
Lifting speed (Load/unload), 36 V			mm/sec (ft/min)	320/430 (62.9/84.6)
Lifting speed (Load/unload), 24 V, option			mm/sec (ft/min)	240/370 (47.2/72.8)
Lowering speed (Load/unload)			mm/sec (ft/min)	430/400 (84.6/78.4)
Length to fork face		L2	mm (in)	2,080 (81.9)
Wheel base		B	mm (in)	1,480 (58.3)
Min turning radius		R	mm (in)	1,818 (71.6)

3. SPECIFICATION FOR MAJOR COMPONENTS

1) CONTROLLER (36 V)

Item	Unit	Traction	Pump	EPS
Nominal battery voltage	V	36	←	←
Maximum output current	A	280 (2 min)	450 (2 min)	45 (2 min)
Output frequency range	Hz	0~200	←	←
Dimensions (L×W×H)	mm	200×150×105	200×150×110	120×150×54
Weight	kg	2	3.5	0.72

2) CONTROLLER (24 V, OPTION)

Item	Unit	Traction	Pump	EPS
Nominal battery voltage	V	24	←	←
Maximum output current	A	320 (2 min)	500 (3 min)	50 (2 min)
Output frequency range	Hz	0~200	←	←
Dimensions (L×W×H)	mm	200×150×105	200×200×120	120×150×54
Weight	kg	2	3.5	0.72

3) MOTOR

Item	Unit	Traction	Pump	EPS
Power	kW	4.3	9.0	0.4
Voltage	Vac	16	16	16
Current	A	204	425	21
Weight	kg	37	41	11

4) HYDRAULIC PUMP

Item	Unit	Specification
Type	-	Fixed displacement gear pump
Displacement	cc/rev	18.4
Rated pressure	bar	210
Speed (max/min)	rpm	3500/500

5) MANIFOLD ASSY

Item	Unit	Specification	
		Platform	Additional lift
Rated flow	lpm	60.4	40
Maximum pressure	bar	240	210
Main relief valve pressure	bar	160	160
Voltage	V	24 or 36	24

6) DRIVE UNIT

Item	Unit	Specification
Gear ratio	-	20.2
Oil quantity	ℓ	2.2

7) WHEELS

Item	Unit	Specification	
		Drive tire	Load tire
Material	-	Urethan	←
Dimension	Outside diameter	305	152
	Width	140	100

8) BRAKES

Item	Unit	Specification
Type	-	Electromagnetic brake

9) BATTERY

Voltage	Capacity	Dimensions						Weight
		Length (L)		Width (W)		Height (H)		
V	Ah	mm	in	mm	in	mm	in	kg (lb)
24	825	972	38.3	415	16.3	790	31.1	730 (1,609.4)

4. TIGHTENING TORQUE FOR MAJOR COMPONENTS

No.	Items		Size	kgf·m	lbf·ft
1	Electric system	Hyd pump motor mounting bolt	M10×1.5	6.5	47
2		Traction motor mounting bolt	M 8×1.25	4.1±0.4	29.7±2.9
3		EPS motor mounting bolt	M10×1.5	8.3±0.8	60±5.8
4	Hydraulic system	Hydraulic pump mounting bolt	M10×1.5	6.5	47
5		MCV mounting bolt, nut	M10×1.5	6.9±1.4	50±10
6		Hydraulic oil tank mounting bolt	M10×1.5	6.5	47
7	Power train system	Drive unit mounting bolt	M12×1.75	14.7±1.5	106±10
8		Drive wheel mounting nut	M14×1.5	15.7±2.3	114±16
9	Others	Head guard mounting bolt	M12×1.75	12.3±2.5	89±18

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)
Drive unit	Gear oil	2.2 (0.58)	SAE 75W-80, 75W-85, 75W-90 SAE 80, 80W-85, 80W-90, 20W-40 SAE 85W-90 SAE 90
Hydraulic oil tank	Hydraulic oil	28 (7.4)	★ISO VG 15 ISO VG 46 ISO VG 68
Fitting (Grease nipple)	Grease	0.1 (0.03)	★NLGI No.1 NLGI No.2

★ : Cold region
Russia, CIS, Mongolia

GROUP 3 PERIODIC REPLACEMENT

For operation safety, never fail to perform periodic maintenance or make periodic replacement of the consumable parts listed in the following.

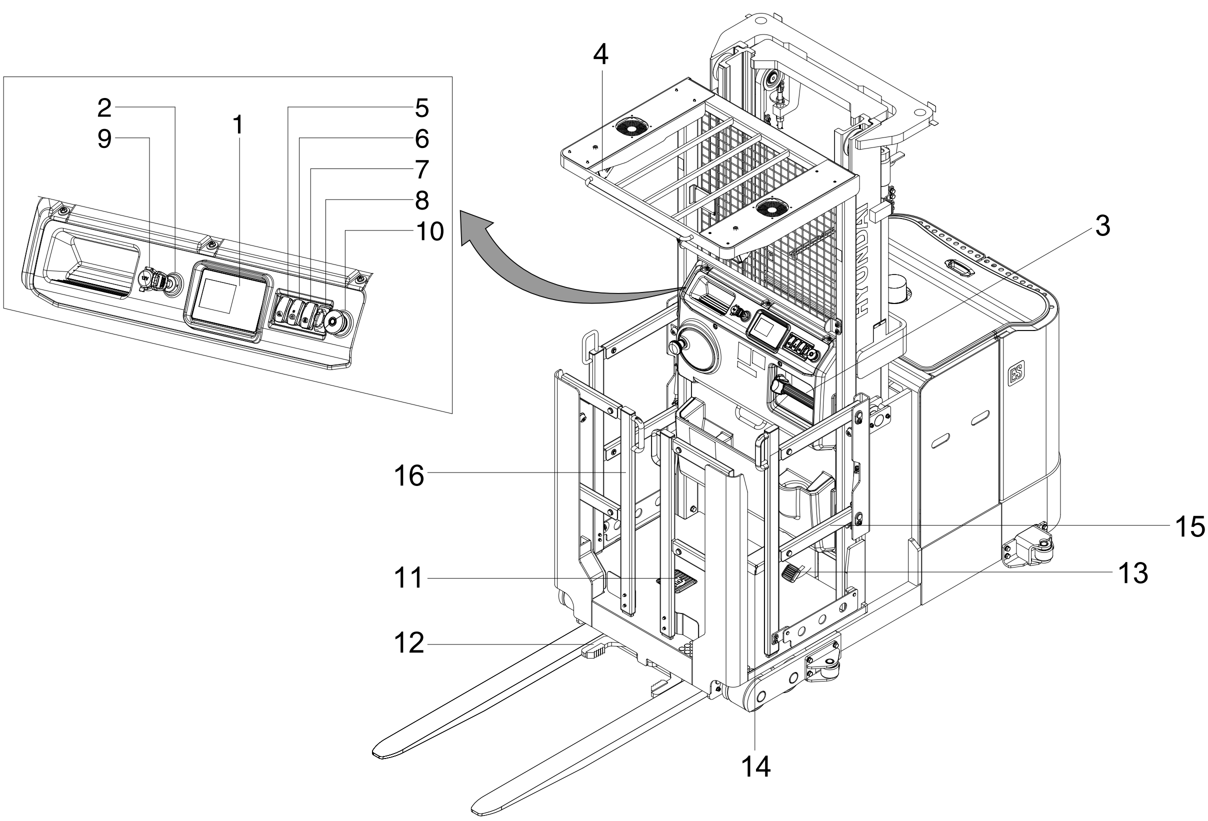
These parts may deteriorate in time and are susceptible to wear. It is difficult to estimate the degree of wear at time of periodic maintenance; therefore, even if no apparent wear is found, always replace with new parts within the prescribed period of replacement(Or earlier if trouble is found).
Note that periodic replacement has nothing to do with guarantee service.

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

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

SECTION 2 REMOVAL AND INSTALLATION OF UNIT

GROUP 1 MAJOR COMPONENTS



13BOP93KY03

1 Display
2 Key switch
3 Multifunction lever
4 Work lamp
5 Work Lamp switch
6 Fan switch
7 Wire guidance switch (OPT)
8 Zone select switch (OPT)
9 Socket (12 V)
10 Emergency switch
11 Dead man switch
12 Pallet clamp
13 Pallet clamp pedal
14 Pallet clamp release pedal
15 Side gate
16 Rear gate
(EU : STD, Other : OPT)

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

GROUP 2 REMOVAL AND INSTALLATION OF UNIT

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

1. MAST

1) REMOVAL

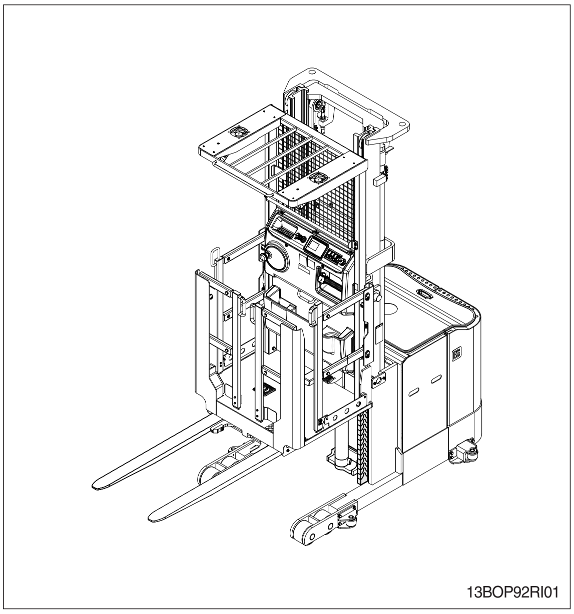
Fork — Mast — Platform & overhead guard — Piping

(1) PREPARATION

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

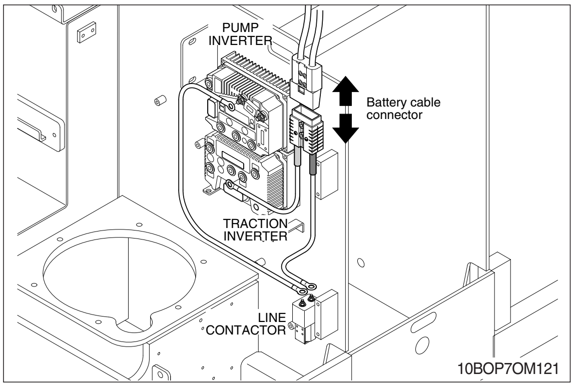
② Prop up blocks under the platform in order that it can avoid from unintentional lowering of the platform.

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



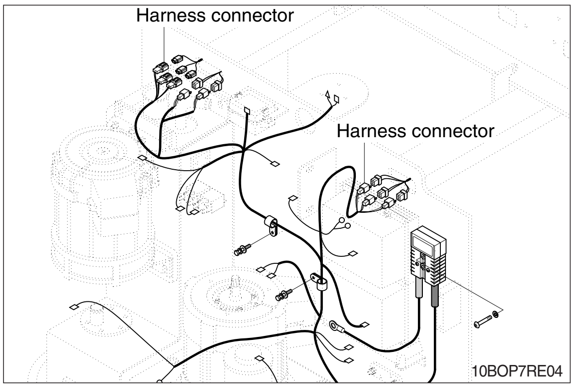
13BOP92RI01

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



10BOP7OM121

④ Disconnect harnesses.

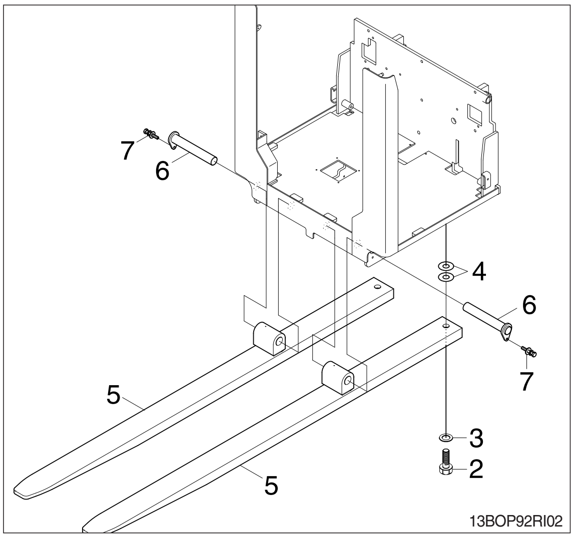


10BOP7RE04

(2) FORKS

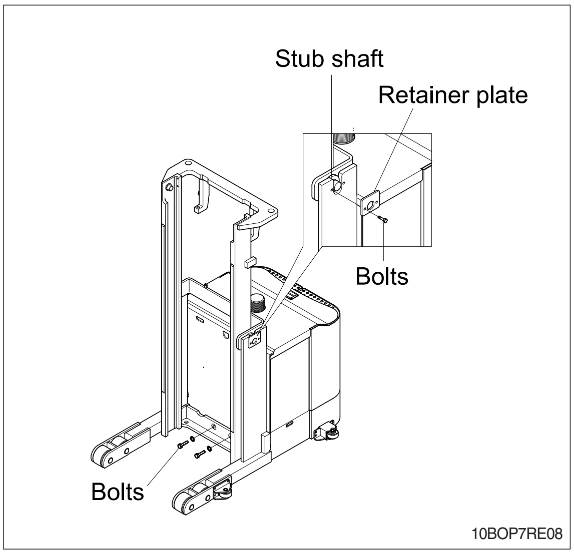
① Loosen and remove bolts (2), washers (3) and shims (4) which are used for fixing the forks (5) under the platform (1).

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



(3) MAST & PLATFORM REMOVAL

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

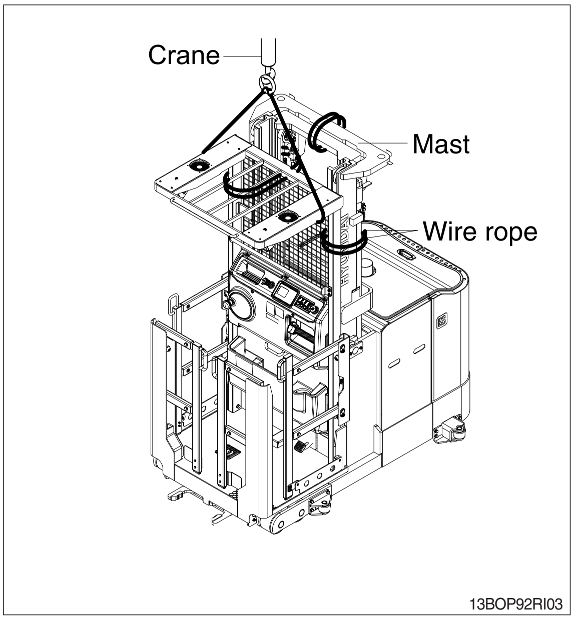


② Raise mast until the stub shafts on the sides of the outer mast rail clear the saddles of the truck frame.

※ Make sure the mast lifts straight up.

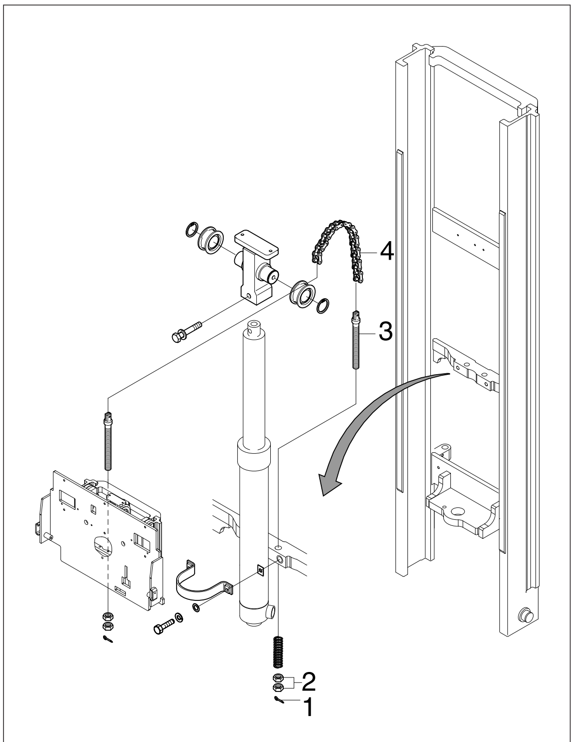
※ Take care to draw out the platform in order that it can not happen damage due to bump between the platform and the inner mast.

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



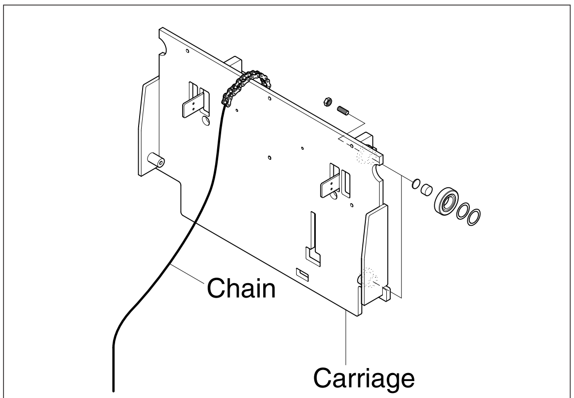
(4) PLATFORM

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



13BOP92RI11

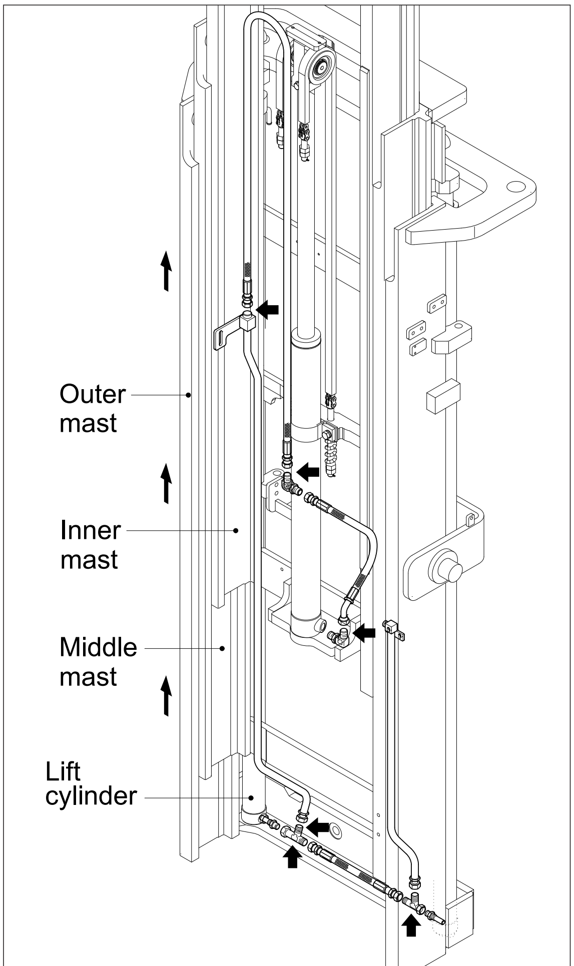
② Pull the chains out of the sheaves and drape them over the front of carriage.



10BOP7RE07

(5) PIPING

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



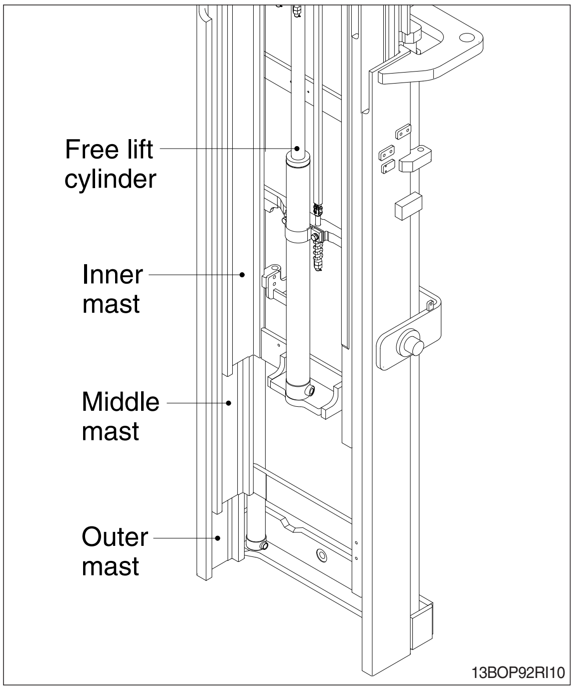
13BOP92RI09

(6) LIFT CYLINDER

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

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

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



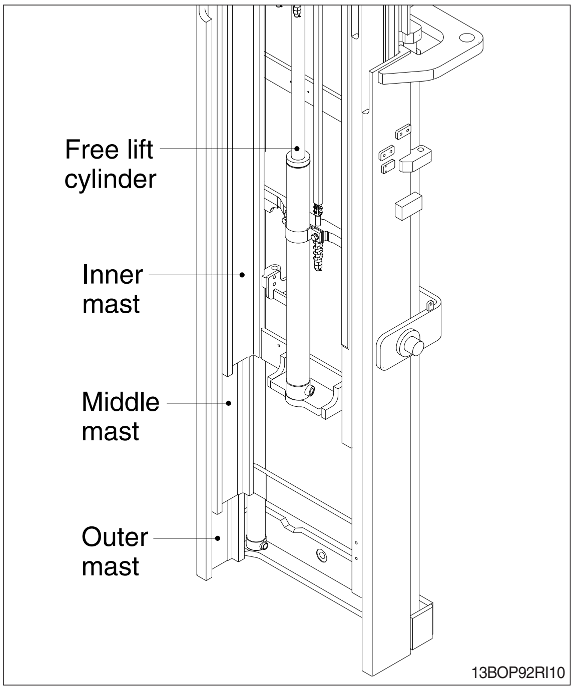
13BOP92RI10

(7) INNER MAST

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

⚠ **Be careful the mast not to swing or fall.**

② Using an universal puller, remove the load rollers.



2) INSTALLATION

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

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

(1) LIFT CYLINDER INSTALLATION AND ADJUSTMENT

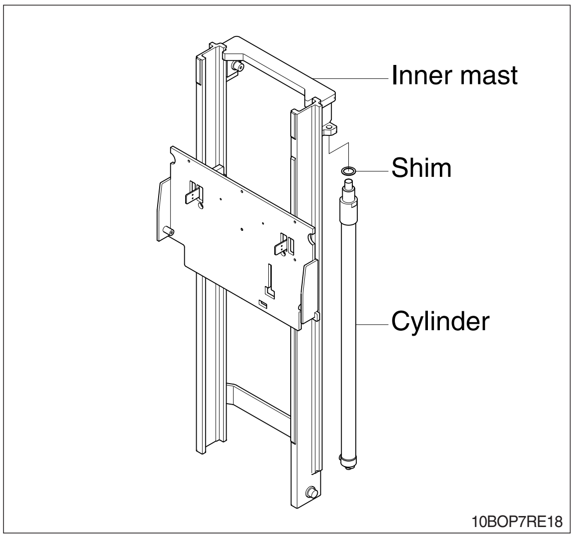
① Assemble the lift cylinder inside the outer mast, then tighten the stopper bolt. If the cylinder assembly has been replaced, adjust as follows so that the left and right cylinders are synchronized at the maximum lifting height.

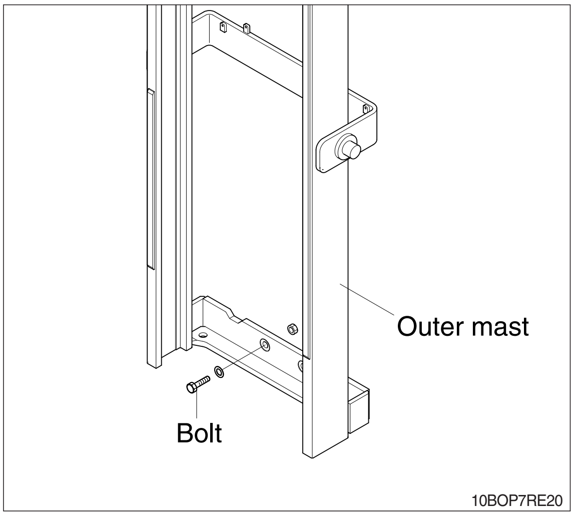
② Assemble the cylinder rod to the inner mast, and check the left-to-right play of the mast at the maximum lifting height.

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

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

· Shim thickness : 1.0mm(0.04in)





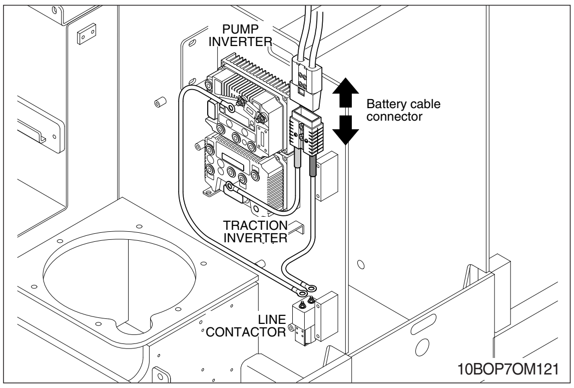
2. POWER TRAIN ASSEMBLY

1) REMOVAL

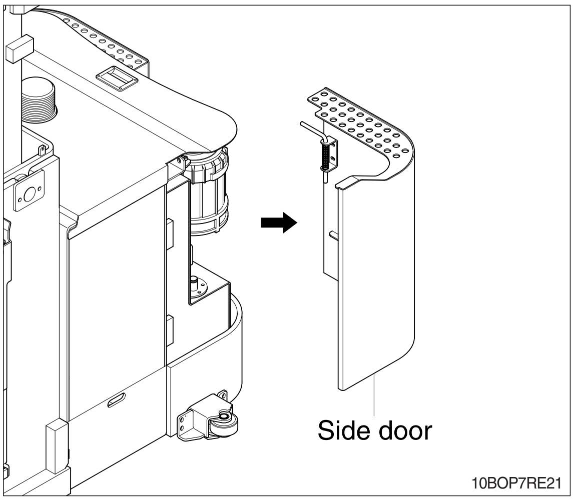
Battery cable — Side door — Pump & pump motor — Drive unit assembly

BRJ7RE001

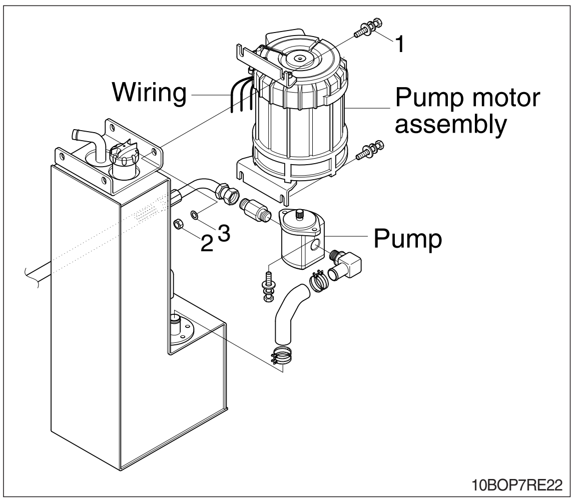
(1) Disconnect the battery cable.



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

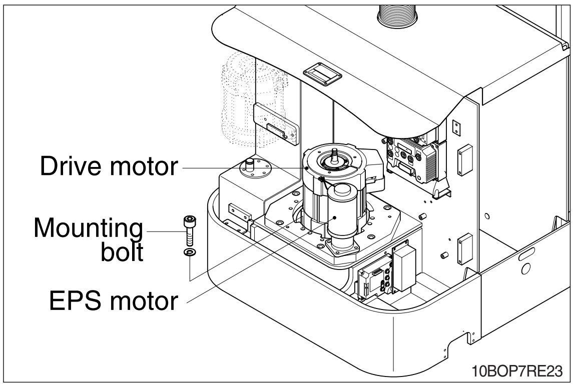


(3) Disconnect the hose, pipe and wiring from pump & motor assembly.
Loosen mounting bolts (1), nuts (2), and washers (3) from frame and then take out the pump & motor assembly.

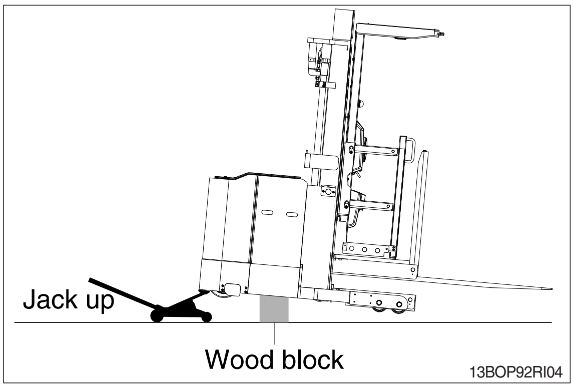


(4) Disconnect the wiring.
① Drive motor wiring
② EPS motor wiring

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

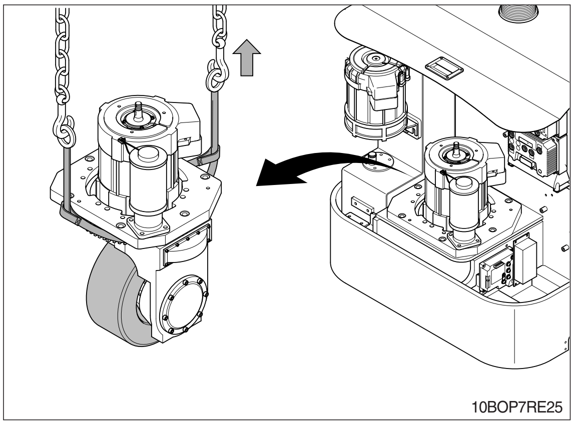


(6) Lift up the frame and support both side of frame with wood block.



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

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



2) INSTALLATION

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

(1) Drive unit mounting bolts : 6EA

· Tightening torque : 13.2~16.2kgf · m
(95.5~117.1lbf · ft)

(2) Drive unit bracket mounting bolt : 6EA

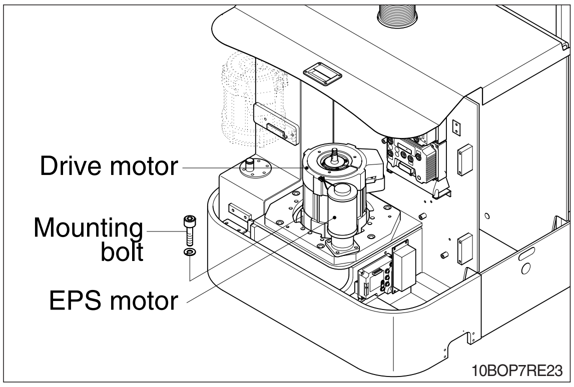
· Tightening torque : 13.2~16.2kgf · m
(95.5~117.1lbf · ft)

(3) Drive motor mounting bolts : 6EA

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

(4) EPS motor mounting bolts : 4EA

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

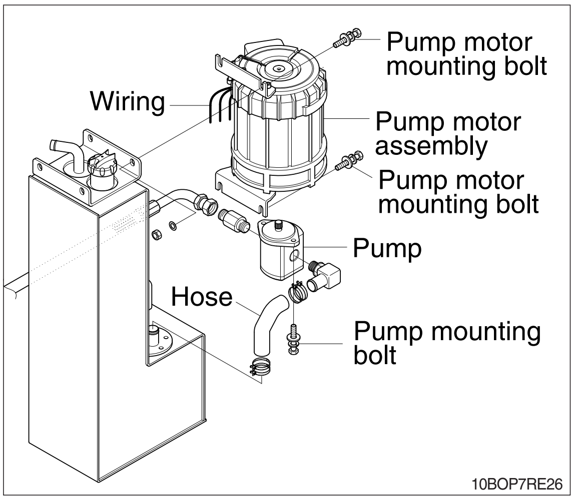


(5) Pump motor mounting bolts : 4EA

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

(6) Pump mounting bolts : 2EA

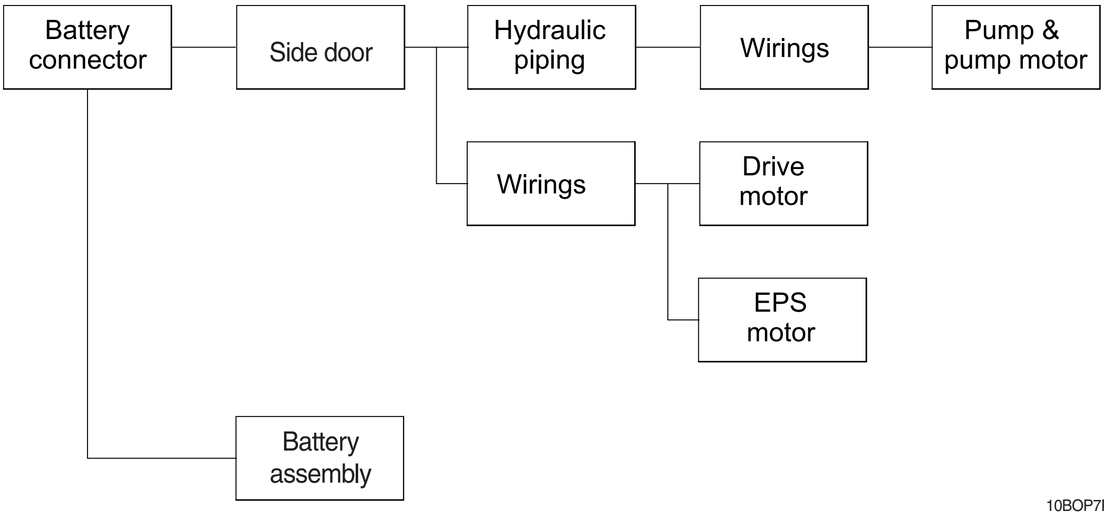
· Tightening torque : 5kgf · m
(63.2lbf · ft)



3. ELECTRICAL COMPONENTS

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

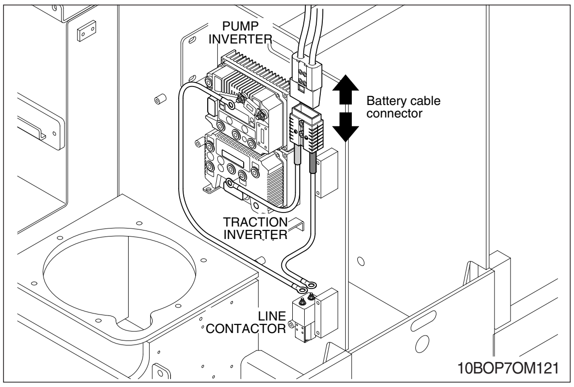
1) REMOVAL



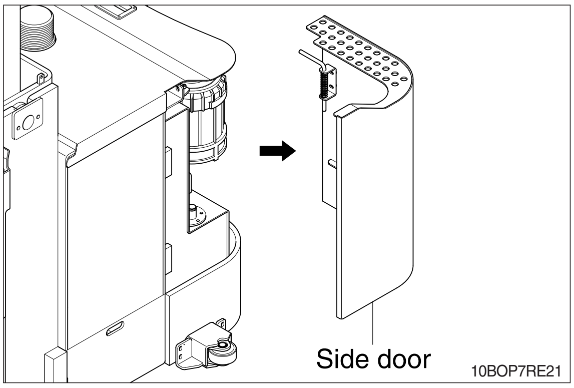
10BOP7RE002

(1) PUMP MOTOR

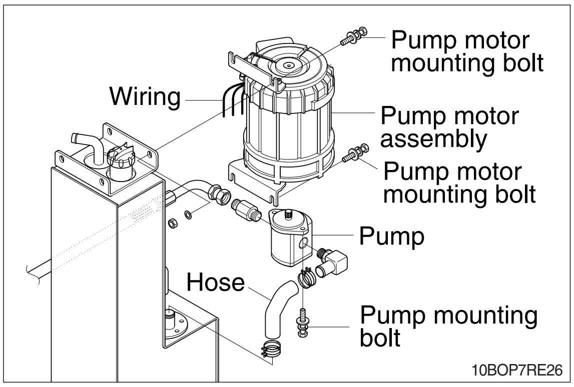
① Disconnect the battery cable.



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

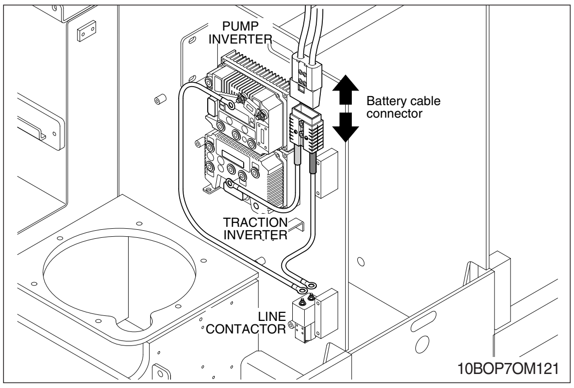


③ Disconnect the hoses, pipes and wiring from pump & motor assembly.
Loosen mounting bolts from frame and then take out the pump & motor assembly.

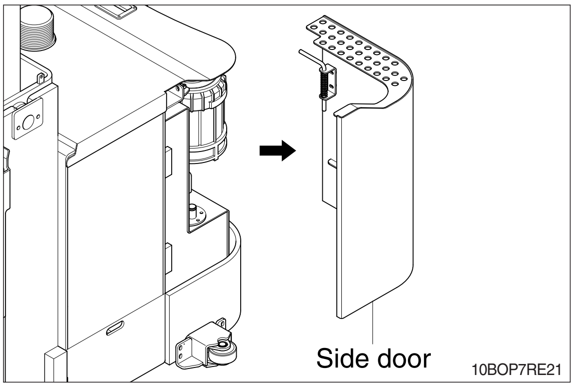


(2) DRIVE MOTOR

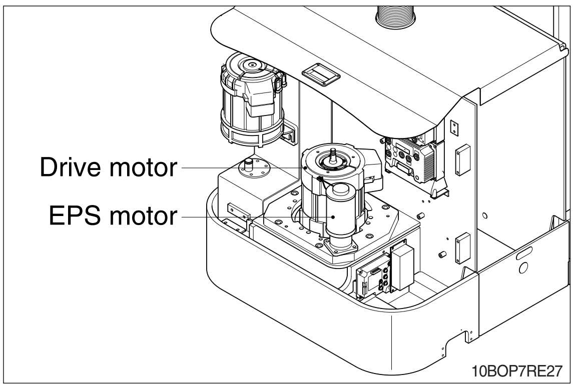
① Disconnect the battery cable.



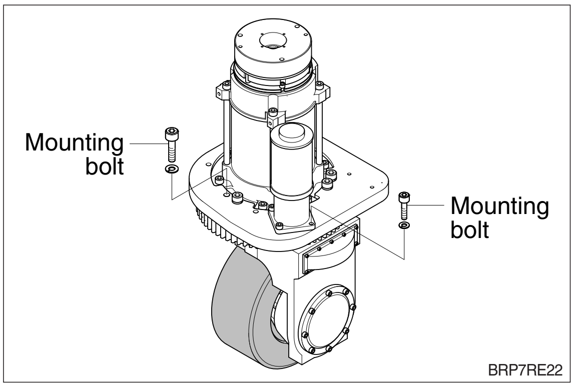
② After loosening the bolts of the hinges, remove the side door.



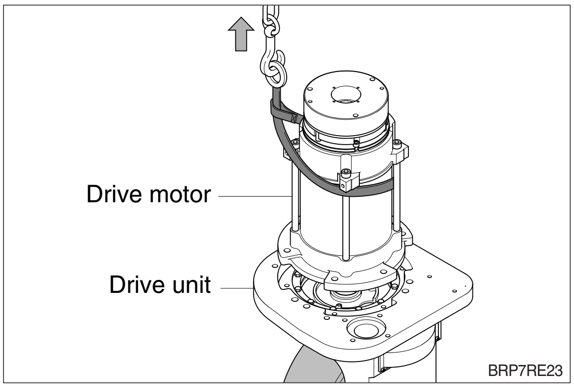
③ Disconnect wirings from the following motors.
a. Drive motor
b. EPS motor



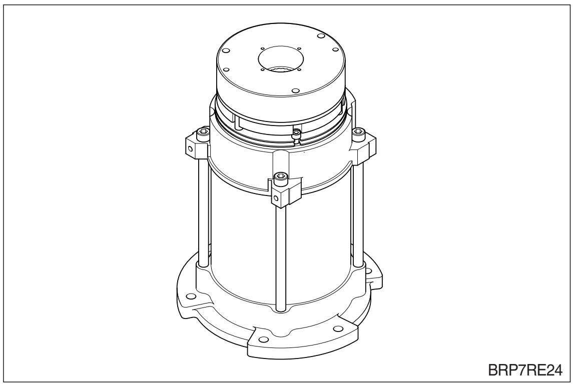
④ Remove bolts to fix the motor and drive unit.



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

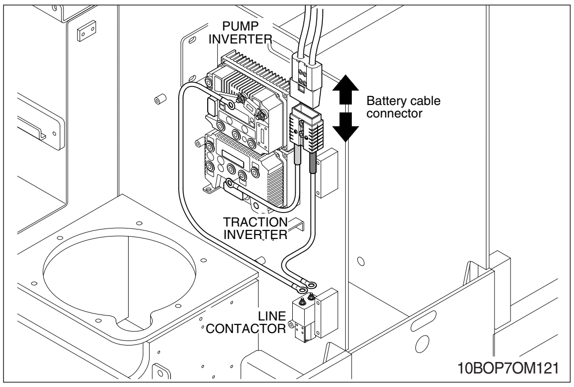


⑥ Put the motor on the clean work bench.

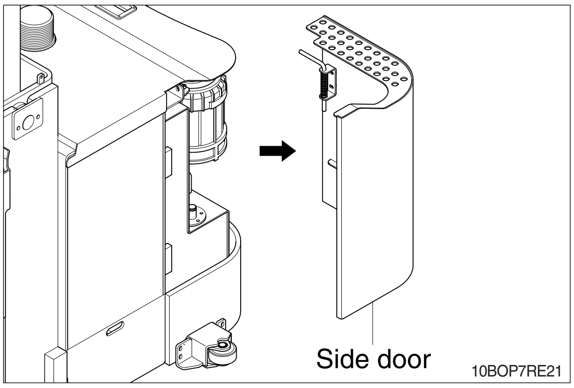


(3) EPS MOTOR

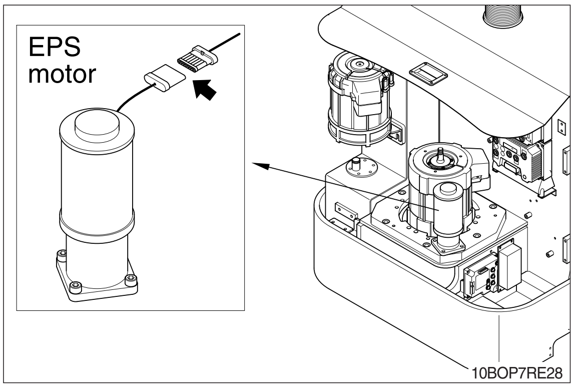
① Disconnect the battery cable.



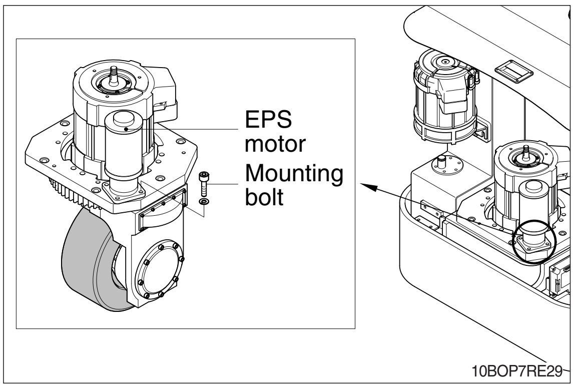
② After loosening the bolts of the hinges, remove the side door.



③ Disconnect wirings.



④ Loosen bolts and remove EPS motor assembly.



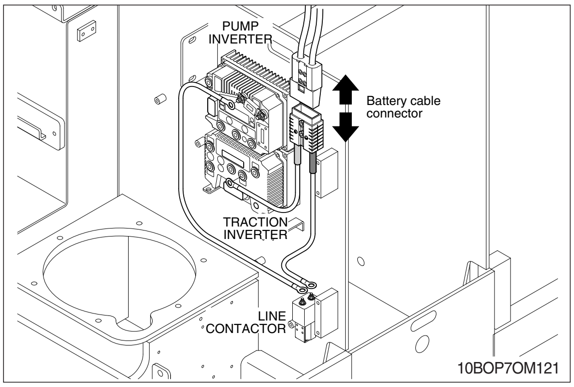
(4) BATTERY REMOVAL

① Turn off the key.

② Release the lock screw of side support in frame.

③ Disconnect the battery connector.

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



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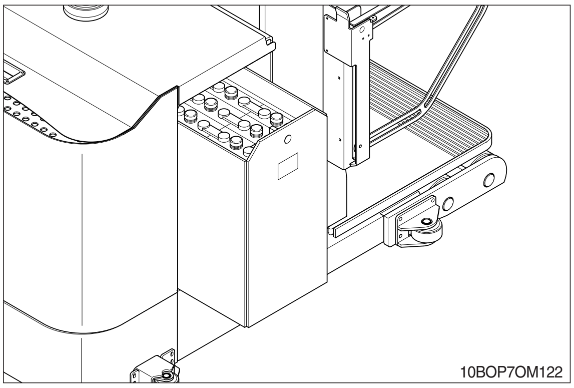


10BOP7OM122

2) INSTALLATION

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

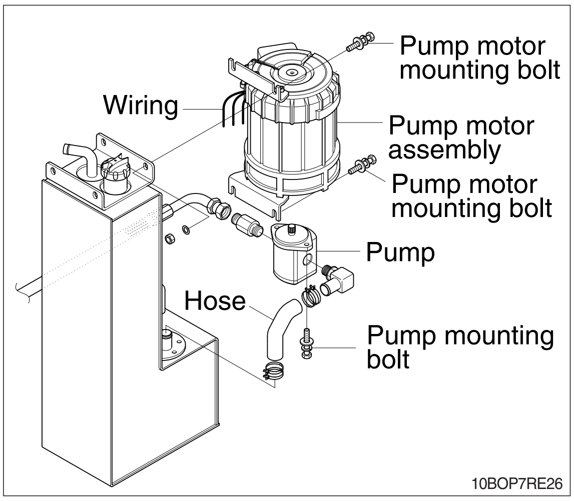
(1) PUMP MOTOR

① Pump motor mounting bolts : 4EA

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

② Hydraulic pump mounting bolts : 2EA

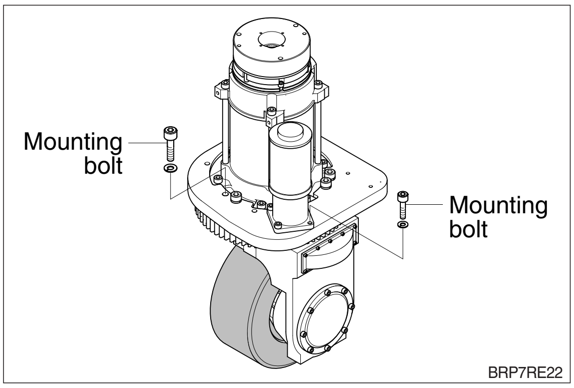
· Tightening torque : 5kgf · m (36.2lbf · ft)



(2) DRIVE MOTOR

① Mounting bolts between drive motor and drive unit.

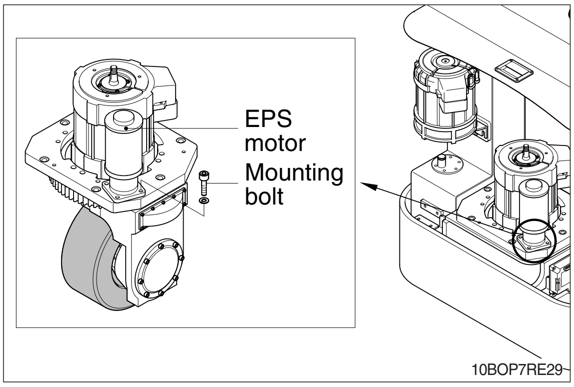
· Tightening torque : 3.7~4.5kgf · m (26.8~32.5lbf · ft)



(3) EPS MOTOR

① EPS motor mounting bolts.

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

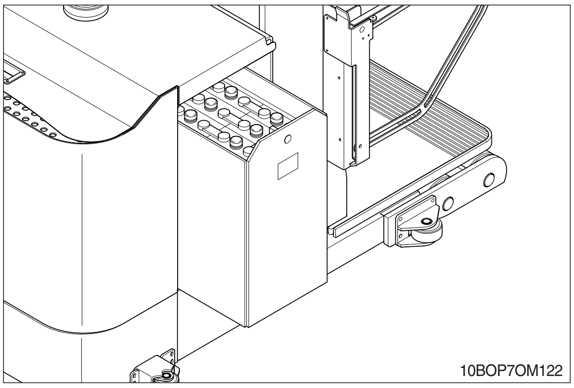


(4) BATTERY INSTALLATION

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

② Adjust the lock screw of side support in frame.

③ Connect the battery connector.



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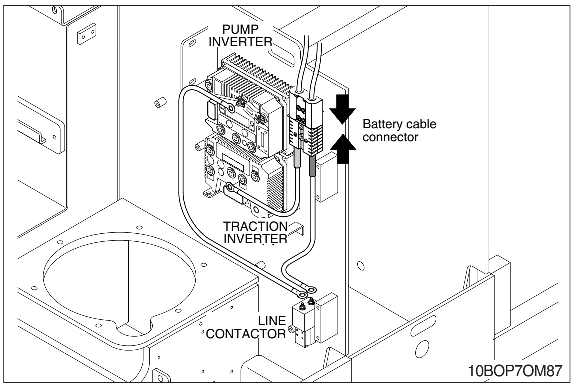


10BOP7OM87

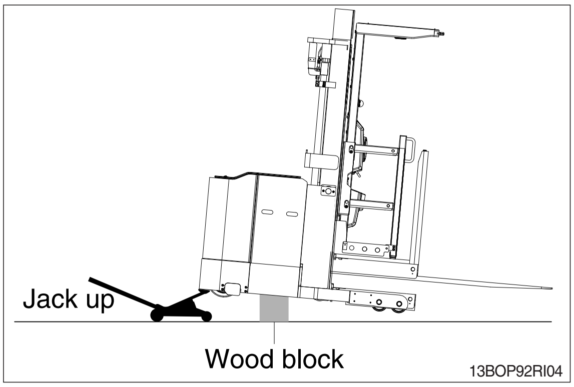
4. TIRE & WHEEL ASSEMBLY

1) REMOVAL

(1) DRIVE TIRE & WHEEL ASSEMBLY

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

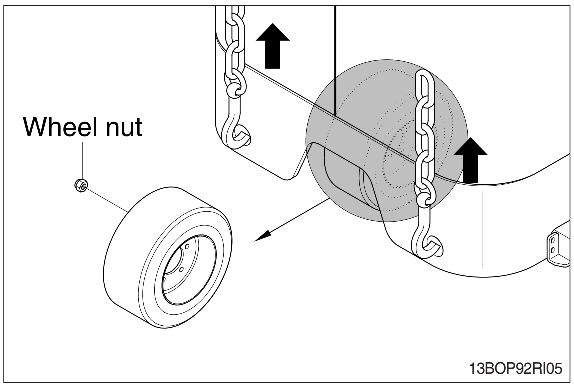
※ **Lift up until the tire clear off the ground.**



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

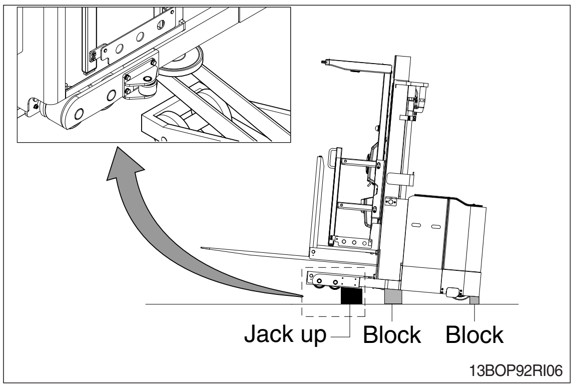
· Wheel nuts : 5EA

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



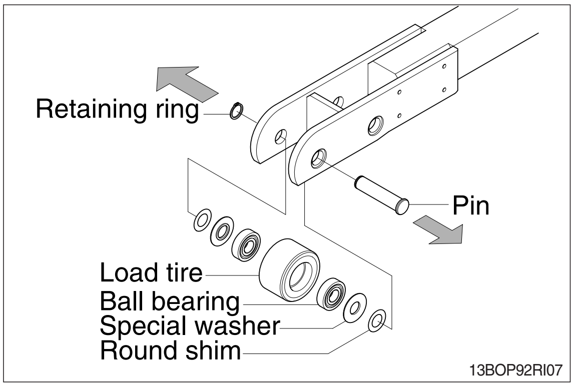
(2) LOAD WHEEL ASSEMBLY

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



② Disassemble load tire assy

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

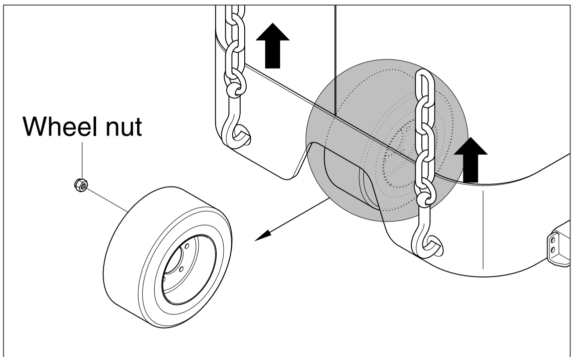


2) INSTALLATION

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

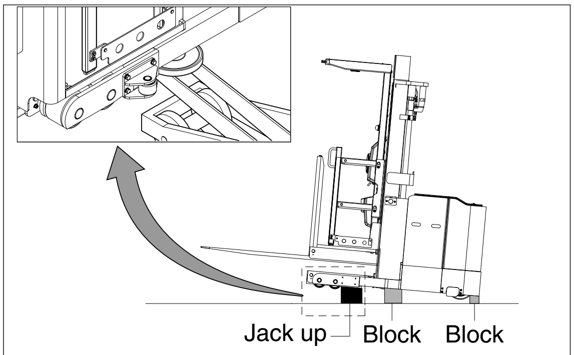
(1) Drive wheel nuts

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



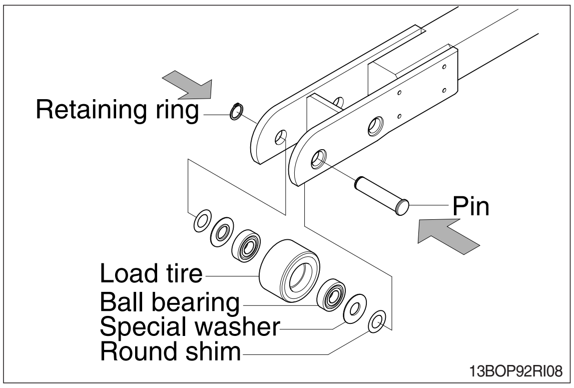
13BOP92RI05

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



13BOP92RI06

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

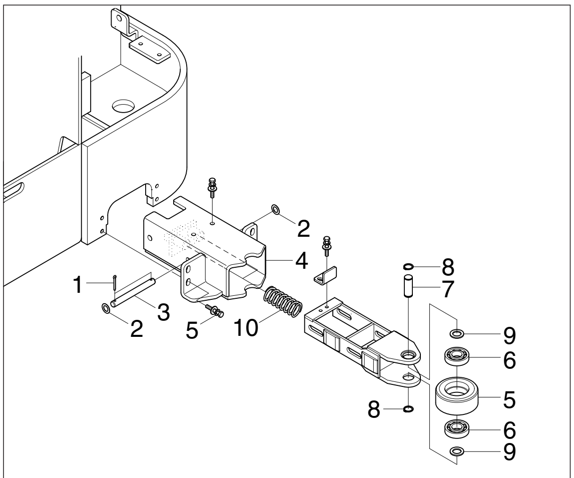


13BOP92RI08

3) FRONT GUIDE ROLLER

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

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



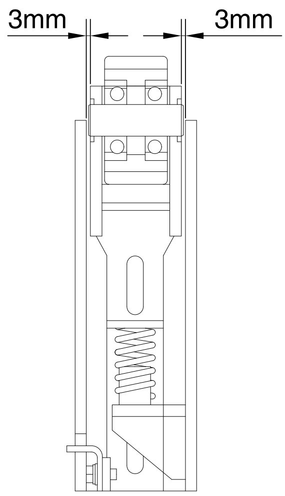
10BOP7RE34

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

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

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

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

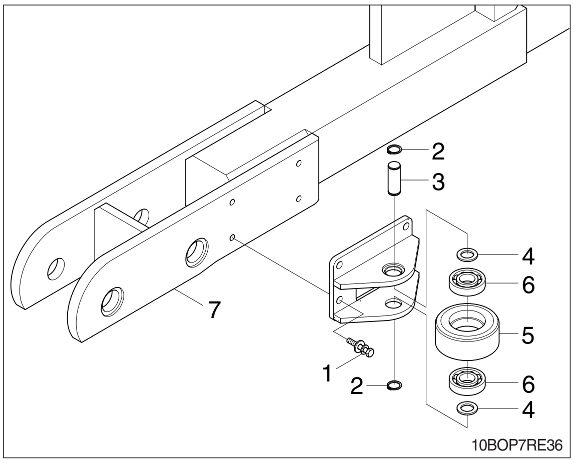


10BOP7RE35

4) REAR GUIDE ROLLER

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

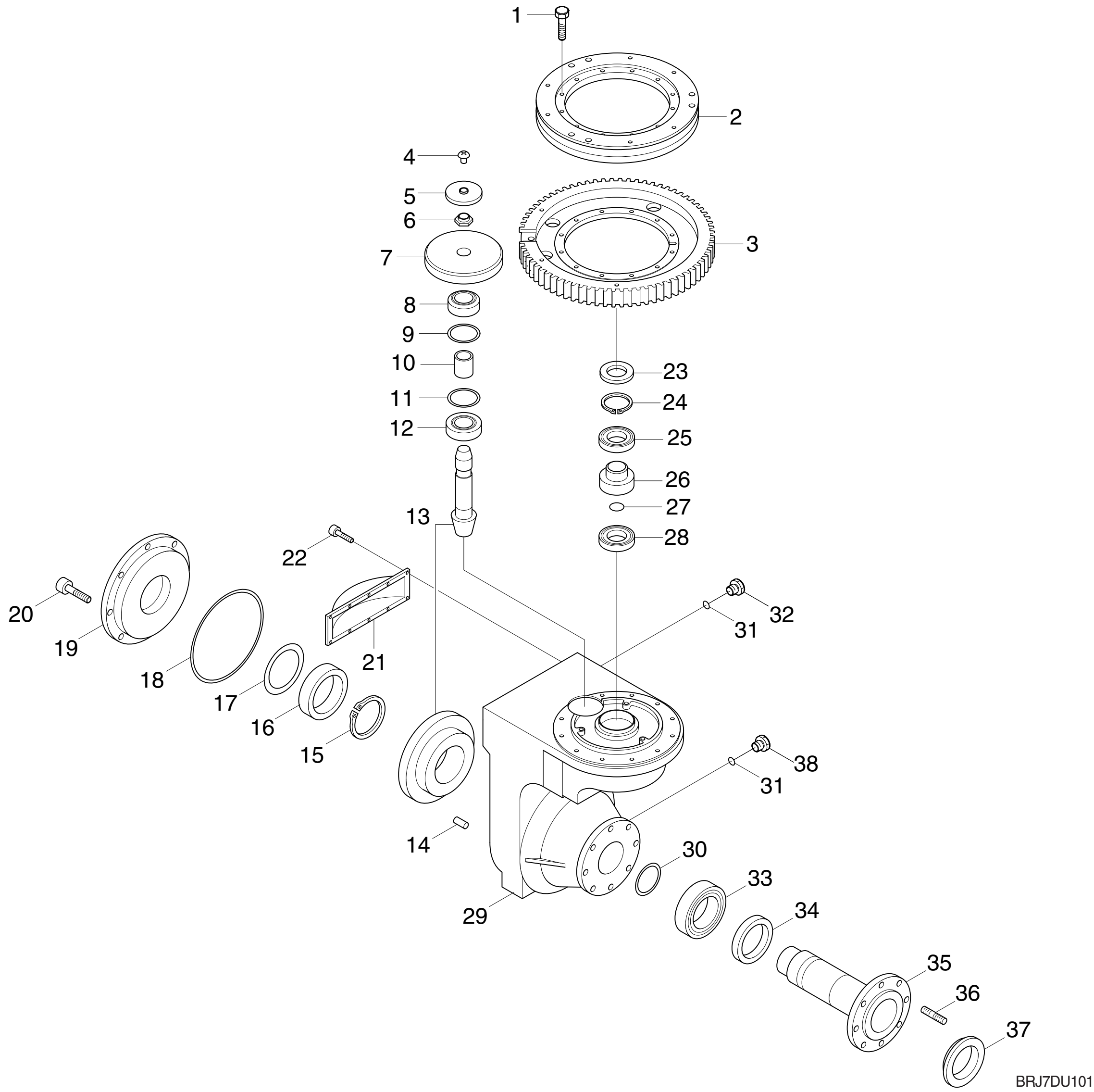
※ After checking condition of the guide wheels and ball bearings, replace it if necessary.



SECTION 3 POWER TRAIN SYSTEM

GROUP 1 STRUCTURE AND OPERATION

1. DRIVE UNIT STRUCTURE



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

2. SPECIFICATION

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

GROUP 2 TROUBLESHOOTING

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

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

GROUP 3 DISASSEMBLY AND ASSEMBLY

1. INSTRUCTION

1) Pay attention to cleanliness and expert like manner for all work to be carried out. Transmission removed from the vehicle has therefore to be cleaned prior to opening. Both utmost care and cleanliness are essential conditions for a correct disassembly and reassembly of the transmission as well as for the installation of each spare part. A fault during installation can result in an early wear and chips or other foreign particles in the transmission can cause fatal damages.
2) Prior to assembly all parts must be cleaned and inspected for wear and other defects.
3) If it is found that removed parts are damaged or worn, do not reinstall but replace them by new ones.
4) If not separately indicated, the housing and cover faces forming an oil tight connection are to be provided with the corresponding sealing compound during assembly.
5) Special devices and special tools are necessary besides the standard tools. Their use is unavoidable for a technically adequate dis- and reassembly. The application of devices, special tools and other fixtures are to be adapted to circumstances of the respective users.
6) Commercial tools and fixtures belonging to the basic equipment are assumed to be available.
7) If not otherwise indicated all pressing operations are made by means of the hand lever press.
8) All screws and threads in this transmission have metric dimensions. Only spanners and socket spanners with metric sizes are allowed to be used.
9) For reassembly all of the indicated setting values, test data and tightening torques must be observed.
10) Observe the described sequence of the working steps.
11) All pictures serve the illustration and are not obliging for this execution.

2. NECESSARY SPECIAL TOOLS FOR DISASSEMBLY AND REASSEMBLY

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

3. SAFETY INSTRUCTIONS

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

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

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

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

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

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

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

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

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

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

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

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

4. COMPLETE DISASSEMBLY

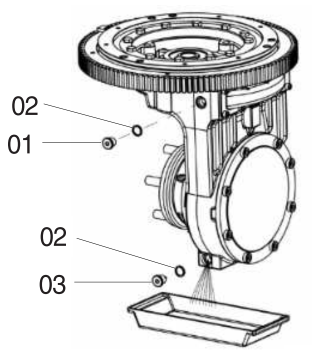
1) GENERAL INSTRUCTIONS DISASSEMBLY

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

BRJ7DU044

2) DRAIN OFF TRANSMISSION OIL

(1) Place a suitable big oil collecting vessel under the oil drain plug.
(2) Loosen the oil filler plug(item 01) with a 6mm allen wrench. Remove the oil filler plug and the sealing ring(item 02).
(3) Loosen the oil drain plug(item 03) with a 6mm allen wrench. Remove the oil drain plug and the sealing ring(item 02).
(4) Have the transmission oil drained into the vessel completely.
※ Do not drain transmission oil into the soil or the sewerage system. Pay attention to the type and quantity of debris.
⚠ High oil temperatures are to be expected after continuous operation of the transmission. Wear temperature-resistant gloves.

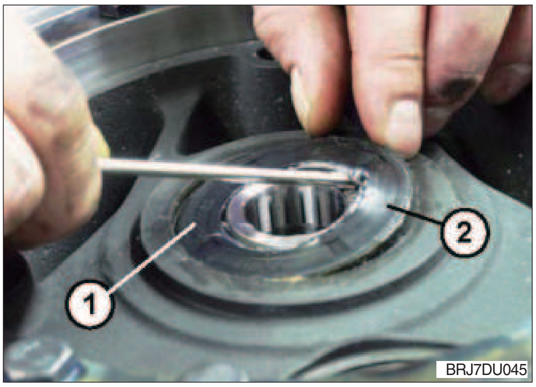


14BRJ7OM119

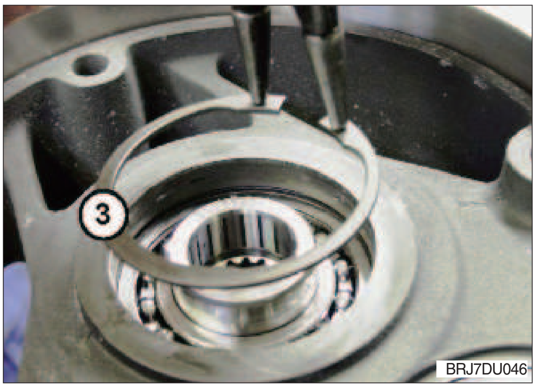
3) REMOVAL OF DRIVE PINION

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

Dispose of the radial sealing ring according to chapter 6.

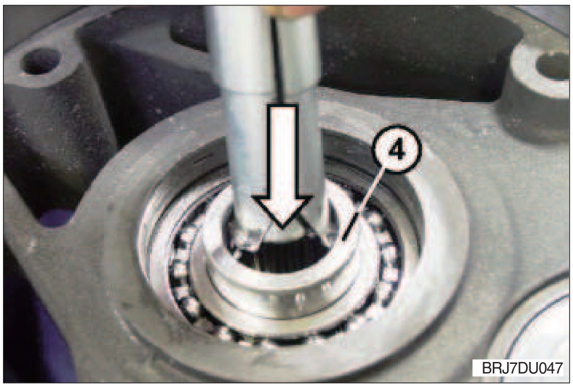


(2) Unsnap and remove the retaining ring (item 3) from the housing bore by means of flat-head pliers.



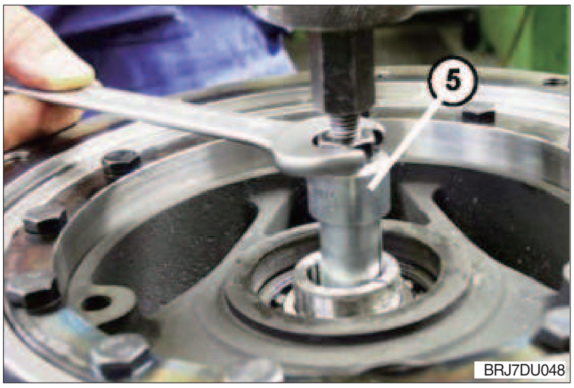
(3) Extracting fixture 225296 is necessary to remove the drive pinion (item 4) from the bore.

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



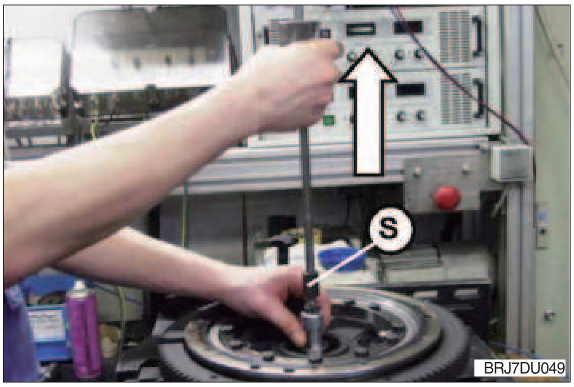
(4) Fasten the hexagon screw of the bearing puller hand-tight so that a sufficient preload of the clamping jaws is given.

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

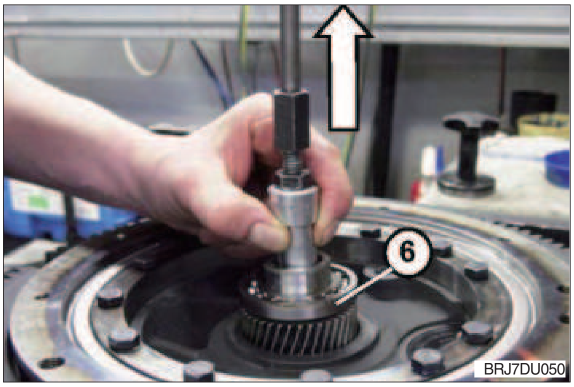


(5) Handle the extracting fixture "S" as shown on the right. Move the handle on the bar upwards strongly several times until the drive pinion is loosened from the bearing seat completely.

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

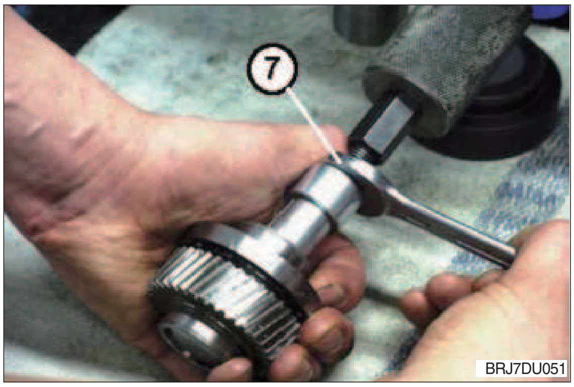


(6) By means of the extracting fixture pull the drive pinion (item 6) out of the housing bore and remove it.

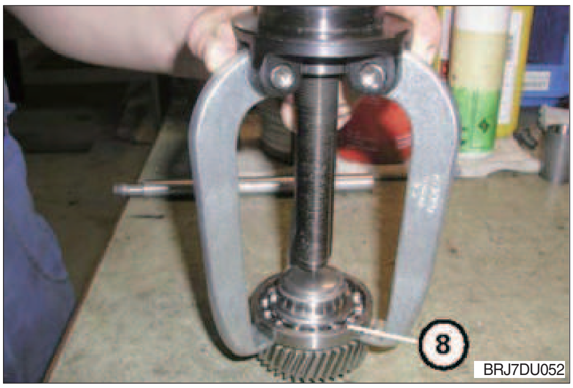


(7) Loosen the hexagon bolt (item 7) and remove the extracting fixture from the drive pinion.

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

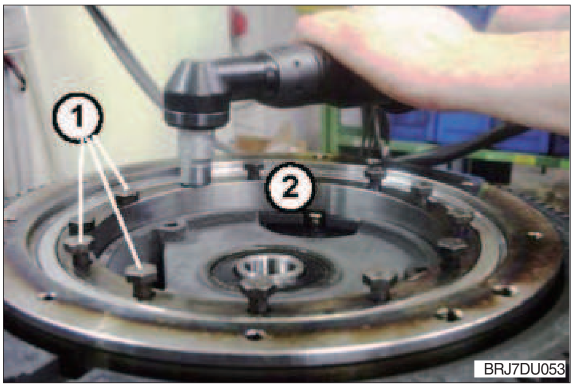


(8) Pull of the grooved ball bearing (item 8) by means of a puller or a parting tool over the bearing seat of the drive pinion and dispose it of according to chapter 6.

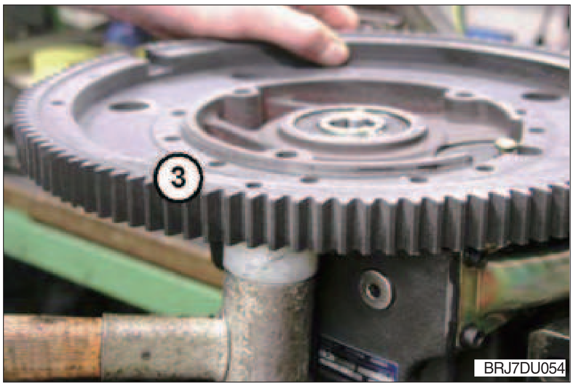


4) REMOVAL OF GEAR RING AND PIVOTED BOGIE BEARING

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



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



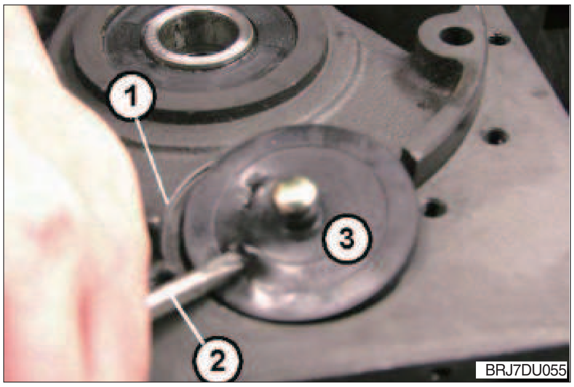
5) DISASSEMBLY OF TRANSMISSION HOUSING WITH TRANSMISSION COMPONENTS

(1) Removal of sealing cap

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

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

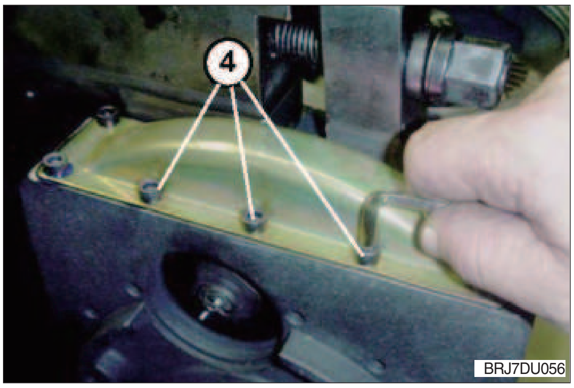
② The breather valve is not to be scrapped.



(2) Removal of side cover

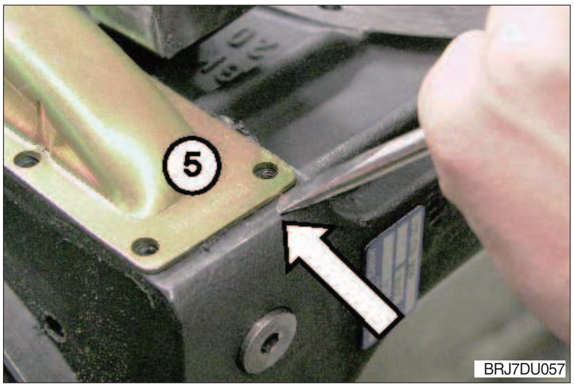
① Loosen and remove the 10 cap screws (item 4) on the side cover.

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



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

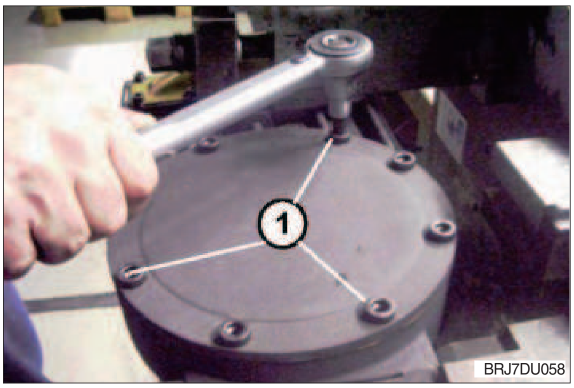
③ Loosen the side cover from the housing by tapping onto the outer contour and dispose it of acc. to chapter 6.



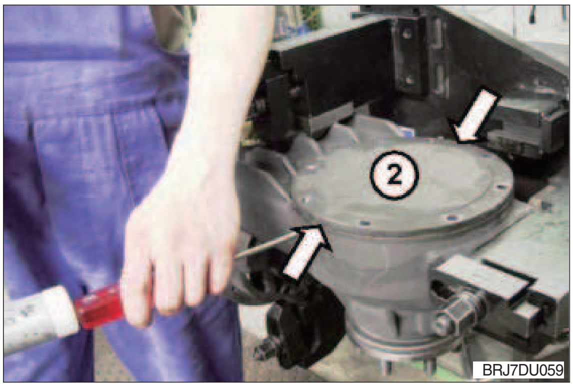
(3) Removal of wheel shaft and crown gear

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

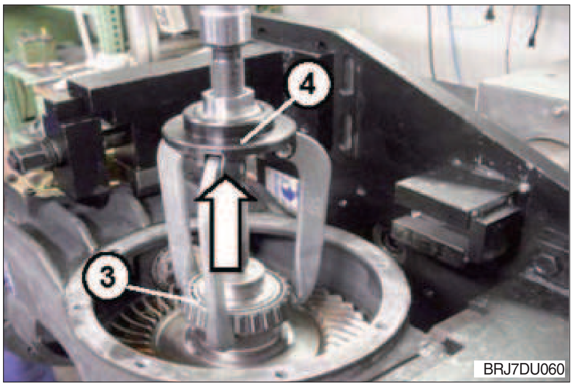
⚠ Do not damage the housing and cover surface! Burrs and other damages on the sealing surface which are caused during the removal have to be eliminated. Touch up damaged sealing surface on the housing with an oil stone!



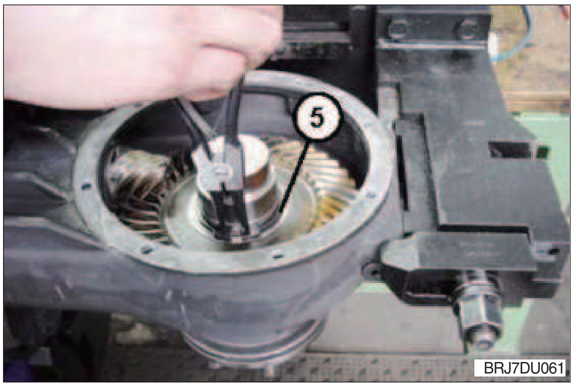
② Loosen the housing cover (item 2) by tapping against the outer edges and remove it. Use the two recesses in the housing.



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



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



(4) Loosening of taper press fit

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

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

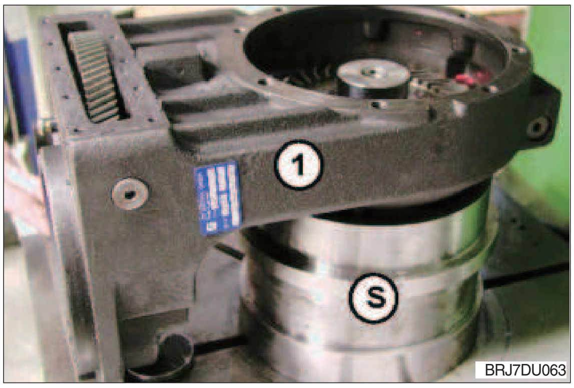
(S) Pressure oil device 62222

BRJ7DU062

② Pressing-off by means of press

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

(S) Press-out fixture 63428

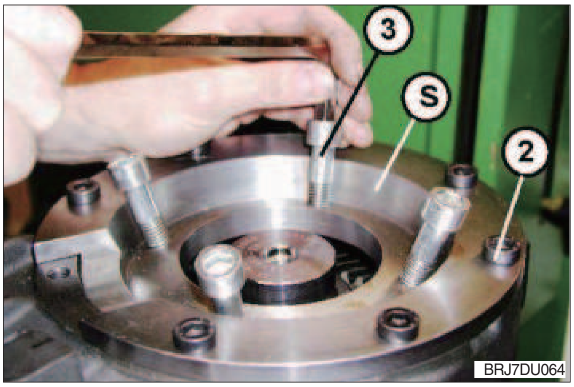


BRJ7DU063

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

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

(S) Holding fixture 62519

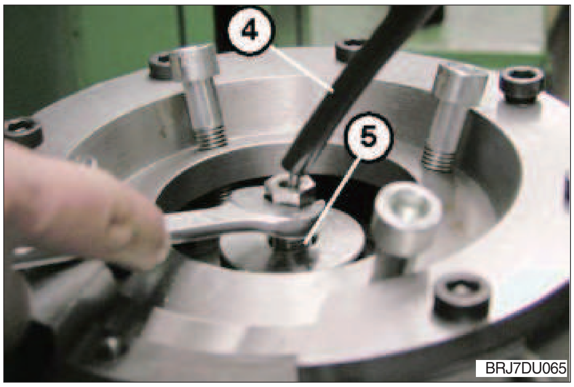


BRJ7DU064

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

Fixedly tighten the connecting nipple with an openjaw spanner.

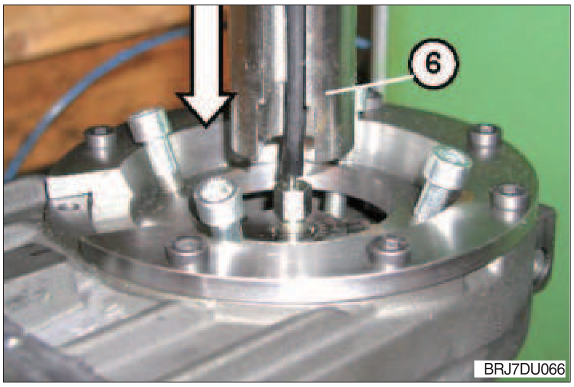
⚠ Pay attention for pressing-off that there is sufficient clearance in pressing-off direction avoiding that the wheel shaft is bottoming. Do not jam the wheel shaft at the pressing-off procedure.



BRJ7DU065

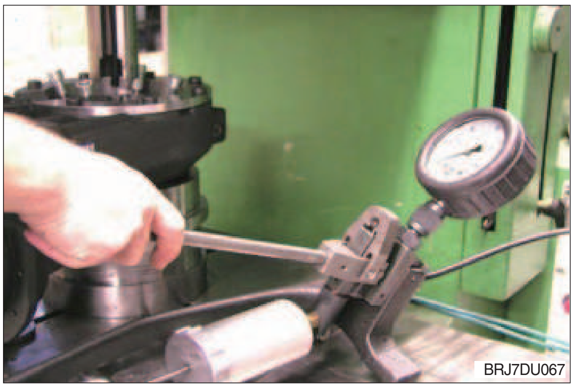
⑤ Mount the stamp (item 6) from the holding fixture (see Figure 64) into the press.

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

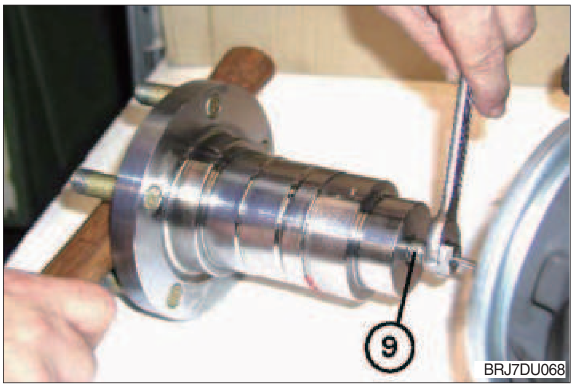


BRJ7DU066

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

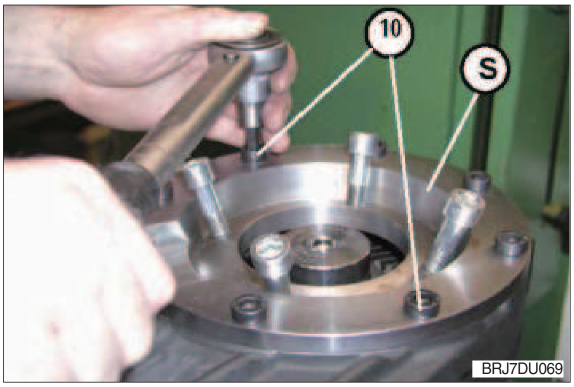

BRJ7DU067

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



BRJ7DU068

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

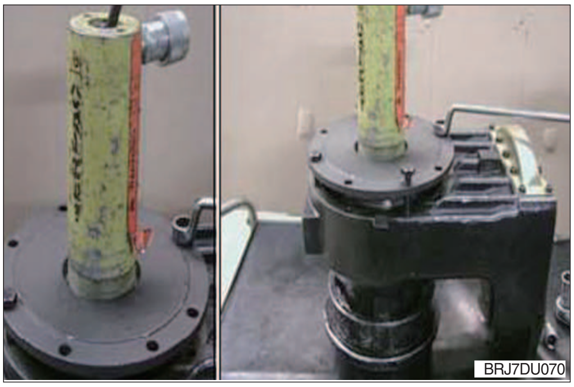


⑨ Pressing-off by means of 2nd hand pump

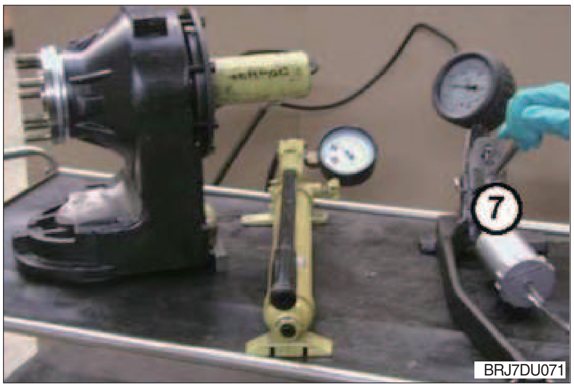
Alternatively the wheel shaft can be pressed off with a second press-out cylinder, e.g. in the mobile area. It is to be proceeded as follows:

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

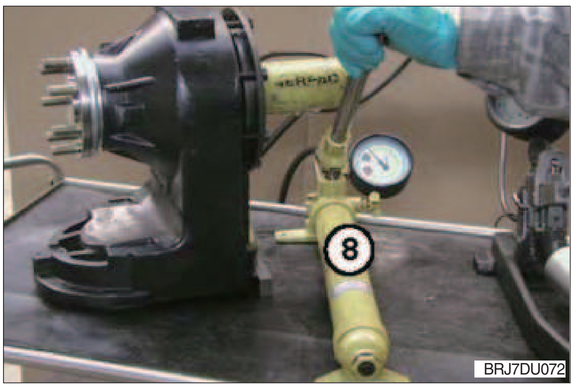
(S) Press-out cylinder 63428



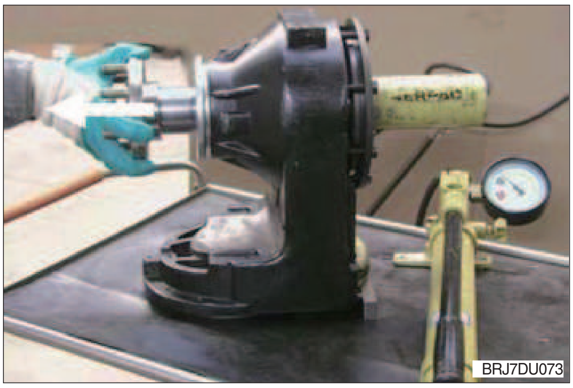
⑩ Actuate the pressure oil device (item 7) until approx. 30MPa/4300psi is reached. Under this pressure the bevel gear is expanded sufficiently.
This pressure is to be kept constant by pumping subsequently until the wheel shaft has been loosened completely.



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

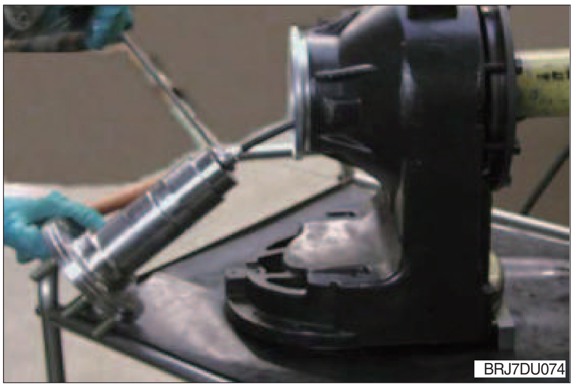


⑫ Take the wheel shaft out of the transmission.



BRJ7DU073

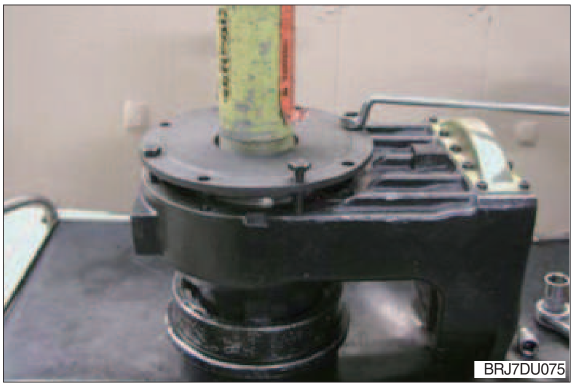
⑬ Unscrew the hydraulic hose from cylinder 1 of the wheel shaft. Wipe off excessive oil.



BRJ7DU074

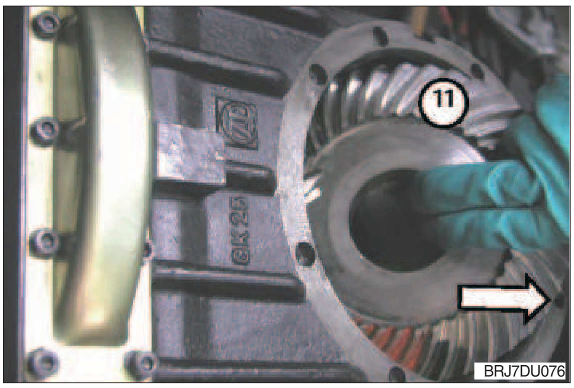
⑭ Unscrew the dis- and assembly fixture from the transmission

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



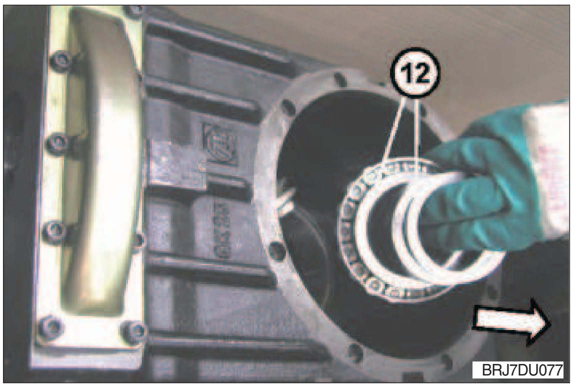
BRJ7DU075

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



BRJ7DU076

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



(5) Removal of bevel pinion shaft

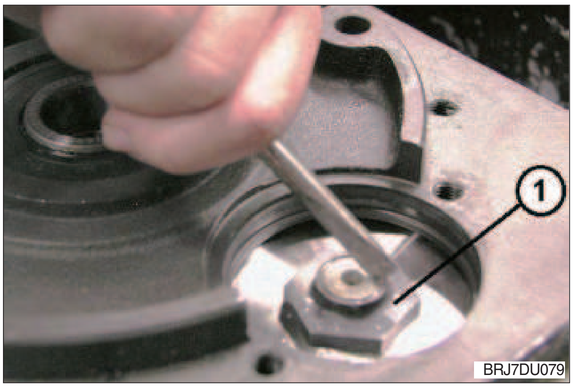
① Put the gear lock "S" into the housing bearing bore of the drive pinion and block the helical gear with it.

(S) Gear lock 62228

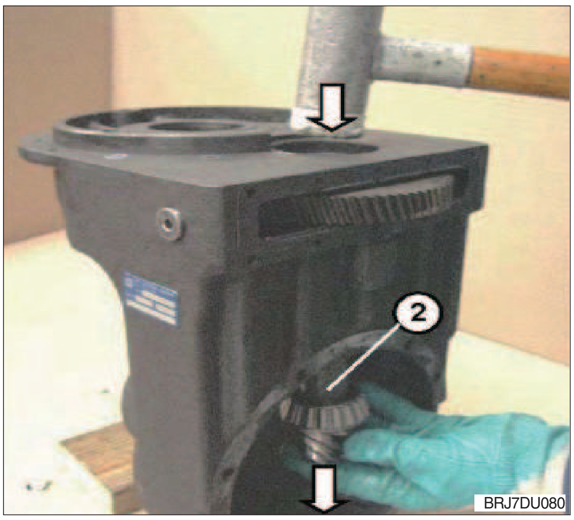
② Unlock the hexagon nut (item 1). Loosen, take off and remove the hexagon nut.

③ Take out and remove the gear lock.

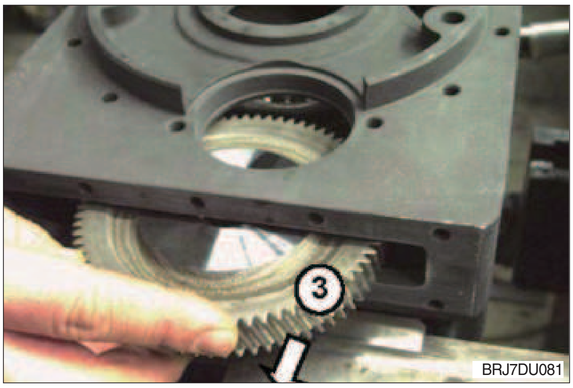
⚠ **Pay attention not to damage the bevel pinion shaft when it is expelled in the following procedure.**



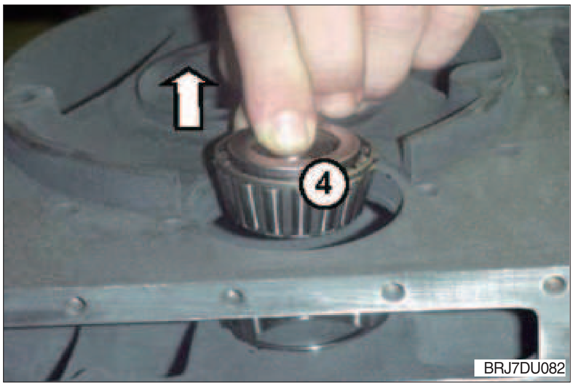
④ By means of a dead-blow soft face hammer expel the bevel pinion shaft (item 2) from the internal gearing and the bearings.



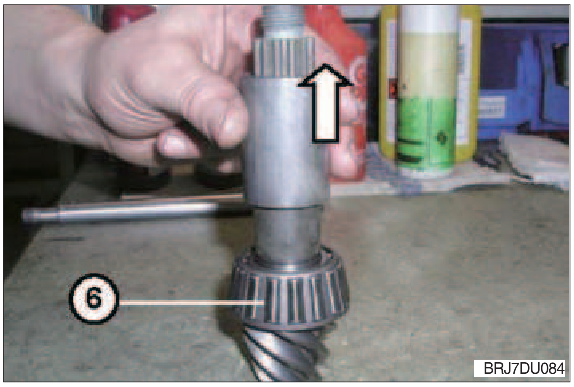
⑤ Pull out, remove and keep the helical gear (item 3) from the cover opening of the housing.



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



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



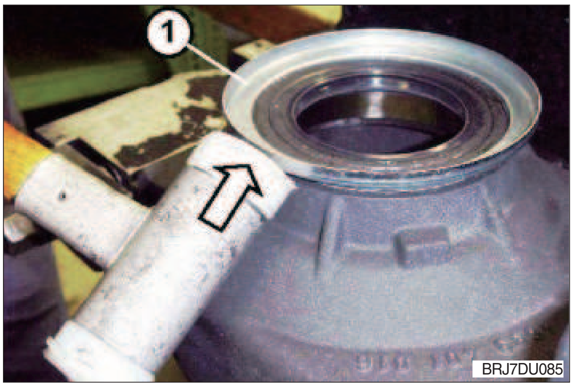
⚠ If disassembly of the bearing inner ring is not possible with a special tool or puller, the bearing cage must be destroyed and the inner ring must be removed by heating.

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

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

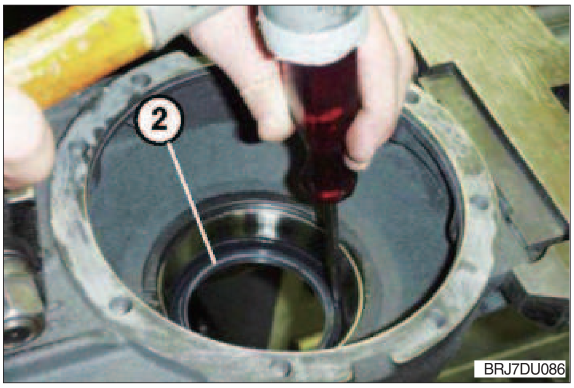
① By means of a hammer remove the thread protective shield (item 1) from the glued joint on the housing.

⚠ Do not damage the housing and supporting face!



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

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



(7) Disassembly of bearings

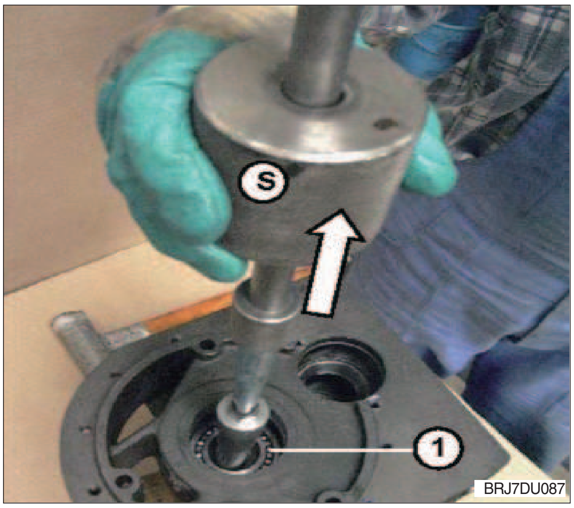
Disassembly bearings drive pinion

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

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

(S) Extracting fixture 225296

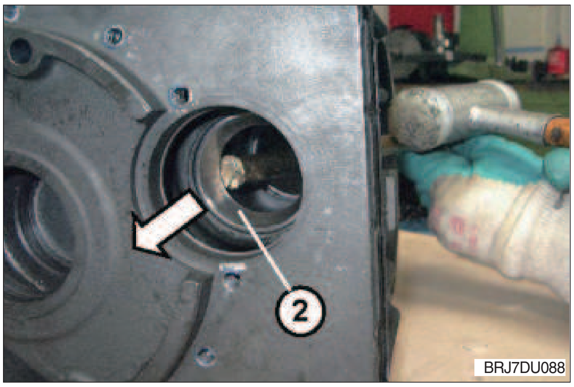
⚠ Upon removal of the bearing outer rings put them to the respective bearing inner ring.



Disassembly bearings bevel pinion shaft

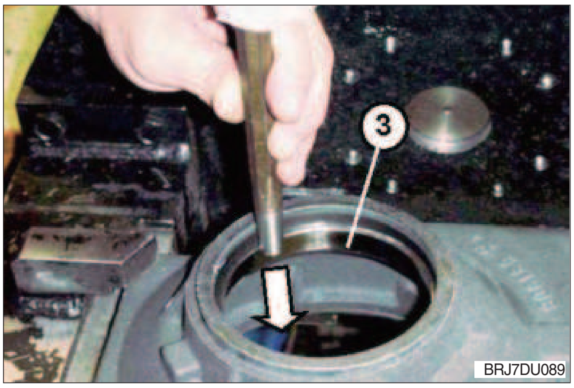
① Expel the outer rings of the taper roller bearings (item 2) on both sides from the housing seat cautiously.

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



Disassembly bearings wheel shaft

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



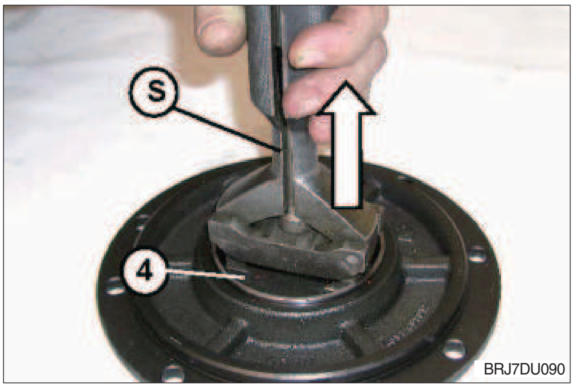
② Pull out and remove the outer ring of the 2nd taper bevel bearing (item 4) with the bearing extracting fixture "S" from the bore of the housing cover.

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

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

(S) Extracting fixture 222863.2

Thus the disassembly is ended.



5. COMPLETE REASSEMBLY

1) GENERAL INSTRUCTIONS FOR REASSEMBLY

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

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

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

2) CONSUMABLES

Suitable cold cleaners, e.g. LOCTITE.

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

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

3) USED DESCRIPTIONS AND SYMBOLS

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

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

4) USE OF REMOVED SHIMS AS BASIS FOR REASSEMBLY

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

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

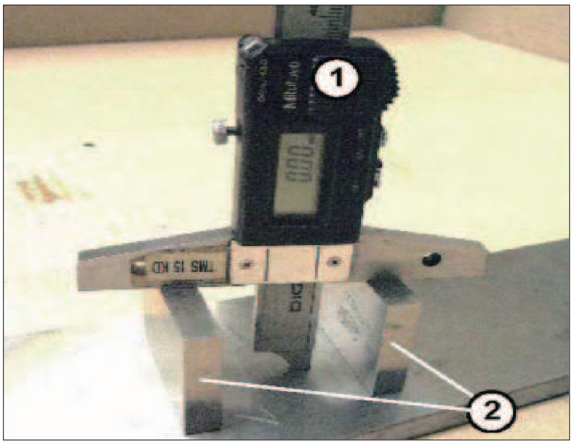
(2) If all of the removed components are to be reused, the original shim thickness has also to be used again.

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

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

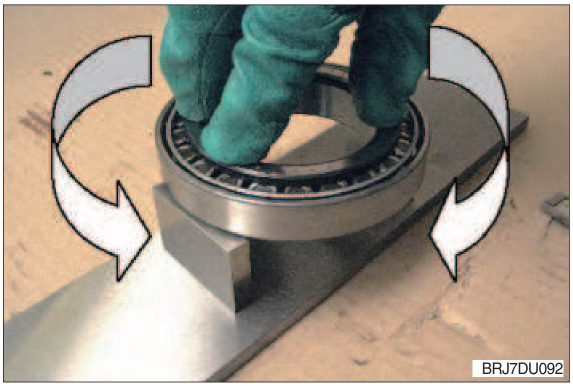
(1) Determination of bearing width general

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



BRJ7DU091

② Put the new bearing on both gauge blocks and roll it as shown.



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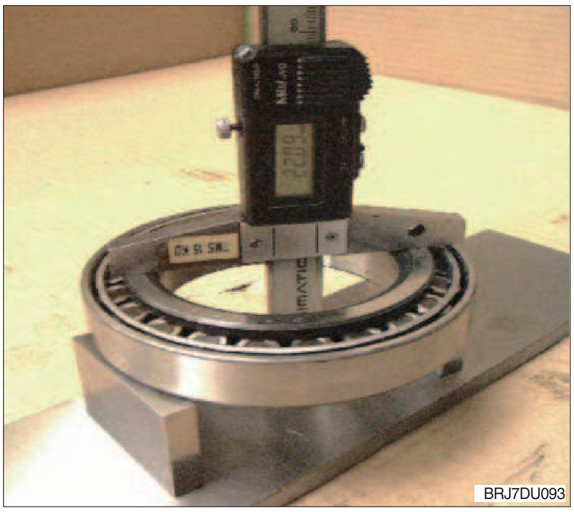
③ Determine dimension "B".
Example : Dimension "B" = 22.09 mm



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(2) Determination of bearing difference for the installation of removal shims

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

Example :

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

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

6) DETERMINATION OF BASIC INSTALLATION DIMENSIONS

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

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

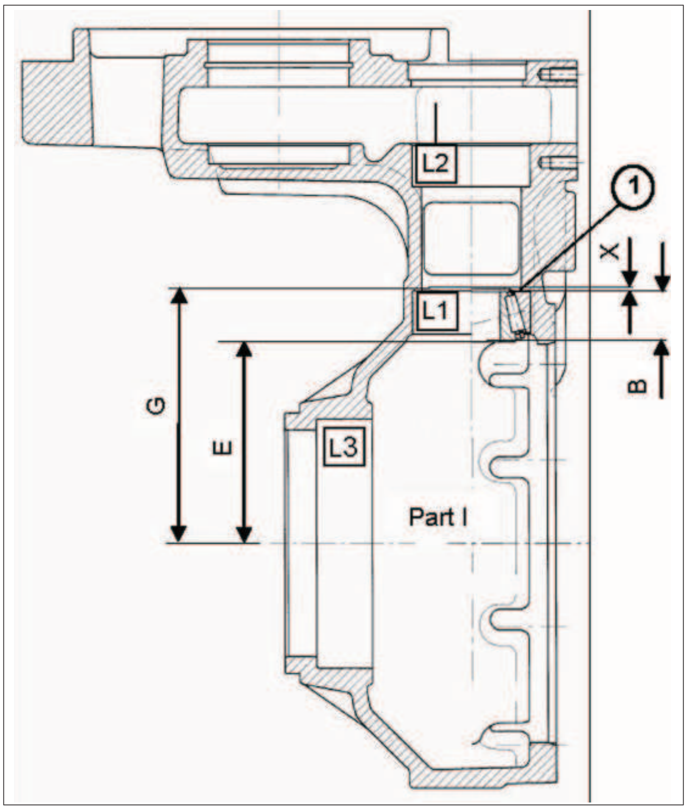
Thickness of the shim (Item 1) and the correct setting of the bevel pinion shaft respectively will be determined according to the following method:

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

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

③ Put measuring fixture part Ⅰ to zero.

(S) Measuring fixture I 62231



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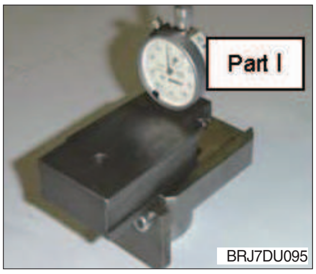
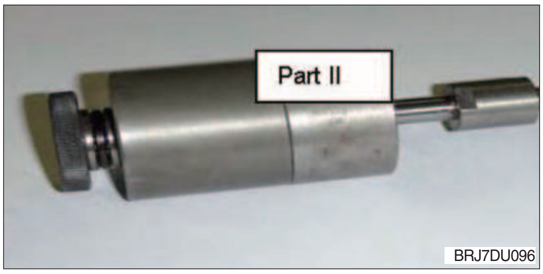
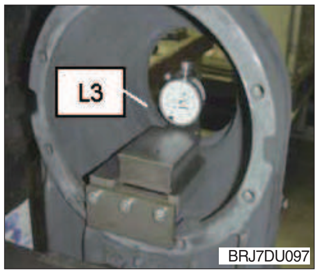






At zero position of the dial gauge the following can be taken as basis:
Dimension "1" = 111.50 mm

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

Example :

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

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

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

Dimension "E" : 89.00 mm

Calculation example

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

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

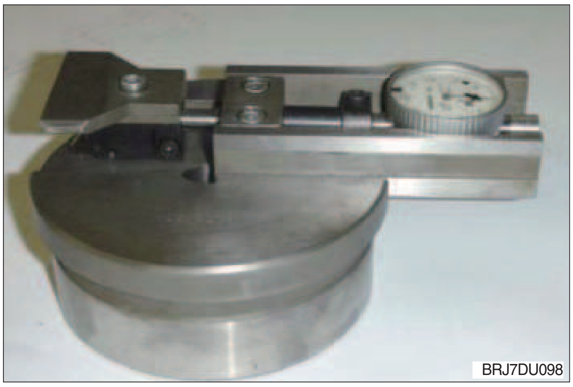
Add shims according to thickness X = 0.46 mm

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

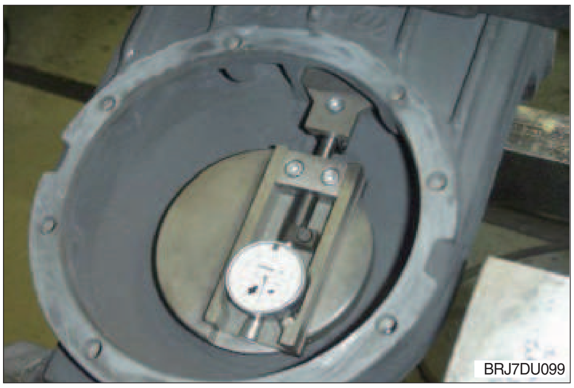
Correct setting of the crown gear is necessary to obtain an optimum torsional backlash of the bevel gearing.

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

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



① Put the measuring fixture into the housing bearing bore L3 until contact is obtained (see Figure 100 or 101).
(S) Measuring fixture 62827



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

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

Example:

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

By means of the equation

X = G - E - B - K1

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

Dimension "E" = 46.00 mm

Example :

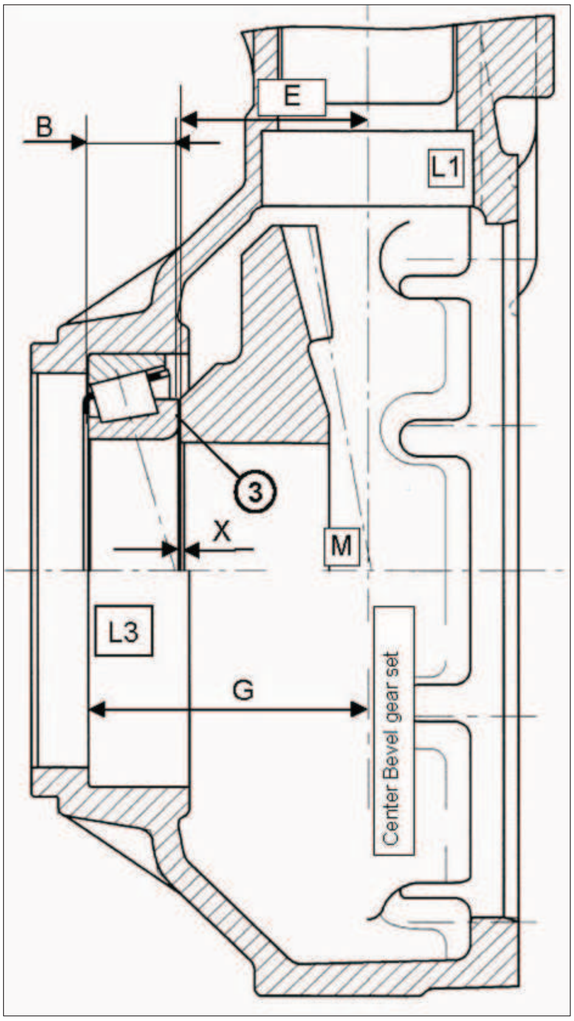
Dimension "G"	68.53 mm
Dimension "B"	22.09 mm
Dimension "E"	46.00 mm
Dimension "K1"	0.11 mm

X = G - E - B - K1

X = 68.53 - 46.00 - 22.09 - 0.11 =

0.37 mm

Schematic sketch



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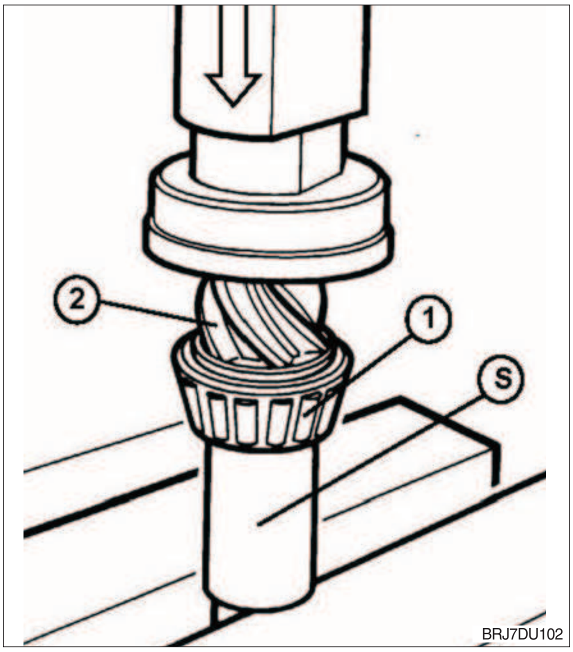
7) INSTALLATION OF BEARING FOR BEVEL PINION SHAFT AND EXACT SETTING OF THE BEARING PRELOAD

(1) Preassembly of bevel pinion shaft with bearing

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

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

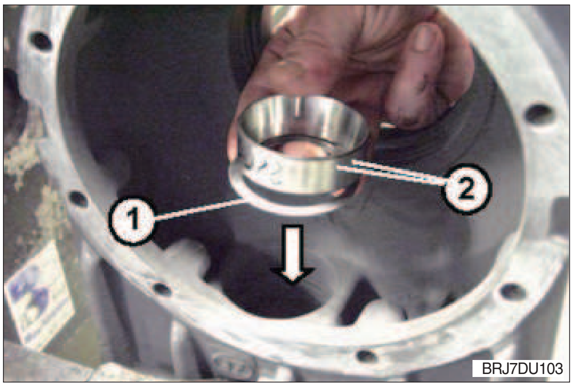


BRJ7DU102

(2) Installation of bearing outer ring into the housing

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

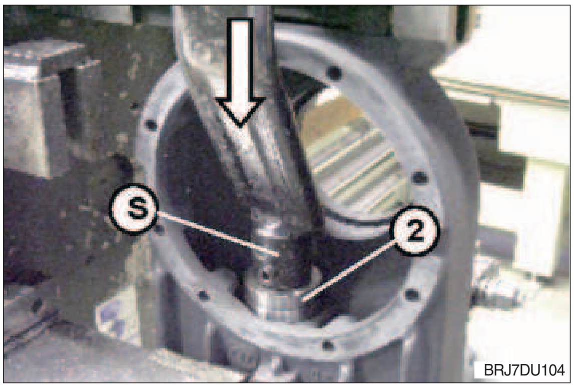
② Put the shim(s) (item 1) and the bearing outer ring (item 2) into the bearing seat.



BRJ7DU103

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

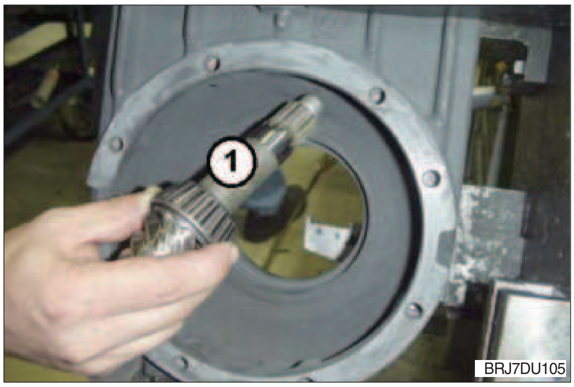
⚠ A repeated measurement of the bearing height is only allowed to result in a deviation of max. ±0.05 mm. Otherwise the process of the shim calculation has to be repeated.
(S) Striking mandrel 62529



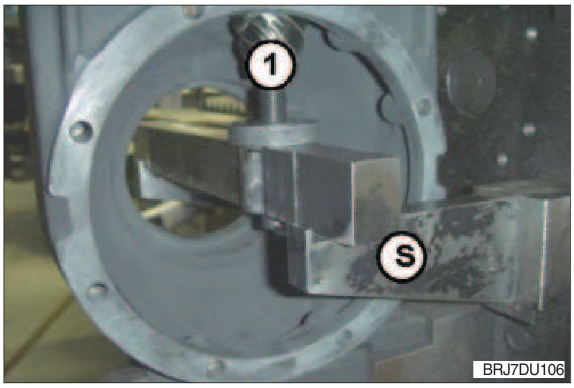
BRJ7DU104

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

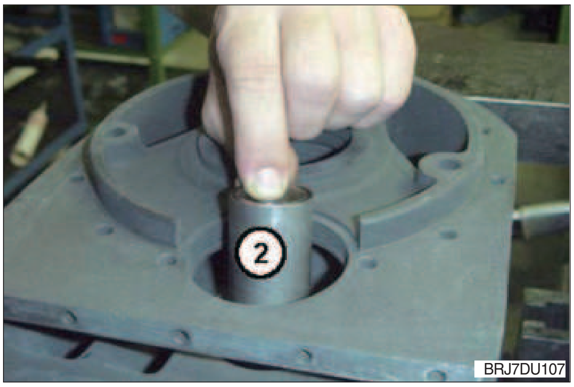
① Install the preassembled bevel pinion shaft (item 1) from the bottom into the housing.



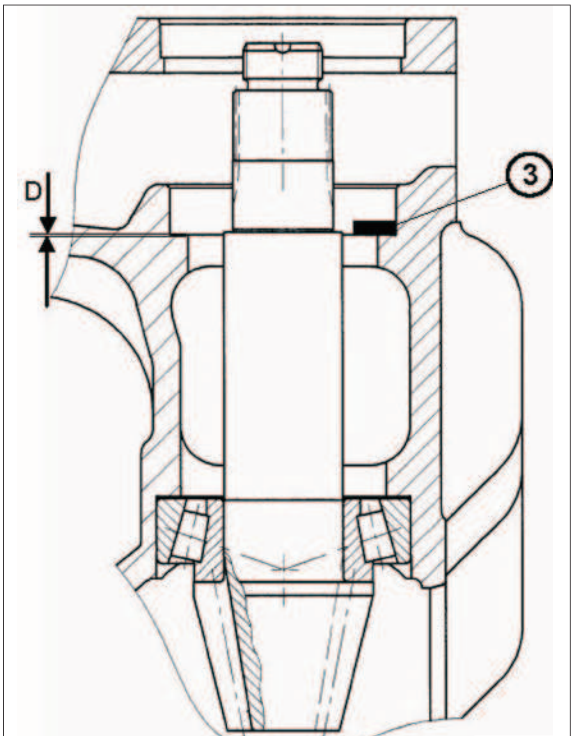
② By means of the counter holder "S" preload the bearing outer ring in the housing hand-tight.
(S) Counter holder 62507-1



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



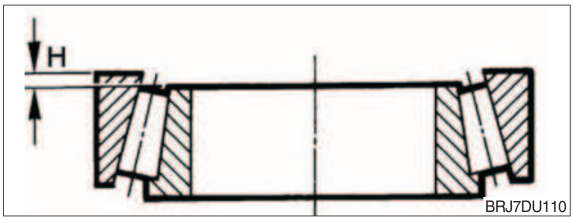
Determine distance dimension "D" from the spacer bush (item 2) to contact of the bearing outer ring in the housing.
(item 3 is the required shim thickness)



BRJ7DU108

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

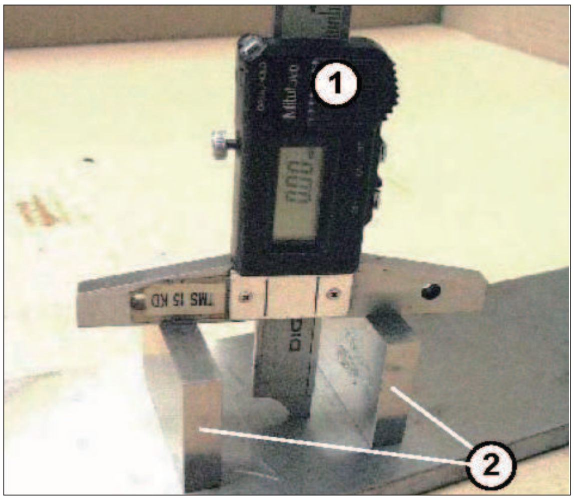
① Arrow gap = Bearing slack H



BRJ7DU110

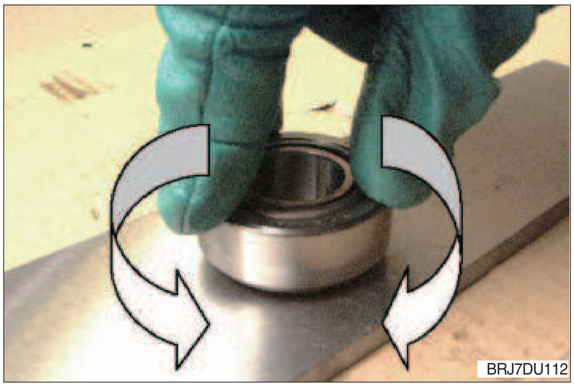
Measure the bearing slack "H" with a measuring fixture and gauge blocks/ measuring ledge in the following steps :

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



BRJ7DU111

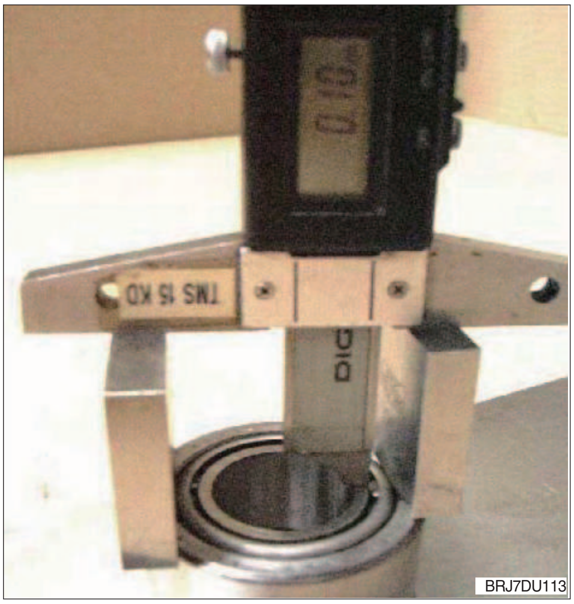
② Rolling-in of bearing.



BRJ7DU112

③ Measuring of bearing slack H.

Example : Dimension "H" = 0.10 mm



BRJ7DU113

(5) Calculation of shims required for upper bevel pinion shaft bearing

By means of the equation

X = D - H

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

Dimension "D" Distance from spacer bush

Dimension "H" Bearing slack of taper roller bearing

Dimension "a" Constant = 0.04 mm

Example :

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

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

X = D - H - a

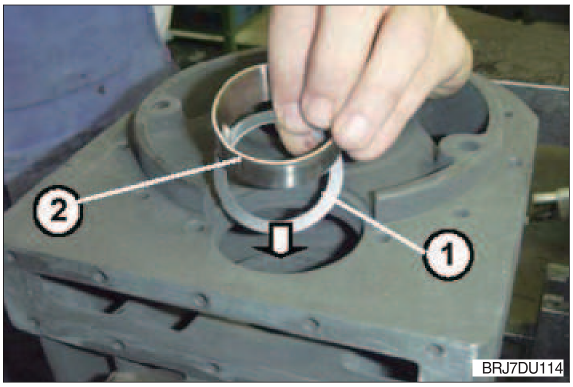
X = 0.7 - 0.10 - 0.04 = 0.56 mm

Add shims corresponding to thickness X = 0.56 mm.

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

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

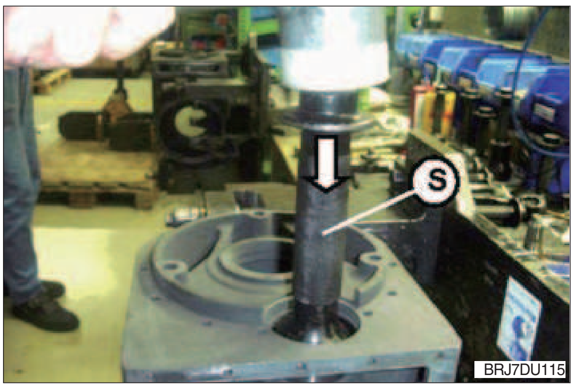
① Put shim(s) (item 1) and bearing outer ring (item 2) into the bearing seat.



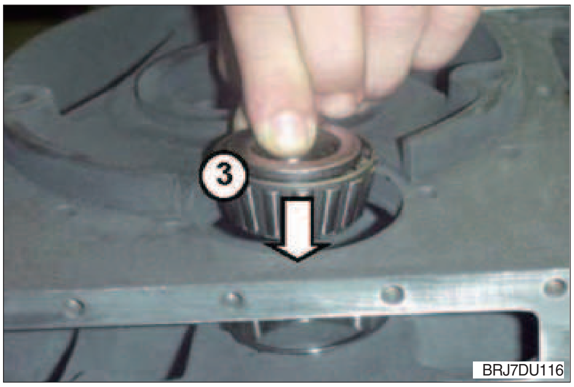
② By means of striking mandrel "S" install the shim(s) and the bearing outer ring into the bearing seat of the housing until contact is obtained.

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

(S) Striking mandrel 62747



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

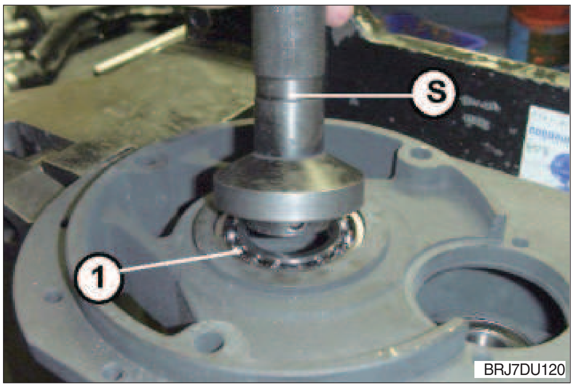


(1) Installation of grooved ball bearing for drive pinion

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

(S) Striking mandrel 62625

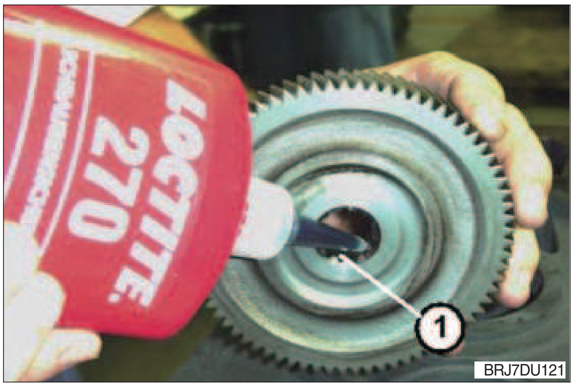
⚠ Prior to installation of the helical gear the lower grooved ball bearing has to be installed into the housing bearing bore.



(2) Installation of helical gear with bevel pinion shaft

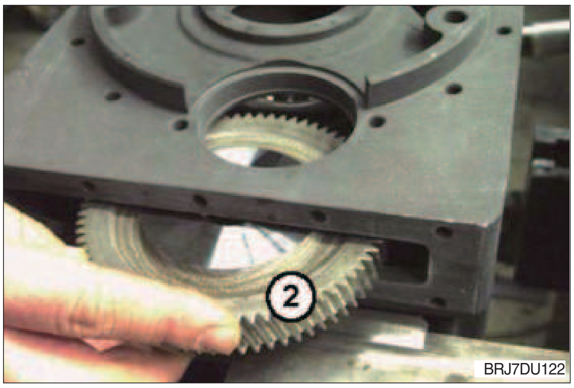
① Apply a thin and even layer of LOCTITE 270 onto the internal gearing of the helical gear (item 1).

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

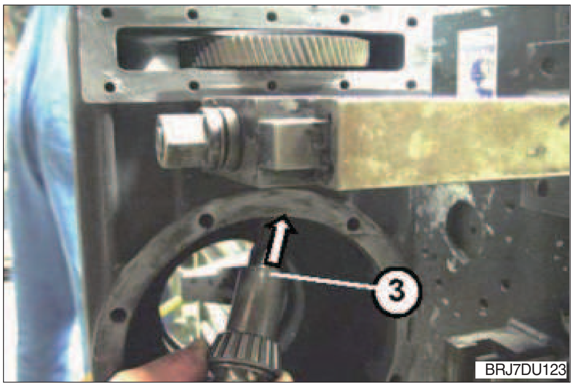


② Insert the helical gear (item 2) by the lateral opening of the housing, align it centrally and put it onto the taper roller bearing.

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

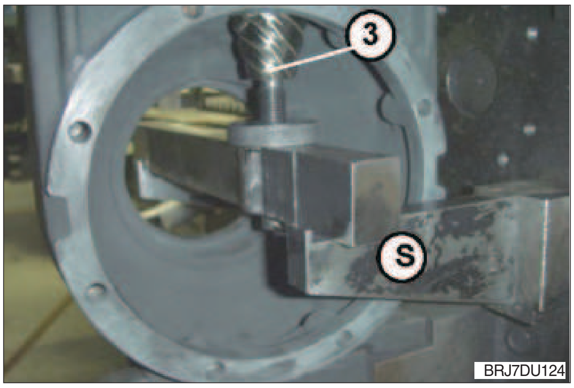


③ Install the bevel pinion with space bush (item3) from the bottom into the housing and assemble is through the profiled seat of the helical gear bore.



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

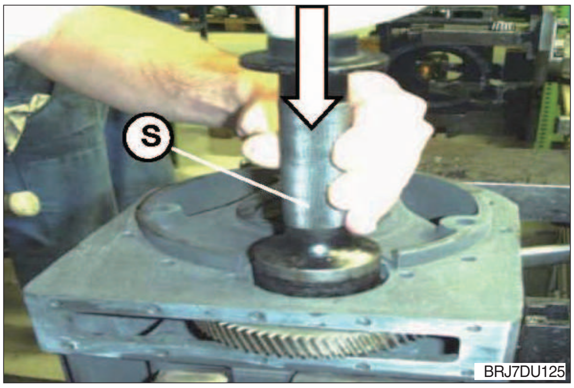
(S) Counter holder 62507-1



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

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

(S) Striking mandrel 62846



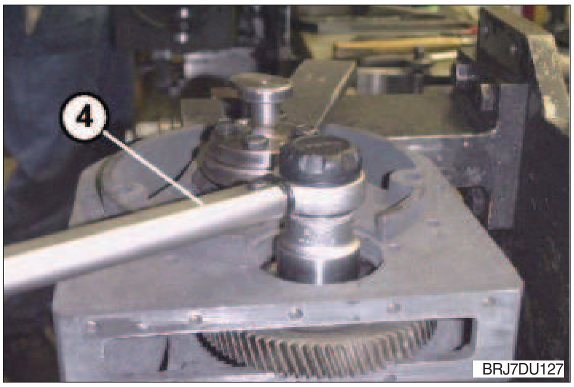
⑦ Insert gear lock "S" into the housing bearing bore of the drive pinion and block the helical gear.

(S) Gear lock 62228

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

Tightening torque : 100 Nm

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



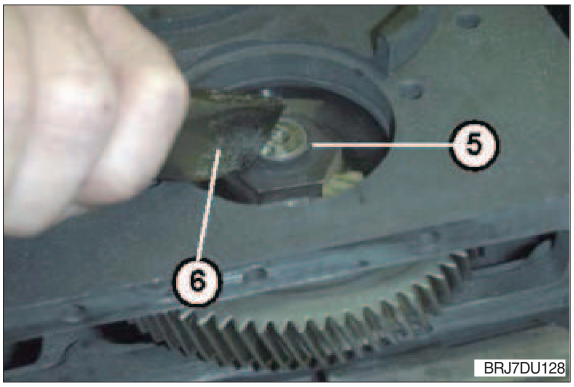
⑨ Turn the bevel pinion shaft and the helical gear respectively by hand several times, that the taper rollers can align in the bearing rings.

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

0.5 ... 1.0 Nm

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

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

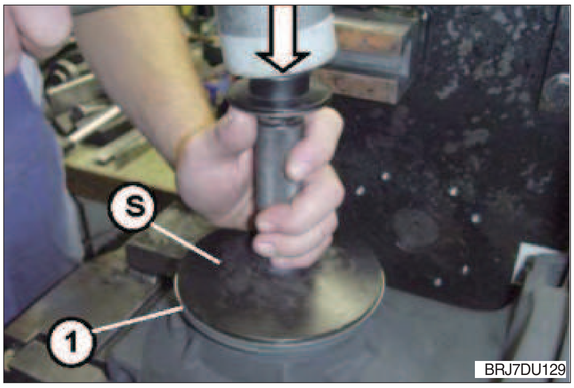


9) INSTALLATION OF CROWN GEAR AND WHEEL SHAFT INTO THE HOUSING

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

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

(S) Striking mandrel 63293



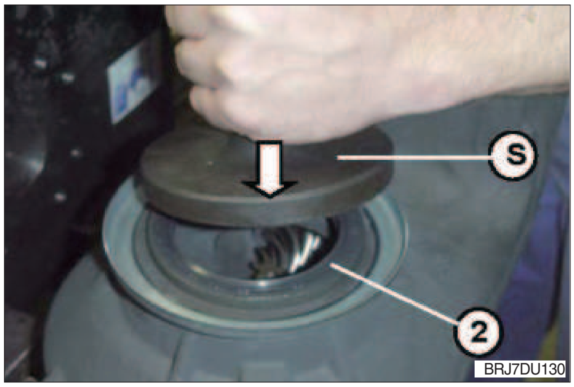
② Apply a thin and even layer of LOCTITE 574 onto the outer diameter of the radial sealing ring.

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

(S) Striking mandrel 63291

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

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

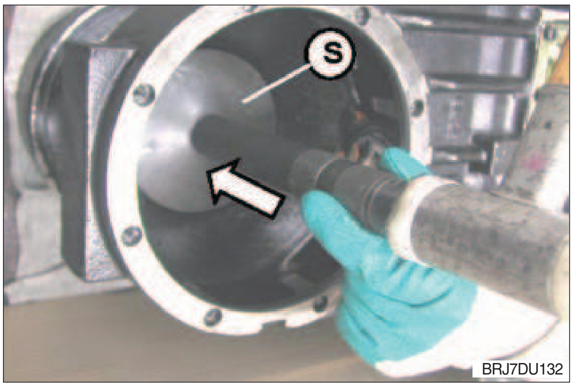


③ Wet the sealing lip of the radial sealing ring with grease (e.g. Shell Alvania R3) slightly.

(2) Installation of taper roller bearing into the housing

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

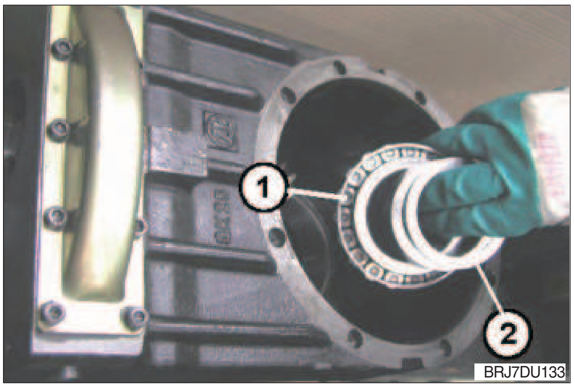
(S) Striking mandrel 62542



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

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

④ Insert shim(s) (item 2).



(3) Determination of control dimension for seat

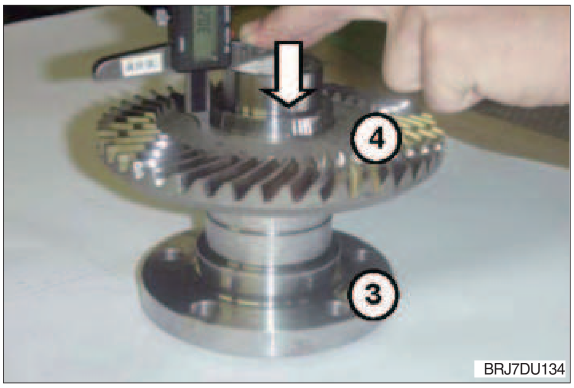
① Place the wheel shaft (item 3) onto a plane and solid support. Mount the crown gear (item 4) onto the taper seat of the wheel shaft by hand cautiously and press it on slightly.

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

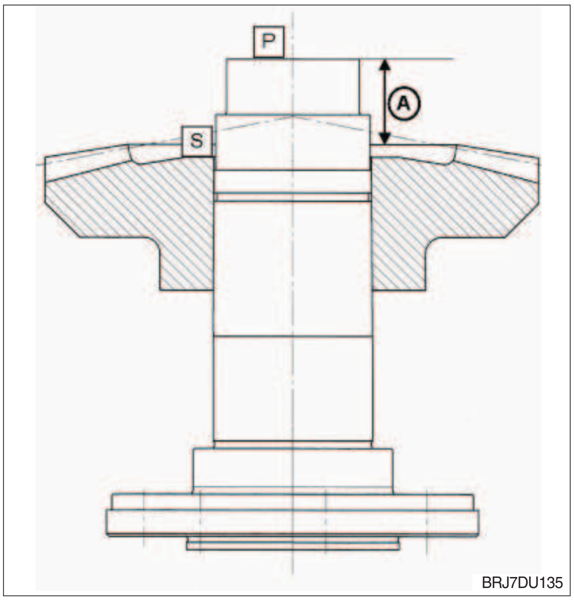
Dimension "A" e.g. 30.85 mm

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

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



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



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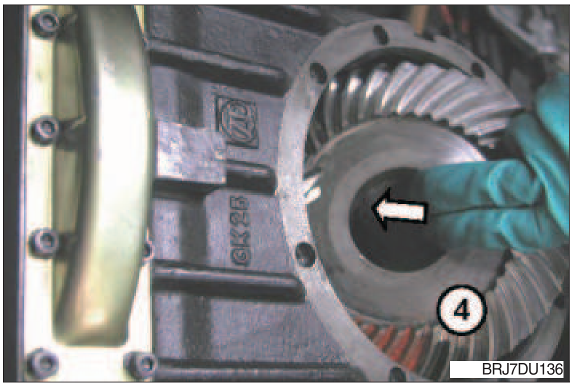
① Assemble the crown gear (item 4) into the housing carefully and insert it into the gearing of the bevel pinion shaft at the same time. Pay attention that the crown gear is aligned centrally to the shim and the bush.



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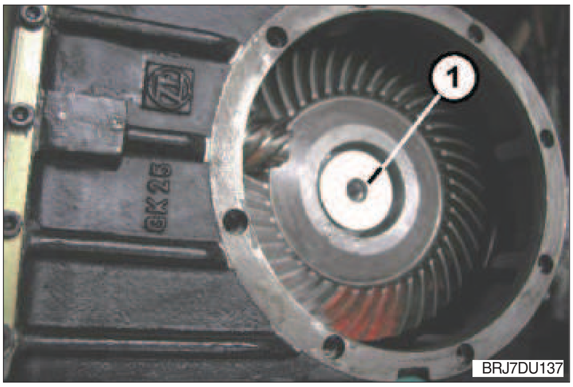
(4) Pressing-on wheel shaft

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

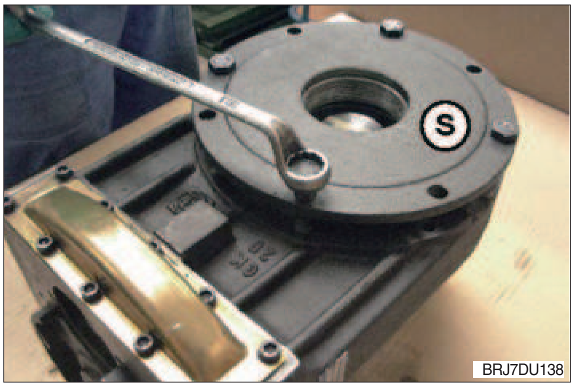
Press-on force: 250 kN up to max. 300 kN.

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



② Screw on the press-on fixture (S).

(S) Press-on fixture 63428



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

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

(5) Determination of seat

⚠ The seat must be 10 to 15 mm.

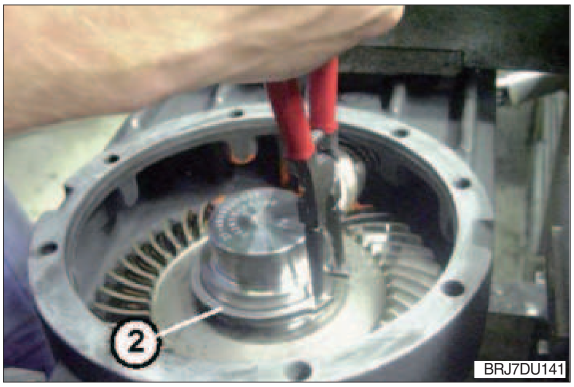
① Measure Dimension A from plane face/ wheel shaft to face/crown gear once again (see chapter 9) (3) at page 3-38 "Determination of control dimension for seat".

Dimension "A" e.g. 44.34 mm

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

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

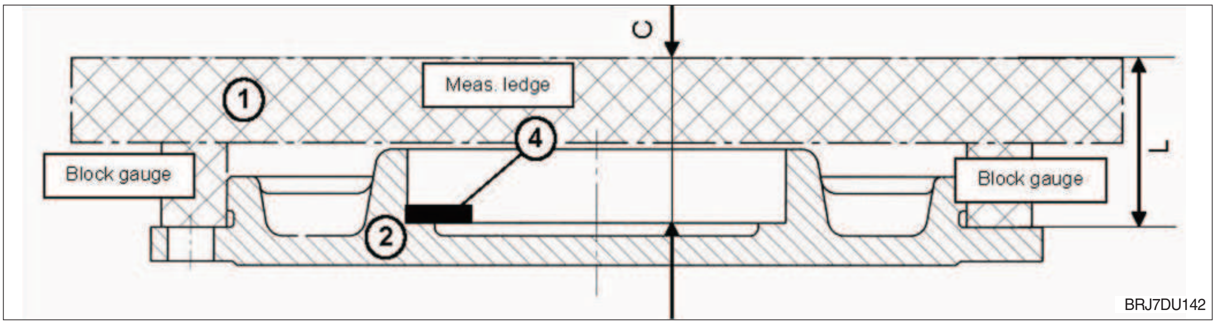
② Install the retaining ring (item 2).



10) INSTALLATION OF BEARING FOR WHEEL SHAFT

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

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



1 Measuring ledge
2 Housing cover

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

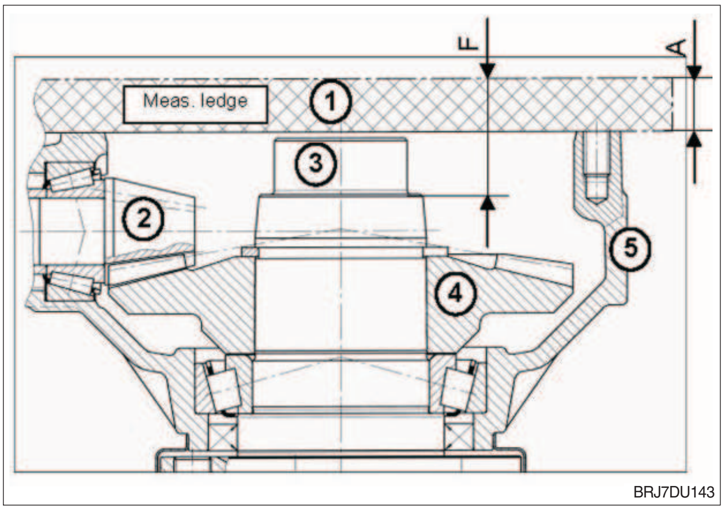
1 Measuring ledge
2 Bevel pinion shaft
3 Wheel shaft
4 Crown gear
5 Housing

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

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

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

Dim. "F"
e.g. 23.01 mm



(2) Calculation of shim required

Thickness of shim can be calculated with the dimensions determined.

Example :

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

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

Constant : a = 0.20 at X1 ≥ 0.31
a = 0.25 at X1 ≤ 0.30

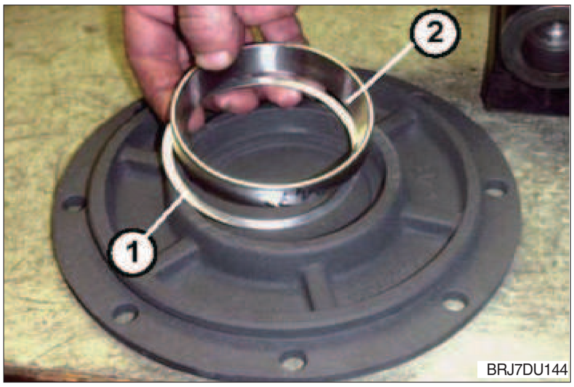
$$X = X1 + a$$
$$X = 0.31 + 0.20 \text{ mm} = 0.51$$

Add shims according to thickness X.

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

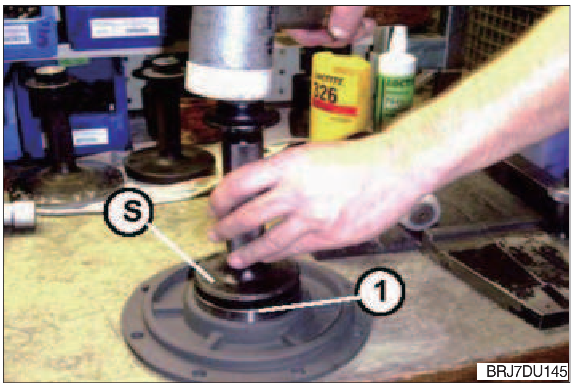
① Prepare the shim thickness determined under chapter (2) above "Calculation of shim required" by means of the differently thick shims.

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



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

(S) Striking mandrel 62748



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

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

(S) Striking mandrel 63294

(4) Installation of housing cover

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

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

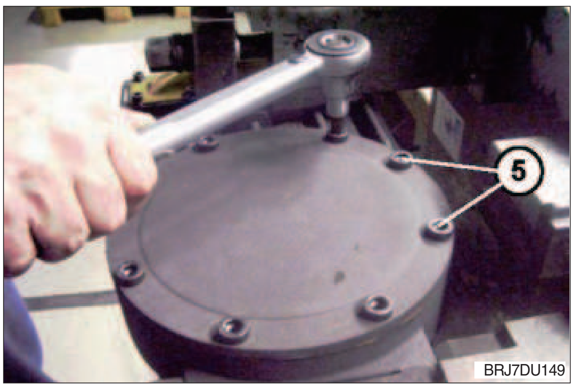
② Plane face for housing cover on the housing is to be cleaned carefully and must be grease-free.

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

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

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

Tightening torque of the cap screws : 46 Nm.

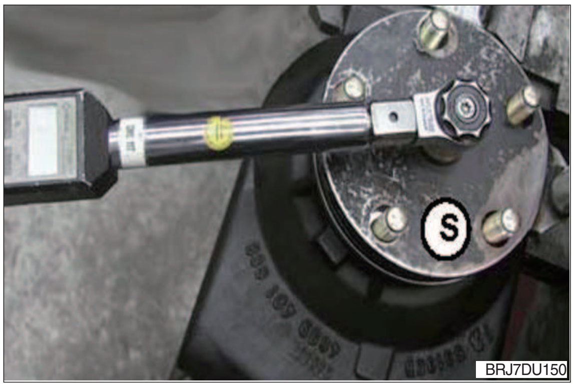


(5) Checking of bearing friction torque on wheel shaft

Rolling

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

(S) : Measuring fixture 62532



BRJ7DU150

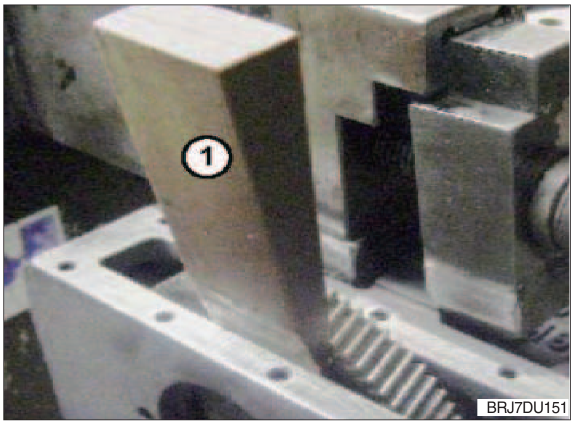
Bearing preload is adjusted correctly when a bearing friction torque of is obtained at the wheel shaft.

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

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

(6) Measuring of torsional backlash on wheel shaft

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



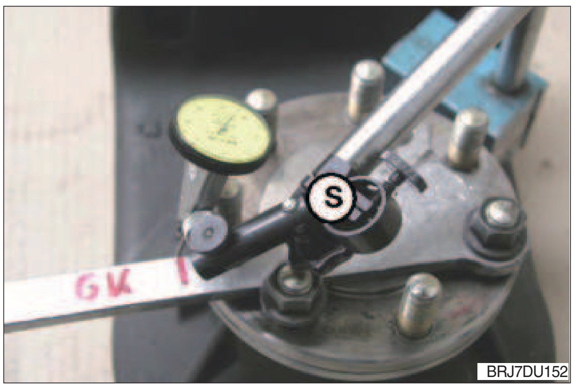
BRJ7DU151

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

(S) Measuring stop 62819

Admissible torsional backlash :
0.10 ~ 0.15 mm

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



BRJ7DU152

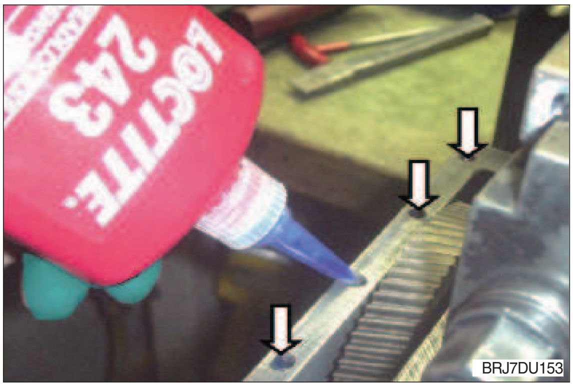
(7) Installation of side cover

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

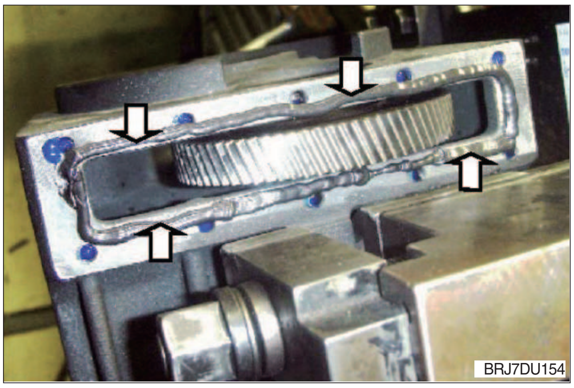
⚠ Wear safety gloves for working with adhesives and observe the LOCTITE instructions.

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

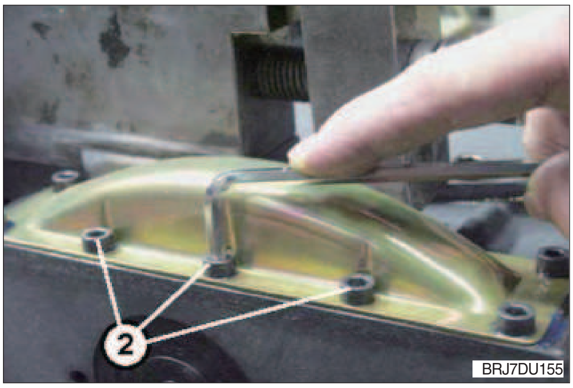
① For sealing of the through holes as well as of the area around the screw the following sealing application is required:
LOCTITE 243 : Product application into the threaded blind holes M6 as sealing function by excess product.



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



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

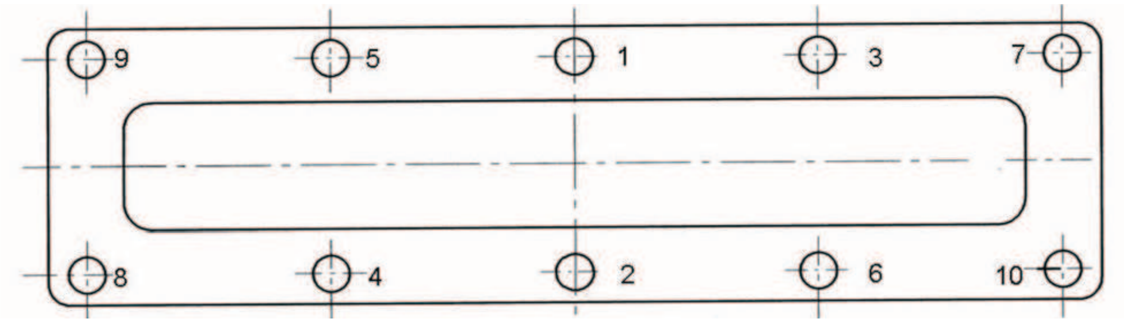


⚠ Do not yet tighten the cap screws with the corresponding tightening torque.

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

Number 1 beginning ...... Number 10 end

Tightening torque of the cap screws : 9.5 Nm



BRJ7DU156

11) PREASSEMBLY AND INSTALLATION OF DRIVE PINION

(1) Installation of ball bearing

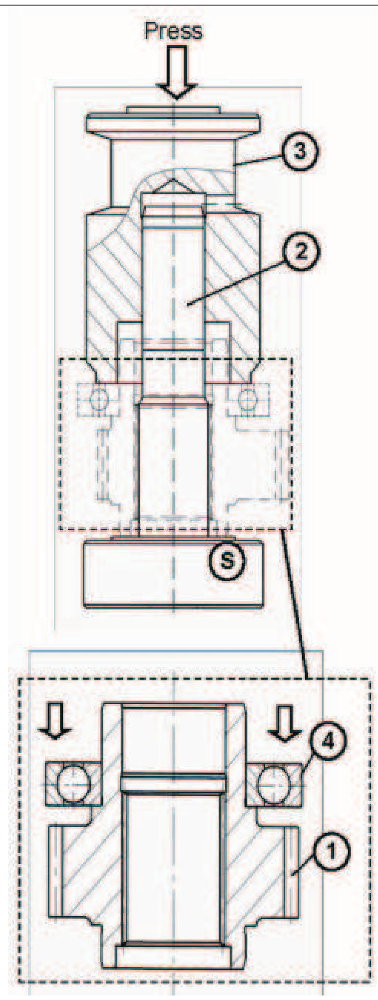
① For mounting of the bearing onto the drive pinion use assembly fixture "S", as shown.

(S) Assembly fixture 62523

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

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

(item 3) Pressing sleeve 63290



BRJ7DU157

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

⚠ Danger of burnings! Wear safety gloves.

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

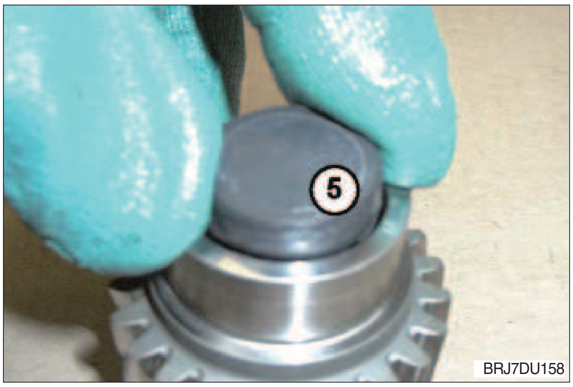
⑥ After cooling down install the bearing subsequently.

(2) Mounting of sealing cap

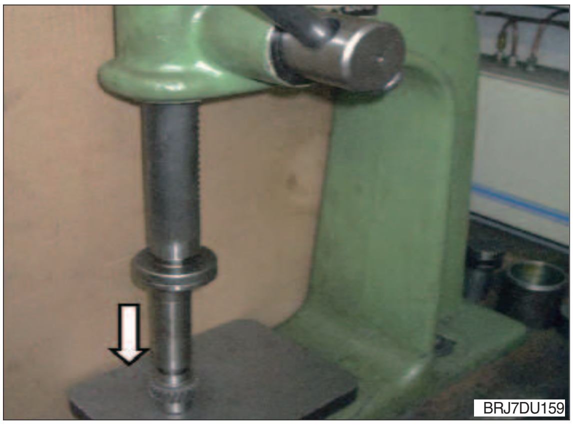
For sealing of the bore in the drive pinion a sealing cap (item 5) must be mounted. This requires the following sealing application:

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

② Insert the sealing cap.



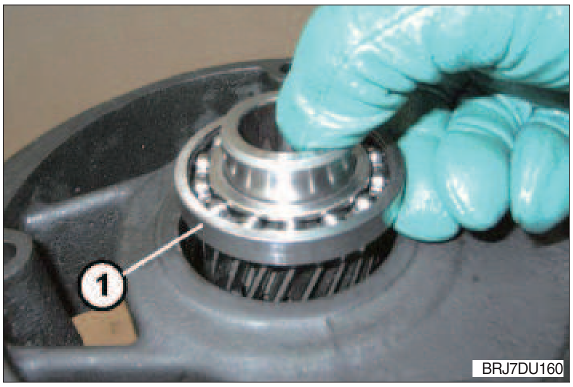
③ Press in the sealing cap with a press until contact is obtained.



(3) Installation of drive pinion

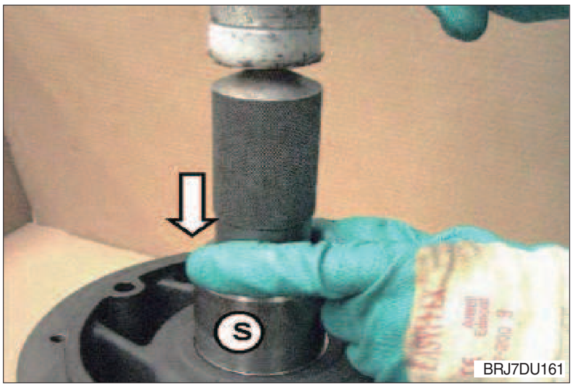
⚠ Pay attention when inserting the drive pinion not to damage the gearing of drive pinion and helical gear. Damages might cause louder running noises and consequential damages!

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

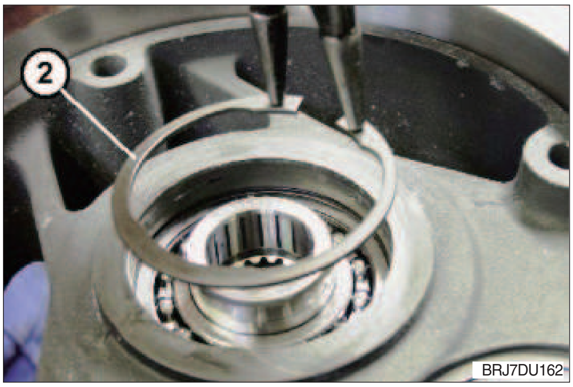


② By means of the striking mandrel "S" install the drive pinion into the bearing seat until contact is obtained.

(S) Striking mandrel 62478



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



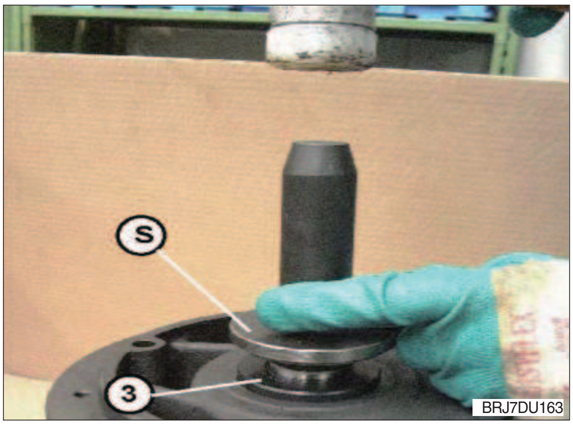
BRJ7DU162

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

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

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

(S) Striking mandrel 62521



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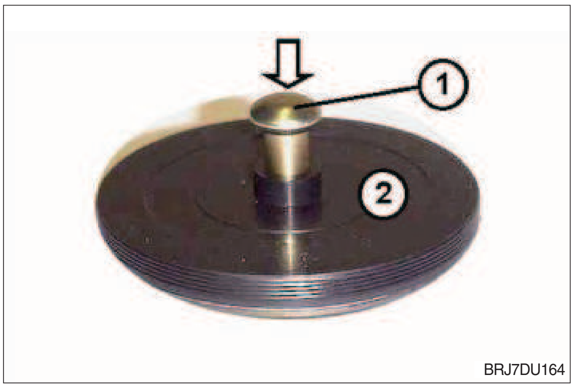
(4) Installation of sealing cap

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

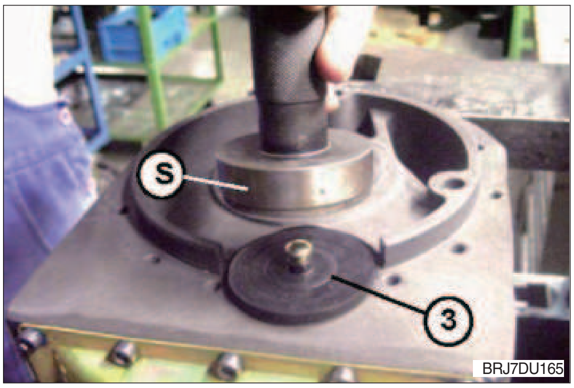


BRJ7DU164

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

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

(S) Striking mandrel 62522

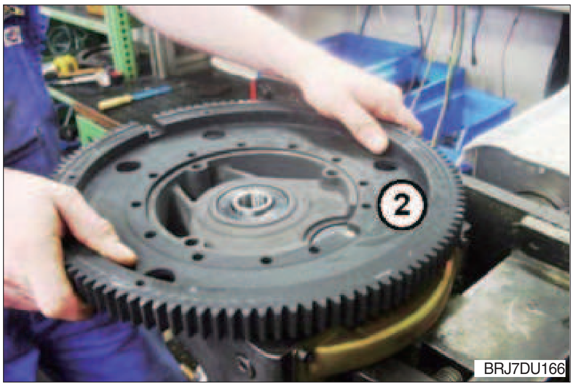


BRJ7DU165

(5) Attachment of pivoted connection geared steering

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

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



BRJ7DU166

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

④ Wet screws M8x40-10.9 with LOCTITE 243.

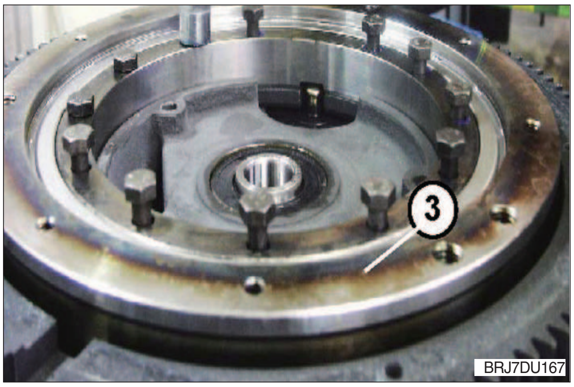
⑤ By means of the screws fasten the pivoted bogie bearing and the gear ring onto the connecting constructions.

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

Sequence of tightening:
Number 1 beginning   Number 12 end

Tightening torque of cap screws : 34 Nm

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



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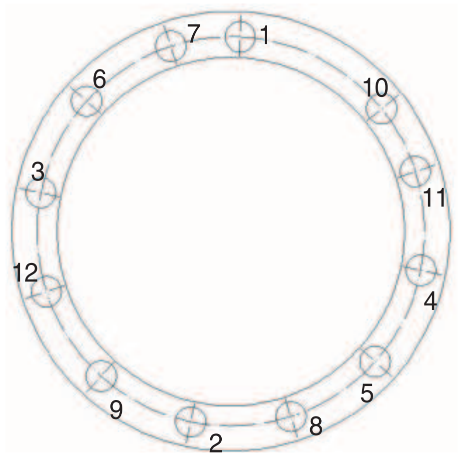


BRJ7DU169

Thus the reassembly is ended.

12) GENERAL INSTRUCTIONS AFTER REASSEMBLY

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

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

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

6. DISPOSAL

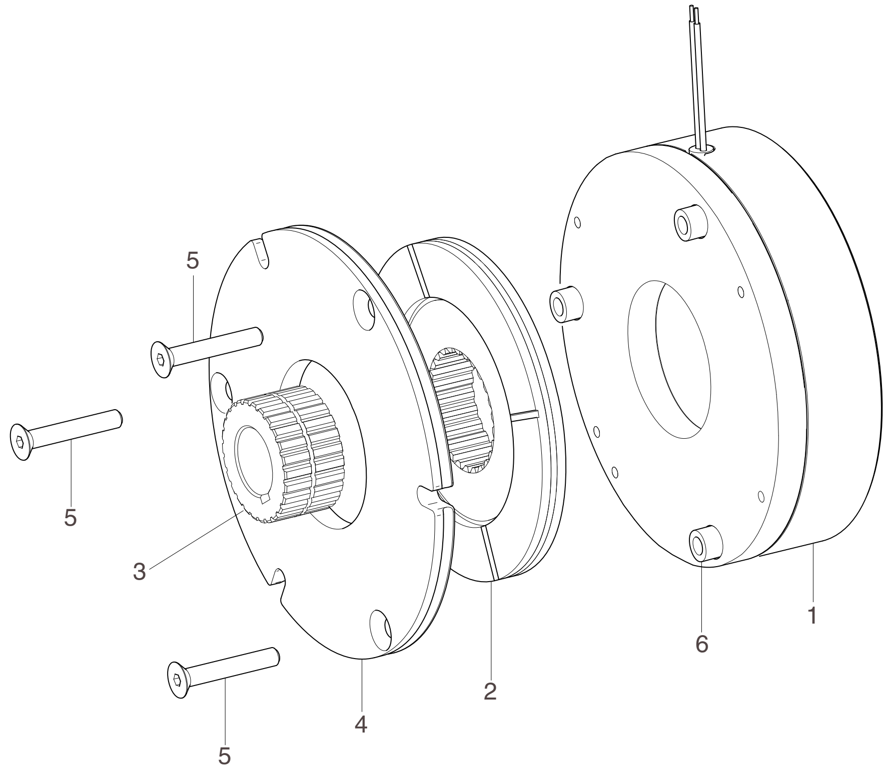
Disposal of the replaced components, materials and substances adequately, environmentally friendly and in accordance with the legal regulations for disposal for the respective material :

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

SECTION 4 BRAKE SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. STRUCTURE



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

2. SPECIFICATION

Description	Unit	Specification
Nominal torque (Standard version)	N·m	70
Max. rotation speed	rpm	5000
Nominal airgap	mm	0.25
Tightening torque of screws	N·m	9.1 (M6 on Ø132,166.5,168 mm)
		22 (M8 on Ø145 mm)
Weight	kg	4.4

3. PRECAUTIONS AND RESTRICTIONS ON USE

1) RESTRICTIONS ON USE

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

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

(3) The equipment can be fitted either horizontally.

(4) This equipment is designed for a maximum ambient temperature of 40℃ (magnet insulation 155℃).

2) PRECAUTIONS AND SAFETY MEASURES

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

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

4. REASSEMBLY AND INSTALLATION

PK brakes are delivered completely assembled, the airgap is adjusted in our workshop.

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

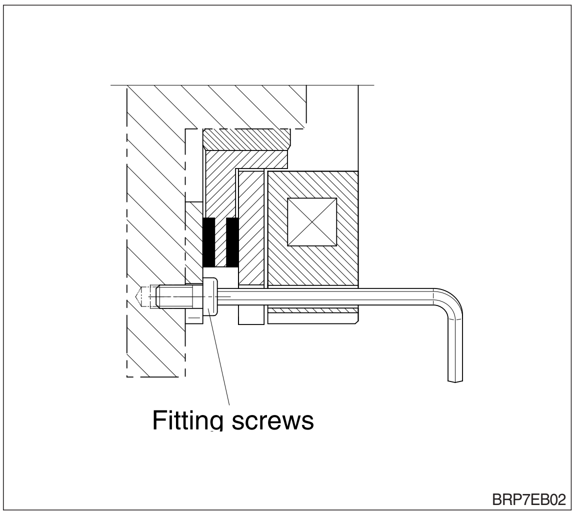
2) Slide the brake onto the hub (#3), taking care not to damage the splines of the disc (#2). Make sure that the disk locates properly on the splines of the hub.

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

4) Switch the equipment on and confirm that the friction disc rotates freely.

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

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

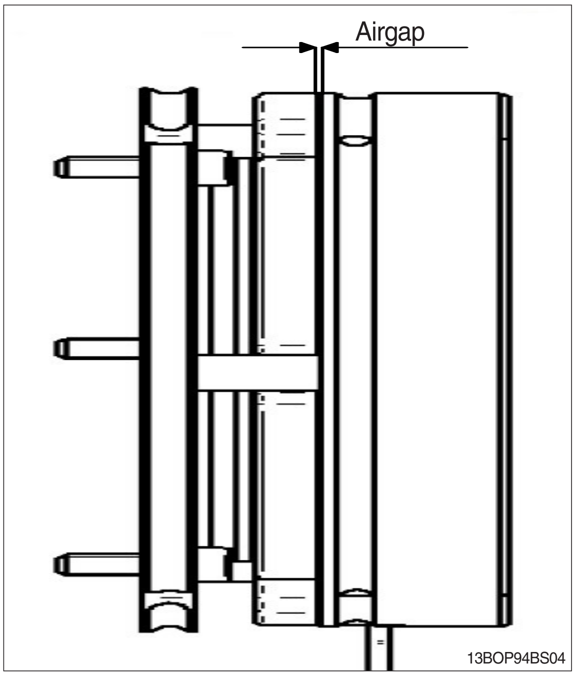


5. MAINTENANCE

⚠ When the maximum airgap is reached (value depending on the end application), the brake must be replaced.

1) The unit must not be disassembled by the customer.

2) With the wear of the disc, the brake airgap (see Fig. BS04) will increase. The airgap value must be checked regularly using feeler gauges.



6. ELECTRICAL CONNECTION

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

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

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

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

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

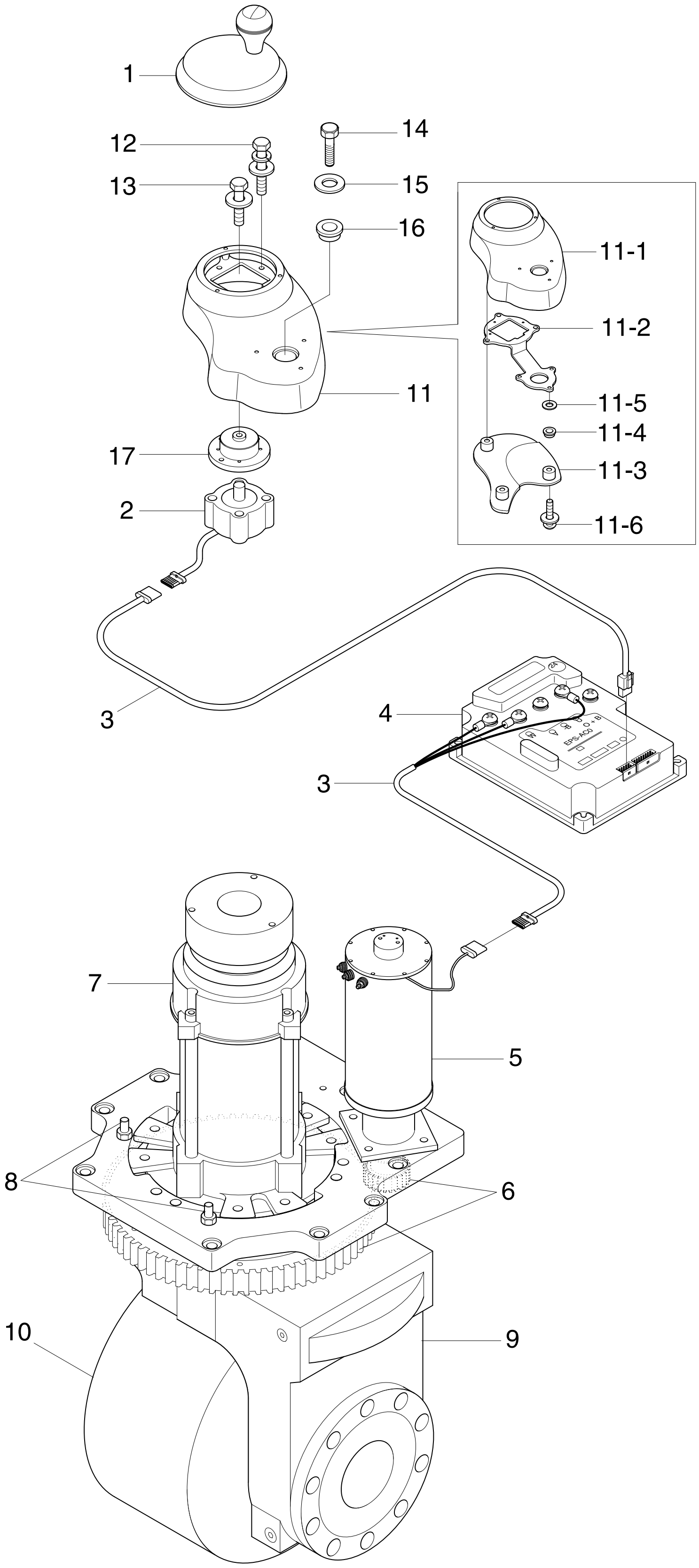
7. TROUBLESHOOTING AND FAULT ELIMINATION

FAULT	CAUSE	REMEDY
Brake does not release.	· Power supply is too low.	· Adjust power supply.
	· Power supply is interrupted.	· Reconnect power supply.
	· Worn disc	· Replace the brake.
	· Coil is damaged.	· Replace the brake.
Brake does not brake.	· Voltage present at switch off position.	· Check the power supply.
	· Grease on friction faces.	· Replace the brake.
Nuisance braking.	· Power supply is too low.	· Adjust power supply.

SECTION 5 STEERING SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. STRUCTURE



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

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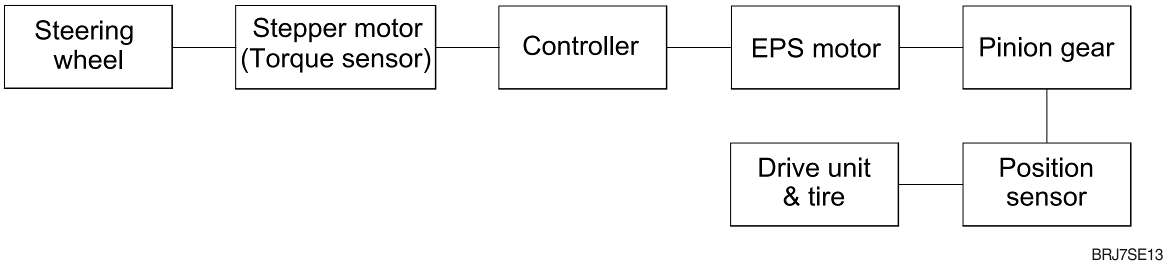
2. FUNCTION



1) Steering wheel

(1) It decides the direction of rotation of the truck.

(2) It transmits the handling of operator.

2) Stepper motor

(1) It is sensing the operation of steering wheel.

(2) It is transmits the output signal to controller.

3) Controller

(1) It decides the torque and the direction of rotation of motor.

(2) It supplied power to motor.

4) EPS motor

(1) It transmits torque to pinion gear.

5) Pinion gear

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

6) Position sensor

(1) It is sensing angle of steering.

(2) It transmits resistance to controller.

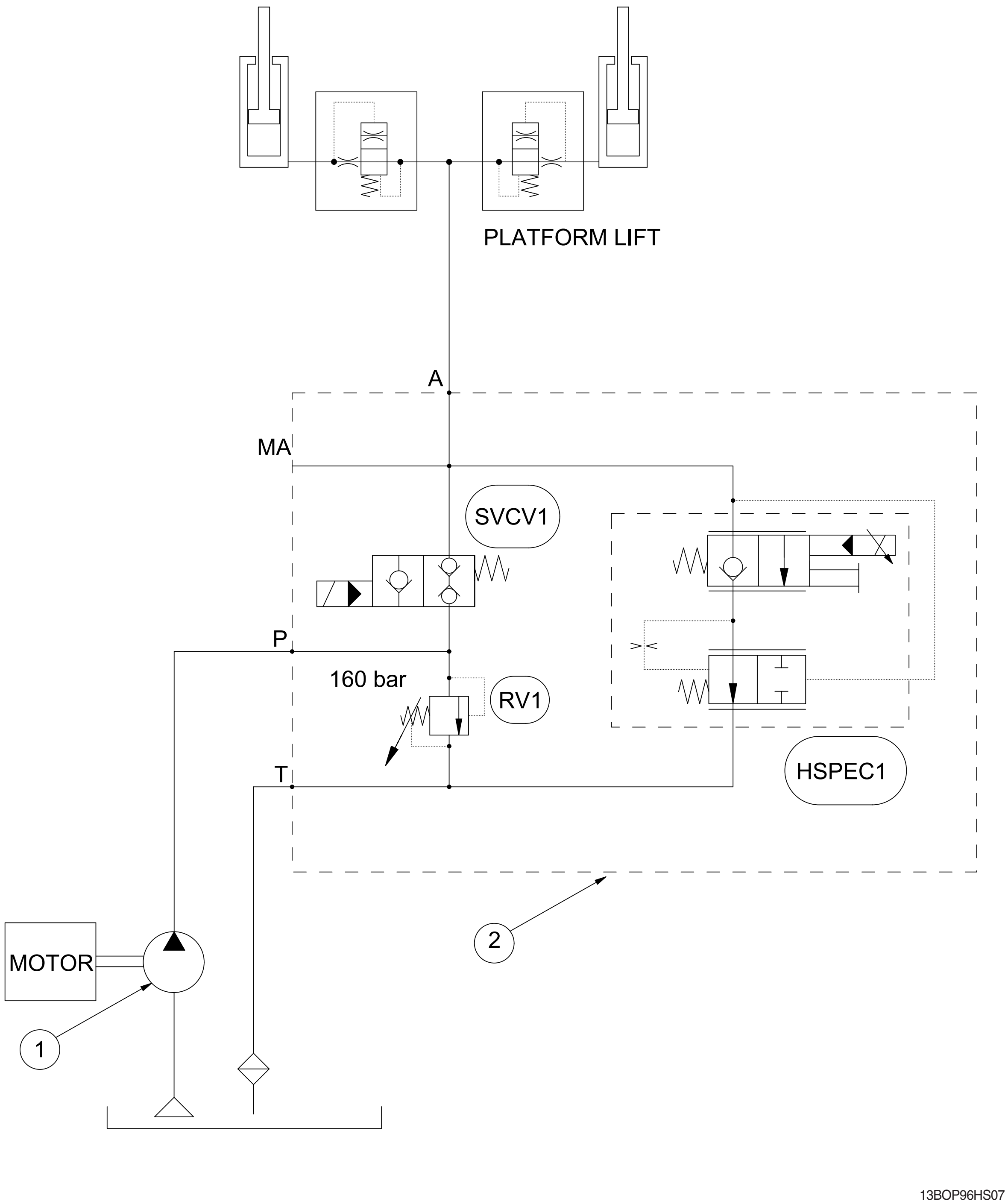
7) Tire

(1) It is rotated by the transmitted torque.

SECTION 6 HYDRAULIC SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

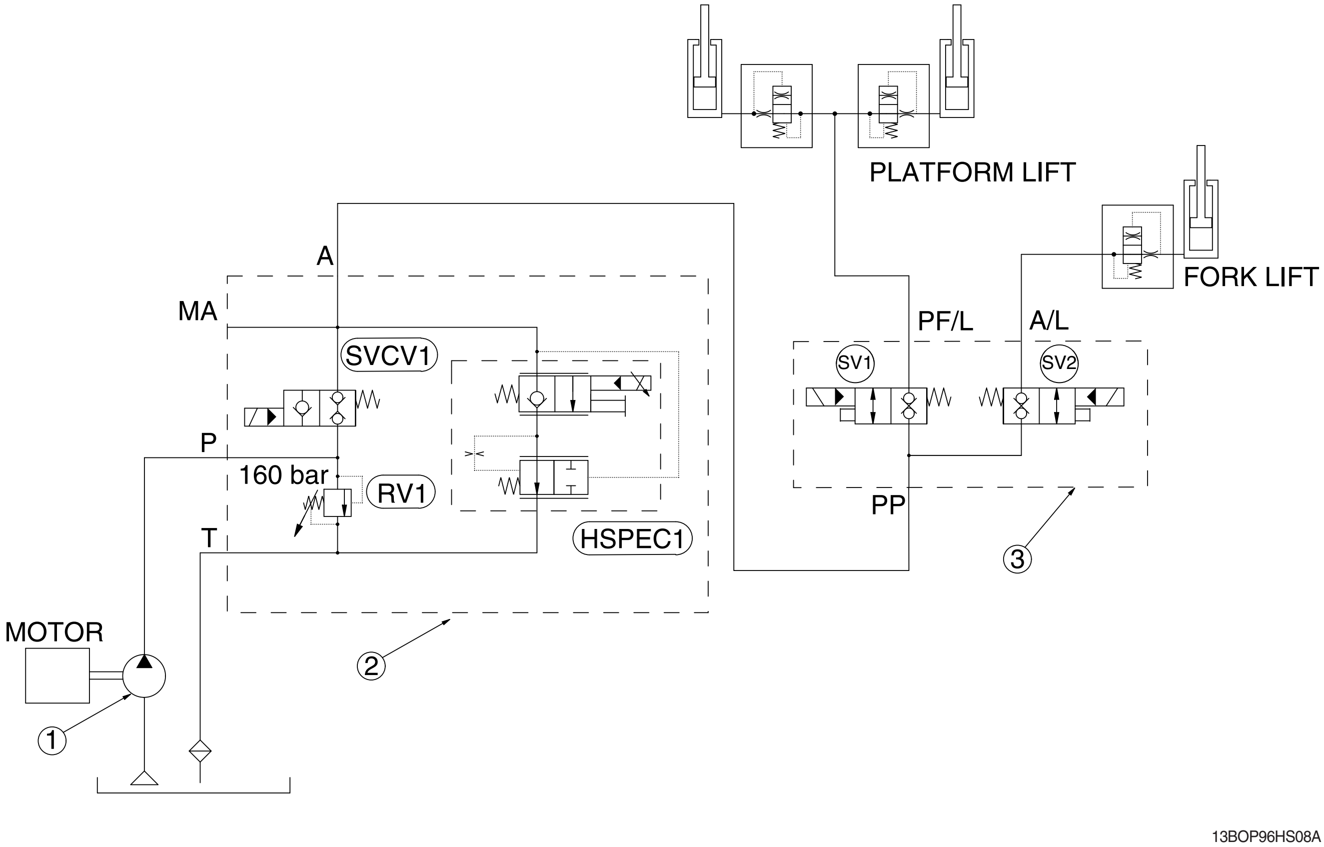
1. HYDRAULIC CIRCUIT (PLATFORM)



1 Hydraulic pump 2 Manifold assy

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

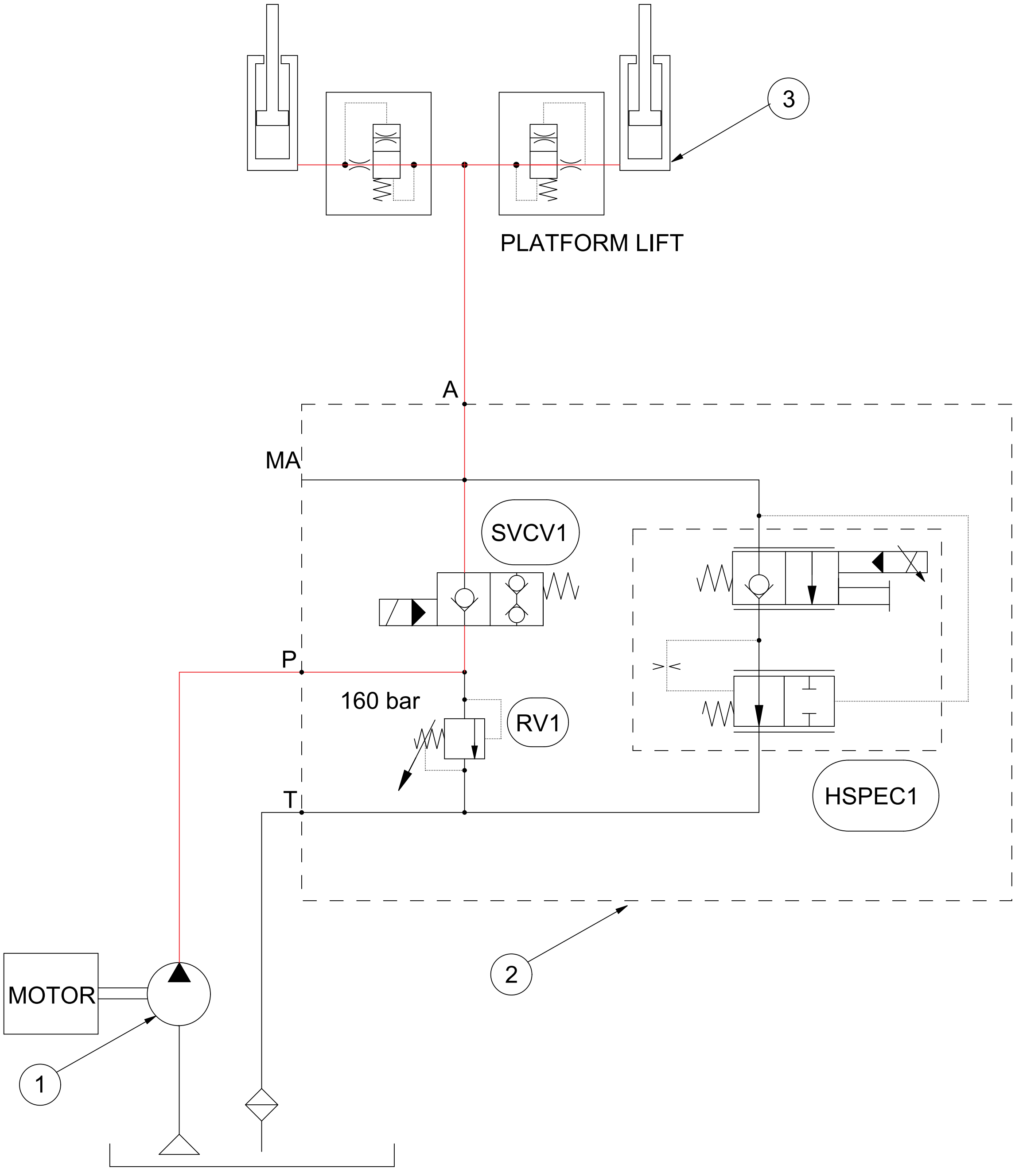
HYDRAULIC CIRCUIT (ADDITIONAL LIFT)



1 Hydraulic pump 2 Manifold assy 3 Manifold assy

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

1) WHEN THE MULTIFUNCTION LEVER IS IN THE LIFT POSITION (PLATFORM)



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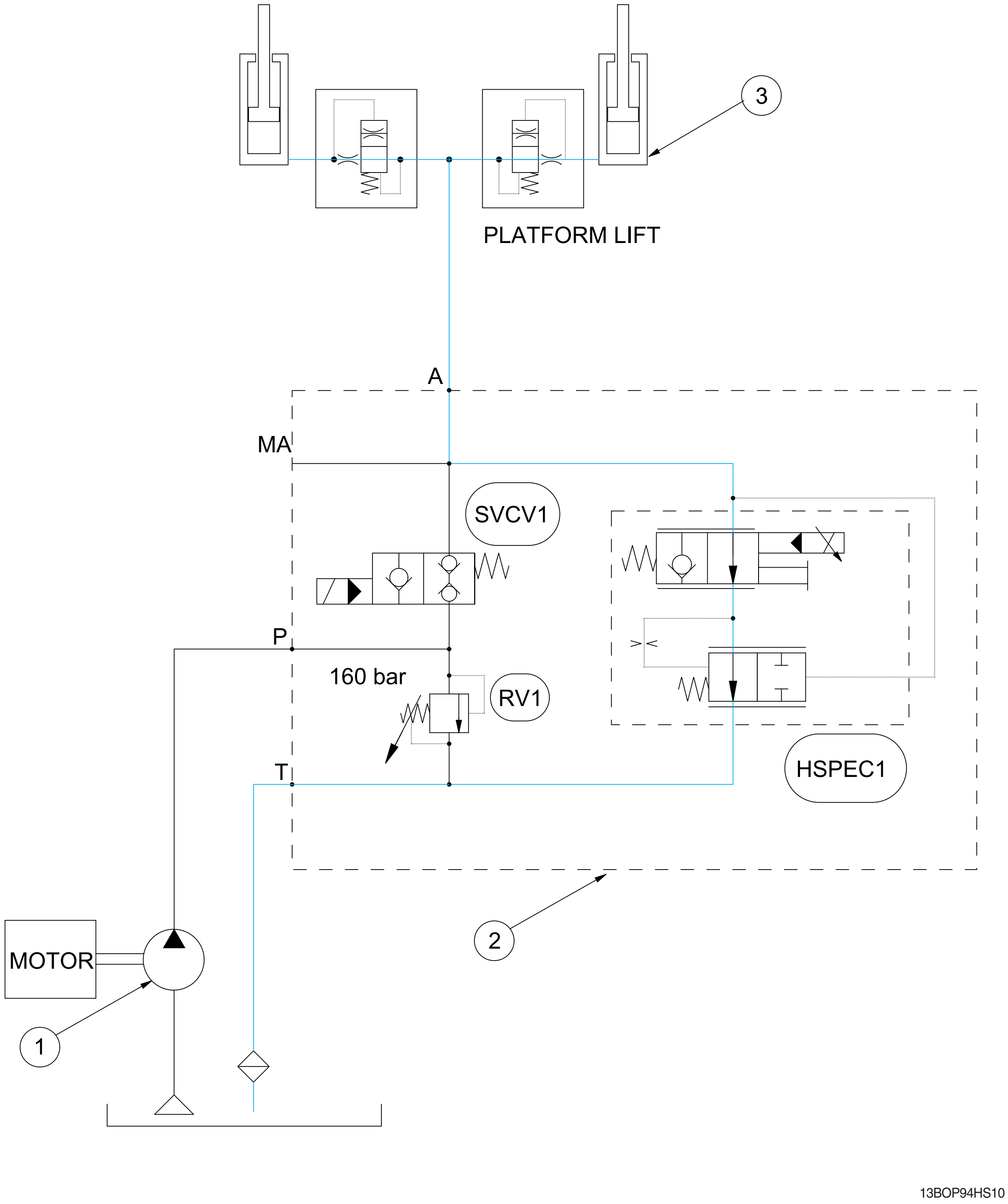
When turning the the multifuction lever to clockwise, the solenoid valve(SVCV1) is energized. The oil from the hydraulic pump(1) flows into the manifold assy(2) and then get into the large chamber of the platform lift cylinder(3). The air of the small chamber of the platform lift cylinder(3) is compressed at the same time. When this happens, the platform goes up.

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

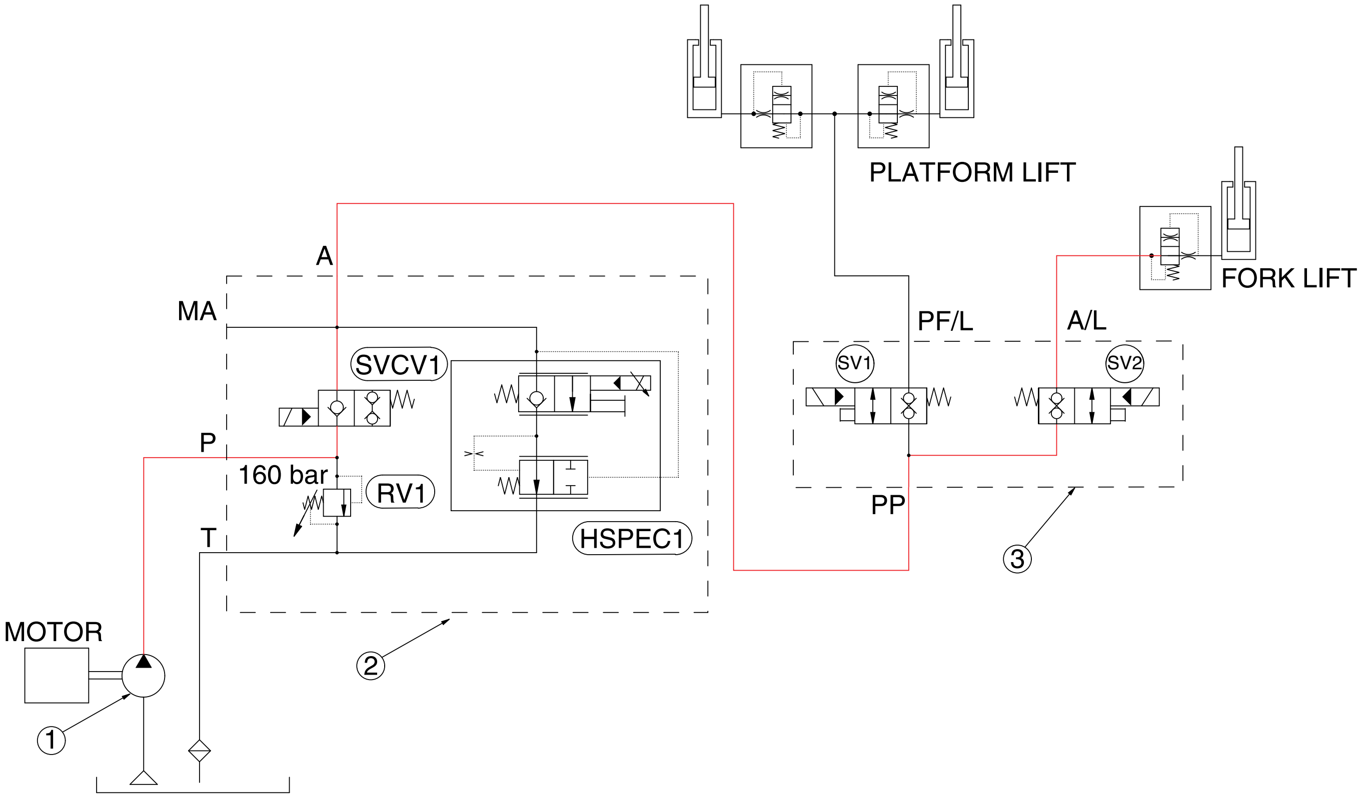
2) WHEN THE MULTIFUNCTION LEVER IS IN THE LOWER POSITION (PLATFORM)



When turning the multifunction lever to counterclockwise, the proportional valve(HSPEC1) is energized. The lift cylinder large chamber connected to (A) port on manifold and oil flows to the return (T) port. The lowering speed is adjusted according to the amount of turning the lever.

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

3) WHEN THE ADDITIONAL LIFT LEVER IS IN THE LIFT POSITION (ADDITIONAL LIFT)

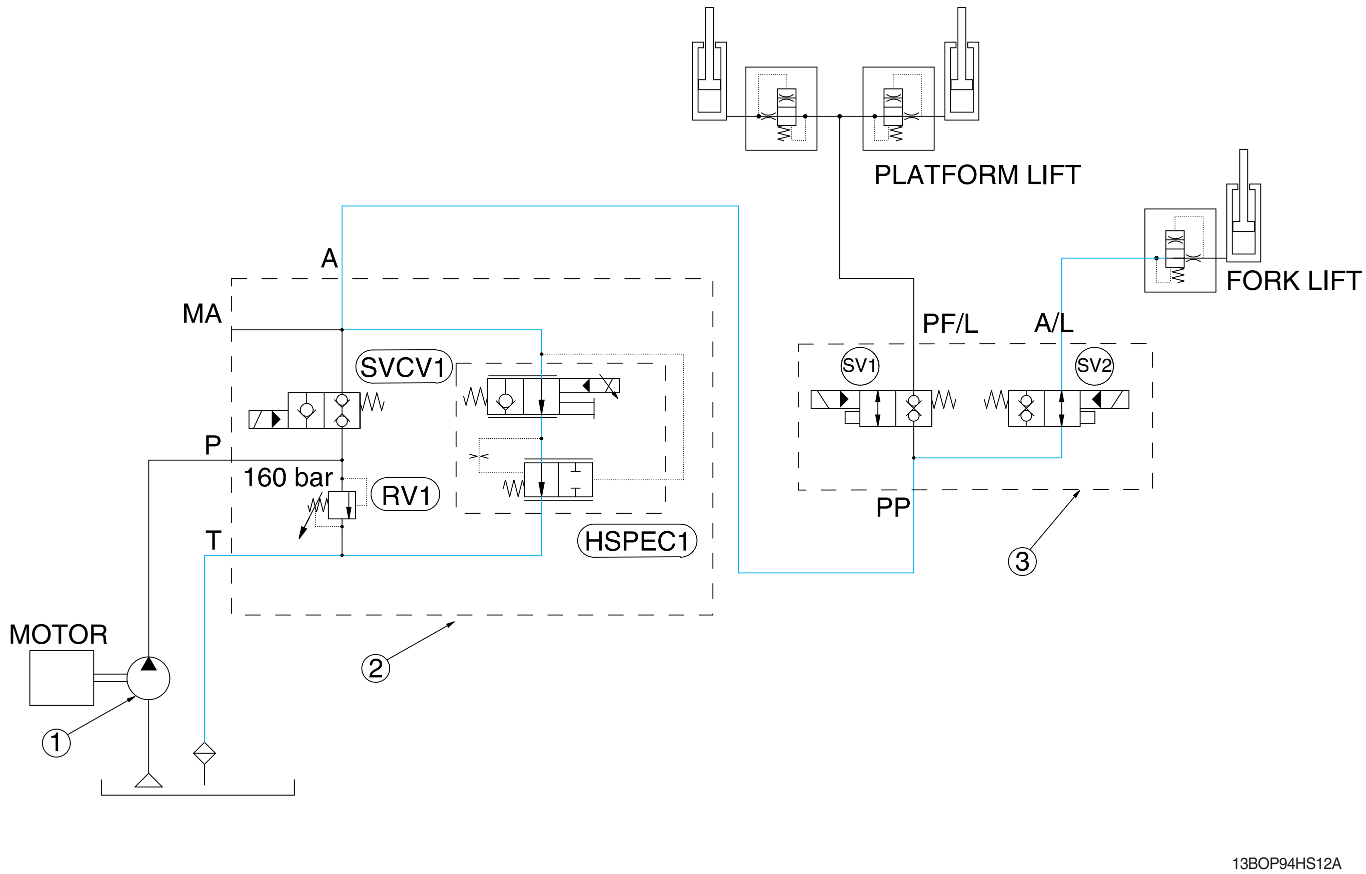


13BOP94HS11A

To lift the additional forks up , presss a switch and push up the fingertip lever for additional lift at the same time. The solenoid valves(SVCV1 and SV2) are energized. The hydraulic oil from the (A) port flows to (PP) port. The oil flows to (A/L) port and forks are lifted up.

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

4) WHEN THE ADDITIONAL LIFT LEVER IS IN THE LOWER POSITION (ADDITIONAL LIFT)

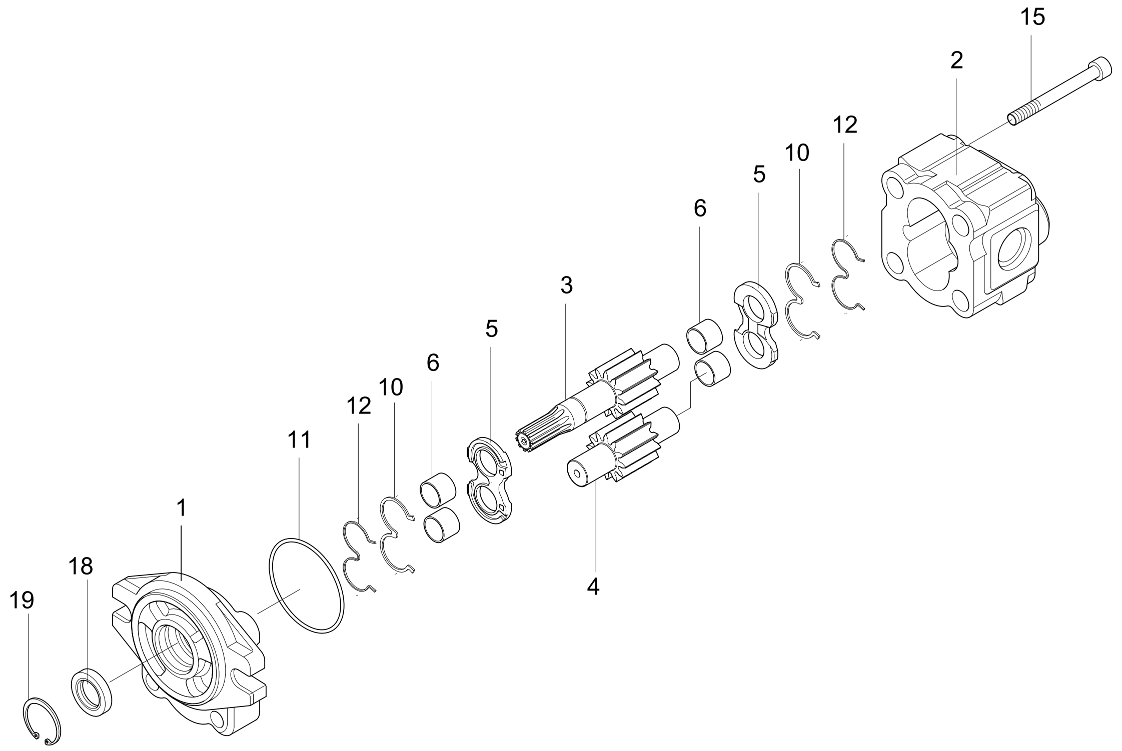


To lower the additional forks, press a switch and push down the fingertip lever for additional forks at the same time. The proportional valve and solenoid valve(HSPEC1 and SV2) are energized. The hydraulic oil from the Fork cylinder flows to (PP) port from (A/L) port. And then oil flows to (A) port and pass through proportional valves then return to tank.

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

2. HYDRAULIC GEAR PUMP

1) STRUCTURE



13BOP96HS13

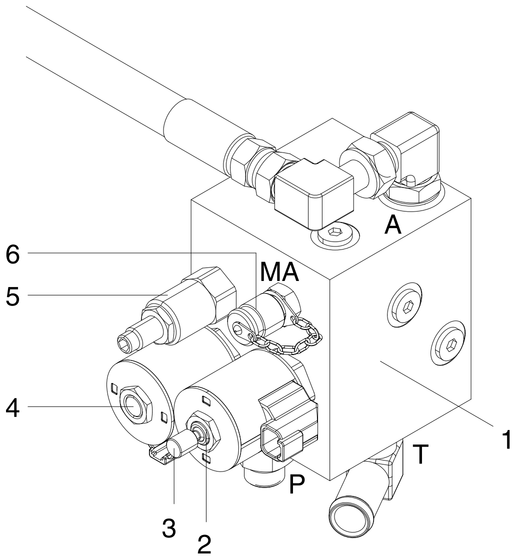
1	Front cover	5	Side plate	12	Back-up
2	Body	6	Bush	15	Bolt
3	Drive gear	10	Gasket (3-shaped)	18	Oil seal
4	Driven gear	11	O-ring	19	Retaining ring

2) OPERATION

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

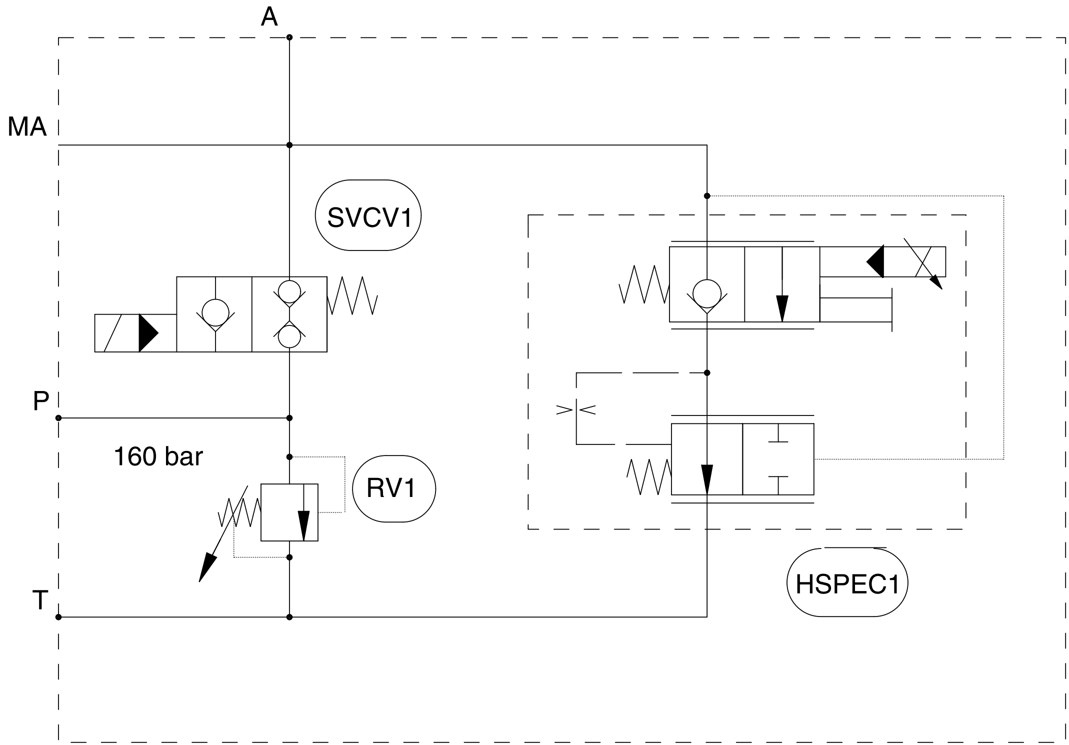
3. MANIFOLD VALVE

1) STRUCTURE



1 Block
2 Lowering proportional SOL.
3 Emergency lowering lever
4 Load holding SOL.
5 Main relief valve
6 Pressure check port

Port	Port size
T	7/8-14UNF
P	
A	
MA	9/16-18UNF



CIRCUIT

13BOP96HS02A

(1) SVC1 : Multi-function valve to control On/Off the lifting cylinder passage and check valve for holding and reverse flow checking.

(2) HSPEC1 : This is a multi-function valve to control lowering cylinder function. There is compensator inside of the valve so control the lowering flow smoothly regardless of load.

(3) RV1 : Relief valve to limit system pressure.

2) EMERGENCY LOWERING

In case that the mast can not be lowered due to a problem in the controller, activate the emergency lowering valve on the manifold assy by rotating lever (emergency lowering lever).

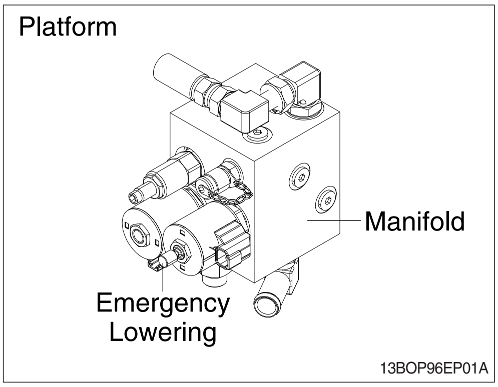
⚠ Manual override features are intended for emergency use, not for continuous-duty operation.

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

1) PLATFORM

(1) Turn off the electric emergency switch.

(2) In order to lower the platform, rotate the main manifold emergency lowering lever counter-clockwise to activate.

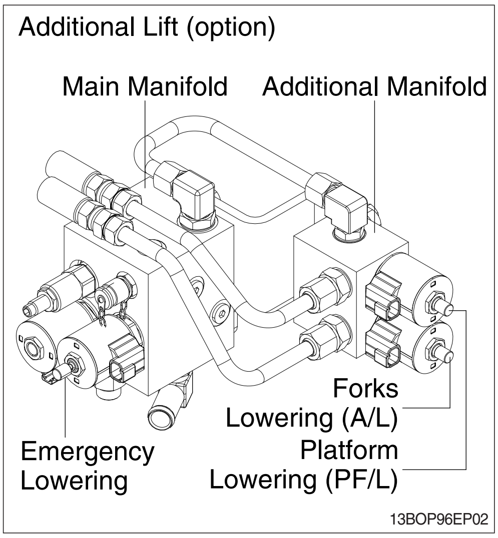


2) ADDITIONAL LIFT (OPTION)

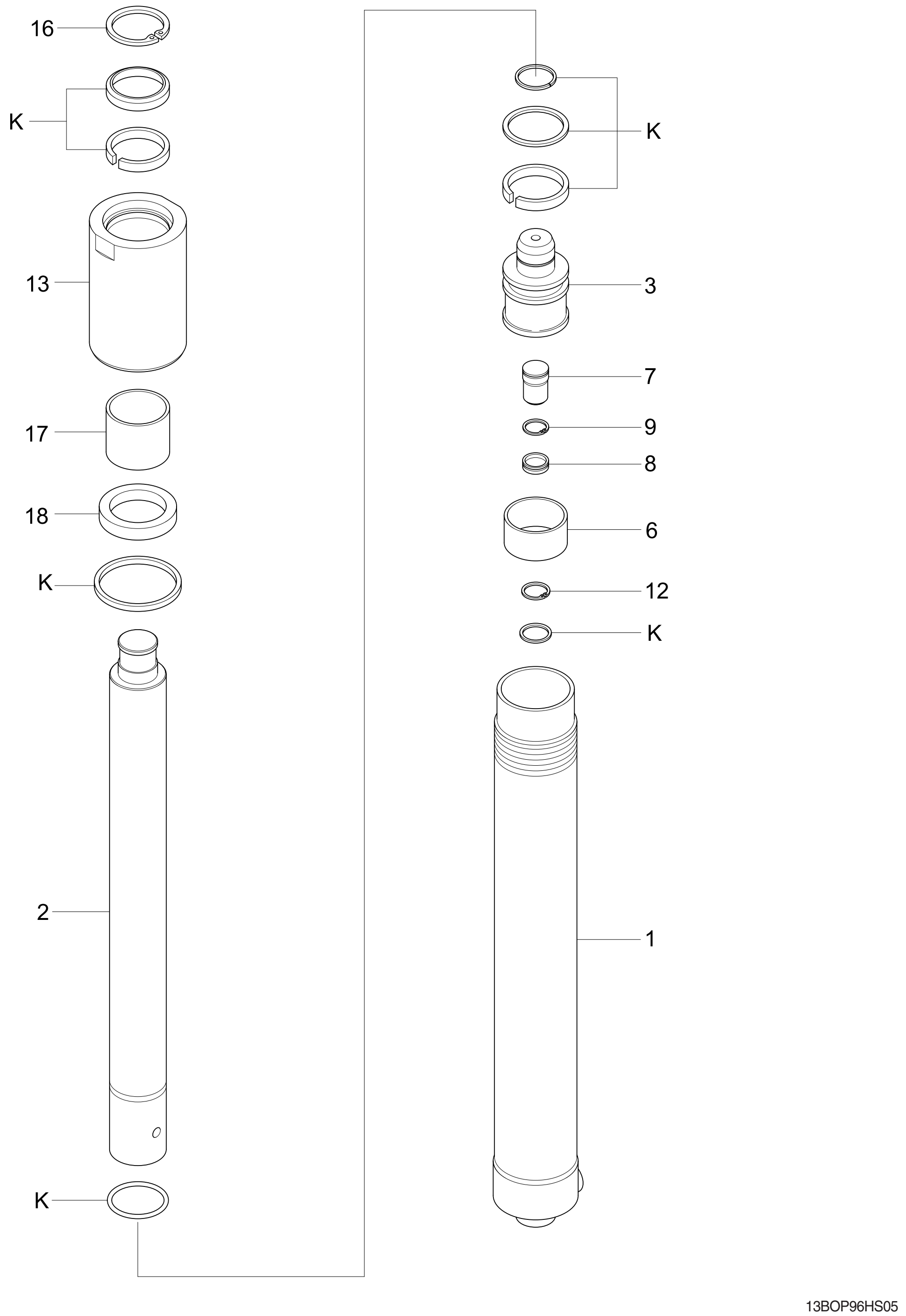
(1) Turn off the electric emergency switch.

(2) In order to lower the platform, rotate additional manifold emergency lowering lever (PF/L) and then main manifold emergency lowering levercounter-clockwise to activate.

(3) After landing the platform to ground, rotates additional manifold emergency lowering lever (A/L) counter-clockwise to lower forks.

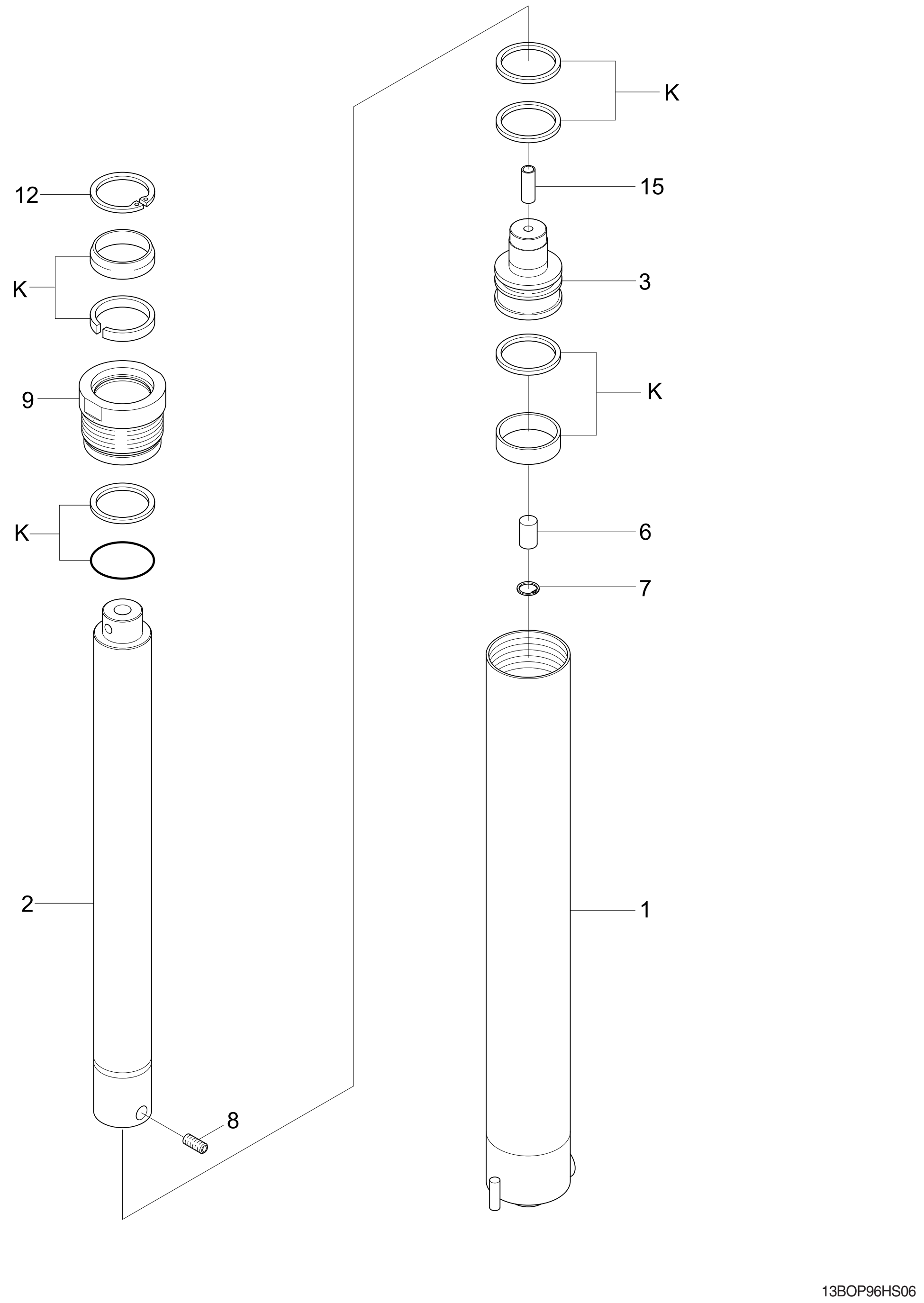


4. LIFT CYLINDER



1	Rod piston	8	Spacer	17	Pin bushing
2	Tube assy	9	Retainer ring	18	Spacer
3	Piston	12	Retainer ring	K	Seal kit
6	Wear ring	13	Rod cover		
7	Check valve	16	Retainer ring		

5. FREE LIFT CYLINDER



1	Tube assy	7	Retainer ring	15	Pipe assy
2	Rod piston	8	Set bolt	K	Seal kit
3	Piston	9	Rod cover		
6	Check valve	12	Retaining ring		

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECKS

1) CHECK ITEM

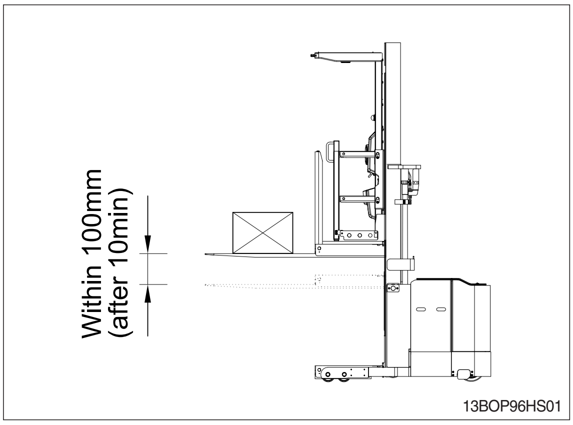
(1) Check visually for deformation, cracks or damage of rod.

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

· Hydraulic drift

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

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

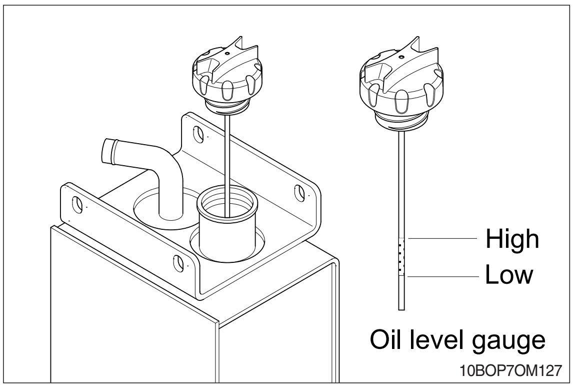


13BOP96HS01

2) HYDRAULIC OIL

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

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



10BOP7OM127

3) MANIFOLD ASSY

(1) Raise forks to maximum height and measure oil pressure.
Check that oil pressure is 160 kgf/cm^2 (2276 psi).

2. TROUBLESHOOTING

1) SYSTEM

Problem	Cause	Remedy
Fast platform lowering speed	· Seal inside control valve defective. · Oil leaks from joint or hose. · Seal inside cylinder defective.	· Replace spool or valve body. · Replace. · Replace packing.
Slow platform lifting speed	· Lack of hydraulic oil. · Hydraulic oil mixed with air. · Oil leaks from joint or hose. · Excessive restriction of oil flow on pump suction side. · Relief valve fails to keep specified pressure. · Poor sealing inside cylinder. · High hydraulic oil viscosity. · Mast fails to move smoothly. · Oil leaks from lift control valve spool. · Oil leaks from tilt control valve spool.	· Add oil. · Bleed air. · Replace. · Clean filter. · Adjust relief valve. · Replace packing. · Change to ISO VG 46. · Adjust roll to rail clearance. · Replace spool or valve body. · Replace spool or valve body.
Hydraulic system makes abnormal sounds	· Excessive restriction of oil flow pump suction side. · Gear or bearing in hydraulic pump defective.	· Clean filter. · Replace gear or bearing.
High oil temperature	· Lack of hydraulic oil. · High oil viscosity. · Oil filter clogged.	· Add oil. · Change to SAE80W-90LSD, class API GL-5 gear oil. · Clean filter.

2) HYDRAULIC GEAR PUMP

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

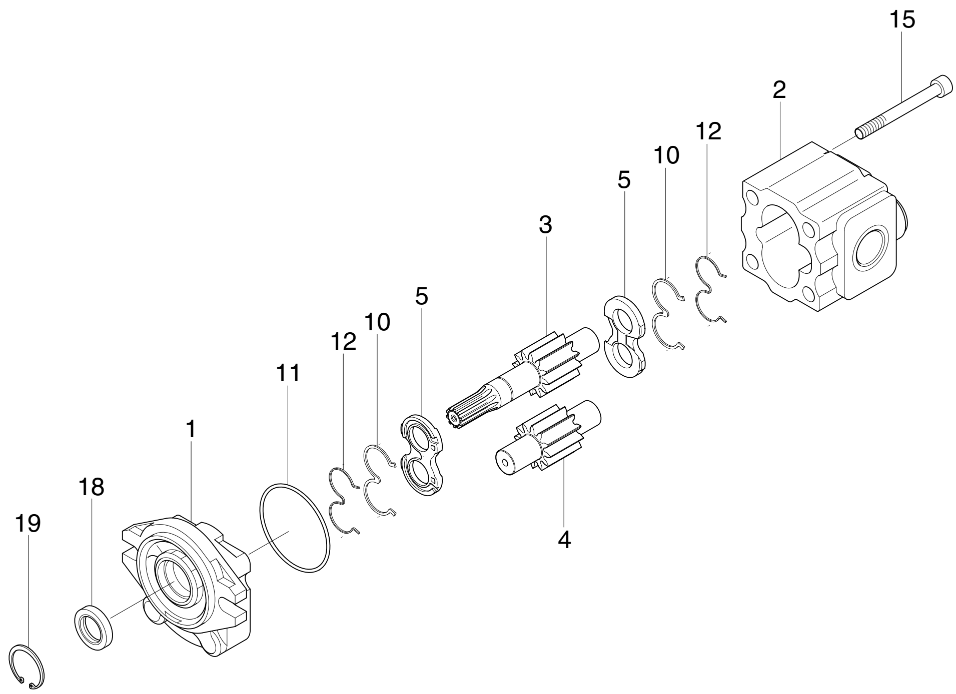
3) LIFT CYLINDER

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

GROUP 3 DISASSEMBLY AND ASSEMBLY

1. HYDRAULIC GEAR PUMP

1) STRUCTURE



15BRXHS26

1	Front cover	5	Side plate	12	Backup ring
2	Body	6	Bushing	15	Bolt
3	Driving gear	10	Gasket	18	Oil seal
4	Inverted gear	11	O-ring	19	Retaining ring

※ Seal kit : 10 (2EA), 11 (1EA), 12 (2EA), 18 (1EA), 19 (1EA)

2) DISASSEMBLY AND ASSEMBLY

(1) Safety Precautions

※ When pump installation, piping, disassembly for repair and inspection, etc. are required, they shall be performed by the technical expert or performed through instruction by the technical expert.

※ Stop the system operation including the pump for removing the pump, and remove the pipings and devices after the surface of the pump is cooled completely to approximately 40 ℃ or less.
If not, there may be risk of oil leakage or burn.

※ Pump shall not be used when the appropriate performance is not shown after re-assembly.
Use by force may damage the device or the system.

※ Discharge the oil when disposing the pump, and handle as industrial waste.

※ Follow the safety regulations for safe use of the pump.

(2) Disassembling

※ Check for oil leakage on the oil seal, pump body and cover joint before disassembling the pump.

⚠ Remove the rust, dust and foreign substances on the shaft end and pump body. If not, the parts may be damaged, or it may penetrate into the pump during reassembly for inappropriate diagnosis of the pump.

※ Pump has a symmetrical part. For proper reassembly, the parts are marked through the method indicated on the disassembly procedure before disassembling the pump. Oil paint that does not damage the parts is used for this purpose.

※ Disassembly is a method of discovering the cause of issues. The pump disassembly procedure is followed.

※ Prepare the new packing, gasket and oil seal before the disassembly.

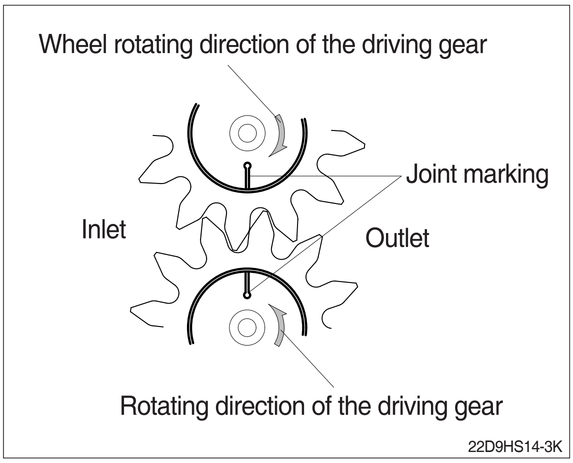
① Fix the front cover mounting part with a vice to enable the body side to be facing upwards.

② Mark the contact section of the front cover (1) and body (2) before the disassembly.

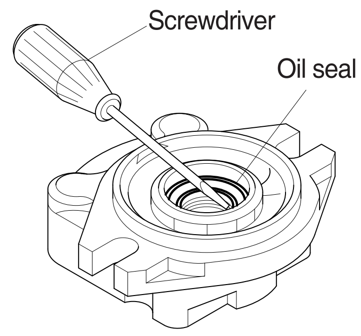
③ Loosen 4 bolts (15) and start the disassembly of the parts in order starting from the body.
The following instructions shall be followed.

④ Mark the shaft end on the body side.

⑤ One pair of the side plate (5), type 3 gasket (10) and backup ring (12) is assembled on another direction, so each pair is attached with a tag to distinguish the place of use. (These are indicated as F and B on the diagram.)



⑥ After disassembling the C-type retaining ring, the end of screwdriver is inserted into the oil seal for disassembly.



22D9HS14-4K

(3) Assembling

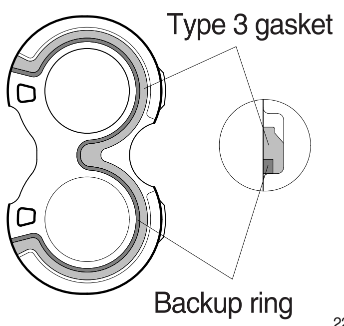
① These parts (10, 11, 12, 18, 19) are replaced with new parts.

② Each part must be removed with dust before the reassembly.

③ The body is placed on the work bench while the holes for the gear are facing upwards.

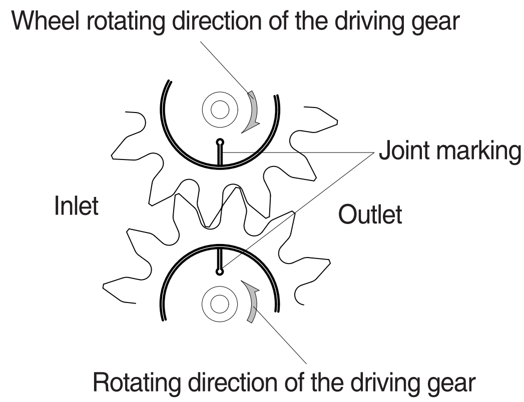
④ Parts are reassembled in order except for the oil seal, retaining ring and bolt.

- Grease is used to fix the type 3 gasket (1) and backup ring (12) to the side plate (5) to prevent the twisting or interlocking.



22D9HS14-5K

- Driving gear and inverted gear are fixed according to the joint mark.



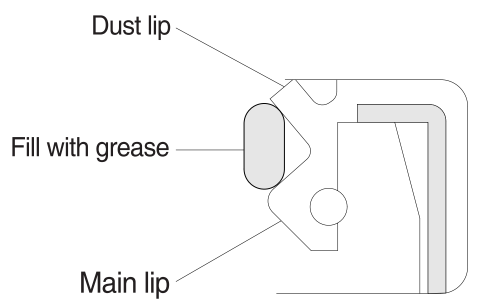
22D9HS14-3K

⑤ Turn the assembled pup to have the front cover facing down, and the mounting parts are fixed to the vice.

⑥ Fasten 4 bolts in 9.0~9.5 kgf·m torque.

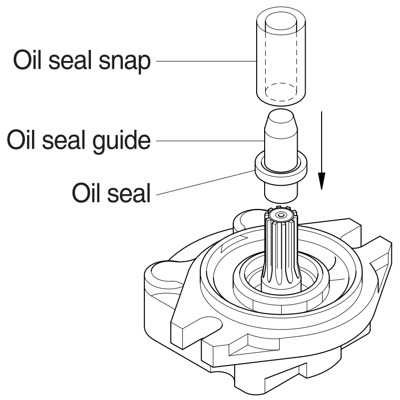
⑦ Turn the assembled pump again to have the front cover facing up, and fix the body on the vice.

⑧ Fill with grease on the grooved part between the main lip and dust lip on the oil seal.



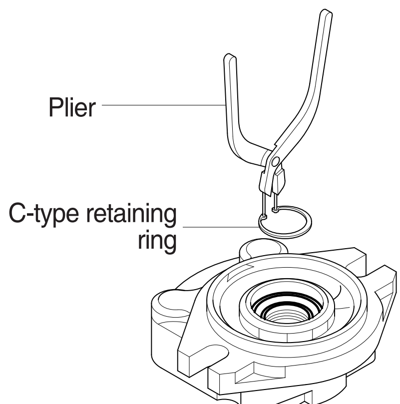
22D9HS14-6K

⑨ Use the oil seal guide and oil seal snap to assemble the oil seal on the body.



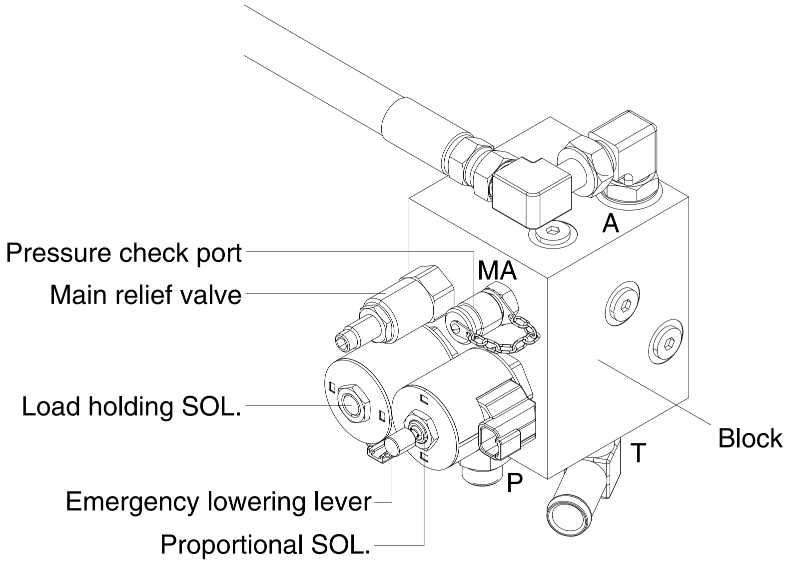
22D9HS14-7K

⑩ Insert the C-type retaining ring on the hole.



22D9HS14-8

2. MANIFOLD VALVE



13BOP96HS04A

1) DISASSEMBLY INSTRUCTION

(1) Main relief valve

① Clean the valve installation surface.

② Disassemble with 1" size spanner.

(2) Load holding SOL.

① Clean the valve installation surface.

② Disassemble nut with 3/4" size spanner.

③ Take out electronic coil.

④ Disassemble valve with 1 1/4" spanner.

(3) Proportional SOL.

① Clean the valve installation surface.

② Disassemble nut with 3/4" size spanner.

③ Take out electronic coil.

④ Disassemble valve with 1 5/16" spanner.

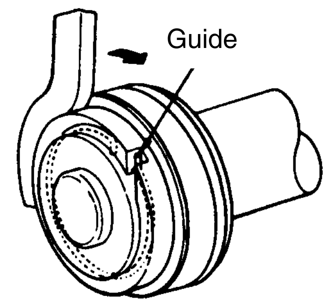
2) ASSEMBLY INSTRUCTION

Assemble is a reverse order of disassemble and should be performed by trained technician with calibrated torque wrench otherwise the manifold performance will be out of specification.

3. LIFT CYLINDER

1) 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.



L15C3HS25

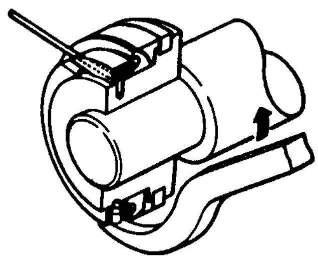
2) CHECK AND INSPECTION

mm(in)

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

3) ASSEMBLY

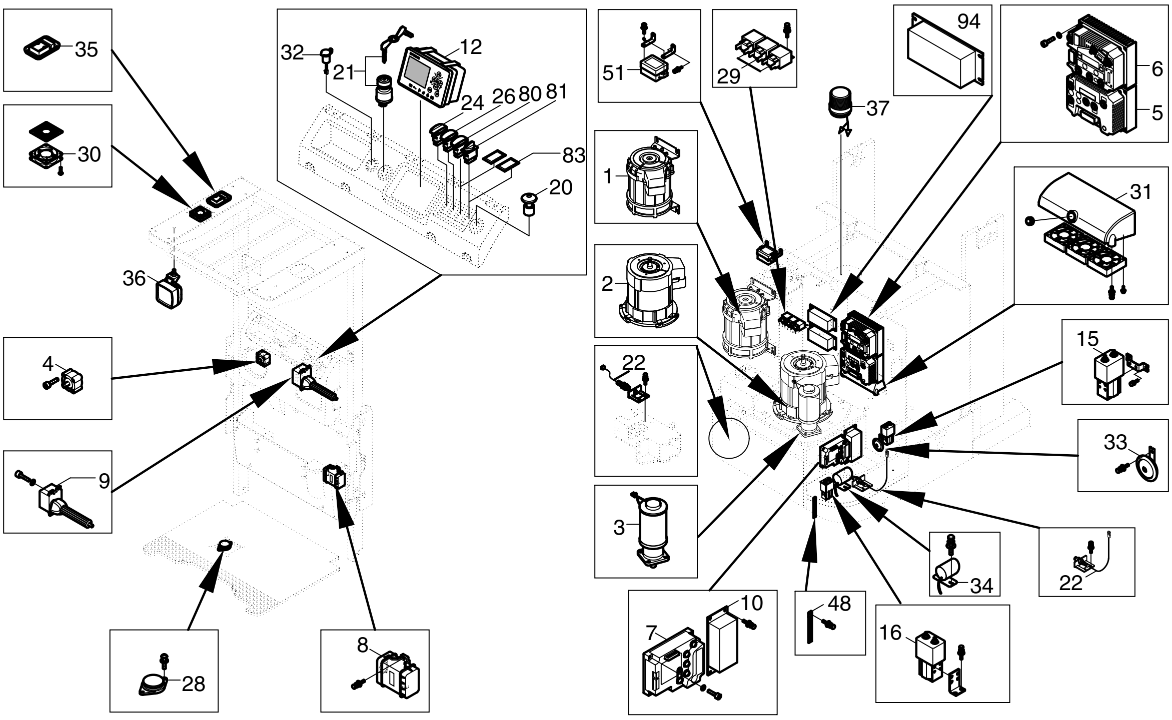
(1) Soak the piston ring in hydraulic oil at a temperature of 40 to 50 ℃, expand the inside diameter and assemble on the piston. Install a piston seal.
Bend the edge of the guide and rotate it to install the guide completely.



L15C3HS26

SECTION 7 ELECTRICAL SYSTEM

GROUP 1 COMPONENT LOCATION

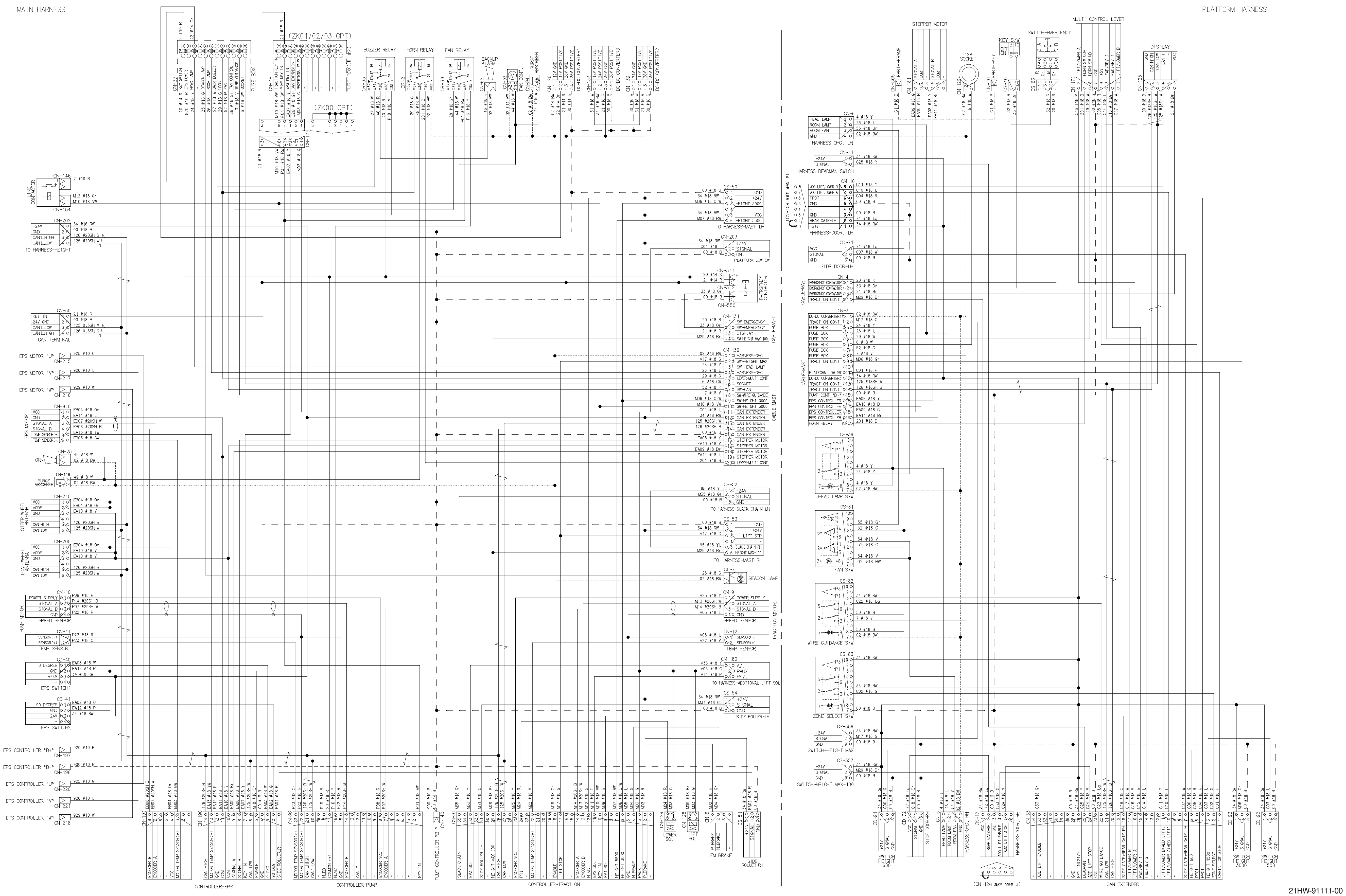


13BOP97ES01A

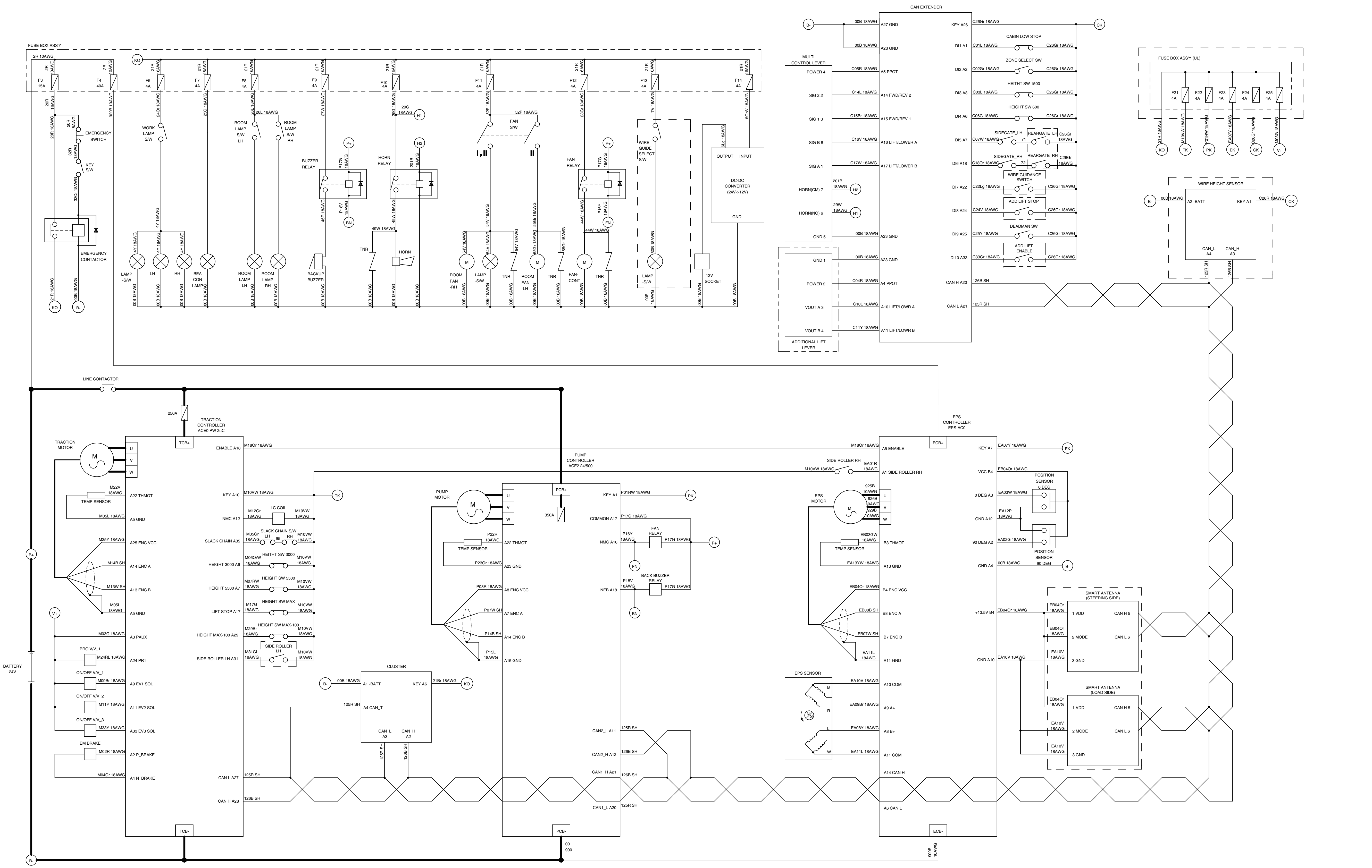
1	Traction motor	16	Contactor	34	Back buzzer
2	Pump motor	20	Emergency switch	35	Room lamp
3	EPS motor	21	Key switch	36	Work lamp
4	Stepping & gear motor	22	Sensor	37	Beacon lamp
5	Traction Controller	24	Work lamp switch	48	Static strap
6	Pump Controller	26	Pan switch	51	Fuse box
7	EPS Controller	28	Dead man switch	80	Wire guidance switch
8	Can extender	29	Horn relay	81	Rotary switch
9	Multifunction lever	30	Cooling fan	83	Panel plug
10	DC converter	31	Fan assy	94	DC converter (36 V, Option)
12	Display	32	Socket		
15	Contactor	33	Horn		

GROUP 2 ELECTRICAL CIRCUIT

1. 36 V POWER



2. 24 V POWER (OPTION)



NOTE

1.B+ : BATTERY POSITIVE
B- : BATTERY NEGATIVE
CK : CAN EXTENDER KEY IN
KO : KEY SWITCH OUT
P+ : FAN/BUZZER RELAY POSITIVE
BN : BUZZER RELAY NEGATIVE
H1 : HORN SWITCH NO
H2 : HORN SWITCH CM
FN : FAN RELAY NEGATIVE
TK : TRACTION KEY IN
PK : PUMP KEY IN
EK : EPS KEY IN
PR : PROPORTIONAL VALVE POSITIVE
V+ : VALVE POSITIVE
V+ : VALVE POSITIVE

2. OPTION
3. SHIELD WIRE
4. 10BO-9

13BOP97ES09

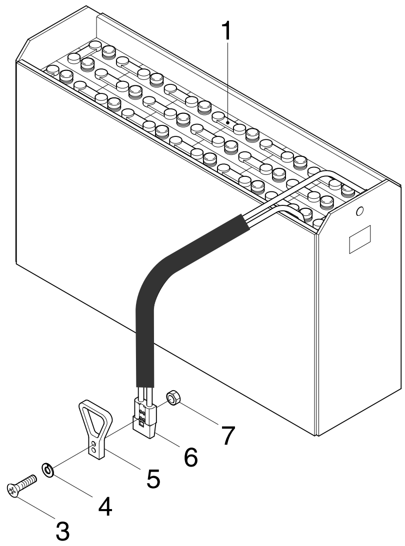
GROUP 3 ELECTRIC COMPONENTS

1. FUNCTIONS OF BATTERY FORKLIFT TRUCK AND ELECTRIC COMPONENTS

The major functions of the battery order picker truck can be divided into DRIVING FUNCTION and LOADING & UNLOADING FUNCTION.
All the components that work DRIVING and LOADING & UNLOADING functions are driven by AC MOTORS. And as the BATTERY works as power source of these motors, a charging device is needed.
To drive the fork lift truck, a DRIVING CONTROL SYSTEM and a multifunction lever is required to select the driving direction and to control the speed of driving motor.
The CONTROL SYSTEM includes some protective circuits that protect the equipment and components from malfunctioning.
A MONITORING SYSTEM is installed in the monitor panel, which monitors the equipment and working condition, and let the operator take proper action. For the monitoring system, there are many sensors such as current sensors, hydraulic pressure sensors, and temperature sensors. The HYUNDAI battery order picker trucks are equipped with the most advanced DRIVING CONTROL SYSTEM currently available world-widely. The operator friendliness features enable him to set the truck conditions properly according to each working circumstance easily on the platform, and the SELF-DIAGNOSTIC function displays current status of truck in working.

2. BATTERY

1) STRUCTURE

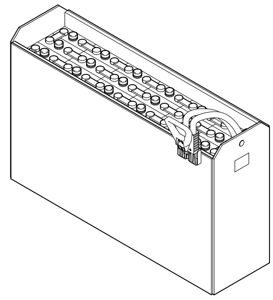


13BOP97ES02

1	Cells	3	Spring washer	5	Connector
2	Bolt	4	Handle connector	6	Nut

2) GENERAL

As in the battery order picker trucks, the battery is an energy source, the handling of the battery is very important. The life and performan-ce of the battery greatly depend on the ordinary handling and maintenance. Therefore, be sure to check and maintain the battery so that it may be kept best.



13BOP97ES03

3) SPECIFICATION AND SERVICE DATA

(1) SPECIFICATION

Voltage	Capacity	Dimensions						Weight
		Length (L)		Width (W)		Height (H)		
V	Ah	mm	in	mm	in	mm	in	kg (lb)
24	825	972	38.3	415	16.3	790	31.1	730 (1,609.4)

(2) SERVICE DATA

Description	Specification
Fully charged specific gravity	1.280(25℃)
End of discharge specific gravity	1.130(25℃)
Discharge end voltage	24V
Electrolyte	Refined dilute sulfuric
Replenishment fluid	Refined water(pure water)
Insulation resistance	More than 1MΩ

4) SAFETY PRECAUTIONS

(1) When a sulfuric acid contact with skin

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

(2) Strict prohibition of fire and ventilation

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

(3) Never place metallic articles on the batteries

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

(4) Handling of charger

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

5) OPERATION PRECAUTIONS

(1) Avoid over-discharge

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

(2) Avoid over-charge

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

(3) Avoid excessive elevation of temperature

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

6) INSTRUCTION

(1) Unpacking

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

(1) Performance and maintenance of batteries

① Initial charge

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

a. By modified constant voltage charger

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

b. By constant voltage constant current charger

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

c. By constant current charger

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

· When a constant value is indicated for more than 1 hour after the battery voltage has reached the maximum value.

· When more than 1 hour of charge is continued after the electrolyte specific gravity has risen fully and becomes constant.

② Discharge and capacity

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

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

③ Specific gravity of electrolyte

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

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

Where, S_{25} : Specific gravity at 25℃

S_t : Actually measured specific gravity at t ℃

t : Electrolyte temperature (℃)

The standard specific gravity for this type of battery is 1.280±0.01(25℃) at full charge condition. If the electrolyte is decreased naturally while using, distilled water shall be replenished up to the specified level. (Never refill sulfuric acid)

Only when large quantity of electrolyte is lost due to spillage, etc., dilute sulfuric acid specified in gravity shall be added.

④ Normal charge

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

a. Charging by modified constant voltage automatic charger

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

b. Charging by constant current constant voltage automatic charger

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

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

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

⑤ Equalizing charge

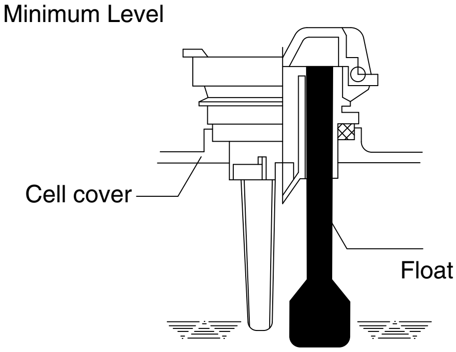
When large number of cells are used in a set of battery, the voltage and specific gravity of respective cells tend to become unequal, resulting in necessity of charging all the cells at an appropriate time in order to equalize them. This is called equalizing charge. Normally the equalizing charge should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

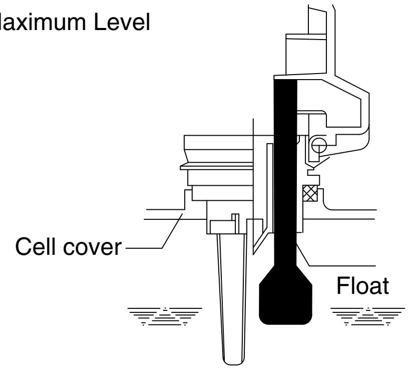
⑥ Water replenishment

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

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

a. Determination of replenishment time and methods(cell with ONE TOUCH CAP)
Confirm the electrolyte level by looking at the float in the ONE TOUCH CAP. If too low as shown in figure, replenish water. Replenishment shall be performed after opening the cover of the plug using syringe and jug. When refilling is completed, close each cover completely until "click" sound is heard.





⑦ Cleaning
If electrolyte spills or the cells are polluted with dust or stains, it will cause generation of leak current. Wipe off dust and stains with moist cloth and clean in such a manner that the cells are kept in dry condition. In the case of plastic containers or covers, never use such organic solvents as paint thinner and gasoline. If used, the plastic containers or covers may suffer cracking. If you are forced to use them, be sure to use white kerosene.

⑧ Notice on charging
The charging area must be well ventilated to facilitate exhaust of gas generated from the battery during charging. Charge the battery in an area free from iron working, welding, etc. Further the battery generates hydrogen, oxygen, acid mist and on rare occasions, hydrogen sulfide during charging depending on the case. Special care may be required in the case of equipment and objects near the battery that may contaminated or damaged. Do not pull out the charging plug during charging, as it will cause sparks. Since hydrogen gas generated during charging may remain in the area surrounding the battery after charging, never bring fire or flame close to this area. In case of counter-balance type vehicles, open the battery cover before charging.

⑨ Repair of failure cell

a. To remove a cell from the circuit or battery from steel tray, it is first necessary that the intercell connector be removed.
b. Before performing any repairs, you must open one-touch caps for gas purging of all cells. After you have finished that, must remove connector covers and on-touch caps from failure cell including surrounding cells. All vent holes of cells removed of one-touch caps must cover by four layers of water dampened cloth and then proceed with repairs. Using an acid syringe withdraw sufficient electrolyte from failure cell to reduce the liquid levels until minimum level indicating of one touch caps.
c. The safe and most efficient method of removing a connector is with hand or electric drill(∅25mm) from failure cell as well as all surrounding cells.

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

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

⑩ Summary of daily maintenance

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

(3) Others

① Storage of batteries

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

② Maintenance record

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

③ Electrolyte temperature

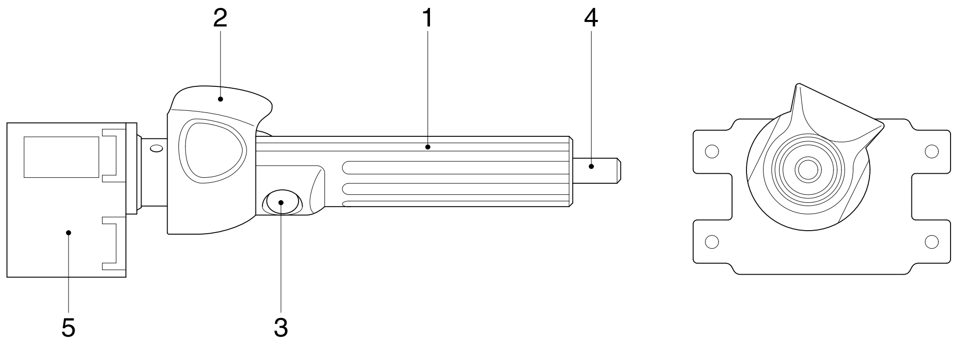
The operating temperature range of batteries is -10~45℃(temperature of electrolyte). If the batteries are exposed to cold atmosphere in discharged condition, the electrolyte may freeze, and in extreme cases, the capacity will be decreased, but, if not frozen, no adverse effects will be exerted over the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

7) TROUBLESHOOTING

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

1) STRUCTURE



10BOP7ML01

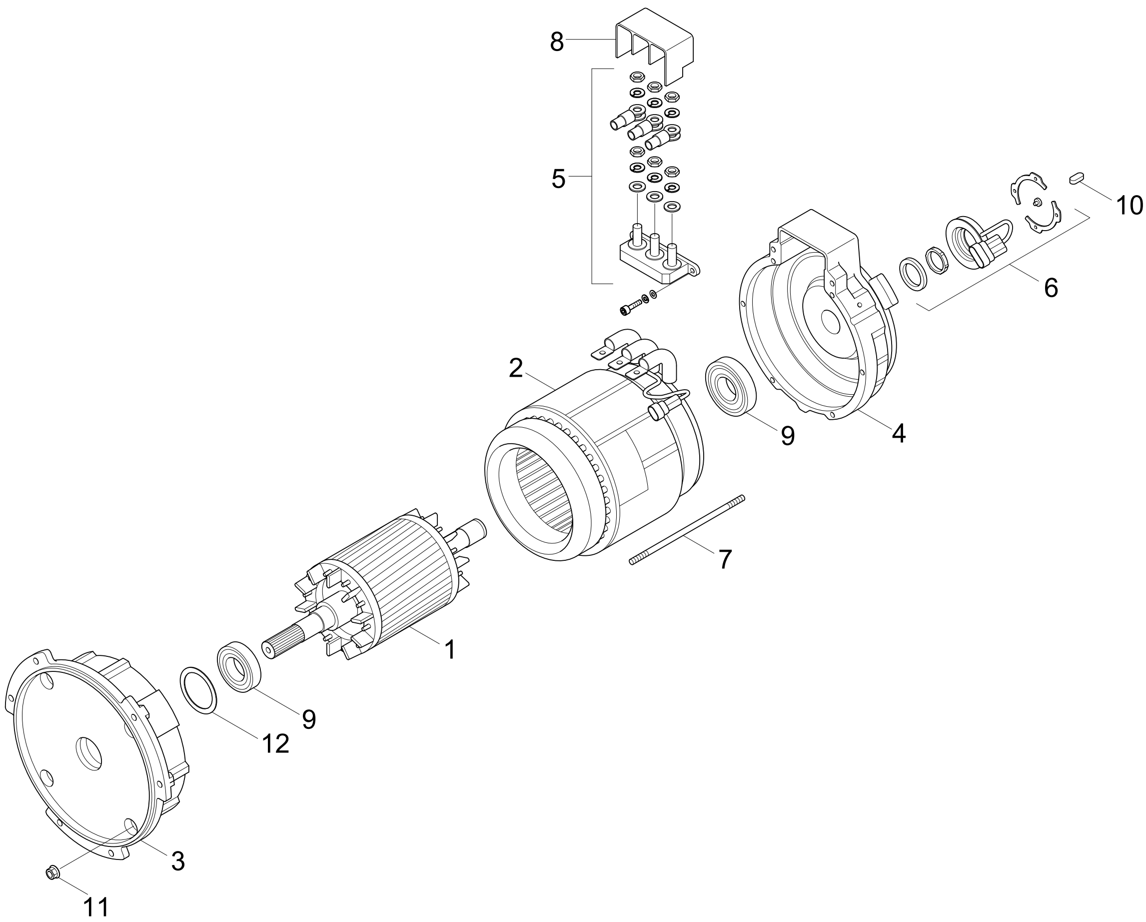
1	Fwd/Rev grip	3	Horn switch	5	Body
2	Lift/Lower grip	4	Center pin		

2) SPECIFICATION

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

4. DRIVE MOTOR

1) STRUCTURE



13BOP97ES04

1	Rotor assy	5	Terminal block	9	Bearing
2	Stator assy	6	Speed sensor kit	10	Key
3	Endbell	7	Stud bolt	11	Flange nut
4	Endbell DE	8	Terminal protector	12	Wave washer

2) SPECIFICATION

Item	Unit	Specification
Type	-	AMDH6003
Rated voltage	Vac	16
Power	kW	4.3
Current	A	204
Speed	rpm	1866

3) INSPECTION

(1) Rotor Assembly

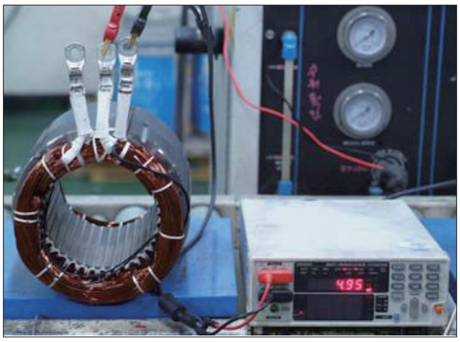
10BOP7TM01

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

(2) Stator Assembly

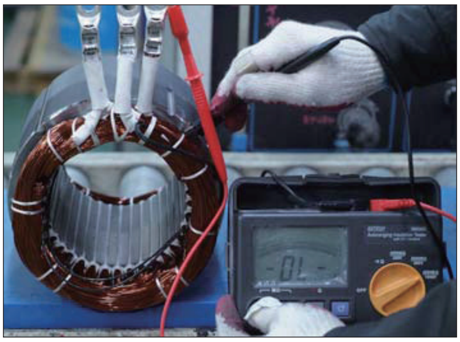
Stator should always be cleaned with compressed air.
If the dirt will not come off lightly wipe off with piece of cotton or soft cloth wetted with gasoline, using care not to damage the coil insulation.

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



10BOP7TM02

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



10BOP7TM03

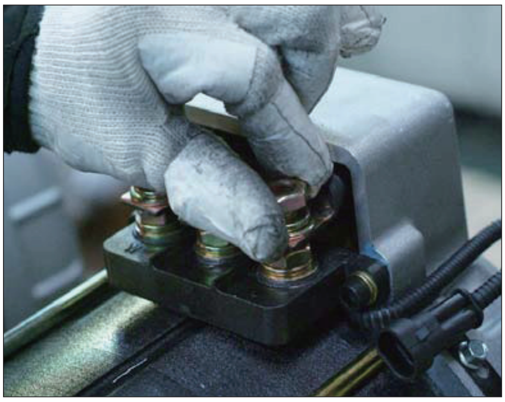
4) DISASSEMBLY FOR AC MOTOR

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

10BOP7TM04

10BOP7TM05

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



10BOP7TM06

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

10BOP7TM07

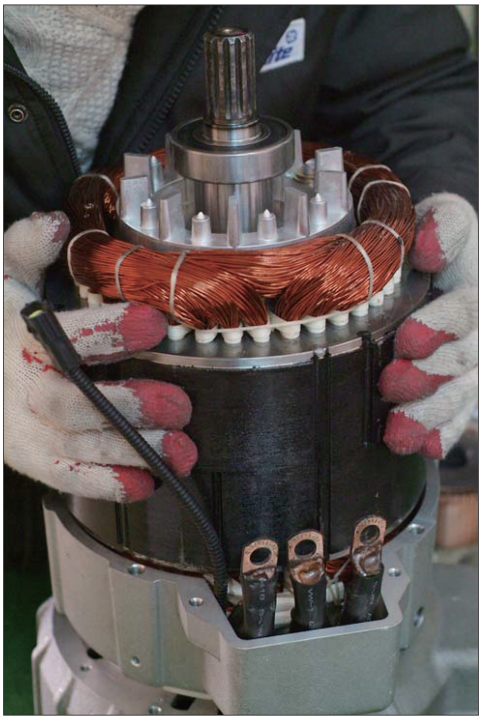
(4) Remove 4 flange nuts with available general tool on the endbell drive side.

10BOP7TM08

(5) Remove endbell de and wave washer.

10BOP7TM09

(6) Remove stator assembly by hand or suitable tool.



(Removing stator)

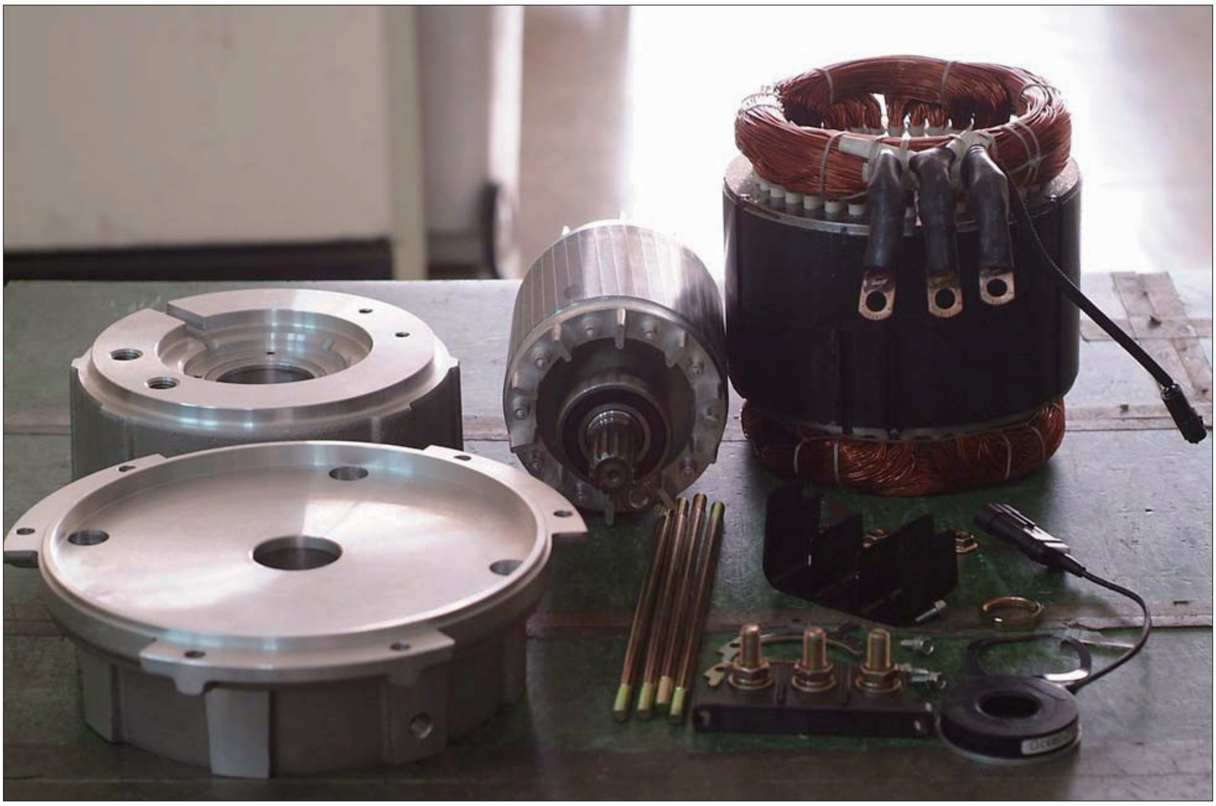
10BOP7TM10

(Removing endbell)

10BOP7TM11

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

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

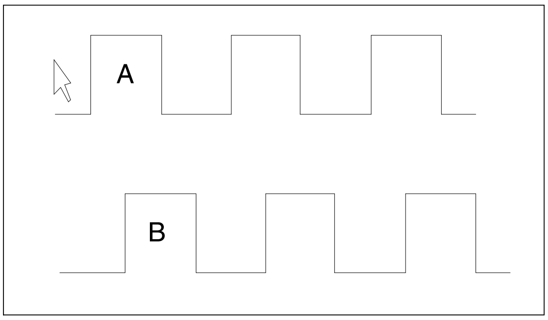


10BOP7TM12

5) ASSEMBLY AND INSTALLATION

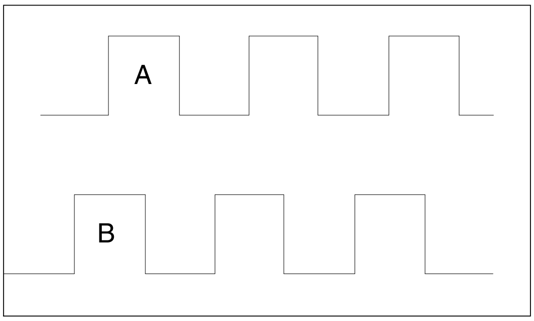
(1) Perform assembly in the reverse order of disassembling.

(2) After assembling, check for speed sensor. Normal signal is as below.



CLOCKWISE ROTATION

10BOP7TM13

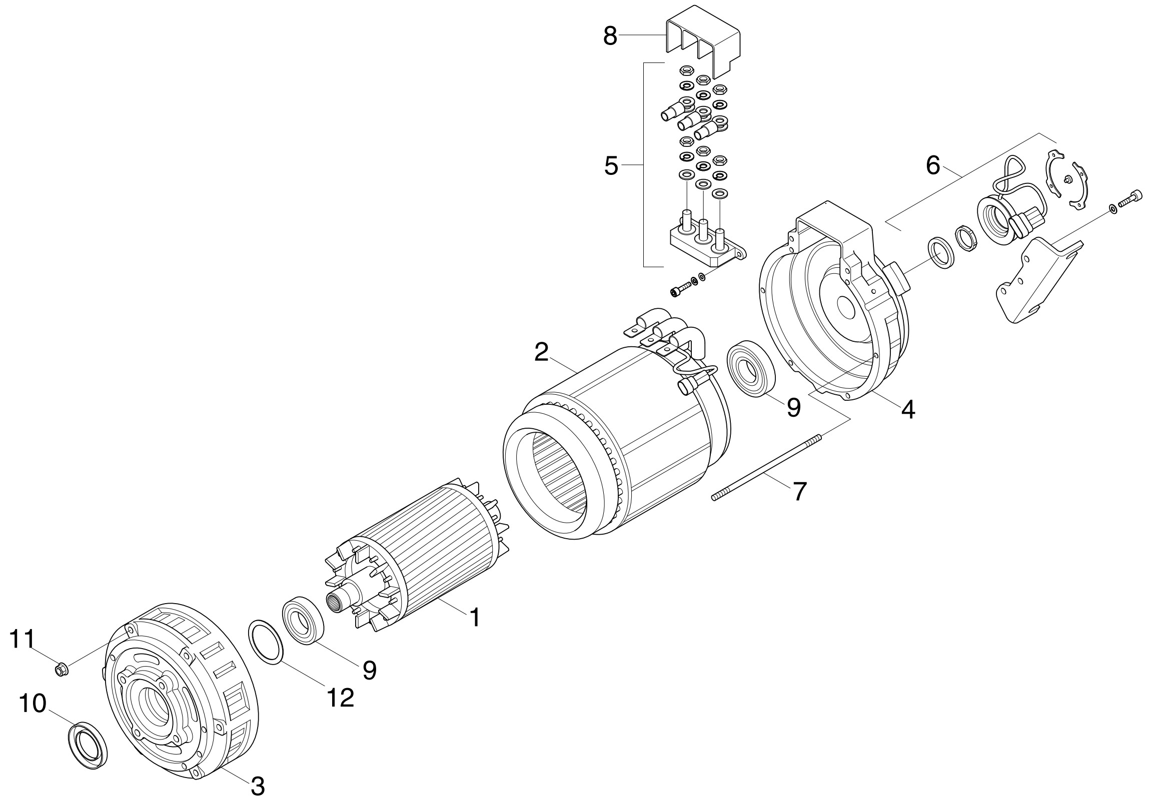


COUNTER CLOCKWISE ROTATION

10BOP7TM14

4. PUMP MOTOR

1) STRUCTURE



1	Rotor assy	5	Terminal block	9	Bearing
2	Stator assy	6	Speed sensor kit	10	Oil seal
3	Endbell	7	Stud bolt	11	Flange nut
4	Endbell DE	8	Terminal protector	12	Wave washer

2) SPECIFICATION

Item	Unit	Specification
Type	-	AMBP4002
Rated voltage	Vac	16
Power	kW	9.0
Current	A	425
Speed	rpm	1720

3) INSPECTION

10BOP7PM01

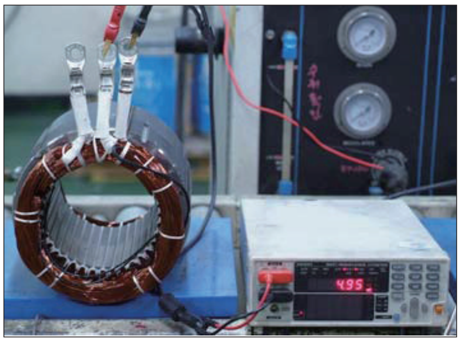
(1) Rotor assembly inspection

- Rotor should always be cleaned with compressed air.
  If the dirt will not come off lightly wipe off with piece of cotton or soft cloth wetted with gasoline.
- Rotor out diameter : Ø123.1±0.05
- Tool : Vernier calipers and standard tool

(2) Stator assembly inspection

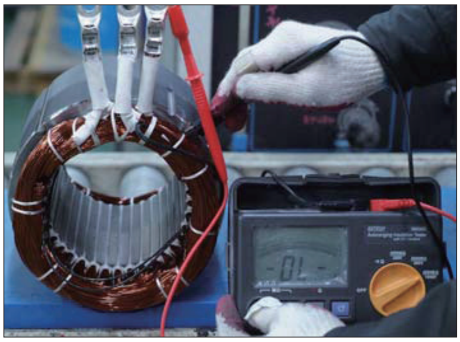
Stator should always be cleaned with compressed air.
If the dirt will not come off lightly wipe off with piece of cotton or soft cloth wetted with gasoline, using care not to damage the coil insulation.

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



10BOP7PM02

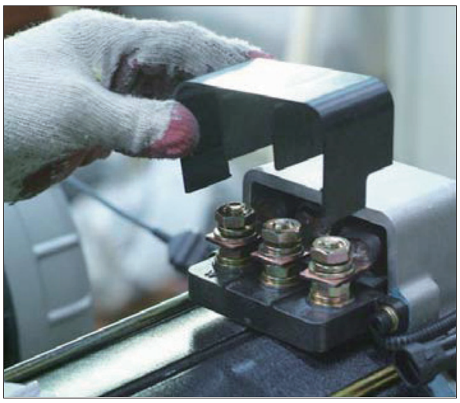
- Insulation test
  Use insulation tester (1000Vac, Min. 10MΩ) and measure as a picture.
  If the insulation is defective, replace with new parts



10BOP7PM03

4) DISASSEMBLY FOR AC MOTOR

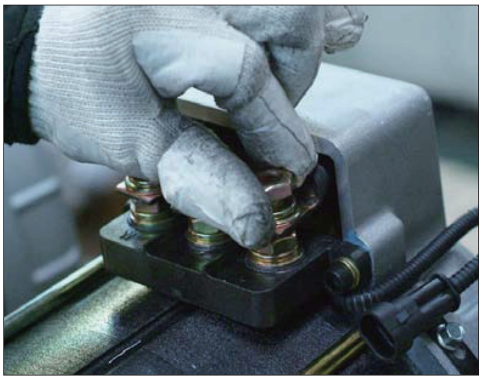
(1) Before disassembling motor, remove terminal protector from the motor and separate thermistor and speed sensor connectors from hanger.



10BOP7PM04

10BOP7PM05

(1) Remove 3 nuts from terminal block of the motor to disassemble terminal block from the motor.



10BOP7PM06

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

10BOP7PM07

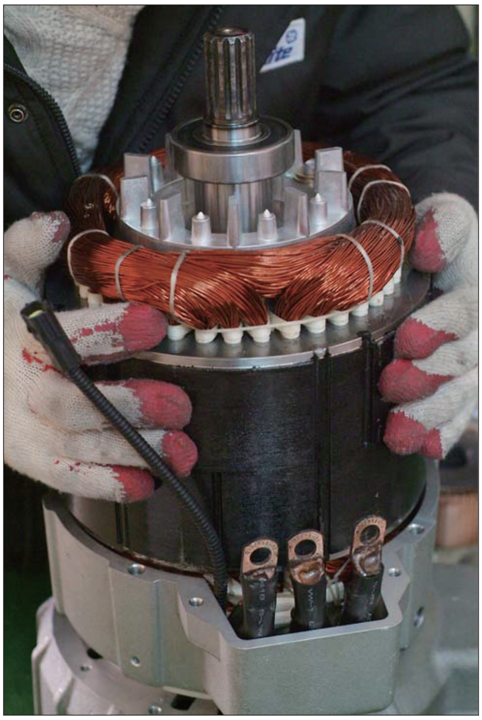
(3) Remove 6 flange nuts with available general tool on the endbell drive side.

10BOP7PM08

(4) Remove endbell de and wave washer.

10BOP7PM09

(5) Remove stator assembly by hand or suitable tool.



(Removing stator)

10BOP7PM10

(Removing endbell)

10BOP7PM11

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

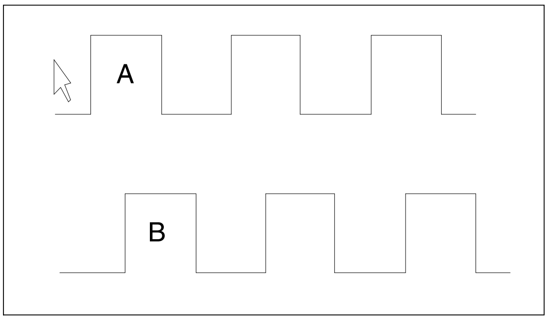
※ The motor are composed of 5-parts.
(Rotor assembly, stator assembly, enbell de, endbell, etc)

10BOP7PM12

5) ASSEMBLY AND INSTALLATION

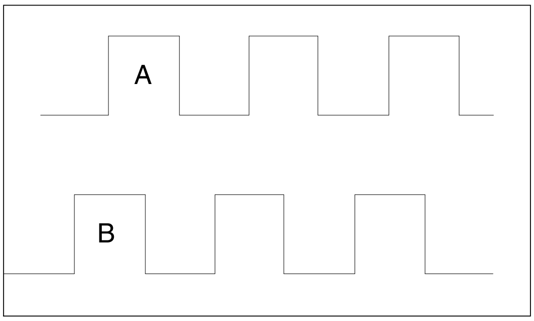
(1) Perform assembly in the reverse order of disassembling.

(2) After assembling, check for speed sensor. Normal signal is as below.



CLOCKWISE ROTATION

10BOP7TM13

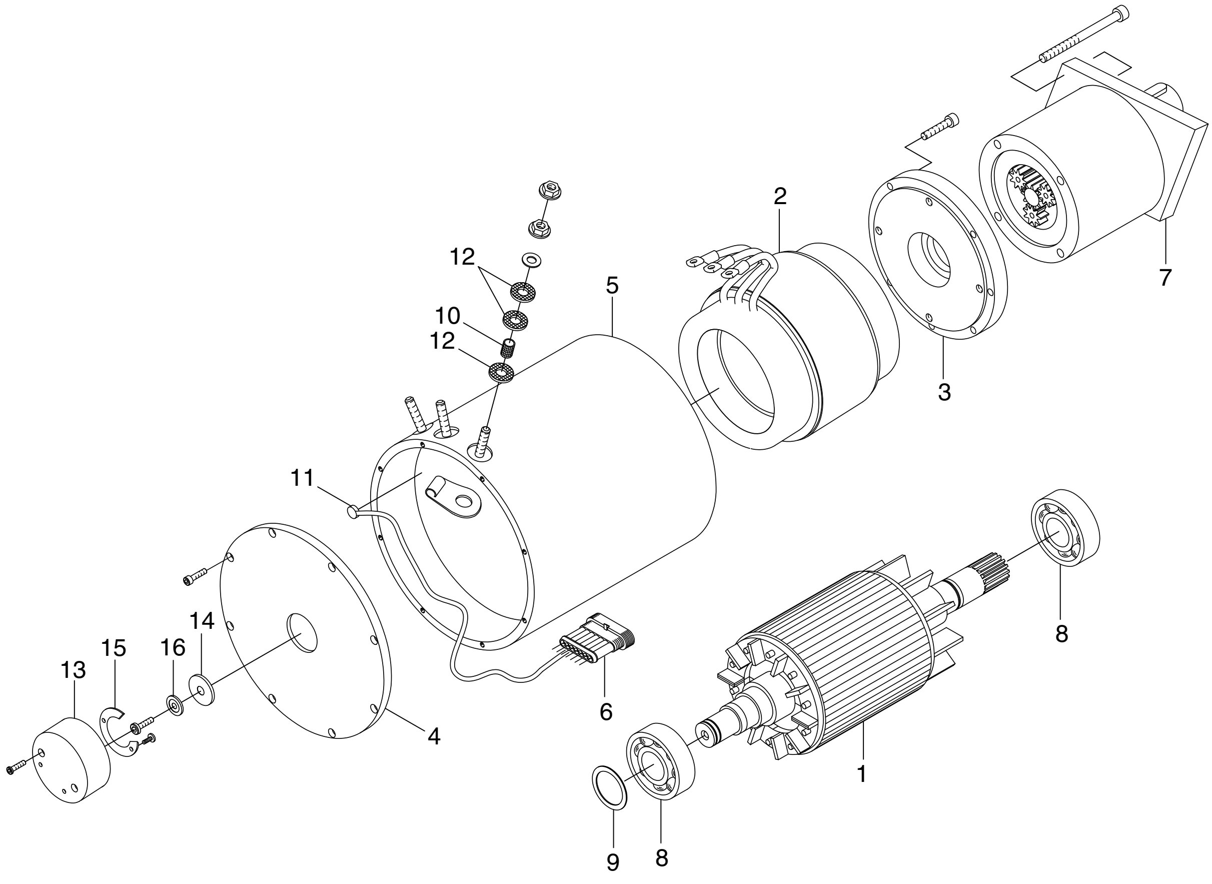


COUNTER CLOCKWISE ROTATION

10BOP7TM14

5. EPS MOTOR

1) STRUCTURE



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

2) SPECIFICATION

Item	Unit	Specification	
		36 V	24 V (Option)
Type	-	G104737A	G104B37
Rated voltage	Vac	31	16
Rated output	W	400	
Insulation	-	Class F	

3) MAINTENANCE INSTRUCTION

※ **Before starting the maintenance please disconnect the power supply.**

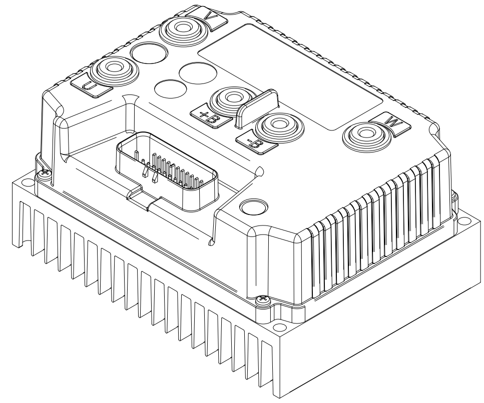
(1) Ball bearing

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

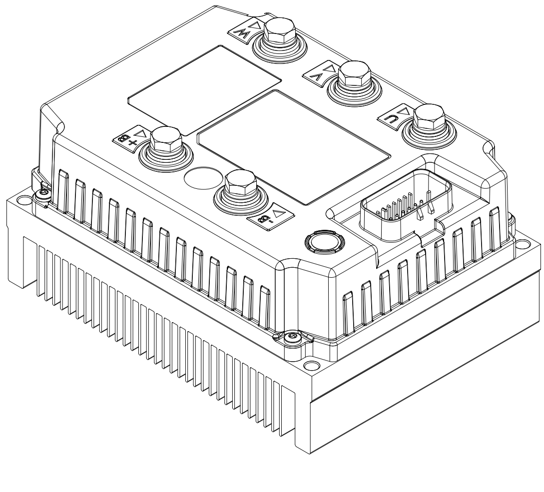
If a bearing which is to be replaced has only one sealing lip, this should be greased with quality bearing grease.

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

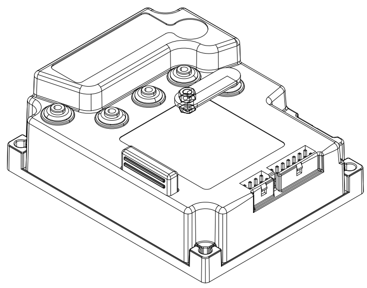
6. CONTROLLER SYSTEM
1) STRUCTURE
(1) 36 V



TRACTION
CONTORLLER (ACE0)



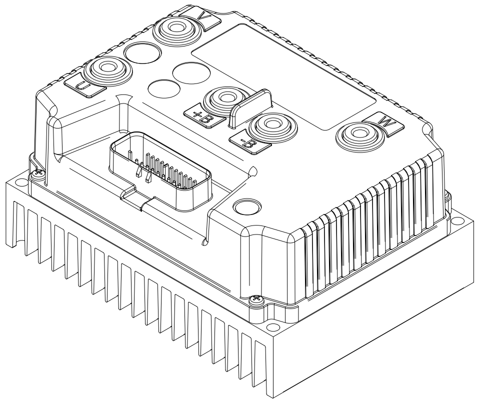
PUMP
CONTORLLER (ACE2 NEW GEN)



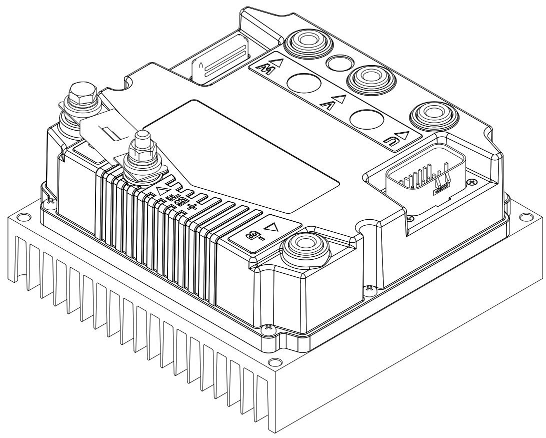
EPS
CONTORLLER (AC0)

13BOP97ES33

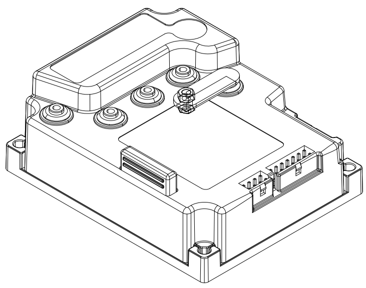
(2) 24 V (Option)



TRACTION
CONTORLLER (ACE0)



PUMP
CONTORLLER (ACE2)



EPS
CONTORLLER (AC0)

13BOP97ES06

2) SPECIFICATIONS

Contoroller		Application	Power	Current limit
36 V	ACE0	Traction	36/48 V	280 A, 2 min
	ACE2 NEW GEN	Pump	36/48 V	450 A, 2 min
	AC0	EPS	36/48 V	45 A, 2 min
24 V (Option)	ACE0	Traction	24 V	320 A, 2 min
	ACE2	Pump	24 V	500 A, 3 min
	AC0	EPS	24 V	50 A, 2 min

3) PIN MAP DESCRIPTION

(1) Traction controller (36 V, 24 V)

No. of Pin	Function	Description
A1	NA	-
A2	P BRAKE	Positive of the electromechanical brake coil
A3	P AUX	Positive supply for electrovalves. This input has to be supplied with positive taken after main contactor
A4	N BRAKE	Electro mechanic brake coil driver output; PWM controlled
A5	GND	Negative of encoder & temp sensor
A6	HEIGHT3000	Input of height 3000 mm switch
A7	HEIGHT5500	Input of height 5500 mm switch
A8	NA	-
A9	SOL1	Output of the ON/OFF electrovalve EV1
A10	KEY	Input of the key switch signal
A11	SOL2	Output of the ON/OFF electrovalve EV2
A12	NMC	Main contactor coil driver output
A13	ENC A	Traction motor encoder phase A
A14	ENC B	Traction motor encoder phase B
A15	NA	-
A16	NA	-
A17	LIFT STOP	Input of lift stop switch
A18	ENABLE	Connection to EPS inverter enable port
A19	NA	-
A20	NA	-
A21	NA	-
A22	TMOT	Traction motor thermal sensor input
A23	NA	-
A24	PR1	Negative of the lower proportional electrovalve driver
A25	ENC VCC	Encoder positive supply
A26	NA	-
A27	CAN L	Low level CAN-BUS voltage I/O.
A28	CAN H	High level CAN-BUS voltage I/O.
A29	HEIGHT MAX-100	Input of height MAX-100mm switch
A30	NA	-
A31	SIDE ROLLER LH	Input of the side roller LH switch (Optional)
A32	NA	-
A33	SOL3	Output of the ON/OFF electrovalve EV3
A34	NA	-
A35	SLACK CHAIN	Input of the slack chain switch

(2) Pump controller

① 36 V

No. of Pin	Function	Description
A1	KEY	Input of the key switch signal
A2	NA	-
A3	NA	-
A4	NA	-
A5	NA	-
A6	NA	-
A7	ENC A	Pump motor encoder phase A
A8	ENC VCC	Encoder positive supply
A9	NA	-
A10	NA	-
A11	NA	-
A12	CAN T	CAN-BUS T (120 Ohm) connected
A13	NA	-
A14	ENC B	Pump motor encoder phase B
A15	ENC GND	Negative of encoder
A16	NMC	Fan relay coil driver output
A17	COMMON	Positive of Fan/Buzzer relay
A18	NEB	Back buzzer relay coil driver output
A19	NA	-
A20	CAN L	Low level CAN-BUS voltage I/O
A21	CAN H	High level CAN-BUS voltage I/O
A22	NCAN	Negative of temperature sensor
A23	PTHERM	Input for motor temperature sensor

② 24 V (Option)

No. of Pin	Function	Description
A1	KEY	Input of the key switch signal
A2	NA	-
A3	NA	-
A4	NA	-
A5	NA	-
A6	NA	-
A7	ENC A	Pump motor encoder phase A
A8	ENC VCC	Encoder positive supply
A9	NA	-
A10	NA	-
A11	CAN2 L	Low level CAN2-BUS voltage I/O.
A12	CAN2 H	High level CAN2-BUS voltage I/O.
A13	NA	-
A14	ENC B	Pump motor encoder phase B
A15	ENC GND	Negative of encoder
A16	NMC	Fan relay coil driver output
A17	COMMON	Positive of Fan/Buzzer relay
A18	NEB	Back buzzer relay coil driver output
A19	NA	-
A20	CAN L	Low level CAN-BUS voltage I/O.
A21	CAN H	High level CAN-BUS voltage I/O.
A22	PTHERM	Input for motor temperature sensor
A23	THERM GND	Negative of temperature sensor

(3) EPS controller (36 V, 24 V)

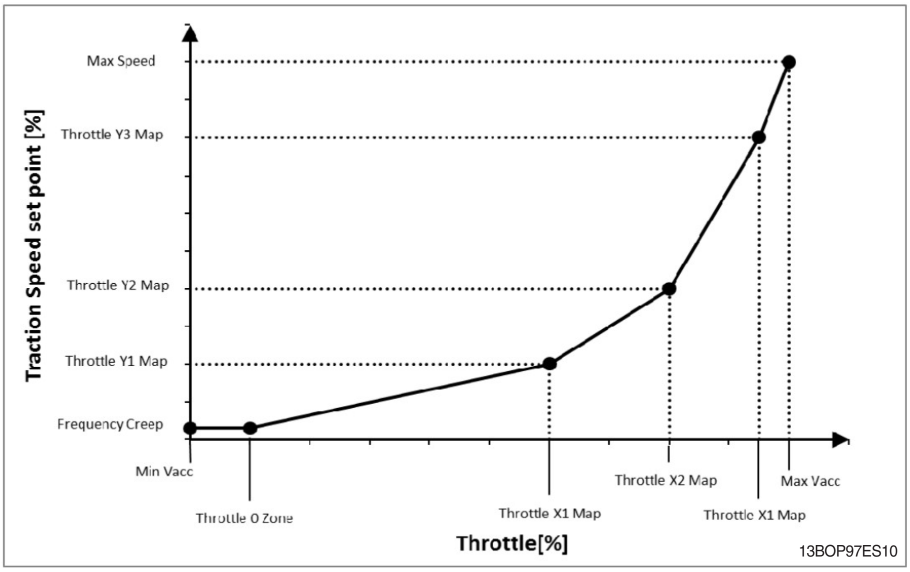
No. of Pin	Function	Description
A1	SIDE ROLLER RH	Input of the side roller RH signal
A2	SW 2	2nd toggle switch (90 degrees)
A3	SW 1	1st toggle switch (0 degrees)
A4	-BATT.	Safety switch lower voltage point
A5	ENABLE	Connection to traction inverter enable port
A6	CAN L	Can bus low
A7	KEY	Key in
A8	DL	Stepper motor D line
A9	QL	Stepper motor Q line
A10	GND	GND. encoder D line negative supply
A11	GND	GND. encoder Q line negative supply and EPS motor encoder negative
A12	GND	GND. SW 1 & SW 2 negative
A13	GND	GND. motor thermal sensor negative
A14	CANH	Can bus high
B1	NA	-
B2	NA	-
B3	THMOT	Motor thermal sensor (KTY84-130) input
B4	VCC	Encoder & SW1, SW2, Smart Antenna positive supply
B5	NA	-
B6	NA	-
B7	ENC B	Encoder channel B
B8	ENC A	Encoder channel A

4) MENU DESCRIPTION

(1) TRACTION CONTROLLER (36 V)

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
EB ON TILLER BRK	This option defines how the electromechanical brake is managed depending on the status of tiller/seat input: - ON = the electromechanical brake is engaged as soon as the tiller input goes into OFF state. The deceleration ramp defined by TILLER BRAKING parameter has no effect. - OFF = when the tiller input goes into OFF state, the “tiller braking” ramp is applied before engaging the electromechanical brake.
STOP ON RAMP	This parameter enables or disables the stop-on-ramp feature (the truck is electrically held in place on a slope for a defined time). - ON = The stop-on-ramp feature is performed for a time set in the AUXILIARY TIME parameter. - OFF = The stop-on-ramp feature is not performed. Instead, a controlled slowdown is performed for a minimum time set in the AUXILIARY TIME arameter. After the AUXILIARY TIME interval, the three-phase bridge is released and, if present, the electromechanical brake activated (see parameter AUX OUT FUNCTION).
PULL IN BRAKING	This parameter enables or disables the functionality that continues to give torque even if the traction (or lift) request has been released. - ON = When the operator releases the traction request, the inverter keeps running the truck, as to oppose the friction that tends to stop it. Similarly, in pump applications, when the operator releases the lift request, the inverter keeps running the pump avoiding the unwanted descent of the forks. - OFF = When the operator releases the traction (or lift) request, the inverter does not power anymore the motor. This setting is useful especially for traction application. When the truck is travelling over a ramp and the driver wants to stop it by gravity, the motor must not be powered anymore, until the truck stops.
SOFT LANDING	This parameter enables or disables the control of the deceleration rate of the truck when the accelerator is released. - ON = When the accelerator is released, the inverter controls the deceleration rate of the truck through the application of a linearly decreasing torque curve. This is useful when the operator releases the accelerator while the truck is going uphill. If the rise is steep, the truck may stop fast and may also go backwards in short time, possibly leading to a dangerous situation. - OFF = When the accelerator is released, the inverter does not control the deceleration rate of the truck, instead it stops driving the motor.
QUICK INVERSION	This parameter defines the quick-inversion functionality. - NONE = The quick-inversion function is not managed. - BRAKE = Upon a quick-inversion request, the motor is braked. - TIMED = The quick-inversion function is timed: upon a QI request the controller drives the motor in the opposite direction for a fixed time (1.5 seconds by default). - BELLY = The quick-inversion function is managed but not timed: upon a QI request the controller drives the motor in the opposite direction until the request is released.
PEDAL BRK ANALOG	This parameter defines the kind of brake pedal adopted. - ON = Brake pedal outputs an analog signal, braking is linear. - OFF = Brake pedal outputs a digital signal, braking is on/off.
HARD & SOFT	This parameter enables or disables the Hard-and-Soft functionality. With H&S, it is possible to start the truck (at reduced speed) only by activating the H&S switch and the accelerator, without the tiller input. ON = H&S function is enabled. OFF = H&S function is disabled.

SET OPTIONS	DESCRIPTION
HB ON / SR OFF	This parameter defines the function associated with input A18. ON = Handbrake. OFF = Speed reduction.
SET MOT. TEMPERAT	Sets the motor temperature sensor type. - NONE = no motor thermal sensor switch is connected. - DIGITAL = a digital (ON/OFF) motor thermal sensor is connected to A22. - OPTION#1 = an analogue motor thermal sensor is connected to A22. The temperature sensor is a KTY 84-130 PTC (positive thermal coefficient resistance). - OPTION#2 = an analogue motor thermal sensor is connected to A22. The temperature sensor is a KTY 83-130 PTC (positive thermal coefficient resistance) - OPTION#3 = an analog motor thermal sensor is connected to A22. The temperature sensor is a PT1000 PTC (positive thermal coefficient resistance).
STEERING TYPE	It allows to select which type of steering unit is connected to the controller. - NONE = NO steering module is present on the truck, ACE0/COMBIAC0 does not wait for CAN message by the EPS and it does not apply EPS and braking steer cutback. - OPTION#1 = EPS is present and it is configured with an ENCODER + TOGGLE SWITCHES. These signals are transmitted to ACE0/COMBIAC0 over CAN bus. - OPTION#2 = EPS is present and it is configured with a POT + ENCODER. These signals are transmitted to ACE0/COMBIAC0 over CAN bus. - ANALOG = A hydraulic steer is used on the truck and ACE0/COMBIAC0 is reading through one of its analog input the signal coming from a wheel potentiometer in order to read the wheel rotation.
MC FUNCTION	This parameter defines the configuration of the NLC output (A12), dedicated to the main – or line – contactor. - OFF = Main contactor is not present. Diagnoses are masked and MC is not driven. - ON = Main contactor is in standalone configuration. Diagnoses are performed and MC is closed after key-on only if they have passed. - OPTION#1 = For a traction-and-pump setup, with only one main contactor for both controllers. Diagnoses are performed and MC is closed after key-on only if they have passed. - OPTION#2 = For a traction-and-pump setup, with two main contactors. Each controller drives its own MC. Diagnoses are performed and MCs are closed after key-on only if they have passed.
M.C. OUTPUT	This parameter defines whether a load coil is connected to the NLC output (A12) or not. - ABSENT = NLC output is not connected to any load coil. - PRESENT = NLC output is connected to a load coil (by default, that of the main contactor).
EBRAKE ON APPL.	This parameter defines whether the application includes an electromechanical brake or not.
AUX OUT FUNCTION	This parameter enables or disables the NEB output (A4), 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.
COMP.VOLT. OUTPUT	This parameter defines the voltage compensation for the MC and EB drivers in dependence of the battery voltage 0 = None. 1 = MC only. 2 = EB only. 3 = MC and EB.
ACCEL MODULATION	This parameter enables or disables the acceleration-modulation function. - OFF = The acceleration rate is inversely proportional to the ACCEL DELAY parameter. - ON = The acceleration ramp is inversely proportional to the ACCEL DELAY parameter only if speed setpoint is greater than 100 Hz. Below 100 Hz the acceleration ramp is also proportional to the speed setpoint, so that the acceleration duration results equal to ACCEL DELAY.

ADJUSTMENTS	DESCRIPTION
THROTTLE Y3 MAP	This parameter defines the accelerator input curve. - Accelerator input curve  13BOP97ES10 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.

<table>
<tr><th>ADJUSTMENTS</th><th>DESCRIPTION</th></tr>
<tr><td>BAT. MIN ADJ.</td><td rowspan="6">During operating condition, the battery-charge detection makes use of two parameters that specify the full-charge voltage (100%) and the discharged-battery voltage (10%): BAT.MAX.ADJ and BAT.MIN.ADJ.

It is possible to adapt the battery-charge detection to your specific battery by changing the above two settings (e.g. if the battery-discharge detection occurs when the battery is not totally discharged, it is necessary to reduce BAT.MIN.ADJ).

Moreover, BDI ADJ STARTUP adjusts the level of the battery charge table at the start-up, in order to evaluate the battery charge at key-on. The minimum variation of the battery charge that can be detected depends on the BDI RESET parameter.

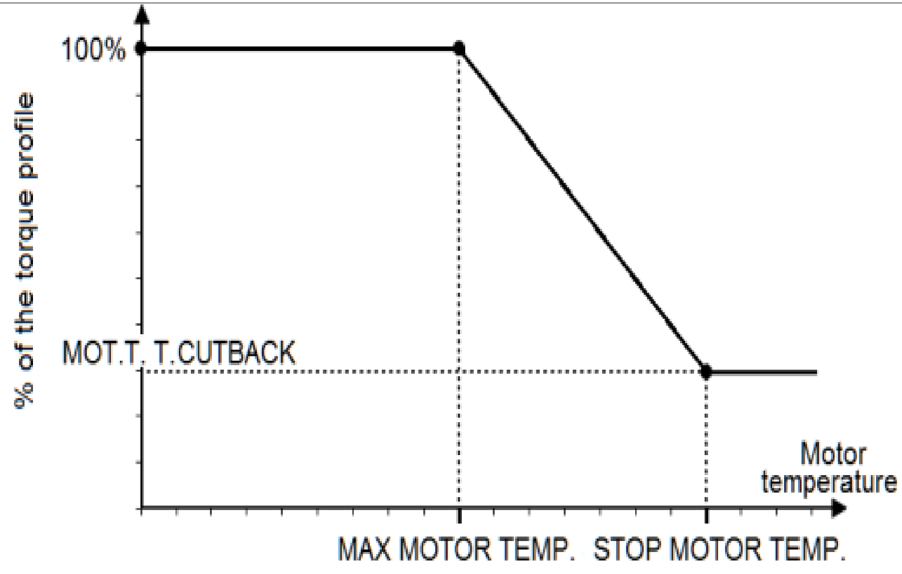
The battery-charge detection works as the following procedure.

Start-up
1) The battery voltage is read from key input when the battery current is zero, which is when the output power stage is not driven. It is evaluated as the average value over a window of time, hereafter addressed as Vbatt.
2) Vbatt is compared with a threshold value which comes as function of the actual charge percentage; by this comparison a new charge percentage is obtained.
3) The threshold value can be changed with the BDI ADJ STARTUP parameter.
4) If the new charge percentage is within the range “last percentage (last value stored in EEPROM) ± BDI RESET” it is discarded; otherwise charge percentage is updated with the new value.

Operating condition
Measure of the battery voltage, together with the charge percentage at the time of the voltage sampling, give information about the instantaneous battery current.

1) The battery voltage is read when the battery current is not zero, which is when the output power stage is driven. Vbatt is evaluated as the average value over a window of time.
2) Vbatt is compared with a threshold value which comes as function of the actual charge percentage; by this comparison the current provided by the battery is obtained.
3) Current obtained at step 2 integrated over time returns the energy drawn from the battery, in Ah.
4) Charge percentage is dynamically updated basing on the energy from step 3.
5) Threshold values for the battery charge can be modified by means of BAT.MAX.ADJ. and BAT.MIN.ADJ. as to adapt the battery-charge detection to the specific battery in use.</td></tr>
<tr><td>BAT. MAX ADJ.</td></tr>
<tr><td>BDI ADJ STUP MIN</td></tr>
<tr><td>BDI ADJ STUP MAX</td></tr>
<tr><td>BDI RESET</td></tr>
<tr><td>BDI RESET 2</td></tr>
<tr><td>BATT.LOW TRESHLD</td><td>This parameter defines the minimum charge percentage below which the BATTERY LOW alarm rises.</td></tr>
<tr><td>BAT.ENERGY SAVER</td><td>When set to ON, this parameter enables the possibility to save the battery charge when it has reached a certain value, through a maximum torque reduction.</td></tr>
<tr><td>VOLTAGE THR LOW</td><td rowspan="2">These parameters define the voltage thresholds for the working voltage range, expressed as percentage of the nominal voltage.
By default, at start-up the controller checks the battery voltage to be within the range from VOLTAGE THR LOW to VOLTAGE THR HIGH.
In case the check fails, alarm WRONG KEY VOLT. is raised.</td></tr>
<tr><td>VOLTAGE THR HIGH</td></tr>
</table>

ADJUSTMENTS	DESCRIPTION
MAX ANGLE RIGHT	This parameter defines the maximum steering-wheel angle while turning right.
MAX ANGLE LEFT	This parameter defines the maximum steering-wheel angle while turning left.
STEER DEAD ANGLE	This parameter defines the maximum steering-wheel angle up to which the permitted traction speed is 100%.
STEER ANGLE 1	This parameter defines the steering-wheel angle at which traction speed is reduced to the value imposed by CURVE SPEED 1. For steering-wheel angles between STEER DEAD ANGLE and STEER ANGLE 1, traction speed is reduced linearly from 100% to CURVE SPEED 1.
MAX ANGLE SP CTB	It determines the angle for speed reduction. (MAX ANGLE SPEED CUTBACK)
SPEED FACTOR	This parameter defines the coefficient used for evaluating the truck speed (in km/h) from the motor frequency (in Hz), according to the following formula: $\text{Speed [km/h]} = 10 \cdot \frac{\text{frequency [Hz]}}{\text{Speed factor}}$
SPEED ON MDI	(Not used) This parameter enables or disables the speed visualization on MDI display: - ON = MDI shows traction speed when the truck is moving. In steady-state condition the speed indication is replaced by the hour-meter indication. - OFF = Standard MDI functionality.
LOAD HM FROM MDI	(Not used) This parameter enables or disables the transfer of the hour-meter to a MDI unit. OFF = controller hour meter is not transferred and recorded on the MDI hour meter. ON = controller hour meter is transferred and recorded on the MDI hour meter (connected via the Serial Link).
MAINTEN. RESET	(Not used)
MAINTENANCE	(Not used)
MC VOLTAGE	This parameter specifies the duty-cycle (t_{ON}/T_{PWM}) of the PWM applied to the main-contactor output (A12) during the first second after the activation signal that causes the main contactor to close.
MC VOLTAGE RED.	This parameter defines a percentage of MC VOLTAGE parameter and it determines the duty-cycle applied after the first second of activation of the contactor.
EB VOLTAGE	This parameter specifies the duty-cycle (t_{ON}/T_{PWM}) of the PWM applied to the electromechanical brake output(A4) during the first second after the activation signal that causes the electromechanical brake to release.
EB VOLTAGE RED.	This parameter defines a percentage of EB VOLTAGE parameter and it determines the duty-cycle applied after the first second since when the electromechanical brake is released.
PWM EV2	This parameter defines the duty-cycle of the PWM applied to EV2 output (A11).
PWM EV3	This parameter defines the duty-cycle of the PWM applied to EV3 output (A33).
MAX. MOTOR TEMP.	This parameter defines the motor temperature above which a 50% cutback is applied to the maximum current. Cutback is valid only during motoring, while during braking the 100% of the maximum current is always available independently by the temperature.

ADJUSTMENTS	DESCRIPTION
STOP MOTOR TEMP.	This parameter defines the maximum motor temperature permitted, above which the controller stops driving the motor.
MOT.T. T. CUTBACK	This parameter defines the motor thermal cutback. The control linearly reduces the motor torque basing on the motor temperature. Reference limits of the linear reduction are MAX MOTOR TEMP and TEMP. MOT. STOP.  13BOP97ES11
MAINTENANCE HOUR	(Not used)
MAINT PRE WARN	((Not used)
DEADBAND ACCEL	This parameter defines the deadband [%] of the ACCEL.

PARAMETER	DESCRIPTION
ACCELER. DELAY	This parameter defines the acceleration ramp, i.e. the time needed to speed up the motor from 0 Hz up to 100 Hz. A special software feature manages the acceleration ramp depending on the speed setpoint. - ACCEL MODULATION = OFF $\text{Accel tims [s]} = \frac{\text{Speed setpoint [Hz]}}{100\ \text{Hz}} \cdot \text{Acceler delay [s]}$ - ACCEL MODULATION = ON Case 1 (red trace in the graph): Final-speed setpoint = 60 Hz ACCEL DELAY = 2.5 s Acceleration rate is re-scaled so that acceleration time results equal to ACCEL DELAY, in this case 2.5 s. Case 2 (green trace in the graph): Final-speed setpoint = 150 Hz ACCEL DELAY = 2.5 s Acceleration time results: $\text{Accel tims [s]} = \frac{150\ \text{Hz}}{100\ \text{Hz}} \cdot \text{Acceler delay} = 3.75\ \text{sec}$ N: N Mode E: E Mode P: P Mode
RELEASE BRAKING	This parameter defines the deceleration ramp performed after the running request is released.
DEADMAN BRAKING	This parameter defines the deceleration ramp performed after the deadman s/w is OFF.
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.
WG BRAKING	This parameter defines the deceleration ramp performed when the Wire Guidance s/w is ON.
WG BRAK END PATH	This parameter defines the deceleration ramp performed when the truck reaches to the end path of the wire guidance.

PARAMETER	DESCRIPTION
ACC. MIN MODUL.	This parameter defines the minimum speed set-point variation for the acceleration modulation to have effect, provided that ACCEL MODULATION = ON. Variations of the speed set-point smaller than ACC. MIN MODUL. result in accelerations shorter than time ACCELER. DELAY. It is expressed as a percentage of 100 Hz, which is the maximum speed set-point variation for the acceleration modulation to have effect. See parameters ACCEL MODULATION and ACCELER. DELAY under SET OPTIONS.
REL. MIN MODUL.	This parameter defines the minimum speed set-point variation for the braking modulation to have effect in release. Variations of the speed set-point smaller than REL. MIN MODUL. result in deceleration shorter than time DECEL. BRAKING. It is expressed as a percentage of 100 Hz, which is the maximum speed set-point variation for the braking modulation to have effect. See parameter DECEL. BRAKING under PARAMETER CHANGE.
MAX SPEED FORW N	This parameter defines the maximum speed in forward direction. N Mode
MAX SPEED FORW E	This parameter defines the maximum speed in forward direction. E Mode
MAX SPEED FORW P	This parameter defines the maximum speed in forward direction. P Mode
MAX SPEED BACK N	This parameter defines the maximum speed in backward direction. N Mode
MAX SPEED BACK E	This parameter defines the maximum speed in backward direction. E Mode
MAX SPEED BACK P	This parameter defines the maximum speed in backward direction. P Mode
TURTLE SPEED N	This parameter defines the maximum speed at turtle mode. N Mode
TURTLE SPEED E	This parameter defines the maximum speed at turtle mode. E Mode
TURTLE SPEED P	This parameter defines the maximum speed at turtle mode. P Mode
BMS WRN1 CB SPE.	This parameter defines the maximum speed performed when the BMS warning 1 is active.
H&S CUTBACK	This parameter defines the maximum speed performed when the Hard-and-Soft function is active. It represents a percentage of TOP MAX SPEED.
CTB. STEER ALARM	This parameter defines the maximum traction speed when an alarm from the EPS is read by the microcontroller, if the alarm is not safety-related. The parameter represents a percentage of TOP MAX SPEED.
MOT.HT MAX SPEED N	The Maximum speed when the Motor Temperature is reached to the MAX. MOTOR TEMP. Setting. N Mode
MOT.HT MAX SPEED E	The Maximum speed when the Motor Temperature is reached to the MAX. MOTOR TEMP. Setting. E Mode
MOT.HT MAX SPEED P	The Maximum speed when the Motor Temperature is reached to the MAX. MOTOR TEMP. Setting. P Mode
CURVE SPEED 1	This parameter defines the maximum traction speed when the steering angle is equal to the STEER ANGLE 1 angle.

<table>
<tr><th>PARAMETER</th><th>DESCRIPTION</th></tr>
<tr><td>WG FWD SPEED</td><td>The Maximum forward speed when wire guidance is performed before lock on.</td></tr>
<tr><td>CUTBACK SPEED 1 N</td><td rowspan="24">The parameters defines the maximum speed by the height of the lift.
<table>
<tr><th rowspan="2">Steering angle</th><th colspan="5">Maximum speed by height of lift</th></tr>
<tr><th>0~600</th><th>~1,500</th><th>~3,000</th><th>~5,500</th><th>5,500~</th></tr>
<tr><td>Angle < 10˚</td><td>MAX FORWORD
MAX BACKWORD</td><td>CUTBACK
SPPED1</td><td>CUTBACK
SPPED2</td><td>CUTBACK
SPPED3</td><td>CUTBACK
SPPED4</td></tr>
<tr><td>10˚ < Angle < 45˚</td><td colspan="5">is linearly decreasing</td></tr>
<tr><td>Angel > 45˚</td><td>CURVE
CUTBACK SP</td><td>AUX
FUNCTION 1</td><td>AUX
FUNCTION 1</td><td>AUX
FUNCTION 1</td><td>AUX
FUNCTION 1</td></tr>
</table></td></tr>
<tr><td>CUTBACK SPEED 2 N</td></tr>
<tr><td>CUTBACK SPEED 3 N</td></tr>
<tr><td>CUTBACK SPEED 4 N</td></tr>
<tr><td>AUX FUNCTION 1 N</td></tr>
<tr><td>AUX FUNCTION 2 N</td></tr>
<tr><td>AUX FUNCTION 3 N</td></tr>
<tr><td>AUX FUNCTION 4 N</td></tr>
<tr><td>CUTBACK SPEED 1 E</td></tr>
<tr><td>CUTBACK SPEED 2 E</td></tr>
<tr><td>CUTBACK SPEED 3 E</td></tr>
<tr><td>CUTBACK SPEED 4 E</td></tr>
<tr><td>AUX FUNCTION 1 E</td></tr>
<tr><td>AUX FUNCTION 2 E</td></tr>
<tr><td>AUX FUNCTION 3 E</td></tr>
<tr><td>AUX FUNCTION 4 E</td></tr>
<tr><td>CUTBACK SPEED 1 P</td></tr>
<tr><td>CUTBACK SPEED 2 P</td></tr>
<tr><td>CUTBACK SPEED 3 P</td></tr>
<tr><td>CUTBACK SPEED 4 P</td></tr>
<tr><td>AUX FUNCTION 1 P</td></tr>
<tr><td>AUX FUNCTION 2 P</td></tr>
<tr><td>AUX FUNCTION 3 P</td></tr>
<tr><td>AUX FUNCTION 4 P</td></tr>
<tr><td>CHAT TIME DELAY</td><td>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.</td></tr>
<tr><td>DEADMAN DELAY</td><td>This parameter defines the delay time after the deadman switch is off.</td></tr>
<tr><td>M.TRAC SPEED RED</td><td>Maximum speed when the MAINTENANCE is set to OPTOIN#2 or #3</td></tr>
<tr><td>BATT. LOW SPEED N</td><td rowspan="3">This parameter defines the maximum current performed according to "BATTERY CHECK" parameter.
N: N Mode
E: E Mode
P: P Mode</td></tr>
<tr><td>BATT. LOW SPEED E</td></tr>
<tr><td>BATT. LOW SPEED P</td></tr>
</table>

PARAMETER	DESCRIPTION
MIN EVP	(Minimum speed when the lift is lowering) This parameter determines the minimum current applied to the EVP when the potentiometer position is at the minimum. This parameter is not effective if the EVP is programmed like an on/off valve.
MAX EVP	(Maximum speed when the lift is lowering) This parameter determines the maximum current applied to the EVP when the potentiometer position is at the maximum. This parameter also determines the current value when the EVP is programmed like an ON/OFF valve.
EVP OPEN DELAY	It determines the current increase rate on EVP. The parameter sets the time needed to increase the current to the maximum possible value.
EVP CLOSE DELAY	It determines the current decrease rate on EVP. This parameter is working when the platform is upper than the CABIN LOW STOP switch. The parameter sets the time needed to decrease the current from the maximum possible value to zero.
EVP CLOSE DE STO	It determines the current decrease rate on EVP. This parameter is working when the platform is lower the CABIN LOW STOP switch. The parameter sets the time needed to decrease the current from the maximum possible value to zero.
MIN EVP FORK	(Minimum speed when the additional lift is lowering) This parameter determines the minimum current applied to the EVP FORK when the potentiometer position is at the minimum. This parameter is not effective if the EVP FORK is programmed like an on/off valve.
MAX EVP FORK	(Maximum speed when the additional lift is lowering) This parameter determines the maximum current applied to the EVP FORK when the potentiometer position is at the maximum. This parameter also determines the current value when the EVP FORK is programmed like an ON/OFF valve.
EVP OPEN FORK	It determines the current increase rate on EVP FORK. The parameter sets the time needed to increase the current to the maximum possible value.
EVP CLOSE FORK	It determines the current decrease rate on EVP FORK. The parameter sets the time needed to decrease the current from the maximum possible value to zero.
MAX EVP RED	(Maximum speed when the lift is lowering below 600mm) This parameter determines the maximum current applied to the EVP when the potentiometer position is at the maximum and the lift is below 600mm. This parameter also determines the current value when the EVP is programmed like an ON/OFF valve.
MIN EVP2	This parameter determines the minimum current applied on the EVP2 when the position of the potentiometer is at the minimum. This parameter is not effective if the EVP2 is programmed like an on/off valve.
MAX EVP2	This parameter determines the maximum current applied to the EVP2 when the position of the potentiometer is at the maximum. This parameter also determines the current value when the EVP2 is programmed like an ON/OFF valve.
EVP2 OPEN DELAY	It determines the acceleration ramp on EVP2. The parameter sets the time needed to increase the current to the maximum possible value.
EVP2 CLOSE DELAY	It determines the deceleration ramp on EVP2. The parameter sets the time needed to decrease the current from the maximum possible value to zero.

TRACTION MASTER	
MONITORING	DESCRIPTION
KEY VOLTAGE	Key voltage measured in real time.
BATTERY VOLTAGE	Battery voltage measured in real time (across the DC bus).
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.
MOTOR VOLTAGE	Theoretical phase- to- phase voltage to be applied at the motor terminals, as a percentage of the supply voltage.
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)
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)
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.
STEER ANGLE	Current steering- wheel angle. When the steering is straight ahead STEER ANGLE is zero.
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.
A7 H.SW4 SW	Status of the Height switch 4 input (pin A7).
A6 H.SW3 SW	Status of the Height switch 3 input (pin A6).
A31 SIDE ROL. L SW	Status of the Side Roller LH switch input (pin A31).
A35 CHAIN LOOS. SW	Status of the Slack Chain switch input (pin A35).
A17 CABIN STOP SW	Status of the Cabin Stop switch input (pin A17).
A29 CABIN LIMIT SW	Status of the Cabin Limit switch input (pin A29).
EPS SAFETY SW	Status of the EPS safety input (pin A18).
A24 SET EVP	Setpoint of the EVP1 output (pin A24).
A9 OUTPUT EV1	Status of the EV1 output (pin A9).

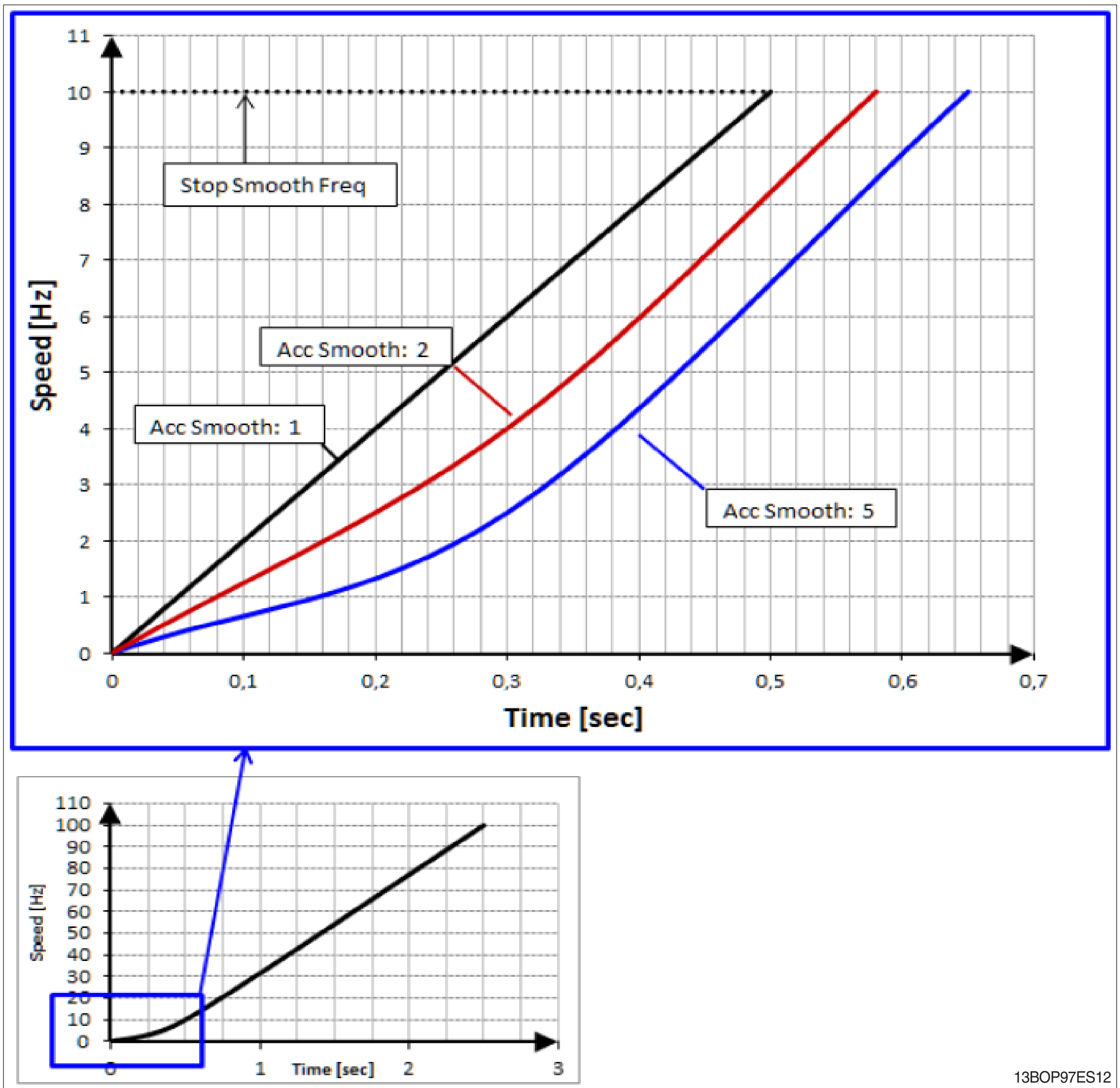
TRACTION MASTER	
MONITORING	DESCRIPTION
A12 MAIN CONT.	Voltage applied over the main contactor coil. It corresponds to the duty cycle value of PWM applied, expressed as percentage.
A4 ELEC.BRAKE	Voltage applied over the electromechanical brake coil. It corresponds to the duty cycle value of PWM applied, expressed as percentage.
EX. A1 CAB. LO. STOP	Status of the Cabin Low Stop switch input (pin A35 of CAN EXTENDER).
EX. A2 ZONE SEL. SW	Status of the Zone Selector switch input (pin A2 of CAN EXTENDER).
EX. A3 H. SW2	Status of the Height switch 2 input (pin A3 of CAN EXTENDER).
EX. A6 H. SW1	Status of the Height switch 1 input (pin A6 of CAN EXTENDER).
EX. A7 GATE SW LH	Status of the Side/Rear Gate LH switch input (pin A7 of CAN EXTENDER).
EX.A18 GATE SW RH	Status of the Side/Rear Gate RH switch input (pin A18 of CAN EXTENDER).
EX. A22 WG SW	Status of the Wire Guidance switch input (pin A22 of CAN EXTENDER).
EX. A25 DEADMAN SW	Status of the Deadman switch input (pin A25 of CAN EXTENDER).
EX. ACCEL A	Voltage of the Accel A analog input (pin A16 of CAN EXTENDER).
EX. ACCEL B	Voltage of the Accel B analog input (pin A17 of CAN EXTENDER).

SET OPTIONS	DESCRIPTION
EVP TYPE	This parameter defines the behavior of output EVP1 (A24). NONE = Output A24 is not enabled. ANALOG = Output A24 manages a PWM-modulated current-controlled proportional valve. DIGITAL = Output A24 manages an on/off valve.
EVP2 TYPE	This parameter defines the behavior of output EVP2 (A23). - NONE = Output A23 is not enabled. - ANALOG = Output A23 manages a PWM current-controlled proportional valve. - DIGITAL = Output A23 manages an on/off valve.
EV1	This parameter defines the behavior of output EV1 (A9). - ABSENT = Output A9 is not enabled. - OPTION#1 = Output A9 manages an ON/OFF valve. By default it is activated by the 1st speed command. - OPTION#2 = free for future use.
EV2	This parameter defines the behavior of output EV2 (A11). - ABSENT = Output A11 is not enabled. - DIGITAL = Output A11 manages a PWM voltage-controlled valve. The PWM frequency is 1 kHz and the duty cycle depends on parameter PWM EV2.
EV3	This parameter defines the behavior of output EV3 (A33). - ABSENT = Output A33 is not enabled. - DIGITAL = Output A33 manages a PWM voltage-controlled valve. The PWM frequency is 1 kHz and the duty cycle depends on parameter PWM EV3.
EV4	This parameter defines the behavior of output EV4 (A34). - ABSENT = Output A34 is not enabled. - DIGITAL = Output A34 manages an on/off valve.
EV5	This parameter defines the behavior of output EV5 (A8). - ABSENT = Output A8 is not enabled. - DIGITAL = Output A8 manages an on/off valve.
HIGH DYNAMIC	This parameter enables or disables the high-dynamic function. - ON = All acceleration and deceleration profiles set by dedicated parameters are ignored and the controller works always with maximum performance. - OFF = Standard behavior.
HORN	(Not used) It enables the control of output HORN (A26). ABSENT = Output A26 is not enabled. DIGITAL = Output A26 manages an ON/OFF valve.
BUZZER DIRECTION	- Option #1 : When the truck is moving to anti-fork direction, buzzer is working. - Option #2 : When the truck is moving to fork direction, buzzer is working. - Option #3 : When the truck is moving to any direction, buzzer is working.
PERFORMANCE	This parameter enables the selection of the performance mode. OFF = normal performance level selected and locked. ON = the user can change the performance level from normal to economy or power.
BMS FUNCTION	This parameter defines the battery monitoring strategy. OFF = The controller monitors the battery voltage and the battery state of charge. ON = The controller receives information about the battery state of charge from the BMS.

SET OPTIONS	DESCRIPTION
BRK TORQUE BMS	This parameter enables the torque profile limitation. OFF = Torque profile limitation disabled. ON = The controller enables the torque profile limitation based on the battery state of charge information transmitted by the BMS. It takes effect only if the BMS FUNCTION parameter is set to ON.
INVERSION MODE	(Not used) This parameter sets the behavior of the Quick-Inversion input (A7): - ON = The Quick-Inversion switch is normally closed (function is active when the switch is open). - OFF = The Quick-Inversion switch is normally open (function is active when the switch is closed).
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.
SAFETY KEY-ON	- ON : When the truck is KEY ON with DEADMAN switch is ON, stopping traction motor. - OFF : When the truck is KEY ON with DEADMAN switch is ON, not stopping traction motor.

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)

PARAMETER	DESCRIPTION
CURVE CUTBACK SP	This parameter defines the maximum traction speed when the steering angle is equal to the STEER ANGLE 2 angle.
FREQUENCY CREEP	This parameter defines the minimum speed when the forward- or reverse-request switch is closed, but the accelerator is at its minimum.
TORQUE CREEP	This parameter defines the minimum torque applied when torque control is enabled and the forward- or reverse-request switch is closed, but the accelerator is at its minimum.
MAX. CURRENT TRA	This parameter defines the maximum current applied to the motor during acceleration, as a percentage of the factory-calibrated maximum current.
MAX. CURRENT BRK	This parameter defines the maximum current applied to the motor during deceleration, as a percentage of the factory-calibrated maximum current.
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.

<table>
<tr><th>PARAMETER</th><th>DESCRIPTION</th></tr>
<tr><td colspan="2">※ 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.


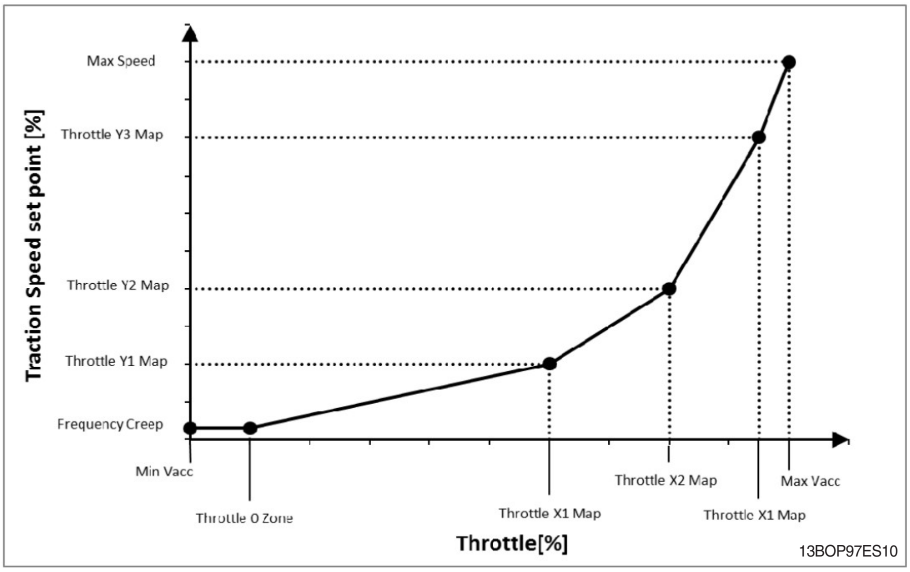
13BOP97ES12</td></tr>
<tr><td>BACKING SPEED</td><td>This parameter defines maximum speed performed when the inching function is active. The parameter represents a percentage of TOP MAX SPEED.</td></tr>
<tr><td>BACKING TIME</td><td>This parameter defines the duration of the inching function.</td></tr>
<tr><td>EB. ENGAGE DELAY</td><td>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 measured or it can be found in the datasheet.</td></tr>
<tr><td>AUXILIARY TIME</td><td>For the encoder version, this parameter defines how long the truck holds in place if the STOP ON RAMP option is ON.</td></tr>
<tr><td>ROLLING DW SPEED</td><td>This parameter defines the maximum speed for the rolling-down function.</td></tr>
</table>

(2) TRACTION CONTROLLER (24 V, 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
EB ON TILLER BRK	This option defines how the electromechanical brake is managed depending on the status of tiller/seat input: - ON = the electromechanical brake is engaged as soon as the tiller input goes into OFF state. The deceleration ramp defined by TILLER BRAKING parameter has no effect. - OFF = when the tiller input goes into OFF state, the “tiller braking” ramp is applied before engaging the electromechanical brake.
STOP ON RAMP	This parameter enables or disables the stop-on-ramp feature (the truck is electrically held in place on a slope for a defined time). - ON = The stop-on-ramp feature is performed for a time set in the AUXILIARY TIME parameter. - OFF = The stop-on-ramp feature is not performed. Instead, a controlled slowdown is performed for a minimum time set in the AUXILIARY TIME arameter. After the AUXILIARY TIME interval, the three-phase bridge is released and, if present, the electromechanical brake activated (see parameter AUX OUT FUNCTION).
PULL IN BRAKING	This parameter enables or disables the functionality that continues to give torque even if the traction (or lift) request has been released. - ON = When the operator releases the traction request, the inverter keeps running the truck, as to oppose the friction that tends to stop it. Similarly, in pump applications, when the operator releases the lift request, the inverter keeps running the pump avoiding the unwanted descent of the forks. - OFF = When the operator releases the traction (or lift) request, the inverter does not power anymore the motor. This setting is useful especially for traction application. When the truck is travelling over a ramp and the driver wants to stop it by gravity, the motor must not be powered anymore, until the truck stops.
SOFT LANDING	This parameter enables or disables the control of the deceleration rate of the truck when the accelerator is released. - ON = When the accelerator is released, the inverter controls the deceleration rate of the truck through the application of a linearly decreasing torque curve. This is useful when the operator releases the accelerator while the truck is going uphill. If the rise is steep, the truck may stop fast and may also go backwards in short time, possibly leading to a dangerous situation. - OFF = When the accelerator is released, the inverter does not control the deceleration rate of the truck, instead it stops driving the motor.
QUICK INVERSION	This parameter defines the quick-inversion functionality. - NONE = The quick-inversion function is not managed. - BRAKE = Upon a quick-inversion request, the motor is braked. - TIMED = The quick-inversion function is timed: upon a QI request the controller drives the motor in the opposite direction for a fixed time (1.5 seconds by default). - BELLY = The quick-inversion function is managed but not timed: upon a QI request the controller drives the motor in the opposite direction until the request is released.
PEDAL BRK ANALOG	This parameter defines the kind of brake pedal adopted. - ON = Brake pedal outputs an analog signal, braking is linear. - OFF = Brake pedal outputs a digital signal, braking is on/off.
HARD & SOFT	This parameter enables or disables the Hard-and-Soft functionality. With H&S, it is possible to start the truck (at reduced speed) only by activating the H&S switch and the accelerator, without the tiller input. ON = H&S function is enabled. OFF = H&S function is disabled.
HB ON / SR OFF	This parameter defines the function associated with input A18. ON = Handbrake. OFF = Speed reduction.

SET OPTIONS	DESCRIPTION
SET MOT. TEMPERAT	Sets the motor temperature sensor type. - NONE = no motor thermal sensor switch is connected. - DIGITAL = a digital (ON/OFF) motor thermal sensor is connected to A22. - OPTION#1 = an analogue motor thermal sensor is connected to A22. The temperature sensor is a KTY 84-130 PTC (positive thermal coefficient resistance). - OPTION#2 = an analogue motor thermal sensor is connected to A22. The temperature sensor is a KTY 83-130 PTC (positive thermal coefficient resistance) - OPTION#3 = an analog motor thermal sensor is connected to A22. The temperature sensor is a PT1000 PTC (positive thermal coefficient resistance).
STEERING TYPE	It allows to select which type of steering unit is connected to the controller. - NONE = NO steering module is present on the truck, ACE0/COMBIAC0 does not wait for CAN message by the EPS and it does not apply EPS and braking steer cutback. - OPTION#1 = EPS is present and it is configured with an ENCODER + TOGGLE SWITCHES. These signals are transmitted to ACE0/COMBIAC0 over CAN bus. - OPTION#2 = EPS is present and it is configured with a POT + ENCODER. These signals are transmitted to ACE0/COMBIAC0 over CAN bus. - ANALOG = A hydraulic steer is used on the truck and ACE0/COMBIAC0 is reading through one of its analog input the signal coming from a wheel potentiometer in order to read the wheel rotation.
MC FUNCTION	This parameter defines the configuration of the NLC output (A12), dedicated to the main – or line – contactor. - OFF = Main contactor is not present. Diagnoses are masked and MC is not driven. - ON = Main contactor is in standalone configuration. Diagnoses are performed and MC is closed after key-on only if they have passed. - OPTION#1 = For a traction-and-pump setup, with only one main contactor for both controllers. Diagnoses are performed and MC is closed after key-on only if they have passed. - OPTION#2 = For a traction-and-pump setup, with two main contactors. Each controller drives its own MC. Diagnoses are performed and MCs are closed after key-on only if they have passed.
M.C. OUTPUT	This parameter defines whether a load coil is connected to the NLC output (A12) or not. - ABSENT = NLC output is not connected to any load coil. - PRESENT = NLC output is connected to a load coil (by default, that of the main contactor).
EBRAKE ON APPL.	This parameter defines whether the application includes an electromechanical brake or not.
AUX OUT FUNCTION	This parameter enables or disables the NEB output (A4), 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.
ACCEL MODULATION	This parameter enables or disables the acceleration-modulation function. - OFF = The acceleration rate is inversely proportional to the ACCEL DELAY parameter. - ON = The acceleration ramp is inversely proportional to the ACCEL DELAY parameter only if speed setpoint is greater than 100 Hz. Below 100 Hz the acceleration ramp is also proportional to the speed setpoint, so that the acceleration duration results equal to ACCEL DELAY.
EVP TYPE	This parameter defines the behavior of output EVP1 (A24). NONE = Output A24 is not enabled. ANALOG = Output A24 manages a PWM-modulated current-controlled proportional valve. DIGITAL = Output A24 manages an on/off valve.
EVP2 TYPE	This parameter defines the behavior of output EVP2 (A23). - NONE = Output A23 is not enabled. - ANALOG = Output A23 manages a PWM current-controlled proportional valve. - DIGITAL = Output A23 manages an on/off valve.

SET OPTIONS	DESCRIPTION
EV1	This parameter defines the behavior of output EV1 (A9). - ABSENT = Output A9 is not enabled. - OPTION#1 = Output A9 manages an ON/OFF valve. By default it is activated by the 1st speed command. - OPTION#2 = free for future use.
EV2	This parameter defines the behavior of output EV2 (A11). - ABSENT = Output A11 is not enabled. - DIGITAL = Output A11 manages a PWM voltage-controlled valve. The PWM frequency is 1 kHz and the duty cycle depends on parameter PWM EV2.
EV3	This parameter defines the behavior of output EV3 (A33). - ABSENT = Output A33 is not enabled. - DIGITAL = Output A33 manages a PWM voltage-controlled valve. The PWM frequency is 1 kHz and the duty cycle depends on parameter PWM EV3.
EV4	This parameter defines the behavior of output EV4 (A34). - ABSENT = Output A34 is not enabled. - DIGITAL = Output A34 manages an on/off valve.
EV5	This parameter defines the behavior of output EV5 (A8). - ABSENT = Output A8 is not enabled. - DIGITAL = Output A8 manages an on/off valve.
HIGH DYNAMIC	This parameter enables or disables the high-dynamic function. - ON = All acceleration and deceleration profiles set by dedicated parameters are ignored and the controller works always with maximum performance. - OFF = Standard behavior.
HORN	(Not used) It enables the control of output HORN (A26). ABSENT = Output A26 is not enabled. DIGITAL = Output A26 manages an ON/OFF valve.
BUZZER DIRECTION	- Option #1 : When the truck is moving to anti-fork direction, buzzer is working. - Option #2 : When the truck is moving to fork direction, buzzer is working. - Option #3 : When the truck is moving to any direction, buzzer is working.
INVERSION MODE	(Not used) This parameter sets the behavior of the Quick-Inversion input (A7): - ON = The Quick-Inversion switch is normally closed (function is active when the switch is open). - OFF = The Quick-Inversion switch is normally open (function is active when the switch is closed).
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.
SAFETY KEY-ON	- ON : When the truck is KEY ON with DEADMAN switch is ON, stopping traction motor. - OFF : When the truck is KEY ON with DEADMAN switch is ON, not stopping traction motor.
BAT. VOLT. COMP	This parameter determines whether the main pull-in and holding voltages are battery voltage compensated - ON : using Battery Voltage Compensation - OFF : not using Battery Voltage Compensation
EM. BAT.VOL. COMP	(Not used)

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 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.

<table>
<tr><th>ADJUSTMENTS</th><th>DESCRIPTION</th></tr>
<tr><td>BAT. MIN ADJ.</td><td rowspan="6">During operating condition, the battery-charge detection makes use of two parameters that specify the full-charge voltage (100%) and the discharged-battery voltage (10%): BAT.MAX.ADJ and BAT.MIN.ADJ.

It is possible to adapt the battery-charge detection to your specific battery by changing the above two settings (e.g. if the battery-discharge detection occurs when the battery is not totally discharged, it is necessary to reduce BAT.MIN.ADJ).

Moreover, BDI ADJ STARTUP adjusts the level of the battery charge table at the start-up, in order to evaluate the battery charge at key-on. The minimum variation of the battery charge that can be detected depends on the BDI RESET parameter.

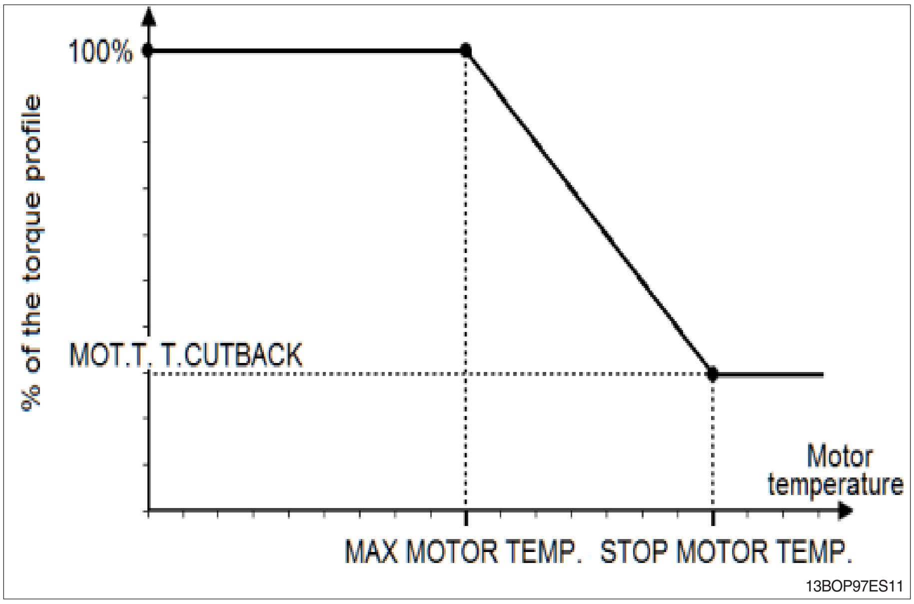
The battery-charge detection works as the following procedure.

Start-up
1) The battery voltage is read from key input when the battery current is zero, which is when the output power stage is not driven. It is evaluated as the average value over a window of time, hereafter addressed as Vbatt.
2) Vbatt is compared with a threshold value which comes as function of the actual charge percentage; by this comparison a new charge percentage is obtained.
3) The threshold value can be changed with the BDI ADJ STARTUP parameter.
4) If the new charge percentage is within the range “last percentage (last value stored in EEPROM) ± BDI RESET” it is discarded; otherwise charge percentage is updated with the new value.

Operating condition
Measure of the battery voltage, together with the charge percentage at the time of the voltage sampling, give information about the instantaneous battery current.

1) The battery voltage is read when the battery current is not zero, which is when the output power stage is driven. Vbatt is evaluated as the average value over a window of time.
2) Vbatt is compared with a threshold value which comes as function of the actual charge percentage; by this comparison the current provided by the battery is obtained.
3) Current obtained at step 2 integrated over time returns the energy drawn from the battery, in Ah.
4) Charge percentage is dynamically updated basing on the energy from step 3.
5) Threshold values for the battery charge can be modified by means of BAT.MAX.ADJ. and BAT.MIN.ADJ. as to adapt the battery-charge detection to the specific battery in use.</td></tr>
<tr><td>BAT. MAX ADJ.</td></tr>
<tr><td>BDI ADJ STUP MIN</td></tr>
<tr><td>BDI ADJ STUP MAX</td></tr>
<tr><td>BDI RESET</td></tr>
<tr><td>BDI RESET 2</td></tr>
<tr><td>BATT.LOW TRESHLD</td><td>This parameter defines the minimum charge percentage below which the BATTERY LOW alarm rises.</td></tr>
<tr><td>BAT.ENERGY SAVER</td><td>When set to ON, this parameter enables the possibility to save the battery charge when it has reached a certain value, through a maximum torque reduction.</td></tr>
<tr><td>MAX ANGLE RIGHT</td><td>This parameter defines the maximum steering-wheel angle while turning right.</td></tr>
<tr><td>MAX ANGLE LEFT</td><td>This parameter defines the maximum steering-wheel angle while turning left.</td></tr>
<tr><td>STEER DEAD ANGLE</td><td>This parameter defines the maximum steering-wheel angle up to which the permitted traction speed is 100%.</td></tr>
</table>

ADJUSTMENTS	DESCRIPTION
STEER ANGLE 1	This parameter defines the steering-wheel angle at which traction speed is reduced to the value imposed by CURVE SPEED 1. For steering-wheel angles between STEER DEAD ANGLE and STEER ANGLE 1, traction speed is reduced linearly from 100% to CURVE SPEED 1.
MAX ANGLE SP CTB	It determines the angle for speed reduction. (MAX ANGLE SPEED CUTBACK)
SPEED FACTOR	This parameter defines the coefficient used for evaluating the truck speed (in km/h) from the motor frequency (in Hz), according to the following formula: $\text{Speed [km/h]} = 10 \cdot \frac{\text{frequency [Hz]}}{\text{Speed factor}}$
SPEED ON MDI	(Not used) This parameter enables or disables the speed visualization on MDI display: - ON = MDI shows traction speed when the truck is moving. In steady-state condition the speed indication is replaced by the hour-meter indication. - OFF = Standard MDI functionality.
LOAD HM FROM MDI	(Not used) This parameter enables or disables the transfer of the hour-meter to a MDI unit. OFF = controller hour meter is not transferred and recorded on the MDI hour meter. ON = controller hour meter is transferred and recorded on the MDI hour meter (connected via the Serial Link).
MAINTEN. RESET	(Not used)
MAINTENANCE	(Not used)
MC VOLTAGE	This parameter specifies the duty-cycle (t_{ON}/T_{PWM}) of the PWM applied to the main-contactor output (A12) during the first second after the activation signal that causes the main contactor to close.
MC VOLTAGE RED.	This parameter defines a percentage of MC VOLTAGE parameter and it determines the duty-cycle applied after the first second of activation of the contactor.
EB VOLTAGE	This parameter specifies the duty-cycle (t_{ON}/T_{PWM}) of the PWM applied to the electromechanical brake output(A4) during the first second after the activation signal that causes the electromechanical brake to release.
EB VOLTAGE RED.	This parameter defines a percentage of EB VOLTAGE parameter and it determines the duty-cycle applied after the first second since when the electromechanical brake is released.
PWM EV2	This parameter defines the duty-cycle of the PWM applied to EV2 output (A11).
PWM EV3	This parameter defines the duty-cycle of the PWM applied to EV3 output (A33).
MAX. MOTOR TEMP.	This parameter defines the motor temperature above which a 50% cutback is applied to the maximum current. Cutback is valid only during motoring, while during braking the 100% of the maximum current is always available independently by the temperature.
STOP MOTOR TEMP.	This parameter defines the maximum motor temperature permitted, above which the controller stops driving the motor.

<table>
<tr><th>ADJUSTMENTS</th><th>DESCRIPTION</th></tr>
<tr><td>MOT.T. T.
CUTBACK</td><td>This parameter defines the motor thermal cutback. The control linearly reduces the motor torque basing on the motor temperature. Reference limits of the linear reduction are MAX MOTOR TEMP and TEMP. MOT. STOP.
</td></tr>
<tr><td>MAINTENANCE
HOUR</td><td>(Not used)</td></tr>
<tr><td>MAINT PRE
WARN</td><td>((Not used)</td></tr>
<tr><td>DEADBAND
ACCEL</td><td>This parameter defines the deadband [%] of the ACCEL.</td></tr>
</table>

<table>
<tr><th>PARAMETER</th><th>DESCRIPTION</th></tr>
<tr><td>ACCELER. DELAY</td><td>This parameter defines the acceleration ramp, i.e. the time needed to speed up the motor from 0 Hz up to 100 Hz. A special software feature manages the acceleration ramp depending on the speed setpoint.

- ACCEL MODULATION = OFF

$$\text{Accel tims [s]} = \frac{\text{Speed setpoint [Hz]}}{\text{100 Hz}} \cdot \text{Acceler delay [s]}$$
- ACCEL MODULATION = ON

Case 1 (red trace in the graph):
Final-speed setpoint = 60 Hz
ACCEL DELAY = 2.5 s
Acceleration rate is re-scaled so that acceleration time results equal to ACCEL DELAY, in this case 2.5 s.

Case 2 (green trace in the graph):
Final-speed setpoint = 150 Hz
ACCEL DELAY = 2.5 s
Acceleration time results:

$$\text{Accel tims [s]} = \frac{\text{150 Hz}}{\text{100 Hz}} \cdot \text{Acceler delay} = 3.75 \text{ sec}$$</td></tr>
</table>

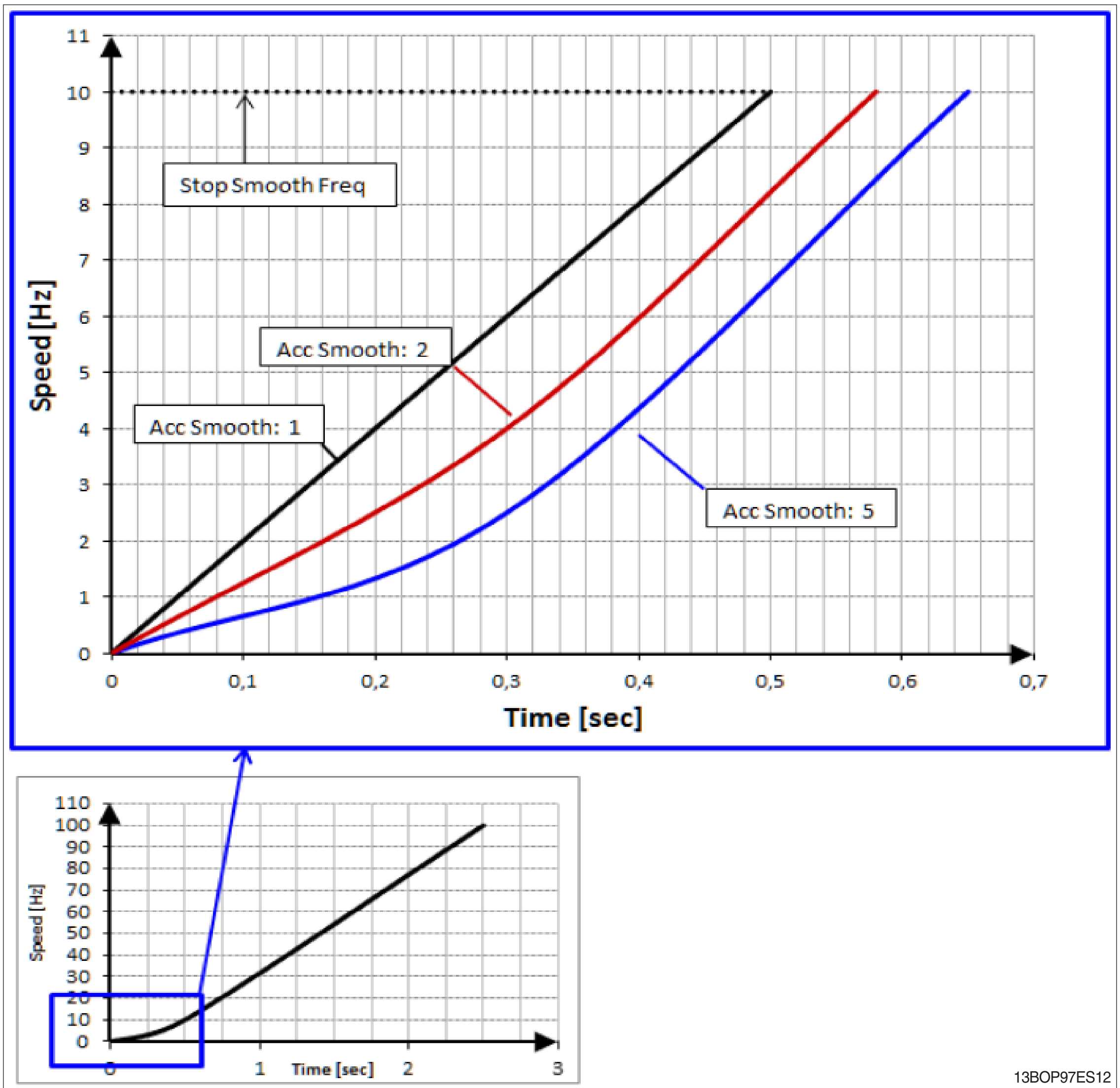
PARAMETER	DESCRIPTION
RELEASE BRAKING	This parameter defines the deceleration ramp performed after the running request is released.
DEADMAN BRAKING	This parameter defines the deceleration ramp performed after the deadman s/w is OFF.
INVERS. BRAKING	This parameter defines the deceleration ramp performed 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.
WG BRAKING	This parameter defines the deceleration ramp performed when the Wire Guidance s/w is ON.
WG BRAK END PATH	This parameter defines the deceleration ramp performed when the truck reaches to the end path of the wire guidance.
MAX SPEED FORW	This parameter defines the maximum speed in forward direction.
MAX SPEED BACK	This parameter defines the maximum speed in backward direction.
TURTLE SPEED	This parameter defines the maximum speed at turtle mode.
H&S CUTBACK	This parameter defines the maximum speed performed when the Hard-and-Soft function is active. It represents a percentage of TOP MAX SPEED.
CTB. STEER ALARM	This parameter defines the maximum traction speed when an alarm from the EPS is read by the microcontroller, if the alarm is not safety-related. The parameter represents a percentage of TOP MAX SPEED.
MOT.HT MAX SPEED	The Maximum speed when the Motor Temperature is reached to the "MAX. MOTOR TEMP. " Setting
CURVE SPEED 1	This parameter defines the maximum traction speed when the steering angle is equal to the STEER ANGLE 1 angle.
CURVE CUTBACK SP	This parameter defines the maximum traction speed when the steering angle is equal to the STEER ANGLE 2 angle.
FREQUENCY CREEP	This parameter defines the minimum speed when the forward- or reverse-request switch is closed, but the accelerator is at its minimum.
TORQUE CREEP	"This parameter defines the minimum torque applied when torque control is enabled and the forward- or reverse-request switch is closed, but the accelerator is at its minimum."
MAX. CURRENT TRA	This parameter defines the maximum current applied to the motor during acceleration, as a percentage of the factory-calibrated maximum current.
MAX. CURRENT BRK	This parameter defines the maximum current applied to the motor during deceleration, as a percentage of the factory-calibrated maximum current.
ACC. SMOOTH	This parameter defines the acceleration profile: 1 results in a linear ramp, higher values result in smoother parabolic profiles.

PARAMETER	DESCRIPTION
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.



BACKING SPEED	This parameter defines maximum speed performed when the inching function is active. The parameter represents a percentage of TOP MAX SPEED.
BACKING TIME	This parameter defines the duration of the inching function.

<table>
<tr><th>PARAMETER</th><th>DESCRIPTION</th></tr>
<tr><td>EB. ENGAGE DELAY</td><td>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 measured or it can be found in the datasheet.</td></tr>
<tr><td>AUXILIARY TIME</td><td>For the encoder version, this parameter defines how long the truck holds in place if the STOP ON RAMP option is ON.</td></tr>
<tr><td>ROLLING DW SPEED</td><td>This parameter defines the maximum speed for the rolling-down function.</td></tr>
<tr><td>WG FWD SPEED</td><td>The Maximum forward speed when wire guidance is performed before lock on.</td></tr>
<tr><td>CUTBACK SPEED 1</td><td rowspan="8">The parameters defines the maximum speed by the height of the lift.
<table>
<tr><td rowspan="2">Steering angle</td><td colspan="5">Maximum speed by height of lift</td></tr>
<tr><td>0~600</td><td>~1,500</td><td>~3,000</td><td>~5,500</td><td>5,500~</td></tr>
<tr><td>Angle < 10°</td><td>MAX FORWORD
MAX BACKWORD</td><td>CUTBACK
SPPED1</td><td>CUTBACK
SPPED2</td><td>CUTBACK
SPPED3</td><td>CUTBACK
SPPED4</td></tr>
<tr><td>10° < Angle < 45°</td><td colspan="5">is linearly decreasing</td></tr>
<tr><td>Angel > 45°</td><td>CURVE
CUTBACK SP</td><td>AUX
FUNCTION 1</td><td>AUX
FUNCTION 1</td><td>AUX
FUNCTION 1</td><td>AUX
FUNCTION 1</td></tr>
</table></td></tr>
<tr><td>CUTBACK SPEED 2</td></tr>
<tr><td>CUTBACK SPEED 3</td></tr>
<tr><td>CUTBACK SPEED 4</td></tr>
<tr><td>AUX FUNCTION 1</td></tr>
<tr><td>AUX FUNCTION 2</td></tr>
<tr><td>AUX FUNCTION 3</td></tr>
<tr><td>AUX FUNCTION 4</td></tr>
<tr><td>DEADMAN DELAY</td><td>This parameter defines the delay time after the deadman switch is off.</td></tr>
<tr><td>M.TRAC SPEED RED</td><td>Maximum speed when the MAINTENANCE is set to OPTOIN#2 or #3</td></tr>
<tr><td>BATT. LOW SPEED</td><td>This parameter defines the maximum speed performed according to "BATTERY CHECK" parameter.</td></tr>
<tr><td>CHAT TIME DELAY</td><td>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.</td></tr>
<tr><td>BATT. LOW CURRENT</td><td>This parameter defines the maximum current performed according to "BATTERY CHECK" parameter.</td></tr>
<tr><td>MIN EVP</td><td>(Minimum speed when the lift is lowering)
This parameter determines the minimum current applied to the EVP when the potentiometer position is at the minimum. This parameter is not effective if the EVP is programmed like an on/off valve.</td></tr>
<tr><td>MAX EVP</td><td>(Maximum speed when the lift is lowering)
This parameter determines the maximum current applied to the EVP when the potentiometer position is at the maximum. This parameter also determines the current value when the EVP is programmed like an ON/OFF valve.</td></tr>
<tr><td>EVP OPEN DELAY</td><td>It determines the current increase rate on EVP. The parameter sets the time needed to increase the current to the maximum possible value.</td></tr>
<tr><td>EVP CLOSE DELAY</td><td>It determines the current decrease rate on EVP. The parameter sets the time needed to decrease the current from the maximum possible value to zero.</td></tr>
<tr><td>MIN EVP FORK</td><td>(Minimum speed when the additional lift is lowering)
This parameter determines the minimum current applied to the EVP FORK when the potentiometer position is at the minimum. This parameter is not effective if the EVP FORK is programmed like an on/off valve.</td></tr>
</table>

PARAMETER	DESCRIPTION
MAX EVP FORK	(Maximum speed when the additional lift is lowering) This parameter determines the maximum current applied to the EVP FORK when the potentiometer position is at the maximum. This parameter also determines the current value when the EVP FORK is programmed like an ON/OFF valve.
EVP OPEN FORK	It determines the current increase rate on EVP FORK. The parameter sets the time needed to increase the current to the maximum possible value.
EVP CLOSE FORK	It determines the current decrease rate on EVP FORK. The parameter sets the time needed to decrease the current from the maximum possible value to zero.
MAX EVP RED	(Maximum speed when the lift is lowering below 600mm) This parameter determines the maximum current applied to the EVP when the potentiometer position is at the maximum and the lift is below 600mm. This parameter also determines the current value when the EVP is programmed like an ON/OFF valve.
MIN EVP2	This parameter determines the minimum current applied on the EVP2 when the position of the potentiometer is at the minimum. This parameter is not effective if the EVP2 is programmed like an on/off valve.
MAX EVP2	This parameter determines the maximum current applied to the EVP2 when the position of the potentiometer is at the maximum. This parameter also determines the current value when the EVP2 is programmed like an ON/OFF valve.
EVP2 OPEN DELAY	It determines the acceleration ramp on EVP2. The parameter sets the time needed to increase the current to the maximum possible value.
EVP2 CLOSE DELAY	It determines the deceleration ramp on EVP2. The parameter sets the time needed to decrease the current from the maximum possible value to zero.

TRACTION MASTER	
MONITORING	DESCRIPTION
KEY VOLTAGE	Key voltage measured in real time.
BATTERY VOLTAGE	Battery voltage measured in real time (across the DC bus).
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.
MOTOR VOLTAGE	Theoretical phase- to- phase voltage to be applied at the motor terminals, as a percentage of the supply voltage.
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)
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)
MOT. POWER WATT	Estimation of the power supplied to the motor.

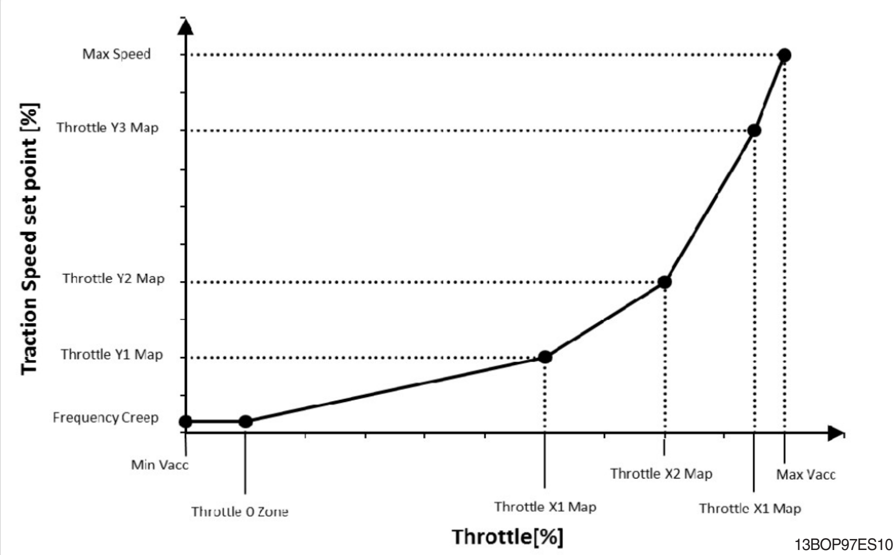
TRACTION MASTER	
MONITORING	DESCRIPTION
STEER ANGLE	Current steering- wheel angle. When the steering is straight ahead STEER ANGLE is zero.
TEMPERATURE	Temperature measured on the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm.
MOTOR TEMPERAT.	Motor-windings temperature. This temperature is used for the MOTOR OVERTEMP alarm.
A7 H.SW4 SW	Status of the Height switch 4 input (pin A7).
A6 H.SW3 SW	Status of the Height switch 3 input (pin A6).
A31 SIDE ROL. L SW	Status of the Side Roller LH switch input (pin A31).
A35 CHAIN LOOS.SW	Status of the Slack Chain switch input (pin A35).
A17 CABIN STOP SW	Status of the Cabin Stop switch input (pin A17).
A29 CABIN LIMIT SW	Status of the Cabin Limit switch input (pin A29).
EPS SAFETY SW	Status of the EPS safety input (pin A18).
A24 SET EVP	Setpoint of the EVP1 output (pin A24).
A9 OUTPUT EV1	Status of the EV1 output (pin A9).
A11 OUTPUT EV2	Status of the EV2 output (pin A11).
A33 OUTPUT EV3	Status of the EV3 output (pin A33).
A12 MAIN CONT.	Voltage applied over the main contactor coil. It corresponds to the duty cycle value of PWM applied, expressed as percentage.
A4 ELEC.BRAKE	Voltage applied over the electromechanical brake coil. It corresponds to the duty cycle value of PWM applied, expressed as percentage.
EX. A1 CAB. LO. STOP	Status of the Cabin Low Stop switch input (pin A35 of CAN EXTENDER).
EX. A2 ZONE SEL. SW	Status of the Zone Selector switch input (pin A2 of CAN EXTENDER).
EX. A3 H. SW2	Status of the Height switch 2 input (pin A3 of CAN EXTENDER).
EX. A6 H. SW1	Status of the Height switch 1 input (pin A6 of CAN EXTENDER).
EX. A7 GATE SW LH	Status of the Side/Rear Gate LH switch input (pin A7 of CAN EXTENDER).
EX.A18 GATE SW RH	Status of the Side/Rear Gate RH switch input (pin A18 of CAN EXTENDER).
EX. A22 WG SW	Status of the Wire Guidance switch input (pin A22 of CAN EXTENDER).
EX. A24 ADD LIFT STOP	Status of the Lift Stop switch input (pin A24 of CAN EXTENDER).
EX. A25 DEADMAN SW	Status of the Deadman switch input (pin A25 of CAN EXTENDER).
EX. A33 ADD LIFT ENA.	Status of the Additional Lift Enable switch input (pin A33 of CAN EXTENDER).
EX. ACCEL A	Voltage of the Accel A analog input (pin A16 of CAN EXTENDER).
EX. ACCEL B	Voltage of the Accel B analog input (pin A17 of CAN EXTENDER).

(3) PUMP CONTROLLER (36 V)

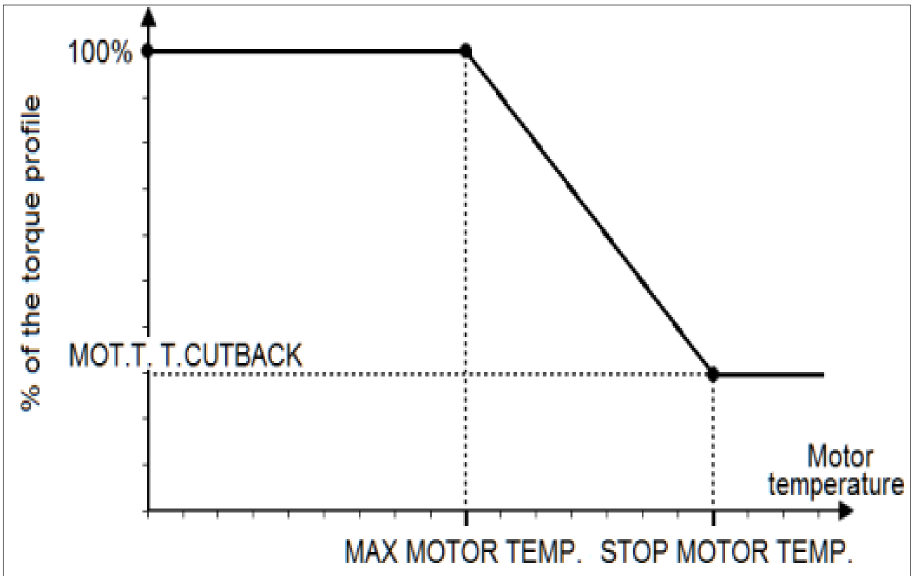
SET OPTIONS	DESCRIPTION
HOUR COUNTER	This option specifies the hour counter mode. It can be set one of two: - RUNNING: The counter registers travel time only - KEY ON: The counter registers when the ""key"" switch is closed
HM CUSTOM 1 OPT.	(Not used)
HM CUSTOM 2 OPT.	(Not used)
BATTERY CHECK	(Not used)
SOFT LANDING	This parameter enables or disables the control of the deceleration rate of the truck when the accelerator is released. - ON = When the accelerator is released, the inverter controls the deceleration rate of the truck through the application of a linearly decreasing torque curve. This is useful when the operator releases the accelerator while the truck is going uphill. If the rise is steep, the truck may stop fast and may also go backwards in short time, possibly leading to a dangerous situation. - OFF = When the accelerator is released, the inverter does not control the deceleration rate of the truck, instead it stops driving the motor.
QUICK INVERSION	This parameter defines the quick-inversion functionality. - NONE = The quick-inversion function is not managed. - BRAKE = Upon a quick-inversion request, the motor is braked. - TIMED = The quick-inversion function is timed: upon a QI request the controller drives the motor in the opposite direction for a fixed time (1.5 seconds by default). - BELLY = The quick-inversion function is managed but not timed: upon a QI request the controller drives the motor in the opposite direction until the request is released.
SET MOT. TEMPERAT	Sets the motor temperature sensor type. - NONE = no motor thermal sensor switch is connected. - DIGITAL = a digital (ON/OFF) motor thermal sensor is connected to A22. - OPTION#1 = an analogue motor thermal sensor is connected to A22. The temperature sensor is a KTY 84-130 PTC (positive thermal coefficient resistance). - OPTION#2 = an analogue motor thermal sensor is connected to A22. The temperature sensor is a KTY 83-130 PTC (positive thermal coefficient resistance) - OPTION#3 = an analog motor thermal sensor is connected to A22. The temperature sensor is a PT1000 PTC (positive thermal coefficient resistance).
FAN RELAY COIL	This parameter defines whether a load coil is connected to the NMC output (A16) or not. - ABSENT = NMC output is not connected to any load coil. - PRESENT = NMC output is connected to a load coil
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.
AUX OUT FUNCTION	This parameter enables or disables the output A18(NEB) : - NONE = Diagnoses are masked and back buzzer relay does not work. - BRAKE = Back buzzer relay works if all the related diagnoses pass.
COMP.VOLT. OUTPUT	This parameter defines the voltage compensation for the MC and EB drivers in dependence of the battery voltage 0 = None. 1 = MC only. 2 = EB only. 3 = MC and EB.

SET OPTIONS	DESCRIPTION
ACCEL MODULATION	This parameter enables or disables the acceleration-modulation function. - OFF = The acceleration rate is inversely proportional to the ACCEL DELAY parameter. - ON = The acceleration ramp is inversely proportional to the ACCEL DELAY parameter only if speed setpoint is greater than 100 Hz. Below 100 Hz the acceleration ramp is also proportional to the speed setpoint, so that the acceleration duration results equal to ACCEL DELAY.
EV1	(Not used)
HIGH DYNAMIC	This parameter enables or disables the high-dynamic function. - ON = All acceleration and deceleration profiles set by dedicated parameters are ignored and the controller works always with maximum performance. - OFF = Standard behavior.
FORK	- OFF : Additional lift function is not used. - ON : Additional lift function is used.
D.M. PUMP	- OFF : lift and lowering function is available after putting ON dead man switch. - ON : lift and lowering function is available without regard to put ON dead man switch.
WIRE HEIGHT	- OFF : Height indicator function is not used. - ON : Heigth indicator function is used.
SAFETY KEY-ON	- ON : When the truck is KEY ON with DEADMAN switch is ON, stopping hyd. pump motor. - OFF : When the truck is KEY ON with DEADMAN switch is ON, not stopping hyd. pump motor.

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)

<table>
<tr><th>ADJUSTMENTS</th><th>DESCRIPTION</th></tr>
<tr><td>THROTTLE Y3 MAP</td><td>This parameter defines the accelerator input curve.
- Accelerator input curve


13BOP97ES10
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.</td></tr>
<tr><td>BATT.LOW TRESHLD</td><td>(Not used)</td></tr>
<tr><td>FAN WORKING TEMP</td><td>(This parameter is used for that COOLING FAN is option #2)
If the temperature of inverter exceeds the temperature indicated in this paramter.</td></tr>
<tr><td>FANWORKING MOTOR</td><td>(This parameter is used for that COOLING FAN is option #2)
If the temperature of motor exceeds the temperature indicated in this paramter.</td></tr>
<tr><td>EB VOLTAGE</td><td>This parameter specifies the duty-cycle (t_{ON}/T_{PWM}) of the PWM applied to the back buzzer relay output(A16) during the first second after the activation signal that causes back buzzer relay to release.</td></tr>
<tr><td>EB VOLTAGE RED.</td><td>This parameter defines a percentage of EB VOLTAGE parameter and it determines the duty-cycle applied after the first second since when the electromechanical brake is released.</td></tr>
<tr><td>PWM EV1</td><td>(Not used)</td></tr>
<tr><td>MAX. MOTOR TEMP.</td><td>This parameter defines the motor temperature above which a 50% cutback is applied to the maximum current. Cutback is valid only during motoring, while during braking the 100% of the maximum current is always available independently by the temperature.</td></tr>
<tr><td>STOP MOTOR TEMP.</td><td>This parameter defines the maximum motor temperature permitted, above which the controller stops driving the motor.</td></tr>
</table>

ADJUSTMENTS	DESCRIPTION
MOT.T. T.CUTBACK	This parameter defines the motor thermal cutback. The control linearly reduces the motor torque basing on the motor temperature. Reference limits of the linear reduction are MAX MOTOR TEMP and TEMP. MOT. STOP.  13BOP97ES11
MAX HEI 1 100MM	(This parameter used for wire height function) It sets the maximun lift height over 100 mm digit with zone selector switch rotating to the left. (ef. set value 10 means 1000 mm) If fork is approached the set height, lifting function is not working.
MAX HEI 1 1MM	(This parameter used for wire height function) It sets the maximun lift height from 1 mm to 99 mm digit. with zone selector switch rotating to the left. (ef. set value 10 means 10 mm) If fork is approached the set height, lifting function is not working.
MAX HEI 2 100MM	(This parameter used for wire height function) It sets the maximun lift height over 100 mm digit with zone selector switch rotating to the right. (ef. set value 10 means 1000 mm) If fork is approached the set height, lifting function is not working.
MAX HEI 2 1MM	(This parameter used for wire height function) It sets the maximun lift height from 1 mm to 99 mm digit. with zone selector switch rotating to the right. (ef. set value 10 means 10 mm) If fork is approached the set height, lifting function is not working.
HEIGHT 1 100MM	(This parameter used for wire height function) It sets the height switch 600 over 100 mm digit. (ef. set value 10 means 1000 mm)
HEIGHT 1 1MM	(This parameter used for wire height function) It sets the height switch 600 from 1 mm to 100 mm digit. (ef. set value 10 means 10 mm)
HEIGHT 2 100MM	(This parameter used for wire height function) It sets the height switch 1500 over 100 mm digit. (ef. set value 10 means 1000 mm)

ADJUSTMENTS	DESCRIPTION
HEIGHT 2 1MM	(This parameter used for wire height function) It sets the height switch 1500 from 1 mm to 100 mm digit. (ef. set value 10 means 10 mm)
HEIGHT 3 100MM	(This parameter used for wire height function) It sets the height switch 3000 over 100 mm digit. (ef. set value 10 means 1000 mm)
HEIGHT 3 1MM	(This parameter used for wire height function) It sets the height switch 3000 from 1 mm to 100 mm digit. (ef. set value 10 means 10 mm)
HEIGHT 4 100MM	(This parameter used for wire height function) It sets the height switch 5500 over 100 mm digit. (ef. set value 10 means 1000 mm)
HEIGHT 4 1MM	(This parameter used for wire height function) It sets the height switch 5500 from 1 mm to 100 mm digit. (ef. set value 10 means 10 mm)
MIN SPEED LIFT	(This parameter used for wire height function) It sets the minimum lifting speed when approaching the target height to stop.
MIN SPEED LOW	(This parameter used for wire height function) It sets the minimum lowering speed when approaching the target height to stop.
MIN SPEED LOW H1	(This parameter used for wire height function) It sets the minimum lowering speed when approaching the target height to stop if the fork is under height switch 600.
OFFSET HEIGHT	(This parameter used for wire height function) It sets the offset of the wire sensor.
SPEED RED. LIFT	(This parameter used for wire height function) It sets the distance at which the lifting speed starts to decrease.
SPEED RED. LOW	(This parameter used for wire height function) It sets the distance at which the lowering speed starts to decrease.
LOW. STOP WINDOW	(This parameter used for wire height function) It sets the lowering stop window when the lift is approaching to the target height.
LIFT STOP WINDOW	(This parameter used for wire height function) It sets the lifting stop window when the lift is approaching to the target height.

PARAMETER	DESCRIPTION
ACCELER. DELAY	This parameter defines the acceleration ramp, i.e. the time needed to speed up the motor from 0 Hz up to 100 Hz. A special software feature manages the acceleration ramp depending on the speed setpoint. - ACCEL MODULATION = OFF $\text{Accel tims [s]} = \frac{\text{Speed setpoint [Hz]}}{\text{100 Hz}} \cdot \text{Acceler delay [s]}$ - ACCEL MODULATION = ON Case 1 (red trace in the graph): Final-speed setpoint = 60 Hz ACCEL DELAY = 2.5 s Acceleration rate is re-scaled so that acceleration time results equal to ACCEL DELAY, in this case 2.5 s. Case 2 (green trace in the graph): Final-speed setpoint = 150 Hz ACCEL DELAY = 2.5 s Acceleration time results: $\text{Accel tims [s]} = \frac{\text{150 Hz}}{\text{100 Hz}} \cdot \text{Acceler delay} = 3.75 \text{ sec}$ N: N Mode E: E Mode P: P Mode
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 UP N	It determines the maximum lifting speed with a potentiometer control. N Mode
MAX SPEED UP E	It determines the maximum lifting speed with a potentiometer control. E Mode
MAX SPEED UP P	It determines the maximum lifting speed with a potentiometer control. P Mode
1ST PUMP SPEED	(Not used) This parameter defines the speed of the pump motor when 1st speed is requested. It represents a percentage of the maximum pump speed.
2ND PUMP SPEED	(Not used) This parameter defines the speed of the pump motor when 2st speed is requested. It represents a percentage of the maximum pump speed.
3RD PUMP SPEED	(Not used) This parameter defines the speed of the pump motor when 3st speed is requested. It represents a percentage of the maximum pump speed.
4TH PUMP SPEED	(Not used) This parameter defines the speed of the pump motor when 4st speed is requested. It represents a percentage of the maximum pump speed.

PARAMETER	DESCRIPTION
5TH PUMP SPEED	(Not used) This parameter defines the speed of the pump motor when 5st speed is requested. It represents a percentage of the maximum pump speed.
HYD PUMP SPEED	(Not used) This parameter defines the speed of the pump motor used for the steering, when HYDRO FUNCTION is ON.
CUTBACK SPEED	(Not used)
CUTBACK SPEED 2	(Not used)
BMS WRN1 CB SPE.	This parameter defines the maximum speed performed when the BMS warning 1 is active.
MOT.HT MAX SPEED N	The Maximum speed when the Motor Temperature is reached to the "MAX. MOTOR TEMP. " Setting. N Mode
MOT.HT MAX SPEED E	The Maximum speed when the Motor Temperature is reached to the "MAX. MOTOR TEMP. " Setting. E Mode
MOT.HT MAX SPEED P	The Maximum speed when the Motor Temperature is reached to the "MAX. MOTOR TEMP. " Setting. P Mode
FREQUENCY CREEP	This parameter defines the minimum speed when the forward- or reverse-request switch is closed, but the accelerator is at its minimum.
MAX. CURRENT TRA	This parameter defines the maximum current applied to the motor during acceleration, as a percentage of the factory-calibrated maximum current.
MAX. CURRENT BRK	(Not used)
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.
AUXILIARY TIME	(Not used)
DEC DEL LIFT LIM	It determines the deceleration ramp. When lift limit function is activated.
LIFT SPEED 1 N	It determines the maximum lift speed when lift height is 600 to 1500 mm. N Mode
LIFT SPEED 2 N	It determines the maximum lift speed when lift height is 1500 to 3000 mm. N Mode
LIFT SPEED 3 N	It determines the maximum lift speed when lift height is 3000 to 5500 mm. N Mode
LIFT SPEED 4 N	It determines the maximum lift speed when lift height is 5500 to END-100 mm. N Mode
LIFT SPEED 1 E	It determines the maximum lift speed when lift height is 600 to 1500 mm. E Mode
LIFT SPEED 2 E	It determines the maximum lift speed when lift height is 1500 to 3000 mm. E Mode
LIFT SPEED 3 E	It determines the maximum lift speed when lift height is 3000 to 5500 mm. E Mode
LIFT SPEED 4 E	It determines the maximum lift speed when lift height is 5500 to END-100 mm. E Mode
LIFT SPEED 1 P	It determines the maximum lift speed when lift height is 600 to 1500 mm. P Mode
LIFT SPEED 2 P	It determines the maximum lift speed when lift height is 1500 to 3000 mm. P Mode
LIFT SPEED 3 P	It determines the maximum lift speed when lift height is 3000 to 5500 mm. P Mode
LIFT SPEED 4 P	It determines the maximum lift speed when lift height is 5500 to END-100 mm. P Mode

PARAMETER	DESCRIPTION
M.PUMP SPEED RED N	(Not used)
M.PUMP SPEED RED E	(Not used)
M.PUMP SPEED RED P	(Not used)
BATT.LOW SPEED N	This parameter defines the maximum speed performed according to "BATTERY CHECK" parameter. N Mode
BATT.LOW SPEED E	This parameter defines the maximum speed performed according to "BATTERY CHECK" parameter. E Mode
BATT.LOW SPEED P	This parameter defines the maximum speed performed according to "BATTERY CHECK" parameter. P Mode
BATT.LOW CURRENT	This parameter defines the maximum current performed according to "BATTERY CHECK" parameter.

PUMP MASTER	
MONITIORING	DESCRIPTION
KEY VOLTAGE	Key voltage measured in real time.
BATTERY VOLTAGE	Battery voltage measured in real time (across the DC bus).
DC BUS CURRENT	Estimation of the DC current the inverter is drawing from the battery.
MOTOR VOLTAGE	Theoretical phase- to- phase voltage to be applied at the motor terminals, as a percentage of the supply voltage.
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)"
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)
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.
TEMPERATURE	Temperature measured on the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm.

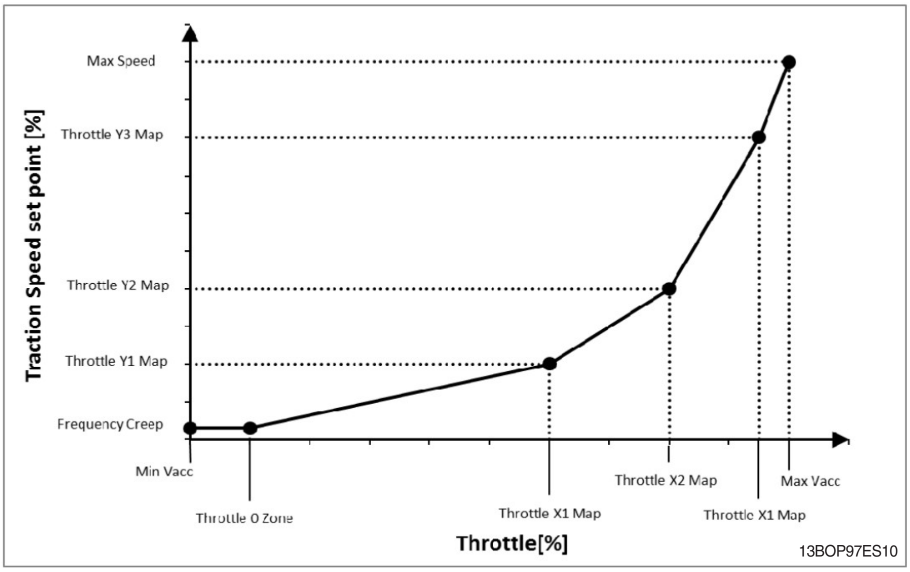
PUMP MASTER	
MONITIORING	DESCRIPTION
MOTOR TEMPERAT.	Motor-windings temperature. This temperature is used for the MOTOR OVERTEMP alarm.
A-16 FAN RELAY	Voltage applied over the fan relay coil. It corresponds to the duty cycle value of PWM applied, expressed as percentage.
A-18 BACK BUZZER REL.	Voltage applied over the back buzzer relay coil. It corresponds to the duty cycle value of PWM applied, expressed as percentage.
EX. A10 ADD FORK A	Voltage of the Additioanl Fork A analog input (pin A10 of CAN EXTENDER).
EX. A11 ADD FORK B	Voltage of the Additioanl Fork B analog input (pin A11 of CAN EXTENDER).
EX. A16 LIFT/LOW A	Voltage of the Lift/Lower A analog input (pin A16 of CAN EXTENDER).
EX. A17 LIFT/LOW B	Voltage of the Lift/Lower B analog input (pin A17 of CAN EXTENDER).

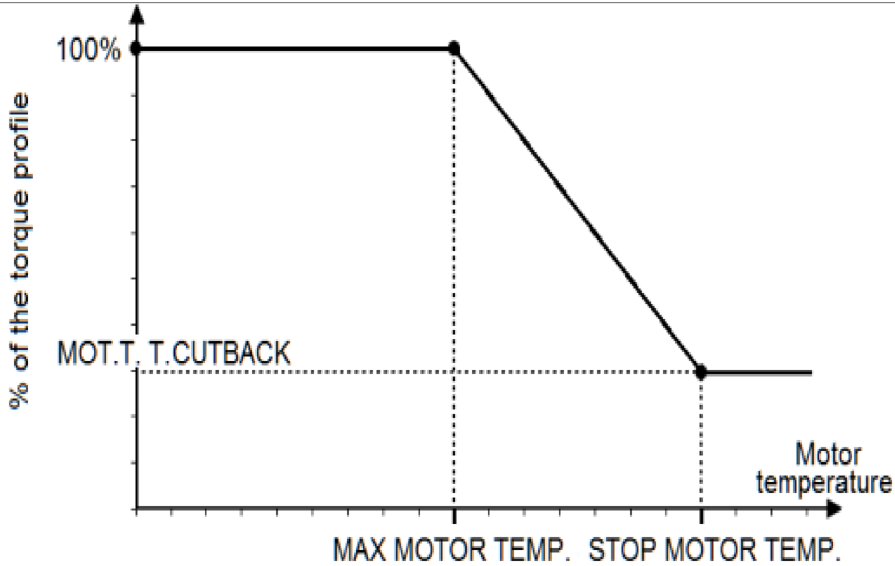
(4) PUMP CONTROLLER (24 V, Option)

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
HM CUSTOM 1 OPT.	(Not used)
HM CUSTOM 2 OPT.	(Not used)
BATTERY CHECK	(Not used)
SOFT LANDING	This parameter enables or disables the control of the deceleration rate of the truck when the accelerator is released. - ON = When the accelerator is released, the inverter controls the deceleration rate of the truck through the application of a linearly decreasing torque curve. This is useful when the operator releases the accelerator while the truck is going uphill. If the rise is steep, the truck may stop fast and may also go backwards in short time, possibly leading to a dangerous situation. - OFF = When the accelerator is released, the inverter does not control the deceleration rate of the truck, instead it stops driving the motor.
QUICK INVERSION	This parameter defines the quick-inversion functionality. - NONE = The quick-inversion function is not managed. - BRAKE = Upon a quick-inversion request, the motor is braked. - TIMED = The quick-inversion function is timed: upon a QI request the controller drives the motor in the opposite direction for a fixed time (1.5 seconds by default). - BELLY = The quick-inversion function is managed but not timed: upon a QI request the controller drives the motor in the opposite direction until the request is released.
SET MOT. TEMPERAT	Sets the motor temperature sensor type. - NONE = no motor thermal sensor switch is connected. - DIGITAL = a digital (ON/OFF) motor thermal sensor is connected to A22. - OPTION#1 = an analogue motor thermal sensor is connected to A22. The temperature sensor is a KTY 84-130 PTC (positive thermal coefficient resistance). - OPTION#2 = an analogue motor thermal sensor is connected to A22. The temperature sensor is a KTY 83-130 PTC (positive thermal coefficient resistance) - OPTION#3 = an analog motor thermal sensor is connected to A22. The temperature sensor is a PT1000 PTC (positive thermal coefficient resistance).
FAN RELAY COIL	This parameter defines whether a load coil is connected to the NMC output (A16) or not. - ABSENT = NMC output is not connected to any load coil. - PRESENT = NMC output is connected to a load coil
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.
AUX OUT FUNCTION	This parameter enables or disables the output A18(NEB) : - NONE = Diagnoses are masked and back buzzer relay does not work. - BRAKE = Back buzzer relay works if all the related diagnoses pass.
ACCEL MODULATION	This parameter enables or disables the acceleration-modulation function. - OFF = The acceleration rate is inversely proportional to the ACCEL DELAY parameter. - ON = The acceleration ramp is inversely proportional to the ACCEL DELAY parameter only if speed setpoint is greater than 100 Hz. Below 100 Hz the acceleration ramp is also proportional to the speed setpoint, so that the acceleration duration results equal to ACCEL DELAY.

SET OPTIONS	DESCRIPTION
EV1	(Not used)
HIGH DYNAMIC	This parameter enables or disables the high-dynamic function. - ON = All acceleration and deceleration profiles set by dedicated parameters are ignored and the controller works always with maximum performance. - OFF = Standard behavior.
FORK	- OFF : Additional lift function is not used. - ON : Additional lift function is used.
D.M. PUMP	- OFF : lift and lowering function is available after putting ON dead man switch. - ON : lift and lowering function is available without regard to put ON dead man switch.
WIRE HEIGHT	- OFF : Height indicator function is not used. - ON : Heigth indicator function is used.
SAFETY KEY-ON	- ON : When the truck is KEY ON with DEADMAN switch is ON, stopping hyd. pump motor. - OFF : When the truck is KEY ON with DEADMAN switch is ON, not stopping hyd. pump motor.

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)

ADJUSTMENTS	DESCRIPTION
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.
BATT.LOW TRESHLD	(Not used)
FAN RELAY VOLT	This parameter specifies the duty-cycle (t_{ON}/T_{PWM}) of the PWM applied to the fan relay output (A16) during the first second after the activation signal that causes the main contactor to close.
FAN RELAY V RED	This parameter defines a percentage of MC VOLTAGE parameter and it determines the duty-cycle applied after the first second of activation of the contactor.
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.
EB VOLTAGE	This parameter specifies the duty-cycle (t_{ON}/T_{PWM}) of the PWM applied to the back buzzer relay output(A16) during the first second after the activation signal that causes back buzzer relay to release.
EB VOLTAGE RED.	This parameter defines a percentage of EB VOLTAGE parameter and it determines the duty-cycle applied after the first second since when the electromechanical brake is released.
PWM EV1	(Not used)
MAX. MOTOR TEMP.	This parameter defines the motor temperature above which a 50% cutback is applied to the maximum current. Cutback is valid only during motoring, while during braking the 100% of the maximum current is always available independently by the temperature.
STOP MOTOR TEMP.	This parameter defines the maximum motor temperature permitted, above which the controller stops driving the motor.

ADJUSTMENTS	DESCRIPTION
MOT.T. T. CUTBACK	This parameter defines the motor thermal cutback. The control linearly reduces the motor torque basing on the motor temperature. Reference limits of the linear reduction are MAX MOTOR TEMP and TEMP. MOT. STOP.  13BOP97ES11
MAX HEI 1 100MM	(This parameter used for wire height function) It sets the maximun lift height over 100 mm digit with zone selector switch rotating to the left. (ef. set value 10 means 1000 mm) If fork is approached the set height, lifting function is not working.
MAX HEI 1 1MM	(This parameter used for wire height function) It sets the maximun lift height from 1 mm to 99 mm digit. with zone selector switch rotating to the left. (ef. set value 10 means 10 mm) If fork is approached the set height, lifting function is not working.
MAX HEI 2 100MM	(This parameter used for wire height function) It sets the maximun lift height over 100 mm digit with zone selector switch rotating to the right. (ef. set value 10 means 1000 mm) If fork is approached the set height, lifting function is not working.
MAX HEI 2 1MM	(This parameter used for wire height function) It sets the maximun lift height from 1 mm to 99 mm digit. with zone selector switch rotating to the right. (ef. set value 10 means 10 mm) If fork is approached the set height, lifting function is not working.
HEIGHT 1 100MM	(This parameter used for wire height function) It sets the height switch 600 over 100 mm digit. (ef. set value 10 means 1000 mm)
HEIGHT 1 1MM	(This parameter used for wire height function) It sets the height switch 600 from 1 mm to 100 mm digit. (ef. set value 10 means 10 mm)
HEIGHT 2 100MM	"(This parameter used for wire height function) It sets the height switch 1500 over 100 mm digit. (ef. set value 10 means 1000 mm)"
HEIGHT 2 1MM	"(This parameter used for wire height function) It sets the height switch 1500 from 1 mm to 100 mm digit. (ef. set value 10 means 10 mm)"

ADJUSTMENTS	DESCRIPTION
HEIGHT 3 100MM	(This parameter used for wire height function) It sets the height switch 3000 over 100 mm digit. (ef. set value 10 means 1000 mm)
HEIGHT 3 1MM	(This parameter used for wire height function) It sets the height switch 3000 from 1 mm to 100 mm digit. (ef. set value 10 means 10 mm)
HEIGHT 4 100MM	(This parameter used for wire height function) It sets the height switch 5500 over 100 mm digit. (ef. set value 10 means 1000 mm)
HEIGHT 4 1MM	(This parameter used for wire height function) It sets the height switch 5500 from 1 mm to 100 mm digit. (ef. set value 10 means 10 mm)
MIN SPEED LIFT	(This parameter used for wire height function) It sets the minimum lifting speed when approaching the target height to stop.
MIN SPEED LOW	(This parameter used for wire height function) It sets the minimum lowering speed when approaching the target height to stop.
MIN SPEED LOW H1	(This parameter used for wire height function) It sets the minimum lowering speed when approaching the target height to stop if the fork is under height switch 600.
OFFSET HEIGHT	(This parameter used for wire height function) It sets the offset of the wire sensor.
SPEED RED. LIFT	(This parameter used for wire height function) It sets the distance at which the lifting speed starts to decrease.
SPEED RED. LOW	(This parameter used for wire height function) It sets the distance at which the lowering speed starts to decrease.
LOW. STOP WINDOW	(This parameter used for wire height function) It sets the lowering stop window when the lift is approaching to the target height.
LIFT STOP WINDOW	(This parameter used for wire height function) It sets the lifting stop window when the lift is approaching to the target height.

PARAMETER	DESCRIPTION
ACCELER. DELAY	This parameter defines the acceleration ramp, i.e. the time needed to speed up the motor from 0 Hz up to 100 Hz. A special software feature manages the acceleration ramp depending on the speed setpoint. - ACCEL MODULATION = OFF $\text{Accel tims [s]} = \frac{\text{Speed setpoint [Hz]}}{\text{100 Hz}} \cdot \text{Acceler delay [s]}$ - ACCEL MODULATION = ON Case 1 (red trace in the graph): Final-speed setpoint = 60 Hz ACCEL DELAY = 2.5 s Acceleration rate is re-scaled so that acceleration time results equal to ACCEL DELAY, in this case 2.5 s. Case 2 (green trace in the graph): Final-speed setpoint = 150 Hz ACCEL DELAY = 2.5 s Acceleration time results: $\text{Accel tims [s]} = \frac{\text{150 Hz}}{\text{100 Hz}} \cdot \text{Acceler delay} = 3.75 \text{ sec}$
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 UP	It determines the maximum lifting speed with a potentiometer control.
MAX SPEED UP FOR	It determines the maximum additional lifting speed with a potentiometer control
1ST PUMP SPEED	(Not used) This parameter defines the speed of the pump motor when 1st speed is requested. It represents a percentage of the maximum pump speed.
2ND PUMP SPEED	(Not used) This parameter defines the speed of the pump motor when 2st speed is requested. It represents a percentage of the maximum pump speed.
3RD PUMP SPEED	(Not used) This parameter defines the speed of the pump motor when 3st speed is requested. It represents a percentage of the maximum pump speed.
4TH PUMP SPEED	(Not used) This parameter defines the speed of the pump motor when 4st speed is requested. It represents a percentage of the maximum pump speed.
5TH PUMP SPEED	(Not used) This parameter defines the speed of the pump motor when 5st speed is requested. It represents a percentage of the maximum pump speed.
HYD PUMP SPEED	(Not used) This parameter defines the speed of the pump motor used for the steering, when HYDRO FUNCTION is ON.

PARAMETER	DESCRIPTION
CUTBACK SPEED	(Not used)
CUTBACK SPEED 2	(Not used)
MOT.HT MAX SPEED	The Maximum speed when the Motor Temperature is reached to the "MAX. MOTOR TEMP. " Setting
FREQUENCY CREEP	This parameter defines the minimum speed when the forward- or reverse-request switch is closed, but the accelerator is at its minimum.
MAX. CURRENT TRA	This parameter defines the maximum current applied to the motor during acceleration, as a percentage of the factory-calibrated maximum current.
MAX. CURRENT BRK	(Not used)
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.
AUXILIARY TIME	(Not used)
DEC DEL LIFT LIM	It determines the deceleration ramp. When lift limit function is activated.
LIFT SPEED 1	It determines the maximum lift speed when lift height is 600 to 1500 mm.
LIFT SPEED 2	It determines the maximum lift speed when lift height is 1500 to 3000 mm.
LIFT SPEED 3	It determines the maximum lift speed when lift height is 3000 to 5500 mm.
LIFT SPEED 4	It determines the maximum lift speed when lift height is 5500 to END-100 mm.
M.PUMP SPEED RED	(Not used)
BATT.LOW SPEED	This parameter defines the maximum speed performed according to "BATTERY CHECK" parameter.
BATT.LOW CURRENT	This parameter defines the maximum current performed according to "BATTERY CHECK" parameter.

PUMP MASTER	
MONITIORING	DESCRIPTION
KEY VOLTAGE	Key voltage measured in real time.
BATTERY VOLTAGE	Battery voltage measured in real time (across the DC bus).
DC BUS CURRENT	Estimation of the DC current the inverter is drawing from the battery.
MOTOR VOLTAGE	Theoretical phase- to- phase voltage to be applied at the motor terminals, as a percentage of the supply voltage.
FREQUENCY	Frequency of the current sine-wave that the inverter is supplying to the motor.

PUMP MASTER	
MONITIORING	DESCRIPTION
MEASURED SPEED	"Motor speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz). (measured value by master micom)"
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)
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.
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.
A-16 FAN RELAY	Voltage applied over the fan relay coil. It corresponds to the duty cycle value of PWM applied, expressed as percentage.
A-18 BACK BUZZER REL.	Voltage applied over the back buzzer relay coil. It corresponds to the duty cycle value of PWM applied, expressed as percentage.
EX. A10 ADD FORK A	Voltage of the Additioanl Fork A analog input (pin A10 of CAN EXTENDER).
EX. A11 ADD FORK B	Voltage of the Additioanl Fork B analog input (pin A11 of CAN EXTENDER).
EX. A16 LIFT/LOW A	Voltage of the Lift/Lower A analog input (pin A16 of CAN EXTENDER).
EX. A17 LIFT/LOW B	Voltage of the Lift/Lower B analog input (pin A17 of CAN EXTENDER).

(5) EPS CONTROLLER (36 V, 24 V)

SET OPTIONS	DESCRIPTION
MICRO CHECK	This option is useful to support debug and troubleshooting. It makes possible to inhibit the supervisor (slave uC) operations and allows the system to run with just the main uC. When entering this operating mode the safety contacts stay open. Therefore, traction shall be disabled. It can be set one of two : -PRESENT: Default setting : enable the operations of the supervisor (slave uC). -ABSENT: Disable the operations of the supervisor (slave uC). The safety contacts stay opened.
ENCODER CONTROL	This option specifies if the motor is controlled via encoder or completely sensorless. Normally it is set OFF. When glitches are heard from the motor, it is necessary to turn to a sensored control. In this case set ENCODER CONTROL to on. Then, take care the encoder resolution used in the software is matched with the actual encoder resolution.
AUTOCENTERING	This option makes the automatic centering (AUTC) operation available. When it is set on, an automatic alignment of the steered wheel on the straight ahead toggle switch is always performed at key-on. When it is set off, the AUTC at key-on is still performed for any configuration but for the open loop (stepper motor at the steering wheel) without angle limitation. In this latest case, the centering must be manually executed. Besides, this option enables the AUTC on demand. A centering request is required in this case to get the AUTC on-demand really performed.
RECOVERY AT REST	(Stepper motor version only).This option enables the function "alignment at the rest position" It consists of the following steps : - When releasing the stepper motor, the SW records the steered wheel angle. - Then it is expected the steered wheel angle does not change meanwhile travelling with a released stepper motor. - If the steered wheel angle changes more than 8 degrees, the system automatically turns back to the recorded position If the driver moves the stepper motor meanwhile an alignment at the rest position is in progress, the alignment will be aborted.
AUX FUNCTION 1	This option sets the steering mode after the feedback sensor has reached the commanded position (it is used only in closed loop configurations (i.e. automatic centering). It can be set one of three : - LEVEL 0 : The steering control is always active when a travel demand is active. The steer control is turned off when the travel demands are deactivated (after a 3 sec delay). - LEVEL 1 : The steering control is alternatively turned off (15 secs long plus the AUXILIARY TIME) and on (3 secs long). - LEVEL 2 : The steering control is alternatively turned off (15 secs long plus the AUXILIARY TIME) and on (3 secs long) but only when a travel demand is active. AUXILIARY TIME is the delay (in secs) the DC standing current takes to arrive to 0.
COMBI CAN PROT.	(Not used)
COMBI HZ OPT.	(Not used)
TRUCK TYPE	This option sets the truck type. - Option #3 : 13BOP-9
AUTO REQ TYPE(W/G)	- None : not used. - Wire Guidance : Wire Guidance function is activated. - Manual : Wire Guidance function is not activated.

ADJUSTMENTS	DESCRIPTION
SET SAT. FREQ.	Set this adjustment to the corner frequency of the motor. SET SAT FREQ is to be meant as the maximum frequency at which the motor supplies the maximum torque (it is the superior limit of the constant torque characteristic). Frequency higher than SET SAT FREQUENCY gets the motor weakened.
OVERSAT FREQ.	The maximum motor frequency is set with the sum between SET SAT FREQ and OVERSAT FREQ. OVERSAT FREQ is the increment, over the SET SAT FREQUENCY, in which the steering motor works with degraded flux (weakening area). Default choice is 1 Hz (i.e. the steering motor never works in the weakening region).
MAXIMUM SLIP	(Factory adjusted). MAXIMUM SLIP modifies the acceleration and deceleration ramp for the frequency in the motor. Higher MAXIMUM SLIP gets faster acceleration and deceleration ramp. If the encoder is used for the motor control (ENCODER CONTROL is On), MAXIMUM SLIP has another meaning: it is the slip to be applied when the control is sourcing the maximum current.
AUX VOLTAGE #1	(Factory adjusted). This is the self-acquired offset value of the stepper motor line connected to CNA#9. The default value is 2.500 mV and can be re-acquired by rolling the DEBUG OUTPUT to 0.
AUX VOLTAGE #2	(Factory adjusted). This is the self-acquired offset value of the stepper motor line connected to CNA#8. The default value is 2.500 mV and can be re-acquired by rolling the DEBUG OUTPUT to 0.
NO LOAD CURRENT	In order it shall be possible to weaken the steering motor when lightened (reducing power loss in the motor), it is necessary to specify the current the motor drains when working full flux and without load (NO LOAD CURRENT). To find this value it is necessary to set the DEBUG OUTPUT to level 10 and to measure the current in the motor when running without load and a frequency close to SET SAT FREQ/2.
SET STEER 0-POS.	(This parameter used for Wire Guidance function) This parameter is used for the procedure of the Wire Guidance setting.
WG REV. OFFSET	(This parameter used for Wire Guidance function) This parameter is used for the procedure of the Wire Guidance setting.
AUTOTEACHING	This option (on/off) is used to launch the autoteaching procedure. Take care there is not mechanical angle limitation before to turn it on. Then recycle the key and the steering motor starts an automatic sequence to collect the ENC COUNT AT 360 and ENC COUNT AT 180. If the collected couple is consistent (ENC COUNT AT 180 stays inside the window from 3/8 to 6/8 of ENC COUNT AT 360) they are automatically saved on the settings SET ENC AT 360 and SET ENC AT 180. If the autoteaching procedure successful ends, the display switches from the DATA ACQUISITION alarm to the collected values (in the range 0 to 5Vdc. Left side shows the ENC COUNT AT 360 value; the right side shows the ENC COUNT AT 180 value). If the couple of values is not consistent they were not saved and the display switches cyclically from the collected data to the DATA ACQUISITION inscription.

PARAMETER	DESCRIPTION
SPEED LIMIT	(Stepper Motor version only). Level 0 to 9. It determines the scaling factor between the speed of the steering wheel and the speed of the steering motor but only when the steering wheel is fast turning. By increasing the SPEED LIMIT value, the steering motor speed increases too. In practice, it sets the maximum motor speed when the steering wheel is fast turning.
AUX FUNCTION 3	(Stepper Motor version only). Level 0 to 9. This setting performs the Dynamic Numbness compensation: it consists of a reduction in the steer sensitivity when the truck is driving at high speed. To get this goal, it is necessary to attenuate the scaling factor between the speed of the steering wheel and the speed of the steering motor. AUX FUNCTION #3 does that but only when the steering wheel is fast turning. This attenuation must be proportional to the drive speed. At full drive speed the attenuation of the scaling factor is maximum. AUX FUNCTION #3 to Level 0 means no attenuation of the scaling factor with the truck speed. AUX FUNCTION #3 to Level 9 means maximum attenuation of the scaling factor with the truck speed. Obviously, to perform the Dynamic Numbness compensation, it is necessary to know the drive speed and so the eps-ac WG must be CAN Bus connected.
SENSITIVITY	(Stepper Motor version only). Level 0 to 9. It determines the scaling factor between the speed of the steering wheel and the speed of the steering motor but only when the steering wheel is slow turning. By increasing the SENSITIVITY value, the steering motor speed increases too. In practice, it changes the sensitivity of the steering wheel when it is slow turning.
AUX FUNCTION 2	(Stepper Motor version only). Level 0 to 9. This setting performs the Dynamic Numbness compensation: it consists of a reduction in the steer sensitivity when the truck is driving at high speed. To get this goal, it is necessary to attenuate the scaling factor between the speed of the steering wheel and the speed of the steering motor. AUX FUNCTION #2 does that but only when the steering wheel is slow turning. This attenuation must be proportional to the drive speed. At full drive speed the attenuation of the scaling factor is maximum. AUX FUNCTION #2 to Level 0 means no attenuation of the scaling factor with the truck speed. AUX FUNCTION #2 to Level 9 means maximum attenuation of the scaling factor with the truck speed. Obviously, to perform the Dynamic Numbness compensation, it is necessary to know the drive speed and so the eps-ac WG must be CAN Bus connected.
CREEP SPEED	Level 0 to 9. It sets a minimum amount of motor torque when the steering motor is slow turning. It is useful to neutralize the recall torque generated by the elastic tyre on the steered wheel.
COMPENSATION	Level 0 to 2. This parameter applies a compensation for the drops in the motor connections to have a real Emf/f control law. - LEVEL 0: No compensation. - LEVEL 1: Compensate the drop on power mosfets and cables. - LEVEL 2: Compensate the drop on power mosfet, cables and motor resistance.
1ST ANGLE COARSE	(RTC version only). This parameter regulates in fine steps the maximum steered wheel angle in the direction where FEEDBACK ENC is higher than 2.5V. It is used in closed loop application only (RTC) and it is a scaling factor between the SET POINT POT reading and the FEEDBACK ENC reading. By increasing this parameter, the maximum steered wheel angle increases too.

PARAMETER	DESCRIPTION
2ND ANGLE COARSE	(RTC version only). This parameter regulates in coarse steps the maximum steered wheel angle in the direction where FEEDBACK ENC is lower than 2.5V. It is used in closed loop application only (RTC) and it is a scaling factor between the SET POINT POT reading and the FEEDBACK ENC reading. By increasing this parameter, the maximum steered wheel angle increases too. The maximum angle in RTC should be regulated in feedforward way by properly adjusting these angle settings. (i.e. in open loop application the angle is limited through the settings MIN and MAX MANUAL ANGLE with LIMIT DEVICE to On when FEEDBACK ENC overtakes the limits. In closed loop we can set MIN and MAX MANUAL ANG to 100% and the angle limitation will be carried out in a more narrow range with the 1ST and 2ND ANGLE settings).
OVERANGLE 3DEGX	(Not used)
ANTIROLLBACK	Adjusts the standstill torque after the steer handle is released and the travel demand deactivated. It is in percentage of the maximum current. Injecting a continuous current in the motor generates the stand still torque. It is useful to neutralize the recall torque generated by the elastic tyre on the steered wheel.
LAG FB REGULAT.	(This parameter used for Wire Guidance function) Level 0 to 9. It is used to set the integral (lag) contribution to a PID algorithm for RTC, AUTC and WG functions. The integral contribution is applied to the FEEDBACK ENC value only. It works like a low pass filter to get smooth the pursuing next to the commanded position. The derivative (lead) contribution generates dither that is possible to reduce by increasing this adjustment. Obviously lag and lead regulations influence the stability of the closed loop and so different setting must be empirically tried to avoid oscillations. - LEVEL 0: lowest lag contribution (high cut off frequency low pass filter). - LEVEL 9: highest lag contribution (low cut off frequency low pass filter).
LEAD FB REGULAT.	(This parameter used for Wire Guidance function) Level 0 to 9. It is used to set the derivative (lead) contribution to a PID algorithm for RTC, AUTC and WG functions. The derivative contribution is applied to the FEEDBACK ENC value only. High LEAD FB REGULAT value brakes the steering motor in advance respect to the commanded position so avoiding the overshooting of the commanded position. On the other side generates damping and dither, close to the commanded position. Obviously lag and lead regulations influence the stability of the closed loop and so different setting must be empirically tried to avoid oscillations. - LEVEL 0: lowest lead contribution (overshooting is favourite). - LEVEL 9: highest lead contribution (damping is favourite).
LAG WG REGULAT.	(This parameter used for Wire Guidance function)
LEAD WG REGULAT.	(This parameter used for Wire Guidance function)
WG FWD GAIN	Level 0 to 9. It is used to set the proportional contribution to a PID algorithm in WG mode and FWD direction only. The proportional contribution is applied to the difference between the commanded position (position error coming from the FWD antenna) and the real position (steered wheel angle). The accuracy of the pursuing between commanded and real position increases if WG FWD GAIN increases.

PARAMETER	DESCRIPTION
WG FWD POT	Level 0 to 9. It is a scaling factor applied to the FEEDBACK ENC value in WG mode FWD direction only. This scaling factor reduces when WG FWD POT increases. To close the loop, the position error coming from the FWD antenna is compared with the FEEDBACK ENC value after the scaling with WG FWD POT. As consequence, when the scaling factor is low also the weight of the FEEDBACK ENC is low and a wider steered wheel angle is required to close the loop. As a thumb rule, WG FWD POT sets the amplitude of the steered wheel angle required to neutralize a certain position error in the FWD antenna. In practice, when WG FWD POT is low, the steered wheel angle makes very short correction to pursuit the commanded position coming from the FWD antenna; when WG FWD POT is high, the steered wheel angle makes large correction to pursuit the commanded position coming from the FWD antenna.
WG REV GAIN	Level 0 to 9. It is used to set the proportional contribute to a PID algorithm in WG mode and REV direction only. The proportional contribution is applied to the difference between the commanded position (position error coming from a combination between REV and FWD antennas) and the real position (steered wheel angle). The accuracy of the pursuing between commanded and real position increases if WG REV GAIN increases.
WG REV POT	Level 0 to 9. It is a scaling factor applied to the FEEDBACK ENC value in WG mode REV direction only. This scaling factor reduces when WG REV POT increases. To close the loop, the position error coming from a combination between REV and FWD antenna is compared with the FEEDBACK ENC value after the scaling with WG REV POT. As consequence, when the scaling factor is low, also the weight of the FEEDBACK ENC is low and a wider steered wheel angle is required to close the loop. As a thumb rule, WG REV POT sets the amplitude of the steered wheel angle required to neutralize a certain position error in the antennas. In practice, when WG REV POT is low, the steered wheel angle makes very short correction to pursuit the commanded position coming from the antennas; when WG REV POT is high, the steered wheel angle makes large correction to pursuit the commanded position coming from the antennas.
WG REV ANT	Level 0 to 9. In WG mode REV direction only, the commanded position is a combination between REV and FWD antenna. In this combination, the scaling factor for the FWD antenna is set with WG REV ANT. This scaling factor increases with the setting WG REV ANT in the range 0 to 0.8. When WG REV ANT is low, also the contribution of the FWD antenna to the position error is low: as consequence the truck makes wide waves on the wire in the steered wheel side because it is insensitive to the FWD antenna error. When WG REV ANT is high, the contribution of the FWD antenna to the position error is high: as consequence the waves in the steered wheel side are attenuated because it is sensitive to the FWD antenna error. Obviously you have to pay something for that: in fact the waves in the REV antenna side increases when WG REV ANT increases. At last, let me underline that care must be taken in order the contribution of the FWD antenna never overcomes the contribution of the REV antenna in WG mode REV direction. To avoid this risk, the FWD antenna is weighed with a scaling factor in the range 0 to 0.8 (depending on WG REV ANT), meanwhile the REV antenna is weighed with a scaling factor equal to 1. Unfortunately, the asymmetries in the truck frame, could distort the signals from the antenna giving more weight to the FWD antenna infringing the above rule. To reduce the risk lower value for WG REV ANT are preferred.
AXLE DISTANCE CM	This adjustment specifies the distance between the axle of the load wheel and the axle of the steered wheel. AXLE DISTANCE CM=200 means 2meters.
FWD DISPLAC CM	This adjustment specifies the distance between the FWD antenna barycenter and the axle of the steered wheel (used in acquisition mode FWD direction only). The distance is positive if the FWD antenna is mounted in front of the steered wheel; it is negative if the antenna is behind the steered wheel. FWD DISPLAC CM=20 means 20cm.
REV DISPLAC CM	This adjustment specifies the distance between the REV antenna barycenter and the axle of the load wheel (used in acquisition mode REV direction only). The distance is positive if the REV antenna is mounted externally respect to the load wheel; it is negative if the antenna is behind the load wheel. REV DISPLAC CM=20 means 20cm

PARAMETER	DESCRIPTION
SMOOTH FWD ACQ	This adjustment is used in acquisition mode FWD direction only. When the truck converges on the wire and the FWD antenna senses the field, the steered wheel rotates to direct the truck toward the line of the wire. As consequence, the FWD antenna crosses and overshoots the wire before it comes back to align the truck with it. It is possible to adjust the amplitude of this overshooting with SMOOTH FWD ACQ. The larger the FWD antenna crosses the wire the shorter the time it takes to turn lock-on mode. - LEVEL 0: Small FWD antenna overshoot. - LEVEL 9: Wide FWD antenna overshoot.
SMOOTH REV ACQ	(Level 0 is suggested). This adjustment is used in acquisition mode REV direction only. When the truck converges on the wire and the REV antenna senses the field, the steered wheel rotates to direct the truck toward the line of the wire. As consequence, the REV antenna crosses and overshoots the wire before it comes back to align the truck with it. It is possible to adjust the amplitude of this overshooting with SMOOTH REV ACQ. - LEVEL 0: Small REV antenna overshoot (suggested). - LEVEL 9: Wide REV antenna overshoot.
MAX ANGLE	This adjustment limits the steered wheel angle when the truck is travelling lock-on on the wire. This angle limitation is done in feedforward way (i.e. by limiting the wished steered wheel angle). MAX ANGLE sets the positive limit for the steered wheel angle (FEEDBACK ENC higher than 2.5V). Angle measurement uses the difference SET MAX ENC – SET MIN ENC corresponding to 180 degrees. (When the feedback potentiometer is present the angle measurement uses the difference SET MAX FB POT – SET MIN FB POT corresponding to 180 degrees). - LEVEL 0: Steered wheel angle limited to +0.75 degrees - LEVEL 1: Steered wheel angle limited to +1 degrees - LEVEL 2: Steered wheel angle limited to +1.25 degrees - LEVEL 3: Steered wheel angle limited to +1.5 degrees - LEVEL 4: Steered wheel angle limited to +1.75 degrees - LEVEL 5: Steered wheel angle limited to +2 degrees - LEVEL 6: Steered wheel angle limited to +2.5 degrees - LEVEL 7: Steered wheel angle limited to +3 degrees - LEVEL 8: Steered wheel angle limited to +4 degrees - LEVEL 9: Steered wheel angle limited to +8 degrees A LOSING STRAIGHT warning occurs when the steered wheel angle overtakes 1.5 times the above limit. An ANGLE alarm occurs when the steered wheel angel overtakes 2 times the above limit.
MIN ANGLE	This adjustment limits the steered wheel angle when the truck is travelling lock-on on the wire. This angle limitation is done in feedforward way (i.e. by limiting the wished steered wheel angle). MIN ANGLE sets the negative limit for the steered wheel angle (FEEDBACK ENC less than 2.5V). Angle measurement uses the difference SET MAX ENC – SET MIN ENC corresponding to 180 degrees. (When the feedback potentiometer is present the angle measurement uses the difference SET MAX FB POT – SET MIN FB POT corresponding to 180 degrees). - LEVEL 0: Steered wheel angle limited to -0.75 degrees - LEVEL 1: Steered wheel angle limited to -1 degrees - LEVEL 2: Steered wheel angle limited to -1.25 degrees - LEVEL 3: Steered wheel angle limited to -1.5 degrees - LEVEL 4: Steered wheel angle limited to -1.75 degrees - LEVEL 5: Steered wheel angle limited to -2 degrees - LEVEL 6: Steered wheel angle limited to -2.5 degrees - LEVEL 7: Steered wheel angle limited to -3 degrees - LEVEL 8: Steered wheel angle limited to -4 degrees - LEVEL 9: Steered wheel angle limited to -8 degrees A LOSING STRAIGHT warning occurs when the steered wheel angel overtakes 1.5 times the above limit. An ANGLE alarm occurs when the steered wheel angel overtakes 2 times the above limit.

PARAMETER	DESCRIPTION
MAX FWD ERR	This adjustment handles a continuous monitoring of the FWD antenna lateral drift (SIDE ERROR FWD) when the truck is travelling lock-on mode. MAX FWD ERR limits the positive drift for SIDE ERROR FWD. When the SIDE ERROR FWD overcomes the limit value showing in the next list, an alarm occurs: - LEVEL 0: SIDE ERROR FWD limited to +24mm - LEVEL 1: SIDE ERROR FWD limited to +28mm - LEVEL 2: SIDE ERROR FWD limited to +32mm - LEVEL 3: SIDE ERROR FWD limited to +36mm - LEVEL 4: SIDE ERROR FWD limited to +40mm - LEVEL 5: SIDE ERROR FWD limited to +45mm - LEVEL 6: SIDE ERROR FWD limited to +50mm - LEVEL 7: SIDE ERROR FWD limited to +56mm - LEVEL 8: SIDE ERROR FWD limited to +62mm - LEVEL 9: SIDE ERROR FWD limited to +68mm When SIDE ERROR FWD overtakes the positive limit specified with this setting, a LATERAL OUT alarm occurs. When SIDE ERROR FWD overtakes 0.75 times the positive limit specified with this setting, a LOSING PATH warning occurs. When all the adjustments MAX FWD ERR, MIN FWD ERR, MAX REV ERR and MIN REV ERR are to Level 9, the LATERAL OUT alarm is masked.
MIN FWD ERR	This adjustment handles a continuous monitoring of the FWD antenna lateral drift (SIDE ERROR FWD) when the truck is travelling lock-on mode. MIN FWD ERR limits the negative drift for SIDE ERROR FWD. When the SIDE ERROR FWD overcomes the limit showing in the next list, an alarm occurs: - LEVEL 0: SIDE ERROR FWD limited to -24mm - LEVEL 1: SIDE ERROR FWD limited to -28mm - LEVEL 2: SIDE ERROR FWD limited to -32mm - LEVEL 3: SIDE ERROR FWD limited to -36mm - LEVEL 4: SIDE ERROR FWD limited to -40mm - LEVEL 5: SIDE ERROR FWD limited to -45mm - LEVEL 6: SIDE ERROR FWD limited to -50mm - LEVEL 7: SIDE ERROR FWD limited to -56mm - LEVEL 8: SIDE ERROR FWD limited to -62mm - LEVEL 9: SIDE ERROR FWD limited to -68mm When SIDE ERROR FWD overtakes the negative limit specified with this setting, a LATERAL OUT alarm occurs. When SIDE ERROR FWD overtakes 0.75 times the negative limit specified with this setting, a LOSING PATH warning occurs. When all the adjustments MAX FWD ERR, MIN FWD ERR, MAX REV ERR and MIN REV ERR are to Level 9, the LATERAL OUT alarm is masked.
MAX REV ERR	This adjustment handles a continuous monitoring of the REV antenna lateral drift (SIDE ERROR REV) when the truck is travelling lock-on mode. MAX REV ERR limits the positive drift for SIDE ERROR REV. When the SIDE ERROR REV overcomes the limit value showing in the next list, an alarm occurs: - LEVEL 0: SIDE ERROR REV limited to +24mm - LEVEL 1: SIDE ERROR REV limited to +28mm - LEVEL 2: SIDE ERROR REV limited to +32mm - LEVEL 3: SIDE ERROR REV limited to +36mm - LEVEL 4: SIDE ERROR REV limited to +40mm - LEVEL 5: SIDE ERROR REV limited to +45mm - LEVEL 6: SIDE ERROR REV limited to +50mm - LEVEL 7: SIDE ERROR REV limited to +56mm - LEVEL 8: SIDE ERROR REV limited to +62mm - LEVEL 9: SIDE ERROR REV limited to +68mm When SIDE ERROR REV overtakes the positive limit specified with this setting, a LATERAL OUT alarm occurs. When SIDE ERROR REV overtakes 0.75 times the positive limit specified with this setting, a LOSING PATH warning occurs. When all the adjustments MAX FWD ERR, MIN FWD ERR, MAX REV ERR and MIN REV ERR are to Level 9, the LATERAL OUT alarm is masked.

PARAMETER	DESCRIPTION
MIN REV ERR	"This adjustment handles a continuous monitoring of the REV antenna lateral drift (SIDE ERROR REV) when the truck is travelling lock-on mode. MIN REV ERR limits the negative drift for SIDE ERROR REV. When the SIDE ERROR REV overcomes the limit value showing in the next list, an alarm occurs: - LEVEL 0: SIDE ERROR REV limited to -24mm - LEVEL 1: SIDE ERROR REV limited to -28mm - LEVEL 2: SIDE ERROR REV limited to -32mm - LEVEL 3: SIDE ERROR REV limited to -36mm - LEVEL 4: SIDE ERROR REV limited to -40mm - LEVEL 5: SIDE ERROR REV limited to -45mm - LEVEL 6: SIDE ERROR REV limited to -50mm - LEVEL 7: SIDE ERROR REV limited to -56mm - LEVEL 8: SIDE ERROR REV limited to -62mm - LEVEL 9: SIDE ERROR REV limited to -68mm When SIDE ERROR REV overtakes the negative limit specified with this setting, a LATERAL OUT alarm occurs. When SIDE ERROR REV overtakes 0.75 times the negative limit specified with this setting, a LOSING PATH warning occurs. When all the adjustments MAX FWD ERR, MIN FWD ERR, MAX REV ERR and MIN REV ERR are to Level 9, the LATERAL OUT alarm is masked. "

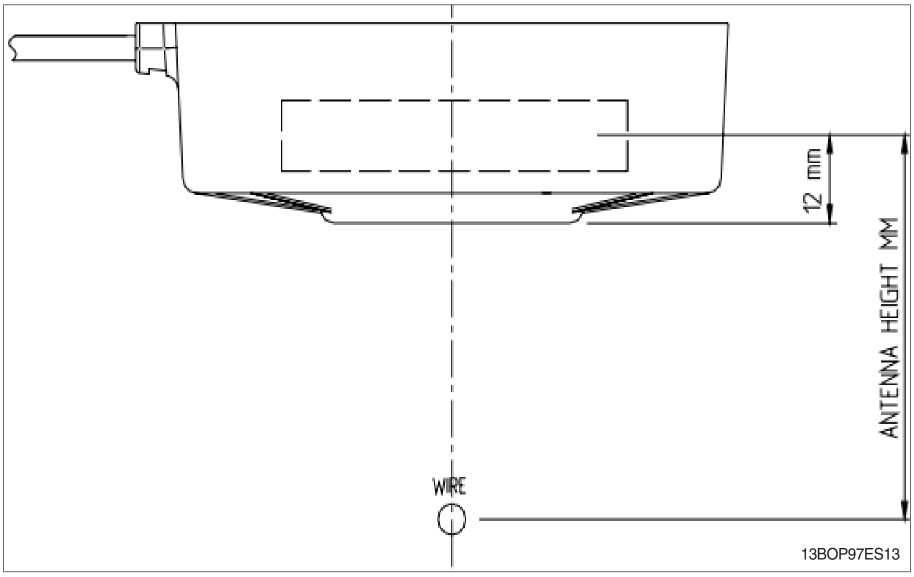
EPS MASTER	
MONITIORING	DESCRIPTION
STEPPER MOTOR	Voltage value with 2 decimal digit. Measurement of the stepper motor speed with sign in the range 0 to ±5Vdc.
SPEED REFERENCE	(Not used)
FEEDBACK ENC.	Voltage value with 2 decimal digit. Measurement (scaled in the range 0 to 5Vdc) of the position of the feedback encoder connected to CNB#7 and CNB#8.
FINE WHEEL ANGLE	(Not used)
TEMPERATURE	Degrees. Temperature of the controller base plate.
MOTOR TEMPERAT.	Degrees. Temperature of the motor windings measured with the thermal sensor inside the motor and connected to CNB#3.
FREQUENCY	Hertz value with 2 decimal digit. This is the frequency applied to the steering motor.
SAT FREQ HZ	"Herz value with 2 decimal digit. This is a real time magnetic flux measurement: Vbattery/ SAT. FREQ HZ provides real time the linked flux in the motor. The flux in the motor is modulated from 75% to 100% of the maximum flux. The maximum flux is Vbattery/SET SAT FREQ. The minimum flux is Vbattery/(1.33*SET SAT FREQ). When the motor is loaded, SAT. FREQ HZ is equal to SET SAT FREQ; when the motor is lightened the flux reduces and SAT. FREQ HZ increases up to 1.33*SET SAT FREQ."
MOTOR VOLTAGE	It is a percentage. 100% means the sine waves in the motor have the maximum PWM amplitude.
MOTOR CURRENT	Ampere value. Root Mean Square value of the line current in the motor.
ENC SPEED	Herz value with 2 decimal digit. This is the speed of the motor measured with the encoder on the motor shaft.

EPS MASTER	
MONITIORING	DESCRIPTION
ENDSTROKE CW	Provides real time the active state (ON) or not of the CW toggle switch (connected to CNA#3). It is On when CNA#3 is low.
ENDSTROKE ACW	Provides real time the active state (ON) or not of the CCW toggle switch (connected to CNA#3). It is On when CNA#3 is low.
CW LIMIT LEVEL	When LIMIT DEVICE is set On, and the feedback sensor overtakes SET MAX ENC (or SET MAX FB POT), the steered wheel angle will be limited and CW LIMIT LEVEL turns ON (active).
ACW LIMIT LEVEL	When LIMIT DEVICE is set On, and the feedback sensor is lower than SET MIN ENC (or SET MIN FB POT), the steered wheel angle will be limited and ACW LIMIT LEVEL turns ON (active).
MM ALARM SWITCH	It is On when the safety contact belonging to the main uC is closed.
SM ALARM SWITCH	It is On when the safety contact belonging to the slave uC (supervisor) is closed.
HIGH RESOL. AD	It turns ON when the feedback pot is processed with a high resolution AD.
ENC COUNT AT 360	Voltage value with two digits in the range 0 to +/-5Vdc value. This reading supplies the encoder counting corresponding to a complete steered wheel revolution in the range 0 to +/- 5.00Vdc. At rest it assumes a 5Vdc value, after a first valid falling edge on the straight ahead sensor it switches from 5Vdc to 0Vdc. After a second valid falling edge on the straight ahead sensor it switches to an intermediate value (between 0Vdc and +/-5Vdc) corresponding to the encoder counting for a full steered wheel revolution.
ENC COUNT AT 180	Voltage value with two digits in the range 0 to +/-5Vdc value. This reading supplies the encoder counting corresponding to a quasi-half steered wheel revolution in the range 0 to +/- 5.00Vdc. At rest it assumes a 5Vdc value, after a first valid falling edge on the straight ahead sensor it switches from 5Vdc to 0Vdc. After a second valid falling edge on the straight ahead sensor it switches to an intermediate value (between 0Vdc and +/-5Vdc) corresponding to the encoder counting for a side to side iron plate rotation. ENC COUNT AT 180 is expected being about a half of the ENC COUNT AT 360.
WHEEL ANGLE	It provides the current angle of the drive wheel by the degree.
AUTO IN PROGRESS	Provides real time the information the eps-ac0 follows the manual command (AUTO INPROGRESS is OFF) or is executing an automatic centering (AUTO IN PROGRESS is ON).
TRUCK MOVING	It provides the state of the travel demand for driving the truck.
LOCK ON	It turns ON when the trucks may drive full speed on the wire in WG mode (lock-on state).
REV ANT LEADS	(Not used)
FWD ANT LEADS	(Not used)
TRACK REV	(Not used)
TRACK FWD	(Not used)
DISTANCE REV	Centimetres with 1 decimal digit. It provides the measurement in CM of the REV antenna lateral shift. This is a coarse estimation in a large window (+/-10 cm) obtained comparing the real time strength of the field with the strength of the field on the aligned truck.
DISTANCE FWD	Centimetres with 1 decimal digit. It provides the measurement in CM of the FWD antenna lateral shift. This is a coarse estimation in a large window (+/-10 cm) obtained comparing the real time strength of the field with the strength of the field on the aligned truck.

EPS MASTER	
MONITIORING	DESCRIPTION
APPR. ANGLE REV	Degrees. It provides the measurement of the incidence angle of the truck against the wire. This measurement is picked up by the REV antenna and transferred via CAN Bus to the eps-ac WG.
APPR. ANGLE FWD	Degrees. It provides the measurement of the incidence angle of the truck against the wire. This measurement is picked up by the FWD antenna and transferred via CAN Bus to the eps-ac WG.
SIDE VIRTUAL ERR	(Not used)
SIDE ERROR REV	Millimetres without decimal digit. It provides the measurement in MM of the REV antenna lateral shift.
SIDE ERROR FWD	Millimetres without decimal digit. It provides the measurement in MM of the FWD antenna lateral shift.
180 DEGREES MODE	(Not used)
LEAD ERR FILT MM	(Not used)

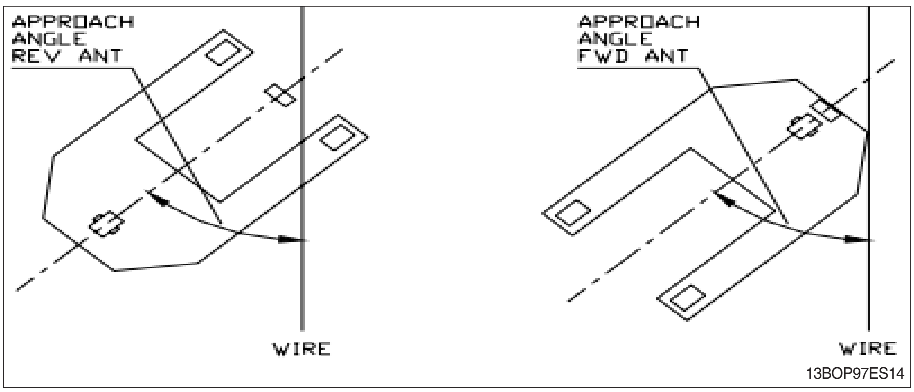
(6) SMART ANTTENA

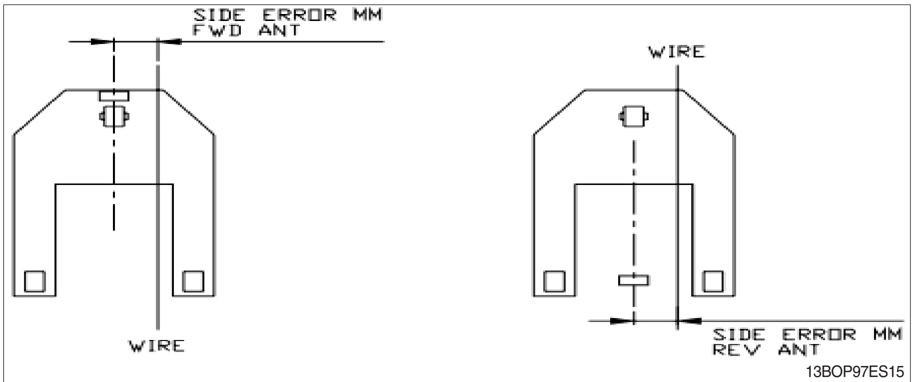
PARAMETER	DESCRIPTION
LINE FREQ. HZ	This is the specification of the frequency in the wire : - 5200 - 6200 - 7000 - 9100 - 10000
LAG REGULATION	This is the integral contribute to an embedded PID corrective network applied to the lateral deviation. This is used in order to avoid the oscillations (instability) of the Wire Guidance closed loop when travelling high speed. During the set-up procedure try different pair settings LAG and LEAD REGULATION until the truck has the best behaviour on the wire during travelling. It is strongly suggested the same setting for LEAD (and LAG) REGULATION on both the antennas. This parameter attenuates at high frequency the dynamic slope of the lateral deviation of the antenna (SIDE ERROR MM). So it works as a low pass filter on the LEAD REGULATION contribute. - Level 0 is for no lag (integral) correction. - Level 9 is for maximum low pass filtering. Intermediate levels are for proportionally increasing lag (integral) contribute.
LEAD REGULATION	This is the derivative contribute to an embedded PID corrective network applied to the lateral deviation. This is used in order to avoid the oscillations (instability) of the Wire Guidance closed loop when travelling high speed. During the set-up procedure try different pair settings LAG and LEAD REGULATION until the truck has the best behaviour on the wire during travelling. It is strongly suggested the same setting for LEAD (and LAG) REGULATION on both the antennas. This parameter amplifies the dyanmic slope of the lateral deviation of the antenna (SIDE ERROR MM). - Level 0 is for no lead (derivative) correction. - Level 9 is for maximum lead (derivative) correction. Intermediate levels are for proportionally increasing lead (derivative) contribute.

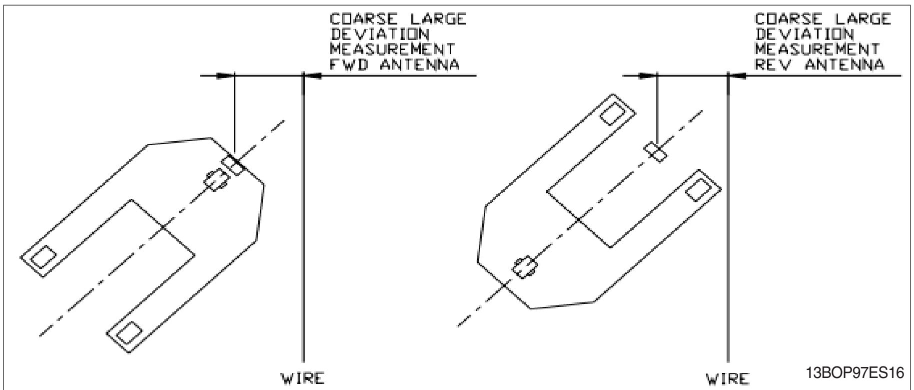
PARAMETER	DESCRIPTION
ACQUISITION AREA	This setting modifies the threshold on the field strength at which the antenna assumes the field perceived. It is tailored on the ALIGNED STRENGTH setting. It defines the area around the wire in which the antenna assumes the wire perceived. - Level 0 is for a low sensitive antenna. (e.g. for an ALIGN STRENGTH = 65% It assumes the field perceived when the FIELD STRENGTH reading is higher than 34%). - Level 9 is for a high sensitive antenna. (e.g. for an ALIGN STRENGTH = 65% It assumes the field perceived when the FIELD STRENGTH reading is higher than 10%). NOTE: disregarding the ALIGNED STRENGTH and ACQUISITION AREA settings, the antenna rejects to assume the field perceived when the FIELD STRENGTH is smaller than a minimum threshold of 10% of the fullscale 100% field strength. Intermediate levels are for proportionally increasing the minimum accepted field strength.
ANT. HEIGHT MM	Specify the height of the antenna against the wire. The value to be booted must be measured between the wire and the core of the Side Coil. The core of the Side Coil is about 12mm upper than the bottom circular surface of the antenna box. This setting gets the SIDE ERROR meausurement directly converted into millimeters. It may assume the range values from 30 to 75 mm in 5mm step. 
STRENGTH ACQ.	This parameter is used for the procedure of the Wire Guidance setting.

MONITORING	DESCRIPTION
SET SAT. FREQ.	Set this adjustment to the corner frequency of the motor. SET SAT FREQ is to be meant as the maximum frequency at which the motor supplies the maximum torque (it is the superior limit of the constant torque characteristic). Frequency higher than SET SAT FREQUENCY gets the motor weakened.
OVERSAT FREQ.	The maximum motor frequency is set with the sum between SET SAT FREQ and OVERSAT FREQ. OVERSAT FREQ is the increment, over the SET SAT FREQUENCY, in which the steering motor works with degraded flux (weakening area). Default choice is 1 Hz (i.e. the steering motor never works in the weakening region).
MAXIMUM SLIP	(Factory adjusted). MAXIMUM SLIP modifies the acceleration and deceleration ramp for the frequency in the motor. Higher MAXIMUM SLIP gets faster acceleration and deceleration ramp. If the encoder is used for the motor control (ENCODER CONTROL is On), MAXIMUM SLIP has another meaning: it is the slip to be applied when the control is sourcing the maximum current.

MONITORING	DESCRIPTION
AUX VOLTAGE #1	(Factory adjusted). This is the self-acquired offset value of the stepper motor line connected to CNA#9. The default value is 2.500 mV and can be re-acquired by rolling the DEBUG OUTPUT to 0.
AUX VOLTAGE #2	(Factory adjusted). This is the self-acquired offset value of the stepper motor line connected to CNA#8. The default value is 2.500 mV and can be re-acquired by rolling the DEBUG OUTPUT to 0.
NO LOAD CURRENT	In order it shall be possible to weaken the steering motor when lightened (reducing power loss in the motor), it is necessary to specify the current the motor drains when working full flux and without load (NO LOAD CURRENT). To find this value it is necessary to set the DEBUG OUTPUT to level 10 and to measure the current in the motor when running without load and a frequency close to SET SAT FREQ/2.
SET STEER 0-POS.	(This parameter used for Wire Guidance function) Please see the procedure of the Wire Guidance setting.
WG REV. OFFSET	(This parameter used for Wire Guidance function) Please see the procedure of the Wire Guidance setting.
AUTOTEACHING	This option (on/off) is used to launch the autoteaching procedure. Take care there is not mechanical angle limitation before to turn it on. Then recycle the key and the steering motor starts an automatic sequence to collect the ENC COUNT AT 360 and ENC COUNT AT 180. If the collected couple is consistent (ENC COUNT AT 180 stays inside the window from 3/8 to 6/8 of ENC COUNT AT 360) they are automatically saved on the settings SET ENC AT 360 and SET ENC AT 180. If the autoteaching procedure successful ends, the display switches from the DATA ACQUISITION alarm to the collected values (in the range 0 to 5Vdc. Left side shows the ENC COUNT AT 360 value; the right side shows the ENC COUNT AT 180 value). If the couple of values is not consistent they were not saved and the display switches cyclically from the collected data to the DATA ACQUISITION inscription.

PARAMETER	DESCRIPTION
FREQUENCY	About 300 Hz. Whatever is the frequency in the wire, it will be converted in a fixed frequency close to 300 Hz that corresponds to the center band frequency of the aboard filters. This conversion frequency is wished being 300 Hz ±20Hz. If it's outside this window it is necessary a fine tuning of the antenna at the real line driver frequency.
APPROACH ANGLE	It provides the angle of the antenna against the wire. The antenna axle is to be aligned with the longitudinal axle of the truck and so the APPROACH ANGLE corresponds to the angle bewteen the longitudinal axle of the truck and the wire. This angle is shown in degrees with sign. The angle reading is clamped to 70 degrees. Higher angle are considered not consistent. This APPROACH ANGLE is used during acquisition. 

<table>
<tr><th>PARAMETER</th><th>DESCRIPTION</th></tr>
<tr><td>SIDE ERROR MM</td><td>It provides the lateral deviation of the barycenter of the antenna against the wire in a narrow window of +/- 80mm around the wire. The reading is directly in millimiters with sign provided that the ANTENNA HEIGHT MM is correctly adjusted. This reading is used for lock-on guide and for the detection the truck is losing the wire path.


13BOP97ES15</td></tr>
<tr><td>SIDE DIST. CM</td><td>It provides a coarse measurement of the distance of the barycenter of the antenna against the wire in a wide window (0 to 20cm). This measurement compares the FIELD STRENGTH with the ALIGNED STRENGTH to estimate the absolute distance of the antenna against the wire. It assumes the value 0.0 when the present field is higher equal than the ALIGNED STRENGTH. The value increases over 0.0 when the present FIELD STRENGTH is smaller than ALIGNED STRENGTH. It does not matter the accuracy of this reading but this information (I mean the field strength against the ALIGNED STRENGTH) is used in the acquisition mode to proportionally correct the steered wheel angle according to the distance of the antenna against the wire.


13BOP97ES16</td></tr>
<tr><td>ALIGNED STRENGTH</td><td>This is just a recording of the field strength the antenna expects to perceive when the truck is aligned on the wire. As the current in the wire may be in a wide range (from 30mA to 100mA) it is useful the Software knows the field strength corresponding to a truck centered on the wire. The ALIGNED STRENGTH value indirectly represents this measurement of the current in the wire. The higher is the current, the higher is the field strength the antenna picks up. This reading is used to equalize the ACQUISITION AREA and the admitted field range, disregarding of the width of the current in the wire. ALIGNED STRENGTH is not a real time measurement; it is just the value acquired at the installation procedure.</td></tr>
<tr><td>FIELD STRENGTH</td><td>This is the real time strength field. It is a percent of the full field range the antenna is able to pick-up. When FIELD STRENGTH is equal higher than ALIGNED STRENGTH, the truck is assumed being aligned on the wire in the coarse SIDE DIST. CM reading (0.0 value).</td></tr>
</table>

PARAMETER	DESCRIPTION
ANT FWD SIDE	ON/OFF. This reading specifies the state of the MODE input (GREY wire). ANT FWD SIDE is ON in the FWD side antenna (MODE to VDD). ANT FWD SIDE is OFF in the REV side antenna (MODE to GND).
PATH	ON/OFF. This reading turns ON when the antenna picks-up the field. The field is assumed perceived when the FIELD STRENGTH is higher than the threshold specified with the ACQUISITION AREA setting (provided that this threshold is higher than 10%).

5) 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.

ADJUSTMENTS VIA SMART CONSOLE (Option)

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

25B9UEL17

※ Please connect and disconnect it 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
```

25B9UEL18

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
```

25B9UEL19

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

25B9UEL20

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

25B9UEL21

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

25B9UEL22

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)

25B9UEL23

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

25B9UEL24

(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

25B9UEL25

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:

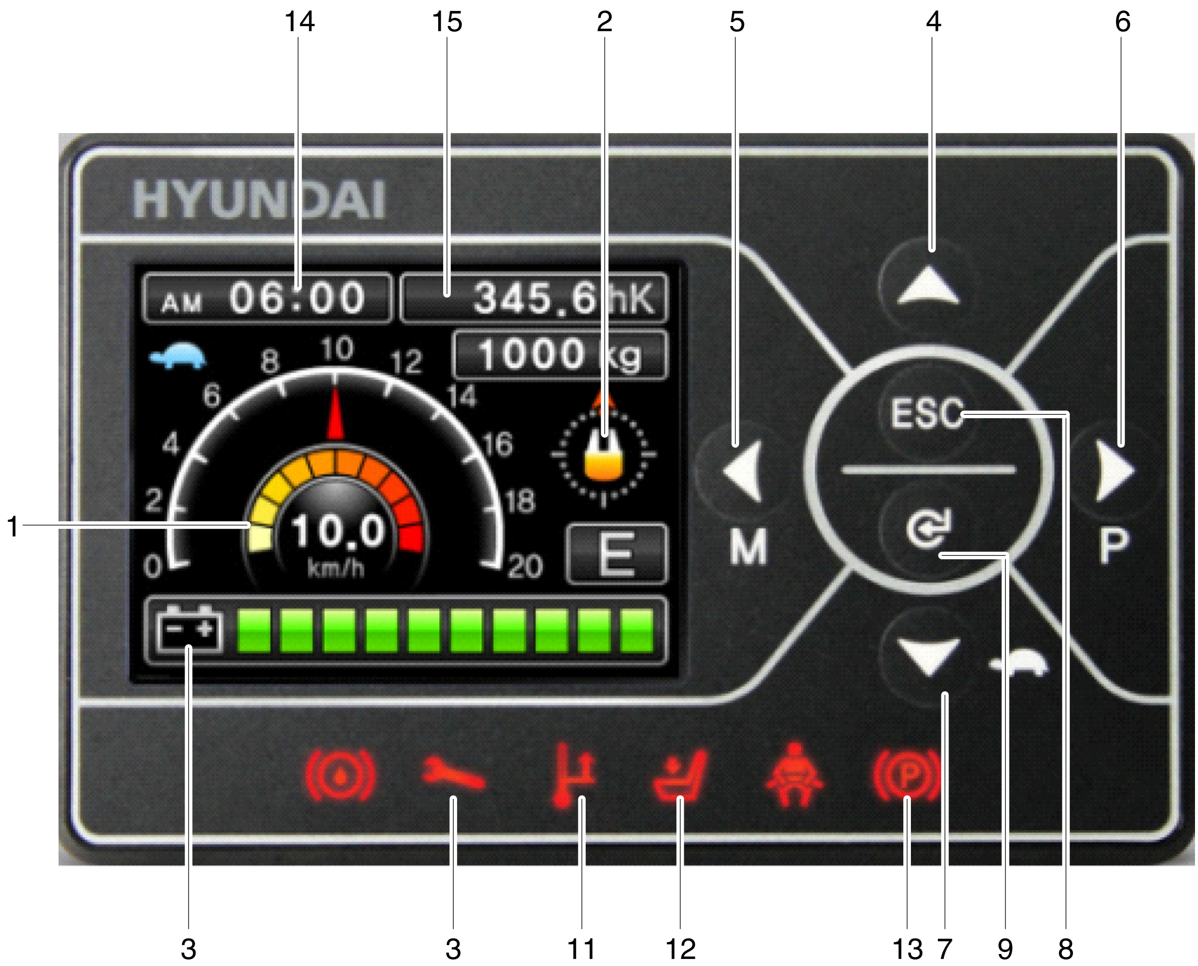
· White: up to 5 occurrences
· Yellow: up to 20,
· Orange: up to 40,
· Red: more than 40.

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.

7. DISPLAY

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.

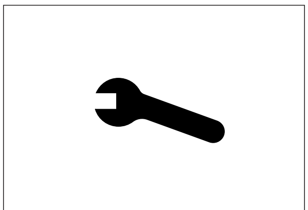


13BOP93KY05A

1	Speed (Digital)	6	Performance / Scroll right	13	Park brake
2	Steering wheel position and travle direction	7	Turtle / Scroll down	14	Time / Height select (OPT)
3	Battery discharge indicator	8	ESC / Back	15	Hour-mater / Height present (OPT)
4	Scroll up / Height indicator (OPT)	9	Enter		
5	Menu / Scroll left	10	Error warning lamp		
		11	High temp warning lamp		
		12	Dead man switch		

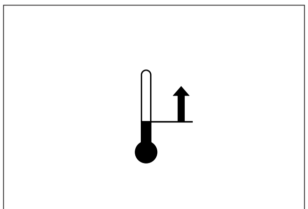
2) WARNING LAMP

(1) Error warning lamp


15BT9UOM0310

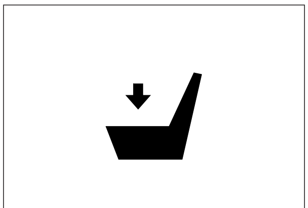
This LED lights when an electric device (controller, motor, cable, etc.) is in abnormal condition.

(2) High temp warning lamp


15BT9UOM0311

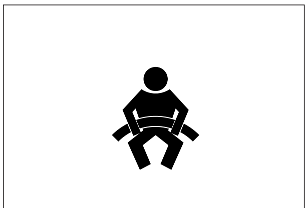
This LED lights when the controller or motor temperature is high.

(3) Dead man switch


15BT9UOM0312

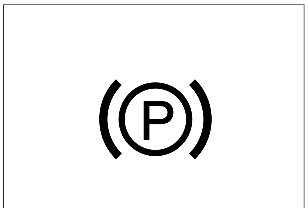
This LED light when the operator step on the dead man switch.

(4) Seat belt warning lamp


15BT9UOM0313

This LED blinks 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.

(5) Parking brake warning lamp

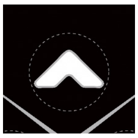

15BT9UOM0314

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.

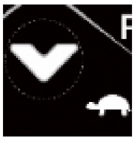
(1) Up button



15BT9UOM0315

Press to select upward move.

(2) DOWN/TURTLE button



15BT9UOM0316

Press to select downward move.
TURTLE MODE ON/OFF

(3) LEFT/MENU button

15BT9UOM0317

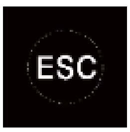
Press to select leftward move.
Go into the menu.

(4) RIGHT/PERFORMANCE button

15BT9UOM0318

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

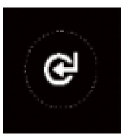
(5) Cancel (ESC) button



15BT9UOM0319

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

(6) ENTER button



15BT9UOM0320

Press to select Enter.

4) LCD FUNCTION

13BOP93KY06

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

(1) Current time

The number shows the current time according to the setting, which can be changed by display setting at page 3-11.

(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 3-11 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

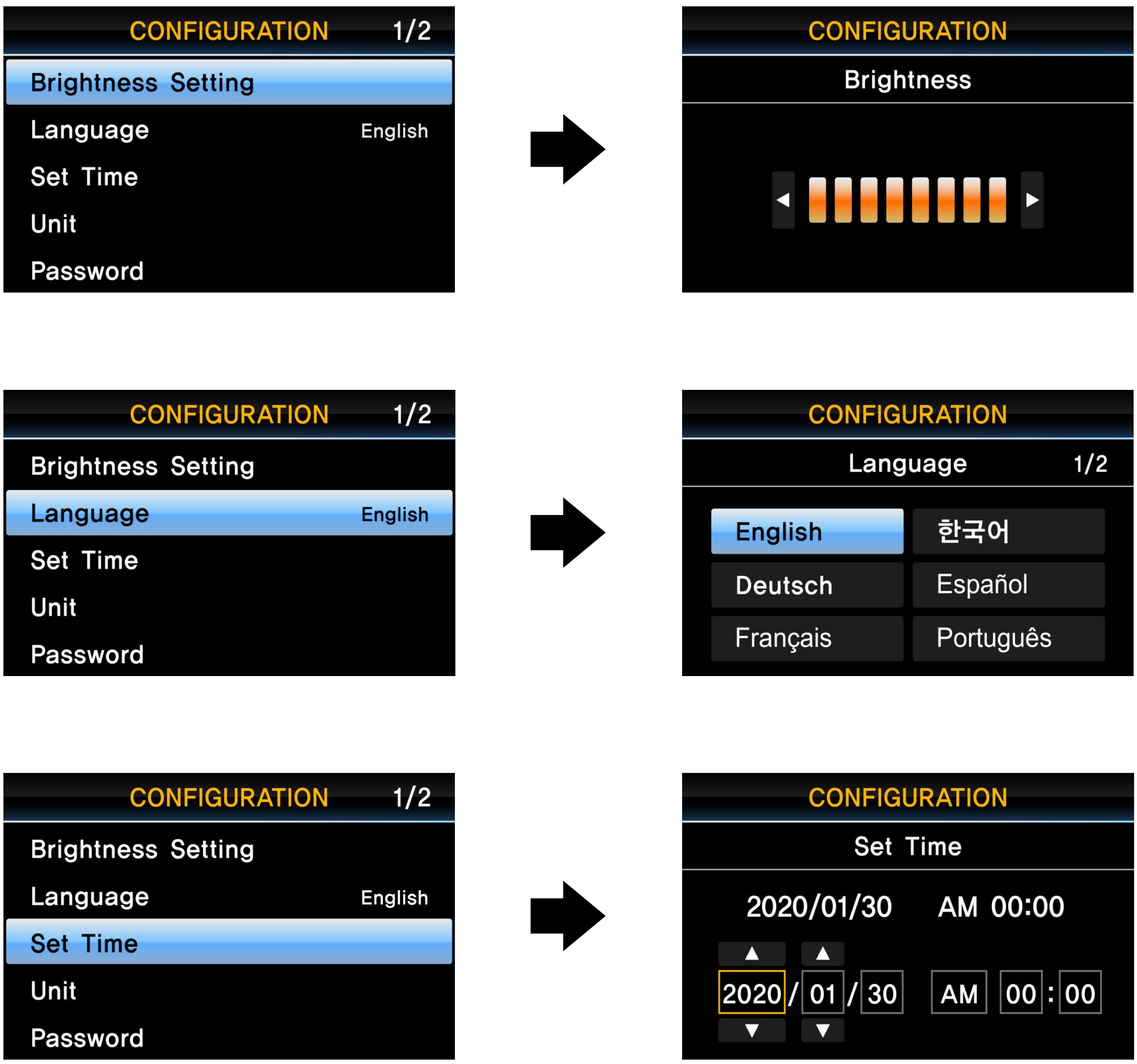
N (Normal) – corresponds to normal performance

E (Economic) – corresponds to economic performance

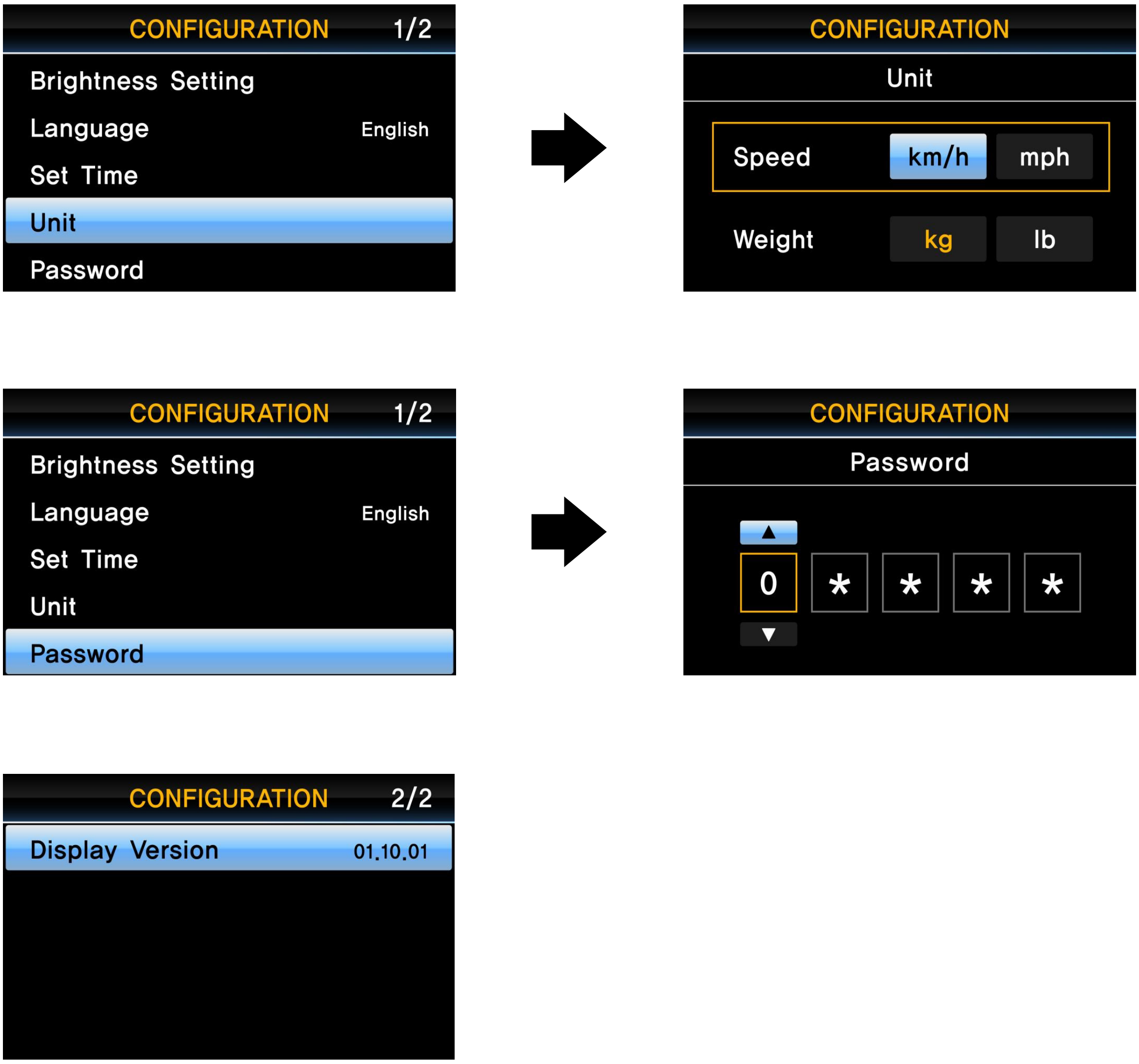
(9) BDI (battery's state of charge)

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.

5) HOW TO SET THE DISPLAY MENU



13BOP93KY23



13BOP93KY23

6) OPERATING HEIGHT INDICATOR (OPT)

(1) Height indicator functions

① The real-time height of the fork is on the display.

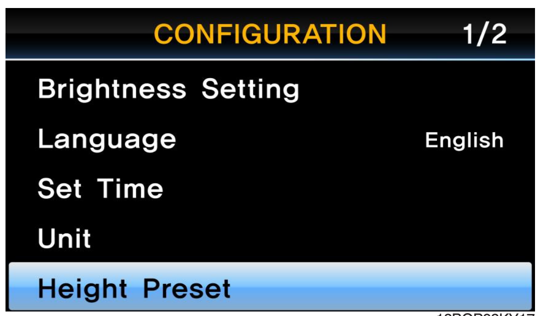
② If you pre-set the heights(Max. 50) on the display and lift or lower the fork, the fork could be automatically stopped at the height.

③ The maximum height can be changed by switching the zone selector swtich.

(2) Height preset setting

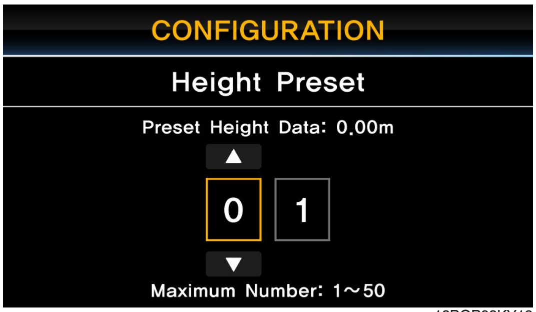
Set the height preset as bleow.

① Press the left button on the main screen to access the configuration.



13BOP93KY17

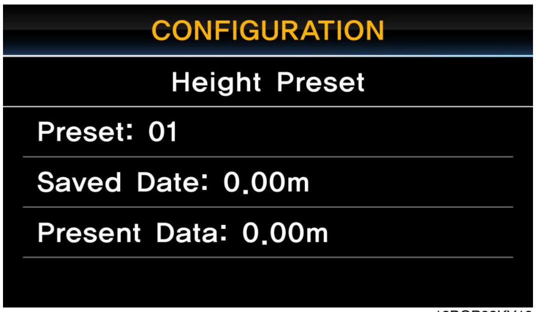
② Select the number of height preset(Max. 50) and press the enter button.



13BOP93KY18

③ Lift the fork up to the height you want to save and press the enter button to save.

※ Preset : The number of HEIGHT PRESET
Saved Data : The height saved in the number.
Present Data : Real-time height.



13BOP93KY19

(3) Height preset operation

The height preset is operated as below.

① Press the up button to display height indicator screen.

13BOP93KY20

※ P01 : The number of preset is blinking.
Left 00.32m : Saved in the number.
Right 00.32m : Real-time height.

② Press up and down button to select the number you want.

③ Press the enter button to target the height.

13BOP93KY21

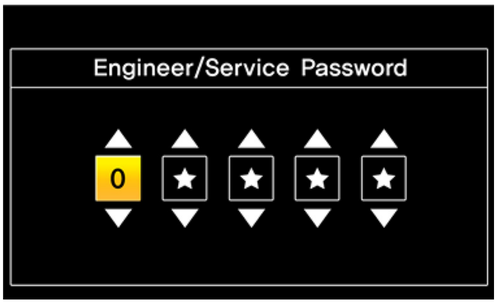
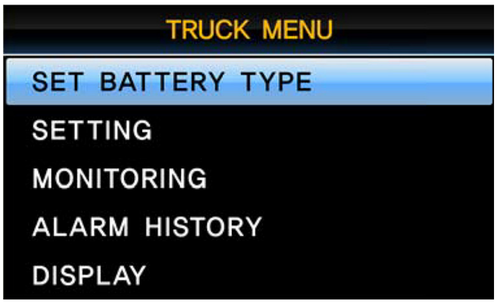
④ Lift or lower the fork to approach to preset height.

※ If the real-time height is 0.16m and preset height is 0.32m, the fork could be only lift.
If the real-time height approach to the height, the fork is automatically stopped and the preset height screen is exited.

13BOP93KY22

7) DESCRIPTION OF THE TRUCK MENU

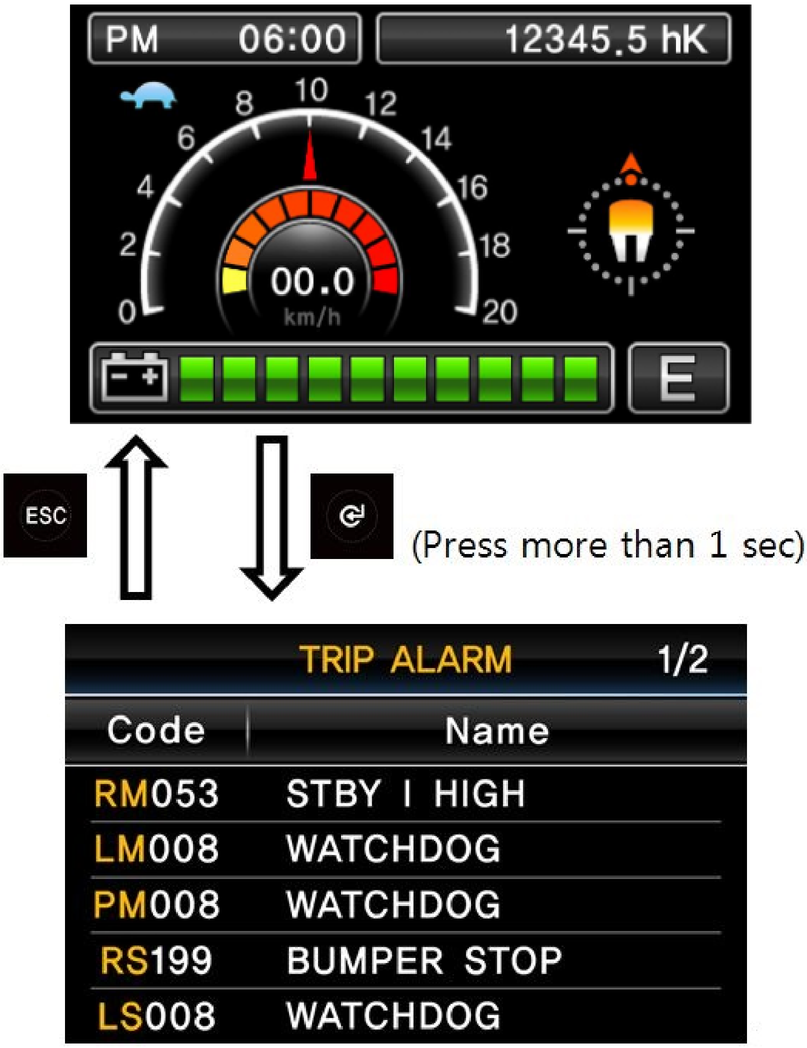
(1) Access to truck menu

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.

8) ALARM & ALARM HISTORY

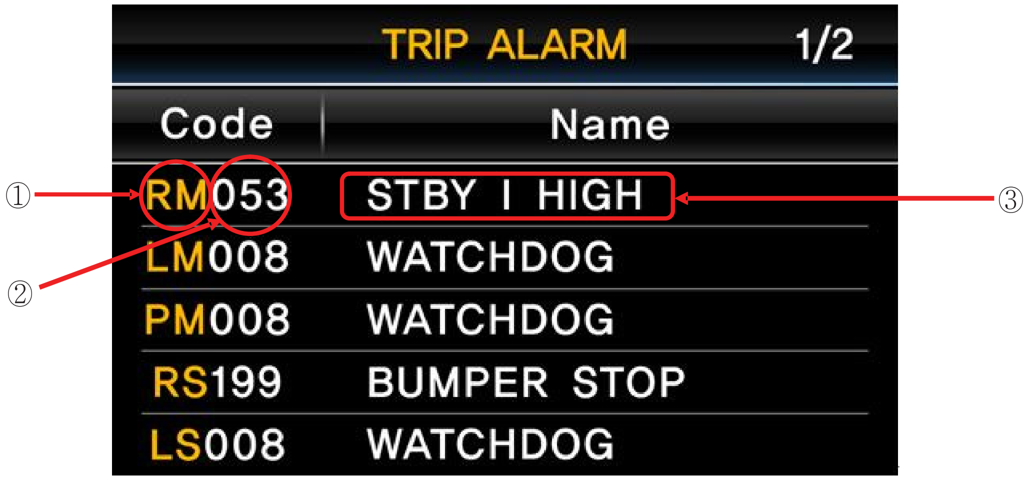
(1) How to check alarms

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 :



13BOP97ES08

(2) Detail description of ALARM SCREEN



15BT9USM07CL04

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

TM : Traction - Master
TS : Traction - Slave
PM : Pump - Master
PS : Pump - Slave
EPSM : EPS - Master
EPSS : EPS - Slave

②Following three letters or digits show alarm code. Please refer to 8. ALARM CODE (Page 7-80).

③This shows a name of ALARM. Please refer to 8. ALARM CODE (Page 7-80).

(3) Alatm history

Alarm History can be looked up as follows ;

15BT9USM07CL5

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

(4) Detail alarm information

15BT9USM07CL6

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

9) TRUCK SETTING USING DISPLAY MENU

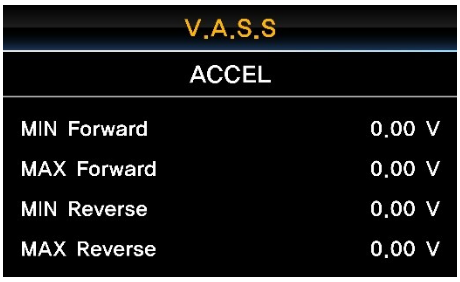
(1) VASS SETTTING

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 & MAIN LIFT SETTING METHOD

When the Traction/Pump controller, Accel lever or Lift lever are replaced, the service man should set the Accel and Lift as below.

<table>
<tr><th>Step</th><th>Display</th><th>Description</th></tr>
<tr><td>1</td><td>

13BOP97ES17</td><td>1. Access to TRUCK MENU.
(Refer to Description of the truck menu)</td></tr>
<tr><td>2</td><td>

13BOP97ES18</td><td>1. Access the "ACCEL" screen via "TRUCK MENU → SETTING → V.A.S.S. → ACCEL"

2. Press the "ENTER" button to start setup.

3. Turn the Accel lever to maximum forward position and place it to neutral.

4. Turn the Accel lever to maximum backward position and place it to neutral.

5. Press the "ENTER" button to save.</td></tr>
<tr><td>3</td><td>

13BOP97ES19</td><td>1. Access the "MAIN LIFT" screen via "TRUCK MENU → SETTING → V.A.S.S. → MAIN LIFT"

2. Press the "ENTER" button to start setup.

3. Turn the Lift lever to maximum lowering position and press "ENTER" to set VACC MAX.

4. Place the Lift lever to neutral and press "ENTER" to set VACC NEUTRAL.

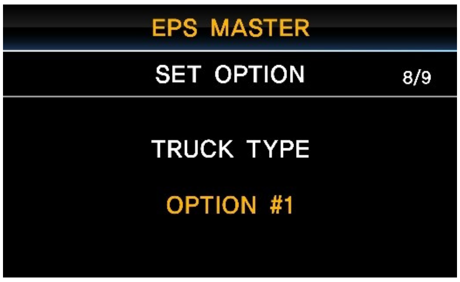
5. Turn the Lift lever to maximum lifting position and press "ENTER" to set VACC MIN.</td></tr>
</table>

② ADDITIONAL LIFT SETTING METHOD

When the Traction/Pump controller or Additional lift lever are replaced in the additional Lift option vehicle, the service man should set the Additional lift as below.

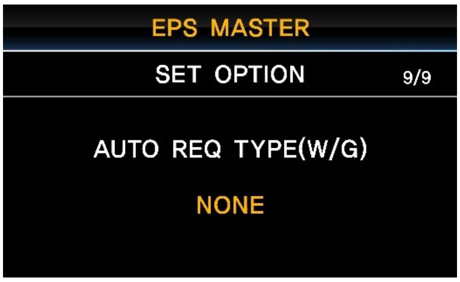
Step	Display	Description
1	 13BOP97ES17	1. Access to TRUCK MENU. (Refer to Description of the truck menu)
2	 13BOP97ES20	1. Access the “FORK” screen via “TRUCK MENU → SETTING → PUMP MASTER → SET OPTION → FORK” 2. Change the “FORK” to ON 3. Repeat the Key-Off and Key-On twice.
3	 13BOP97ES21	1. Access the “ADDITIONAL LIFT” screen via “TRUCK MENU → SETTING → V.A.S.S → ADDITIONAL LIFT ” 2. Press the “ENTER” button to start setup. 3. Turn the Additional Lift lever to maximum lowering position and press “ENTER” to set VACC MAX FORK. 4. Place the Additional Lift lever to neutral and press “ENTER” to set VACC NEUTRAL. 5. Turn the Additional Lift lever to maximum lifting position and press “ENTER” to set VACC MIN FORK.

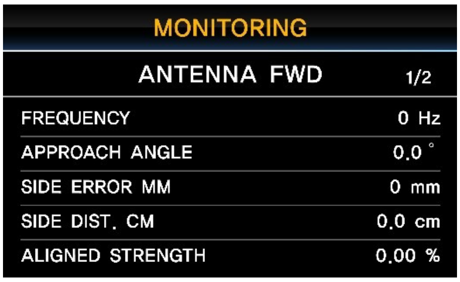
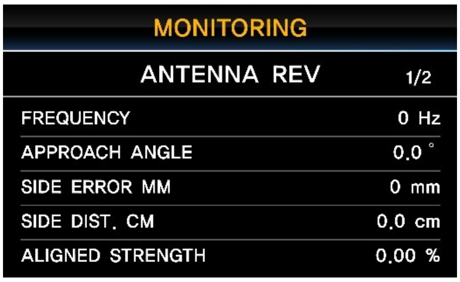
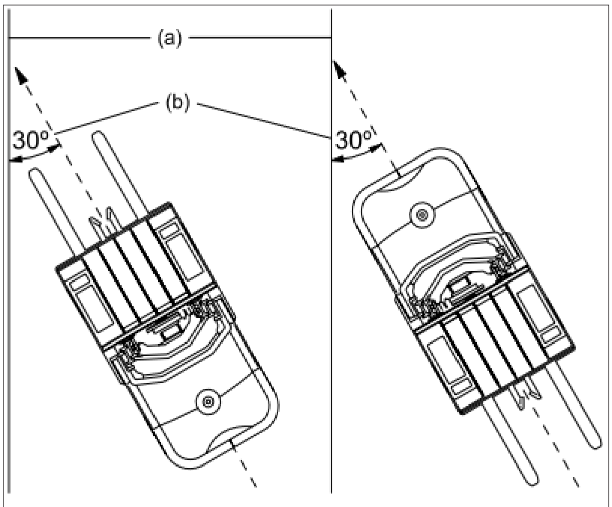
(2) EPS SETTING

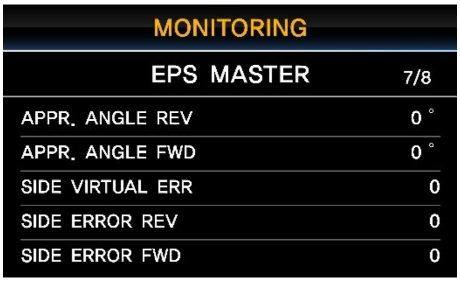
Step	Display	Description
1	 13BOP97ES17	1. Access to TRUCK MENU. (Refer to Description of the truck menu)
2	 13BOP97ES22	1. Access the “TRUCK TYPE” screen via “TRUCK MENU → EPS MASTER → SET OPTION → TRUCK TYPE” 2. Change the TRUCK TYPE to OPTION #3 3. Repeat Key-OFF and Key-ON twice.
3	 13BOP97ES23	1. Access the “AUTOTEACHING” screen via “TRUCK MENU → EPS MASTER → ADJUSTMENTS → AUTO TEACHING” 2. Change the AUTOTEACHING to ON. 3. Key –OFF and Key-On once. 4. Steering wheel rotates left and right and auto setup is completed.

(3) WIRE GUIDANCE SETTING (OPT)

This setting method is for wire guidance option vehicle.

Step	Display	Description
1	 13BOP97ES17	1. Access to TRUCK MENU. (Refer to Description of the truck menu)
2	 13BOP97ES24	1. Access the "AUTO REQ. TYPE(W/G)" screen via "TRUCK MENU → SETTING → EPS MASTER → SET OPTION → AUTO REQ. TYPE(W/G)" 2. Change the "AUTO REQ. TYPE(W/G)" value to "Wire Guidance".
3	 13BOP97ES25	1. Access the "LINE FREQ. HZ" screen via "TRUCK MENU → SETTING → ANTENNA FWD → PARAMETER → LINE FREQ. HZ " 2. Change the "LINE FREQ. HZ" value to "7KHz". (Same as the Frequency value of frequency generator installed in the factory)
4	 13BOP97ES26	1. Access the "STRENGTH ACQ." screen via "TRUCK MENU → SETTING → ANTENNA FWD → PARAMETER → STRENGTH ACQ." 2. SIDE ERROR MM is monitored in this screen. This value gets closer to zero as the smart antenna (Antenna) gets closer to the frequency generator's wire. 3. Move the vehicle to place the antenna (Fork side antenna) closer to the frequency generator's wire. When the SIDE ERROR MM value is 0, change the "STRENGTH ACQ" to "ON" and save. 4. Key-Off and Key-On once.

Step	Display	Description
5	 13BOP97ES27	1. Access the "ALIGNED STRENGTH" screen via "TRUCK MENU → MONITORING → ANTENNA FWD → ALIGNED STRENGTH" 2. Check that "ALIGNED STRENGTH" value is in the range of 50~90%.
6	 13BOP97ES28	1. Repeat the Step 1~4 for "ANTENNA REV" (Steering wheel side antenna)
7		1. Turn On the Wire Guidance S/W(WGS) and forward the vehicle to place the fork side antenna closer to the frequency generator's wire. ※The maximum vehicle speed is automatically reduced when the WGS is On. ※The approach angle to the wire must not exceed 30 degrees.  13BOP97ES29 2. If the fork side antenna detects the wire, the vehicle will steer automatically. (From this point on, Manual steering is not allowed) 3. The vehicle will align with wire and "Lock on". After Lock on, The vehicle can run at the maximum speed. ※If WGS is off, the Wire Guidance function stops.

Step	Display	Description
8	 13BOP97ES30	1. Drive more than 3m at low speed (below 3km/h) while locked on. Access the “SIDE ERROR REV” and “SIDE ERROR FWD” screen via “TRUCK MENU → MONITORING → EPS MASTER → SIDE ERROR REV & SIDE ERROR FWD”. Adjust the position of the steering wheel side antenna as follows. ※SIDE ERROR FWD > SIDE ERROR REV → Steering wheel side antenna: RH ※SIDE ERROR REV > SIDE ERROR RWD → Steering wheel side antenna: LH 2. Adjust the position until FWD and REV are equal.
9	 13BOP97ES31	1. Access the “SET STEER 0-POS” screen via “TRUCK MENU → SETTING → EPS MASTER → ADJUSTMENT → SET STEER 0-POS” and SIDE ERROR FWD is monitored in this screen. 2. Drive more than 3m at low speed (below 3km/h) while locked on. Adjust the SET STEER 0-POS as follows. ※SIDE ERROR FWD: "Negative" → Reduce the value of SET STEER 0-POS. ※SIDE ERROR FWD: "Positive" → Increase the value of SET STEER 0-POS. 3. After adjusting the SET STEER 0-POS, Drive more than 3m at low speed (below 3km/h) while locked on. And adjust SIDE ERROR FWD until the value is “-1 ~ +1”
10	 13BOP97ES32	1. Access the “WG REV. OFFSET” screen via “TRUCK MENU → SETTING → EPS MASTER → ADJUSTMENT → WG REV. OFFSET” and SIDE ERROR REV is monitored in this screen. 2. Drive back more than 3m at low speed (below 3km/h) while locked on. Adjust the WG REV. OFFSET as follows. ※SIDE ERROR REV: "Negative" → Reduce the value of WG REV. OFFSET. ※SIDE ERROR REV: "Positive" → Increase the value of WG REV. OFFSET. 3. After adjusting the WG REV. OFFSET, Drive back more than 3m at low speed (below 3km/h) while locked on. Adjust the SIDE ERROR REV to minimize. ※SIDE ERROR REV value is not constant and may fluctuate due to antenna location. Adjust it to minimize the average of the values.

8. DIAGNOSTIC FAULT CODES

1) 36 V POWER

※ T = Traction P = PUMP M = MASTER S= SLAVE

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
8	WATCHDOG	O	O	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 CAN bus malfunctioning, which blinds master-supervisor communication.
17	LOGIC FAILURE #3	O	O	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		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	O	O	Cause The controller detects an under-voltage condition at the KEY input A3 (A1). Under-voltage threshold depends on the controller version. Troubleshooting (fault at startup or in standby) Fault can be caused by a key input signal characterized by pulses below the under-voltage 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.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
28	PUMP VMN LOW	O		O		Cause 1: At start-up, the power bridge is found to be faulty in the sense that one of the three legs is not able to drive the motor phase high. Troubleshooting 1: Check the motor internal connections. Check the motor power-cables connections. If the issue is not solved, replace the controller. Cause 2: While the motor is running, one of the three motor phases is sensed to lower than expected. Troubleshooting 2: motor connections. Check that the LC power contact closes properly, with a good contact. If the issue is not solved, replace the controller.
29	PUMP VMN HIGH	O		O		Cause 1: At start-up, the power bridge is found to be faulty in the sense that one of the three legs is not able to drive the motor phase low. Troubleshooting 1: Check the motor internal connections. Check the motor power cables. If the issue is not solved, replace the controller. Cause 2: At start-up the power bridge works as expected. After the main contactor closes, one of the phase voltages higher than half the battery voltage. Troubleshooting 2: Check the motor connections. Check that the LC power contact closes properly, with a good contact. If the issue is not solved, replace the controller.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
30	VMN LOW	O		O		Cause 1: At start-up, the power bridge is found to be faulty in the sense that one of the three legs is not able to drive the motor phase high. Troubleshooting 1: Check the motor internal connections. Check the motor power-cables connections. If the issue is not solved, replace the controller. Cause 2: While the motor is running, one of the three motor phases is sensed to lower than expected. Troubleshooting 2: Check the motor connections. Check that the LC power contact closes properly, with a good contact. If the issue is not solved, replace the controller.
31	VMN HIGH	O		O		Cause 1: At start-up, the power bridge is found to be faulty in the sense that one of the three legs is not able to drive the motor phase low. Troubleshooting 1: Check the motor internal connections. Check the motor power cables. If the issue is not solved, replace the controller. Cause 2: At start-up the power bridge works as expected. After the main contactor closes, one of the phase voltages higher than half the battery voltage. Troubleshooting 2: Check the motor connections. Check that the LC power contact closes properly, with a good contact. If the issue is not solved, replace the controller.
37	CONTACTOR CLOSED	O		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.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
38	CONTACTOR OPEN	O		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 Zapi technician.
52	PUMP I=0 EVER	O		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		O		Cause In standby, the current sensors detect values different from zero. The current sensors or the current feedback circuits are faulty. Troubleshooting Replace the controller.
60	CAPACITOR CHARGE	O		O		It is related to the capacitor-charging system: 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.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
62	TH. PROTECTION	O		O		Cause: The temperature of the controller base plate exceeds 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. See paragraph 5.6). 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.
65	MOTOR TEMPERAT.	O		O		Cause: This warning occurs when the temperature sensor is open (if digital) or if it exceeds the threshold defined by MAX. MOTOR TEMP. (if analog). See paragraph 8.2.3. Troubleshooting: Check the temperature read by the thermal sensor inside the motor through the MOTOR TEMPERATURE reading in the TESTER function. Check the sensor resistance 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.
66	BATTERY LOW	O		O		Cause: Parameter BATTERY CHECK is other than 0 (SET OPTION list) and battery charge is evaluated to be lower than BATT.LOW TRESHLD (ADJUSTMENTS list). 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 (ADJUSTMENTS list) with the value measured through the voltmeter. If the problem is not solved, replace the logic board.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
74	DRIVER SHORTED	O		O		Cause The driver of the LC coil is shorted. Troubleshooting Check if there is a short or a low impedance path between NLC (A16) and -B. The driver circuit is damaged; replace the logic board.
75	CONTACTOR DRIVER	O		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 POT MISMATCH	O		O		Cause: The ACC POT input A5 (A3) is sensed above the minimum value acquired by 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.
79	INCORRECT START	O		O		Cause: Incorrect starting sequence. Possible reasons for this alarm are: - A travel demand active at key-on. - Seat or tiller input active at key on. Troubleshooting: Check the state of the inputs at key-on. Check wirings and the micro-switches for failures. Through the TESTER function, check the states of the inputs are coherent with the those of the micro-switches . If the problem is not solved, replace the logic board.
80	FORW + BACK	O		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 micro-switches . If the problem is not solved, replace the logic board.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
86	PEDAL WIRE KO	O		O		Cause: Fault in accelerator negative (NPOT) input circuit Troubleshooting: Check wiring
121	BMS WARNING 1	O		O		Cause: The battery monitoring system is in WARNING 1 status. (This error is only for lithium battery)
121	BMS WARNING 0	O		O		Cause: The battery monitoring system is in WARNING 0 status. (This error is only for lithium battery)
122	POT MISM. LIFT	O		O		Cause: This alarm can occur only if the auxiliary potentiometer is of crossed-twin type, in combination with the main potentiometer (see parameter AUX.POT. TYPE under the SET OPTIONS list, paragraph 8.2.2). The sum of main and auxiliary potentiometers is not constant. Troubleshooting: Verify that the main and auxiliary potentiometers are properly connected. Check the mechanical and electrical functionality of the main and auxiliary potentiometers. Perform the acquisition of the potentiometers; ask for assistance to a Zapi technician if necessary.
123	WRONG HEIGHT POS	O		O		Wrong HEIGHT POS parameters values. The alarm activates if the following chain of inequalities is not respected: HEIGHT POS 1 < HEIGHT POS 2 < HEIGHT POS 3 < HEIGHT POS 4
124	HEIGHT OK REL	O		O		When using the Pre-Height function (see HEIGHT INDICATION specification document), this alarm indicates the pre-height has been reached. Remove pre-height request from display and remove LIFT or LOWER requests.
125	WRONG DIRECTION	O		O		This alarm activates when: - pre-height is higher than actual height but LIFT direction is selected - pre-height is lower thant acutal height but LOWER direction is selected
126	HEIGHT MAX LIFT	O		O		This alarm activates when: Actual height >= (MAX HEIGHT - LIFT STOP WINDOW) Only LOWER direction is allowed
127	FINGERTIPS ACQ	O		O		Cabin (or fork if FORK is ON) teaching parameters have not been set correctly. The correct setting must be: VACC MAX CABIN > VACC NEUTRAL CAB > VACC MIN CABIN
128	CHAIN LOOSEN	O		O		Chain Loosen switch (A35 of ACE0) is Open

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
129	MAINTENANCE SW	O		O		MAINTENANCE ENABLE SW [MES] is CLOSE
130	MAINT PRE WARN	O		O		Cause: The truck hours reached MAINT PRE WARN parameter value Troubleshooting: Perform the truck maintainance and reset the alarm using MAINTEN. RESET parameter
131	DISPLAY ENABLE	O		O		Cause: The display enable signal has not been received to operate the truck Troubleshooting: Check the wirings.
132	SCHED. OVERFILL	O		O		CPU load too high, the scheduled software task are not more performed with correct period or within the time limit. Hardware failure or software development error, contact the support.
133	PUMP MOT ALARM	O		O		Cause This alarm is present only in traction controllers. A safety-related blocking alarm is present on the pump controller. Troubleshooting Check the alarm on pump controller.
134	HYDRO OUTMISM.XX	O		O		Cause There is a mismatch between the setpoint and the feedback for one of the hydraulics outputs. The hexadecimal value XX identifies the output. 01 – mismatch between the setpoint and the feedback for DC pump 02 – mismatch between the setpoint and the feedback for EVP1 03 – mismatch between the setpoint and the feedback for EVP2 04 – mismatch between the setpoint and the feedback for AUX1 05 – mismatch between the setpoint and the feedback for AUX2 06 – mismatch between the setpoint and the feedback for AUX3 07 – mismatch between the setpoint and the feedback for AUX4 08 – mismatch between the setpoint and the feedback for AUX5 09 – mismatch between the setpoint and the feedback for AUX6 Troubleshooting Check if there is a short circuit or a low impedance path between the negative terminal of the involved output and -B. If the problem is not solved, ask for assistance to a Zapi technician.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
135	CURR.SENS. NULL	O		O		Problem related to the current sensor. Check if it's a faulty or incorrectly installed sensor; it is possible the current feedback circuits are malfunctioning
136	CURR.SENS. RANGE	O		O		Current sensors out of range.
137	SLAVE MOT ALARM	O		O		Cause This alarm is present only in master traction controllers. A safety-related blocking alarm is present on the slave traction controller. Troubleshooting Check the alarm on slave traction controller.
138	BACK EMF HIGH	O		O		Cause: When MOTOR TYPE (under SPECIAL ADJUST.) is set to BL MOTOR, the maximum traction speed is imposed by the motor speed constant; high back EMF values may damage the inverter. While motoring, if the traction speed exceeds the speed limit imposed by the motor speed constant, the software limits the motor speed and rises the alarm BACK EMF HIGH. Troubleshooting: Ask for assistance
139	THERM. PU.SENS.KO	O		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.
140	1175 NOT ACTIVE	O		O		Cause The Safety Functions related to EN1175 are active, but the controller is configured as one of the controllers type which do not support those Safety Functions. Troubleshooting Set Special Adjustment SAFETY LEVEL to 3, to disable the EN1175 Safety Functions
141	STO-SS1 ACTIVEXX	O		O		Cause One between the STO and the SS1 procedures is in progress. The hexadecimal value XX facilitates Zapi technicians debugging the problem. Troubleshooting Wait until the STO procedure or SS1 procedure or both are done.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
142	STO-SS1 ALARM XX	O		O		Cause One between the STO and the SS1 procedures has reported an alarm. The hexadecimal value XX facilitates Zapi technicians debugging the problem. Troubleshooting The fault condition could be due to a timeout of the STO or SS1 procedure; the braking took too long. Check if the truck follows the imposed braking ramp and ask for assistance to a Zapi technician. In case the problem is not solved, replace the logic board.
143	SAFETY INIT. XX	O		O		Cause One of the safety related modules has reported an error during its initialization. The hexadecimal value XX facilitates Zapi technicians debugging the problem. Troubleshooting The fault condition could be due to wrong adjustments of the safety related parameters. Ask for assistance to a Zapi technician. By the TESTER function, verify the state of the STO and SS1 safety inputs. Check the STO and SS1 connections. In case the problem is not solved, replace the logic board.
144	SAFETY WARN. XX	O		O		Cause Mismatch in traction/pump/valves setpoint calculation between the Application Layer and the EN1175 SW Layer. The application setpoint is higher than the EN1175 setpoint. The hexadecimal value XX identifies the output for which the mismatch has occurred. Troubleshooting Ask for assistance to a Zapi technician.
145	SAFETY SW. XX	O		O		Cause One of the safety related modules has reported an error. The hexadecimal value XX facilitates Zapi technicians debugging the problem. Troubleshooting The fault condition could be due to wrong adjustments of the safety related parameters. Ask for assistance to a Zapi technician. By the TESTER function, verify the state of the STO and SS1 safety inputs. Check the STO and SS1 connections. In case the problem is not solved, replace the logic board.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
146	MULTIMOT DIAG. XX	O		O		Cause One of the safety related diagnosis has failed. The hexadecimal value XX facilitates Zapi technicians debugging the problem. Troubleshooting The fault condition could be due to wrong adjustments of the safety related parameters. Ask for assistance to a Zapi technician. By the TESTER function, verify the state of the STO and SS1 safety inputs. Check the STO and SS1 connections. In case the problem is not solved, replace the logic board.
147	BMS FAULT	O		O		Cause: The battery monitoring system is in FAULT status. It is received through CAN mgs. Troubleshooting: Check the BMS(Battery Management System).
148	BMS NOT READY	O		O		Cause: This alarm occurs if the BMS FUNCTION is enabled and the controller does not receive any information about the battery state of charge; the battery management system is not operative. Troubleshooting: Check the battery charge and the battery management system status. Check the CAN bus communication.
149	WRONG PERFORM.	O		O		Cause This alarm occurs only if the PERFORMANCE parameter under SET OPTIONS is set to ON. The three performance levels (economy, normal, power) are not set in an ascending order of performance. Troubleshooting Check the performance settings under the PERFORM. ECONOMY and PERFORM. POWER lists. The performance related parameters must be set in such a way that the economy mode results in the weakest and the power mode results the highest. Contact a Zapi technician for assistance.
150	NO CAN MSG DISP	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).

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
151	POT MISMATCH	O		O		Cause: The sum of ACC 1 and ACC 2 input voltages do not match the supply voltage of the sensor. Troubleshooting: - Check the wirings. - Check the accelerator sensor output voltages.
152	SENSOR SUPPLY XX	O		O		Cause: The current supplied on pin PENC A10 (A8) or PPOT A4 (A2) is outside the range MIN.CURR.SUPPLY1/2 through 200 mA. The hexadecimal value XX defines the following cases: 01: PENC A10 (A8) below MIN.CURR.SUPPLY1. 02: PENC A10 (A8) above 200 mA. 11: PPOT A4 (A2) below MIN.CURR.SUPPLY2. 12: PPOT A4 (A2) above 200 mA.
153	OFFSET SPD. SENS.	O		O		Cause: It is necessary to acquire the offset angle between the stator and the speed sensor, i.e. they mutual angular misalignment. An automatic function is dedicated to this procedure. Troubleshooting: Perform the teaching procedure.
154	AGV	O		O		Cause: The automatic guide is enabled and the periodic automatic-guide-request CAN message is missed. Troubleshooting: Check the CAN bus communication. Verify that the controller receives the periodic automatic-guide-request message. If necessary, ask for assistance to a Zapi technician in order to record and verify the CAN traces.
155	WAIT MOTOR STILL	O		O		Cause: The controller is waiting for the motor to stop rotating. This warning can only appear in ACE2 for brushless motors.
157	FAULT DRV. POWER	O		O		NOT used in this truck.
158	NOT RDY DRV. POW.	O		O		NOT used in this truck.
159	HVIL FAIL	O		O		NOT used in this truck.
160	SENS BAT TEMP KO	O		O		NOT used in this truck.
161	RPM HIGH	O		O		Cause: This alarm occurs in Gen. Set versions when the speed exceeds the threshold speed.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
162	POS.EB.SHORT PIN	O		O		Cause: The voltage on terminal PEB, downstream the internal smart diver and input PIN, is sensed higher than expected with the smart driver driven OFF. Troubleshooting: Verify that the parameter POSITIVE E.B. is set in accordance with the actual coil positive supply. Check if there is an external short or a low impedance path between PEB and the positive battery terminal +B. If the issue is not resolved, the problem is in the controller; replaced it.
163	ED SLIP MISMATCH	O		O		Cause: The control detects a mismatch between the expected slip and the evaluated one. This diagnostic occurs only if ED COMPENSATION = TRUE.
164	POS.EB.SHORT GND	O		O		Cause: The voltage on terminal PEB, downstream the internal smart diver and input PIN, is sensed lower than expected after the smart driver is driven ON. Troubleshooting: Verify that the parameter POSITIVE E.B. is set in accordance with the actual coil positive supply. Check if there is an external short or a low impedance path between PEB and any ground reference (-B or GND). If the issue is not resolved, the problem is in the controller; replaced it.
168	SPEED FB.ERR. XX	O		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.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
169	EMERGENCY	O		O		Cause: This alarm occurs when parameter EMERGENCY INPUT is set to 1 (see paragraph 8.2.2) and the emergency input is active. Troubleshooting: The emergency input has been activated. Wait until the emergency conditions cease and restore the emergency input.
170	WRONG KEY VOLT.	O		O		Cause The measured key voltage is not within the range defined by parameters SET BATTERY, VOLTAGE THR LOW and VOLTAGE THR HIGH under SET OPTIONS. Troubleshooting Check the settings of parameters SET BATTERY, VOLTAGE THR LOW and VOLTAGE THR HIGH under SET OPTIONS to be in accordance with the battery in use. Adjust the SET KEY VOLTAGE calibration under ADJUSTMENTS: tune it to be in accordance with the actual 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		O		Cause: Controller is acquiring data from the absolute feedback sensor. Troubleshooting: The alarm ends when the acquisition is done.
172	ACQUIRE ABORT	O		O		Cause: The acquiring procedure relative to the absolute feedback sensor aborted.
173	ACQUIRE END	O		O		Cause: Absolute feedback sensor acquired.
175	SPEED OVERHEAD	O		O		Cause: The motor speed has exceeded the maximum defined by parameter TOP MAX SPEED (under HARDWARE SETTINGS) by more than a 100 Hz excess. Troubleshooting: Check the motor parameters. Ask for assistance to a Zapi technician.
176	EVP COIL SHORT.	O		O		NOT used in this truck.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
177	COIL SHOR. EB.			O		Cause: This alarm occurs when there is an overload on pin NEB. Troubleshooting: The typical root cause is in the wiring harness or in the load coil. Check the connections between the controller output and the load. Collect information about the coil characteristics and ask for assistance to a Zapi technician in order to verify that it complies with the driver specifications.
178	MOTOR TEMP. STOP	O		O		Cause: The temperature sensor has overtaken the threshold defined by MOTOR TEMP. STOP. 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		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		O		Cause The motor current has exceeded the hardware-fixed limit. Troubleshooting If the alarm condition occurs again, ask for assistance to a Zapi technician. The fault condition could be affected by wrong adjustments of motor parameters.
181	WRONG FBSENS.SET	O		O		Cause Mismatch between parameters ENCODER PULSES 1 and ENCODER PULSES 2. Troubleshooting Set the two parameters with the same value, according to the adopted encoder.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
182	EVP2 COIL OPEN	O				Cause: An open-load condition is detected on the proportional valve output EVP2 Troubleshooting: Check the EVP2 coil. Check the wiring. If the problem is not solved, replace the logic board.
183	EVP2 DRIV. SHORT	O				Cause The EVP2 Driver, on output NEVP (A19), is shorted to ground. The microcontroller detects a mismatch between the valve set-point and the feedback of the EVP2 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 EVP2 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.
184	EVP2 DRIVER OPEN	O				Cause: The EVP2 driver, on output NEVP, is not able to drive the EVP2 coil. The device itself or its driving circuit is damaged. Troubleshooting: This fault is not related to external components. Replace the logic board.
185	TILLER ERROR	O		O		Cause: Input mismatch between H&S input and TILLER/SEAT input: the two inputs are activated at the same time. Troubleshooting: - Check if there are wrong connections in the external wiring. - Using the TESTER function of the controller verify that the input-related readings are in accordance with the actual state of the external input switches. - Check if there is a short circuit between pins H&S input & TILLER/SEAT input - In case no failures/problems have been
186	WAIT MOT.P STILL	O		O		The controller is waiting for the motor to stop rotating. This warning can only appear in ACE2 or ACE 3 for brushless motors.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
187	LIFT+LOWER	O		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		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.
188	HYDRO SP MISM.XX		O		O	Setpoint mismatch of an hydraulic output. Only active if SAFETY LEVEL >= 4
189	PUMP INC START	O		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.
190	PUMP VMN NOT OK	O		O		Cause: Switching the LC on, the software checks the output voltage on -P connector, and expects that it is at a steady state value (if DC PUMP options is set to ON, see paragraph 8.2.1 - DC PUMP). If the voltage is too low, this alarm occurs. Troubleshooting: If it is repetitive, it is necessary to replace the controller.
190	SCHED. OVERFILL		O		O	CPU load too high, the scheduled software task are not more performed with correct period or within the time limit. Hardware failure or software development error, contact the support.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
191	PUMP I NO ZERO	O		O		Cause: In standby condition (pump motor not driven), the feedback coming from the current sensor in the pump chopper gives a value out of a permitted range. Troubleshooting: This type of fault is not related to external components; replace the controller.
191	MULTIMOT DIAG XX		O		O	Generic safety alarm in multi-motor configuration. Only active if SAFETY LEVEL >= 4
192	PUMP VACC RANGE	O		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.
192	SAFETY INIT. XX		O		O	Cause One of the safety related modules has reported an error during its initialization. The hexadecimal value XX facilitates Zapi technicians debugging the problem. Troubleshooting The fault condition could be due to wrong adjustments of the safety related parameters. Ask for assistance to a Zapi technician. By the TESTER function, verify the state of the STO and SS1 safety inputs. Check the STO and SS1 connections. In case the problem is not solved, replace the logic board.
193	SMARTDRIVER KO	O		O		It is not used in this truck.
193	SAFETY WARN. XX		O		O	Cause Mismatch in traction/pump/valves setpoint calculation between the Application Layer and the EN1175 SW Layer. The application setpoint is higher than the EN1175 setpoint. The hexadecimal value XX identifies the output for which the mismatch has occurred. Troubleshooting Ask for assistance to a Zapi technician.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
194	AUX BATT. SHORT.	O		O		Cause: The voltage on PEB output (A17) is at high value even if it should not. The parameter POSITIVE E.B. has to be set in accordance with the hardware configuration, because the software makes a proper diagnosis depending on the parameter; a wrong setting could generate a false fault. This alarm can only appear if POSITIVE E.B. = 1 (PEB from TILLER/SEAT). Troubleshooting: Verify that the parameter POSITIVE E.B. is set in accordance with the actual coil positive supply. In case no failures/problems have been found, the problem is in the controller, which has to be replaced.
194	SAFETY SW. XX		O		O	Cause One of the safety related modules has reported an error. The hexadecimal value XX facilitates Zapi technicians debugging the problem. Troubleshooting The fault condition could be due to wrong adjustments of the safety related parameters. Ask for assistance to a Zapi technician. By the TESTER function, verify the state of the STO and SS1 safety inputs. Check the STO and SS1 connections. In case the problem is not solved, replace the logic board.
195	POS. EB. SHORTED	O		O		Cause: The voltage on terminal PEB is at the high value even if the smart driver is turned OFF. Troubleshooting: - Verify that the parameter POSITIVE EB is set in accordance with the actual coil positive supply. Since the software makes a proper diagnosis depending on the parameter, a wrong setting could generate a false fault. - Check if there is a short or a low impedance path between PEB and the positive battery terminal +B. In case no failures/problems can be found, the problem is in the controller, which has to be replaced.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
195	SAFETY DIAG. XX		O		O	Cause One of the safety related diagnosis has failed. The hexadecimal value XX facilitates Zapi technicians debugging the problem. Troubleshooting The fault condition could be due to wrong adjustments of the safety related parameters. Ask for assistance to a Zapi technician. By the TESTER function, verify the state of the STO and SS1 safety inputs. Check the STO and SS1 connections. In case the problem is not solved, replace the logic board.
196	MOT.PHASE SH.	O		O		Cause A short circuit between two motor phases occurred. The hexadecimal value XX identifies the pair of shorted phases. 36: U – V 37: U – W 38: V – W Troubleshooting Verify the motor phases connection on the motor and inverters sides. Check the motor power cables. Replace the controller. If the alarm does not disappear, the problem is in the motor; replace it.
196	NO CAN MSG DISP		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).
197	WRONG SLAVE VER.	O		O		Cause: There is a mismatch in the software versions of master and supervisor microcontrollers. Troubleshooting: Upload the software to the correct version or ask for assistance to a Zapi technician.
197	FINGERTIPS ACQ		O		O	Cabin (or fork if FORK is ON) teaching parameters have not been set correctly. The correct setting must be: VACC MAX CABIN > VACC NEUTRAL CAB > VACC MIN CABIN
198	M/S PAR CHK MISM	O		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.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
199	PARAM TRANSFER	O		O		Cause: Master microcontroller is transferring parameters to the supervisor. Troubleshooting: Wait until the end of the procedure. If the alarm remains longer, re-cycle the key.
199	STO-SS1 ALARM XX		O		O	Cause One between the STO and the SS1 procedures has reported an alarm. The hexadecimal value XX facilitates Zapi technicians debugging the problem. Troubleshooting The fault condition could be due to a timeout of the STO or SS1 procedure; the braking took too long. Check if the truck follows the imposed braking ramp and ask for assistance to a Zapi technician. In case the problem is not solved, replace the logic board.
200	VDC OFF SHORTED	O		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.
200	STEER SENSOR KO		O		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	CURRENT PROFILE	O		O		Cause: There is an error in the choice of the current profile parameters. Points P0 through P3 are expected to describe a descending profile. Troubleshooting: Check the values under the CURRENT PROFILE list.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
201	WRONG FBSENS.SET		O		O	Cause Mismatch between parameters ENCODER PULSES 1 and ENCODER PULSES 2. Troubleshooting Set the two parameters with the same value, according to the adopted encoder.
202	VDC LINK OVERV.	O	O	O	O	Cause This fault is displayed when the controller detects an overvoltage condition. Overvoltage threshold depends on the nominal voltage of the controller. As soon as the fault occurs, power bridge and MC are opened. The condition is triggered using the same HW interrupt used for under-voltage detection, microcontroller discerns between the two evaluating the voltage present across DC-link capacitors: High voltage Overvoltage condition Low/normal voltage Under-voltage condition
203	HW FAULT MC	O		O		Cause: At start-up, some hardware circuit intended to enable and disable the power bridge or the LC driver on output NLC (A16) is found to be faulty. The hexadecimal value XX facilitates Zapi technicians debugging the problem. Troubleshooting This type of fault is related to internal components. Replace the logic board.
204	BRAKE RUN OUT	O		O		Cause: The CPOT BRAKE input read by the microcontroller is out of the range defined by parameters SET PBRK. MIN and SET PBRK. MAX (ADJUSTMENTS list). 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.
205	EPS RELAY OPEN	O		O		Cause: The controller receives from EPS information about the safety contacts being open. Troubleshooting: Verify the EPS functionality.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
206	INIT VMN HIGH	O		O		Cause Before closing the main contactor and before driving power bridge, one or more motor phases voltage are sensed to be higher than expected. A short circuit or a low-impedance path to the positive rail is affecting the power section. 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. If the motor connections are fine and there are no external low-impedance paths, the problem resides inside the controller; replace it.
207	INIT VMN LOW	O		O		Cause Before closing the main contactor and before driving power bridge, one or more motor phases voltage are sensed to be lower than expected. A short circuit or a low-impedance path to the negative rail is affecting the power section. 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	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	TM	TS	PM	PS	DESCRIPTION
209	PARAM RESTORE	O	O	O	O	Cause: The controller has restored the default settings. If a CLEAR EEPROM has been made before the last key re-cycle, this warning informs you that EEPROM was correctly cleared. Troubleshooting: A travel demand or a pump request cancels the alarm. If the alarm appears at key-on without any CLEAR EEPROM performed, replace the controller.
210	WRONG RAM MEM.	O	O	O	O	Cause: The algorithm implemented to check the main RAM registers finds wrong contents: the register is corrupted. This alarm inhibits the machine operations. Troubleshooting Try to switch the key off and then on again, if the alarm is still present replace the logic board.
211	STALL ROTOR	O		O		Cause: The traction rotor is stuck or the controller does not correctly receive the encoder signals. Troubleshooting: Check the encoder condition. Check the wiring. Through the TESTER function, check if the sign of FREQUENCY 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.
212	POWER MISMATCH	O		O		Cause The error between the power set-point and the estimated power is out of range. Troubleshooting Ask for assistance to a Zapi technician about the correct adjustment of the motor
212	W.SET. TG-EB XX		O		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 HCE technician. - If the problem is not solved, replace the logic board.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
213	POSITIVE LC OPEN	O		O		Cause: The voltage feedback of the LC driver, output NLC (A16), 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. In case no failures/problems have been found, the problem is in the controller, which has to be replaced.
213	INPUT MISMATCH		O		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 HCE technician. - If the problem is not solved, replace the logic board.
214	EVP COIL OPEN	O		O		Cause: An open-load condition is detected on the proportional valve output NEVP (A19). Troubleshooting: Check the EVP coil. Check the wiring. If the problem is not solved, replace the logic board.
215	EVP DRIV. SHORT.	O		O		Cause The EVP driver, on output NEVP (A19), is shorted to ground. 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	TM	TS	PM	PS	DESCRIPTION
216	EB. COIL OPEN	O		O		Cause: An open-load condition is detected on the output NEB. Troubleshooting: Check the coil. Check the wiring. Check the positive terminal, possibly from pin PEB or downstream the main contactor. If the problem is not solved, replace the logic board.
217	PEV NOT OK	O		O		Cause: Terminal PIN A24 is not connected to the battery or the voltage is different from that defined by parameter SET POSITIVE PEB (see the ADJUSTMENTS list). This alarm can occur if one output among EVP, EV1, EV2 and EV3 is present or AUX OUT FUNCTION is active. Troubleshooting: Check PIN terminal A24: it must be connected to the battery voltage (after the main contactor). Set the nominal voltage for the outputs by parameter SET POSITIVE PEB in the ADJUSTMENTS list.
218	SENS MOT TEMP KO	O		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		O		Cause: The logic board measures a key voltage value that is constantly under the minimum value allowed. Troubleshooting: Check that the battery used as supply for the inverter has the same nominal voltage of the inverter. Check the battery voltage, if it is out of the allowed range replace the battery. In case the problem is not solved, the problem is in the logic board, replace it.
221	HANDBRAKE	O		O		Cause: Handbrake input is active. Troubleshooting: - Check that handbrake is not active by mistake. - Check the SR/HB input state through the TESTER function. - Check the wirings. - Check if there are failures in the microswitches. - If the problem is not solved, replace the logic board.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
221	SPEED FB.ERR. XX		O		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 engine 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.
222	SEAT MISMATCH	O		O		Cause This alarm can appear only in a traction-and-pump configuration or in a multi-motor one. A mismatch is detected between the two TILLER/ SEAT inputs A8 (A6) of the two controllers. 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. If the issue is not solved, replace the controller.
223	COIL SHOR. MC	O		O		Cause: This alarm occurs when there is an overload on the main contactor driver, on pin NLC (A16). Troubleshooting: The typical root cause is in the wiring harness or in the load coil. Check the connections between the controller output and the load. Collect information about the coil characteristics and ask for assistance to a Zapi technician in order to verify that it complies with the driver specifications.
224	WAITING FOR NODE	O		O		Cause: The controller receives from the CAN bus 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 CAN bus is in fault condition.
225	MPU VIOLATION	O	O	O	O	Either the Memory Protection Unit (MPU) has blocked an unprivileged routine from the access to the safety-reserved memory area, or the MPU initialization routine has failed. The hexadecimal value XX helps Zapi technicians debugging the problem.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
226	VACC OUT RANGE	O		O		Cause: The ACC POT input (A3) read by the microcontroller is not within the range MIN VACC through MAX VACC, programmed by the PROGRAMM VACC function. The minimum and maximum acquired values are inconsistent. Troubleshooting: Acquire the maximum and minimum potentiometer values by 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		O		Cause At start-up, some hardware circuit intended to enable and disable the power bridge is found to be faulty. The hexadecimal value XX facilitates Zapi technicians debugging the problem. Troubleshooting This type of fault is related to internal components. Replace the logic board.
227	OUT MISMATCH XX		O		O	Cause: This is a safety related test. Supervisor µC has detected that master µC is driving the traction motor in a wrong way (not corresponding to the operator request). The hexadecimal value XX facilitates HCE technicians debugging the problem. Troubleshooting: - Checks the matching of the parameters between Master and Supervisor. - Ask for assistance to a HCE technician. - If the problem is not solved, replace the logic board.
228	SEAT OPEN TILLER OPEN	O		O		Cause: Tiller/seat input has been inactive for more than 120 seconds. Troubleshooting: Activate the tiller/seat input. Check the tiller/seat input state through the TESTER function. Check the wirings. Check if there are failures in the micro-switches . If the problem is not solved, replace the logic board.
229	HW FAULT EB.	O		O		Cause: At start-up, the hardware circuit dedicated to enable and disable on output NEB (A18) is found to be faulty. The hexadecimal value XX facilitates Zapi technicians debugging the problem. Troubleshooting: This type of fault is not related to external components. Replace the logic board.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
229	NO CAN WR MSG.XX		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).
230	LC COIL OPEN	O		O		Cause An open-load condition is detected on the proportional valve output NLC. Troubleshooting Check the LC coil. Check the wiring. Check the LC positive terminal, possibly from the key line. If the problem is not solved, replace the logic board.
230	SOFTWARE ERROR		O		O	Several are the causes that generate this alarm and are related to the checks done by the SW : for instance CAN bus off, bad EEPROM read/write
231	ECC FAIL		O		O	Either the Error Correction Codes module (ECC) has detected and corrected some error in the RAM memory, or its startup test routine has failed. The hexadecimal value XX helps Zapi technicians debugging the problem. Repeated ECC fails mean that the RAM or ECC module is not reliable. Replace the controller.
232	CONT. DRV. EV	O		O		Cause: One or more on/off valve drivers are not able to drive the load. For the meaning of code XX, refer to paragraph 10.5. Troubleshooting: The device or its driving circuit is damaged. Replace the controller.
233	POWERMOS SHORTED	O		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		O		Cause: One or more on/off valve drivers are shorted. For the meaning of code XX, refer to paragraph 10.5. Troubleshooting: Check if there is a short circuit or a low impedance path between the negative terminals of the involved coils and -B. If the problem is not solved, replace the logic board.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
235	CTRAP THRESHOLD	O		O		Cause This alarm occurs when a mismatch is detected between the set-point for the overcurrent detection circuit (dependent on parameter DUTY PWM CTRAP) and the feedback of the actual threshold value. Troubleshooting The failure lies in the controller hardware. Replace the logic board.
236	CURRENT GAIN	O		O		Cause: The 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 Zapi technician in order to do the adjustment procedure of the current gain parameters.
237	ANALOG INPUT	O	O	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		O		Cause: At startup, the hardware circuit dedicated to enable and disable the EV drivers is found to be faulty. For the meaning of code XX, refer to paragraph 10.5. Troubleshooting: This type of fault is not related to external components. Replace the logic board.
239	CONTROLLER MISM.	O	O	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 Zapi technician in order to verify that the firmware is correct.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
240	EVP DRIVER OPEN	O		O		Cause: The EVP driver, on output NEVP (A19), 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.
240	OUT MISMATCH PU		O		O	Cause: This is a safety related test. Supervisor µC has detected that master µC is driving the pump motor in a wrong way (not corresponding to the operator request). Troubleshooting: - Checks the matching of the parameters between Master and Supervisor. - Ask for assistance to a HCE technician. - If the problem is not solved, replace the logic board
241	COIL SHOR. EVAUX	O		O		Cause: This alarm occurs when there is an overload on any of the auxiliary voltage- controlled outputs: NEV1 A25, NEV2 A34 and NEV3 A35. Troubleshooting: The typical root cause is in the wiring harness or in the load coil. Check the connections between the controller output and the load. Collect information about the coil characteristics and ask for assistance to a Zapi technician in order to verify that it complies with the driver specifications.
241	SP MISMATCH PUMP		O		O	Cause: This is a safety related test. The supervisor µC has detected a mismatch in the DC-pump speed setpoint with respect to the master µC. Troubleshooting: - Check the matching of the parameters between master and supervisor. - Ask for assistance to a HCE technician. - If the problem is not solved, replace the logic board
242	OPEN COIL EV.	O		O		It is not used in this truck.
242	SP MISMATCH XX		O		O	Cause: This is a safety related test. The supervisor µC has detected a mismatch in the speed setpoint with respect to the master µC. The hexadecimal value XX facilitates HCE technicians debugging the problem. Troubleshooting: - Check the matching of the parameters between master and supervisor. - Ask for assistance to a HCE technician. - If the problem is not solved, replace the logic board
243	THROTTLE PROG.	O		O		Cause: A wrong profile has been set in the throttle profile. Troubleshooting: Set properly the throttle-related parameters.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
244	WARNING SLAVE	O		O		Cause: Warning on supervisor microcontroller. Troubleshooting: Connect the Console to the supervisor microcontroller and check which alarm is present.
245	IQ MISMATCHED	O		O		Cause The error between the estimated q-axis current and the related set-point is out of range. Troubleshooting Ask for assistance to a Zapi technician in order to do the correct adjustment of the motor parameters.
246	EB. DRIV.OPEN	O		O		Cause: The EB 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		O		Cause: Controller in calibration state. Troubleshooting: The alarm ends when the acquisition is done.
248	NO CAN MSG.	O	O	O	O	Cause CAN bus communication does not work properly. The hexadecimal value XX identifies the faulty node. Troubleshooting Verify the CAN bus network and the devices connected to it. By a multimeter check the impedance between CANH and CANL; it shall be 60 Ω. If the alarm persists, replace the logic board.
249	MAINTENANCE HOUR	O		O		Cause This alarm occurs when the switch input ENABLE MAINTENANCE, read by the ACE0 and sent via CAN to the ACE2, is closed. Troubleshooting : Release the switch input ENABLE MAINTENANCE.
250	THERMIC SENS. KO	O		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.

CODE	ALARM	TM	TS	PM	PS	DESCRIPTION
251	WRONG SET BAT.	O		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 Zapi technician. Through the TESTER function, check that the KEY VOLTAGE reading shows the same value as the key voltage measured with a voltmeter on pin A3 (A1). If it does not match, then modify the ADJUST BATTERY parameter according to the value read by the voltmeter. Replace the battery.
252	EVP2 COIL SHORT.	O				Cause: This alarm occurs when there is an overload on pin EVP2. Troubleshooting: The typical root cause is in the wiring harness or in the load coil. Check the connections between the controller output and the load. Collect information about the coil characteristics and ask for assistance to a Zapi technician in order to verify that it complies with the driver specifications.
253	FIELD ORIENT. KO	O		O		Cause The error between the estimated Id (d-axis current) and the relative set-point is out of range. Troubleshooting Ask for assistance to a Zapi technician in order to do the correct adjustment of the motor parameters.
254	EB. DRIV.SHRT.	O		O		Cause: The pin A18 driver is shorted. The microcontroller detects a mismatch between the set-point and the feedback at the pin A18 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 settings of the pin A18-related parameters. If the problem is not solved, replace the controller.

2) 24 V POWER (OPTION)

※ T = Traction P = PUMP M = MASTER S= SLAVE

CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
8	08	WATCHDOG	O	O	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 CAN bus malfunctioning, which blinds master-supervisor communication. This manual contains a number of instructions and safety recommendations regarding driving, handling, lubrication, maintenance, inspection and adjustment of the excavator.
17	11	LOGIC FAILURE #3	O	O	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	12	LOGIC FAILURE #2	O		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	13	LOGIC FAILURE #1	O	O	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 : 24V - 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.

※ T = Traction P = PUMP M = MASTER S= SLAVE

CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
30	1E	VMN LOW	O		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.
31	1F	VMN HIGH	O		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.

※ T = Traction P = PUMP M = MASTER S= SLAVE

CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
37	25	CONTACTOR CLOSED	O		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	26	CONTACTOR OPEN	O		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 HCE technician.
52	34	PUMP I=0 EVER	O		O		Cause: While truck is running, current value is 0 for more than 1 sec. Remedy: - Check the Main contactor - Check the controller
53	35	STBY I HIGH	O		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	3C	CAPACITOR CHARGE	O		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.

※ T = Traction   P = PUMP   M = MASTER   S= SLAVE

CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
62	3E	TH. PROTECTION	O		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.
65	41	MOTOR TEMPERAT.	O		O		Cause: This warning occurs when the temperature sensor is open (if digital) or if it has overtaken the MAX. MOTOR TEMP. threshold (if analog) 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.
66	42	BATTERY LOW	O		O		Cause: Parameter BATTERY CHECK is other than 0 (SET OPTION list) 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	4A	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 NMC(A12) and -B. - The driver circuit is damaged; replace the logic board.
					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.

※ T = Traction P = PUMP M = MASTER S= SLAVE

CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
75	4B	CONTACTOR DRIVER	O		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	4E	VACC NOT OK	O		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.
79	4F	INCORRECT START	O		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	50	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	52	ENCODER ERROR	O		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.

※ T = Traction P = PUMP M = MASTER S= SLAVE

CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
82	52	ENCODER ERROR	O		O		- 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.
146	92	WRONG DIRECTION			O		Cause: This alarm occurs if the user operate the lift lever in a wrong direction, when the preset function is activated. (for example, if preset height is 3m and present height is 5m, the user is doing lifting. It can cause this alarm. Because of wrong operation direction.)
147	93	HEIGHT MAX LIFT			O		Cause: This alarm occurs if the measured height is same as set max height. It is just warnning. But if the height is diffirent from real max height, please set max height again.
148	94	CHAIN LOOSER			O		Cause: This alarm occurs when the chain looser switch, read by the traction and sent via CAN to the pump, is opened.
149	95	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
150	96	DISPLAY ENABLE	O				Cause: The display enable signal has not been received to operate the truck
151	97	POT MISMATCH	O		O		Cause: CAN Tiller has to read 6 potentiometers signals : 2 signals for the fork lift & lower, 2 signal for the accelerator and 2 signals for the cabin lift & lower. All these information are sent to the ACE0 via CAN, and the ACE0 checks the coherence between the signal couple. If one of these 3 couples show an incoherence between the 2 signals, this alarm is set. Troubleshooting: Check the harness related to the 3 potentiometers and if the alarm still remains then it could be a problem inside the controller, which has to be changed.
153	99	OFFSET SPD. SENS.	O		O		Cause: It is necessary to acquire the offset angle between the stator and the speed sensor, i.e. they mutual angular misalignment. An automatic function is dedicated to this procedure. Troubleshooting: Perform the teaching procedure: in OPTIONS, select ABS SENS. ACQUIRE.

※ T = Traction P = PUMP M = MASTER S= SLAVE

CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
155	9B	WAIT MOTOR STILL	O		O		Cause: The controller is waiting for the motor to stop rotating. This warning can only appear in controllers for brush-less motors.
161	A1	RPM HIGH	O		O		Cause: This alarm occurs in Gen. Set versions when the speed exceeds the threshold speed.
162	A2	BUMPER STOP	O		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 the controller is in CAN OPEN configuration (see parameter CONTROLLER TYPE in SPECIAL ADJUST. list, paragraph 8.2.4). 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	A3	ED SLIP MISMATCH	O		O		Cause: The control detects a mismatch between the expected slip and the evaluated one. This diagnostic occurs only if ED COMPENSATION = TRUE.
164	A4	PWM ACQ. ERROR	O		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.
168	A8	SIN/COS D. ERR XX	O		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 HCE technicians 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 HCE technician.

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CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
169	A9	ENCODER D.ERR XX	O		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 HCE technicians 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 HCE technician.
170	AA	WRONG KEY VOLT.	O		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	AB	ACQUIRING A.S.	O		O		Cause: Controller is acquiring data from the absolute feedback sensor. Troubleshooting: The alarm ends when the acquisition is done.
172	AC	ACQUIRE ABORT	O		O		Cause: The acquiring procedure relative to the absolute feedback sensor aborted.
173	AD	ACQUIRE END	O		O		Cause: Absolute feedback sensor acquired.
175	AF	SPEED FB. ERROR	O		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 engine 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.

※ T = Traction P = PUMP M = MASTER S= SLAVE

CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
176	B0	HOME SENS. ERR XX	O		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 HCE technicians debugging the problem. Troubleshooting: Repeat the auto-teaching procedure.
177	B1	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 HCE technician 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. "
178	B2	MOTOR TEMP. STOP	O		O		Cause: The temperature sensor has overtaken the threshold defined by STOP MOTOR TEMP. 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	B3	STEER SENSOR KO	O		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.

※ T = Traction P = PUMP M = MASTER S= SLAVE

CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
180	B4	OVERLOAD	O		O		Cause: The motor current has overcome the limit fixed by hardware. Troubleshooting: If the alarm condition occurs again, ask for assistance to a HCE technician. The fault condition could be affected by wrong adjustments of motor parameters.
181	B5	WRONG ENC SET	O		O		Cause: Mismatch between parameters ENCODER PULSES 1 and ENCODER PULSES 2. Troubleshooting: Set the two parameters with the same value, according to the adopted encoder.
182	B6	EVP2 COIL OPEN	O				Cause: No load is connected between the EVP2 output (A23) and the electrovalve positive terminal. Troubleshooting: - Check the EVP2 condition. - Check the EVP2 wiring. - If the problem is not solved, replace the logic board.
183	B7	EVP2 DRIV. SHORT	O				Cause: - The EVP2 driver (output A23) is shorted. - The microcontroller detects a mismatch between the valve set-point and the feedback of the EVP2 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: o the voltage applied across the EVP2 coil, o the current in the coil, o features of the coil. Ask for assistance to HCE 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.
184	B8	EVP2 DRIVER OPEN	O				Cause: The EVP2 driver is not able to drive the EVP2 coil. The device itself or its driving circuit is damaged. Troubleshooting: This fault is not related to external components. Replace the logic board.
185	B9	TILLER ERROR	O		O		Cause: Input mismatch between the Hard&Soft input (A6) and the TILLER/SEAT input (A1): the two inputs are activated at the same time. Troubleshooting: - Check if there are wrong connections in the external wiring.

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CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
185	B9	TILLER ERROR	O		O		- Using the TESTER menu of the controller verify that what the controller sees in input is in accordance with the actual state of the external switch inputs. - Check if there is a short circuit between A6 and A1. - In case no failures/problems have been found, the problem is in the controller, which has to be replaced.
186	BA	WAIT MOT.P STILL	O		O		Cause: If DC Pump option is set to ON, the software expects the voltage on -P output to be at a “steady state” value, before switching the LC on. If the voltage is different, it could be due to the fact that the motor connected to -P is not still. For this reason, the software waits 30 seconds for the voltage to be at the “steady state” value (and for the pump motor to be still). After this time, the software assumes that the problem is not due to the fact that the pump motor is not still, and show the PUMP VMN NOT OK alarm. Troubleshooting: - If the motor connected to -P is still moving, just wait for it to be still. - If not, in 30 seconds the alarm PUMP VMN NOT OK will appear.
187	BB	LIFT+LOWER	O		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. - Check if there are failures in the microswitches. - If the problem is not solved, replace the logic board.
188	BC	PUMP VACC NOT OK	O		O		Cause: The minimum voltage of the lift potentiometer is not correctly set. Troubleshooting: It is suggested to repeat the acquiring procedure of MIN LIFT and MAX LIFT
189	BD	PUMP INC START	O		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.
190	BE	PUMP VMN NOT OK	O		O		Cause: Switching the LC on, the software checks the output voltage on -P connector, and expects that it is at a “steady state” value. If the voltage is too low, this alarm occurs.

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CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
190	BE	PUMP VMN NOT OK	O		O		Troubleshooting: Please check: - The motor connected to -P must be completely still before this alarm occurs. The software waits 30 seconds before showing this alarm. During this time it shows the WAIT MOTOR STILL warning. - Motor internal connections - Motor power cables connections - Motor leakage to truck frame - If the motor connections are ok, the problem is inside the controller it is necessary to replace the logic board.
191	BF	PUMP I NO ZERO	O		O		Cause: In standby condition (pump motor not driven), the feedback coming from the current sensor in the pump chopper gives a value out of a permitted range, because the pump current is not zero. Troubleshooting: This type of fault is not related to external components; replace the controller.
193	C1	SMARTDRIVER KO	O		O		Cause: There is a hardware problem in the smart driver circuit (high-side driver on pin A2). The driver is set to be ON but the output voltage does not increase. Troubleshooting: - Verify that the EB coil is connected correctly between pin A2 and pin A4. - Verify that the parameter POSITIVE E.B.is set in accordance with the actual configuration. The software, in fact, depending on specific parameter value, makes a proper diagnosis; a wrong configuration of this parameter could generate a false fault. - In case no failures/problems have been found, the problem is in the controller, which has to be replaced."
194	C2	AUX BATT. SHORT.	O		O		Cause: The voltage on PEB output (pin A2) is at high value even if it should not. For the versions where the smart driver is not installed (36/48V and 80V), it is possible to decide where the positive supply for pin A2 comes from by choosing a dedicated hardware configuration. The parameter POSITIVE E.B. has to be set in accordance with the hardware configuration, because the software makes a proper diagnosis depending on the parameter; a wrong setting could generate a false fault. The available choices are: - 0 = PEB is managed by the smart driver (available for 24V version only). - 1 = PEB comes from the TILLER input (A1). - 2 = PEB comes from PEV (A3). PEV must be connected to terminal +B of the controller. This is the default configuration for 36/48V and 80V version. This alarm can only appear if POSITIVE E.B. is set as 1 TILLER/SEAT.

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CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
194	C2	AUX BATT. SHORT.	O		O		Troubleshooting: - Verify that the parameter POSITIVE E.B. is set in accordance with the actual coil positive supply. - In case no failures/problems have been found, the problem is in the controller, which has to be replaced.
195	C3	POS. EB. SHORTED	O		O		Cause: The voltage on pin A2 is high even if the smart driver is turned OFF. Troubleshooting: - Verify that the parameter POSITIVE E.B. is set in accordance with the actual coil positive supply. - Check if there is a short or a low impedance path between pin A2 and of the +B. In case no failures/problems have been found, the problem is in the controller, which has to be replaced.
196	C4	MOT.PHASE SH.XX	O		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
197	C5	WRONG SLAVE VER.	O		O		Cause: Wrong software version on supervisor uC. Troubleshooting: Upload the correct software version or ask for assistance to a HCE technician.
197	C5	WRONG SLAVE VER.	O		O		Cause: Wrong software version on supervisor uC. Troubleshooting: Upload the correct software version or ask for assistance to a HCE technician.
199	C7	PARAM TRANSFER	O		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		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 the controller is in CAN OPEN configuration. Troubleshooting - Turn off one or both inputs dedicated to the bumper functionality.

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<table>
<tr><th>CODE</th><th>HEX</th><th>ALARM</th><th>TM</th><th>TS</th><th>PM</th><th>PS</th><th>DESCRIPTION</th></tr>
<tr><td>199</td><td>C</td><td>BUMPER STOP</td><td></td><td>O</td><td></td><td>O</td><td>- 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.</td></tr>
<tr><td rowspan="2">200</td><td rowspan="2">C8</td><td>VDC OFF SHORTED</td><td>O</td><td></td><td>O</td><td></td><td>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.</td></tr>
<tr><td>STEER SENSOR KO</td><td></td><td>O</td><td></td><td>O</td><td>Cause:
The voltage read by the microcontroller at the steering-sensor input is not within the range from STEER RIGHT VOLT to STEER LEFT VOLT, programmed through the STEER ACQUIRING function.

Troubleshooting:
- Acquire the maximum and minimum values from the steering potentiometer through the STEER ACQUIRING function.
- Check the mechanical calibration and the functionality of the potentiometer.
- If the problem is not solved, replace the logic board.</td></tr>
<tr><td rowspan="2">201</td><td>C9</td><td>TORQUE PROFILE</td><td>O</td><td></td><td>O</td><td></td><td>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.</td></tr>
<tr><td>00</td><td>WRONG ENC SET</td><td></td><td>O</td><td></td><td>O</td><td>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.</td></tr>
<tr><td>202</td><td>CA</td><td>VDC LINK OVERV.</td><td>O</td><td>O</td><td>O</td><td>O</td><td>Cause:
This fault is displayed when the controller detects an overvoltage condition. Overvoltage threshold is 65 V for 36/48V controllers and 116 V for 80V controllers.
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>
</table>

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CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
204	CC	BRAKE RUN OUT	O		O		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.
205	CD	EPS RELAY OPEN	O		O		Cause: The controller receives from EPS information about the safety contacts being open. Troubleshooting: Verify the EPS functionality.
206	CE	INIT VMN HIGH XX	O		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	CF	INIT VMN LOW XX	O		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	D0	EEPROM KO	O	O	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.

※ T = Traction   P = PUMP   M = MASTER   S= SLAVE

CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
208	D0	EEPROM KO	O	O	O	O	Troubleshooting: Execute a CLEAR EEPROM procedure. 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.
209	D1	PARAM RESTORE	O	O	O	O	Cause: The controller has restored the default settings. If a CLEAR EEPROM has been made before the last key re-cycle, this warning informs you that EEPROM was correctly cleared. Troubleshooting: - A travel demand or a pump request cancels the alarm. - If the alarm appears at key-on without any CLEAR EEPROM performed, replace the controller.
210	D2	WRONG RAM MEM.	O	O	O	O	Cause: The algorithm implemented to check the main RAM registers finds wrong contents: the register is “dirty”. This alarm inhibits the machine operations. Troubleshooting: Try to switch the key off and then on again, if the alarm is still present replace the logic board.
211	D3	STALL ROTOR	O		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 FREQUENCY 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.
212	D4	POWER MISMATCH	O		O		Cause: The error between the power setpoint and the estimated power is out of range. Troubleshooting: Ask for assistance to a HCE technician about the correct adjustment of the motor parameters.
		W.SET. TG-EB XX		O		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 HCE technician. - If the problem is not solved, replace the logic board.
213	D5	POSITIVE LC OPEN	O				Cause: The positive voltage of LC is different from expected.

※ T = Traction   P = PUMP   M = MASTER   S= SLAVE

CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
213	D5	POSITIVE LC OPEN	O				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		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 HCE technician. - If the problem is not solved, replace the logic board.
214	D6	EVP COIL OPEN	O				Cause: No load is connected between the EVP output (A24) and the electrovalve positive terminal. Troubleshooting: - Check the EVP condition. - Check the EVP wiring. - If the problem is not solved, replace the logic board.
		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	D7	EVP DRIV. SHORT.	O				Cause: - The EVP driver (output A24) 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: o the voltage applied across the EVP coil, o the current in the coil, o features of the coil. Ask for assistance to HCE 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.
		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.

※ T = Traction P = PUMP M = MASTER S= SLAVE

CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
215	D7	EVP DRIV. SHORT.			O		Troubleshooting: - Check if there is a short circuit or a low-impedance conduction path between the negative of the coil and -BATT. - Collect information about: o the voltage applied across the EVP coil, o the current in the coil, o features of the coil. Ask for assistance to HCE 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.
216	D8	EB. COIL OPEN	O		O		Cause: This fault appears when no load is connected between the NEB output (A4) and the EB positive terminal PEB (A2). Troubleshooting: - Check the EB coil. - Check the wiring. - If the problem is not solved, replace the logic board.
217	D9	PEV NOT OK	O		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 NAUX1 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.
218	DA	SENS MOT TEMP KO	O		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	DC	VKEY OFF SHORTED	O		O		Cause: At key-on, the logic board measures a voltage value of the KEY input that is constantly out of range, below the minimum 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 not ok, replace the logic board.
221	DD	HANDBRAKE	O		O		Cause: Handbrake input is active.

※ T = Traction P = PUMP M = MASTER S= SLAVE

CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
221	DD	HANDBRAKE	O		O		Troubleshooting: - Check that handbrake is not active by mistake. - Check the SR/HB input state through the TESTER function. - Check the wirings. - Check if there are failures in the microswitches. - If the problem is not solved, replace the logic board.
222	DE	SEAT MISMATCH	O				Cause: This alarm can appear only in a Traction + Pump configuration or in a multimotor one. There is an input mismatch between the traction controller and the pump controller relatively to the TILLER/SEAT input (A1): 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.
		SEAT MISMATCH			O		Cause: This alarm can appear only in a Traction + Pump configuration. There is an input mismatch between the traction controller and the pump controller relatively to the 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	DF	MC-EF COIL SHOR.	O				Cause: This alarm occurs when there is an overload of the MC driver(A12) and EB driver(A2). As soon as the overload condition disappears, the alarm will be removed automically by releasing and then enabling a travel demand. Troubleshooting: - Check the conncections between the controller outputs and the loads. - Collect information about characteristics of the coils connected to the two drivers and ask for assistance to a HCE technician 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.
		COIL SHOR. MC			O		Cause: This alarm occurs when an overload of the MC driver (output NMC A16) occurs.

※ T = Traction P = PUMP M = MASTER S= SLAVE

CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
223	DF	COIL SHOR. MC			O		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 HCE technician 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	E0	WAITING FOR NODE	O		O		Cause: The controller receives from the CAN bus 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 CAN bus is in fault condition.
226	E2	VACC OUT RANGE	O		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	E3	HW FAULT XX	O				Cause: At start-up, some hardware circuit intended to enable and disable the power bridge or the LC driver (output A12) is found to be faulty. The hexadecimal value “XX” facilitates HCE technicians debugging the problem. Troubleshooting: This type of fault is related to internal components. Replace the logic board.
		HW FAULT XX			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 HCE technicians debugging the problem. Troubleshooting: This type of fault is related to internal components. Replace the logic board.
		OUT MISMATCH XX		O		O	Cause: This is a safety related test. Supervisor μC has detected that master μC is driving the traction motor in a wrong way (not corresponding to the operator request). The hexadecimal value “XX” facilitates HCE technicians debugging the problem.

※ T = Traction P = PUMP M = MASTER S= SLAVE

CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
227	E3	OUT MISMATCH XX		O		O	Troubleshooting: - Checks the matching of the parameters between Master and Supervisor. - Ask for assistance to a HCE technician. - If the problem is not solved, replace the logic board.
228	E4	CHAT TIME	O				Cause: The chat time has expired. Troubleshooting: To activate traction or pump request
		TILLER OPEN			O		Cause: Tiller/seat input has been inactive for more than 30 seconds. Troubleshooting: - Activate the tiller/seat input. - Check the tiller/seat input state through the TESTER function. - Check the wirings. - Check if there are failures in the microswitches. - If the problem is not solved, replace the logic board.
229	E5	HW FAULT EB.XX	O		O		Cause: At start-up, the hardware circuit dedicated to enable and disable the EB driver (output A4) is found to be faulty. The hexadecimal value “XX” facilitates HCE technicians debugging the problem. Troubleshooting: This type of fault is not related to external components. Replace the logic board.
		NO CAN WR MSG.XX		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).
230	E6	LC COIL OPEN	O				Cause: This fault appears when no load is connected between the NMC output A12 and the positive voltage (for example the KEY voltage). 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.
		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.

※ T = Traction P = PUMP M = MASTER S= SLAVE

CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
230	E6	LC COIL OPEN			O		- If the alarm is still present, than the problem is inside the logic board; replace it.
		SOFTWARE ERROR		O		O	Several are the causes that generate this alarm and are related to the checks done by the SW : for instance CAN bus off, bad EEPROM read/write,…
232	E8	CONT. DRV. EV	O		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	E9	POWERMOS SHORTED	O		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	EA	DRV. SHOR. EV	O		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. - If the problem is not solved, replace the logic board.
235	EB	CTRAP THRESHOLD	O				Cause: This alarm occurs when a mismatch is detected between the setpoint for the overcurrent detection circuit and the feedback of the actual threshold value. Troubleshooting: The failure lies in the controller hardware. Replace the logic board.
236	EC	CURRENT GAIN	O		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 HCE technician in order to do the adjustment procedure of the current gain parameters. "
237	ED	ANALOG INPUT	O	O	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.

※ T = Traction P = PUMP M = MASTER S= SLAVE

CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
238	EE	HW FAULT EV.	O		O		Cause: At start-up, the hardware circuit dedicated to enable and disable the EV drivers is found to be faulty. The hexadecimal value “XX” facilitates HCE technicians debugging the problem. Troubleshooting: This type of fault is not related to external components. Replace the logic board.
239	EF	CONTROLLER MISM.	O	O	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 HCE technician in order to verify that the firmware is correct.
240	F0	EVP DRIVER OPEN	O		O		Cause: The EVP driver 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		O	Cause: This is a safety related test. Supervisor μC has detected that master μC is driving the pump motor in a wrong way (not corresponding to the operator request). Troubleshooting: - Checks the matching of the parameters between Master and Supervisor. - Ask for assistance to a HCE technician. - If the problem is not solved, replace the logic board
241	F1	COIL SHOR. EVAUX	O				Cause: This alarm occurs when an overload of the EV drivers occurs. Troubleshooting: - Check the connections between the controller outputs and the loads. - Collect information about characteristics of the coils connected to the drivers and ask for assistance to a HCE technician 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.
		SP MISMATCH PUMP		O		O	Cause: This is a safety related test. The supervisor μC has detected a mismatch in the DC-pump speed setpoint with respect to the master μC.

※ T = Traction P = PUMP M = MASTER S= SLAVE

CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
241	F1	SP MISMATCH PUMP		O		O	Troubleshooting: - Check the matching of the parameters between master and supervisor. - Ask for assistance to a HCE technician. - If the problem is not solved, replace the logic board
242	F2	OPEN COIL EV.	O				Cause: This fault appears when no load is connected between one or more EV outputs and the positive terminal PEV (pin A3). Troubleshooting: - Check the coils. - Check the wiring. - If the problem is not solved, replace the logic board.
		OPEN COIL EV.			O		Cause: This fault appears when no load is connected between the NAUX1 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		O	Cause: This is a safety related test. The supervisor μC has detected a mismatch in the speed setpoint with respect to the master μC. The hexadecimal value "XX" facilitates HCE technicians debugging the problem. Troubleshooting: - Check the matching of the parameters between master and supervisor. - Ask for assistance to a HCE technician. - If the problem is not solved, replace the logic board
243	F3	THROTTLE PROG.	O				Cause: A wrong profile has been set in the throttle profile. Troubleshooting: Set properly the throttle-related parameters (see paragraph 9.8).
244	F4	WARNING SLAVE	O		O		Cause: Warning on supervisor uC. Troubleshooting: Connect the Console to the supervisor uC and check which alarm is present.
245	F5	IQ MISMATCHED	O		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 HCE technician in order to do the correct adjustment of the motor parameters.
246	F6	EB. DRIV. OPEN	O		O		Cause: The EB coil driver is not able to drive the load. The device itself or its driving circuit is damaged.

※ T = Traction P = PUMP M = MASTER S= SLAVE

CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
246	F6	EB. DRIV. OPEN	O		O		Troubleshooting: This type of fault is not related to external components. Replace the logic board.
247	F7	DATA ACQUISITION	O		O		Cause: Controller in calibration state. Troubleshooting: The alarm ends when the acquisition is done.
248	F8	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	F9	MAINTENANCE HOUR	O				This alarm occurs when the switch input ENABLE MAINTENANCE, read by the ACE0 and sent via CAN to the ACE2, is closed. Troubleshooting : Release the switch input ENABLE MAINTENANCE.
		CHECK UP NEEDED			O		Cause: This is a warning to point out that it is time for the programmed maintenance. Troubleshooting: Turn on the CHECK UP DONE option after that the maintenance service.
250	FA	THERMIC SENS. KO	O		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	FB	WRONG SET BAT.	O				Cause: At start-up, the controller checks the battery voltage (measured at the KEY input A10) 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 HCE technician. - Through the TESTER function, check that the KEY VOLTAGE reading shows the same value as the key voltage measured with a voltmeter on pin A10. If it does not match, then modify the ADJUST BATTERY parameter according to the value read by the voltmeter. - Replace the battery.

※ T = Traction P = PUMP M = MASTER S= SLAVE

CODE	HEX	ALARM	TM	TS	PM	PS	DESCRIPTION
251	FB	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 HCE technician. - 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	FC	WRONG ZERO	O		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.
253	FD	FIELD ORIENT. KO	O		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 HCE technician in order to do the correct adjustment of the motor parameters.
254	FE	EB. DRIV.SHRT.	O		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.

3) 36 V, 24 V

※ E =EPS   M = MASTER

CODE	HEX	ALARM	EM	DESCRIPTION
6	06	SERIAL ERROR #1	O	- Cause: Main uC and Slave uC communicate via a local serial interface. This alarm occurs when the slave uC does not receive the communication from the main uC through this serial interface. - Remedy: It is necessary to replace the Controller.
13	0D	EEPROM KO	O	- Cause: It occurs if a test to write and read one location in EEPROM fails. The SW expects to read the written value. It occurs also when the hour counter gives different values between the three redundant locations in which it is recorded. It occurs also when the busy bit of the EEPROM does not rise within 12msec. - Remedy: It is necessary to replace the Controller.
16	10	LOGIC FAILURE #4	O	- Cause: This alarm occurs in the rest state if the output of the voltage amplifier of the phase Vu-Vw have a drift larger than +/-0.25V. - Remedy: It is necessary to replace the controller.
17	11	LOGIC FAILURE #3	O	- Cause: This alarm occurs in the rest state if the output of the voltage amplifier of the phase Vv-Vu have a drift larger than +/-0.25V. - Remedy: It is necessary to replace the controller.
18	12	LOGIC FAILURE #2	O	- Cause: This alarm occurs when the real voltage between phases U and W of the motor is different from the desired. - Remedy: It is necessary to replace the Controller.
19	13	LOGIC FAILURE #1	O	- Cause: This alarm occurs when the real voltage between phases U and V of the motor is different from the desired. - Remedy: It is necessary to replace the Controller.
32	20	VMN NOT OK	O	- Cause: This alarm occurs in the initial rest state after key on if the outputs of the motor voltage amplifiers are not in the window from 2.2 to 2.8Vdc. - Remedy: It is necessary to replace the controller.
48	30	MAIN CONT. OPEN	O	- Cause: This alarm occurs only when the setting CAN BUS is PRESENT. Then the eps-ac WG waits for a via CAN information that the traction controller has closed the main contactor. If this information lacks more than about 1.5secs, this alarm occurs. - Remedy: Find, on the traction controller, the reason for keeping the main contactor open.
53	35	STBY I HIGH	O	- Cause: This alarm occurs two ways: 1) In the initial rest state after key on, if the outputs of the current amplifiers are not comprised in the window 2.2 to 2.8Vdc. 2) After the initial diagnosis this alarm occurs when the outputs of the current amplifiers at rest, have a drift larger than +/-0.15V. - Remedy: It is necessary to replace the controller.
61	3D	HIGH TEMPERATURE	O	- Cause: This alarm occurs if either the temperature of the controller base plate overtakes 75 degrees or the thermal sensor on the current shunt measures a temperature outside the range –45 to +160 degrees.

※ E =EPS M = MASTER

CODE	HEX	ALARM	EM	DESCRIPTION
61	3D	HIGH TEMPERATURE	O	- Remedy: If the cause is a temperature higher 75 degrees, improve the cooling of the controller; otherwise it is necessary to replace the controller.
65	41	MOTOR TEMPERAT.	O	- Cause: This alarm occurs only when DIAG MOTOR TEMP is on and the thermal sensor inside the motor measures a temperature higher than 150 degrees. It occurs also when trying to acquire the motor resistance with a temperature in the motor higher than 150 degree (still with DIAG MOTOR TEMP to ON). - Remedy: Check the thermal sensor in the motor is right working. If it is, improve the cooling of the motor.
70	46	HIGH CURRENT	O	- Cause: This alarm occurs if the circuit to limit via hardware the current in the motor is always active. - Remedy: Check the motor is suited to work with the eps-ac WG (not oversized). Otherwise it is necessary to replace the Controller.
71	47	POWER FAILURE #3	O	- Cause: This alarm occurs when the current in the phase W of the motor is zero and the motor is commanded for moving. - Remedy: Check the power fuse is OK. Check the battery positive arrives to the controller. Check the continuity of the motor cable phase W. Otherwise it is necessary to replace the Controller.
72	48	POWER FAILURE #2	O	- Cause: This alarm occurs when the current in the phase V of the motor is zero and the motor is commanded for moving. - Remedy: Check the power fuse is OK. Check the battery positive arrives to the controller. Check the continuity of the motor cable phase V. Otherwise it is necessary to replace the Controller.
83	53	BAD ENCODER SIGN	O	- Cause: It occurs when the ENC SPEED in the tester menu has opposite sign than FREQUENCY in the tester menu. - Remedy: Swap the channels of the encoder (CNB#8 with CNB#7).
84	54	STEER SENSOR KO	O	- Cause: This alarm occurs if the command potentiometer (CPOC1 on CNA#9 or CPOC2 on CNA#8) changes with a jerk larger than MAX SP SLOPE. This alarm is used to catch a discontinuity in the voltages of the command potentiometer. - Remedy: Change the twin pot.
85	55	STEER HAZARD	O	- Cause: This is just a warning to inform that the steering controller is limiting the angle in the steering direction. No speed reduction occurs on the traction.
99	63	INPUT ERROR #1	O	- Cause: It occurs when the voltage on CNA#4 (NK1: Lower Potential Terminal of the Safety Contacts is higher than 12 V before to turn the safety contacts closed. - Remedy: When the safety contacts are open, the voltage on CNA#4 is expected to be close to 0 Vdc and this is independent from whether the safety contacts are connected to a plus battery or to a minus battery. In the first case (safety contacts connected to a plus battery), when the safety contacts are open, CNA#4 is connected to a minus battery through a load. Only a harness mistake may connect NK1 to a higher than 12 V voltage.
207	CF	SL. LATERAL OUT	O	- Cause: The slave uC makes its own diagnosis on the antenna errors. The slave uC raises this alarm if the truck is lock-on and at least one antenna's error overtakes a fixed threshold of 100mm.

※ E =EPS M = MASTER

CODE	HEX	ALARM	EM	DESCRIPTION
207	CF	SL. LATERAL OUT	O	- Remedy: This alarm should never occur because the main uC must discovery a lateral out condition early than the slave uC. So, replace the controller in case of SL. LATERAL OUT alarm.
208	D0	SL. ANT. MISSING	O	- Cause: The slave uC makes its own diagnosis on the communication with the antennas via local CAN Bus. This alarm occurs when the slave uC is not able to communicate with one antenna. - Remedy: Try to activate the communication with the FWD and REV antenna using the hand-set connected to the eps-ac WG. Replace the antenna that it is not possible to communicate with.
209	D1	ANTENNA FAILURE	O	- Cause: This alarm occurs when one antenna is alarmed. - Remedy: Try to activate the communication with the FWD and REV antenna using the hand-set connected to the eps-ac WG. Replace the alarmed antenna.
213	D5	SL CENTERING	O	- Cause: This alarm occurs when an automatic centering is requested from steady state condition. Then the slave uC expects the angle measured on the steered wheel goes into a window from -20 to +20 degrees before the traction turns moving. In case the traction turns moving with a steered wheel outside that window, this alarm occurs. - Remedy: It is necessary to replace the controller.
214	D6	SL EPS NOT ALL.	O	- Cause: This alarm occurs at key on: a) when the initial automatic centering is expected. AND b) the slave uC detects the encoder is at rest longer than two secs AND c) within this two secs delay, the main uC does not communicate that the automatic centering was successfully ended. - Remedy: It is necessary to replace the controller.
215	D7	CAN BUS KO SL.	O	- Cause: This alarm occurs when the slave uC does not receive any CAN Bus frame from the main uC. - Remedy: It is necessary to replace the controller.
216	D8	MICRO SLAVE #8	O	- Cause: It occurs when the encoder counting of the main uC is not matched with the encoder counting of the slave uC. - Remedy: It is necessary to replace the controller.
218	DA	CLOCK PAL NOT OK	O	- Cause: The main uC sends an analog signal towards the slave uC to reset the slave uC on demand. When the slave uC detects this analog signal external to a window from 2.2 to 2.8 and not in the range to generate the reset on demand, the slave uC raises this alarm. - Remedy: It is necessary to replace the controller.
219	DB	STEPPER MOT MISM	O	- Cause: This alarm occurs if the frequency and the amplitude of the voltages from the stepper motor lines are mismatched in between (i.e. the voltage from the D and Q line of the stepper motor have high amplitude but with very low frequency). In normal condition when the amplitude of the stepper motor lines increases, the frequency of the stepper motor lines must increase too. This alarm occurs also if a stepper motor line (D or Q) is short circuited to minus battery. - Remedy: Check if a stepper motor line is short circuited to minus battery. Otherwise it is necessary to replace the controller.

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CODE	HEX	ALARM	EM	DESCRIPTION
220	DC	MOTOR LOCKED	O	- Cause: This alarm occurs if the current in the steering motor stays higher than 90% of the maximum current longer than 1 sec. - Remedy: Search for a mechanical problem locking the motor. To make easier the fault catching, set DEBUG OUTPUT to level 11.
221	DD	MICRO SLAVE #4	O	- Cause: It occurs in one of the following conditions: (Open loop application only) If the slave uC detects the stator voltage phasor rotates in the opposite direction respect to the sign of the stepper motor speed, this alarm occurs. (Closed loop application only) If the slave uC detects the stator voltage phasor rotates in the opposite direction respect to the commanded position, this alarm occurs. (i.e. slave uC detects the actual sign of the frequency in the motor opposes the sign that the frequency should have according the command). - Remedy: It is necessary to replace the controller.
222	DE	FB SENS LOCKED	O	- Cause: This alarm occurs only when option ENCODER CONTROL is off. Then, if the encoder is frozen and the steering motor is demanded for moving at higher than 40% of the maximum motor speed, this alarm occurs. - Remedy: Check the encoder is right working. This alarm may be masked (for the trouble shooting activity only) by setting special adjustment DEBUG OUTPUT to level 11 and recycling the key. Then it is possible to verify the reading ENC SPEED is frozen or not meanwhile the steering motor is turning.
223	DF	JERKING FB	O	- Cause: This alarm occurs if the feedback potentiometer changes with a jerk larger than 0.3V in 16msec. This alarm is used to catch a discontinuity in the voltages of the feedback potentiometer. - Remedy: Change the feedback potentiometer.
225	E1	CURRENT GAIN	O	- Cause: This alarm occurs when the parameters to compensate for the gain of the current amplifiers (ADJUSTMENT #03 and ADJUSTMENT #04) have the default values (i.e. the maximum current was not regulated). - Remedy: It is necessary to send the controller to Zapi to perform the maximum current regulation.
226	E2	NO SYNC	O	- Cause: Every 16msec, inside the code cycle, the main uC rises and then lowers an input for the slave uC (SYNC). When the slave uC detects no edge for more than 100 msec on this input, this alarm occurs. This is just a watch dog function: when the main uC does not execute the code cycle it does not update the SYNC signal and the slave uC cuts off the steer and traction. - Remedy: It is necessary to replace the controller.
227	E3	SLAVE COM. ERROR	O	- Cause: Main uC and Slave uC communicate via a local serial interface. This alarm occurs when the main uC does not receive the communication from the slave uC through this serial interface. - Remedy: It is necessary to replace the controller.

※ E =EPS M = MASTER

<table>
<tr><th>CODE</th><th>HEX</th><th>ALARM</th><th>EM</th><th>DESCRIPTION</th></tr>
<tr><td>228</td><td>E4</td><td>POSITION ERROR</td><td>O</td><td>
This alarm occurs for an error in the redundant test of the feedback sensors. Here we have an encoder and two toggle switches. This alarm occurs whether the sector (toggle switches configuration) and the encoder counting are not matched. The sector is provided with the FEEDBACK SECTOR reading in the tester menu ; the encoder counting is provided with the WHEEL ANGLE reading in the tester menu.
<table>
<tr><th>WHEEL ANGLE (degrees)</th><th>Admitted SECTOR</th><th>Admitted PEEDBACK SECTOR</th></tr>
<tr><td>-22 to +22</td><td>1^{st} or 4^{th}</td><td>3.13V or 1.88V</td></tr>
<tr><td>+23 to +67</td><td>1^{st}</td><td>3.13V</td></tr>
<tr><td>+68 to +112</td><td>1^{st} or 2^{nd}</td><td>3.13V to 4.39V</td></tr>
<tr><td>+113 to +157</td><td>2^{nd}</td><td>4.39V</td></tr>
</table>
<table>
<tr><th>WHEEL ANGLE (degrees)</th><th>Admitted SECTOR</th><th>Admitted PEEDBACK SECTOR</th></tr>
<tr><td>+158 to -158</td><td>2^{nd} or 3^{rd}</td><td>4.39V or 0.62V</td></tr>
<tr><td>-157 to -113</td><td>3^{rd}</td><td>0.62V</td></tr>
<tr><td>-112 to -68</td><td>3^{rd} or 4^{th}</td><td>0.62V to 1.88V</td></tr>
<tr><td>-67 to -23</td><td>4^{th}</td><td>1.88V</td></tr>
</table>
When the FEEDBACK SECTOR and WHEEL ANGLE don't meet the above correspondence, an alarm POSITION ERROR occurs in less than 100msec. If the alarm occurs when installing a new controller, be sure the AUX FUNCTION 11 corresponds to the toggle switches arrangement you have and SET ENC AT 360 was correctly set.
</td></tr>
<tr><td>229</td><td>E5</td><td>LOOK. FOR PATH</td><td>O</td><td>- Cause: This is just a warning to inform that the truck is acquiring the wire in WG mode. The truck speed will be reduced properly.</td></tr>
<tr><td>230</td><td>E6</td><td>PATH OUT</td><td>O</td><td>- Cause: This alarm occurs in WG mode if the truck is lock-on and at least one antenna looses the field.

- Remedy: Check the wire is still present under the truck, there is the current in the inductive wire and the antennas are right working.</td></tr>
<tr><td>231</td><td>E7</td><td>LATERAL OUT</td><td>O</td><td>- Cause: This alarm occurs in WG mode if the truck is lock-on and at least one antenna’s error overtakes the thresholds set with MAX FWD ERR, MIN FWD ERR, MAX REV ERR and MIN REV ERR. In the steered wheel direction, only the error in the FWD antenna is used to raise this alarm.

- Remedy: This alarm occurs for too wide waves around the wire in lock-on mode. Check if this is your case. To reduce the amplitude of these waves try different setting LEAD and LAG FB REGULATION (on both antennas and eps-ac WG) and try different settings for WG FWD GAIN, WG FWD POT, WG REV GAIN, WG REV POT, WG REV ANT in the eps-ac WG.</td></tr>
</table>

※ E =EPS M = MASTER

<table>
<tr><th>CODE</th><th>HEX</th><th>ALARM</th><th>EM</th><th>DESCRIPTION</th></tr>
<tr><td>232</td><td>E8</td><td>ANGLE</td><td>O</td><td>When the steered wheel angle is higher than 2 times the limiting threshold, an ANGLE alarm occurs. This means the alarm occurs for a steered wheel angle higher than 2*(0.75, 1, 1.25, 1.5, 1.75, 2, 2.5, 3, 4, 8) degrees.
<table>
<tr><th>MIN ANG LOCK ON
MAX ANG LOCK ON
(level)</th><th>ANGLE LIMITED
TO
(degrees)</th><th>LOSING STRAIGHT
THRESHOLD
(degrees)</th><th>ANGLE ALARM
THRESHOLD
(degrees)</th><th>ANGLE ALARM
THRESHOLD
(feedback enc △V)</th></tr>
<tr><td>0</td><td>0.75</td><td>1.125</td><td>1.5</td><td>21mV</td></tr>
<tr><td>1</td><td>1</td><td>1.5</td><td>2</td><td>28mV</td></tr>
<tr><td>2</td><td>1.25</td><td>1.875</td><td>2.5</td><td>35mV</td></tr>
<tr><td>3</td><td>1.5</td><td>2.25</td><td>3</td><td>42mV</td></tr>
<tr><td>4</td><td>1.75</td><td>2.625</td><td>3.5</td><td>49mV</td></tr>
<tr><td>5</td><td>2</td><td>3</td><td>4</td><td>56mV</td></tr>
<tr><td>6</td><td>2.5</td><td>3.75</td><td>5</td><td>69mV</td></tr>
<tr><td>7</td><td>3</td><td>4.5</td><td>6</td><td>83mV</td></tr>
<tr><td>8</td><td>4</td><td>6</td><td>8</td><td>111mV</td></tr>
<tr><td>9</td><td>8</td><td>12</td><td>16</td><td>222mV</td></tr>
</table></td></tr>
<tr><td>233</td><td>E9</td><td>LOSING PATH</td><td>O</td><td>When at least one of the antennas has a lateral drift larger than 3/4 of the limit specified with MIN FWD ERR, MAX FWD ERR, MIN REV ERR, MAX REV ERR a LOSING PATH warning with a speed reduction request occurs. This means the warning occurs for a lateral drift higher than 0.75*(24, 28, 32, 36, 40, 45, 50, 56, 62, 68) mm.
<table>
<tr><th>MIN FWD EPR
MAX FWD EPR
MIN REV EPR
MAX REV EPR
(level)</th><th>LOSING PATH
THRESHOLD
(millimetres)</th><th>LATERAL OUT
ALRAM
THRESHOLD
(millimetres)</th><th>LATERAL OUT
ALARM
THRESHOLD
(side error fwd)
(side error rev)</th></tr>
<tr><td>0</td><td>18</td><td>24</td><td>24</td></tr>
<tr><td>1</td><td>21</td><td>28</td><td>28</td></tr>
<tr><td>2</td><td>24</td><td>32</td><td>32</td></tr>
<tr><td>3</td><td>27</td><td>36</td><td>36</td></tr>
<tr><td>4</td><td>30</td><td>40</td><td>40</td></tr>
<tr><td>5</td><td>33.75</td><td>45</td><td>45</td></tr>
<tr><td>6</td><td>37.5</td><td>50</td><td>50</td></tr>
<tr><td>7</td><td>42</td><td>56</td><td>56</td></tr>
<tr><td>8</td><td>46.5</td><td>62</td><td>62</td></tr>
<tr><td>9</td><td>51</td><td>68</td><td>68</td></tr>
</table></td></tr>
</table>

※ E =EPS   M = MASTER

<table>
<tr><th>CODE</th><th>HEX</th><th>ALARM</th><th>EM</th><th>DESCRIPTION</th></tr>
<tr><td>234</td><td>EA</td><td>ANGLE</td><td>O</td><td>When the steered wheel angle is higher than 1.5 times the limiting threshold, a LOSING STRAIGHT warning with a speed reduction request occurs. This means the warning occurs for a steered wheel angle higher than 1.5*(0.75, 1, 1.25, 1.5, 1.75, 2, 2.5, 3, 4, 8) degrees.
<table>
<tr><th>MIN ANG LOCK ON
MAX ANG LOCK ON
(level)</th><th>ANGLE LIMITED
TO
(degrees)</th><th>LOSING STRAIGHT
THRESHOLD
(degrees)</th><th>ANGLE ALARM
THRESHOLD
(degrees)</th><th>ANGLE ALARM
THRESHOLD
(feedback enc △V)</th></tr>
<tr><td>0</td><td>0.75</td><td>1.125</td><td>1.5</td><td>21mV</td></tr>
<tr><td>1</td><td>1</td><td>1.5</td><td>2</td><td>28mV</td></tr>
<tr><td>2</td><td>1.25</td><td>1.875</td><td>2.5</td><td>35mV</td></tr>
<tr><td>3</td><td>1.5</td><td>2.25</td><td>3</td><td>42mV</td></tr>
<tr><td>4</td><td>1.75</td><td>2.625</td><td>3.5</td><td>49mV</td></tr>
<tr><td>5</td><td>2</td><td>3</td><td>4</td><td>56mV</td></tr>
<tr><td>6</td><td>2.5</td><td>3.75</td><td>5</td><td>69mV</td></tr>
<tr><td>7</td><td>3</td><td>4.5</td><td>6</td><td>83mV</td></tr>
<tr><td>8</td><td>4</td><td>6</td><td>8</td><td>111mV</td></tr>
<tr><td>9</td><td>8</td><td>12</td><td>16</td><td>222mV</td></tr>
</table></td></tr>
<tr><td>235</td><td>EB</td><td>WRONG ANT. RECEP</td><td>O</td><td>- Cause: This alarm occurs when at least one antenna has a wrong stuffing sequence of the CAN Bus frame. the stuffing sequence is used to discover whether the program of at least one antenna is frozen.

- Remedy: It is necessary to replace the antennas.</td></tr>
<tr><td>236</td><td>EC</td><td>ANT. MISSING</td><td>O</td><td>- Cause: This alarm occurs when at least one antenna does not communicate with the eps-ac WG via the local CAN Bus.

- Remedy: Try to activate the communication with the FWD and REV antenna
using the hand-set connected to the eps-ac WG. Replace the antenna that it is not possible to communicate with.</td></tr>
<tr><td>237</td><td>ED</td><td>WAITING DATA</td><td>O</td><td>- Cause: This warning occurs only if CAN BUS is PRESENT. At key-on the eps-ac WG asks to the traction controller to send a list of parameters via CAN Bus. From the request until the parameters are correctly relieved, this warning occurs. The steer is not activated yet and the safety relays remain open when this warning is present.</td></tr>
<tr><td>238</td><td>EE</td><td>EPS NOT ALIGNED</td><td>O</td><td>- Cause: This is a real alarm that cut off the traction. It occurs at the initial alignment if the straight-ahead condition is not matched within 6sec. Throughout this 6secs delay, the steer is not activated yet, the safety relays are open and the traction is stopped.</td></tr>
<tr><td>239</td><td>EF</td><td>WAITING FOR TRAC</td><td>O</td><td>- Cause: At key-on the eps-ac WG needs an assent from the traction controller to close the safety contacts and to turn onto operational mode. Until this assent is not relieved, this warning occurs. The steer is not activated yet and the safety relays remain open when this warning is present.</td></tr>
<tr><td>241</td><td>F1</td><td>ENCODER ERROR</td><td>O</td><td>- Cause: It occurs when ENCODER CONTROL is set ON and the real frequency does not pursuit the commanded frequency

- Remedy: This condition is several times due to either, a mismatching between the Encoder resolution used in the SW and the real encoder resolution, or a wrong connection between the two encoder channels. In this latest case swap the channels of the encoder (CNB#8 with CNB#7).</td></tr>
</table>

※ E =EPS M = MASTER

CODE	HEX	ALARM	EM	DESCRIPTION
242	F2	Q LINE SENSOR KO	O	- Cause: This alarm occurs when the mean voltage on the Quadrature line of the stepper motor (connection CNA#8) is not null: the voltage on every stepper motor line is a sine wave with null mean voltage. - Remedy: Check the continuity of the stepper motor connections. In particular the resistance between CNA#8 and the minus battery (with the stepper motor at rest) is expected being very low (close to 30 ohms).
243	F3	D LINE SENSOR KO	O	- Cause: This alarm occurs when the mean voltage on the Direct line of the stepper motor (connection CNA#9) is not null: the voltage on every stepper motor line is a sine wave with null mean voltage. - Remedy: Check the continuity of the stepper motor connections. In particular the resistance between CNA#9 and the minus battery (with the stepper motor at rest) is expected being very low (close to 30 ohms).
244	F4	GAIN EEPROM KO	O	- Cause: The parameters to compensate for the gain of the current amplifiers (ADJUSTMENT #03 and ADJUSTMENT #04) are recorded in a not volatile memory (eeprom) with a redundant handling. In fact every adjustment is recorded in three eeprom locations. If the values in these three locations are different in between this alarm occurs. - Remedy: It is necessary to send the controller to Zapi to execute the maximum current regulation.
245	F5	DATA ACQUISITION	O	- Cause: This alarm occurs two ways: 1) When hardware setting AUTOTEACHING is turned On and the key recycled. Then, during the consequent autoteaching procedure, a DATA ACQUISITION alarm occurs 2) When acquiring the motor resistance or when adjusting the parameters to compensate for the gain of the current amplifiers (maximum current factory adjusted). - Remedy: Recycle the key.
246	F6	MICRO SLAVE KO	O	- Cause: In stepper motor application, this alarm occurs if the main uC is detecting a direction of the stepper motor not matched with the one that the slave uC is detecting. In closed loop application, this alarm occurs if the main uC is detecting a direction of the steering error not matched with the one that the slave uC is detecting.
246	F6	MICRO SLAVE KO	O	Furthermore, this alarm occurs also if the main uC is detecting no steering limitation meanwhile the slave uC is detecting e steering limitation. - Remedy: It is necessary to replace the controller.
247	F7	CAN BUS KO	O	- Cause: This alarm occurs only when the setting CAN BUS is PRESENT. Then the eps-ac WG must receive the event messages from the traction controller. If these messages lack more than about 1sec, this alarm occurs. - Remedy: Check the CAN Bus communication system and analyse the frames from the traction controller to the steer controllers.

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CODE	HEX	ALARM	EM	DESCRIPTION
248	F8	S.P OUT OF RANGE	O	- Cause: This alarm occurs for a fault on the command potentiometer (CPOC1 on CNB#3, CPOC2 on CNB#9). When a single command pot is chosen, the alarm occurs if its wiper exits the range from 0.8Vdc to 4.2Vdc. When the twin pot is chosen, the alarm occurs if the sum of the two wiper voltages (CPOC1+CPOC2) exits the range from 4.5Vdc to 5.5Vdc. - Remedy: Check the connections of the potentiometer. This alarm occurs when one connection of the command potentiometer is broken.
249	F9	F.B OUT OF RANGE	O	- Cause: This alarm occurs for a fault on the feedback potentiometer (CPOT on CNA#11). This alarm occurs if CPOT exits the range from 0.3Vdc to 4.7Vdc. - Remedy: Check the connections of the feedback potentiometer. This alarm occurs when one connection of the feedback potentiometer is broken.
250	FA	MICRO SLAVE	O	- Cause: It occurs when the information on the status bus between the main uC and the slave uC is frozen to the 0xFF value (the slave uC does not update the status bus configuration). - Remedy: It is necessary to replace the Controller.
251	FB	KM OPEN	O	- Cause: This alarm occurs if the slave uC detects the safety contact, of the main uC, open when expected being closed. - Remedy: It is necessary to replace the controller.
252	FC	KS OPEN	O	- Cause: This alarm occurs if the main uC detects the safety contact, of the slave uC, open when expected being closed. - Remedy: It is necessary to replace the controller.
253	FD	KM CLOSED	O	- Cause: This alarm occurs at key on if the slave uC detects the safety contact, of the main uC, closed prior to be commanded. - Remedy: This alarm occurs if the connection CNA#5 (K1) is around a voltage of 12 Vdc when switching on the key. In fact, when the safety contacts are open, K1 is expected being connected to a battery voltage (not 12 V). Search for a harness problem or replace the controller.
254	FE	KS CLOSED	O	- Cause: This alarm occurs if the main uC detects the safety contact, of the slave uC, closed prior to be commanded. - Remedy: This alarm occurs if the connection CNA#4 (NK1) is around a voltage of 12 Vdc when switching on the key. In fact, when the safety contacts are open, NK1 is expected being connected to a minus battery voltage (not 12 V). Search for a harness problem or replace the controller.

9. BATTERY CHARGER

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

1) BASIC INFORMATION

(1) What is charger

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

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

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

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

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

④ It prevents from under charging and overcharging.

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

(2) Notice on caring chargers

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

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

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

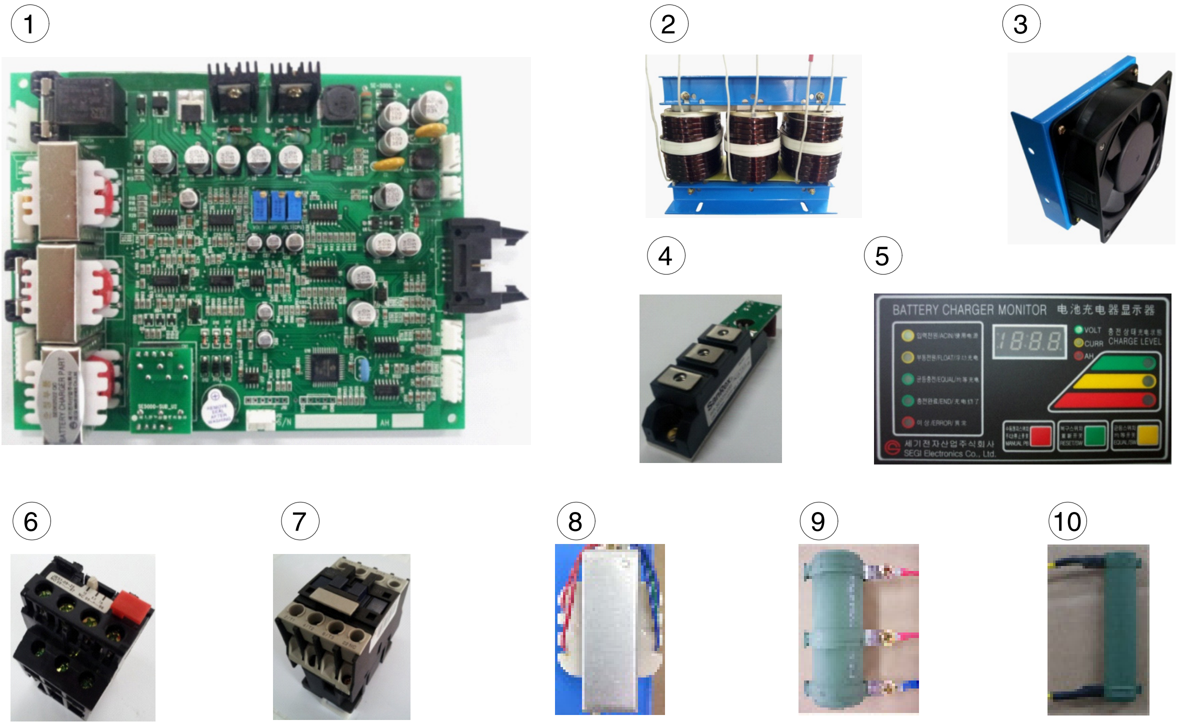
④ Check the electrolyte of the battery every week and provide distilled water immediately if it is required. (Electrolyte has to be provided between 10~12 ㎜ level on the positive plate inside storage battery)

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

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

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

(3) Names of each part (independent items)



22B9BAT30

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

2) CHARGER INSTALLATION METHOD

(1) Location for charger installation

① Dry and well ventilated place.

② No inflammable and B7 fire are near by.

③ Safe place where no collision possibility with people or equipment is.

(2) Check points before installing charger

① Enough capacity of AC input power source to operate charger.

② Standard electric wire for power source by capacity.

(3) Table for capacity of charger input cable

<table>
<tr><th>48 V battery</th><th>Capacity of cable</th><th>Input voltage</th><th>Remarks</th></tr>
<tr><td>200-365 AH</td><td>4P - 2.5 mm^2</td><td rowspan="10">Based on
3Ø380 V
3Ø440 V</td><td rowspan="10">For 3Ø220V, one step higher capacity cable should be used.
(2.5 mm^2 → 4mm^2)</td></tr>
<tr><td>400-580 AH</td><td>4P - 4 mm^2</td></tr>
<tr><td>600-800 AH</td><td>4P - 6 mm^2</td></tr>
<tr><td>850-1000 AH</td><td>4P - 10 mm^2</td></tr>
<tr><td>24 V battery</td><td>-</td></tr>
<tr><td>200-600 AH</td><td>4P - 2.5 mm^2</td></tr>
<tr><td>700-1000 AH</td><td>4P - 4 mm^2</td></tr>
<tr><td>80V battery</td><td>-</td></tr>
<tr><td>500-600 AH</td><td>4P - 6 mm^2</td></tr>
<tr><td>700-800 AH</td><td>4P - 10 mm^2</td></tr>
</table>

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.

22B9BAT01

· 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.

BOP7BAT02

(2) Equalized charging

① Equalized charging is

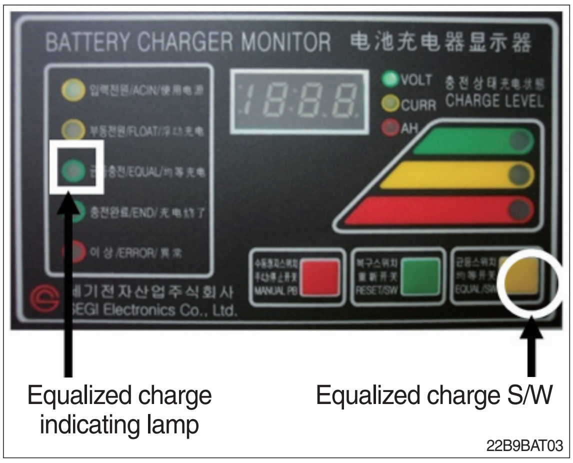
Equalized charging is to correct the battery when it does not normally perform its functions as the voltage differences are too big between cells of a battery.

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.

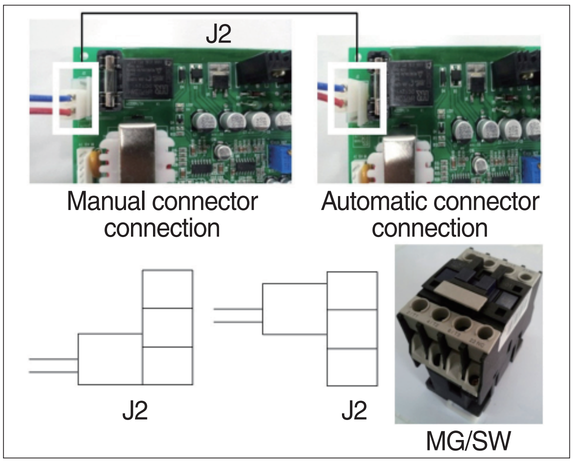
※ When the green charging condition lamp is on (over 85% charged), the equalized charging switch is locked that it does not operate even pushing the button.



(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)



22B9BAT04

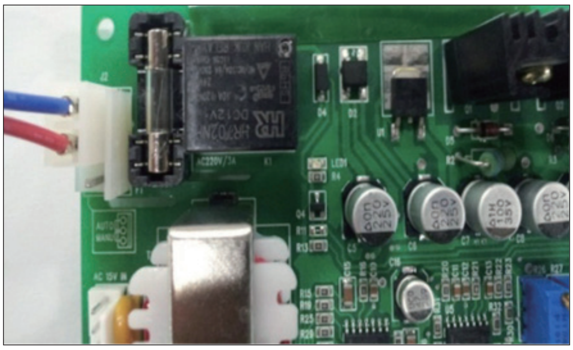
(4) Checking charging voltage soft start function (Refer to the monitor)

① Plug it into a manual connector and input after 5 sec., a floating charge, charging status red LED lights up.
② After 15 sec., charging status yellow LED lights up.
③ After a green LED lights up, if measured voltage comes out as 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.**



22B9BAT11

No	Code	Description of error
1	E.F	EPROM fail
2	O.V	Over voltage - Refer to page 7-90
3	O.C	Over current - Refer to page 7-89, 7-91.
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 7-88.
8	A.F	Power supply error (absent phase) - Check if input cable is open.
9	A.C	AC fail (black out) - Check if input voltage is right.
10	L.C	Low current (If this sign is on for setting value (60 sec), charging is over).
11	F	Manual stop.

4) CHECK POINTS BEFORE APPLYING A/S

(1) AC input power source switch is input.

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

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

(4) Check the front cover indicator.

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

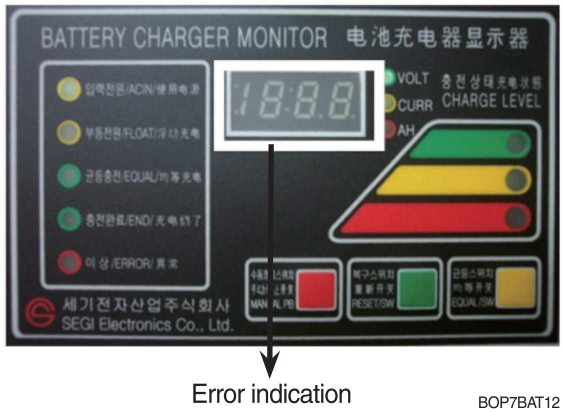
② A.O : Error on selection of input power source of 220V or 380V - Check it appropriately with full three phases.

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

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

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

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



BOP7BAT12

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.

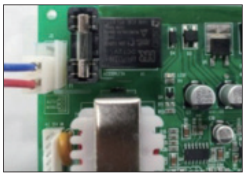
⑦ SCR module checking method

(2) Troubleshooting

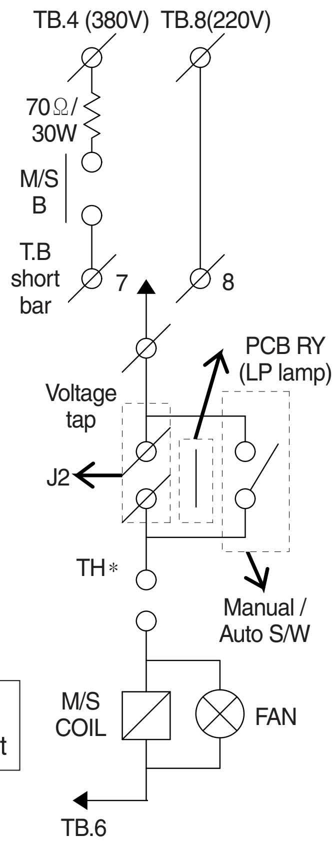
① Only floating charge lamp is on after indicating "A.O", It's not charged.

- 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)



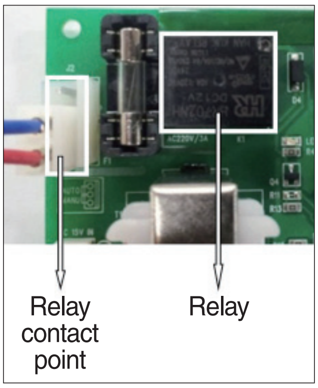
M/S electrical circuit

Check the rated voltage

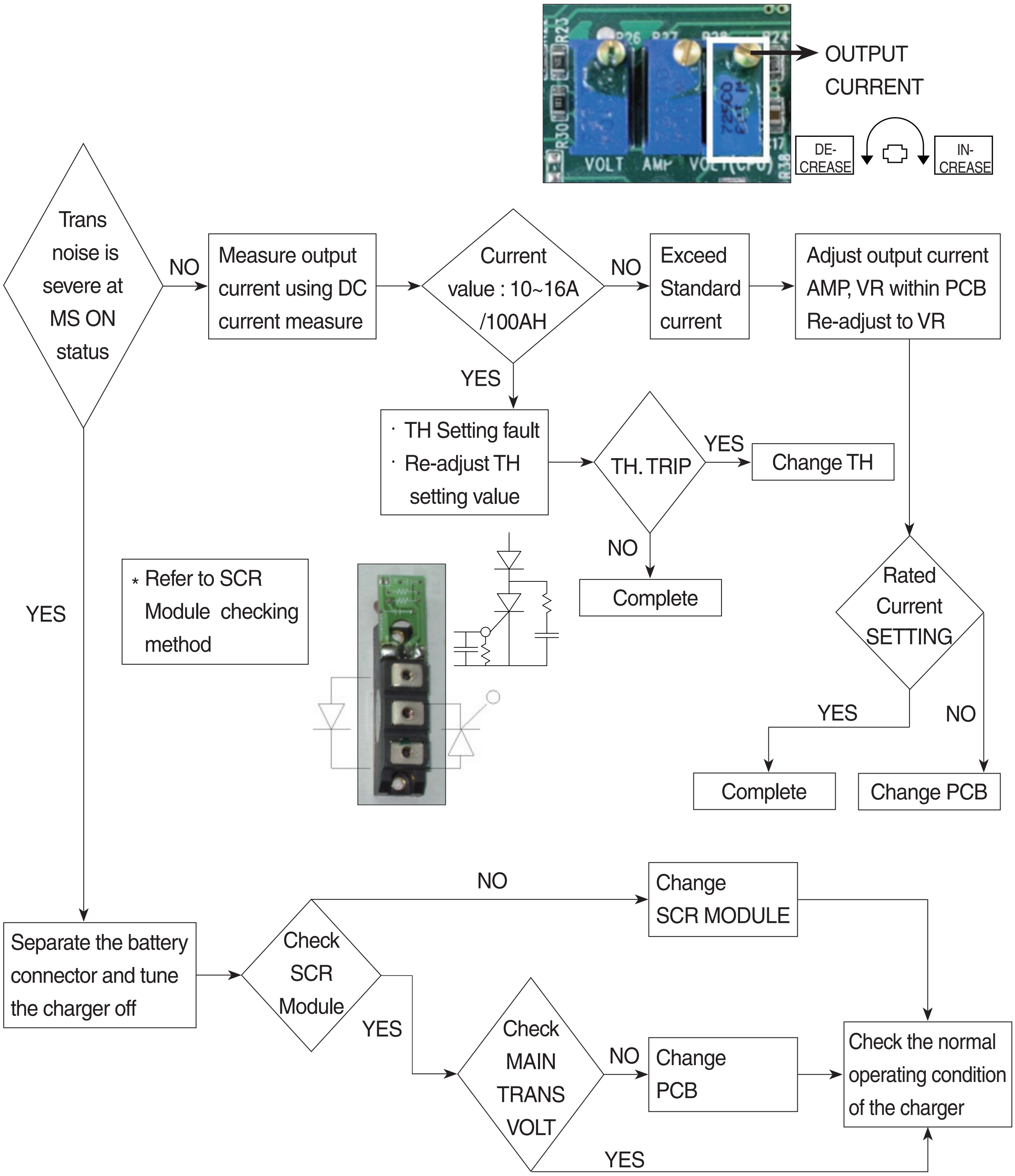
- NO → Input power supply is not supplied.
  - Check external lead cable.
  - Check the connection of external input connecter
  - Check external NFB TRIP
- YES → Insert automatic/manual connector (J2) at the upper part of PCB to manual, after separating battery connector.

AC INPUT MS switch ON

- 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**
    - YES → MS COIL fault
    - NO → TH contact fault / CN4 contact fault / PCB RELAY fault / TH manual restoration release
- YES → **PCB LP lamp lights up**
  - NO → Change PCB
  - YES → CN4 contact fault / PCB RY contact fault



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

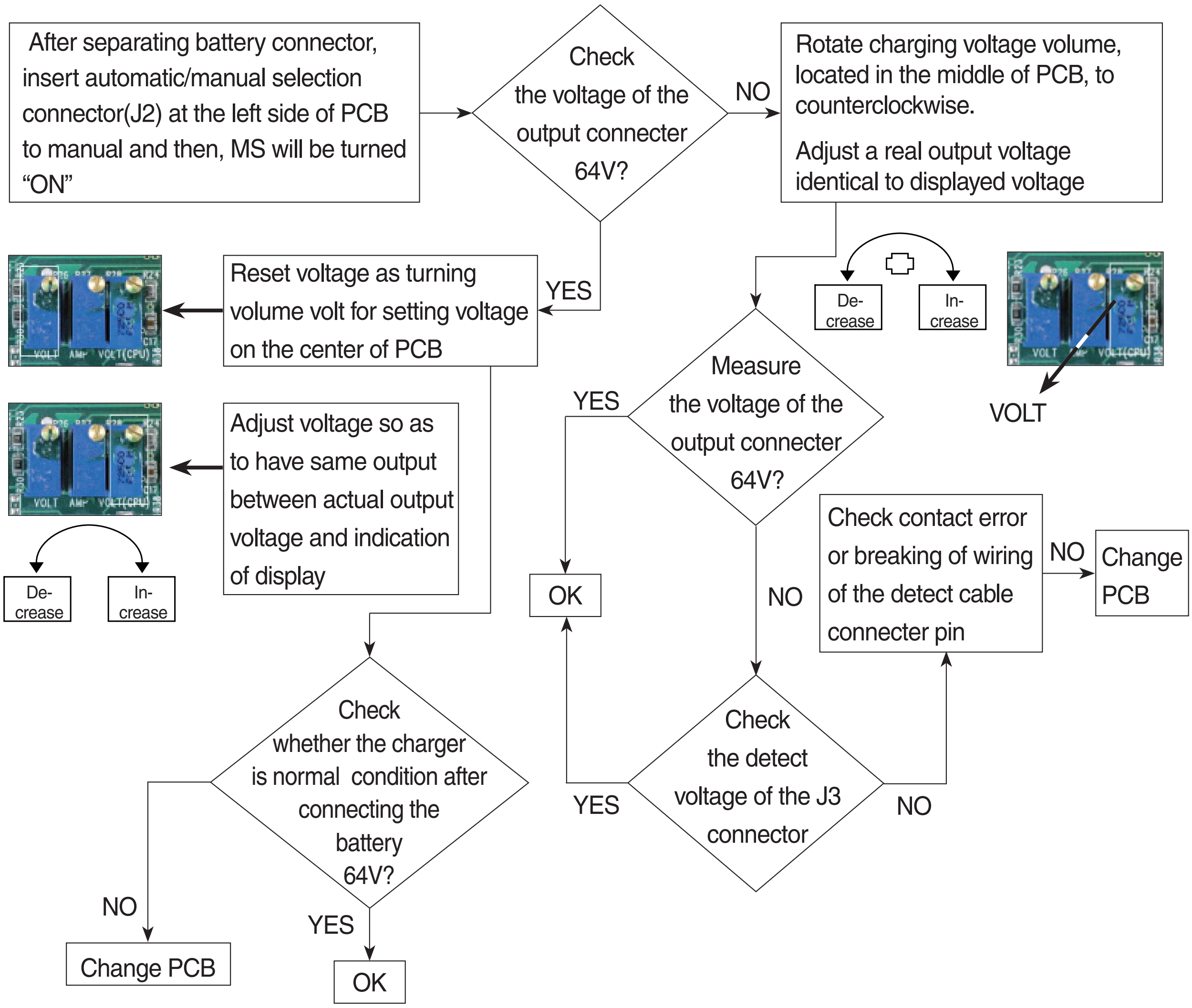


③ Charger TRIP is occurred after abnormality lamp is on.

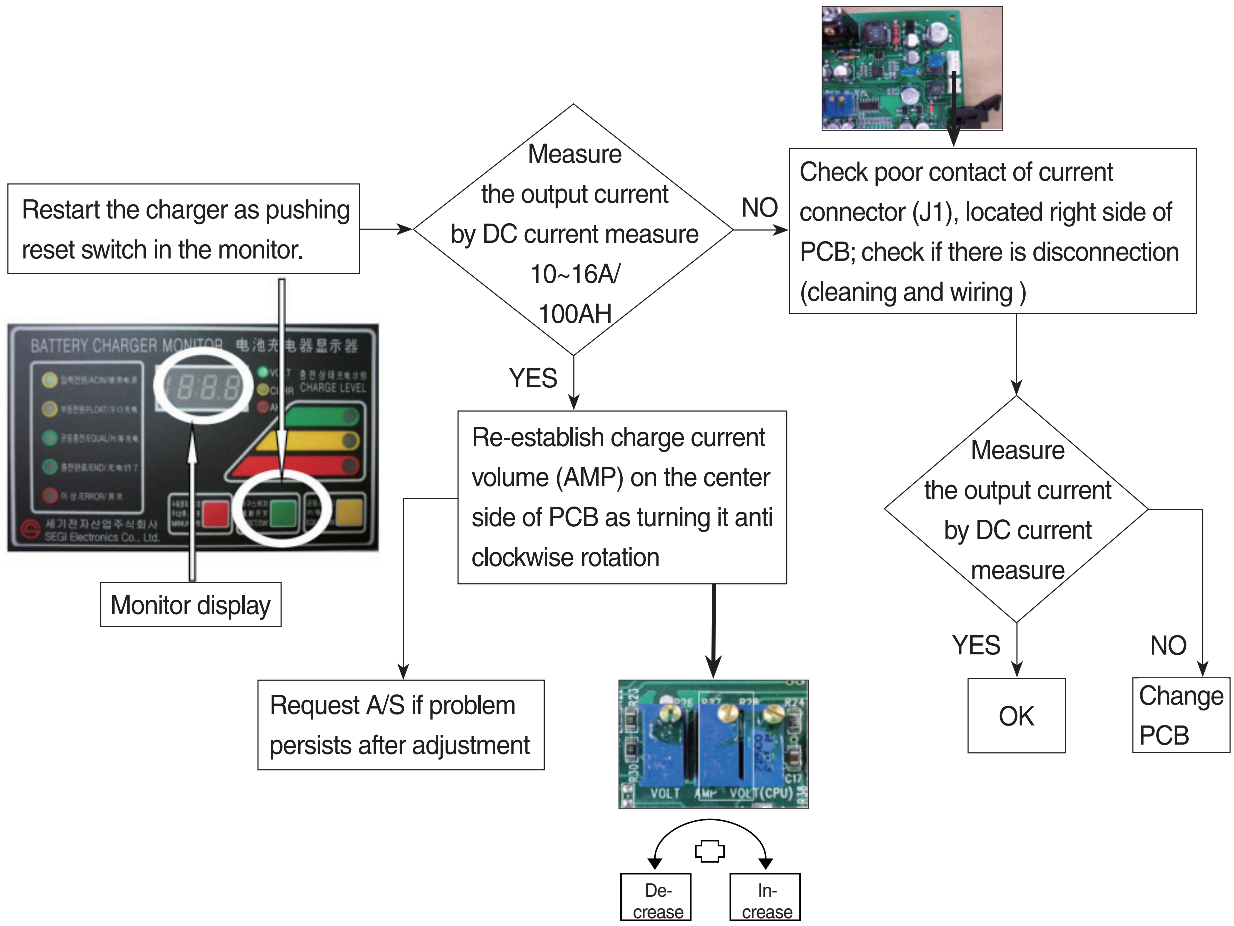
In case error code is "O.V" → Over-voltage output / Set at 66V (In case of BATT 48V)

34V (In case of BATT 24V)

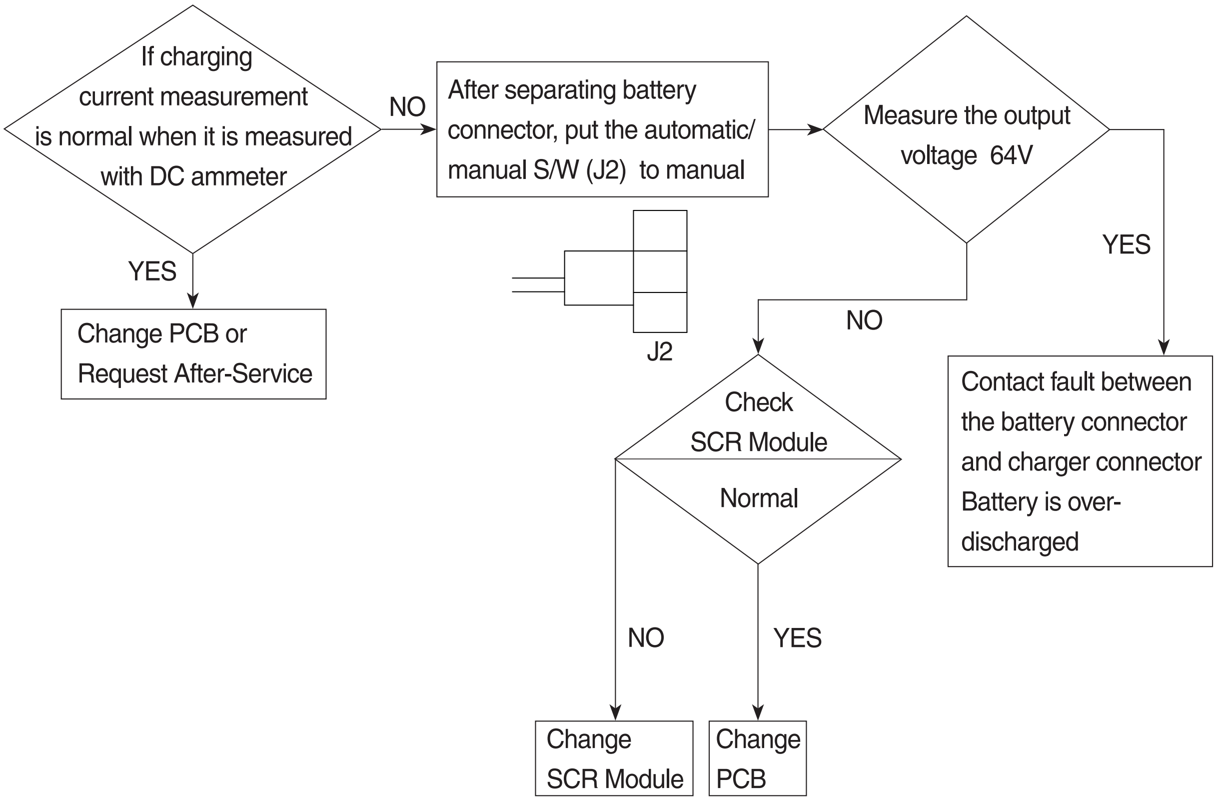
108V (In case of BATT 80V)



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.

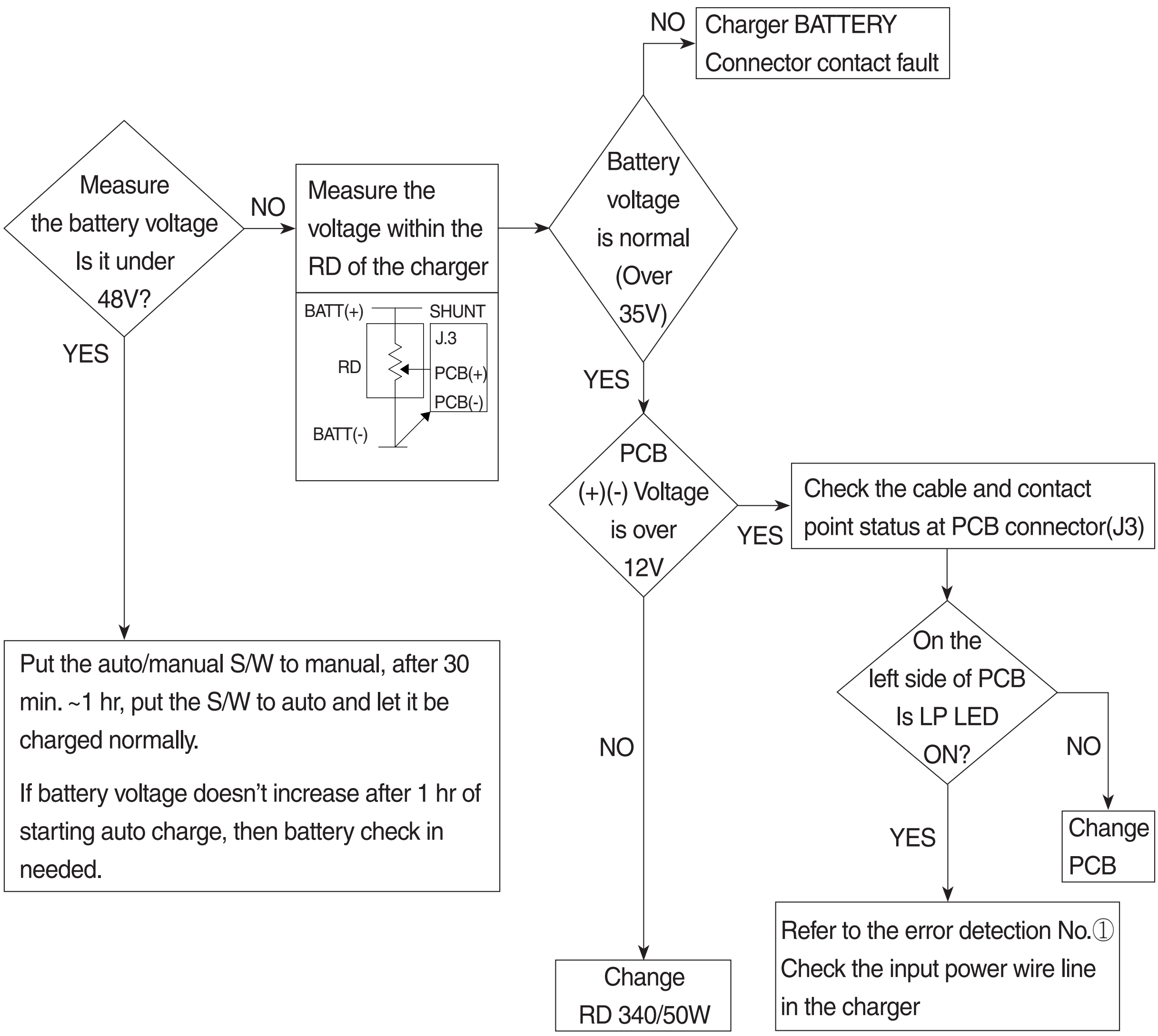


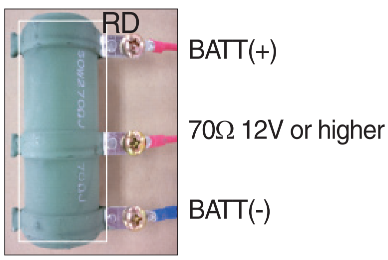
⑤ Charger TRIP is occurred after it started charging and charging completion lamp is on.
(In case input voltage is normal - Refer to the error detection No. 1)
Restore the charger as pushing reset switch.



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)

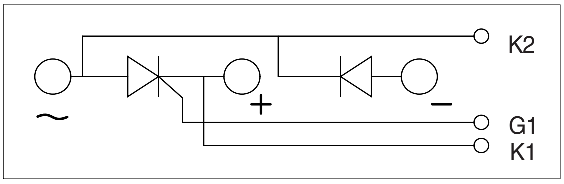




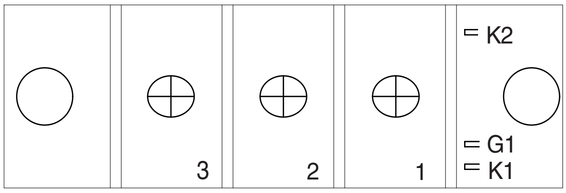
(based on 48V)

7) HOW TO CHECK THE SCR MODULE

Circuit

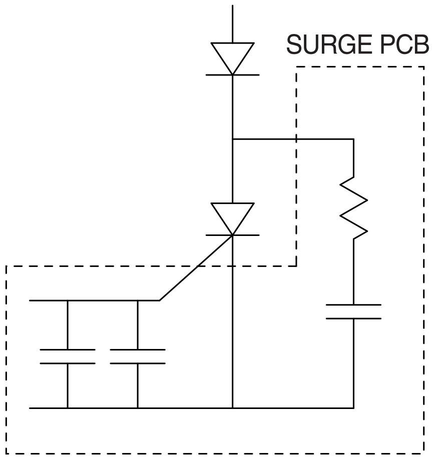


Real diagram

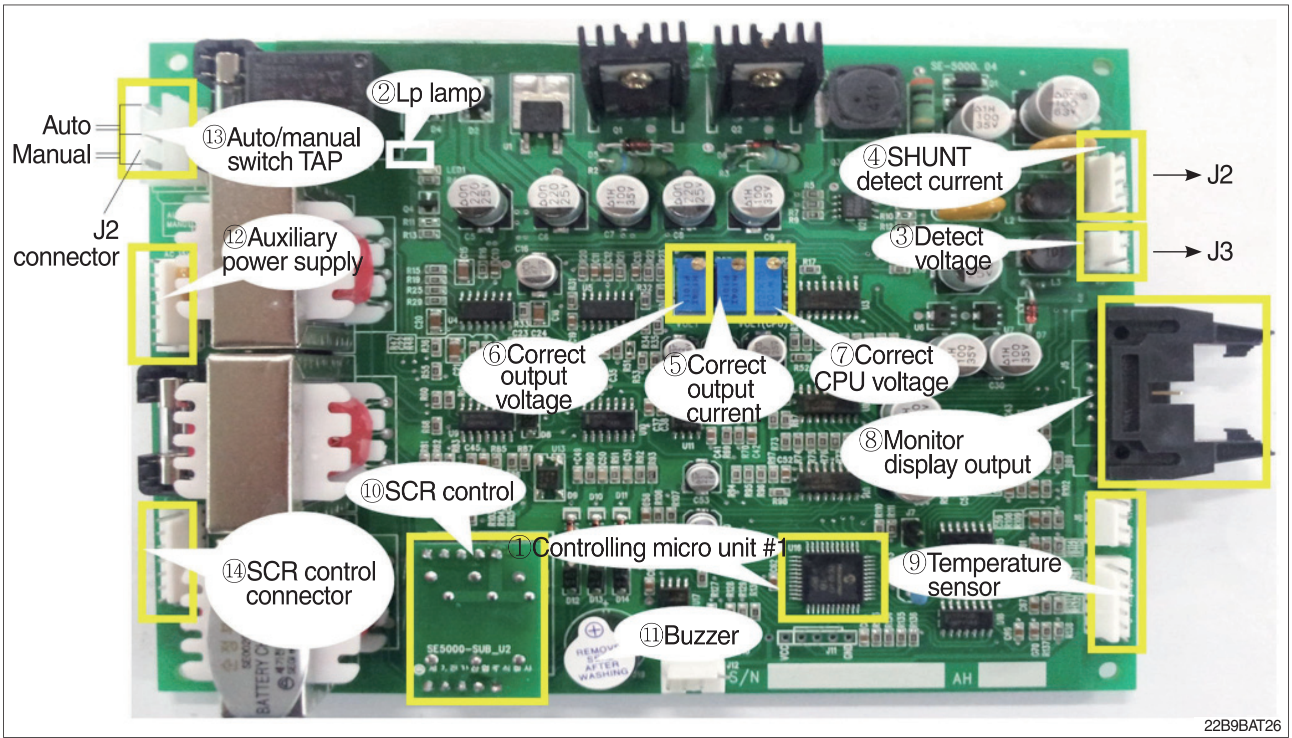


* Before checking SCR MODULE, be sure to disconnect bus bar and wire on the terminal.

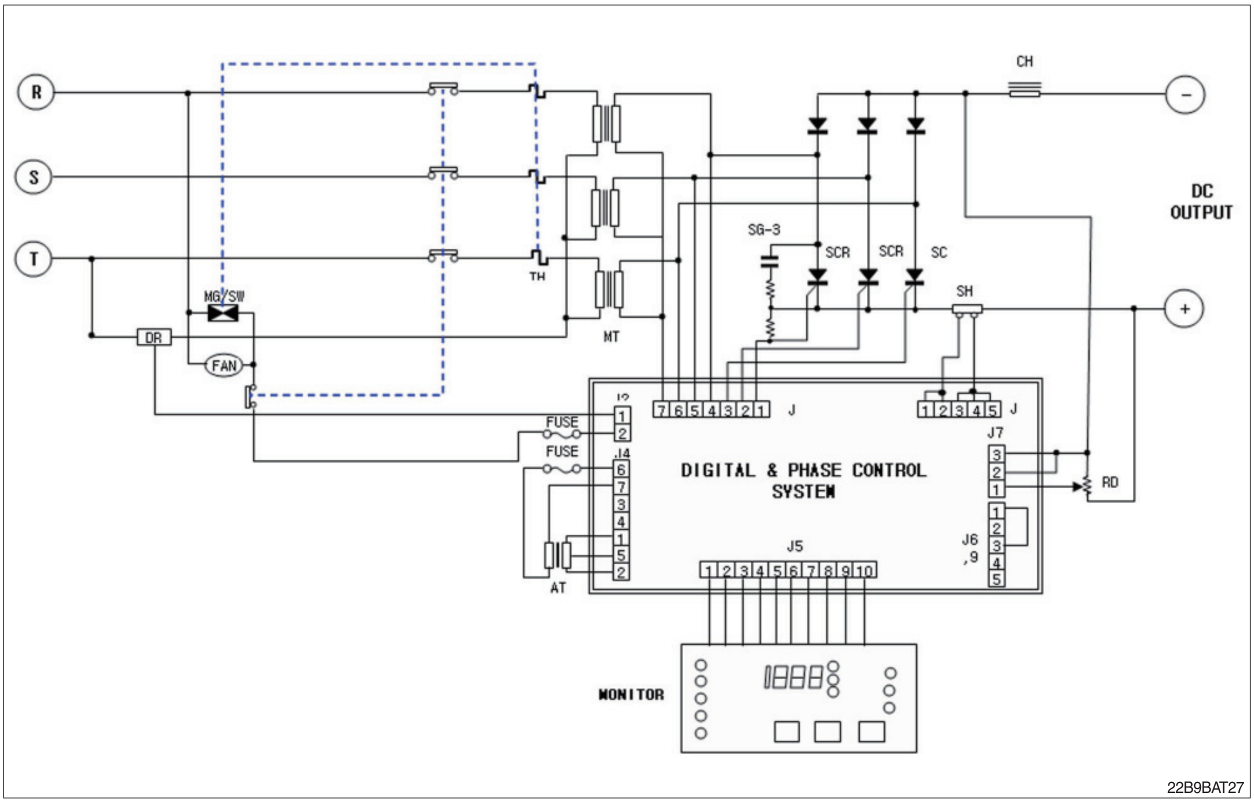
No.	Measuring point (Real diagram)	Measure value (Measurement of digital tester)
1	No.1 ~ No.3	Forward : Under 100 k ohm Reverse : Infinity (∞)
2	No.2 ~ No.3	Forward : Infinity (∞) Reverse : Infinity (∞)
3	G1 ~ K1	Forward : Under 100 ohm Reverse : Under 100 ohm But It depends on the module. If it is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



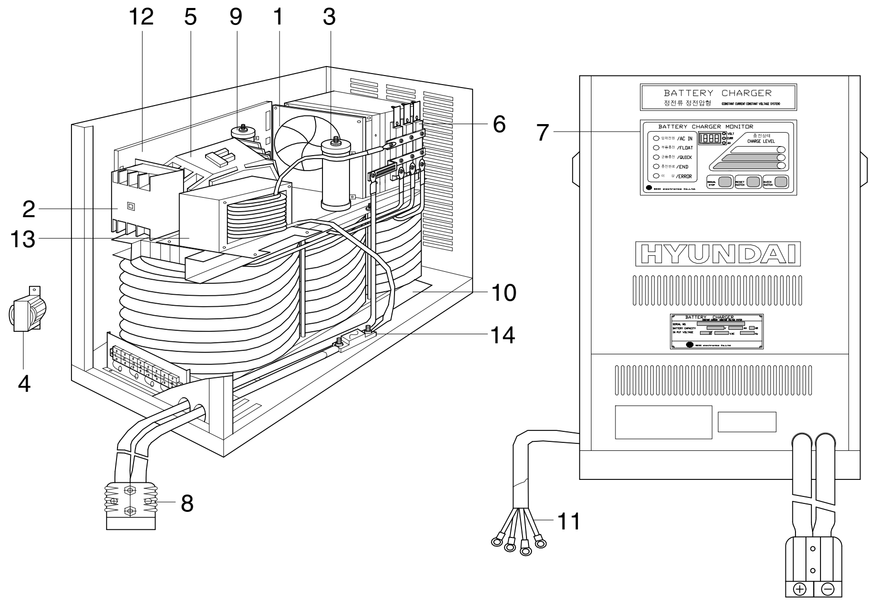
8) PCB MAJOR PARTS (NAME AND LOCATION)



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
MT
MG/SW
DR
FAN
SH
FUSE
FUSE
J2
J4
J
J
J7
DIGITAL & PHASE CONTROL
SYSTEM
RD
J5
J6
,9
AT
MONITOR
22B9BAT27

CHARGER INTERIOR PARTS



22B9BAT28

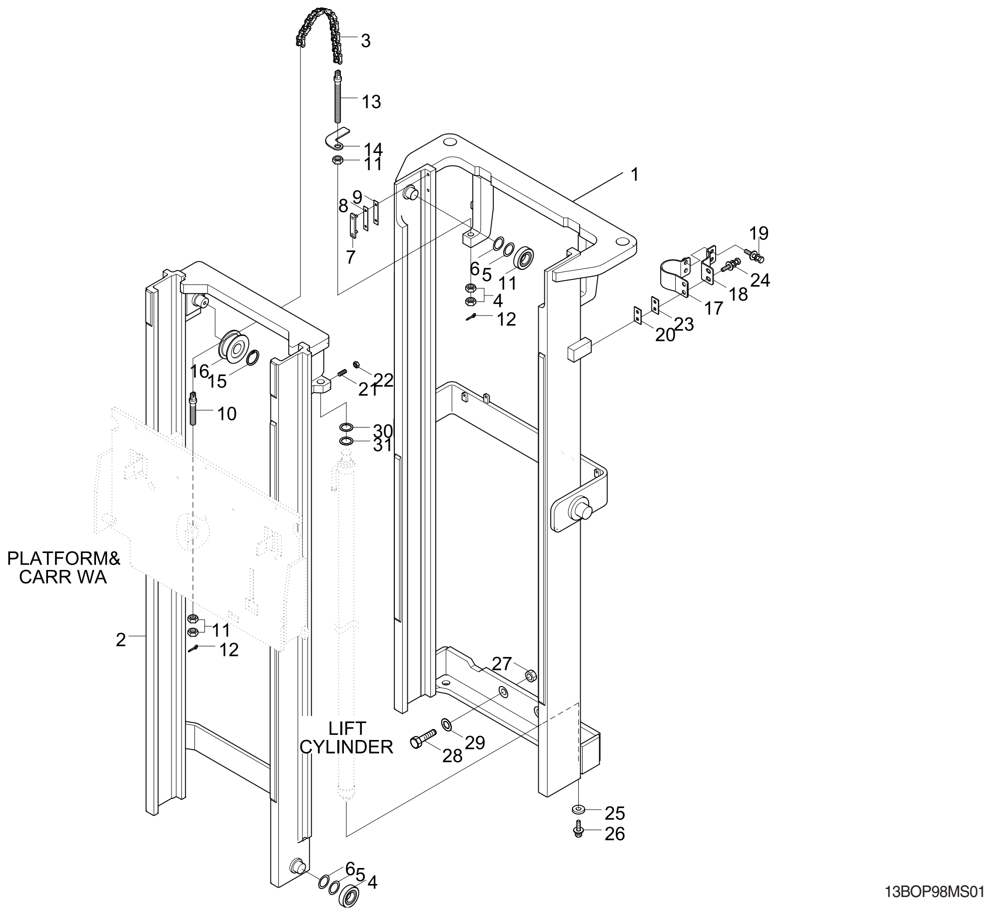
No	Part name	Remarks
1	AC fan	
2	Over load	
3	Resister RD	
4	Trans-aux	
5	Magnet switch	
6	SCR module	
7	Monitor	
8	DC out cable	
9	Resister DR	
10	Main transformer	
11	AC input cable	
12	Main control board	
13	Filter	
14	Fuse	

SECTION 8 MAST

GROUP 1 STRUCTURE

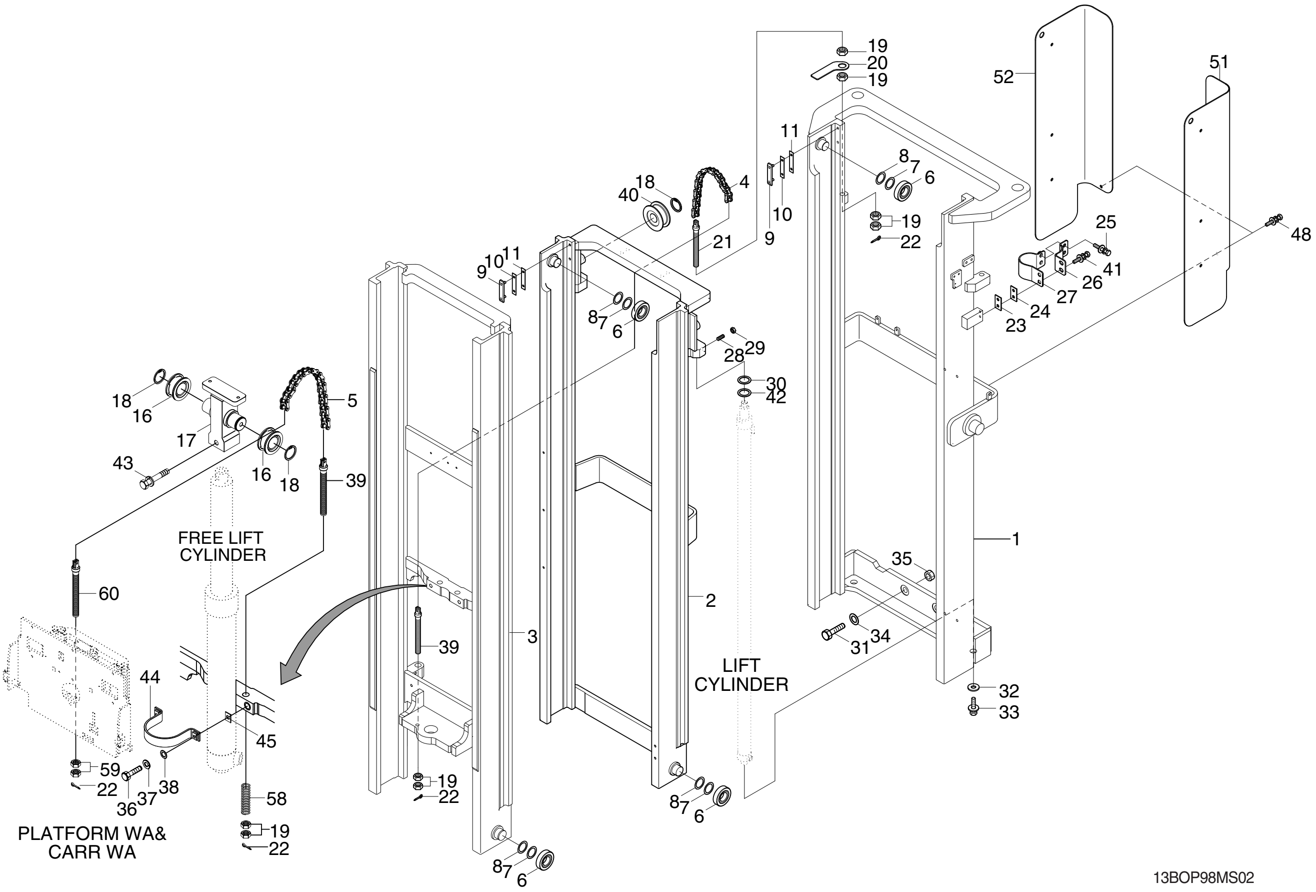
1. MAST

1) V MAST



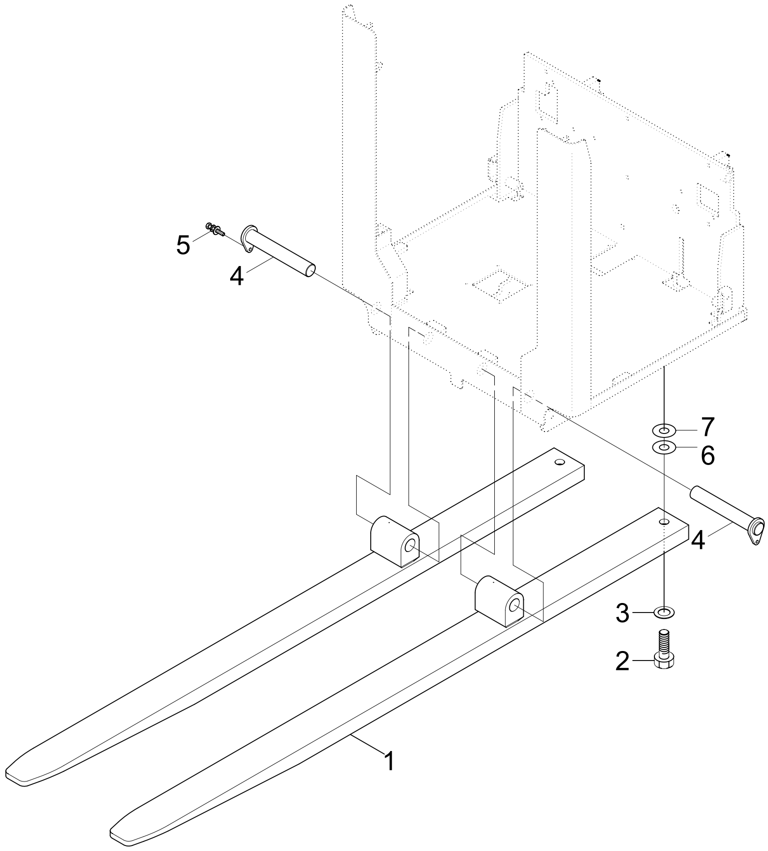
1	Outer mast	13	Anchor bolt	23	Shim
2	Inner mast	14	Plate	24	Washer bolt
3	Chain assy	15	Retainer C ring	25	Wahser
4	Loadroller bearing	16	Chain guard	26	Washer bolt
5	Shim	17	Clamp	27	Hex nut
6	Shim	18	Clamp	28	Hex bolt
7	Backup liner	19	Washer bolt	29	Harden washer
10	Anchor bolt	20	Shim	30	Shim
11	Hex nut	21	Set Screw	31	Shim
12	Split pin	22	Hex nut		

2) TF MAST



1	Outer mast	21	Anchor bolt	37	Spring washer
2	Middle mast	22	Split pin	38	Plain washer
3	Inner mast	23	Shim	39	Anchor bolt
4	Chain assy	24	Shim	40	bearing
5	Chain assy	25	Washer bolt	41	Washer bolt
6	Loadroller bearing	26	Clamp	42	Shim
7	Shim	27	Clamp	43	Washer bolt
8	Shim	28	Set screw	44	Mast in clamp
9	Backup liner	29	Hex nut	45	Shim
10	Shim	30	Shim	48	Washer bolt
11	Shim	31	Hex bolt	51	LH guard plate
16	Chain guard	32	Washer	52	RH guard plate
17	Sheave bracket	33	Washer bolt	58	Suspension spring
18	Retainer C ring	34	Harden Washer	59	Self nut
19	Hex nut	35	Hex nut	60	Anchor bolt
20	Plate	36	Hex bolt		

2. PLATFORM AND FORK



13BOP98MS03

1	Fork assy	4	Fork pin	6	Shim (0.5t)
2	Hex bolt	5	Bolt-Washer	7	Shim (1.0t)
3	Washer				

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

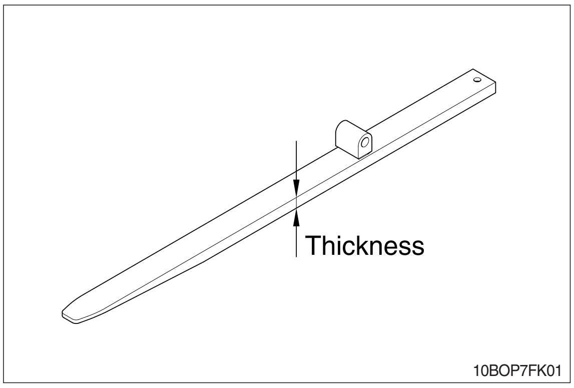
1. OPERATIONAL CHECKS

1) FORKS

(1) Measure thickness of root of forks and check that it is more than specified value.
EX : ℓ =1820mm (71.7in)

mm(in)

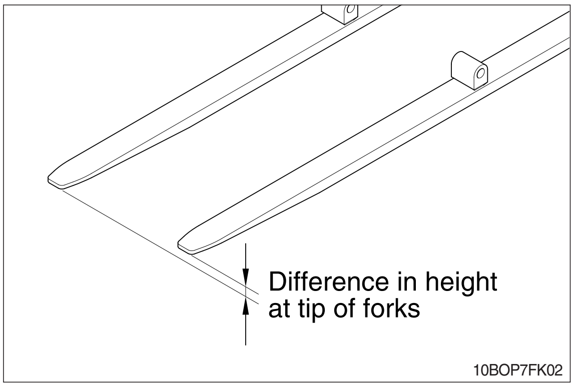
STD Fork assy	Standard	Limit
64HW-11030	40 (1.6)	36 (1.4)



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

mm

Fork length	Height difference
equal or bleow 1500	3
above 1500	4



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

2. MAST

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

2. TROUBLESHOOTING

1) MAST

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

2) FORKS

<table>
<tr><th>Problem</th><th>Cause</th><th>Remedy</th></tr>
<tr><td>Abrasion</td><td>Long-time operations causes the fork to wear and reduces the thickness of the fork.
Inspection for thickness is needed.
· Wear limit : Must be 90% of fork thickness</td><td>If the measured value is below the wear limit, replace fork.</td></tr>
<tr><td>Distortion</td><td>Forks are bent out of shape by a number of reasons such as overloading, glancing blows against walls and objects, and picking up load unevenly.
· Difference in fork tip height<table><tr><th>Fork length (mm)</th><th>Height difference(mm)</th></tr><tr><td>equal or below 1500</td><td>3</td></tr><tr><td>above 1500</td><td>4</td></tr></table></td><td>If the measured value exceeds the allowance, replace fork.</td></tr>
<tr><td>Fatigue</td><td>Fatigue failure may result from the fatigue crack even though the stress to fork is below the static strength of the fork. Therefore, a daily inspection should be done.
· Crack on the fork heel.
· Crack on the fork weldments.</td><td>Repair fork by expert.
In case of excessive distortion, replace fork.</td></tr>
</table>

GROUP 3 ADJUSTMENT

1. MAST LOAD ROLLER (V MAST)

1) INNER/OUTER MAST ROLLER CLEARANCE ADJUSTMENT

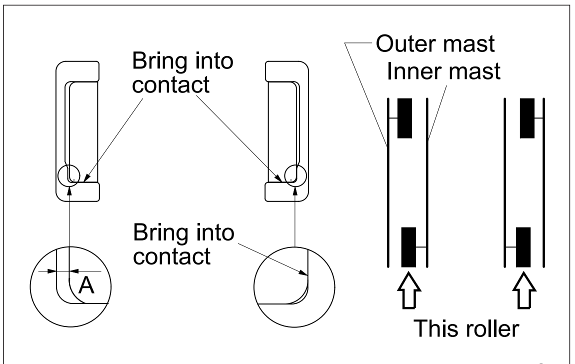
(1) Measure the clearance with the mast overlap at near 480mm.

(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.

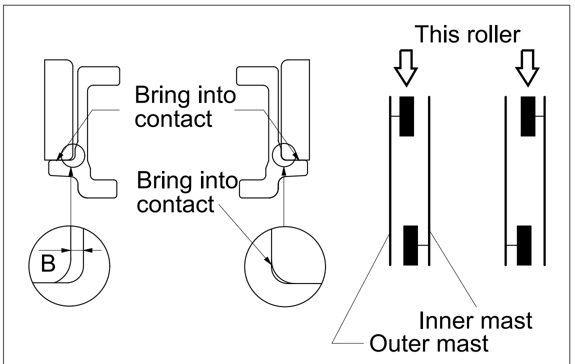
- · Standard clearance A, B = 0.3 ~ 0.6mm
- · Shim thickness 0.5, 1.0mm

(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.



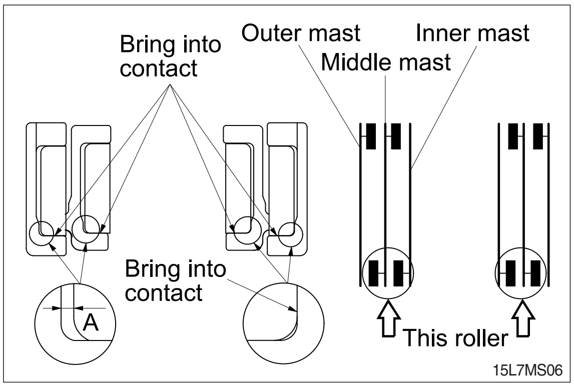
15L7MS04



15L7MS05

2. MAST LOAD ROLLER (TF MAST)

1) INNER AND MIDDLE MAST ROLLER CLEARANCE ADJUSTMENT



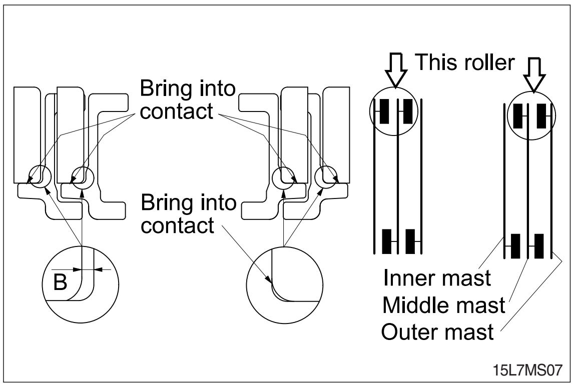
(1) Measure the clearance with the mast overlap at near 480mm.

(2) Shift the inner mast to one side to bring the roller into contact with the outer mast and the middle mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner and middle mast roller shim, respectively.
- · Standard clearance A = 0.3~0.6mm
- · Shim thickness 0.5, 1.0mm

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

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

2) OUTER AND MIDDLE MAST UPPER ROLLER CLEARANCE ADJUSTMENT.



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

(2) Shift the inner mast to one side to bring the roller into contact with the middle mast and the inner mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the outer and middle mast roller shim, respectively.
- · Standard clearance B = 0.3~0.6mm
- · Shim thickness 0.5, 1.0mm

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

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

3) CARRIAGE LOAD ROLLER

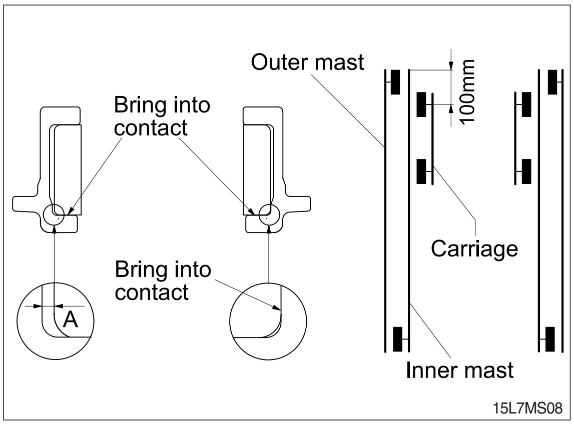
(1) Measure the clearance when the center of the carriage upper roller is 100mm from the top of the inner mast.

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

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

(3) Distribute the shim thickness equally to the left and right roller. Refer to Carriage assembly.

(4) After the adjustment, the carriage should move smoothly along the overall mast length.



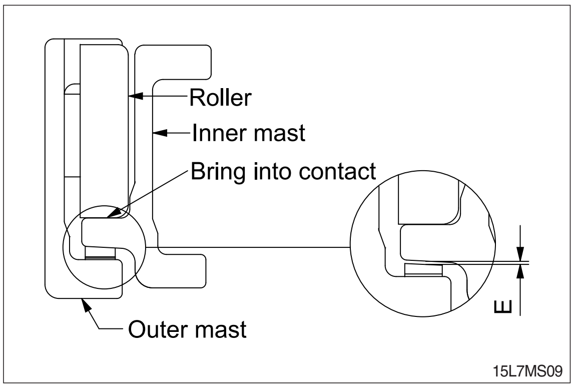
4) MAST BACK UP LINER

(1) Measure the clearance with the inner mast at the bottom position.

(2) With the inner mast in contact with the outer mast roller, adjust the clearance between the mast back up liner and inner mast to the following value by inserting the back up liner shim.

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

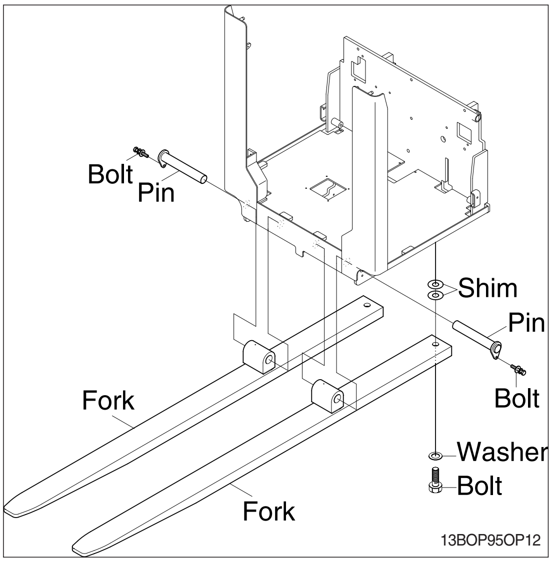
(3) After the adjustment, the mast should move smoothly.



GROUP 4 REMOVAL AND INSTALLATION

1. FORKS

1) Lower the fork and platform assy until the forks are approximately 25mm(1in) from the floor.
2) Loosen and remove bolt washers and shims which are used for fixing the forks under the platform.
3) Loosen and remove bolts, pin weld assys which are used for fixing the forks to the platform.
4) Remove the fork one after another.
5) Assembly procedure of the forks is the reverse order of the removal procedure.

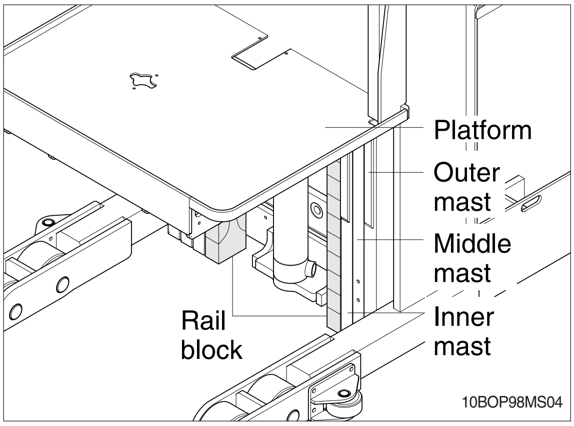


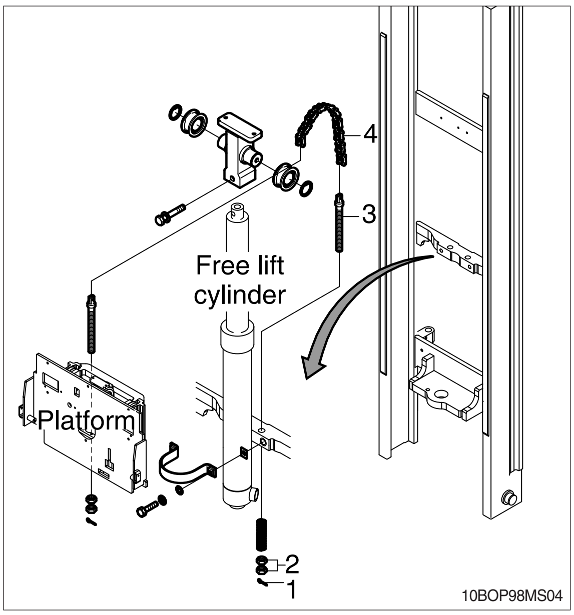
2. PLATFORM

1) Lift up the platform high enough to put up the blocks under the platform.
   While lifting up the platform, the lift chains can be slacked.
   Loosen and remove split pin, nuts from anchor bolt of the chains.
   Lift up slowly upright the platform using overhead hoist or overhead crane until it is reached to near the top of the inner mast, and them draw out carefully the platform upright

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

※ Inspect all parts of the platform for wear of damage.
Replace the defected parks if necessary.





3. MASTER

1) MAST LOAD ROLLER AND BACK UP LINER

(1) 3 stage mast (TF mast)

① Remove the carriage assembly and move to one side.

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

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

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

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

⑥ Using the overhead hoist raise inner and middle masts. Place 4 inch block of wood under the free lift cylinder bracket of the inner mast then lower mast sections (this will create slack in the chains).

⑦ Remove retaining rings securing chain sheaves to sheave support brackets. While support chains, remove chain sheaves and let chains hang free. The upper outer and lower middle mast rollers and back up liners are now exposed.

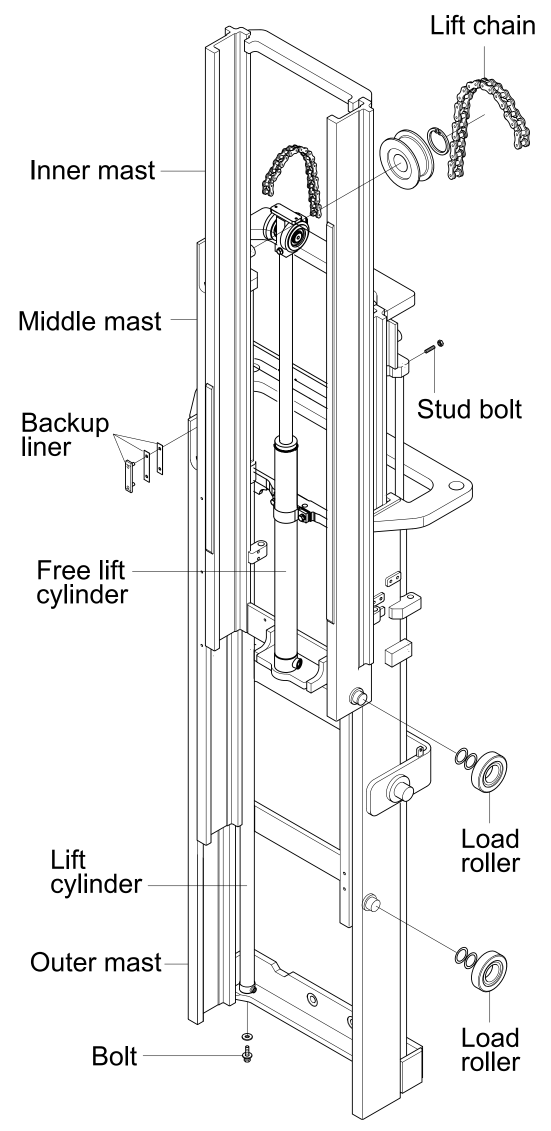
⑧ Using a pryer, remove load rollers from load bracket. Remove back up liners and shims.

⑨ Attach chains or sling to the middle mast section at top crossmember. Using an overhead hoist, slowly raise the middle mast until top and bottom rollers are exposed.

⑩ Using a player, remove load rollers from load roller bracket.

⑪ Thoroughly clean, inspect and replace all worn or damaged parts.

⑫ Reverse the above procedure to assemble. Refer to MAST LOAD ROLLER ADJUSTMENT paragraph.



2) ELEVATING MAST

(1) Inner and middle mast (TF mast)

① After completing all necessary steps for load rollers and back up liner removal. Remove rear chains and sheave support if not already done.

② Disconnect free lift cylinder hose. Drain hose into a suitable pan or container and cap hose.

③ While supporting free lift cylinder assembly, remove bolts and washers securing cylinder to mast crossmember.

④ Place a sling around free lift cylinder and attach to an overhead hoist. Slowly raise and move cylinder to one side.

⑤ Attach chains or sling to the inner mast section at top crossmember. Using an overhead hoist slowly raise the upright straight up and out of middle mast section.

⑥ Attach chains or sling to the middle mast section at top crossmember. Using an overhead hoist slowly raise the upright straight up and out of outer mast section.

⑦ Replace upright and reverse above procedure to install. Make all necessary measurements and adjustments.

3) CHAIN

(1) Rear chain sheave (TF mast)

① Raise and secure block under platform and inner mast section.

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

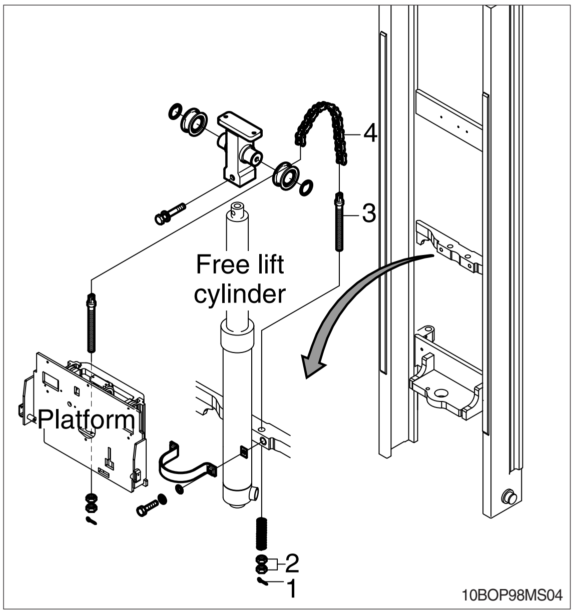
③ Remove chains.

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

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

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

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



(2) Chain wheel bearing support (TF mast)

① Remove the platform and move to one side.

② After removing bolt to securing chain wheel bearing support assembly to free lift cylinder.
After a sling to the chain wheel bearing support assembly, using an overhead hoist, lift support assembly straight up and off of free lift cylinder. Move assembly to work area.

③ Remove retaining ring securing chain wheel bearing to chain wheel bearing support.

④ Remove bearing retaining ring from chain wheel bearing and press bearings from chain wheel bearings.

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

⑥ Reverse the above procedure to install.

(3) Rear chain (TF mast)

① Remove the platform and move to one side. Refer to platform removal and installation.

② Raise and securely block truck approximately 6 inches from the floor.

③ Using a sling or chain around inner mast section attached to an overhead hoist, slowly raise inner mast until there is enough slack in the chains to remove them. Block inner mast section.

④ Remove split pins and chain anchor pins securing chains to chain anchor(part of inner mast).

⑤ While supporting the chains, remove split and chain anchor pins securing chains to chain anchors attached to outer mast section.

⑥ Remove chains.

⑦ Reverse the above to assemble and install. Use new split pins in chain anchor pins. Refer to this section for load chain lubrication and adjustment.

(4) Lift chain

① Place a sling around platform and attach to an overhead hoist. Lift and secure high enough platform so that split and chain anchor pins on carriage can be easily be removed. Remove chain anchor pins from platform and drape chains out over carriage.

② Place a wooden block under the platform and lower the platform on the block.

③ While supporting the chains, remove split pins and chain anchor pins from chain anchors.

④ Remove chains and wash them with solvent. Refer to this section for load chain inspection and maintenance.

⑤ Reverse the above procedure to assemble and install. Use new split pins in chain anchor pins.
Refer to this section for load chain lubrication and adjustment.

(5) Load chain inspection and maintenance

After every 200 hours of truck operation, lift chains should be inspected and lubricated inspect for the following chain conditions :

① **Wear**

As the chain flexes on and off the chain wheel bearings, the joints very gradually wear. The stretch a chain developes in service is due to material being worn off pin outer diameter and pitch hole inner diameter on the inside plate.

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

② Rust and corrosion

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

③ Cracked plate

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

④ Tight joints

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

Tight joints in lift chains can be caused by :

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

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

⑤ Protruding or turned pins

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

⑥ Chain side wear

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

⑦ Chain anchors and chain wheel bearings

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

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

⑧ Chain wear scale

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

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

(6) Load chain lubrication and adjustment

① Lubrication

The most important consideration in field maintenance of lift chains is lubrication. Hard working, heavily loaded chains cannot be expected to give satisfactory wear life without scheduled periodic re-lubrication. Like all bearing surfaces, the precision manufactured, hardened steel, joint-wearing surfaces require a film of oil between mating parts to prevent rapid wear. Oil must penetrate the chain joint to prevent wear. Applying oil to external surfaces will prevent rust, but oil must flow into the live bearing surfaces for maximum wear life. Frequency of re-lube will vary with operating conditions and environment, the best estimate of lube period is 200 hours. Trucks parked outdoors or trucks in extremely severe service, may require more frequent re-lube to maintain an oil film on all chain surface.

· Wipe off the old oil with a clean cloth and blow out the remaining dirt with compressed air.
⚠Wear eye protection.
· With a clean brush, apply EP-140 extreme pressure lubricant or heavy motor oil(40W).

② Replacement

Replace chains as a pair. It will be virtually impossible to maintain uniform loading between the strands if a new chain is put into service opposite an old chain. The joints in the old chain will be greater than that on the new chain, greatly complicating the problem of maintaining equal chain tension. The new chain will wear more slowly causing it to bear the major portion of the load resulting in premature wear and fatigue failure. Don't steam clean or decrease new chains.
The manufacturer's grease is effective in reducing wear and corrosion. If the original factory lube is dried out or wiped off, soak the new chain in heavy engine oil for at 1/2 hour prior to installing on truck. After the old chains have been stripped from the mast, very carefully inspect chain anchors and chain wheel bearing. Broken, cracked or worn anchor must be replaced using the new anchor pin and split pin. Do not paint newly replaced chain after it has been installed.

③ Adjustment

Chain adjustments are important for the following reasons :

· Equal loading of chain.
· Proper sequencing of mast.
· Prevent over-stretching of chains.
· Prevent chains from jumping off sheaves if they are too loose.

④ Adjustment procedure

· With mast in its fully collapsed and vertical position, lower the fork to the floor.
· Adjust the chain length by loosening or tightening nut on the chain anchor.

After making adjustment on the mast, be sure to tighten the nut.