JLG®
An Oshkosh Corporation Company

Service and Maintenance Manual

Model

1230ES

3121222

January 31, 2019 - Rev T

ANSI

CE

AS/NZS

JLG®

SECTION A. INTRODUCTION - MAINTENANCE SAFETY PRECAUTIONS

GENERAL

This section contains the general safety precautions which must be observed during maintenance of the aerial platform. It is of utmost importance that maintenance personnel pay strict attention to these warnings and precautions to avoid possible injury to themselves or others, or damage to the equipment. A maintenance program must be followed to ensure that the machine is safe to operate.

⚠ WARNING

MODIFICATION OR ALTERATION OF AN AERIAL WORK PLATFORM SHALL BE MADE ONLY WITH WRITTEN PERMISSION FROM THE MANUFACTURER.

The specific precautions to be observed during maintenance are inserted at the appropriate point in the manual. These precautions are, for the most part, those that apply when servicing hydraulic and larger machine component parts.

Your safety, and that of others, is the first consideration when engaging in the maintenance of equipment. Always be conscious of weight. Never attempt to move heavy parts without the aid of a mechanical device. Do not allow heavy objects to rest in an unstable position. When raising a portion of the equipment, ensure that adequate support is provided.

⚠ WARNING

SINCE THE MACHINE MANUFACTURER HAS NO DIRECT CONTROL OVER THE FIELD INSPECTION AND MAINTENANCE, SAFETY IN THIS AREA RESPONSIBILITY OF THE OWNER/OPERATOR.

HYDRAULIC SYSTEM SAFETY

It should be noted that the machines hydraulic systems operate at extremely high potentially dangerous pressures. Every effort should be made to relieve any system pressure prior to disconnecting or removing any portion of the system.

MAINTENANCE

⚠ WARNING

FAILURE TO COMPLY WITH SAFETY PRECAUTIONS LISTED IN THIS SECTION COULD RESULT IN MACHINE DAMAGE, PERSONNEL INJURY OR DEATH AND IS A SAFETY VIOLATION.

- ENSURE REPLACEMENT PARTS OR COMPONENTS ARE IDENTICAL OR EQUIVALENT TO ORIGINAL PARTS OR COMPONENTS.
- NO SMOKING IS MANDATORY. NEVER REFUEL DURING ELECTRICAL STORMS. ENSURE THAT FUEL CAP IS CLOSED AND SECURE AT ALL OTHER TIMES.
- REMOVE ALL RINGS, WATCHES AND JEWELRY WHEN PERFORMING ANY MAINTENANCE.
- DO NOT WEAR LONG HAIR UNRESTRAINED, OR LOOSE-FITTING CLOTHING AND NECKTIES WHICH ARE APT TO BECOME CAUGHT ON OR ENTANGLED IN EQUIPMENT.
- OBSERVE AND OBEY ALL WARNINGS AND CAUTIONS ON MACHINE AND IN SERVICE MANUAL.
- KEEP OIL, GREASE, WATER, ETC. WIPED FROM STANDING SURFACES AND HAND HOLDS.
- USE CAUTION WHEN CHECKING A HOT, PRESSURIZED COOLANT SYSTEM.
- NEVER WORK UNDER AN ELEVATED SCISSOR UNTIL PLATFORM HAS BEEN SAFELY RESTRAINED FROM ANY MOVEMENT BY BLOCKING OR OVERHEAD SLING, OR SAFETY PROP HAS BEEN ENGAGED.
- BEFORE MAKING ADJUSTMENTS, LUBRICATING OR PERFORMING ANY OTHER MAINTENANCE, SHUT OFF ALL POWER CONTROLS.
- BATTERY SHOULD ALWAYS BE DISCONNECTED DURING REPLACEMENT OF ELECTRICAL COMPONENTS.
- KEEP ALL SUPPORT EQUIPMENT AND ATTACHMENTS STOWED IN THEIR PROPER PLACE.
- USE ONLY APPROVED, NONFLAMMABLE CLEANING SOLVENTS.

REVISION LOG

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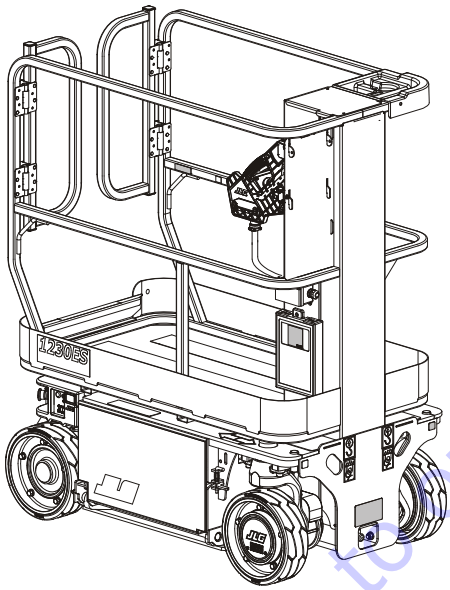

Table 1-1. Operating Specifications

Description	Model 1230ES
Platform	
Maximum Platform Height	12 ft. (3.66 m)
Lift Up Time - w/maximum rated load	11 - 17 seconds
Lift Down Time - w/maximum rated load	11 - 25 seconds
Driving	
Maximum Drive Speed Stowed: Elevated:	3 mph (4.8 kph) 0.5 mph (0.8 kph)
Maximum **Stowed** Travel Grade (Gradeability)	25% (14°)
Maximum **Stowed** Travel Grade (Sideslope)	5°
Inside Turning Radius	4.4 in. (11.2 cm)
Outside Turning Radius	57.6 in. (1.46 m)
Chassis	
Approximate Gross Machine Weight - Global	1775 lb. (805 kg) - ANSI/CSA 1740 lb. (790 kg) - CE/AUS/JPN 2360 lb. (1070 kg) - AUS w/CWT
Maximum Tire Load (per wheel)	880 lb (400 kg) 1050 lb. (520 kg) - AUS w/CWT
Ground Bearing Pressure	123 PSI (8.7 kg/cm^2) 160 PSI (11.2 kg/cm2) - AUS w/CWT
Ground Clearance: (pot hole protection system up): (pot hole protection system down):	2.6 in (66 mm) 0.5 in (12.2 mm)
Maximum Operating Wind Speed	28 mph - ANSI/CSA/AUS w/CWT 0 m/s - CE/AUST - Indoor Use Only

Table 1-1. Operating Specifications (Continued)

Description	Model 1230ES
Maximum Horizontal Manual Side Force: (Platform fully extended with Maximum load)	ANSI/CSA - 100 lb force - (445 N) CE/AUS - Indoor Only - 45 lb. force - 200 N AUS w/CWT - Indoor - 89 lb. force - 400 N AUS w/CWT - Outdoor - 45 lb. force - 200 N
Maximum Hydraulic System Pressure Setting	1600 psi (110 bar) - Lift 1250 psi (86 bar) - Steer
Electrical System Voltage (DC)	24V

1.1 OPERATING SPECIFICATIONS

Platform Capacities

Table 1-2. Platform Capacities

MACHINE MODEL	SPECIFICATION	MAXIMUM PLATFORM CAPACITY	MAXIMUM PERSONS ALLOWED IN PLATFORM	MAX. SIDE FORCE (Platform Fully Extended @ Max. Capacity)	MAXIMUM OPERATING WIND SPEED
1230ES	ANSI/CSA	500 lb. (227 Kg)	Indoor/Outdoor - 2 Persons	100 lb. (445 N)	28 mph (12.5 m/s)
	CE/AUS (Indoor Only)	230 Kg	Indoor - 1 Persons + 150 Kg	200 N	0 m/s
	AUS w/CWT	500 lb. (230 Kg)	Indoor - 2 Persons + 70 Kg	400 N	0 m/s
		500 lb. (230 Kg)	Outdoor - 1 Person + 150 Kg	200 N	28 mph (12.5 m/s)

Dimensional Data

Table 1-3. Dimensions

Description	Model 1230ES	
Platform Height - Elevated (Platform base to ground)	12 ft.	3.66m
Platform Height - Stowed (Platform base to ground)	22 in.	56cm
Working Height	18 ft.	5.48m
Overall Stowed Machine Height	65.39 in. (166 cm) 68.6 in. (174.2 cm) - AUS w/CWT	
Rail Height (From platform floor)	43.8 in.	111.2cm
Overall Machine Width	30 in.	76cm
Overall Machine Length	53.5 in.	1.36m
Platform Size - Length	49.4 in.	1.26m
Platform Size - Width	27 in.	69cm
Wheelbase	40.75 in.	103.5cm

Tires

Table 1-4. Tire Specifications

Description	Model 1230ES
Size	12.72 in. x 3.937 in. (323mm x 100mm)
Max Tire Load	2500 lb. (1134 kg)
Wheel Bolt Torque	120 ft lb (163 Nm)

Batteries

Table 1-5. Battery Specifications

Description	Model 1230ES
Voltage (24V System - Series)	6 V per battery (deep cycle)
Amp Hour - (Std Battery)	220 Amp Hour @ 20 HR. Rate
Reserve Capacity - (Std Battery)	447 Minutes
Amp Hour - (AGM Battery)	213 Amp Hour @ 20 HR. Rate
Reserve Capacity - (AGM Battery)	492 Minutes

Critical Stability Weights

⚠ WARNING

DO NOT REPLACE ITEMS CRITICAL TO STABILITY, SUCH AS BATTERIES OR SOLID TIRES, WITH ITEMS OF DIFFERENT WEIGHT OR SPECIFICATION. DO NOT MODIFY UNIT IN ANY WAY TO AFFECT STABILITY.

Table 1-6. Critical Stability Weights

Component	Model 1230 ES	
Wheel and Tire Assembly (each)	15 lb.	7 kg
Wheel/Tire and Drive Assembly (each)	93 lb.	42 kg
Batteries - Standard (each)	62 lb.	28 kg
Batteries - Standard - Combined	248 lb.	112 kg
Batteries - AGM (each)	69.2 lb.	31.4 kg
Batteries - AGM - Combined	276.8 lb.	125.6 kg

1.2 LUBRICATION

Lubrication Capacities

Table 1-7. Capacities

Component	1230ES	
Hydraulic Tank	0.80 Gal.	3 L
Hydraulic System (Including Tank)	1.75 Gal.	4.1 L

Hydraulic Oil

NOTE: *Machines built in Europe installed hydraulic oil (Nervofluid 15) which has a BLUE TINT for identification purposes only, but is fully compatible and can be mixed with any of the JLG recommended hydraulic oils mentioned following.*

Table 1-8. Hydraulic Oil

Hydraulic System Operating Temperature Range	SAE Viscosity Grade
0°F to +23°F (-18°C to -5°C)	10W
0°F to 210°F (-18°C to +99°C)	10W-20, 10W-30
50°F to 210°F (+10°C to +210°C)	20W-20

NOTE: *Hydraulic oils must have anti-wear qualities at least to API Service Classification GL-3, and sufficient chemical stability for mobile hydraulic system service. JLG recommends Mobilfluid DTE 11M hydraulic oil, which has an SAE viscosity index of 140.*

When temperatures remain below 20°F (-7°C), JLG recommends the use of Mobil DTE13. Aside from JLG recommendations, it is not advisable to mix oils of different brands or types, as they may not contain the same required additives or be of comparable viscosities.

Lubrication Specifications

Table 1-9. Lubrication Specifications

Key	Specifications
MPG	Multipurpose Grease having a minimum dripping point of 350° F. Excellent water resistance and adhesive qualities, and being of extreme pressure type. (Timken OK 40 pounds minimum.)
EPGL	Extreme Pressure Gear Lube (oil) meeting API service classification GL-5 or MIL-Spec MIL-L-2105.
HO	Hydraulic Oil - Mobil DTE 11M or Nervofluid 15 (Europe)

Hydraulic Oil Specifications

Table 1-10. Nervofluid 15

ISO Viscosity Grade	#15
Density	0.860 kg/dm^3 @ 59°F (15°C)
Pour Point, Max	-40° C (-40° F)
Flash Point, Min.	175° C (347° F)
Viscosity	
at 40° C	14.9 mm^2/s
at 100° C	3.8 mm^2/s
Viscosity Index	153

Table 1-11. Mobil DTE 10 Excel 15

ISO Viscosity Grade	#15
Pour Point, Max	-54° C
Flash Point, Min.	182° C
Density at 15°C	0.8375 kg/l
Density at 60°F	0.0302 lb/in^3
Viscosity	
at 40° C	15.8 cSt
at 100° C	4.07 cSt
Viscosity Index	168

Table 1-12. Mobil EAL Environsyn H 32

ISO Viscosity Grade	#32
Pour Point, Max	-39°C (-38°F)
Flash Point, Min.	268°C (514°F)
Density at 15°C	0.869 kg/l
Operating Temperature	-29°C (-20°F) to -93°C (-200°F)
Viscosity	
at 40°C	33.1 cSt
at 100°C	6.36 cSt
Viscosity Index	147

Table 1-13. Mobil SHC Hydraulic EAL 32

ISO Viscosity Grade	#32
Pour Point, Max	-33°C (-27°F)
Flash Point, Min.	282°C (540°F)
Density at 15°C	0.936 kg/l
Operating Temperature	-17°C (-1.4°F) to -93°C (-200°F)
Viscosity	
at 40°C	31.1 cSt
at 100°C	6.2 cSt
Viscosity Index	152

Oil Check Procedure

Lube Point(s) - Hydraulic Reservoir
Reservoir Capacity: 0.80 Gal. (3 L)
Lube - Hydraulic Oil
Interval - Check Daily

NOTE: *Be certain the hydraulic oil has warmed to operating temperature before checking the oil level in the reservoir.*

1. From either side of the machine, open the **side access door on the base frame (1)**. Locate the **hydraulic oil reservoir (2)** on the **pump unit (3)**. Check the oil level in the hydraulic reservoir by looking at the markings on the side of the tank. The reservoir is marked with **MIN (minimum) and MAX (maximum) markings (4)**. The oil level must be within these markings to operate properly.
2. If additional oil is required, wipe all dirt and debris from the **filler/breather cap (5)** area, add proper grade of oil by using a funnel with a flexible spout or a plastic squeeze bottle. Fill until oil level is between the **MIN and MAX markings (4)**.

NOTE: *Care should be taken not to introduce any impurities (dirt, water etc.) while cap is removed.*

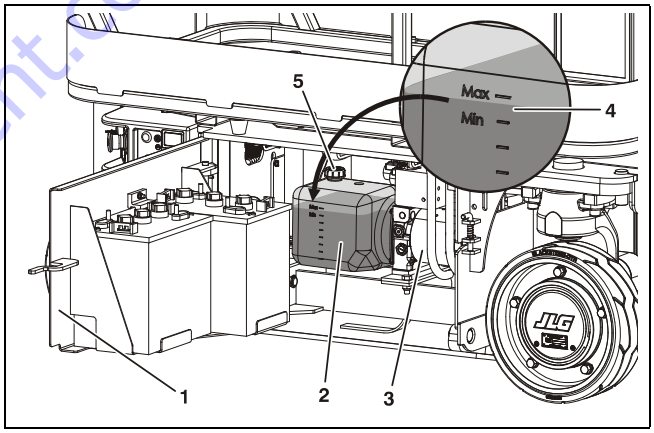

Figure 1-1. Hydraulic Oil Check Procedure

NOTE: *Recommended lubricating intervals are based on machine operations under normal conditions. For machines used in multi-shift operations and/or exposed to hostile environments or conditions, lubrication frequencies must be increased accordingly.*

1.3 CYLINDER SPECIFICATIONS

NOTE: *All dimensions are given in inches (in), with the metric equivalent, centimeters (cm), given in parentheses.*

Table 1-14. Cylinder Specifications

Description	Bore in./(cm)	Stroke in./(cm)	Rod Dia. in./(cm)
Lift Cylinder	1.57 (4)	124 (315)	1.18 (3)
Steer Cylinder	1.97 (5)	4.21 (10.7)	0.98 (2.5)

1.4 TORQUE REQUIREMENTS

When maintenance becomes necessary or a fastener has loosened, refer to the applicable Torque Chart in this section of the manual to determine proper torque values for various size fasteners.

1.5 SERIAL NUMBER LOCATIONS

For machine identification, a metal serial number plate is affixed to the machine. The plate is mounted behind the left rear wheel on the side of the base frame. The machine serial number can also be found on a bar code label placed on the platform control station mounting plate in the platform.

Values for Zinc Yellow Chromate Fasteners (Ref 4150707)																		
SAE GRADE 5 BOLTS & GRADE 2 NUTS													SAE GRADE 8 (HEX HD) BOLTS & GRADE 8 NUTS*						
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load	Torque (Dry)		Torque Lubricated		Torque (Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140)		Torque (Loctite® 262™ or Vibra-TITE™ 131)		Clamp Load	Torque (Dry or Loctite® 263) K= 0.20		Torque (Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140) K=.18		Torque (Loctite® 262™ or Vibra-TITE™ 131) K=0.15	
		In	Sq In	LB	IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]	LB	IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]
4	40	0.1120	0.00604	380	8	0.9	6	0.7											
	48	0.1120	0.00661	420	9	1.0	7	0.8											
6	32	0.1380	0.00909	580	16	1.8	12	1.4											
	40	0.1380	0.01015	610	18	2.0	13	1.5											
8	32	0.1640	0.01400	900	30	3.4	22	2.5											
	36	0.1640	0.01474	940	31	3.5	23	2.6					1320	43	5				
10	24	0.1900	0.01750	1120	43	4.8	32	3.5					1580	60	7				
	32	0.1900	0.02000	1285	49	5.5	36	4					1800	68	8				
1/4	20	0.2500	0.0318	2020	96	10.8	75	9	105	12			2860	143	16	129	15		
	28	0.2500	0.0364	2320	120	13.5	86	10	135	15			3280	164	19	148	17		
		In	Sq In	LB	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m]	LB	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m]
5/16	18	0.3125	0.0524	3340	17	23	13	18	19	26	16	22	4720	25	35	20	25	20	25
	24	0.3125	0.0580	3700	19	26	14	19	21	29	17	23	5220	25	35	25	35	20	25
3/8	16	0.3750	0.0775	4940	30	41	23	31	35	48	28	38	7000	45	60	40	55	35	50
	24	0.3750	0.0878	5600	35	47	25	34	40	54	32	43	7900	50	70	45	60	35	50
7/16	14	0.4375	0.1063	6800	50	68	35	47	55	75	45	61	9550	70	95	65	90	50	70
	20	0.4375	0.1187	7550	55	75	40	54	60	82	50	68	10700	80	110	70	95	60	80
1/2	13	0.5000	0.1419	9050	75	102	55	75	85	116	68	92	12750	105	145	95	130	80	110
	20	0.5000	0.1599	10700	90	122	65	88	100	136	80	108	14400	120	165	110	150	90	120
9/16	12	0.5625	0.1820	11600	110	149	80	108	120	163	98	133	16400	155	210	140	190	115	155
	18	0.5625	0.2030	12950	120	163	90	122	135	184	109	148	18250	170	230	155	210	130	175
5/8	11	0.6250	0.2260	14400	150	203	110	149	165	224	135	183	20350	210	285	190	260	160	220
	18	0.6250	0.2560	16300	170	230	130	176	190	258	153	207	23000	240	325	215	290	180	245
3/4	10	0.7500	0.3340	21300	260	353	200		285	388	240	325	30100	375	510	340	460	280	380
	16	0.7500	0.3730	23800	300	407	220	298	330	449	268	363	33600	420	570	380	515	315	430
7/8	9	0.8750	0.4620	29400	430	583	320	434	475	646	386	523	41600	605	825	545	740	455	620
	14	0.8750	0.5090	32400	470	637	350	475	520	707	425	576	45800	670	910	600	815	500	680
1	8	1.0000	0.6060	38600	640	868	480	651	675	918	579	785	51500	860	1170	770	1045	645	875
	12	1.0000	0.6630	42200	700	949	530	719	735	1000	633	858	59700	995	1355	895	1215	745	1015
1 1/8	7	1.1250	0.7630	42300	800	1085	600	813	840	1142	714	968	68700	1290	1755	1160	1580	965	1310
	12	1.1250	0.8560	47500	880	1193	660	895	925	1258	802	1087	77000	1445	1965	1300	1770	1085	1475
1 1/4	7	1.2500	0.9690	53800	1120	1518	840	1139	1175	1598	1009	1368	87200	1815	2470	1635	2225	1365	1855
	12	1.2500	1.0730	59600	1240	1681	920	1247	1300	1768	1118	1516	96600	2015	2740	1810	2460	1510	2055
1 3/8	6	1.3750	1.1550	64100	1460	1979	1100	1491	1525	2074	1322	1792	104000	2385	3245	2145	2915	1785	2430
	12	1.3750	1.3150	73000	1680	2278	1260	1708	1750	2380	1506	2042	118100	2705	3680	2435	3310	2030	2760
1 1/2	6	1.5000	1.4050	78000	1940	2630	1460	1979	2025	2754	1755	2379	126500	3165	4305	2845	3870	2370	3225
	12	1.5000	1.5800	87700	2200	2983	1640	2224	2300	3128	1974	2676	142200	3555	4835	3200	4350	2665	3625

NOTES: 1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
3. * ASSEMBLY USES HARDENED WASHER

NO. 5000059 REV. K

REFERENCE JLG THREAD LOCKING COMPOUND

JLG P/N	Loctite® P/N	ND Industries P/N	Description
0100011	242™	Vibra-TITE™ 121	Medium Strength (Blue)
0100019	271™	Vibra-TITE™ 140	High Strength (Red)
0100071	262™	Vibra-TITE™ 131	Medium - High Strength (Red)

Figure 1-2. Torque Chart (SAE Fasteners - Sheet 1 of 5)

Values for Magni Coating Fasteners (Ref 4150701)																
				SAE GRADE 5 BOLTS & GRADE 2 NUTS							SAE GRADE 8 (HEX HD) BOLTS & GRADE 8 NUTS*						
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load	Torque (Dry) K=0.17		Torque (Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140) K=0.16		Torque (Loctite® 262™ or Vibra-TITE™ 131) K=0.15		Clamp Load	Torque (Dry or Loctite® 263) K= 0.17		Torque (Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140) K=.16		Torque (Loctite® 262™ or Vibra-TITE™ 131) K=0.15	
		In	Sq In	LB	IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]	LB	IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]
4	40	0.1120	0.00604	380	7	0.8											
	48	0.1120	0.00661	420	8	0.9											
6	32	0.1380	0.00909	580	14	1.5											
	40	0.1380	0.01015	610	14	1.6											
8	32	0.1640	0.01400	900	25	2.8											
	36	0.1640	0.01474	940	26	2.9					1320	37	4				
10	24	0.1900	0.01750	1120	36	4.1					1580	51	6				
	32	0.1900	0.02000	1285	42	4.7					1800	58	7				
1/4	20	0.2500	0.0318	2020	86	9.7	80	9			2860	122	14	114	13		
	28	0.2500	0.0364	2320	99	11.1	95	11			3280	139	16	131	15		
		In	Sq In	LB	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m]	LB	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m]
5/16	18	0.3125	0.0524	3340	15	20	14	19	15	20	4720	20	25	20	25	20	25
	24	0.3125	0.0580	3700	15	20	15	21	15	20	5220	25	35	20	25	20	25
3/8	16	0.3750	0.0775	4940	25	35	25	34	25	34	7000	35	50	35	50	35	50
	24	0.3750	0.0878	5600	30	40	28	38	25	34	7900	40	55	40	55	35	50
7/16	14	0.4375	0.1063	6800	40	55	40	54	35	48	9550	60	80	55	75	50	70
	20	0.4375	0.1187	7550	45	60	44	60	40	54	10700	65	90	60	80	60	80
1/2	13	0.5000	0.1419	9050	65	90	60	82	55	75	12750	90	120	85	115	80	110
	20	0.5000	0.1599	10700	75	100	71	97	65	88	14400	100	135	95	130	90	120
9/16	12	0.5625	0.1820	11600	90	120	87	118	80	109	16400	130	175	125	170	115	155
	18	0.5625	0.2030	12950	105	145	97	132	90	122	18250	145	195	135	185	130	175
5/8	11	0.6250	0.2260	14400	130	175	120	163	115	156	20350	180	245	170	230	160	220
	18	0.6250	0.2560	16300	145	195	136	185	125	170	23000	205	280	190	260	180	245
3/4	10	0.7500	0.3340	21300	225	305	213	290	200	272	30100	320	435	300	410	280	380
	16	0.7500	0.3730	23800	255	345	238	324	225	306	33600	355	485	335	455	315	430
7/8	9	0.8750	0.4620	29400	365	495	343	466	320	435	41600	515	700	485	660	455	620
	14	0.8750	0.5090	32400	400	545	378	514	355	483	45800	570	775	535	730	500	680
1	8	1.0000	0.6060	38600	545	740	515	700	480	653	51500	730	995	685	930	645	875
	12	1.0000	0.6630	42200	600	815	563	765	530	721	59700	845	1150	795	1080	745	1015
1 1/8	7	1.1250	0.7630	42300	675	920	635	863	595	809	68700	1095	1490	1030	1400	965	1310
	12	1.1250	0.8560	47500	755	1025	713	969	670	911	77000	1225	1665	1155	1570	1085	1475
1 1/4	7	1.2500	0.9690	53800	955	1300	897	1219	840	1142	87200	1545	2100	1455	1980	1365	1855
	12	1.2500	1.0730	59600	1055	1435	993	1351	930	1265	96600	1710	2325	1610	2190	1510	2055
1 3/8	6	1.3750	1.1550	64100	1250	1700	1175	1598	1100	1496	104000	2025	2755	1905	2590	1785	2430
	12	1.3750	1.3150	73000	1420	1930	1338	1820	1255	1707	118100	2300	3130	2165	2945	2030	2760
1 1/2	6	1.5000	1.4050	78000	1660	2260	1560	2122	1465	1992	126500	2690	3660	2530	3440	2370	3225
	12	1.5000	1.5800	87700	1865	2535	1754	2385	1645	2237	142200	3020	4105	2845	3870	2665	3625

NOTES: 1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
3. * ASSEMBLY USES HARDENED WASHER

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Figure 1-3. Torque Chart (SAE Fasteners - Sheet 2 of 5)

Size	TPI	Bolt Dia	Tensile Stress Area	Magni Coating (Ref 4150701)*: Clamp Load See Note 4	Torque (Dry) K = .17		Torque (Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140 OR Precoat 85®) K=0.16		Torque (Loctite® 262™ or Vibra-TITE™ 131) K=0.15		Zinc Yellow Chromate Fasteners (Ref 4150707)*: Clamp Load See Note 4	Torque (Dry) K = .20		Torque (Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140 OR Precoat 85®) K=0.18		Torque (Loctite® 262™ or Vibra-TITE™ 131) K=0.15	
		In	Sq In	LB	IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]	LB	IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]
4	40	0.1120	0.00604														
	48	0.1120	0.00661														
6	32	0.1380	0.00909														
	40	0.1380	0.01015														
8	32	0.1640	0.01400														
	36	0.1640	0.01474														
10	24	0.1900	0.01750														
	32	0.1900	0.02000														
1/4	20	0.2500	0.0318	2860	122	14	114	13			2860	143	16	129	15		
	28	0.2500	0.0364	3280	139	16	131	15			3280	164	19	148	17		
		In	Sq In	LB	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m]	LB	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m]
5/16	18	0.3125	0.0524	4720	20	25	20	25	20	25	4720	25	35	20	25	20	25
	24	0.3125	0.0580	5220	25	35	20	25	20	25	5220	25	35	25	35	20	25
3/8	16	0.3750	0.0775	7000	35	50	35	50	35	50	7000	45	60	40	55	35	50
	24	0.3750	0.0878	7900	40	55	40	55	35	50	7900	50	70	45	60	35	50
7/16	14	0.4375	0.1063	9550	60	80	55	75	50	70	9550	70	95	65	90	50	70
	20	0.4375	0.1187	10700	65	90	60	80	60	80	10700	80	110	70	95	60	80
1/2	13	0.5000	0.1419	12750	90	120	85	115	80	110	12750	105	145	95	130	80	110
	20	0.5000	0.1599	14400	100	135	95	130	90	120	14400	120	165	110	150	90	120
9/16	12	0.5625	0.1820	16400	130	175	125	170	115	155	16400	155	210	140	190	115	155
	18	0.5625	0.2030	18250	145	195	135	185	130	175	18250	170	230	155	210	130	175
5/8	11	0.6250	0.2260	20350	180	245	170	230	160	220	20350	210	285	190	260	160	220
	18	0.6250	0.2560	23000	205	280	190	260	180	245	23000	240	325	215	290	180	245
3/4	10	0.7500	0.3340	30100	320	435	300		280	380	30100	375	510	340	460	280	380
	16	0.7500	0.3730	33600	355	485	335	455	315	430	33600	420	570	380	515	315	430
7/8	9	0.8750	0.4620	41600	515	700	485	660	455	620	41600	605	825	545	740	455	620
	14	0.8750	0.5090	45800	570	775	535	730	500	680	45800	670	910	600	815	500	680
1	8	1.0000	0.6060	51500	730	995	685	930	645	875	51500	860	1170	775	1055	645	875
	12	1.0000	0.6630	59700	845	1150	795	1080	745	1015	59700	995	1355	895	1215	745	1015
1 1/8	7	1.1250	0.7630	68700	1095	1490	1030	1400	965	1310	68700	1290	1755	1160	1580	965	1310
	12	1.1250	0.8560	77000	1225	1665	1155	1570	1085	1475	77000	1445	1965	1300	1770	1085	1475
1 1/4	7	1.2500	0.9690	87200	1545	2100	1455	1980	1365	1855	87200	1815	2470	1635	2225	1365	1855
	12	1.2500	1.0730	96600	1710	2325	1610	2190	1510	2055	96600	2015	2740	1810	2460	1510	2055
1 3/8	6	1.3750	1.1550	104000	2025	2755	1905	2590	1785	2430	104000	2385	3245	2145	2915	1785	2430
	12	1.3750	1.3150	118100	2300	3130	2165	2945	2030	2760	118100	2705	3680	2435	3310	2030	2760
1 1/2	6	1.5000	1.4050	126500	2690	3660	2530	3440	2370	3225	126500	3165	4305	2845	3870	2370	3225
	12	1.5000	1.5800	142200	3020	4105	2845	3870	2665	3625	142200	3555	4835	3200	4350	2665	3625

SOCKET HEAD CAP SCREWS

NOTES: 1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
*3. ASSEMBLY USES HARDENED WASHER OR FASTENER IS PLACED AGAINST PLATED STEEL OR RAW ALUMINUM
4. CLAMP LOAD LISTED FOR SHCS IS SAME AS GRADE 8 OR CLASS 10.9 AND DOES NOT REPRESENT FULL STRENGTH CAPABILITY OF SHCS. IF HIGHER LOAD IS REQUIRED, ADDITIONAL TESTING IS REQUIRED.

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Figure 1-4. Torque Chart (SAE Fasteners - Sheet 3 of 5)

			Values for Zinc Yellow Chromate Fasteners (Ref 4150707)								
			CLASS 8.8 METRIC (HEX/SOCKET HEAD) BOLTS CLASS 8 METRIC NUTS					CLASS 10.9 METRIC (HEX HEAD) BOLTS CLASS 10 METRIC NUTS CLASS 12.9 SOCKET HEAD CAP SCREWS M3 - M5*			
Size	PITCH	Tensile Stress Area	Clamp Load	Torque (Dry or Loctite® 263™)	Torque (Lub)	Torque (Loctite® 262™ OR Vibra-TITE™ 131)	Torque (Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140)	Clamp Load	Torque (Dry or Loctite® 263™) K = 0.20	Torque (Lub OR Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140) K= 0.18	Torque (Loctite® 262™ OR Vibra-TITE™ 131) K=0.15
		Sq mm	KN	[N.m]	[N.m]	[N.m]	[N.m]	KN	[N.m]	[N.m]	[N.m]
3	0.5	5.03	2.19	1.3	1.0	1.2	1.4	3.13			
3.5	0.6	6.78	2.95	2.1	1.6	1.9	2.3	4.22			
4	0.7	8.78	3.82	3.1	2.3	2.8	3.4	5.47			
5	0.8	14.20	6.18	6.2	4.6	5.6	6.8	8.85			
6	1	20.10	8.74	11	7.9	9.4	12	12.5			
7	1	28.90	12.6	18	13	16	19	18.0	25	23	19
8	1.25	36.60	15.9	26	19	23	28	22.8	37	33	27
10	1.5	58.00	25.2	50	38	45	55	36.1	70	65	55
12	1.75	84.30	36.7	88	66	79	97	52.5	125	115	95
14	2	115	50.0	140	105	126	154	71.6	200	180	150
16	2	157	68.3	219	164	197	241	97.8	315	280	235
18	2.5	192	83.5	301	226	271	331	119.5	430	385	325
20	2.5	245	106.5	426	320	383	469	152.5	610	550	460
22	2.5	303	132.0	581	436	523	639	189.0	830	750	625
24	3	353	153.5	737	553	663	811	222.0	1065	960	800
27	3	459	199.5	1080	810	970	1130	286.0	1545	1390	1160
30	3.5	561	244.0	1460	1100	1320	1530	349.5	2095	1885	1575
33	3.5	694	302.0	1990	1490	1790	2090	432.5	2855	2570	2140
36	4	817	355.5	2560	1920	2300	2690	509.0	3665	3300	2750
42	4.5	1120	487.0	4090	3070	3680	4290	698.0	5865	5275	4395

NOTES: 1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
*3. ASSEMBLY USES HARDENED WASHER OR FASTENER IS PLACED AGAINST PLATED STEEL OR RAW ALUMINUM
4. CLAMP LOAD LISTED FOR SHCS IS SAME AS GRADE 8 OR CLASS 10.9 AND DOES NOT REPRESENT FULL STRENGTH CAPABILITY OF SHCS. IF HIGHER LOAD IS REQUIRED, ADDITIONAL TESTING IS REQUIRED.

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Figure 1-5. Torque Chart (METRIC Fasteners - Sheet 4 of 5)

Values for Magni Coated Fasteners (Ref 4150701)										
			CLASS 8.8 METRIC (HEX/SOCKET HEAD) BOLTS CLASS 8 METRIC NUTS				CLASS 10.9 METRIC (HEX HEAD) BOLTS CLASS 10 METRIC NUTS CLASS 12.9 SOCKET HEAD CAP SCREWS M6 AND ABOVE*			
Size	PITCH	Tensile Stress Area	Clamp Load	Torque (Dry or Loctite® 263™) K=0.17	Torque (Loctite® 262™ OR Vibra-TITE™ 131) K=0.16	Torque (Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140) K=0.15	Clamp Load	Torque (Dry or Loctite® 263™) K = 0.17	Torque (Lub OR Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140) K= 0.16	Torque (Loctite® 262™ OR Vibra-TITE™ 131) K=0.15
		Sq mm	KN	[N.m]	[N.m]	[N.m]	KN	[N.m]	[N.m]	[N.m]
3	0.5	5.03	2.19	1.1	1.1	1.0	3.13			
3.5	0.6	6.78	2.95	1.8	1.7	1.5	4.22			
4	0.7	8.78	3.82	2.6	2.4	2.3	5.47			
5	0.8	14.20	6.18	5.3	4.9	4.6	8.85			
6	1	20.10	8.74	9	8.4	7.9	12.5	13	12	11
7	1	28.90	12.6	15	14	13	18.0	21	20	19
8	1.25	36.60	15.9	22	20	19	22.8	31	29	27
10	1.5	58.00	25.2	43	40	38	36.1	61	58	55
12	1.75	84.30	36.7	75	70	66	52.5	105	100	95
14	2	115	50.0	119	110	105	71.6	170	160	150
16	2	157	68.3	186	175	165	97.8	265	250	235
18	2.5	192	83.5	256	240	225	119.5	365	345	325
20	2.5	245	106.5	362	340	320	152.5	520	490	460
22	2.5	303	132.0	494	465	435	189.0	705	665	625
24	3	353	153.5	627	590	555	222.0	905	850	800
27	3	459	199.5	916	860	810	286.0	1315	1235	1160
30	3.5	561	244.0	1245	1170	1100	349.5	1780	1680	1575
33	3.5	694	302.0	1694	1595	1495	432.5	2425	2285	2140
36	4	817	355.5	2176	2050	1920	509.0	3115	2930	2750
42	4.5	1120	487.0	3477	3275	3070	698.0	4985	4690	4395

NOTES: 1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
*3. ASSEMBLY USES HARDENED WASHER OR FASTENER IS PLACED AGAINST PLATED STEEL OR RAW ALUMINUM
4. CLAMP LOAD LISTED FOR SHCS IS SAME AS GRADE 8 OR CLASS 10.9 AND DOES NOT REPRESENT FULL STRENGTH CAPABILITY OF SHCS. IF HIGHER LOAD IS REQUIRED, ADDITIONAL TESTING IS REQUIRED.

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Figure 1-6. Torque Chart (METRIC Fasteners - Sheet 5 of 5)

SECTION 2. GENERAL SERVICE INFORMATION

2.1 MACHINE PREPARATION, INSPECTION, AND MAINTENANCE

General

This section provides the necessary information needed by those personnel that are responsible to place the machine in operation readiness and maintain its safe operating condition. For maximum service life and safe operation, ensure that all the necessary inspections and maintenance have been completed before placing the machine into service. With proper care, maintenance, and inspections performed per JLG's recommendations, and with any and all discrepancies corrected, this product will be fit for continued use.

Preparation, Inspection, and Maintenance

It is important to establish and conform to a comprehensive inspection and preventive maintenance program. The following table outlines the periodic machine inspections and maintenance recommended by JLG Industries, Inc. Consult your national, regional, or local regulations for further requirements for aerial work platforms. The frequency of inspections and maintenance must be increased as environment, severity and frequency of usage requires.

Pre-Start Inspection

It is the User's or Operator's primary responsibility to perform a Pre-Start Inspection of the machine prior to use daily or at each change of operator. Reference the Operator's and Safety Manual for completion procedures for the Pre-Start Inspection. The Operator and Safety Manual must be read in its entirety and understood prior to performing the Pre-Start Inspection.

Pre-Delivery Inspection and Frequent Inspection

The Pre-Delivery Inspection and Frequent Inspection shall be performed by a qualified JLG equipment mechanic. JLG Industries, Inc. recognizes a qualified JLG equipment mechanic as a person who, by possession of a recognized degree, certificate, extensive knowledge, training, or experience, has successfully demonstrated the ability and proficiency to service, repair, and maintain the subject JLG product model.

The Pre-Delivery Inspection and Frequent Inspection procedures are performed in the same manner, but at different times. The Pre-Delivery Inspection shall be performed prior to each sale, lease, or rental delivery. The Frequent Inspection shall be accomplished for each machine in service for 3 months; out of service for a period of more than 3 months; or when purchased used. The frequency of this inspection must be increased as environment, severity and frequency of usage requires.

Reference the JLG Pre-Delivery and Frequent Inspection Form and the Inspection and Preventative Maintenance Schedule for items requiring inspection during the performance of these inspections. Reference the appropriate areas of this manual for servicing and maintenance procedures.

Annual Machine Inspection

The Annual Machine Inspection must be performed by a Factory-Trained Service Technician on an annual basis, no later than thirteen (13) months from the date of the prior Annual Machine Inspection. JLG Industries, Inc. recognizes a Factory-Trained Service Technician as a person who has successfully completed the JLG Service Training School for the subject JLG product model. Refer the machine Service and Maintenance Manual and appropriate JLG inspection form for performance of this inspection.

Refer the JLG Annual Machine Inspection Form and the Inspection and Preventative Maintenance Schedule for items requiring inspection during the performance of this inspection. Reference the appropriate areas of this manual for servicing and maintenance procedures.

For the purpose of receiving safety-related bulletins, it is important that JLG Industries, Inc. has updated ownership information for each machine. When performing each Annual Machine Inspection, notify JLG Industries, Inc. of the current machine ownership.

Preventative Maintenance

In conjunction with the specified inspections, maintenance shall be performed by a qualified JLG equipment mechanic. JLG Industries, Inc. recognizes a qualified JLG equipment mechanic as a person who, by possession of a recognized degree, certificate, extensive knowledge, training, or experience, has successfully demonstrated the ability and proficiency to service, repair, and maintain the subject JLG product model.

Reference Table 2-2, Preventive Maintenance & Inspection Schedule., and the appropriate areas of this manual for servicing and maintenance procedures. The frequency of service and maintenance must be increased as environment, severity and frequency of usage requires.

Table 2-1. Maintenance and Inspection Requirements.

TYPE	FREQUENCY	PRIMARY RESPONSIBILITY	SERVICE QUALIFICATION	REFERENCE
Pre-Start Inspection	Prior to use each day; or At each Operator change.	User or Operator	User or Operator	Operator and Safety Manual
Pre-Delivery Inspection	Prior to each sale, lease, or rental delivery.	Owner, Dealer, or User	Qualified JLG Mechanic	Service and Maintenance Manual and applicable JLG inspection form.
Frequent Inspection	In service for 3 months; or Out of service for a period of more than 3 months; or Purchased used.	Owner, Dealer, or User	Qualified JLG Mechanic	Service and Maintenance Manual and applicable JLG inspection form.
Annual Machine Inspection	Annually, no later than 13 months from the date of the prior inspection.	Owner, Dealer, or User	Factory-Trained Service Technician (Recommended)	Service and Maintenance Manual and applicable JLG inspection form.
Preventative Maintenance	At intervals as specified in the Service and Maintenance Manual.	Owner, Dealer, or User	Qualified JLG Mechanic	Service and Maintenance Manual

2.2 PREVENTIVE MAINTENANCE AND INSPECTION SCHEDULE

(See Table 2-2.)

The preventive maintenance and inspection checks are listed and defined in the following table. This table is divided into two basic parts, the “AREA” to be inspected and the “INTERVAL” at which the inspection is to take place. Under the “AREA” portion of the table, the various systems along with the components that make up that system are listed. The “INTERVAL” portion of the table is divided into two columns representing the various inspection time periods. The numbers listed within the interval column represent the applicable inspection code for which that component is to be checked.

The checks and services listed in this schedule are not intended to replace any local or regional regulations that may pertain to this type of equipment nor should the lists be considered as all inclusive. Variances in interval times may occur due to climate and/or conditions and depending on the location and use of the machine.

Table 2-2. Preventive Maintenance & Inspection Schedule.

AREA ON MACHINE	INTERVAL	
	Pre-Delivery[1] or Frequent [2] (Quarterly) Inspection	Annual[3] (Yearly) Inspection
MAST AND PLATFORM ASSEMBLY		
Mast Sections	2,3	2,3
Chains, Cables and Sequencing Cables	1	1,2
Chains Lubricating	1,7	1,2,7,9
Platform, Platform Gate and latches	1,3	1,3
Guard Rails and parts	1,2	1,2
Covers & Shields		1
Slide Pads		1,2
Floor	1,2	1,2
Lanyard Anchorage Point	1,2,6	1,2,6
BASE ASSEMBLY		
Brake release		3
Wheel lug nut	1[50]	1[50]
CHASSIS ASSEMBLY		
Cover Installation	1,5	1,5
Static Strap	1	1
Wheel and Tire Assemblies	1,2	1,2
Drive Motors	1,4,5	1,4,5
Drive Motor Brushes		
FUNCTIONS/CONTROLS		
Controls operate properly return to neutral/off when released	3,9	3,9
Emergency Stop Switches (Ground & Platform)		3
Touch pad, LED's light when pads depressed	3	3
Drive Lift mode selector switch	3	3
Manual Descent or Auxiliary power	3	3
Enclosure & protective boot\guard	3	3
Ground controls override platform controls	3,7	3,7
Function Control Locks, Guards, or Detents	3	3
Brake Release		3
POWER SYSTEM		
Battery fluid level correct	1,2	1,2
Motors free of damage	2	2
All electrical connections tight, free of frays & corrosion	1,4	1,4
Batteries	1,2,4,8	1,2,4,8
Battery Charger		3
HYDRAULIC/ELECTRIC SYSTEM		
Hydraulic Pumps	1,2,4	1,2,3,4,5
Hydraulic Cylinders	2,4,5	2,4,5
Hydraulic Hoses, Lines, and Fittings	1,4	1,4
Hydraulic Reservoir, Cap, and Breather	3,5	3,5
Hydraulic Filters	1,4,5	1,4,5
Hydraulic Fluid	4	4

Table 2-2. Preventive Maintenance & Inspection Schedule. (Continued)

AREA ON MACHINE	INTERVAL	
	Pre-Delivery[1] or Frequent [2] (Quarterly) Inspection	Annual[3] (Yearly) Inspection
Hydraulic Valves	1,2,4	1,2,4
Steer Cylinder Attachment Pins and Pin Retainers	1,2	1,2
Electrical connections	1,2	1,2
Instruments, Gauges Switches, lights, horn		3
GENERAL		
No Unauthorized Modifications or Additions	9	9
General Structural Condition and Welds	2	2
Paint and Appearance	5	5
Notify JLG of Machine Ownership	9	9
Annual Machine Inspection Due	9	9
All Relevant Safety Publications Incorporated	9	9
All Decals/Placards Installed, Secure, Legible	9	9
All Fasteners, Pins, Shields, and Covers		1,2
Function Test of All Systems	9	9
Stamp Inspection Date on Frame		9

Footnotes:

[1] Prior to each sale, lease, or delivery

[2] In service for 3 months; Out of service for 3 months or more; Purchased used

[3] Annually, no later than 13 months from the date of the prior inspection, Includes all daily and quarterly inspections, mandated by regulating body

[50] Indicates a 50 hour interval required to perform task after initial use of machine. This only occurs once in machine life

Performance Codes:

1 - Check for proper and secure: installation, adjustment, or torque
2 - Visual inspection for damage: (cracks, corrosion, abrasions, distortion, excessive wear, broken welds, gouges, chafing and threads showing)
3 - Proper operation
4 - Check for proper sealing, signs of leakage and fluid level
5 - Clean and free of debris
6 - Decals installed and legible
7 - Check for proper tolerances, routing, and lubrication
8 - Fully Charged
9 - Verify/Perform

2.3 SERVICING AND MAINTENANCE GUIDELINES

General

The following information is provided to assist you in the use and application of servicing and maintenance procedures contained in this chapter.

Safety and Workmanship

Your safety, and that of others, is the first consideration when engaging in the maintenance of equipment. Always be conscious of component weight. Never attempt to move heavy parts without the aid of a mechanical device. Do not allow heavy objects to rest in an unstable position. When raising a portion of the equipment, ensure that adequate support is provided.

⚠ WARNING

NEVER WORK UNDER AN ELEVATED PLATFORM UNTIL PLATFORM HAS BEEN SAFELY RESTRAINED FROM ANY MOVEMENT BY BLOCKING OR OVERHEAD SLING.

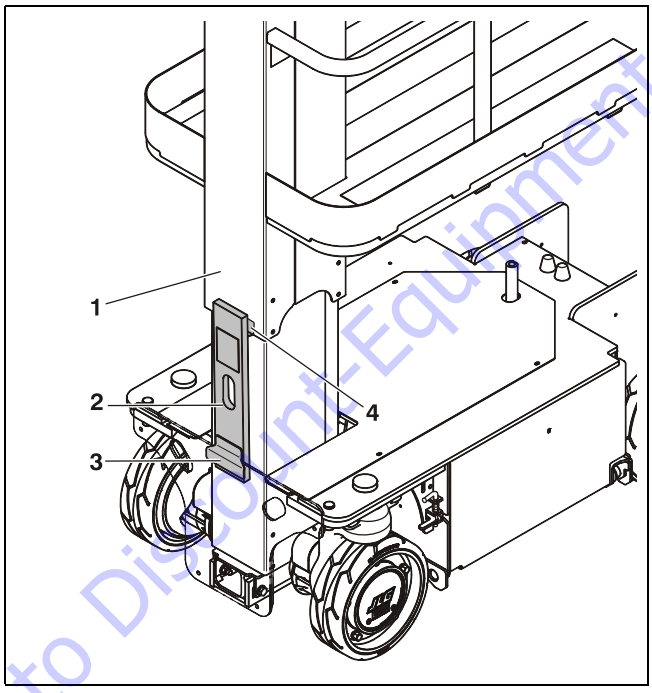

Figure 2-1. Platform Mast Support Tool.

1. Elevate platform/outer mast (1) approximately 3 ft. (1m).
2. Place mast support tool (2) between the mast and the front frame by hooking the bracket (3) over the front frame plate at bottom as shown above.
3. Lower the platform until the bottom edge of the platform/outer mast section (1) is resting on the hook bracket (4) at the top of the mast support tool.

Cleanliness

The most important single item in preserving the long service life of a machine is to keep dirt and foreign materials out of the vital components. Precautions have been taken to safeguard against this. Shields, covers, seals, and filters are provided to keep the wheel bearings, mast sections and oil supply clean; however, these items must be maintained on a scheduled basis in order to function properly.

At any time when oil lines are disconnected, clear adjacent areas as well as the openings and fittings themselves. As soon as a line or component is disconnected, cap or cover all openings to prevent entry of foreign matter.

Clean and inspect all parts during servicing or maintenance, and assure that all passages and openings are unobstructed. Cover all parts to keep them clean. Be sure all parts are clean before they are installed. New parts should remain in their containers until they are ready to be used.

Components Removal and Installation

Use adjustable lifting devices, whenever possible, if mechanical assistance is required. All slings *(chains, cables, etc.)* should be parallel to each other and as near perpendicular as possible to top of part being lifted.

Should it be necessary to remove a component on an angle, keep in mind that the capacity of an eyebolt or similar bracket lessens, as the angle between the supporting structure and the component becomes less than 90 degrees.

If a part resists removal, check to see whether all nuts, bolts, cables, brackets, wiring, etc., have been removed and that no adjacent parts are interfering.

Component Disassembly and Reassembly

When disassembling or reassembling a component, complete the procedural steps in sequence. Do not partially disassemble or assemble one part, then start on another. Always recheck your work to assure that nothing has been overlooked. Do not make any adjustments, other than those recommended, without obtaining proper approval.

Pressure-Fit Parts

When assembling pressure-fit parts, use an “anti-seize” or molybdenum disulfide base compound to lubricate the mating surface.

Bearings

When a bearing is removed, cover it to keep out dirt and abrasives. Clean bearings in nonflammable cleaning solvent and allow to drip dry. Compressed air can be used but do not spin the bearing.

Discard bearings if the races and balls *(or rollers)* are pitted, scored, or burned.

If bearing is found to be serviceable, apply a light coat of oil and wrap it in clean *(waxed)* paper. Do not unwrap reusable or new bearings until they are ready to install.

Lubricate new or used serviceable bearings before installation. When pressing a bearing into a retainer or bore, apply pressure to the outer race. If the bearing is to be installed on a shaft, apply pressure to the inner race.

Gaskets

Check that holes in gaskets align with openings in the mating parts. If it becomes necessary to hand-fabricate a gasket, use gasket material or stock of equivalent material and thickness. Be sure to cut holes in the right location, as blank gaskets can cause serious system damage.

Bolt Usage and Torque Application

Use bolts of proper length. A bolt which is too long will bottom before the head is tight against its related part. If a bolt is too short, there will not be enough thread area to engage and hold the part properly. When replacing bolts, use only those having the same specifications of the original, or one which is equivalent.

Unless specific torque requirements are given within the text, standard torque values should be used on heat-treated bolts, studs, and steel nuts, in accordance with recommended shop practices or the Torque Chart Figures in Section 1 of this Service Manual.

Hydraulic Lines and Electrical Wiring

Clearly mark or tag hydraulic lines and electrical wiring, as well as their receptacles, when disconnecting or removing them from the unit. This will assure that they are correctly reinstalled.

Hydraulic System

Keep the system clean. If evidence of metal or rubber particles is found in the hydraulic system, drain and flush the entire system.

Disassemble and reassemble parts on clean work surface. Clean all metal parts with non-flammable cleaning solvent. Lubricate components, as required, to aid assembly.

Lubrication and Servicing

Components and assemblies requiring lubrication and servicing are shown in Section 1.2, Lubrication.Service applicable components with the amount, type, and grade of lubricant recommended in this manual, at the specified intervals. When recommended lubricants are not available, consult your local supplier for an equivalent that meets or exceeds the specifications listed.

Batteries

Clean batteries, using a non-metallic brush and a solution of baking soda and water. Rinse with clean water. After cleaning, thoroughly dry batteries and coat terminals with an anti-corrosion compound.

2.4 LUBRICATION INFORMATION

Hydraulic System

The primary enemy of a hydraulic system is contamination. Contaminants enter the system by various means, e.g., using inadequate hydraulic oil, allowing moisture, grease, filings, sealing components, sand, etc., to enter when performing maintenance, or by permitting the pump to cavitate due to insufficient system warm-up or leaks in the pump supply.

The design and manufacturing tolerances of the component working parts are very close, therefore, even the smallest amount of dirt or foreign matter entering a system can cause wear or damage to the components and generally results in faulty operation. Every precaution must be taken to keep hydraulic oil clean, including reserve oil in storage.

Cloudy oils indicate a high moisture content which permits organic growth, resulting in oxidation or corrosion. If this condition occurs, the system must be drained, flushed, and refilled with clean oil.

It is not advisable to mix oils of different brands or types, as they may not contain the same required additives or be of comparable viscosities. Good grade mineral oils, with viscosities suited to the ambient temperatures in which the machine is operating, are recommended for use.

NOTE: *Metal particles may appear in the oil of new machines due to the wear-in of meshing components.*

Lubrication Specifications

Specified lubricants, as recommended by the component manufacturers, are always the best choice, however, multi-purpose greases usually have the qualities which meet a variety of single purpose grease requirements. Should any question arise regarding the use of greases in maintenance stock, consult your local supplier for evaluation. Refer to Section 1.2, Lubrication of this Service Manual for an explanation of the lubricant key designations appearing in the Lubrication Chart.

Hydraulic Oil

For best performance, JLG recommends the use of ISO-Vg grade 15 oil with a viscosity range between 15-250 SUS at 100 degrees F *(32-54 cST at 40 degrees C)*. Refer to Section 1.2, Lubrication of this Service Manual for recommended hydraulic oils.

Changing Hydraulic Oil

Use of any of the recommended hydraulic oils eliminates the need for changing the oil on a regular basis. If it is necessary to change the oil, use only those oils meeting or exceeding the specifications appearing in this manual. If unable to obtain the same type of oil supplied with the machine, consult local supplier for assistance in selecting the proper equivalent. Avoid mixing petroleum and synthetic base oils. JLG Industries recommends changing the hydraulic oil annually.

Use every precaution to keep the hydraulic oil clean. If the oil must be poured from the original container into another, be sure to clean all possible contaminants from the service container.

While the unit is shut down, a good preventive maintenance measure is to make a thorough inspection of all hydraulic components, lines, fittings, etc., as well as a functional check of each system, before placing the machine back in service.

NOTES:

SECTION 3. THEORY OF OPERATION - 1230ES

3.1 OVERVIEW

The GROUND MODULE is the master system controller. Most functions are dispatched and coordinated from this module, all other system modules handle sub-tasks. All characterized information (values) are stored into the ground module (i.e., Personalities, Machine Setups or Calibrations). If the ground module is reprogrammed, this information is lost. The technician should record Personalities and Machine Setups before programming so they can be restored afterwards. Otherwise, default values can be used as a starting point to restore previous configuration.

The PLATFORM MODULE reads switch and joystick positions and relays that information to the GROUND MODULE. It uses information from the CAN bus for operator display. It also reports faults pertaining to devices in the Platform Control Station. In ground mode, the platform control station may be removed from the vehicle without affecting operation.

The POWER MODULE controls the main contactor, drive motors and hydraulic pump motor via commands from the CAN bus. It also measures current applied to these loads and input voltage for fault protection and reporting.

For safe operation of the vehicle, the control system will not allow certain functions under certain conditions. These are called interlocks. Specific interlocks are discussed below. The interlocks discussed assume that all control system devices are functioning properly unless indicated. Fault conditions will generate DTC's and additional interlocks. Some faults only show up at power-up when the control system performs a self-test. All controls should be left alone during this test.

Note that the market and model of the machine affects what personalities and setups are visible by the Analyzer. The appropriate information is displayed for the given model and market. The market and model must be set properly for safe and lawful operation of the machine.

3.2 MODES OF OPERATION

Ground Mode

In Ground Mode, all visual indicators (LED) in the Platform are off. In fact, the Platform Control Box may be entirely disconnected as a normal measure (to secure the vehicle), and this does not prevent Ground Mode operation. When the machine is powered up in ground mode, only the functions in the Ground control station are operational, namely Lift Up and Down. Lift Up and Down is controlled by a two-position, momentary toggle switch with a center off position. The switch has the same effect as placing the joystick in the full up or full down position.

Platform mode

In platform mode the Platform Control Box is enabled. It is the primary control station for the vehicle. At power-up indicators applicable to the vehicle configuration illuminate for a lamp check: Battery Discharge Indicator, System Distress Indicator and Tilt Indicator.

3.3 CAN COMMUNICATIONS

CAN (Controller Area Network) is the type of two-wire differential serial communication link used between the platform board, ground board, and the power module for control of the vehicle. This type of network has matured since its invention in 1986 and is used extensively in many kinds of machines.

Two-Wire Differential: The signal meaning is derived from the difference in voltage between two wires, usually twisted together in a common "jacket". This jacket can also contain a shield surrounding the wires inside for noise protection. Any noise that does penetrate the shield will affect both wires the same. However, the difference in voltage stays the same, therefore signal meaning is not corrupted. This differs from one-wire signals in that one-wire signals derive the signal meaning from the difference between the signal wire and system ground wire. The system ground is the ground for many signals, as well as power. Any noise on either wire will change the signal and may corrupt it.

Serial Communication Link: Modules on the link send messages digitally, bit by bit along the wires where different voltage levels represent a "1" or a "0". The 1's and 0's are assembled by the receiver according to the protocol used to determine the messages meaning. Using serial communication allows two wires to replace many more. It also allows use of sensor and switch information in multiple places without duplicating those sensors and switches.

CAN: On a bus, all modules on the bus are connected to the same wires. A CAN bus could be represented on a schematic by a long pair of straight lines with multiple modules connected to them by short pairs of lines. It has a termination resistor at both ends of the long lines placed between the two wires, These resistors are approximately 120 Ohms. On a JLG aerial work platform, this is typically in the platform and in the chassis. These resistors may be in the harness or in the module. A complete CAN circuit measures approximately 60 Ohms between the two wires and these wires are open to the shield.

Each module on the CAN bus broadcasts its messages according to a priority assigned to the message. All the other modules will receive the message and determine if it is important to them. Typical message traffic is 300 - 500 messages per second. The high bus speed allow all modules to be constantly updated around 20 times per second. A CAN network also has error detection and handling for robust communications.

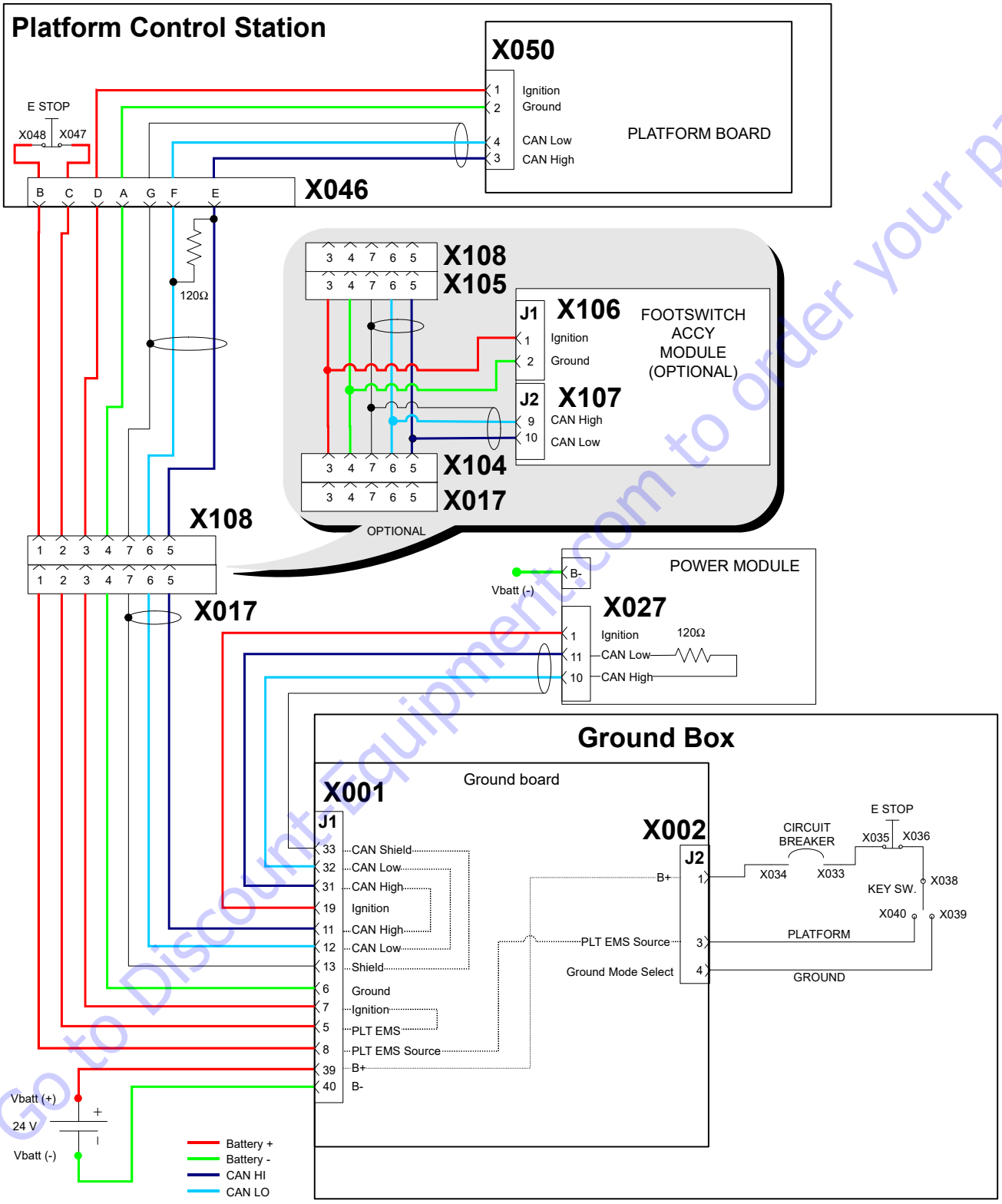

Figure 3-1. Basic Electronic Module Connections

3.4 CONTROLS & SENSORS

Elevation

The elevation sensor is an inductive proximity switch. It must be powered to operate. There is a 1.3k Ohm resistor where it connects to the ground module to produce the proper signal for the ground module. (See electrical schematic in Section 9 for details.) If Ferrous material is present, i.e. the mast is fully retracted, it will close. The sensor is calibrated mechanically.

The control system uses a combination of the elevation proximity switch and pothole protection switches to determine if the platform is elevated. If these sensors do not agree a fault is thrown.

Joystick

The joystick is used to "command" both lift and drive. The Lift/Drive switch selects which one is applicable. This command may be modified by the control system based on interlocks and personalities.

On the joystick there are three switches and the control handle. The joystick control handle sensor is not a simple potentiometer. There is a position sensing element, and signal conditioning circuitry in it to generate the position signal. It is powered by 5VDC supplied from the platform controller. When centered it will output approximately 2.5VDC. Fully forward, it will output approximately 1 VDC. Fully backward, it will output approximately 4 VDC. On the handle is the trigger switch that must be depressed in order to operate the vehicle. This prevents unintentional movement. To pass start-up tests the three switches must be open and the joystick must be centered.

Joystick personalities to define the centered position (where command is 0%), minimum and maximum forward, as well as minimum and maximum reverse can be accessed. Joystick system Personality settings can be changed via ANALYZER -> PERSONALITIES -> ACCELERATOR as follows:

- FWD MIN - The forward extent of the centered position. Values between this and REV MIN are where 0% is commanded.
- REV MIN - The reverse extent of the centered position. Values between this and FWD MIN are where 0% is commanded.
- FWD MAX - Joystick voltage where 100% will be commanded.
- REV MAX - Joystick signal voltage where -100% will be commanded.

Tilt

The control system monitors the tilt sensor to determine if the vehicle is tilted excessively. This condition is called "Tilted". In the CE, Australia and Japan markets, if the vehicle tilt angle in any direction is greater than or equal to 3.5°, the control system considers the machine tilted. In other markets, the vehicle is considered Tilted if the vehicle tilt angle front to back is greater than or equal to 3.0° or tilt left to right is greater than or equal to 1.5°.

3.5 TRACTION

The traction, or drive system, moves the vehicle along the ground by electric motors. The Armatures (rotating windings) of the separately-excited drive motors are wired in parallel to the Power Module's M1 and M2 terminals. The M1 Terminal is always at the same voltage as the +B (Battery Voltage when the Line Contactor is closed) and allows the module to measure current with the internal shunt (extremely low impedance). The M2 Terminal is pulled to Ground by the Armature Switch MOSFET's (connected to -B Terminal).

To provide variable speed control, the Armature MOSFET transistors switch On and Off at high frequencies (PWM/pulse-width modulation, 16kHz). The Duty Cycle (On & Off time) is varied to control the voltage applied to the Armatures. When the MOSFET's spend 50% of the period On and 50% Off, approximately ½ of the available power will be applied to the Armatures (50% Duty Cycle). Similarly, the MOSFET are On continuously (100% Duty Cycle) to apply all available Battery power to the Armatures (as in Driving at Full Speed).

Instead of permanent magnets, the separately-excited drive motors use electro-magnets (called Field Windings) located in the stator (non-rotating) portion of the motor. Field windings are preferable to permanent magnets because the Power Module can adjust the stator's magnetism for optimum motor performance. When climbing a grade at low speeds, the Power Module may apply as much as 40A to the field windings for more electro-motive force. On level terrain, the Power Module will apply as little as 14A to the fields for higher rotational speeds and better electrical efficiency.

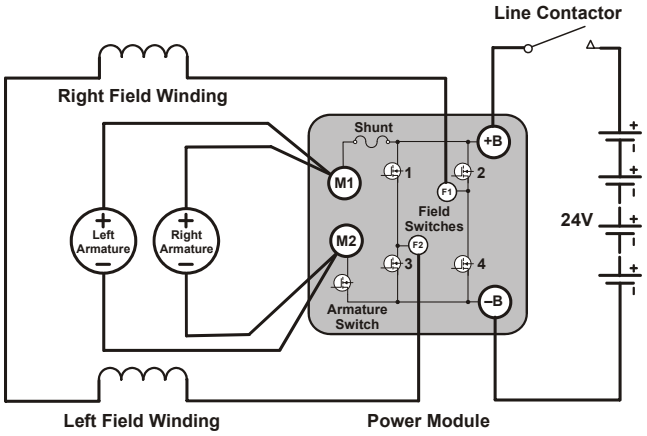

Figure 3-2. Drive Motors Schematic - 1600346 (SEVCON) Power Module

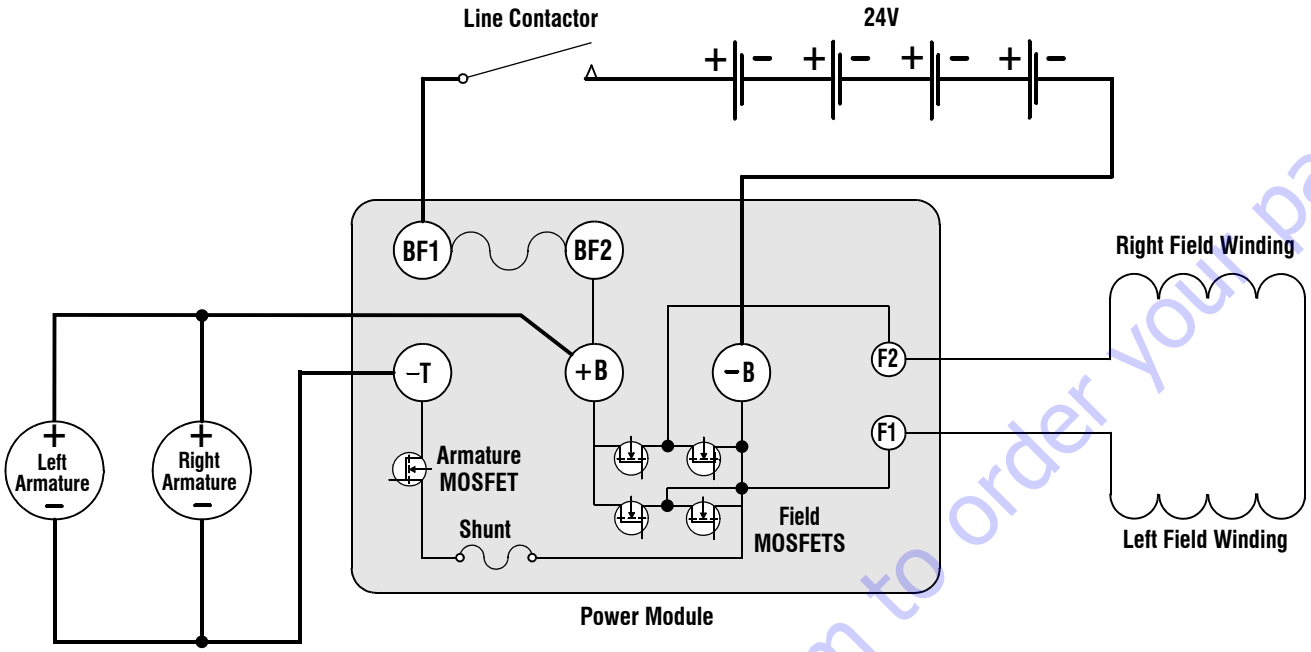

Figure 3-3. Drive Motors Schematic - 1001092456 (ZAPI) Power Module

The Field Windings also provide direction reversal for traction. When driving forward, MOSFET switches 1 and 4 turn On to apply positive potential to F2 and ground potential to F1. In reverse, MOSFET switches 2 and 3 turn On to apply positive potential to F1 and ground potential to F2. Theses switches are pulse-width modulated by the Power Module to maintain a fixed relationship between Field and Armature Current.

Two electrically-released parking brakes are mounted to the rear of the drive motors. The Ground Module energizes the two 24V electro-magnets when appropriate to allow vehicle motion. The parking brakes can be released electrically for emergency vehicle towing.

Personalities

Traction system Personality settings can be changed via ANALYZER -> PERSONALITIES -> DRIVE:

- ACCEL - Time to ramp from 0% to 100% of command
- DECEL - Time to ramp from 0% to 100% of command
- MINIMUM - Minimum drive speed (Creep)
- MAXIMUM - Maximum drive speed when platform is stowed
- ELEV. MAX - Maximum drive speed when platform is elevated

Interlocks

As the machine travels down an incline the drive power output will be reduced proportionally to avoid overspeeding the vehicle. A bad tilt sensor will force the control system to assume maximum incline and reduce drive power accordingly.

Creep mode (reduced drive speed) will be active if the control system determines the platform is elevated. Drive may be prevented by a different interlock, however.

Drive will be prevented if any of the following occur:

- Vehicle is tilted, elevated and ANALYZER -> MACHINE SETUP -> TILT CUTOUT is set to YES.
- Batteries are being charged (0V is applied to ground board J1-29)
- Vehicle is elevated above the calibrated Drive Cutout height and ANALYZER -> MACHINE SETUP -> DRIVE CUTOUT is set to YES.

3.6 PUMP/LIFT/MAST

An electrically driven hydraulic pump provides hydraulic pressure to actuate the steering and lift up. Lift down is "powered" by gravity. The lift actuator is a three stage hydraulic cylinder. The cylinder pistons are not sealed so fluid can flow from one cylinder to the next. The area of the piston that fluid touches on both sides does not provide lift because the forces on both sides cancel each other. The area of the piston with the rod behind it provides the lifting force necessary because no pressure is there to cancel the force applied by the pressure on the other side.

To lift the platform, the solenoid energizes and opens the lift up valve. The pump speed is set proportional to joystick position. Fluid flows into the first cylinder, through the hollow rod. This extends the barrel of the first cylinder. The rod to the second cylinder is attached to the barrel of the first cylinder. Fluid is passed by a port in the first cylinder to the hollow rod of the second cylinder. That extends the second cylinder. The barrel of the second cylinder is attached to the barrel of the third cylinder. A port in the barrel of the second cylinder passes fluid to the third cylinder. This extends the third cylinder, and lifts the platform. To bring down the platform, the lift down valve opens, proportional to joystick position, and allows fluid out of the cylinder, allowing it to retract by gravity.

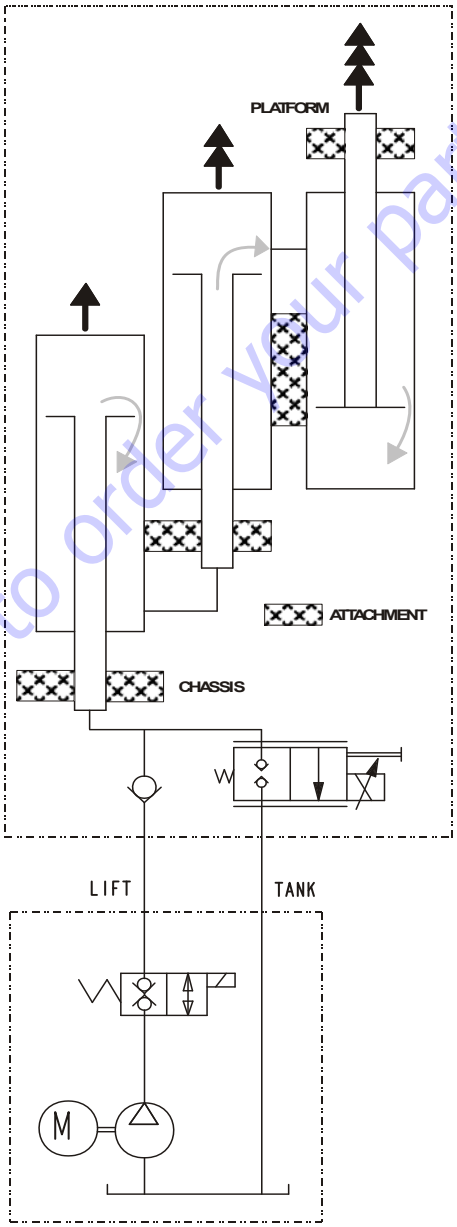

Figure 3-4. Lift System

The Power Module is essentially a "low-side" switch for the pump motor. The positive terminal of the pump is tied to Battery Positive after the Line Contactor. The negative terminal of the pump connects to the P Terminal of the Power Module, which switches current through MOSFET transistors to the Battery Negative.

For variable speed pump operation, the MOSFET transistors switch On and Off at high frequencies (16kHz). The Duty Cycle is varied to control the voltage applied to the pump motor. When the MOSFET's spend 50% of the period On and 50% Off, approximately ½ of the available Battery power will be applied to the pump motor. Similarly, the MOSFET are On continuously

(100% Duty Cycle) to apply all available Battery power to the pump motor (as in Lift Up at full speed).

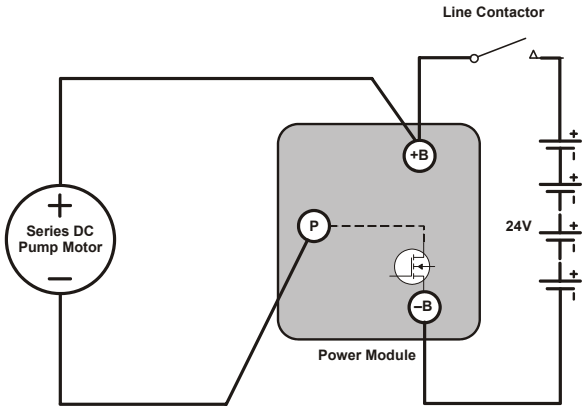

Figure 3-5. Hydraulic Pump Electrical Schematic - 1600423 (SEVCON) Power Module

When the Control System is energized, the voltage at the P Terminal will be approximately +24V (referenced to -B) when the pump is static. The P Terminal will be approximately at +1V (referenced to -B) when the pump is running at full speed (Lift Up from Ground Mode).

Personalities

Lift system Personality settings can be changed via ANALYZER -> PERSONALITIES -> LIFT:

- ACCEL - Time to ramp from 0% to 100% command
- DECEL - Time to ramp from 100% to 0% command
- UP MIN - Minimum pump speed up (Creep)
- UP MAX - Maximum pump speed up
- DN MIN - Minimum pump speed down (Creep)
- DN MAX - Maximum pump speed down

Interlocks

Lift up will be prevented under the following circumstances.

- Vehicle is tilted, elevated and ANALYZER -> MACHINE SETUP -> TILT CUTOUT is set to YES.
- Charging of the vehicle's battery is in progress and ANALYZER -> MACHINE SETUP -> CHARGER INTERLOC is set to DRV & LIFT UP.

3.7 STEER

Steering is actuated by a double action hydraulic cylinder. To change steering angle of the drive wheels, the steer left or steer right solenoid is energized and the pump is energized. Pressure is applied to one side of the piston and drained from the other. The pump speed, and thereby the rate of steering angle change, is adjusted based on drive speed. This adjustment is modified by steer personality settings.

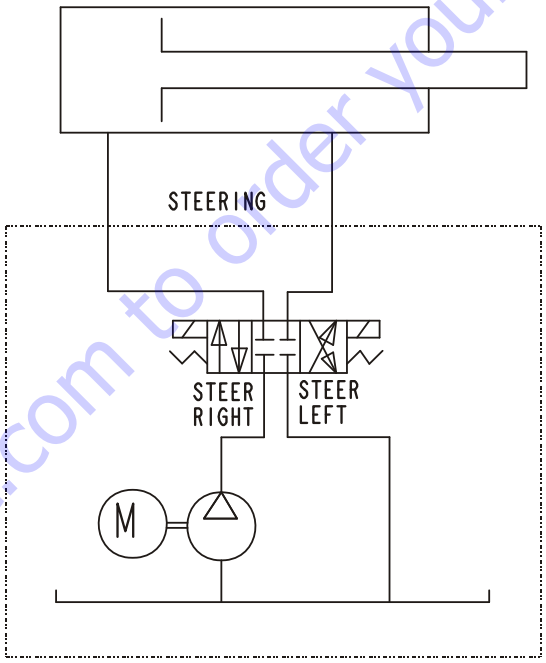

Figure 3-6. Steer System

Personalities

Steer system Personality settings can be changed via ANALYZER -> PERSONALITIES -> STEER:

- STATIC - Pump commanded % power when drive command is 0%
- DRIVE - Pump commanded % power when drive command is 100%

Interlocks

Steering is prevented whenever conditions are present to prevent drive. See Interlocks on Pg. 4

PARTS FINDER

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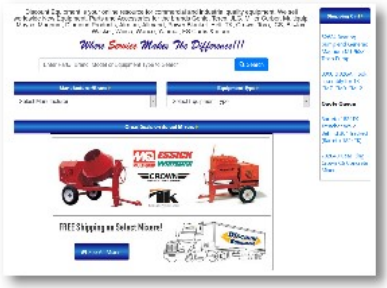

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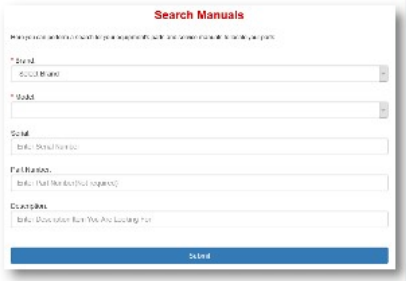

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SECTION 4. BASE COMPONENTS

4.1 BASE ASSEMBLY COMPONENTS

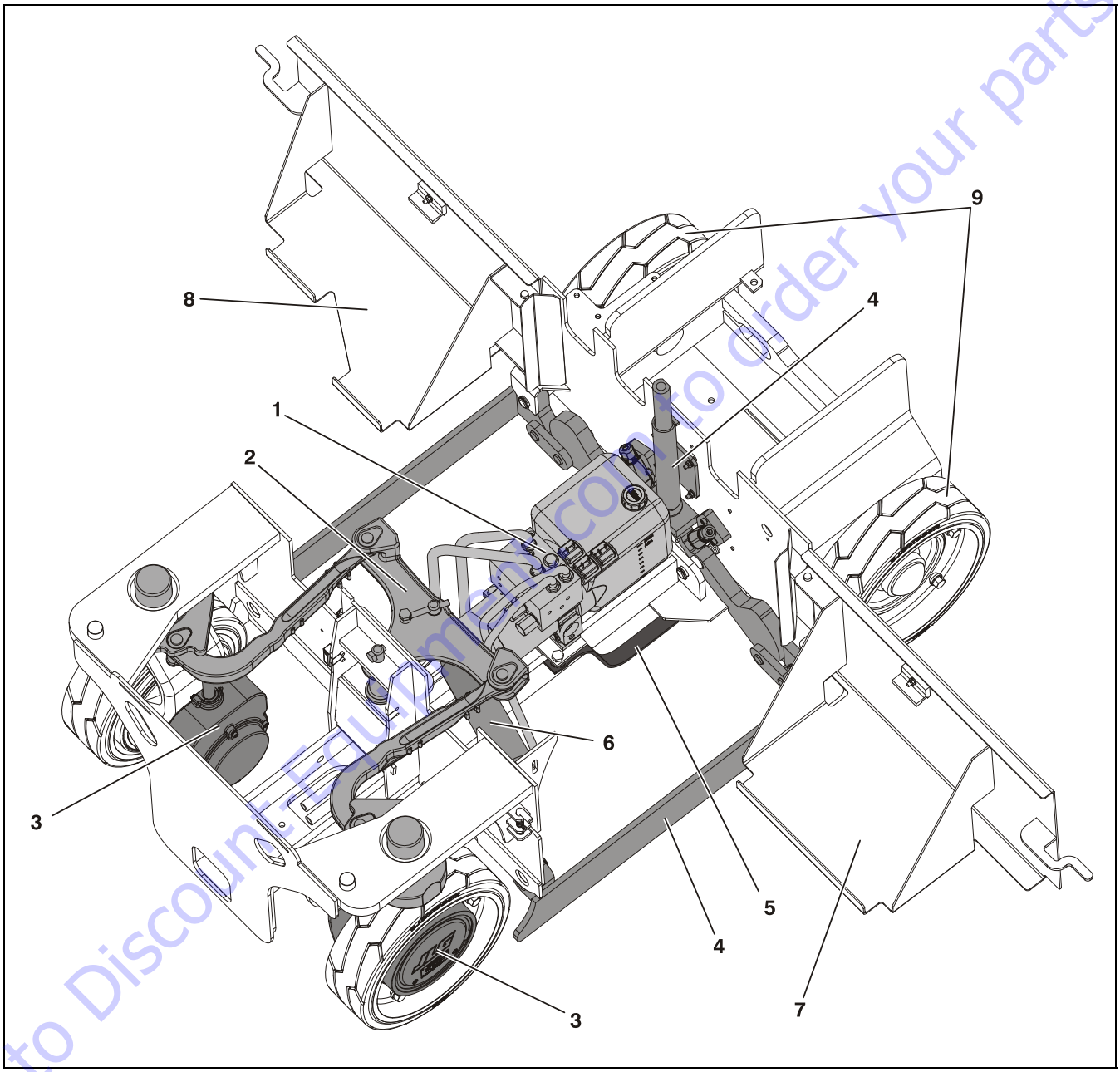


Figure 4-1. Base Assembly Components.

1. Hydraulic Pump/Tank/Valve Assy.
2. Steering Linkage Assembly
3. Drive Motor/Spindle Assemblies
4. Pot Hole Protection Assembly
5. Static Strap
6. Steer Cylinder Assembly
7. Left Side (Battery Tray) Door
8. Right Side (Battery Tray) Door
9. Rear Wheel Assembly

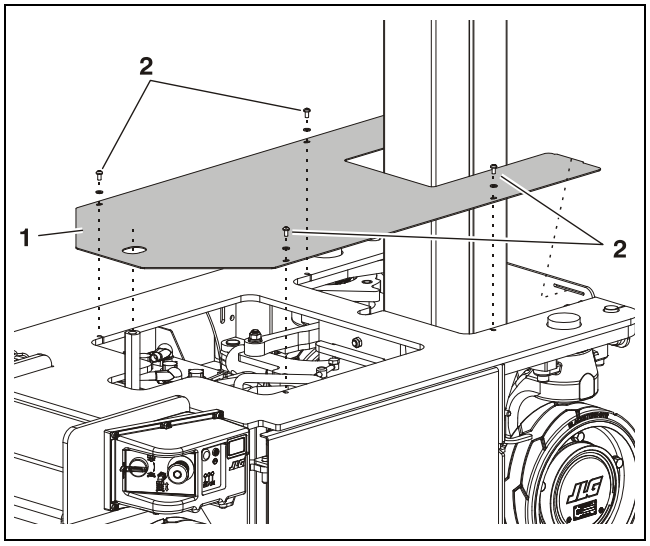
NOTE: *Base assembly shown without base top weldment for illustrative purposes only.*

4.2 BASE FRAME COVERS

Base Top Cover - Installation

⚠ WARNING

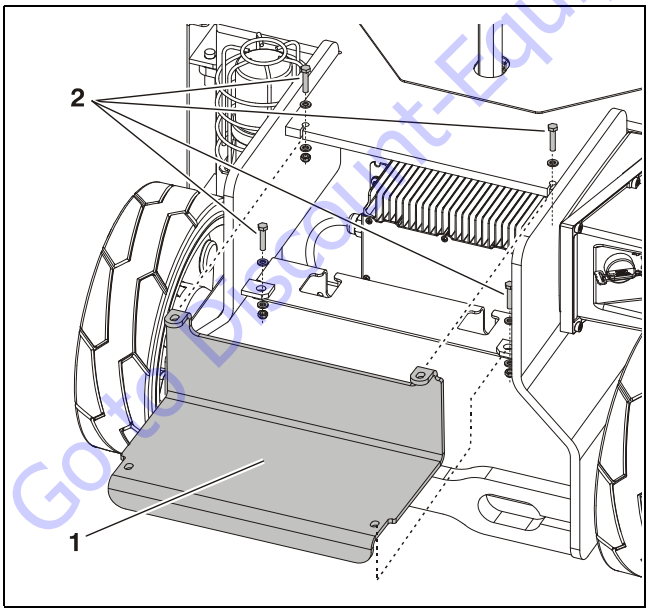
NEVER WORK UNDER AN ELEVATED PLATFORM UNTIL THE PLATFORM HAS BEEN SAFELY RESTRAINED FROM ANY MOVEMENT BY BLOCKING OR OVERHEAD SLING.



Base Top Cover Installation

1. Base Top Cover
2. (4) Attach Screws/Washers

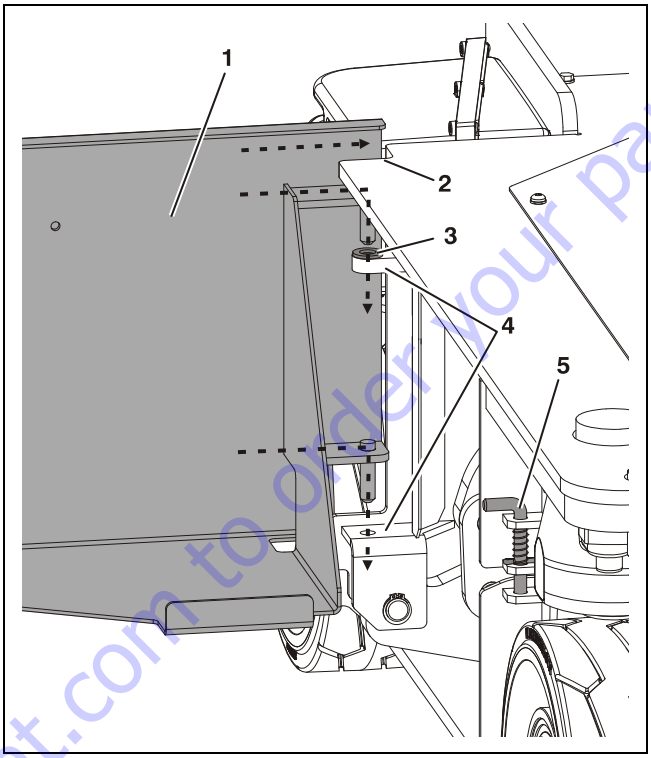
Step Plate/Battery Charger Cover - Installation



Step Plate/Battery Charger Cover Installation

1. Step Plate Cover
2. Attach Screws/Washers/Nuts

Battery Tray/Side Door - Installation



Battery Tray/Side Door - Installation
(Same for both sides)

1. Battery Tray/Door
2. Cutout in Base Frame
3. Washer(s)
4. Base Frame Hinge
5. Door Latch Pin

NOTE: *Before assembly lubricate (coat) the door hinge pins with Loctite Moly Paste Lubricant (JLG Part No. - 3020039).*
Lift door (1) into cutout in base frame (2), align the upper and lower hinge pins on the door with the holes in the upper and lower base frame hinge (4) and lower door until set.
If door needs any adjustment up or down to align with the latch pin slot (5), remove the door and add or remove washers (3) at the upper hinge pin.

4.3 WHEELS AND TIRES - DRIVE AND REAR

Tire Wear and Damage

Inspect tires periodically for wear or damage. Tires with worn edges or distorted profiles require replacement. Tires with significant damage in the tread area or side wall, require immediate evaluation before replacing the machine into service.

Wheel and Tire Replacement

Replacement wheels must have the same diameter and profile as the original. Replacement tires must be the same size and rating as the tire being replaced.

Wheel Installation

It is extremely important to apply and maintain proper wheel mounting torque.

⚠ WARNING

WHEEL LUG NUTS MUST BE INSTALLED AND MAINTAINED AT THE PROPER TORQUE TO PREVENT LOOSE WHEELS, BROKEN LUG NUTS, AND POSSIBLE SEPARATION OF WHEEL FROM THE AXLE. BE SURE TO USE ONLY THE LUG NUTS MATCHED TO THE CONE ANGLE OF THE WHEEL.

Tighten the lug nuts to the proper torque to prevent wheels from coming loose. Use a torque wrench to tighten the fasteners. If you do not have a torque wrench, tighten the fasteners with a lug wrench, then immediately have a service garage or dealer tighten the lug nuts to the proper torque. Over-tightening will result in breaking the lug nuts or permanently deforming the mounting holes in the wheels. The proper procedure for attaching wheels is as follows:

1. Start all lug nuts by hand to prevent cross threading. DO NOT use a lubricant on threads or nuts.
2. Tighten lug nuts in the following sequence.

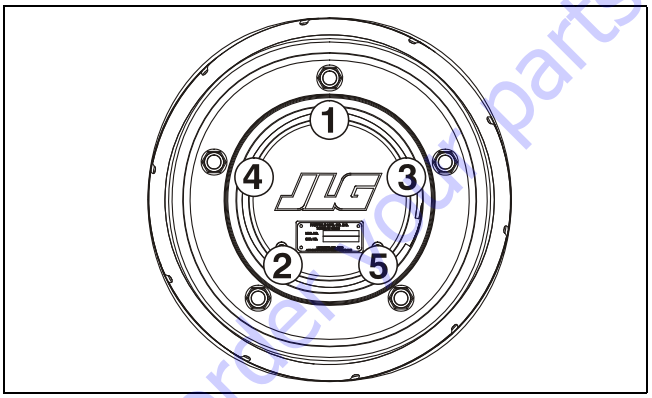


Figure 4-2. Wheel Lug Nut Tightening Sequence

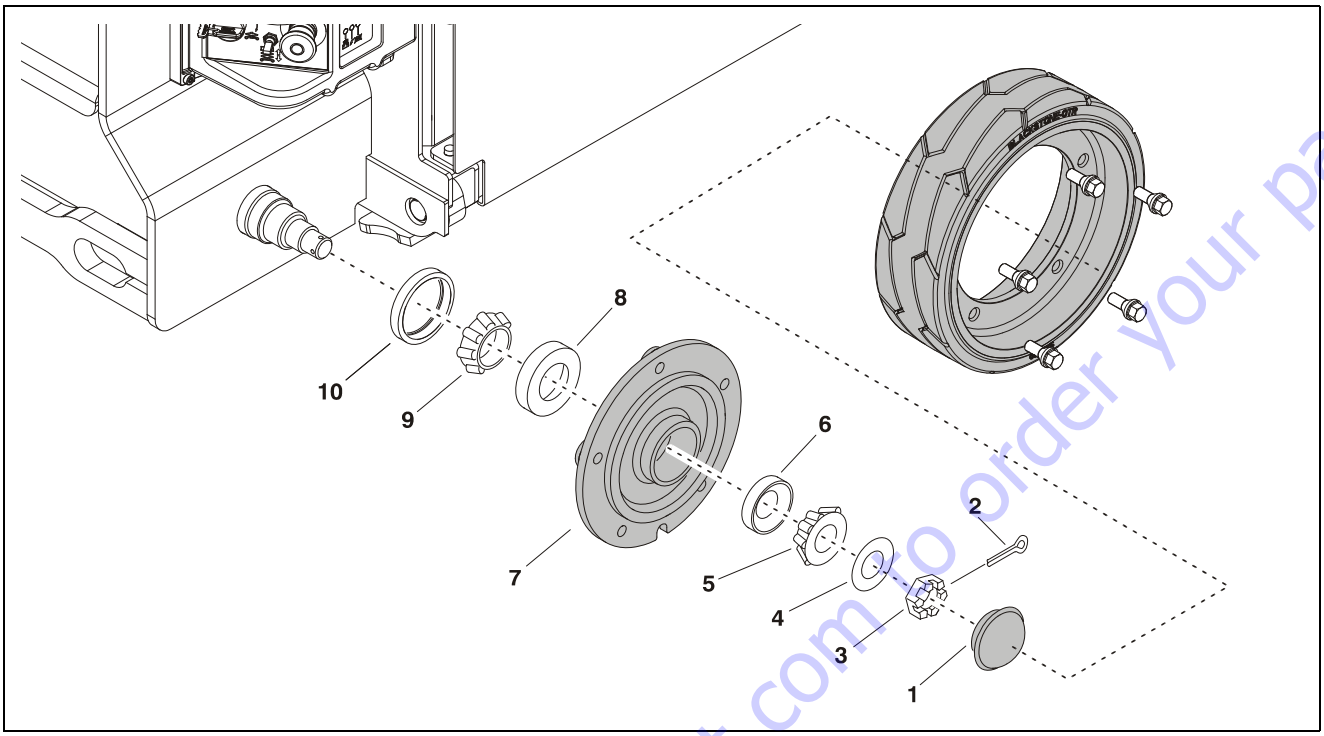
3. The tightening of the lug nuts should be done in stages. Following the recommended sequence, tighten lug nuts per wheel torque.

Table 4-1. Wheel Torque Chart

TORQUE SEQUENCE		
1st Stage	2nd Stage	3rd Stage
20-30 ft lbs (28 - 42 Nm)	65-80 ft lbs (91 - 112 Nm)	105 - 120 ft lbs (142 - 163 Nm)

4. Wheel lug nuts should be torqued after the first 50 hours of operation and after each wheel removal. Check torque every 3 months or 150 hours of operation.

4.4 REAR WHEEL HUB - INSTALLATION



Rear Wheel Hub Installation

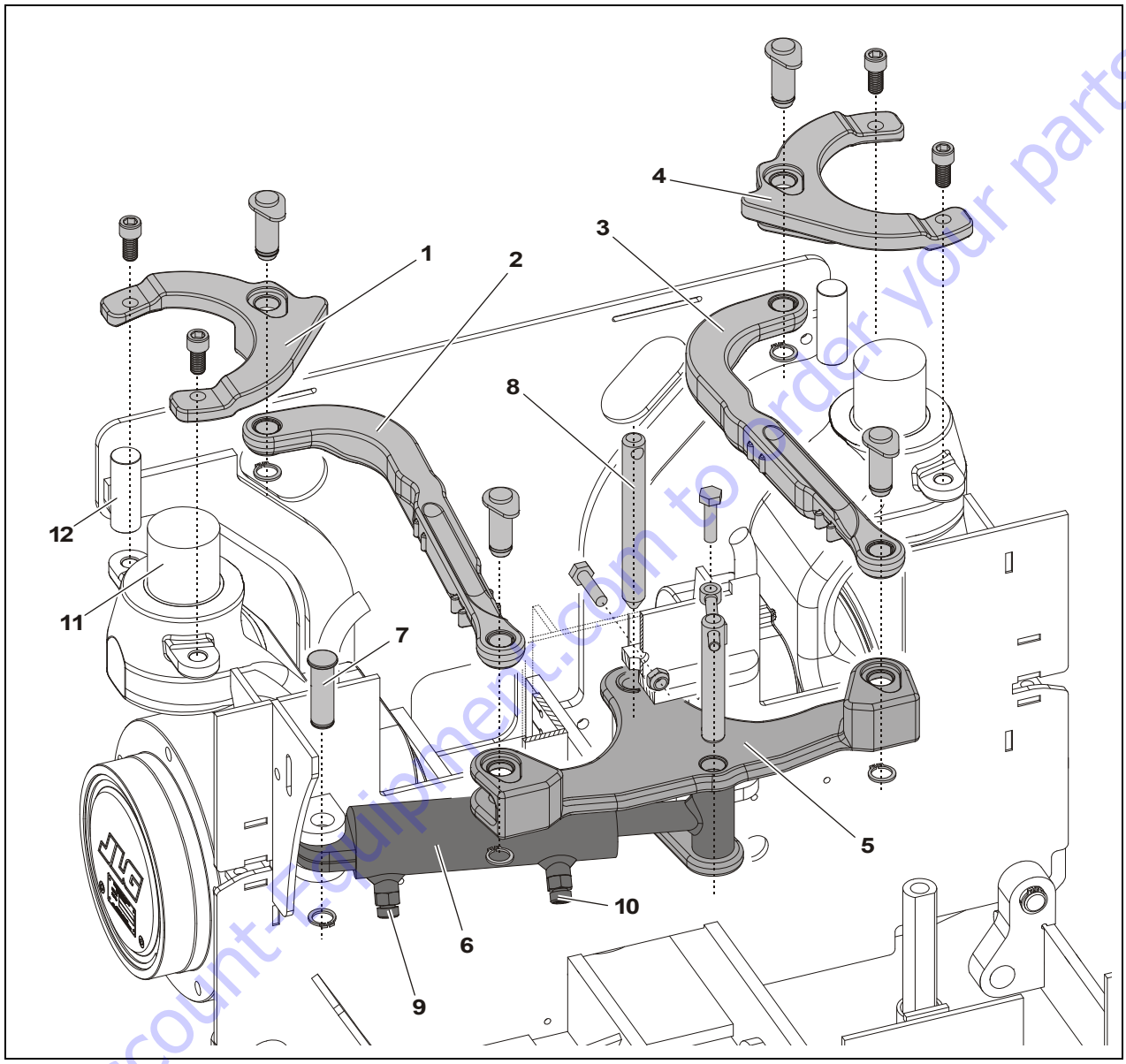
1. Hub Cap
2. Cotter Pin
3. Spindle Nut
4. Washer
5. Outer Tapered Roller Bearing (a)
6. Outer Bearing Race (a)
7. Wheel Mounting Hub (a)
8. Inner Bearing Race (a)
9. Inner Tapered Roller Bearing (a)
10. Hub Seal

NOTE: *(a) Bearing race (6, 8) are press fitted to wheel mounting hub (7) and are only available for service as a complete hub assembly. Also before installing or re-installing the inner and outer taper roller bearings, be certain they are lubricated (packed) with multi-purpose grease.*
Later design incorporated wheels lugs into hub, tighten wheel lug nuts same as lug bolts, per step 6 below.

NOTE: *Before assembly check that inner and outer taper roller bearings are lubricated (packed) with mutli-purpose grease.*

1. Tighten spindle nut to 30-40 ft. lbs. (40-54 nm) to properly seat bearings.
2. Loosen spindle nut completely until it can be turned by hand.
3. Then finger tighten spindle nut by hand without rotating the wheel mounting hub.
4. Install cotter pin, if necessary nut may be backed off to nearest slot, if more than 1/2 the cotter pin hole is visible, the nut may be tightened slightly to get the cotter pin installed.
5. Before installing the hub cap, check wheel hub for excessive end play.
   a. Rotate hub by hand, hub should rotate freely, if too tight, back the nut off to the next cotter pin hole.
   b. Hub should not be noticeably loose when moved parallel with spindle center-line.
6. Install wheel, torque wheel per specification in Section 4.3.

4.5 STEERING LINKAGE ASSEMBLY - INSTALLATION



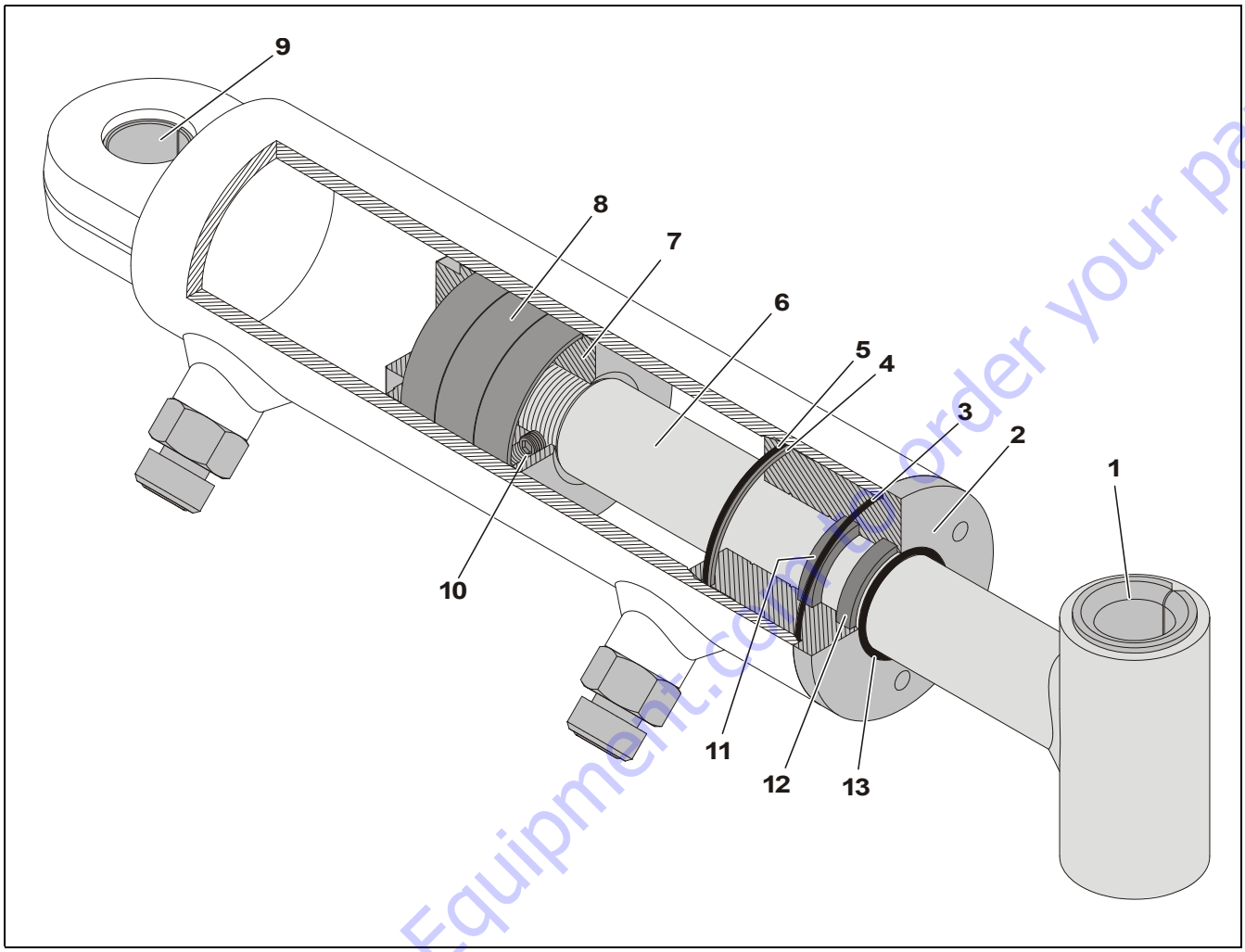
Steering Linkage Assembly - Installation

(Shown with top of base frame weldment removed for illustrative purposes only)

1. Left Steering Knuckle Lug
2. Left Steering Arm Link
3. Right Steering Arm Link
4. Right Steering Knuckle Lug
5. Steering Cross Link
6. Hydraulic Steer Cylinder
7. Steer Cylinder Anchor Pin
8. Cross Link Anchor Pin
9. Steer Cylinder - Steer Right Port
10. Steer Cylinder - Steer Left Port
11. King Pin
12. Steering Knuckle Stop

NOTE: *All pinned journals must have the proper bushings installed.*
On final assembly apply Loctite #242 to screw threads of the steer cylinder Cross Link Anchor pin keeper screw.
On final assembly, apply Loctite #271 to the knuckle lug to spindle attach screws and torque to 70 ft. lbs (97 N,m)

4.6 STEER CYLINDER - SERVICING



Steer Cylinder Components

1. Rod End Bushing
2. Cylinder Head (Gland) (a)
3. O'Ring Seal
4. Backing Ring
5. O'Ring Seal
6. Cylinder Rod
7. Piston (b)
8. Piston Seal
9. Bushing
10. Piston Set Screw
11. Main Gland Seal
12. Wiper Seal
13. O'Ring Seal

NOTE: *(a) On final assembly torque cylinder head (Gland) to 500Nm (112 ft. lb.)*
(b) Apply Loctite #242 to threads before final assembly and torque to 260Nm (55 ft. lb.)

Refer to Section 3.7, STEER - Theory of Operation for more detailed information on Steer Cylinder System.

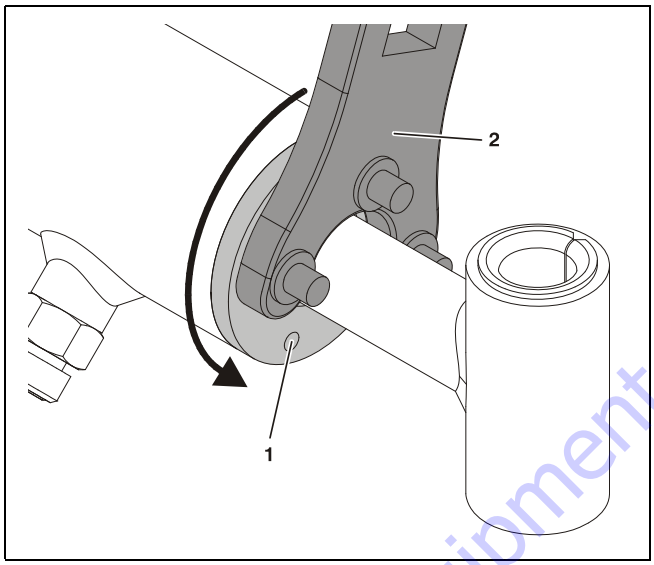
Steer Cylinder Disassembly

NOTICE

DISASSEMBLY OF THE CYLINDER SHOULD BE PERFORMED ON A CLEAN WORK SURFACE IN A DIRT FREE WORK AREA.

NOTICE

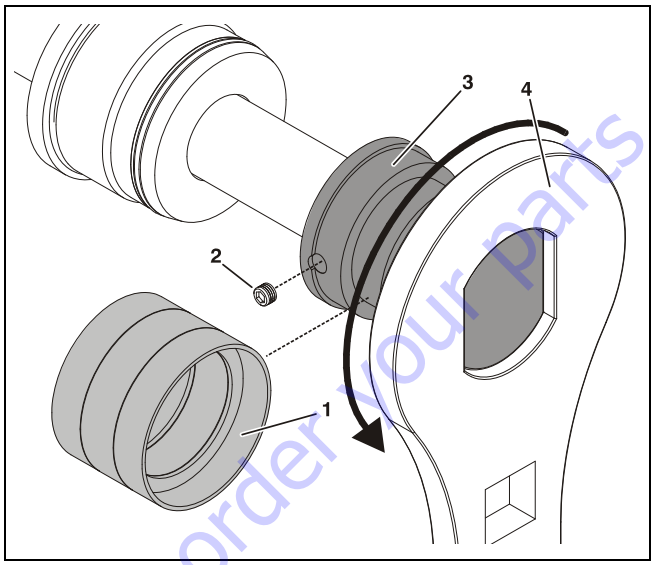
PROTECT THE CYLINDER ROD SURFACE. DAMAGE TO THE CYLINDER ROD CHROME FINISH DUE TO SCRATCHING, INDENDATION, CHIPPING OR OTHERWISE WILL CAUSE EVENTUAL GLAND SEAL FAILURE. THE CYLINDER ROD MUST BE REPLACED IF DAMAGED.



Cylinder Head (Gland) - Removal

1. Cylinder Head (Gland)
2. Spanner Wrench (48mm - 1.89" Dia. - 5mm Pin Dia.)

1. Using the proper size spanner wrench (48mm - 1.89" Dia., 5mm Pin Dia.), remove the cylinder head (gland) turning the head counterclockwise until it is free of the cylinder barrel.
2. Carefully slide the complete cylinder rod, cylinder head (gland), piston assembly out of the cylinder barrel.
3. Remove the piston (kban) seal from the piston.
4. Loosen and remove the piston set screw from the hole in the side of the piston.
5. Using the proper spanner wrench, remove the piston from the cylinder rod.
6. Slide the cylinder head (gland) off the piston end of the cylinder rod.
7. Remove all the seals, o'rings, and backing ring from the cylinder head (gland).



Piston - Removal

1. Piston (Kban) Seal
2. Piston Set Screw
3. Piston
4. Spanner Wrench

8. If replacing, remove the bushings from the end of the cylinder rod and the cylinder barrel.

Hydraulic Cylinder Component Inspection

CYLINDER ROD

There should be no scratches or pits deep enough to catch the fingernail. Pits that go to the base metal are unacceptable. Scratches that catch the fingernail but are not to the base metal, less than 0.5 inch long and primarily in the circumferential direction are acceptable provided they cannot cut the rod seal. Chrome should be present over the entire surface of the rod and the lack thereof is unacceptable. In the event that an unacceptable condition occurs, the rod should be repaired or replaced.

CYLINDER HEAD (GLAND)

Visually inspect the inside bore for scratches or polishing. Deep scratches are unacceptable. Polishing indicates uneven loading and when this occurs, the bore should be checked for out-of-roundness. If out-of-roundness exceed 0.007", this is unacceptable. Check the condition of the dynamic seals (wiper, rod seals) looking particularly for metallic particles embedded in the seal surface. It is normal to cut the static seal on the retaining ring groove upon disassembly. Remove the rod seal, static o-ring and backup and rod wiper. Damage to the seal grooves, particularly on the sealing surfaces, is unacceptable. In the event that an unacceptable condition occurs, the head should be replaced.

PISTON

Visually inspect the outside surface for scratches or polishing. Deep scratches are unacceptable. Polishing indicates uneven loading and when this occurs, the diameter should be checked for out-of-roundness. If out-of-roundness exceeds 0.007", this is unacceptable. Check the condition of the dynamic seals and bearings looking particularly for metallic particles embedded in the bearing and in the piston seal surface. Remove the seals and bearings. Damage to the seal grooves, particularly on the sealing surfaces, is unacceptable. In the event that an unacceptable condition occurs, the piston should be replaced.

TUBE ASSEMBLY

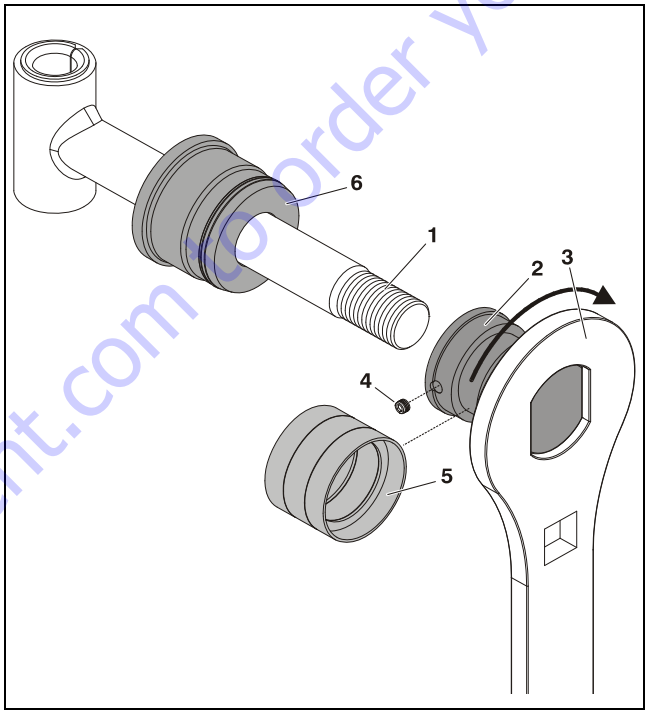
Visually inspect the inside bore for scratches and pits. There should be no scratches or pits deep enough to catch the fingernail. Scratches that catch the fingernail but are less than 0.5 inch long and primarily in the circumferential direction are acceptable provided they cannot cut the piston seal. The roughness of the bore should be between 10 and 20 µ inches RMS. Significant variation (greater than 8 µ inches difference) are unacceptable. In the event that an unacceptable condition occurs, the tube assembly should be repaired or replaced.

Steer Cylinder - Assembly

NOTE: *Prior to cylinder assembly, ensure the proper JLG seal kits are used, see the JLG Parts Manual.*

NOTICE

APPLY A LIGHT FILM OF THE HYDRAULIC OIL TO BE USED FOR OPERATION TO ALL COMPONENTS TO BE ASSEMBLED, EXCEPT THE THREADED AREAS WHERE LOCTITE IS TO BE APPLIED.



Piston Installation

1. Threaded End of Rod (a)
2. Piston (b)
3. Cylinder Head (Gland)
4. Piston Set Screw (c)
5. Piston (Kban) Seal

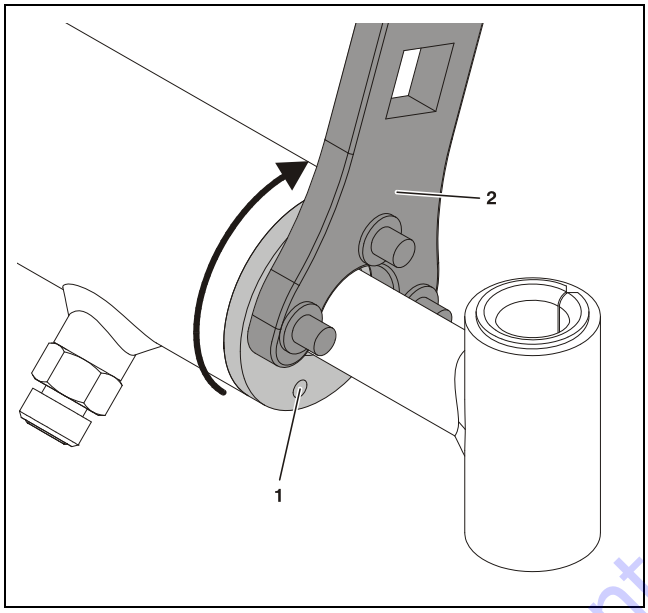
NOTE: *(a) Apply Loctite #242 on final assembly*
(b) Torque piston to 260Nm (55 ft. lb.)
(c) Apply Loctite #222 and torque to 20Nm (5 ft. lb.)

1. Load the seals, o'rings, and backing ring onto the cylinder head (gland).
2. Lubricate the cylinder rod surface with clean hydraulic oil, then slide the cylinder head (gland) assembly onto the rod.
3. Check that the threads on the cylinder rod and inside the piston are clean and free of any hydraulic oil.
4. Apply Loctite #242 to the threads of the cylinder rod and thread the piston onto the end of the cylinder rod,

tighten piston with the proper spanner wrench and torque the piston to 260Nm (55 ft. lb.).

5. Apply Loctite #222 to the threads of the piston set screw, thread the screw into the hole in the side of the piston and tighten to 20Nm (5 ft. lb.).

6. Place a new piston (kban) seal onto the piston.



Cylinder Head Installation

1. Cylinder Head (Gland)
2. Spanner Wrench (48mm - 1.89" Dia., 5mm Pin Dia.)

7. Lubricate the o'ring seals on the cylinder head. Check that the threads on the cylinder head and inside the cylinder barrel are clean and free of any debris.

NOTICE

EXTREME CARE SHOULD BE TAKEN WHEN INSTALLING THE CYLINDER ROD, HEAD, AND PISTON INTO THE CYLINDER BARREL. AVOID PULLING THE ROD OFF CENTER, WHICH COULD CAUSE DAMAGE TO THE PISTON AND CYLINDER BARREL SURFACES.

8. Carefully slide the loaded cylinder rod assembly into the cylinder barrel.

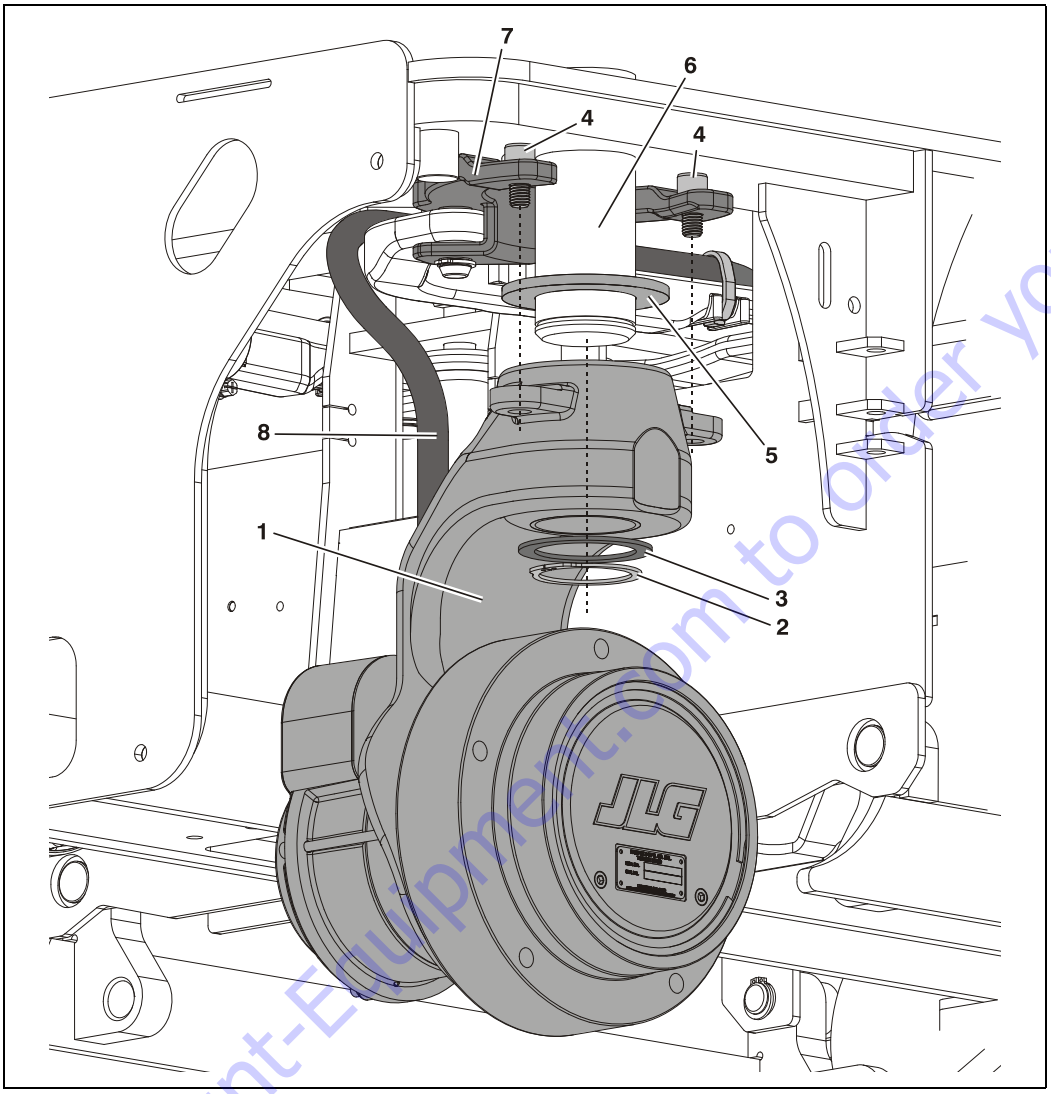
9. Screw the cylinder head in until tight, torque the cylinder head to 55Nm (112 ft. lb.), using the proper spanner wrench.

10. Reinstall the steer cylinder back onto the machine.

11. Power up machine and cycle the steering left and right until the steering is working smoothly.

12. Check the hydraulic oil level in the hydraulic oil tank located on the pump/valve/tank assembly. Oil level should be between min. and max. on the side of the tank.

4.7 DRIVE MOTOR/SPINDLE ASSEMBLY - INSTALLATION



Drive Motor/Spindle Assembly - Installation
(Left front shown - installation same for both sides)

1. DriveMotor/Spindle Assembly
2. 60mm External Retaining Ring
3. Spindle Retaining Washer
4. Knuckle Lug Attach Screws (a)
5. 60mm Thrush Washer
6. King Pin *(welded to frame)* (b)
7. Steering Knuckle Lug
8. Drive Motor Power Harness (c)

NOTE: *Before removing the drive motor/spindle assembly, disconnect machine power then disconnect the drive motor wiring harness (item 8) either from the power module and unstrap from the harness from the steering arms, or by removing the drive motor cover and disconnecting from the motor.*
(a) *Remove the spindle retaining ring (item 2), lower and support drive motor/spindle assembly just enough to access the top of the knuckle attach screws and remove them. On final assembly, apply Loctite #271 to the spindle to knuckle lug attach screws and torque to 70 ft. lbs (97 N,m)*
(b) *Coat king pin with moly paste lubricant prior to installation of spindle assembly.*

4.8 WHEEL DRIVE ASSEMBLY - SERVICING

The component parts of the left and right drive motor assemblies are identical. The left drive motor is run in the reverse direction of the right motor.

NOTICE

FOR DETAILS ON THE TRACTION SYSTEM ELECTRICAL THEORY OF OPERATION SEE SECTION 4.

Drive Motor Electrical Evaluation

Several basic electrical tests can be performed on the Drive Motors. Failure of one of these evaluations is significant and may indicate that the device is physically damaged.

Make all measurements with a voltmeter set to resistance scale (Ohms). Disconnect the Main Battery Disconnect and all drive motor cables during this analysis.

1. **Resistance < 2 Ohms Red to Black Armature Wires.**

   The heavy red and black conductors are connected to the motor's armature winding. The winding is a very low impedance and should appear to be a short-circuit for an ordinary voltmeter (other tests can determine if the armature is truly shorted). High resistance can signal corrosion, improper crimps, damaged cabling, worn brushes, a faulty commutator, or an open armature winding.

2. **Resistance < 2 Ohms Blue to Orange Field Wires.**

   The blue and orange conductors are connected to the motor's field winding. In order to make this measurement, it will be necessary to disconnect the butt-splice on the two orange wires or use a piercing meter probe. As with the armature, the field is a very low impedance and should appear to be a short-circuit for an ordinary voltmeter. High resistance can signal corrosion, improper crimps, damaged connectors, damaged cabling, or an open field winding.

3. **Resistance 15-25 Ohms Yellow to Brown Brake Wires.**

   The yellow and brown wires are connected to the integral brake. Improper resistance can signal corrosion, improper crimps, damaged cabling, or a fault solenoid.

4. **Resistance > 1 mOhm Red Armature Wire to Motor Housing.**

   The armature winding should be electrically isolated from the motor housing. Low resistance may be an indication of a crushed cable, a burned cable, or a burned armature winding. Investigate by disconnecting the drive motor cable from the motor and re-measure resistance (isolation).

5. **Resistance > 1 mOhm Blue Field Wire to Motor Housing**.

   The field winding should also be electrically isolated from the motor housing. Low resistance may be an indication of a crushed cable, a burned cable, or a burned field winding. Investigate by disconnecting the drive motor cable from the motor and re-measure resistance (isolation).

6. **Resistance > 1 mOhm Red Armature Wire to Blue Field Wire**.

   The armature and field windings should also be electrically isolated from one another. Low resistance may be an indication of a crushed cable, a burned cable, damaged windings. Investigate by disconnecting the drive motor cable from the motor and re-measure resistance (isolation).

Roll And Leak Testing

Torque-Hub units should always be roll and leak tested before disassembly and after assembly to make sure that the unit's gears, bearings and seals are working properly. The following information briefly outlines what to look for when performing these tests.

NOTE: *The brake must be released before performing the roll test. This can be accomplished by supplying 24 Volts D.C. to the gray 2-pin brake connector.*

The Roll Test

The purpose of the roll test is to determine if the unit's gears are rotating freely and properly. You should be able to rotate the wheel or hub of the gearbox by hand. If you feel more drag in the gears only at certain points, then the gears are not rolling freely and should be examined for improper installation or defects. Some gear packages roll with more difficulty than others. Do not be concerned if the gears in your unit seem to roll hard as long as they roll with consistency.

The Leak Test

The purpose of a leak test is to make sure the unit is air tight. You can tell if your unit has a leak if the pressure gauge reading on your leak checking fitting starts to fall after the unit has been pressurized and allowed to equalize. Leaks will most likely occur at the pipe plugs, the main seal or wherever o-rings are located. The exact location of a leak can usually be detected by brushing a soap and water solution around the main seal and where the o-rings or gaskets meet on the exterior of the unit, then checking for air bubbles. If a leak is detected in a seal, o-ring or gasket, the part must be replaced, and the unit rechecked. Leak test at 10 psi for 20 minutes.

NOTE: *Due to the small air volume inside this Torque-Hub, it will pressurize to 10 psi very quickly. If the pressure becomes excessive in the unit the seals will be destroyed.*

Oil Type & Capacity

This torque hub unit is shipped with ISO 68 viscosity oil *(hydraulic fluid)*. It is designed to utilize the same oil throughout its service life. However, should it need to be serviced the oil will need to be drained and replaced.

When serviced, fill the unit with ISO grade 68 oil or oil of a similar viscosity *(80W gear oil or 20W engine oil)*.

The gearbox will need to be filled with 10 oz. of oil.

Oil Filling Instructions

10 oz. of gearbox oil will fill the gearbox cavity approximately half full. To check the oil level, rotate the wheel so that the cover plugs are at 12 o-clock and 3 o-clock. Allow the oil to settle. Slowly loosen the 3 o-clock plug. If oil begins to come out then the oil level is sufficient. If no oil is noticed at the 3 o-clock plug location, then remove both plugs. Slowly add oil at the 12 o-clock plug location until oil begins to seep out of the 3-clock plug location. Re-install and tighten plugs to 6-8 ft-lbs.

Drive Motor Power Harness Routing

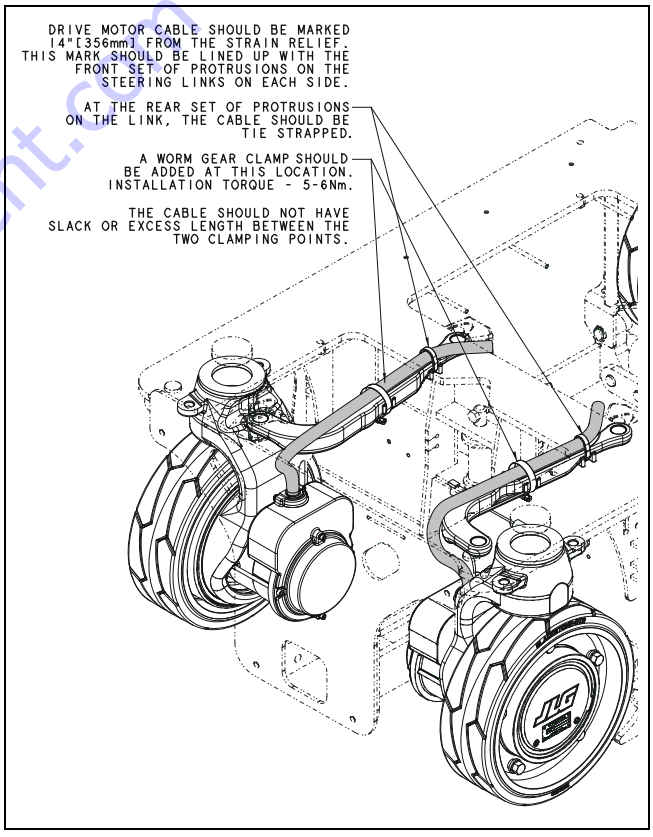


Figure 4-3. Drive Motor Power Harness Routing

Wheel Drive Brake - Manual Disengage Procedure

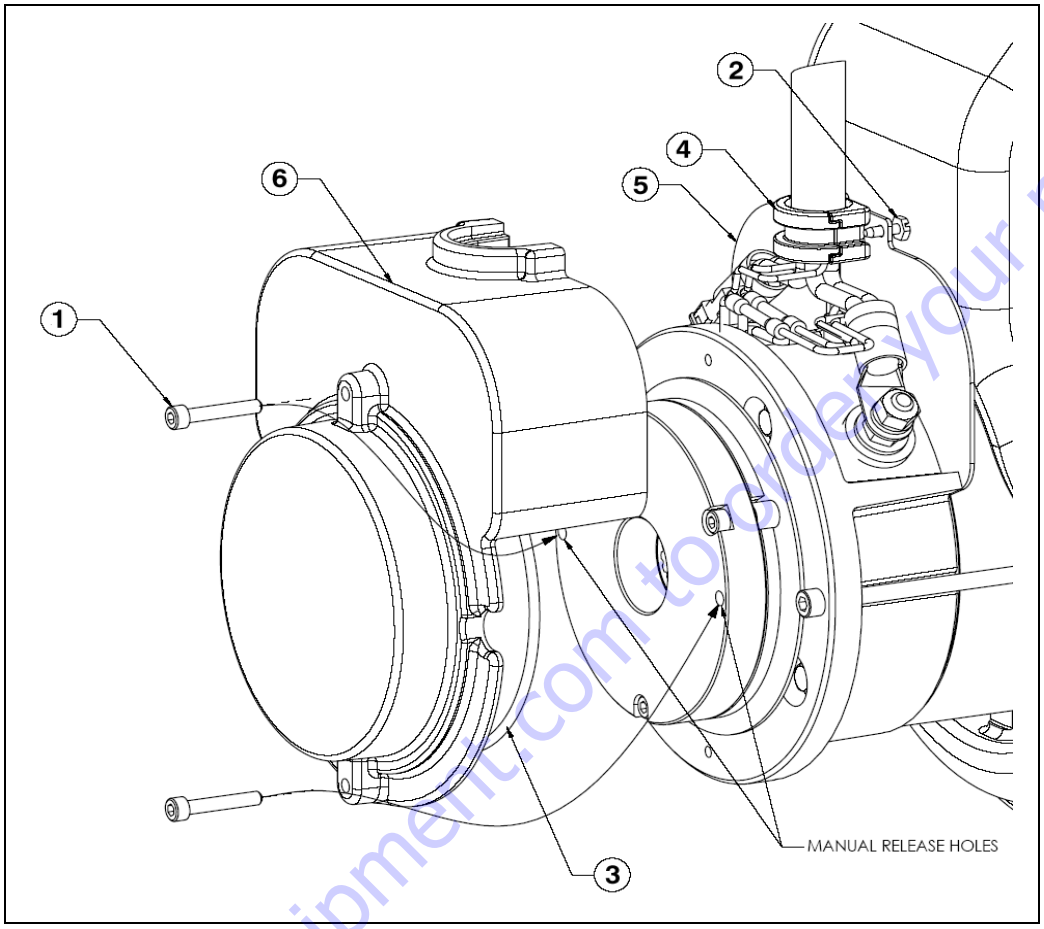


Figure 4-4. Brake Manual Disengage Procedure

In the event of a power loss to the Torque-Hub, the parking brake will engage as a safety precaution. Should the unit need to be towed or pushed to an area where it can be serviced or recharged the operator will need to manually disengage the parking brakes. The following procedure outlines how this is to be done.

⚠ CAUTION

IF THE MACHINE IS ON ANY INCLINE, THE WHEELS MUST BE ADEQUATELY BLOCKED PRIOR TO MANUALLY DISENGAGING THE BRAKES. FAILURE TO DO SO MAY RESULT IN INJURY OR EVEN DEATH.

1. Make sure the E-stop plunger is pushed in and the key is removed from the key switch on the Ground Control Station.
2. Remove the 2 Back Cover Bolts (1). The Back Cover Bolts are also the release bolts for the brake. The size of the back cover bolts (5) is 0.8 x 20mm long.
3. Remove the 2 Cover Plate Bolts (2) from the front of the cover area near the cable exit. The size of the Cover Plate Bolts is (#8 -32UNC x .500 inches long)
4. Remove the Cover Plate (6), Strain Relief (4), Back Cover (7), and Cover O'ring (3).
5. Insert the Back Cover Bolts (1) into the two holes in the brake housing at the 3 and 9 o'clock positions.
6. Tighten down bolts and the brake will disengage.
7. Repeat this procedure for the other wheel drive.

⚠ CAUTION

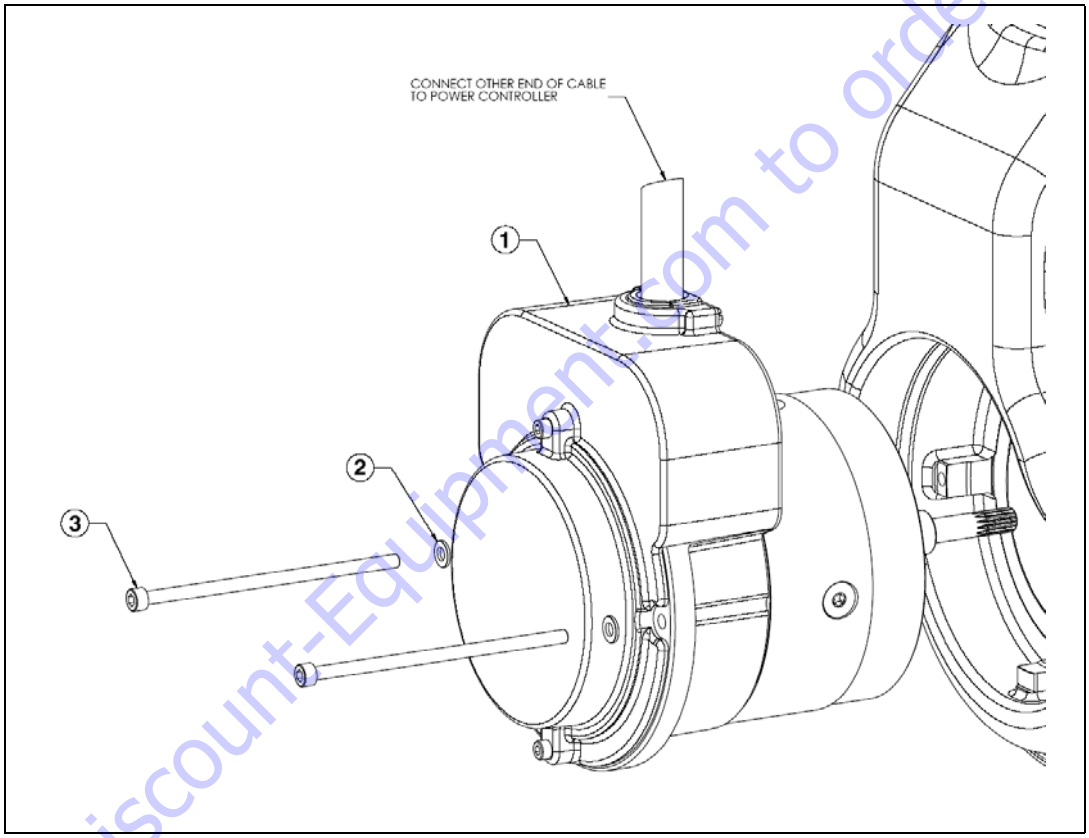
THE DISENGAGE BOLTS MUST BE REMOVED FROM THE BRAKE HOUSING AFTER THE MACHINE IS TOWED OR PUSHED TO ITS SERVICING LOCATION. THE BRAKES CAN NOT BE ENGAGED WITH THE DISENGAGE BOLTS IN THE BRAKE HOUSING. THIS WILL CAUSE THE MACHINE TO ROLL WHEN PARKED ON AN INCLINE.

Wheel Drive Motor Assembly - Removal From Machine

The electric wheel drive assemblies are mounted indepentent of each other on the base frame at the front of the machine.

The wheel drive assembly consists of an 24V DC electric motor driving a 45.13:1 ratio gear box, the assembly also included a friction disk parking brake assembly. This brake assembly is mounted on the end of the drive motor assembly.

1. Elevate the machine enough to remove the drive wheel(s).
2. Before disconnecting machine power at the batteries, power up the machine and turn the steering to expose the back of the drive motor to be removed.
3. Now disconnect machine power at the quick-disconnect (short cable) on the machine right side batteries.
4. Remove the drive wheel mounting lugs and remove the wheel(s).
5. Disconnect the power/brake harness to the drive motor to be removed at the power module.
6. Mark the position of and remove the tie straps holding the drive motor power harness to the steering linkage. Pull the harness throught the base frame until free.
7. Before removing the drive motor from the gear box, remove the pipe plugs on the gear box cover (wheel side) and drain the oil from the gear box.
8. Remove the two (2) long cap screws attaching the drive motor to the spindle and gear box.
9. Carefully slide the drive motor assembly out of the gear box/spindle assembly and place on workbench.



Wheel Drive Assembly - Removal

1. Drive Motor Assembly
2. Mounting Bolt Washers
3. Drive Motor Mounting Bolts

NOTE: *Removal same for left and right drive motor.*

Drive Motor Disassembly

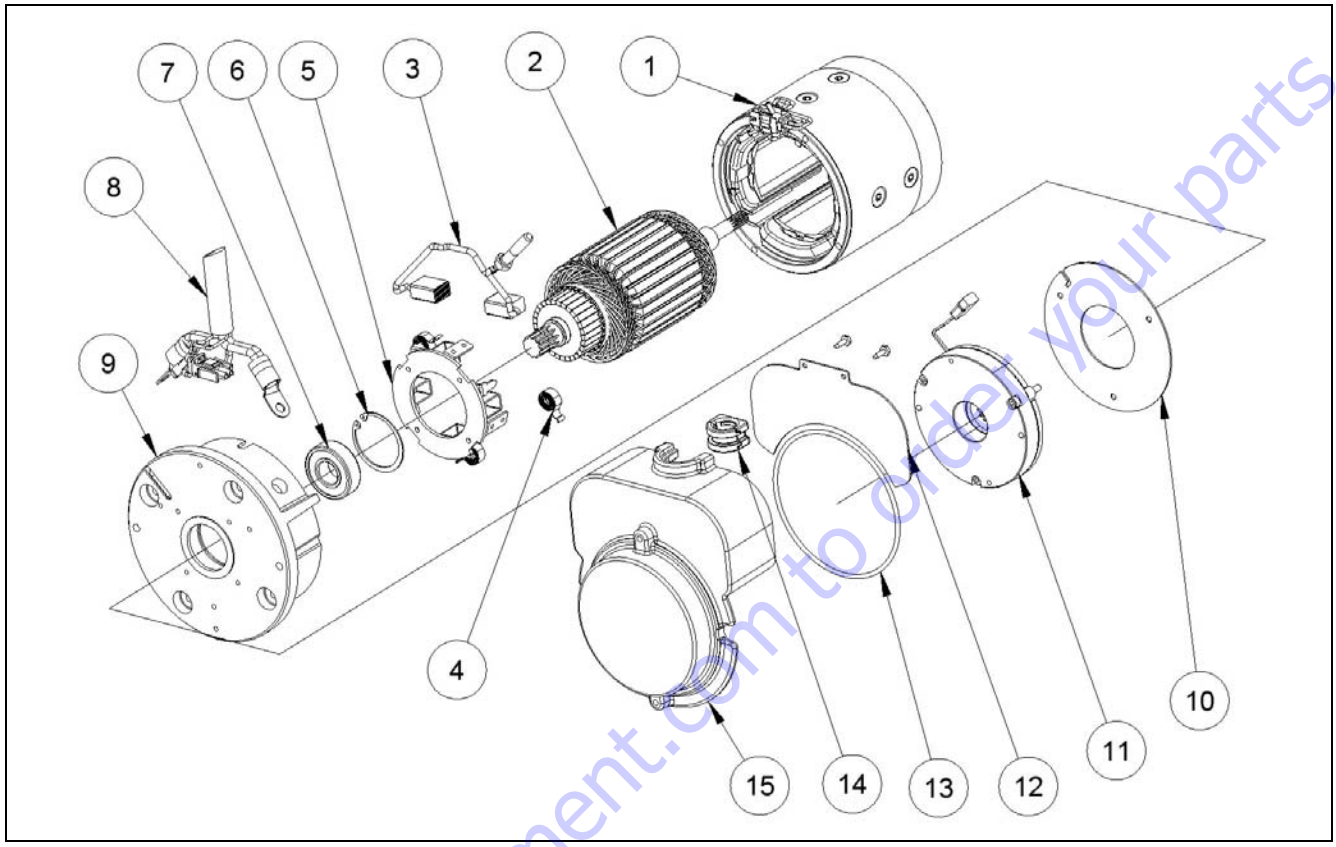


Figure 4-5. Drive Motor Disassembly

1. Remove the 2 (#8-32UNC x .500in long) screws holding the cover plate (12) in place (See Figure 4-6.) and remove the cover plate from the motor.
2. Remove the 2 (M5 x 0.8 x 20mm long) screws holding the cover (15) in place and set aside. These screws are needed later to manually release the brake. Slide the strain relief bushing (14) and wire harness out of the cover and remove the cover from the motor. Remove strain relief bushing from wire harness and set aside.
3. Discard the O-ring (13) located inside the cover.
4. Remove the wire harness (8) from the motor by disconnecting the field connection, brake connection, and armature connections. (See Figure 4-7.).
5. Install the 2 cover mounting screws into the threaded holes in the brake assembly and tighten to manually release the brake. (See Figure 4-7.) or image in the "Manual Disengage Procedure" (See Figure 4-4.).
6. Remove the 3 screws holding the brake assembly (11) to the motor. Carefully remove the brake assembly and friction disk (10) from the motor by sliding off of the shaft. (See Figure 4-7.).
7. Remove the screws holding the commutator end head (9) in place and remove the commutator end head from the frame and field assembly (1). The armature (2) will be attached to the commutator end head.
8. Pull back the brush springs (4) in the commutator end head, pull the brush back and rest the springs on the side of the brush. The brushes should move freely within the holders.
9. Use an arbor press or a bearing puller to remove the armature from the commutator end head assembly.
10. Remove the snap ring (6) and bearing (7) from the commutator end head. Discard the bearing.

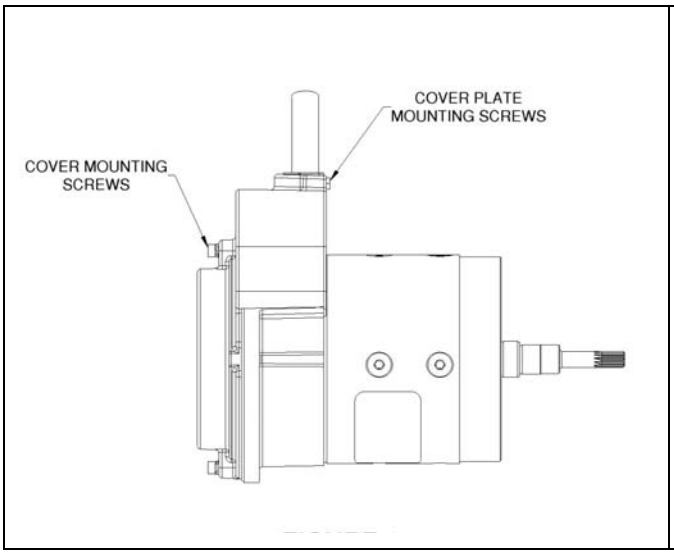


Figure 4-6. Drive Motor Side View

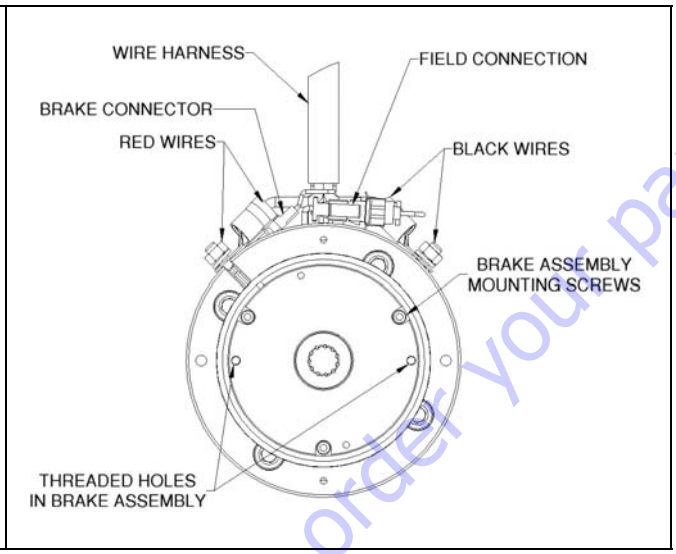


Figure 4-7. Drive Motor End View (Brake End)

Drive Motor Inspection and Servicing

(Reference Figure 4-5. - Drive Motor Disassembly Illustration)

1. Carefully blow out any accumulated carbon dust and dirt from the end head and the frame and field assembly using clean, oil free, compressed air.
2. Replace brushes (3) that are worn below their usable length (.600 in.), show signs of uneven wear or signs of overheating, such as discolored brush shunts and brush springs. Brushes should always be replaced in complete sets of four or eight. Use identical replacement parts; do not substitute brush grades as the brushes are matched to the motor type and application to provide the best service. Substituting brushes of the wrong grade can cause premature commutator failure and excessive brush wear.
3. Make sure the brush box assembly (5) is tight on the commutator end head. Replace brush box assemblies in the commutator end head if they are physically damaged or brush holders are loose on the brush plate.
4. Visually inspect the frame and field assembly (1) for overheating or other signs of damage. Check all wiring to insure that the insulation is in good condition. Verify that pole screws are torqued to 250-300 in-lb [28.2-33.9 N-m]. Verify field resistance using a suitable ohmmeter per the appropriate motor specification. Verify that the field is electrically isolated from the frame using a dielectric tester. Replace as necessary.
5. Visually inspect the armature (2) assembly for signs of overheating or physical damage. Visually inspect the seal surface of the shaft for excessive wear. Check for grounded circuits using a dielectric tester by applying voltage between the commutator and the shaft. Visually inspect the commutator for excessive wear and overheating. Replace as necessary.
6. Visually inspect the brake surfaces for excessive wear. Remove any RTV Silicone sealant that may be present on the friction disc, cover, or commutator end head. Replace brake assembly (11) if necessary.
7. Visually inspect the wire harness (8) for frayed insulation, loose terminals, or other damage. Replace as necessary.

Drive Motor - Reassembly

(See Figure 4-5.)

1. After inspection and servicing, reassemble the wiring in the commutator end head (9) as originally found. Ensure the wiring does not contact metal parts and that it allows the brushes to move unrestricted in the holders. Motor terminals must be assembled as shown *(See Figure 4-8.)*. Torque bottom terminal nut to 110-140 in-lb [12.4-15.8 N-m].

2. After the motor has been disassembled, it is recommended that new bearings be installed because bearings may have been damaged during removal. Although the bearings may appear and feel good, the bearing races could be "brinelled" *(races or balls deformed)* and may exhibit noise and vibration problems or fail within a relatively short period of service. Press a new bearing into the commutator end head, pressing on the outer race only. *(See Figure 4-9.)* Replace the snap ring (6) in the snap ring groove.

3. Press the armature (2) commutator end into the commutator end head and bearing assembly, carefully supporting the inner-race of the bearing. *(See Figure 4-9.)*.

4. Carefully release the brush springs (4) allowing the brushes to contact the commutator. Make sure brush shunts do not interfere with spring movement.

5. Assemble the commutator end head to the frame and field assembly (1) and tighten the screws to 120-140 in-lb [13.6-15.8 N-m]. Make sure to align the field connection with the notch in the commutator end head. Seal wires where they exit from commutator end head with a small amount of RTV Silicone Sealant.

6. Align wires from brake assembly (11) into notch in friction disc (10). Install both items onto shaft of motor aligning wires with groove in commutator end head. Secure brake assembly to commutator end head using 3 bolts and apply small bead of RTV Silicone sealant around wires between friction disc and commutator end head and in notch in friction disc.

7. Install wire harness (8) to motor by connecting the field and brake connectors and securing the armature terminals to the terminal studs. Refer to Figure 4-7. for proper connections. Motor terminals must be assembled as shown *(See Figure 4-8.)*. Always secure the bottom nut with a wrench as you tighten the top nut. Torque top nut to 90-110 in-lb [10.2-12.4 N-m].

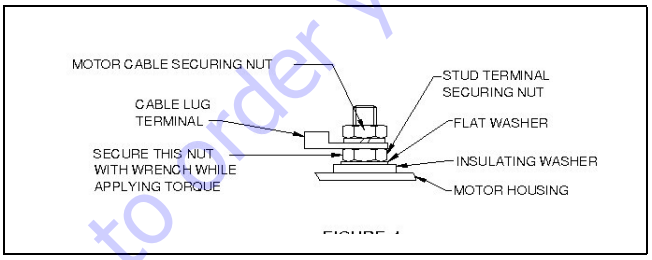


Figure 4-8. Motor Terminal Assembly

8. Remove manual release screws from brake assembly. Apply new o-ring (13) and affix cover (15) to motor using the 2 manual release screws. A small dab of RTV Silicone sealant may be used to secure the o-ring into the o-ring groove in the cover to aid in assembly.

9. Assemble strain relief bushing (14) around jacket of wire harness and slide into slot in cover.

10. Align cover plate (12) with groove in frame and field and affix using 2 screws.

11. Reinstall motor per instructions - *See Page 4-28*.

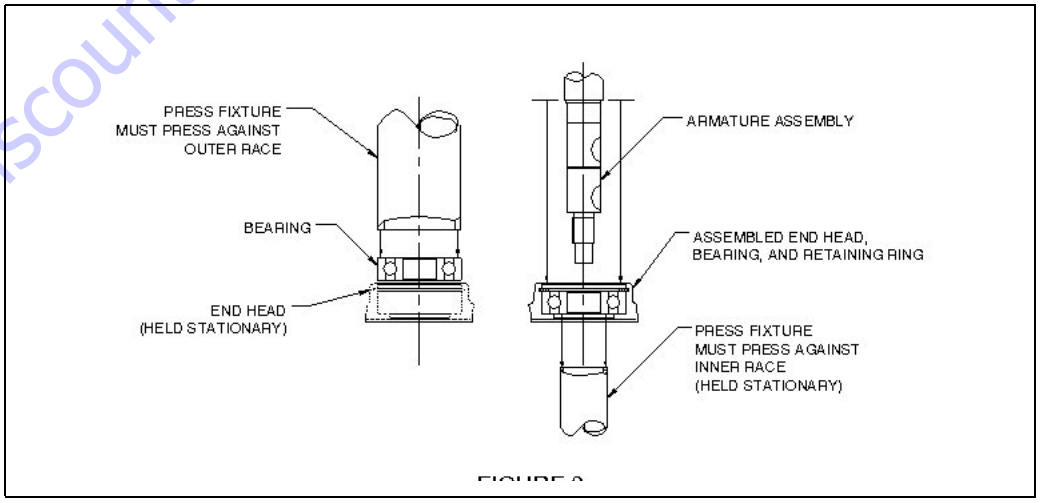
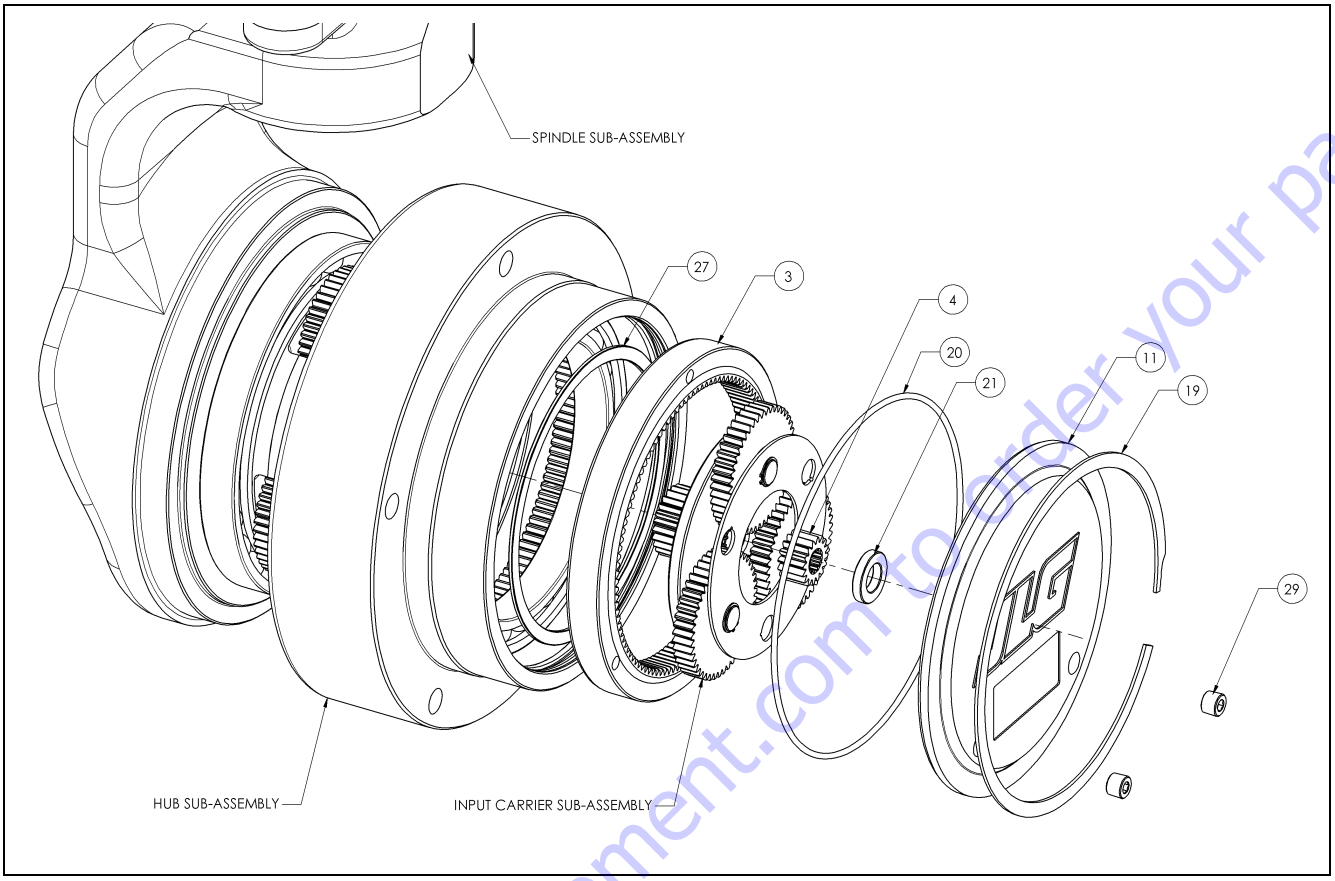


Figure 4-9. Bearing Replacement Procedure

Main Gear Box Disassembly



Main Gear Box Disassembly

1. Using a screwdriver, pry the end of the Retaining Ring (19) out of the groove in the Hub Subassembly, then grasp the loose end of the Retaining Ring (19) with pliers and pull the rest of the way out.
2. Remove Cover (11). Thrust Washer (21) should remain in the inner counterbore of the Cover (11) when removed.

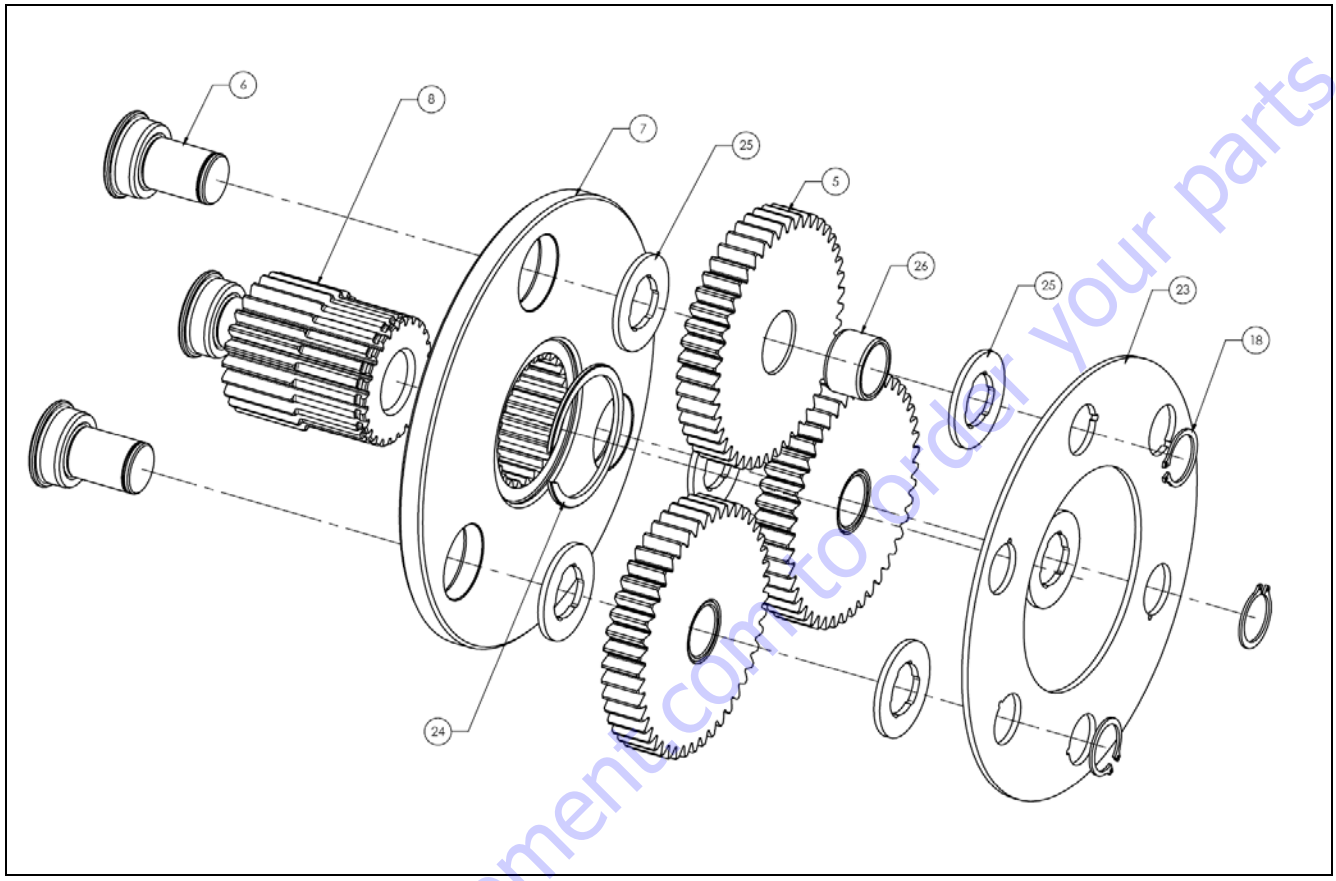
NOTE: *To remove the cover the motor must be removed. Slide a rod through the motor shaft hole and gently tap with a rubber hammer to force the cover out.*

3. Remove Input Sun Gear (4).
4. Remove Input Carrier Subassembly.
5. Remove Cover (11) O-ring (20).
6. Remove Input Ring Gear (3).

NOTE: *The Input Ring Gear (3) is held in with a press fit on its outside diameter. Insert jacking screws (1/4-20UNC, grade 8) with at least 1.5 inches of thread length into each of the three tapped holes to force the ring gear out. Be sure and alternate between the jacking screws to keep the ring gear from becoming misaligned in the bore. The screws will push against the outer race of the main bearing. This bearing will have to be replaced afterwards.*

7. Using a screwdriver, remove Spiral Retaining Ring (27).
8. Pull Hub Subassembly off of the Spindle (1) Subassembly.

Input Carrier Disassembly



Input Carrier Disassembly

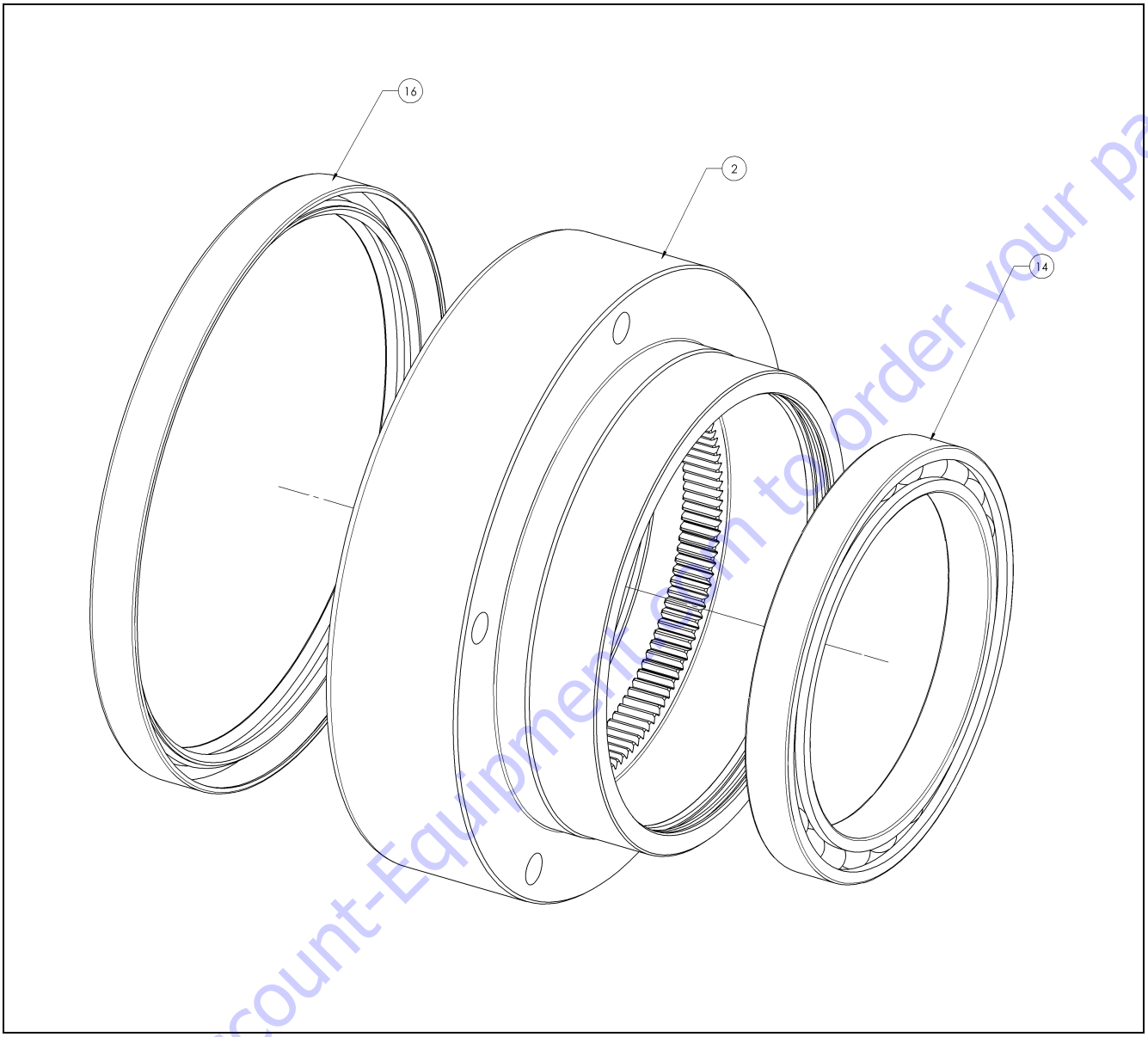
1. Remove Retaining Rings (18) from each of the three Planet Shafts (6).

NOTE: *Do not overstress these Retaining Rings when removing them.*

2. Remove Thrust Plate (23).
3. Remove Thrust Washer (25) from each Planet Shaft (6).
4. Slide each Input Planet Gear (5) off the Planet Shaft (6).
5. Press out Bushing (26) from the bore of each Planet Gear (5). Bushings cannot be reused when removed.
6. Remove the other Thrust Washer (25) from each Planet Shaft (6).
7. Remove Retaining Ring (24) from Output Sun Gear (8).
8. Slide Output Sun Gear (8) out from the center of the Input Carrier (7).
9. Remove the three Planet Shafts (6) from the Input Carrier.

NOTE: *The Planet Shafts (6) are held in with a press fit. To avoid damage to the parts, use an arbor or hydraulic press to remove the Planet Shafts (6).*

Hub - Disassembly



Hub Disassembly

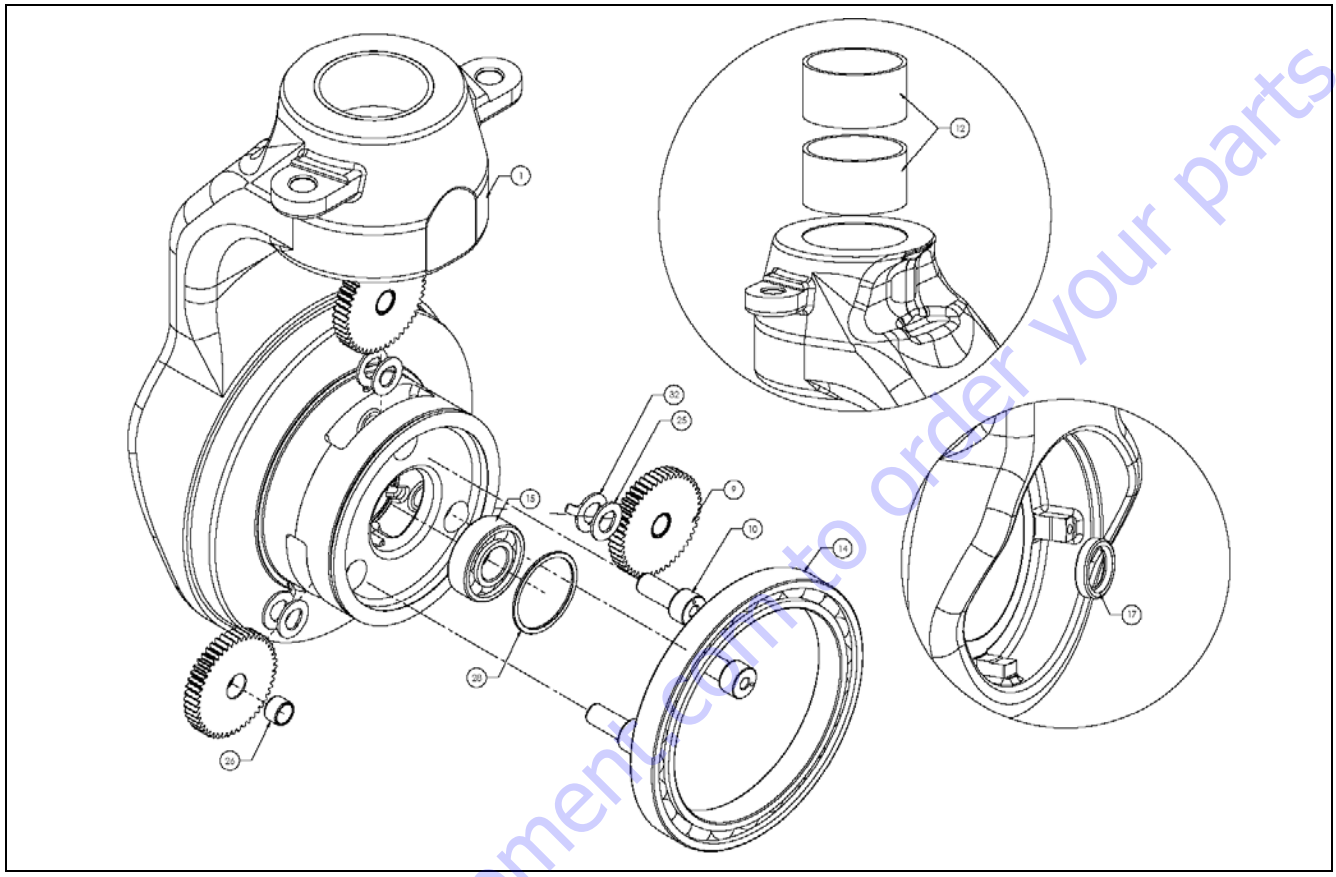
1. Remove Main Wheel Bearing (14).

NOTE: *This part is held in the hub with a press fit. To remove have the hub setting seal side up. Use a plate or rod with a large enough diameter push in the inner race of the bearing. Apply force to the push the bearing out. This bearing will need to be replaced upon reassembly.*

2. Remove main Lip Seal (16).

NOTE: *This Lip Seal (16) is also held in with a press fit. Remove the Lip Seal only if the hub or seal needs to be replaced. The Lip Seal will most likely become damaged during removal. Try not to damage the hub bore.*

Spindle Disassembly



Spindle Disassembly

1. Place unit on bench with Planet Gears (9) facing up.
2. Remove three Output Planet Shafts (10)

NOTE: *These Planet Shafts are held in with a press fit. Use the tapped hole in the end of the pin in conjunction with a slide hammer or similar tool to remove them.*

3. Remove the Output Planet Gear (9), Thrust Washer (25), and Tanged Washer (32) out each of gear "window" of the Spindle (1).

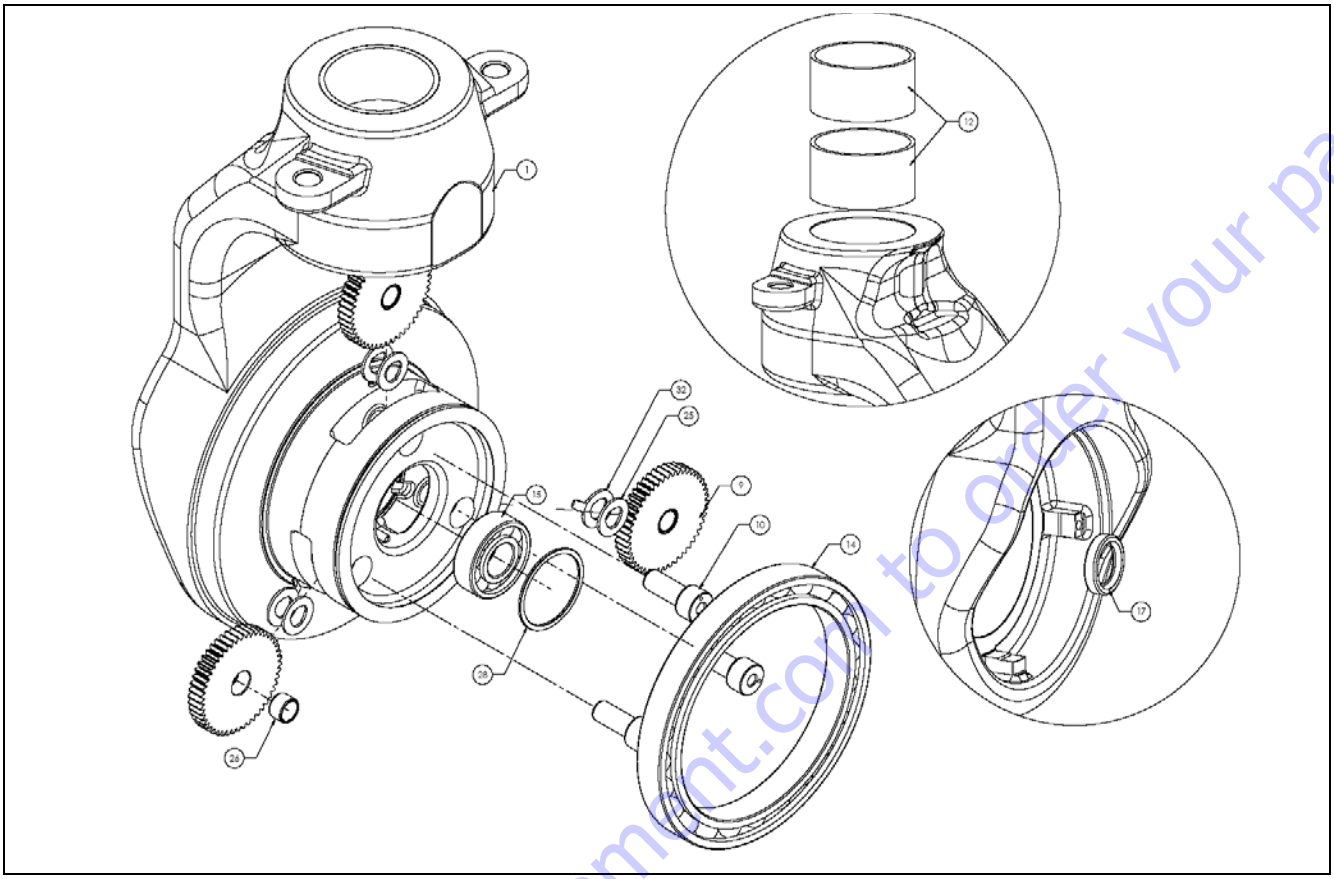
NOTE: *The Output Planet Gears (9) are a very similar size to the Input Planet Gears (5), tag or label the Planet Gears to avoid confusion.*

4. Press out Bushing (26) from the bore of each Planet Gear (9). Bushings cannot be reused when removed
5. Use appropriate tool to remove the shaft bearing Retaining Ring (28).
6. Remove the shaft Ball Bearing (15) from the center bore.
7. Press out the Motor Shaft Seal (17) from the center bore.
8. Remove the Main Bearing (14) from the outside diameter of the Spindle (1).

NOTE: *This bearing is held in with a press fit. You will need to pry against the Spindle (1) to remove it. A new bearing should be used when the unit is reassembled.*

9. Press out the Main Bushings (12) at the top of the Spindle (1) neck.

Spindle Sub-Assembly



Spindle Sub-Assembly

1. Using the appropriate pressing tool (T-207925), press in the 2 Main Bushings (12) in the upper bore of the Spindle (1). The lower bushing needs to flush with the bottom of the bore and the upper bushing needs to be flush with the bottom of the bore.
2. Using the appropriate pressing tool (T-182377), press on Main Bearing (14) until it is fully seated.
3. Insert the Motor Shaft Bearing (15) into the center bore of the Spindle (1). The bearing is a slight slip fit, but it may require some press to assemble if the bearing becomes misaligned.
4. Retain the Motor Shaft Bearing (15) installing Spiral Retaining Ring (28) into groove in Spindle (1).
5. Use the Output Planet Pin (10) as a pressing tool to install the Planet Bushing (26) into the bore of each Planet Gear (9). The shaft will help guide the bushing into the bore as well as prevent damage from the press.
6. Place Tanged Thrust Washer (32) into each planet "window" of the Spindle (1). Make sure the tang sits in the cast groove on the inside of the window.
7. Place a Thrust Washer (25) onto the Output Planet Gear (9). Line up the bores as best as you can. Use grease to hold the Thrust Washer in place.
8. Slide the Output Planet Gear (9) into the window with the Tanged Thrust Washer (32) until the bores line up.
9. Insert an Output Planet Shaft (10) into the Planet Shaft hole of the Spindle (1) and through the bores of the Thrust Washers (25) & (32) and the Planet Gear (9).
10. Before pressing the Output Planet Shaft (10) into the Spindle (1), make sure the gear spins freely.

(continued next page)

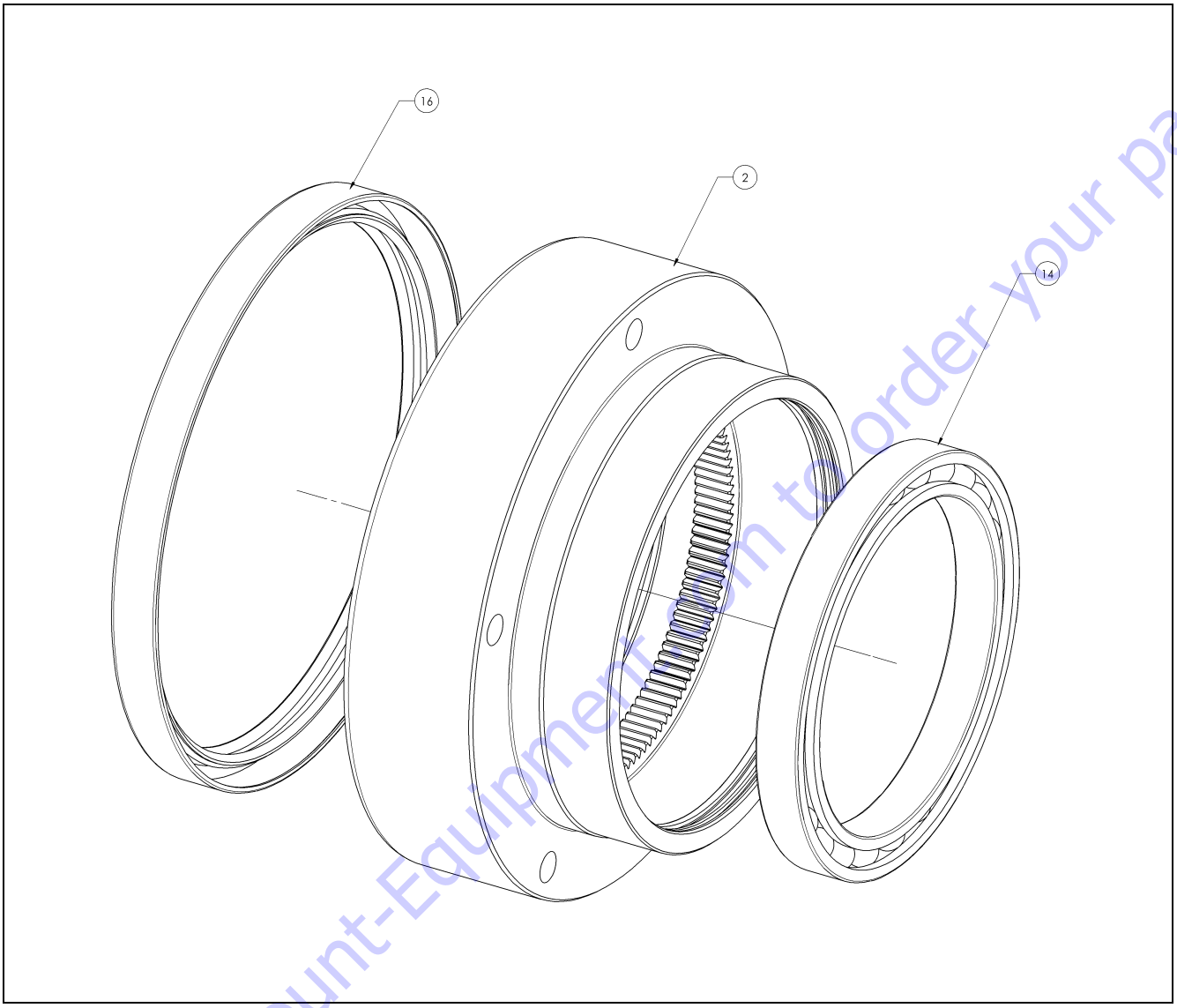
11. Press the Output Planet Shaft (10) into the Spindle (1) until it bottoms out. Make sure the Output Planet Gear (9) turns freely after the Planet Shaft is pressed in.

12. Repeat Steps 5-11 for the other two Output Planet Gears (9).

13. Turn the Spindle (1) over so that the carrier end is down.

14. Using a flat plate or rod, press the Motor Shaft Seal (17) into the center bore so that it is flush with the face of the Spindle (1).

Hub Sub-Assembly



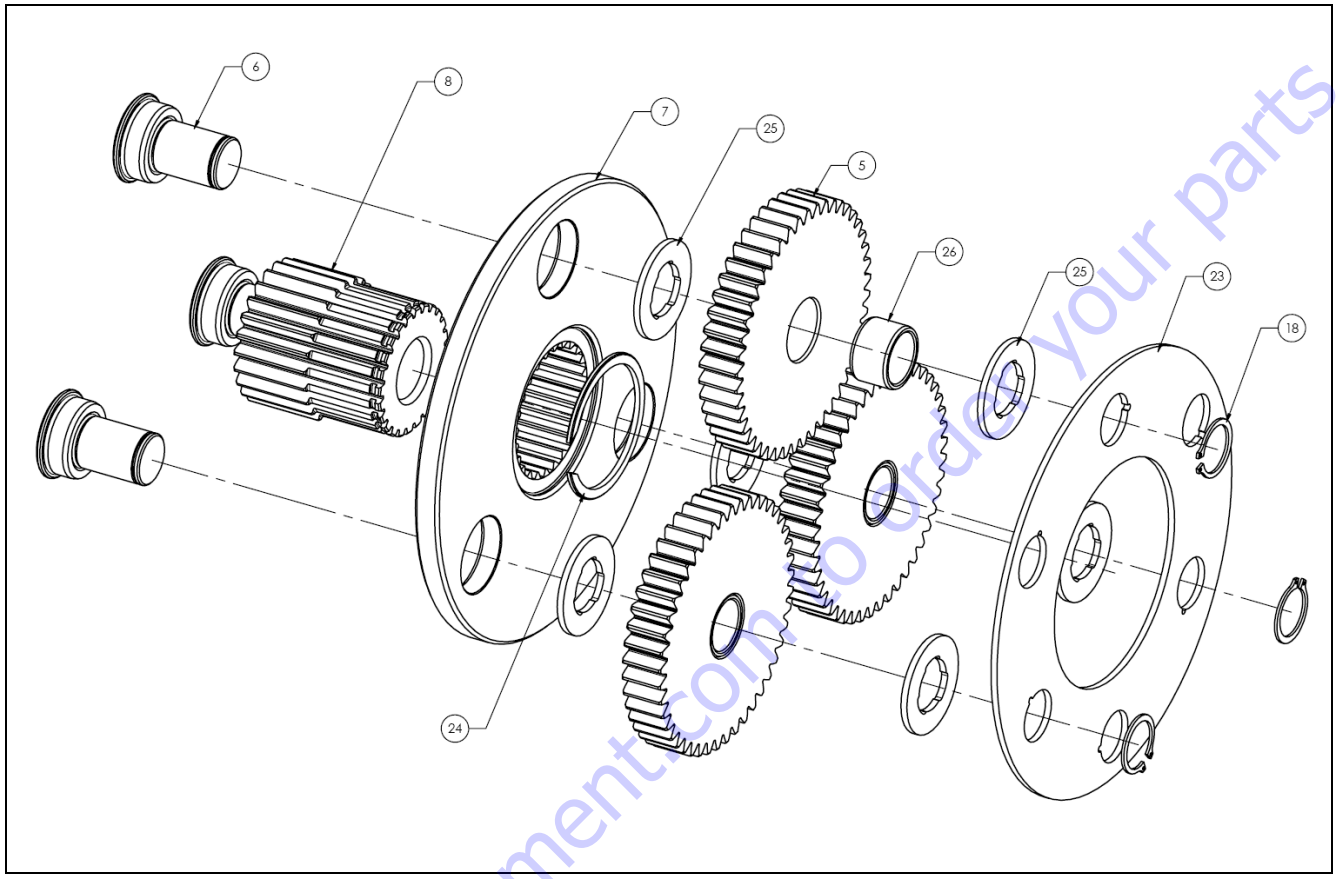
Hub Sub-Assembly

1. Put Hub (2) on a table with the tapped holes facing down.
2. Using a flat plate in conjunction with a pressing tool, press in the Seal (16) so it is flush with the edge of the hub.

NOTE: *NOTE: The Seal has a thin outer shell that can be easily damaged if not installed with care. It is a good idea to start the Seal into the bore with a rubber mallet before pressing.*

3. Flip the Hub (2) over
4. Using the appropriate pressing tool (T-174356), press the Main Bearing (15) into the bore until it bottoms out.

Input Carrier Sub-Assembly

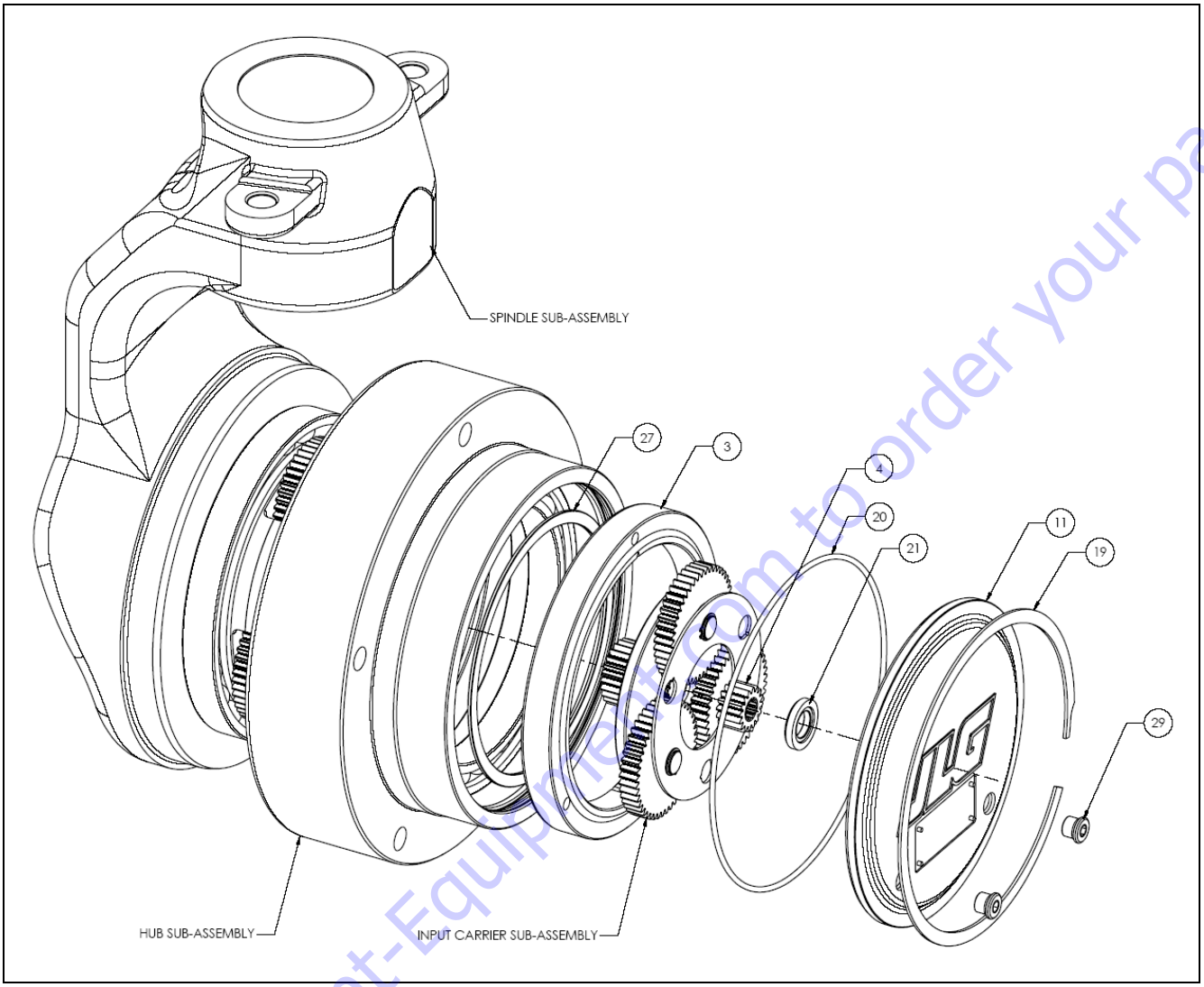


Input Carrier Sub-Assembly

1. Use the Input Planet Shaft (6) as a pressing tool to install the Planet Bushing (26) into the bore of each Planet Gear (5). The shaft will help guide the bushing into the bore as well as prevent damage from the press.
2. Press three Input Planet Shafts (6) into the three holes of the Input Carrier (7). The head of the Input Planet Shaft (6) needs to sit flush in the counterbore of the Input Carrier (7) hole
3. Insert Output Sun Gear (8) into the splined bore of the Input Carrier (7). The gear tooth end of the Output Sun Gear (8) should protrude in the opposite direction of the Input Planet Shafts (6).
4. Using retaining ring pliers, install the Retaining Ring (24) into the groove of the Output Sun Gear (8). Make sure that the Retaining Ring (24) is correctly seated in the groove and that the Output Sun Gear (8) cannot be pulled out of the Input Carrier (7).
5. Place a Thrust Washer (25) on each side of the Input Planet Gear (5). Line up the bores as well as you can visually. Additional grease may help hold everything together.
6. Place the Input Planet Gear (5) and Thrust Washers (25) onto the Input Planet Shaft (6) sticking out from the Input Carrier (7).
7. Repeat 5 & 6 for the other 2 Planet Gears.
8. Put the Thrust Plate (23) onto the three Input Planet Shafts (6). Use the three holes on the innermost bolt circle. The other three holes are for a different gear ratio.
9. Using the appropriate retaining ring pliers put a Retaining Ring (18) into the groove of each Input Planet Shaft (6).

NOTE: *Do not overstress the Retaining Rings (18).*

Main Gear Box Sub-Assembly



Main Gear Box Sub-Assembly

1. Inspect seal surface of Spindle (1). Remove any debris that may be present.
2. Apply a coating of grease to the Lip Seal (not shown) in the Hub Subassembly.
3. Place Spindle (1) Sub-Assembly on table with carrier side up.
4. Carefully install the Hub Subassembly (seal side down) onto the Spindle (1). This installation should be a slip fit and takes place in 3 stages.
5. **Stage 1:** The hub slides together until the gear teeth of the hub hit the gear teeth of the 3 output planets.
6. **Stage 2:** Find the Planet Gear that is tight and turn it until you feel it go into mesh with the hub gear teeth, apply slight downward pressure to the hub and then find the next gear that is tight and do the same.
7. **Stage 3:** Once all the Planet Gears are in mesh apply pressure to the hub, it should push on the rest of the way.
8. Install Retaining Ring (27) into the groove on the OD of the Spindle (1) carrier. This is a Spiral Retaining Ring so it will not require pliers. You will need to pull the Retaining Ring (27) apart and work it into the groove.

(continued next page)

9. Using the appropriate pressing tool (T-174356), press in the Input Ring Gear (3) into the bore of Hub Subassembly.

NOTE: *Do not use excessive pressing force because it will be reacted by the main wheel bearings.*

10. Install the Input Carrier Subassembly into mesh. The Output Sun Gear (8) portion of the Input Carrier Subassembly will mesh with the Output Planet Gears (9) and the Input Planet Gears (5) mounted on the Input Carrier Subassembly will mesh with the Input Ring Gear (3).
11. Install the Input Sun Gear (4) into the area between the three Input Planet Gears (5).
12. Apply a coating of grease to the Cover (11) O-ring (20) and install it into the o-ring groove of the Hub Subassembly.

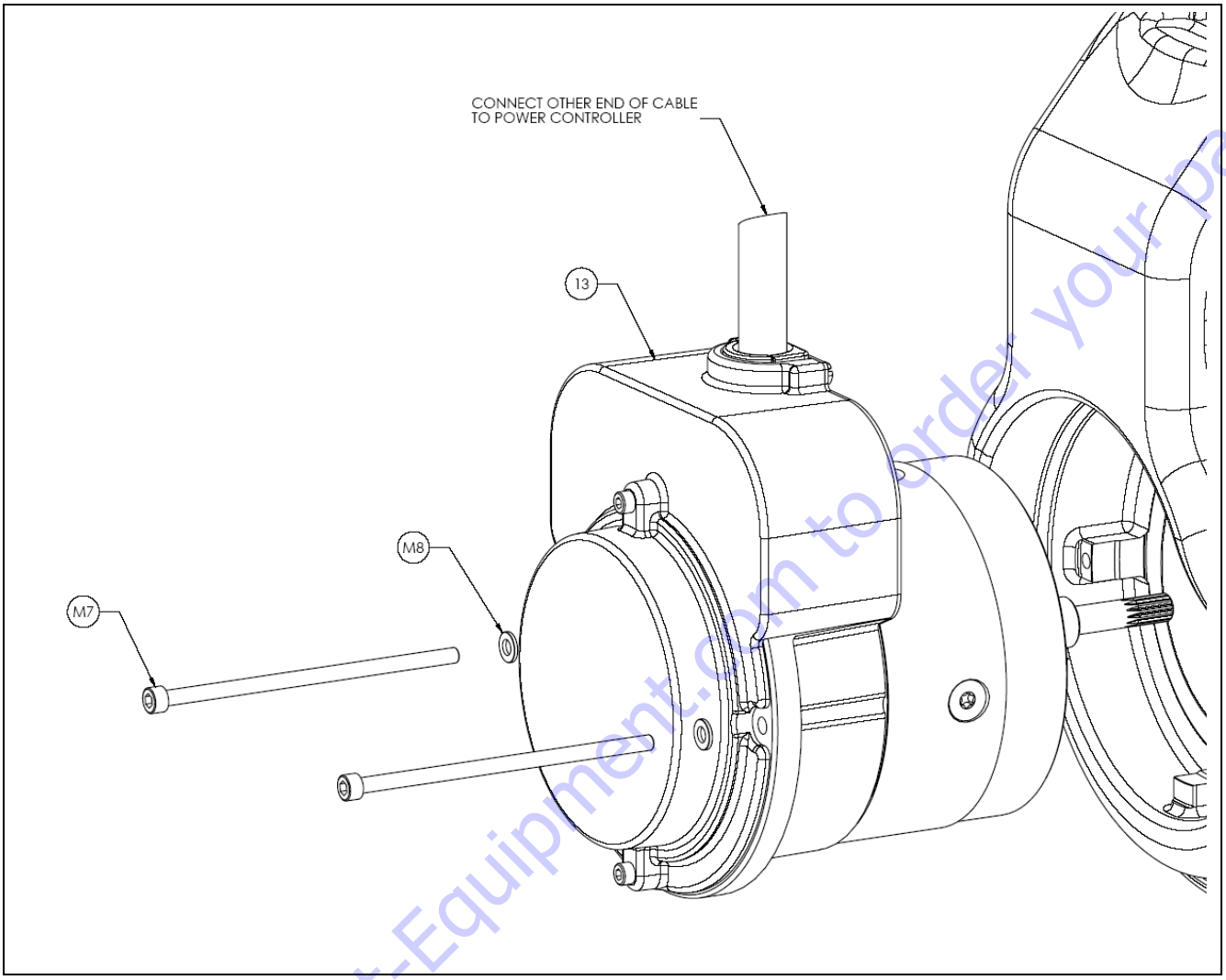
NOTE: *It may be helpful to stretch the O-ring (20) out prior to assembly to avoid pinching or shearing when the Cover (11) is assembled.*

13. Apply Loctite 380 or 480 glue to Cover Thrust Washer (21) and place it in the center counter bore of the Cover (11) so that the steel face of the washer is out of the bore.

NOTE: *Make sure that both the Cover Thrust Washer (21) and the Cover (11) have good clean surfaces for the Loctite to properly adhere.*

14. Center the Cover (11) in the hub bore so that the "JLG" logo is up. Push it into the bore.
15. Install the Cover Retaining Ring (19) into the groove of the Hub Sub-assembly.

Motor Assembly



Motor Assembly

1. Insert motor (13) into back of the gearbox. Motor will pilot on the 4 bosses in the gearbox. Try to keep the end of the motor shaft from causing damage to the lip seal in the gearbox.

NOTE: *The motor may need to be rotated to line up the sun gear splines with the motor shaft splines.*

2. Install the 2 Motor Mounting Bolts (M7) and Washers (M8). Tighten to 9-11 ft-lbs.
3. Connect the end of the power cable to the power controller, route cable per instruction in Figure 4-3.
4. Fill the gearbox with oil, See Oil Type & Capacity on Page 4-12.

4.9 HYDRAULIC PUMP/MOTOR/VALVE ASSEMBLY - SERVICE PROCEDURE

Refer to Section 3.6, PUMP/LIFT/MAST - Theory of Operation for more detailed information on Pump/Motor/Valve System.

Common Difficulties

The following difficulties can be examined using the JLG Analyzer, a voltmeter, and simple hand tools. Unless otherwise noted, the Control System shall be energized in Ground Mode during testing. For a convenient Ground Reference, place the black meter lead on the negative post of the left battery in the left-side battery compartment. The vehicle should be placed on a firm, level surface for all analysis.

1. **Ground Module Interlocks**

   There are a variety of interlocks that prevent Lift Up due to system events (Tilted, Elevation Angle Sensor Not Calibrated, etc). Before investigating Pump System issues, examine the JLG Analyzer's HELP Menu while attempting to Lift Up from Ground Mode. Refer to Section 5 for explanations of the Analyzer Help Messages.

2. **Power Module Diagnostic Issues**

   The Power Module executes a self-test during every power-up to ensure proper functionality. If a Diagnostic Issue is detected, the Power Module will not energize the Line Contactor. Instead, it will flash the Green LED. Since these issues may impact both the Traction and Pump Systems, please refer to the section for Power Module Diagnostics.

3. **Open-Circuit between +B Terminal and Pump Motor Positive Terminal**

   This issue will allow the vehicle to drive, but Lift Up and Steer Functionality will be lost and the Pump Motor will not operate. Under DIAGNOSTICS - PUMP, the JLG Analyzer will show PUMP PWM 100% and PUMP CUR 0.0A when Lift Up is operated from Ground Mode.

   As shown in the diagram, the voltage measured between the Pump Motor Positive Terminal and Ground Reference should be 24V. If it is not, examine the cable between the terminal and the Power Module compartment. Inspect crimps for corrosion and ensure that bolted connections are tight. Ensure that the cable is not crushed where it passes between the frame side sheets and the cylinder assembly.

4. **Open-Circuit between Pump Motor Negative Terminal and P Terminal**

   This issue will allow the vehicle to drive, but Lift Up and Steer Functionality will be lost and the Pump Motor will not operate. Under DIAGNOSTICS - PUMP, the JLG Analyzer will show PUMP PWM 100% and PUMP CUR 0.0A when Lift Up is operated from Ground Mode.

   After ensuring there is not an Open-Circuit between the +B Terminal and Pump Motor Positive Terminal, check that the voltage measured between the Pump Motor Negative Terminal and Ground Reference is 24V. If not, examine the issues within Open-Circuit Pump Motor. This voltage should ramp to approximately 0V when Lift Up is operated from Ground Mode. If not, examine the cable between the terminal and the Power Module compartment (P Terminal). Inspect crimps for corrosion and ensure that bolted connections are tight. Ensure that the cable is not crushed where it passes between the frame side sheets and the cylinder assembly.

5. **Open-Circuit Pump Motor**

   This issue will allow the vehicle to drive, but Lift Up and Steer Functionality will be lost and the Pump Motor will not operate. Under DIAGNOSTICS - PUMP, the JLG Analyzer will show PUMP PWM 100% and PUMP CUR 0.0A when Lift Up is operated from Ground Mode.

   Pull the Main Battery Disconnect to completely de-energize the Control System. Next, detach the cable from Pump Motor Positive Terminal. Using a voltmeter set for resistance measurement (Ohms), ensure that the resistance between the Pump Motor Positive and Negative Terminals is less than 2 Ohms. If not, examine the pump motor for worn brushes or broken terminals. After examination, re-connect the Pump Motor Positive Terminal and the Main Battery Disconnect.

6. **Short-Circuit between Pump Motor Positive and Negative Terminals**

   This issue will allow the vehicle to drive, but Lift Up and Steer Functionality will be lost and the Pump Motor will not operate. Under DIAGNOSTICS - PUMP, the JLG Analyzer will show an erratic reading for PUMP PWM % and PUMP CUR will hover around 150A when Lift Up is operated from Ground Mode.

   Pull the Main Battery Disconnect to completely de-energize the Control System. Next, detach both Pump Motor Terminals and insulate them independently. Re-connect the Main Battery Disconnect and re-try Lift Up. If the same symptoms persist (erratic PUMP PWM%, PUMP CUR around 150A), examine the cabling between the Pump Motor and Power Module compartment for a short-circuit (most likely near area where cylinder retracts between frame side sheets or near pot-hole mechanism). If the symptoms change, suspect a short-circuited (or mechanically frozen) pump motor.

   A clamp-on ammeter (set for 200A DC) can be placed on either Pump Motor Cable for verification. During Lift Up, the ammeter will read approximately 150A.

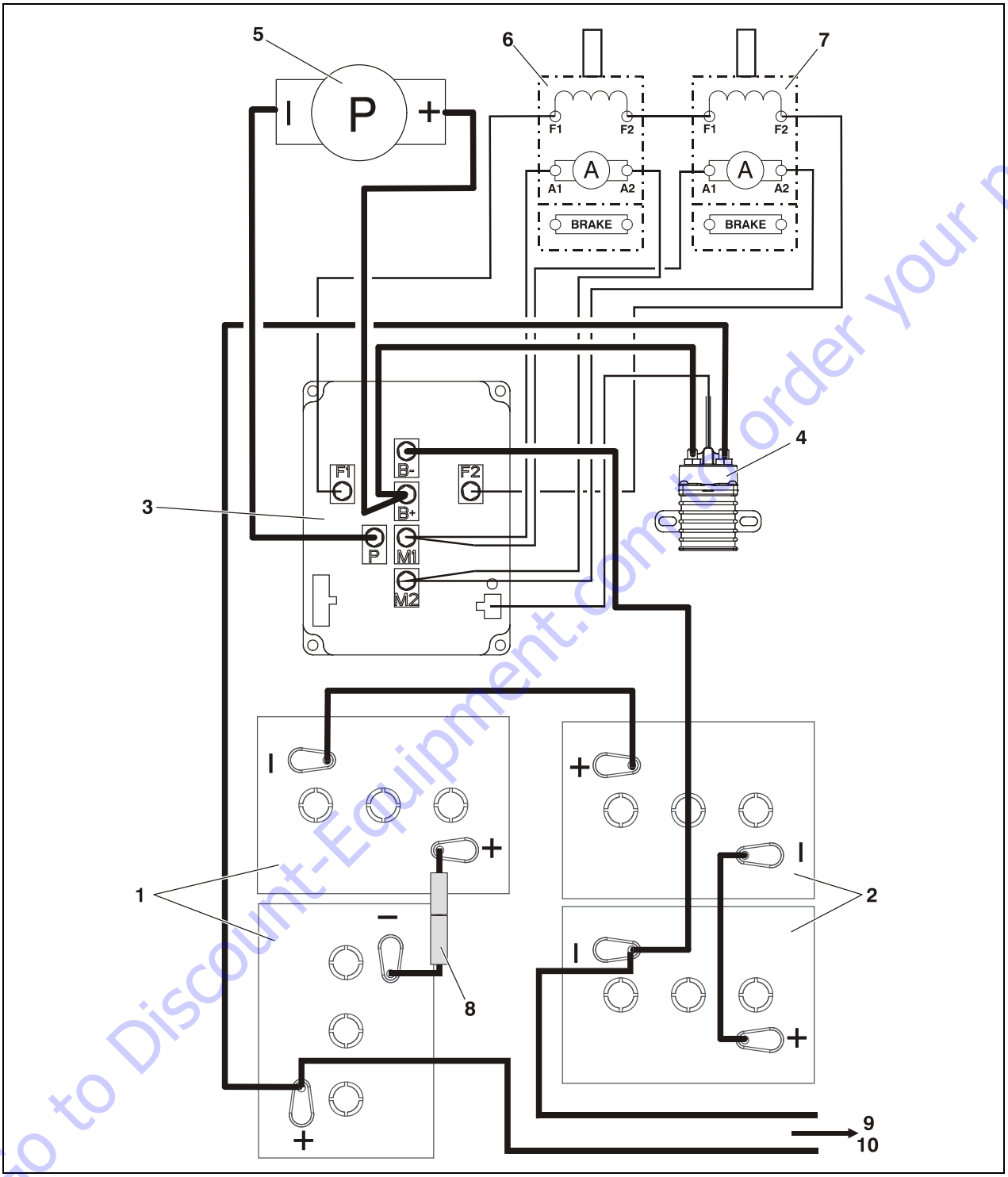


Figure 4-10. Main Electrical Power Connections - (1600346 - SEVCON Power Module)

1. Right Side Batteries
2. Left Side Batteries
3. Power Module
4. Main Power Contactor Relay
5. Hydraulic Pump Motor
6. Right Drive Motor
7. Left Drive Motor
8. Battery Power Quick-Disconnect
9. To Battery Charger
10. To Charger or Inverter (Option, If Equipped)

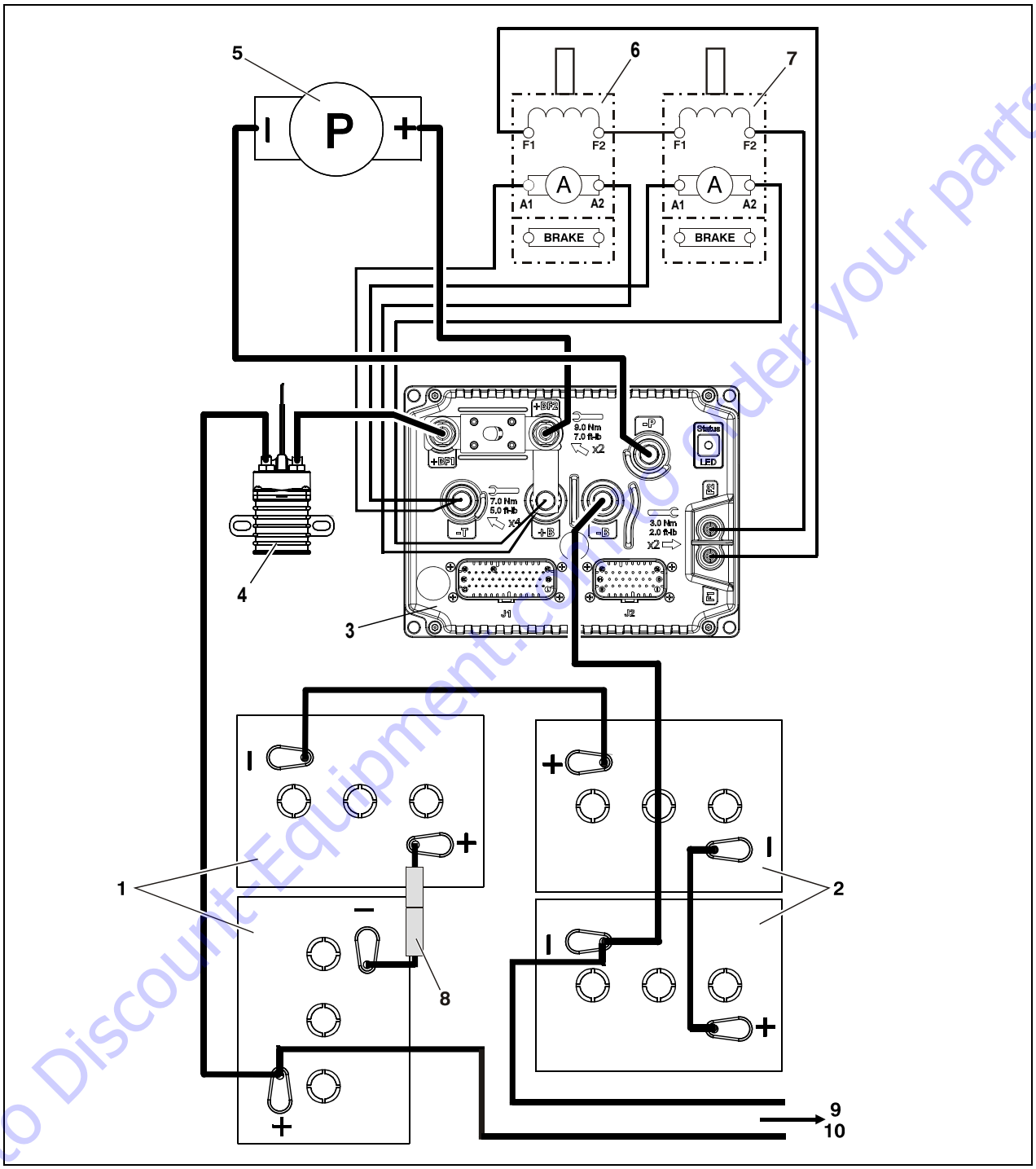


Figure 4-11. Main Electrical Power Connections - (1001092456 - ZAPI Power Module)

1. Right Side Batteries
2. Left Side Batteries
3. Power Module
4. Main Power Contactor Relay
5. Hydraulic Pump Motor
6. Right Drive Motor
7. Left Drive Motor
8. Battery Power Quick-Disconnect
9. To Battery Charger
10. To Charger or Inverter (Option, If Equipped)

Pump Components

The following is a complete disassembly/assembly of the machines' pump/motor/valve assembly.

NOTE: *During reassembly of the pump/motor assembly, lubricate all seals and o-rings with JLG recommended hydraulic fluid.*
Also keep all internal metal parts clean and coated with hydraulic fluid to prevent surface corrosion.
JLG recommends replacing all seals and o-rings when disassembling and reassembling the pump/motor unit.

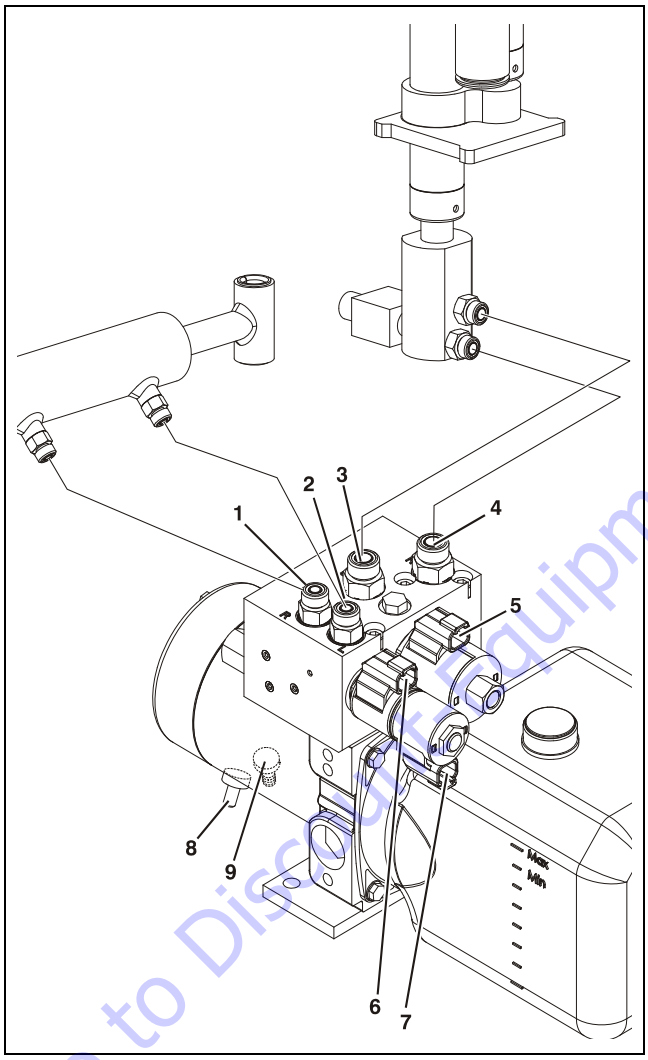
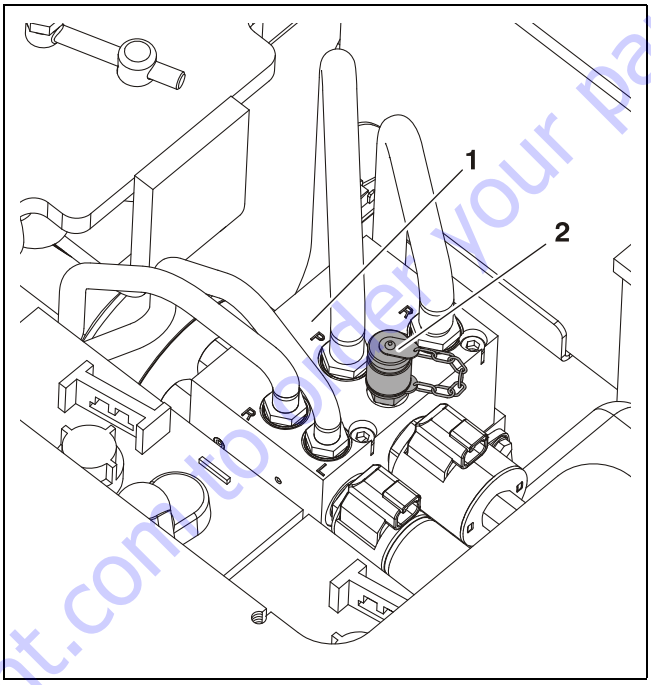


Figure 4-12. Hydraulic Pump - Hydraulic Line and Electrical Connections

1. Steer Right - Hyd. Line
2. Steer Left - Hyd. Line
3. Cyl. Lift-Up - Hyd. Line
4. Cyl. Return - Hyd. Line
5. Cylinder Lift-Up Solenoid
6. Steer Right Solenoid
7. Steer Left Solenoid
8. Pump Motor Pos (+)
9. Pump Motor Neg (–)

Hydraulic System Pressure Check Port

The port for hydraulic system lift pressure check is provided on the valve body of the hydraulic pump assembly as shown in the following illustration.



Hydraulic Pressure Check Port

1. Pump Valve Body
2. Pressure Check Port Shown with Optional Fitting

Hydraulic System Pressure Settings

Perform final hydraulic pressure setting with oil at normal operating temperature. If pressure is set when cold, function may not operate properly after oil has warmed.

Turning relief adjustment screw **clockwise - increases pressure**, turning adjustment screw **counterclockwise - decreases pressure**. DO NOT EXCEED MAXIMUM PRESSURE SETTINGS. *(See Figure 4-13.)*

Table 4-2. Hydraulic Pressure Settings

1230ES	MAXIMUM PRESSURE SETTING
Main	1600 PSI (110 Bar)
Steer - Left/Right	1250 PSI (86 Bar)

Component	Coil Rating
Lift-Up Solenoid	28 Ohm
Steer - Left/Right Solenoid	33 Ohm

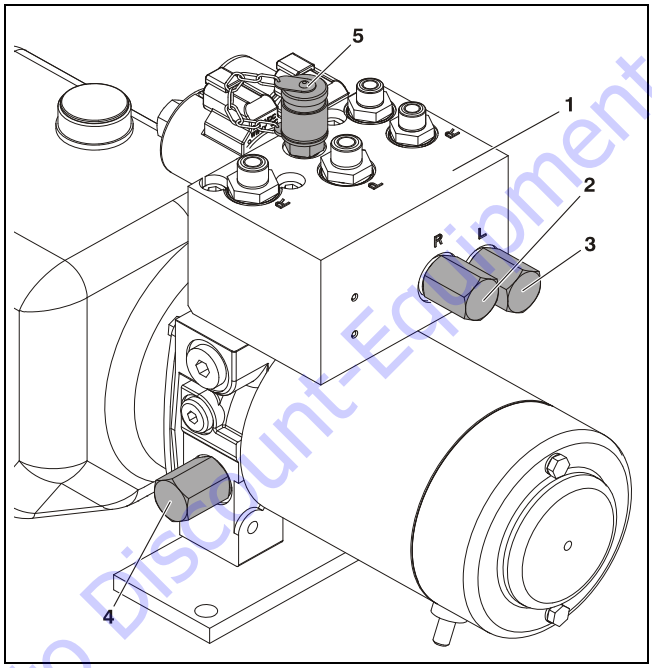
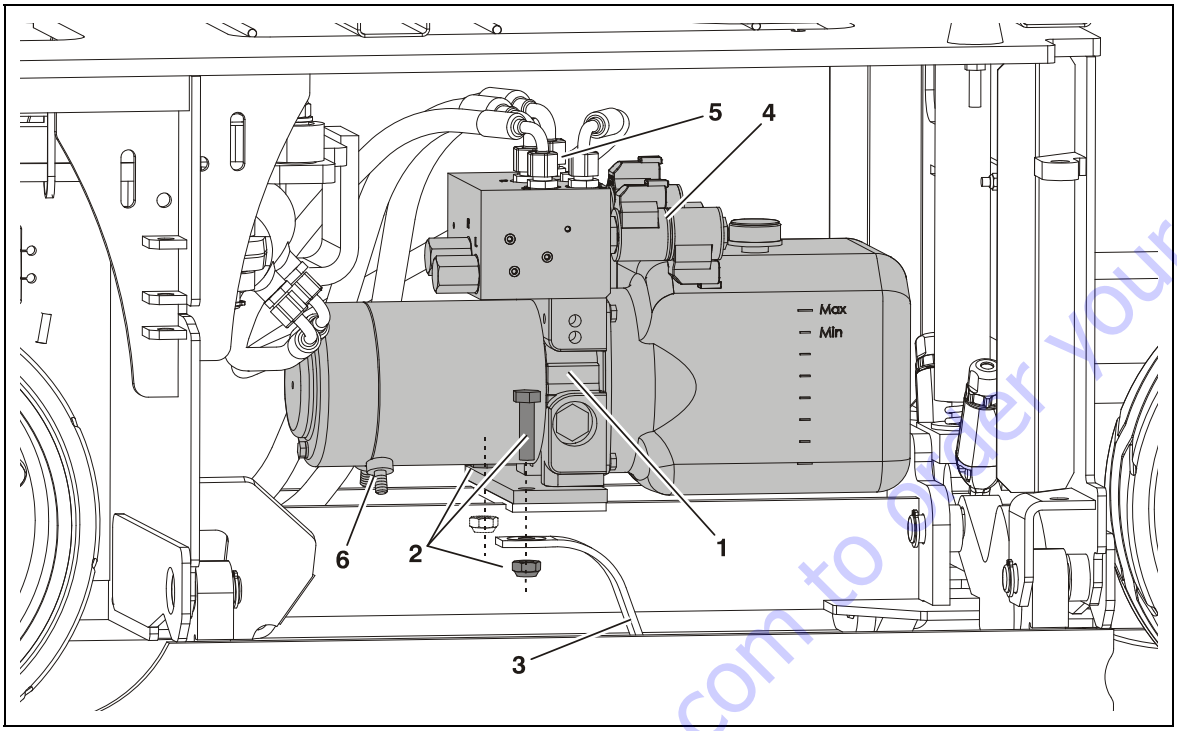


Figure 4-13. Relief Pressure Setting Locations

1. Pump Valve Body
2. Steering Right Pressure Relief
3. Steering Left Pressure Relief
4. Main Pressure Relief
5. Pressure Gauge Check Port

1. To check the lift pressure, attach pressure gauge to the check port on top of the valve body.
   To check steer pressure remove either the left or right steer hose fitting on the valve body and plumb a pressure gauge at that point.
2. Power up machine, warm up oil to normal operating temperature.
3. Check initial pressure for each function, lift and steering.
4. Adjust pressure relief according to settings shown in Table 4-2. Lift pressure setting must be adjusted to raise the maximum capacity allowed in the platform with the mast fully extended. Do not exceed the MAXIMUM pressure settings.

Pump/Motor/Valve Assembly - Removal/Installation



Hydraulic Pump/Valve/Tank - Installation

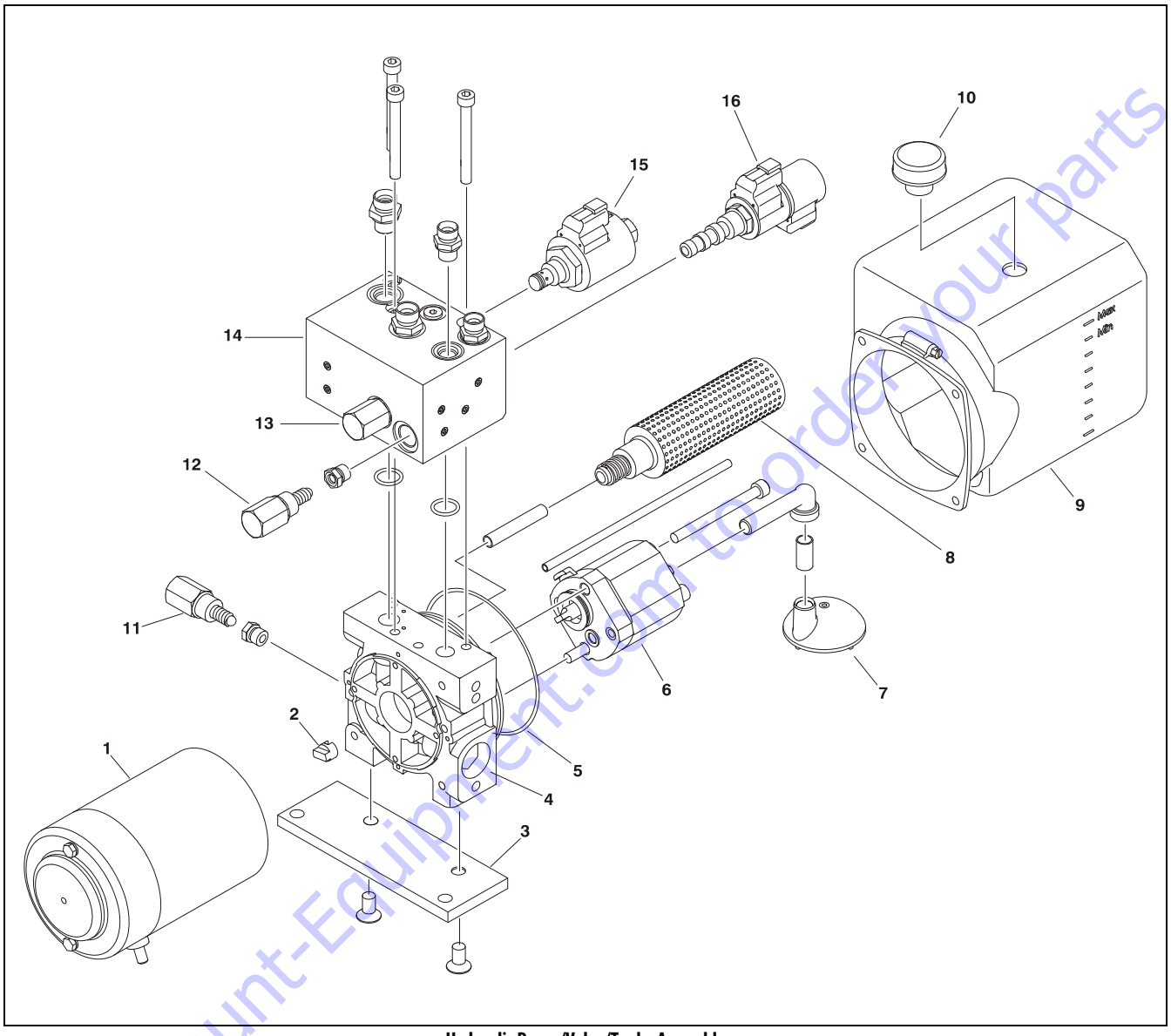
1. Pump/Valve/Tank Assembly
2. Pump Assy. Mounting Screw/Nuts
3. Static Strap
4. Valve Bank Solenoid Connections
5. Steer/Lift-Up/Return Hydraulic Lines
6. Pump Motor Power Connection Terminals (a)

NOTE: *(a) Apply dielectric grease to terminals during installation of cables. Torque nuts to 5 - 7 ft. lb. (7 - 9 Nm)*

⚠ CAUTION

BE CERTAIN THE MAST IS FULLY LOWERED BEFORE REMOVING ANY HYDRAULIC LINES FROM THE PUMP UNIT. WEAR PROTECTIVE GEAR WHEN WORKING AROUND PRESSURIZED HYDRAULIC LINES. REMOVE CONNECTIONS CAREFULLY AND CAP ALL LINES.

1. Disconnect machine electrical power using the quick disconnect on the left side batteries.
2. Disconnect the pump motor power cables from the power terminals on the side of the motor housing.
3. Label and then unplug the harness connectors from the lift-up, and steer solenoids on the pump valve bank assembly.
4. Label and carefully disconnect the hydraulic lines from the top of the valve bank assembly.
5. Finally remove the two (2) mounting screws and nuts from pump mounting plate under the pump and remove the pump/motor/valve assembly from the machine.



Hydraulic Pump/Valve/Tank - Assembly

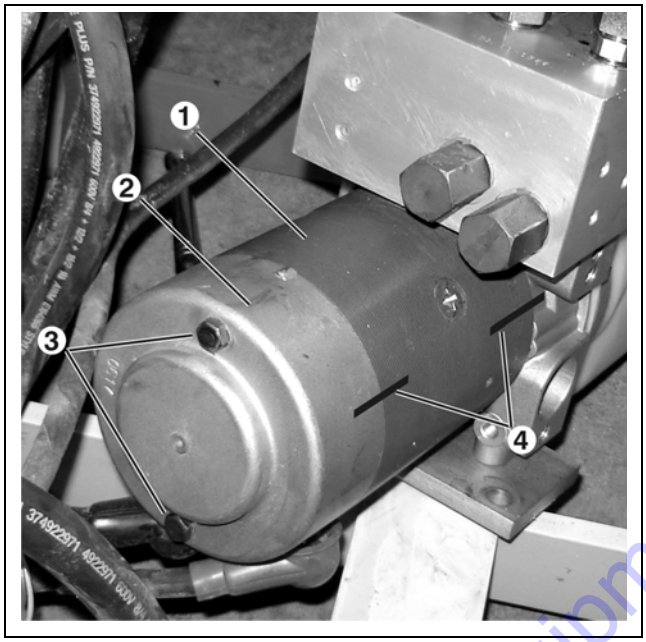
1. Pump Motor Assembly
2. Motor to Pump Coupler
3. Pump to Frame Mounting Flange
4. Pump Valve Body
5. Tank Oil Ring Seal
6. Hydraulic Pump
7. Pick-Up w/Filter Screen
8. Return Flow Filter/Diffuser
9. Tank
10. Tank Breather Cap
11. Main Pressure Relief
12. Left Steer Pressure Relief
13. Right Steer Pressure Relief
14. Lift/Steer Valve Body
15. Lift Selenoid Valve
16. Left/Right Steer Selenoid Valve

Motor Cover/Motor Installation

NOTICE

DISCONNECT THE BATTERIES BEFORE PERFORMING THESE PROCEDURES.

This procedure requires removing the pump to frame mounting bolts and nuts and rotating the pump assembly horizontally far enough to allow removal of the pump motor cover. No pump connections, hyraulic or electrical need be disconnected.



Motor Cover/Motor Installation

1. Motor Assembly
2. Motor Cover
3. Motor Assembly Screws (a)
4. Disassembly Marks (b)

NOTE: *(a) When reassembling, DO NOT OVERTIGHTEN motor assembly screws (3), torque is 8 Nm (70 in. lb.).*
(b) Place marks on body to help with reassembly alignment.

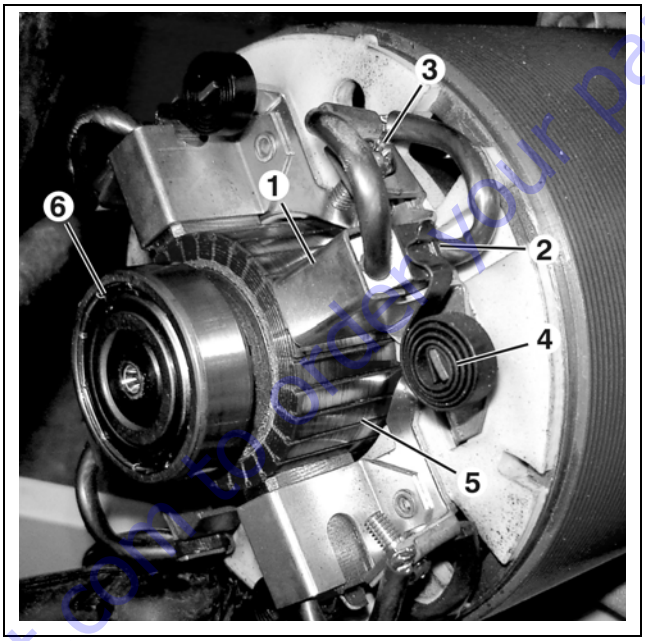
Preventative Maintenance - Brush Wear - Dust Removal Procedure

Due to a possible build-up of dust from brush wear inside the pump motor cover around the brushes and armature under heavy usage. It is recommended per the Preventative Maintenance and Inspection Schedule - Section-2 (Table 2-2), to perform this dust cleaning task on an annual basis.

Follow the procedure show above for motor cover removal. Once the motor cover is removed, blow any accumulated brush dust from inside the cover and around the brushes, and armature commutator. Check brushes for wear, replace if necessary. Once complete, reassemble for operation, **do not overtighten the motor cover bolts into the aluminum valve body, 8 Nm (70 in. lb.)**.

Motor Brush Installation

Once pump motor cover has been removed, inspect the rotor commutator for excessive wear before installing a new brush set.



Brush Installation

1. Brush Holder
2. Brush
3. Brush Terminal Screw
4. Brush Tension Spring
5. Commutator on Armature
6. Motor Cover Bearing

Installation the same for all four (4) brush assemblies.

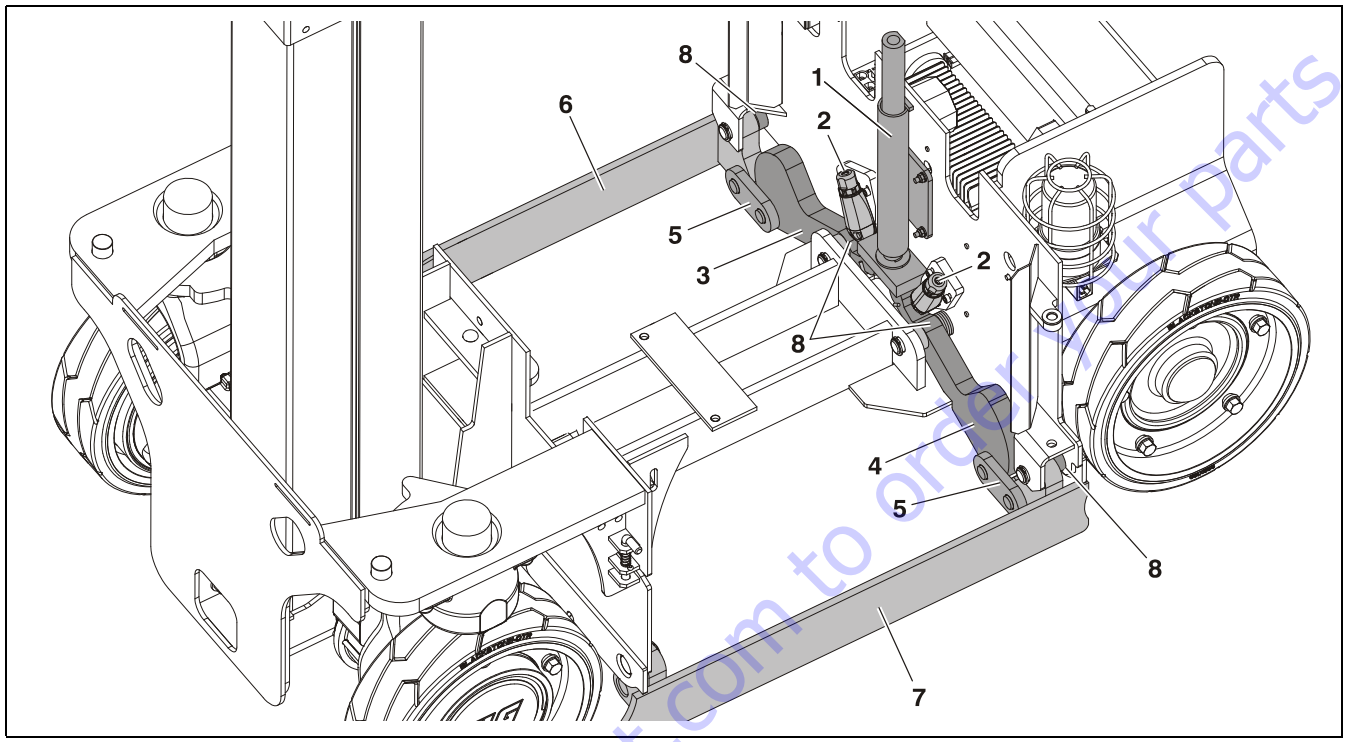
Note: *Clean the rotor commutator and brushes with a non-conductive electrical cleaner before assembly.*
Attach the brush terminal end to the terminal post using the terminal screw (3), then push the brush (2) down into it's holder (1), slide the tension spring (4) onto the top of the brush.

After final assembly of the brushes check that all brush terminal screws are tight and the brush springs are positioned properly before installing the motor cover and motor to the pump valve body.

NOTICE

DO NOT OVERTIGHTEN THE PUMP MOTOR ASSEMBLY SCREWS INTO THE ALUMINUM VALVE BODY. (8 NM OR 70 IN. LB.)

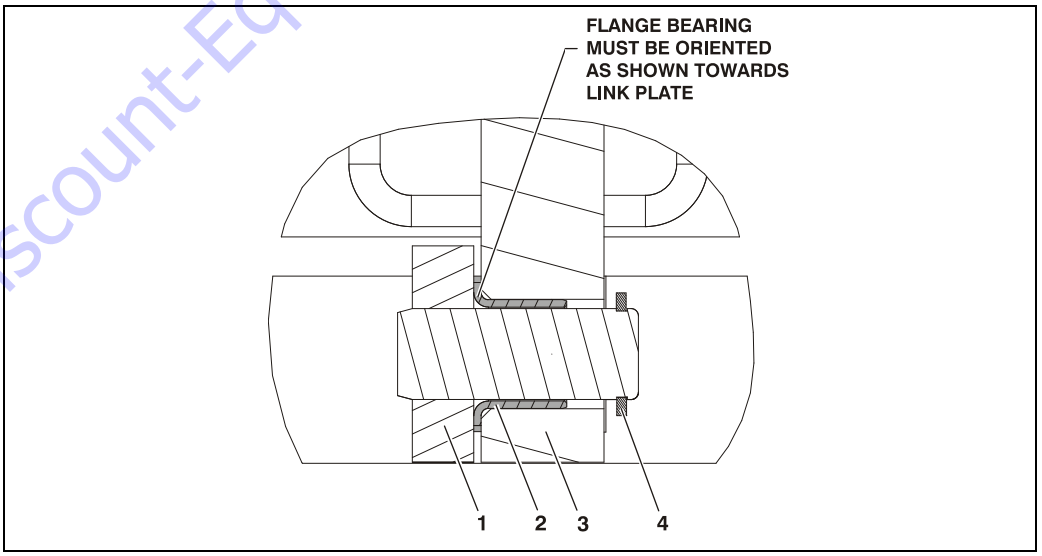
4.10 POT HOLE PROTECTION SYSTEM



Pot-Hole-Protection System Components

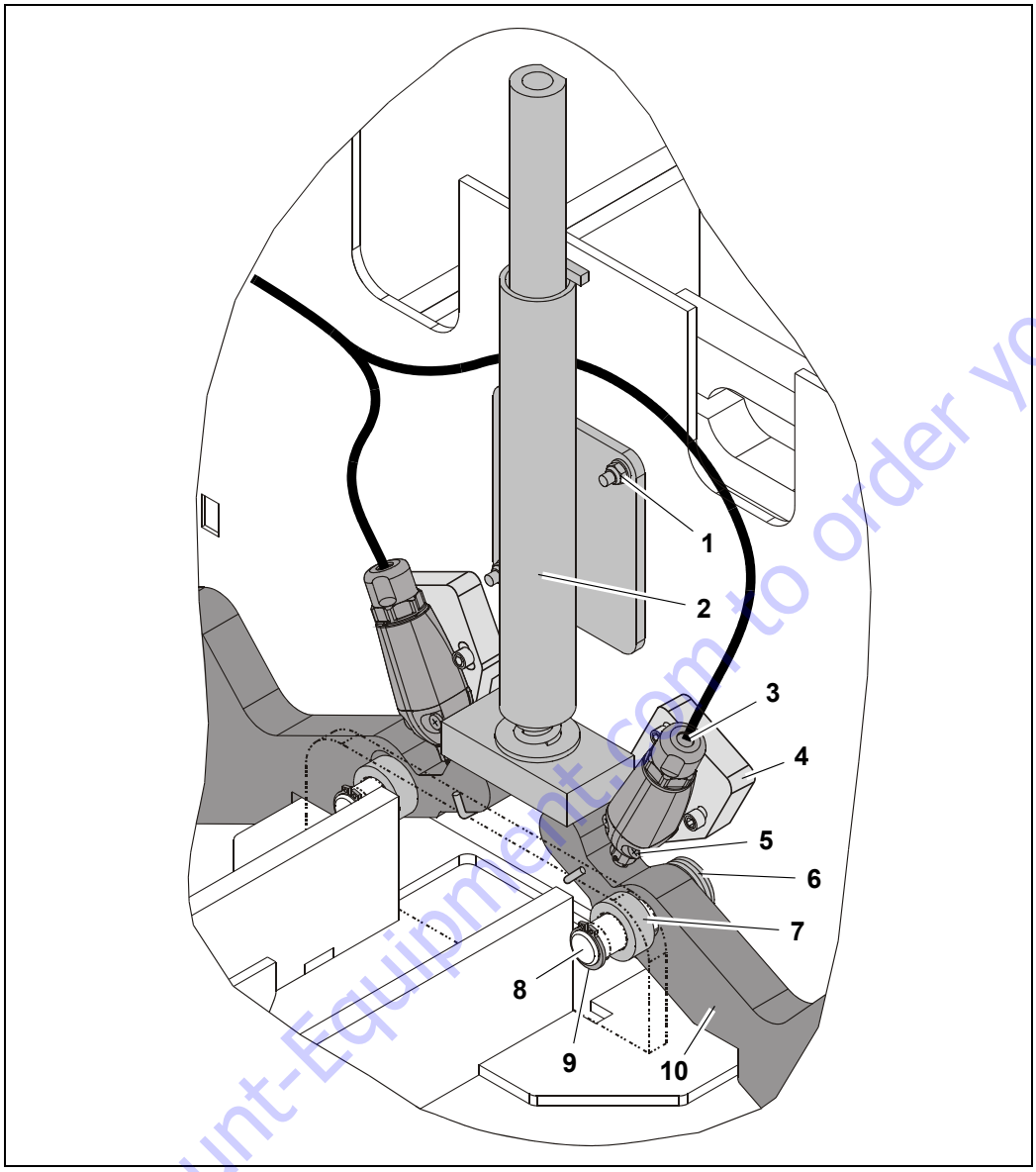
(Some components hidden for illustrative purposes only.)

1. PHP Actuator (Platform)
2. Right/Left PHP Limit Switch
3. Right Side Counterbalance Link
4. Left Side Counterbalance Link
5. PHP Link Plate
6. Right PHP Bar
7. Left PHP Bar
8. Spacer Tube and Torsion Springs



PHP Pin and Flange Bearing Installation

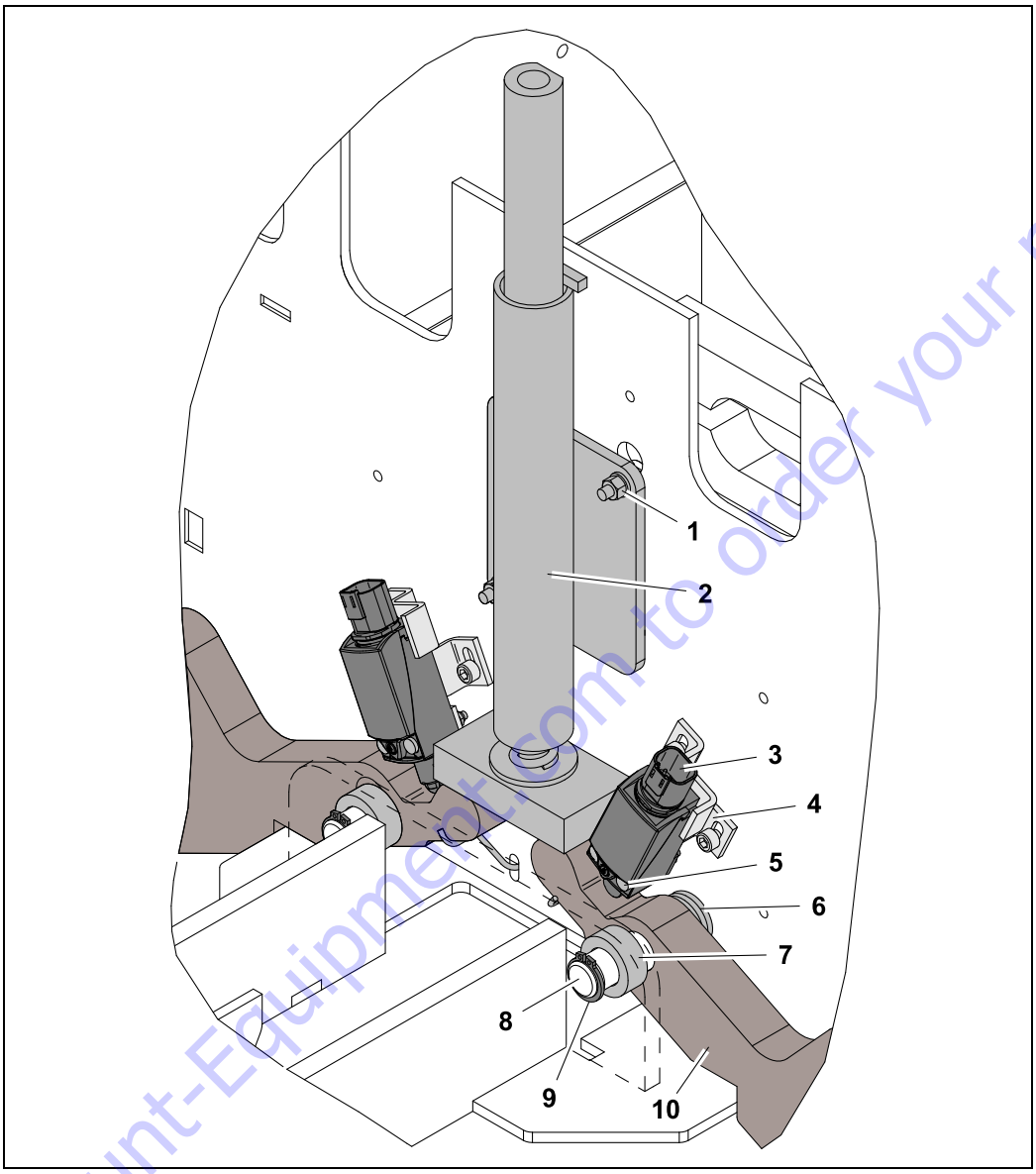
1. PHP Link Plate Pin **2.** Flange Bearing **3.** PHP Counterweight Link **4.** Retaining Ring



Actuator - Limit Switch - Counterweight Installation (Machines Prior to S/N-0130013258)

1. Actuator Attach Screws/Nuts
2. PHP Actuator Assembly
3. Limit Switch (a)
4. Limit Switch Mounting Block (b)
5. Limit Switch Attach Screws
6. Torsion Spring (c)
7. Tube Spacer
8. Counterbalance Link Mounting Pin
9. Pin Retaining Ring
10. Left Side Countbalance Link

NOTE: *Assembly same for both the left and right side PHP components.*
(a) When the pothole is in the deployed position (bars down), adjust limit switch plunger just past "click", re-tighten mounting block screws to frame.
(b) Apply Loctite #222 to mounting block screw threads on final tightening.
(c) Hook spring through slot in frame and the other end around the counterweight lug, then slide the attach pin through the frame, spring, counterweight, tube spacer, install the pin retaining ring.



Actuator - Limit Switch - Counterweight Installation (Machines S/N-0130013258 to Present)

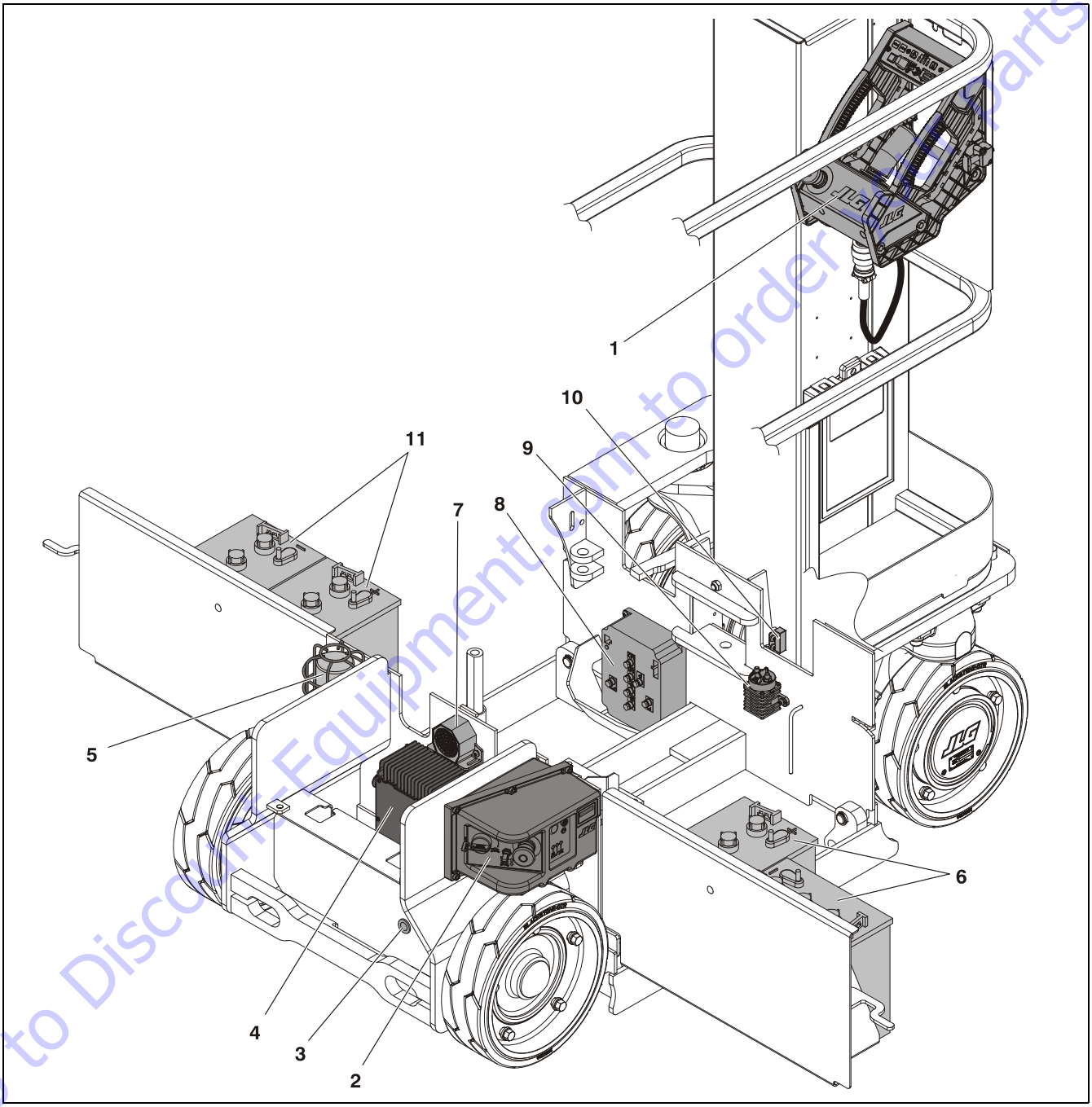
1. Actuator Attach Screws/Nuts
2. PHP Actuator Assembly
3. Limit Switch (a)
4. Limit Switch Mounting Bracket (b)
5. Limit Switch Attach Screws
6. Torsion Spring (c)
7. Tube Spacer
8. Counterbalance Link Mounting Pin
9. Pin Retaining Ring
10. Left Side Countbalance Link

NOTE: *Assembly same for both the left and right side PHP components.*
(a) When the pothole is in the deployed position (bars down), adjust limit switch plunger just past "click", re-tighten mounting block screws to frame.
(b) Apply Loctite #222 to mounting screw threads on final tightening.
(c) Hook spring through slot in frame and the other end around the counterweight lug, then slide the attach pin through the frame, spring, counterweight, tube spacer, install the pin retaining ring.

NOTES:

SECTION 5. CONTROL COMPONENTS

5.1 CONTROL COMPONENTS OVERVIEW



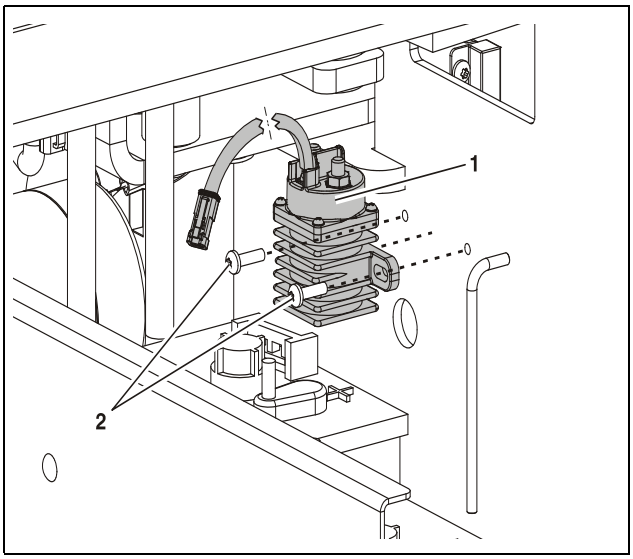
Control Components Overview

1. Platform Control Station
2. Ground Control Station
3. Manual Brake Release Switch
4. Battery Charger or Inverter/Charger
5. Warning Beacon
6. Right Side Batteries
7. Ground Alarm
8. Power Module
9. Main Contactor Power Relay
10. Elevation Cut-Back Sensor
11. Left Side Batteries

5.2 CONTROL COMPONENTS - SERVICE

Main Power Contactor Relay

The main power contactor relay is located on the bulkhead on the right-front, inside the compartment as shown following.

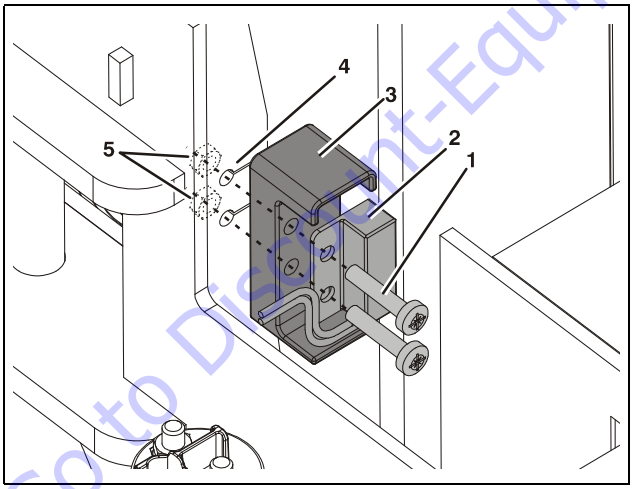


Main Power Relay - Installation

1. Main Power Relay
2. Attach Screws

Note: *See (See Figure 5-1.) for electrical wiring connections.*

Elevation Limit Switch

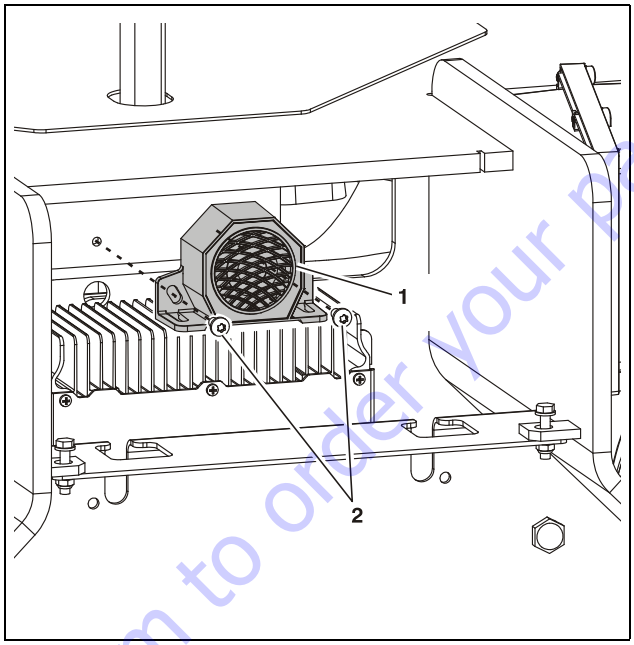


Elevation Limit Switch - Installation

1. Attach Screws
2. Elevation Limit Switch
3. Switch Mounting Block
4. Mounting Holes in Frame
5. Attach Nuts

Note: *Located on right-front of machine frame behind drive wheel assembly next to mast.*

Ground Alarm

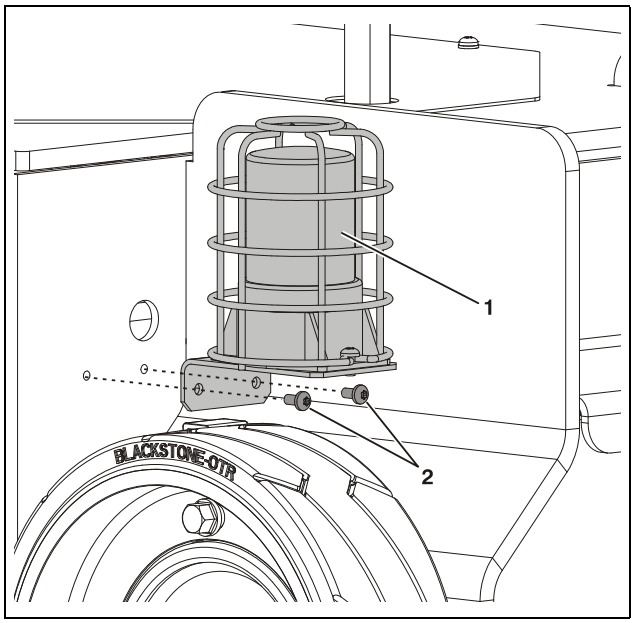


Ground Alarm - Installation

1. Ground Alarm
2. Attach Screws

Note: *Remove the charger/step-plate cover on the rear of the machine, mounted just above the battery charger.*

Warning Beacon - Frame Mounted

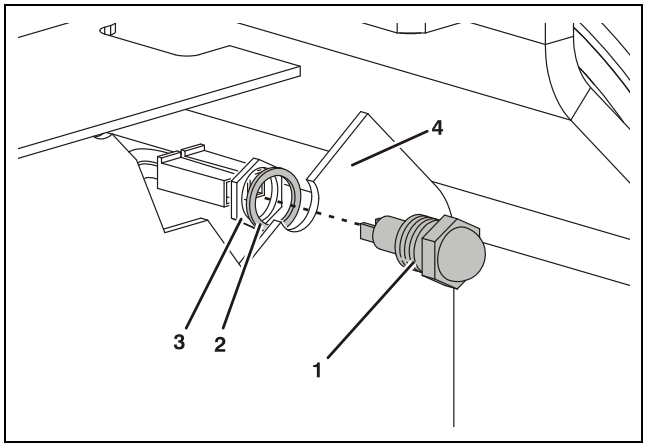


Warning Beacon - Installation

1. Beacon Assembly
2. Attach Screws

Note: *Located on base frame just above the left rear wheel.*

Manual Brake Release Switch



Manual Brake Release Switch - Installation

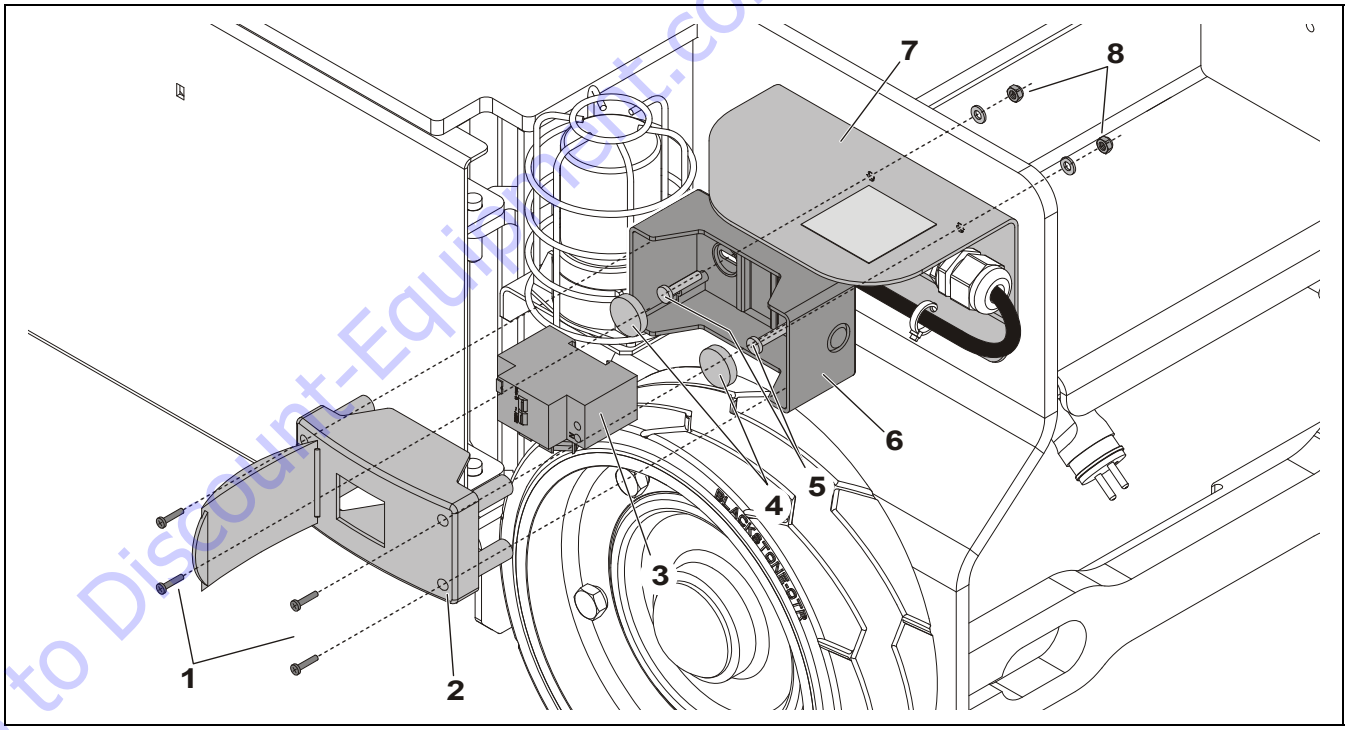
1. Release Switch
2. Washer
3. Nut
4. Charger/Step Plate Cover

Note: *Located on rear of machine, under charger/step plate cover.*

AC Power - Breaker Box Installation (CE Specification Machines ONLY)

The AC power breaker box is wired inline on the power circuit of the AC receptacle box mounted in the platform.

See illustration below for mounting instructions, for Information on the various plugs types and specific wiring for each plug type see Section 9.12, AC POWER RECEPTACLES AND WIRING (PLATFORM) - CE SPEC MACHINES ONLY in Section 9 of this manual.



AC Power - Breaker Box - Installation (CE Specification Machines ONLY)

1. Cover Plate Mounting Screws
2. Cover Plate
3. Breaker Assembly
4. Mounting Screw Plugs
5. Box to Frame Mounting Screws
6. Breaker Box Base
7. Breaker Box Shield
8. Box to Frame Mounting Screw - Nuts and Washers

Note: *Located on left rear of machine, just above the machine nameplate.*

5.3 TRACTION SYSTEM

Refer to Section 3.5, TRACTION - Theory of Operation for more detailed information on Traction System.

Common Traction System Difficulties

1. **Ground Module Interlocks**

   There are a variety of interlocks that prevent Drive due to system events (Elevated but Pot-Hole Mechanism Failed to Deploy, etc.). Before investigating Traction System issues, examine the JLG Analyzer's HELP Menu while attempting to Drive from Platform Mode. Refer to the Section 5 for explanation of the JLG Analyzer Help Messages.

2. **Power Module Diagnostic Issues**

   The Power Module executes a self-test during every power-up to ensure proper functionality. If a Diagnostic Issue is detected, the Power Module will not energize the Line Contactor. Instead, it will flash the Green LED, please refer to Power Module Diagnostics in Section 5.4, POWER MODULE - P/N-1600346.

3. **Open-Circuit Motor Armature**

   This issue will allow the vehicle to drive, but one motor will handle the entire traction load. Motor overheating and excessive tire wear will result, along with a lack of traction control.

   This situation can be detected by elevating the vehicle's front wheels and engaging drive (platform stowed). Under DIAGNOSTICS - TRACTION, the JLG Analyzer's ARM CUR display (Armature Current Reading) should be less than 50A. One wheel will rotate at full speed, while the other will not rotate at all. The Power Module's self-diagnostics cannot detect this fault unless both armatures are open-circuit.

   To find the source of the difficulty, pull the Main Battery Disconnect and investigate the wiring pathways from the Power Controller's M1 and M2 terminals to the armature on the motor that does not rotate. Investigate for issues like improper crimps, loose terminals, and corrosion.

4. **Short-Circuit Motor Armature**

   This issue will allow the vehicle to drive very slowly or not at all. Rapid motor overheating (one motor) will result.

   This situation can be detected by elevating the vehicle's front wheels and engaging drive (platform stowed). Under DIAGNOSTICS - TRACTION, the JLG Analyzer's ARM CUR display (Armature Current Reading) will hover around 350A. The FLD CUR display (Field Current Reading) will hover around 40A. Neither wheel will rotate at normal speed, but it will be possible to rotate the drive wheel by hand. The Power Module's self-diagnostics cannot detect this fault since the situation appears identical to climbing a steep grade.

   To find the source of the difficulty, pull the Main Battery Disconnect and disconnect the Armature Wiring (heavy red and black conductors) from the suspected drive motor leading to the Power Module's M1 and M2 Terminals. Re-test the traction function. If the remaining drive motor is able to reach full speed (and Armature Current is less than 50A), the drive motor that has been disconnected is fault. Investigate for crushed and burned cables. Note if the drive motor smells burned.

5. **Open-Circuit Motor Field**

   This issue will allow the vehicle to drive very slowly or not at all. Rapid motor overheating (both motors) will result.

   This situation can be detected by elevating the vehicle's front wheels and engaging drive (platform stowed). Under DIAGNOSTICS - TRACTION, the JLG Analyzer's ARM CUR display (Armature Current Reading) will hover around 350A. The FLD CUR display (Field Current Reading) will be erratic or low (less than 10A). Neither wheel will rotate at normal speed, but it will be possible to rotate the drive wheel by hand.

   To find the source of the difficulty, pull the Main Battery Disconnect and disconnect the Field Wiring (two blue wires leading to F1 and F2 Terminals) from the Power Module. Using a voltmeter set for resistance scale (Ohms), investigate if there is a short-circuit (less than 5 Ohms) between the two blue wires (this is normal). If not, investigate for improper crimps, burned cables, damaged cables, or damaged field windings.

6. **Short-Circuit Brake Release**

   This issue will not allow the vehicle to drive. Rapid motor overheating (both motors) will result. Continued attempts to drive the vehicle may result in armature damage.

   This situation can be detected by elevating the vehicle's front wheels and engaging drive (platform stowed). Under DIAGNOSTICS - TRACTION, the JLG Analyzer's ARM CUR display (Armature Current Reading) will hover around 350A. The FLD CUR display (Field Current Reading) will hover around 40A. Neither wheel will rotate, and it will be impossible to rotate either drive wheel by hand. The Ground Module cannot detect this fault during power-up or self-test since energizing the brakes could pose a hazard. However, it may detect this issue during Drive (investigate using JLG Analyzer).

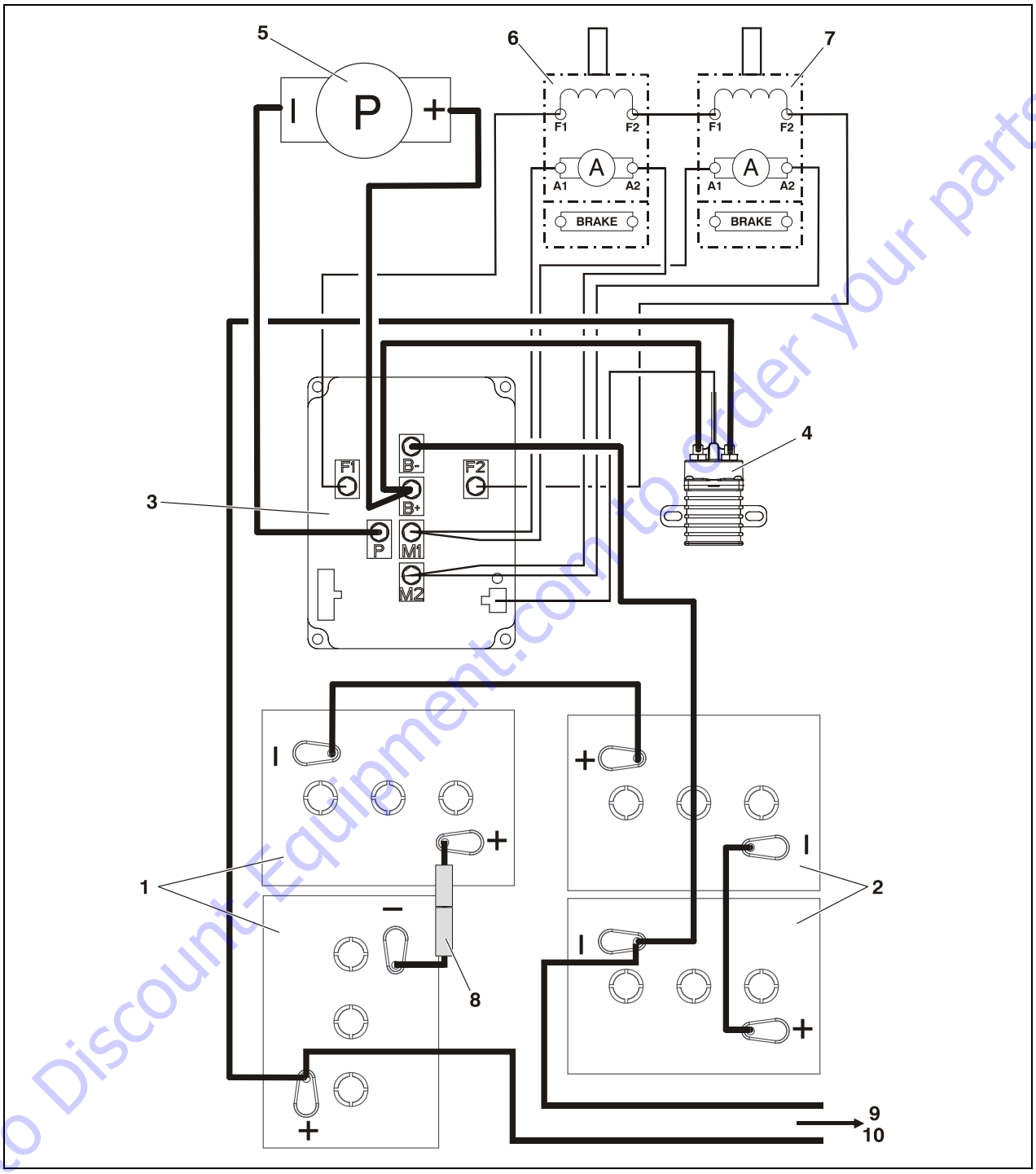


Figure 5-1. Main Electrical Power Connections - (1600346 - SEVCON Power Module)

1. Right Side Batteries
2. Left Side Batteries
3. Power Module
4. Main Power Contactor Relay
5. Hydraulic Pump Motor
6. Right Drive Motor
7. Left Drive Motor
8. Battery Power Quick-Disconnect
9. To Battery Charger
10. To Charger or Inverter (Option, If Equipped)

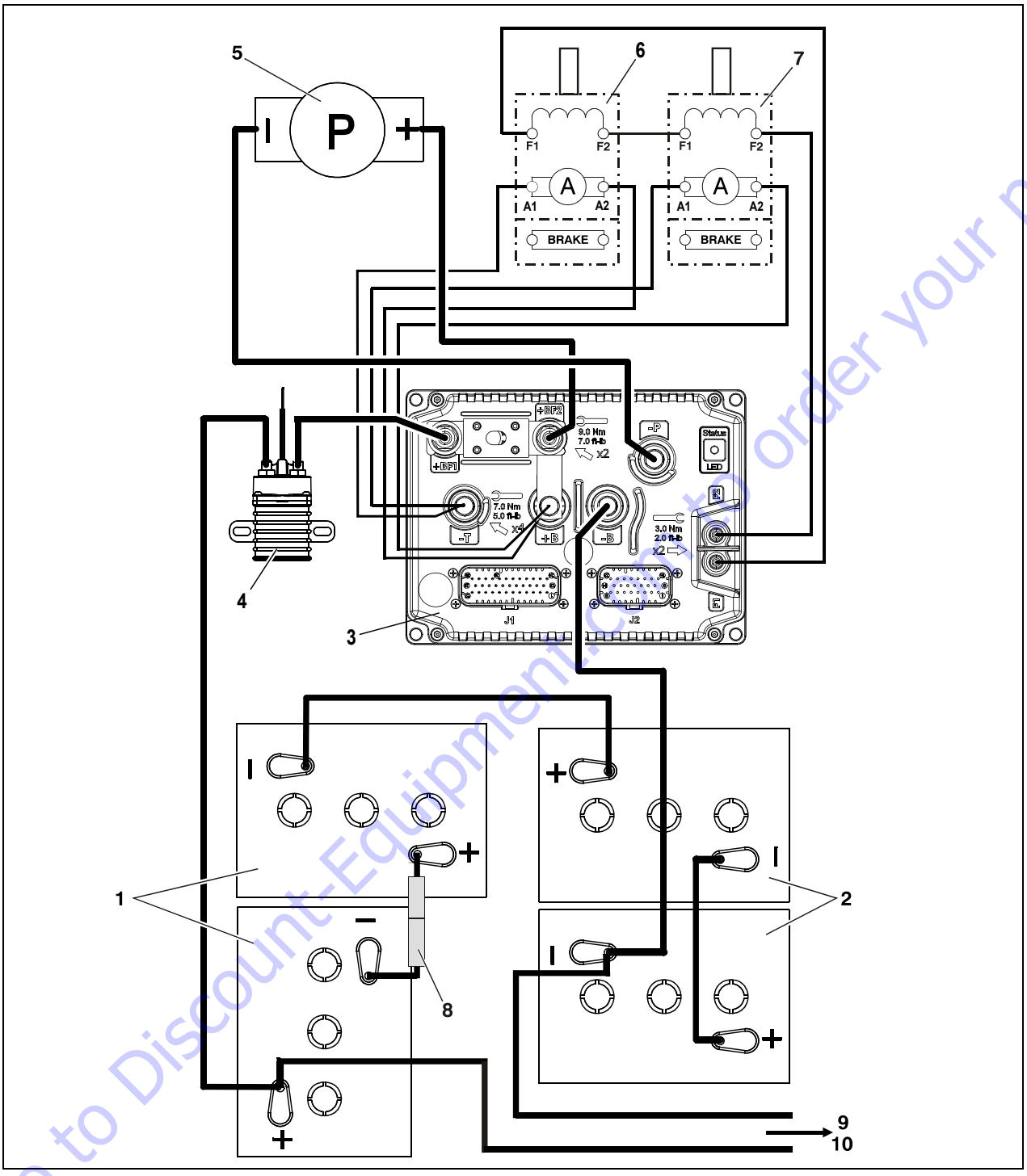


Figure 5-2. Main Electrical Power Connections - (1001092456 - ZAPI Power Module)

1. Right Side Batteries
2. Left Side Batteries
3. Power Module
4. Main Power Contactor Relay
5. Hydraulic Pump Motor
6. Right Drive Motor
7. Left Drive Motor
8. Battery Power Quick-Disconnect
9. To Battery Charger
10. To Charger or Inverter (Option, If Equipped)

To find the source of the difficulty, remove the rear cover from either drive motor. Insert voltmeter leads into the white connector leading to the brake solenoid (yellow and brown wires) and attempt to drive (Platform Mode). The Ground Module will apply approximately 24V to the brake release solenoids (wired in parallel) during drive, but will reduce this voltage in the event of a short-circuit. If this voltage is improper (less than 8V), investigate using resistance measurement (refer to Drive Motor Electrical Evaluation). Suspect damaged cabling, burned cabling, or faulty brake release solenoids. Trace the brake release cabling from the Power Module Compartment to the Ground Module Connector J1-24.

7. Open-Circuit Brake Release

This issue will not allow the vehicle to drive. Rapid motor overheating (both motors) will result. Continued attempts to drive the vehicle may result in armature damage.

This situation can be detected by elevating the vehicle's front wheels and engaging drive (platform stowed). Under DIAGNOSTICS - TRACTION, the JLG Analyzer's ARM CUR display (Armature Current Reading) will hover around 350A. The FLD CUR display (Field Current Reading) will hover around 40A. It is possible that one wheel may rotate, or neither may rotate (depending on the location of the open-circuit). Listen for the brake release solenoid when activating drive. The Ground Module cannot detect this fault during power-up or self-test since energizing the brakes could pose a hazard. However, it may detect this issue during Drive (investigate using JLG Analyzer).

If one wheel rotates, the open-circuit is located in the wiring for that specific drive motor (Power Module compartment or Drive Motor Cable). Investigate for improper crimps, unlatched connectors, damaged cables, or open brake release solenoids (refer to Drive Motor Electrical Evaluation).

If neither wheel rotates, the open-circuit is located in the wiring between the Power Module compartment and Ground Module. Using a voltmeter, measure the brake release voltage on either brake connector in the Power Module compartment during drive (should be approximately 24V). Investigate for improper crimps, unlatched connectors, damaged harnessing, or a faulty Ground Module. As an alternative, insert a short piece of wire with a Deutsch Female Crimp directly into Ground Module's J1-24 and measure voltage as a diagnostic measure (eject vehicle harness from that pin).

5.4 POWER MODULE - P/N-1600346

NOTICE

1230ES SCISSORS BUILT STARTING IN MID YEAR 2010 REPLACED THE SEVCON POWER MODULE (P/N-1600473) WITH THE ZAPI POWER MODULE (P/N-1001092456).

The Sevcon Power Module is located at the front-left side of the machine inside the compartment as shown in *Figure 5-3.* below. Use the following instructions when removing and installing the power module.

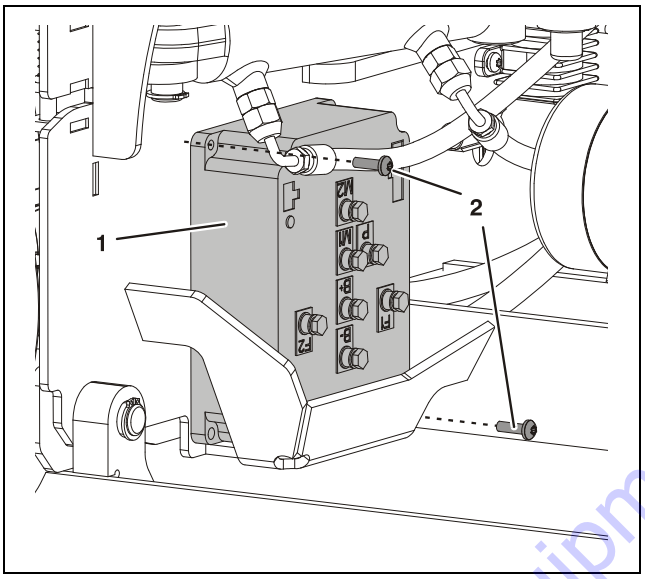


Figure 5-3. Power Module - Installation

1. Power Module
2. Mounting Screws

Removal

1. Turn off power machine power and disconnect the batteries.

NOTE: *Note the wire terminal locations when removing the Power Module (See Figure 5-1.).*

2. Disconnect all wires from the power module and remove the module mounting bolts, remove module from the machine.

Installation

1. Be sure that the terminals are oriented as shown.
2. After installing the power module, begin connecting the wires back to the controller. (Reference Figure 5-1.)

NOTICE

DO NOT OVERTIGHTEN THE TERMINAL BOLTS, OR DAMAGE TO THE UNIT COULD OCCUR.

3. Torque the terminal bolts to 5 ft lb. (7 Nm).
4. After all connections to the power module are made, the battery can be reconnected.

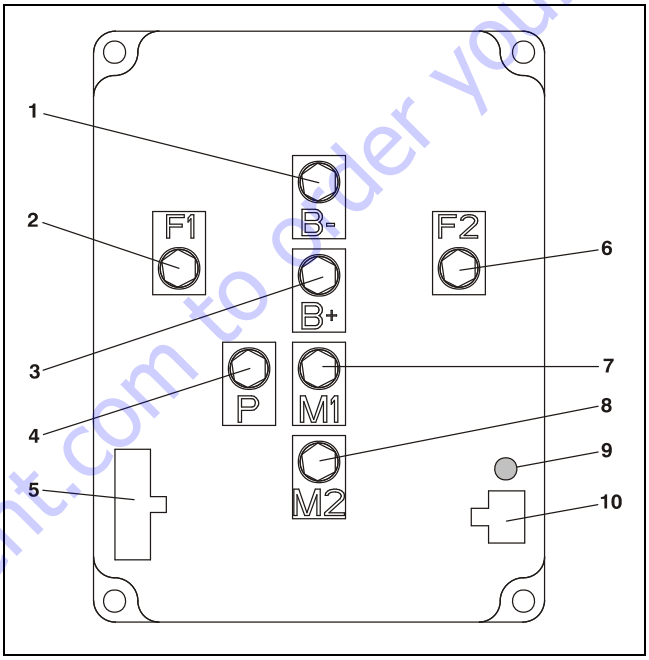


Figure 5-4. Sevcon Power Module Terminals

1. B – (battery (–) terminal)
2. F1 (motor field terminal)
3. B+ (battery (+) terminal)
4. P - (pump (–) terminal)
5. Mini-Fit Jr/B-Connector
6. F2 - (motor field terminal)
7. M1 - (motor armature terminal)
8. M2 - (motor armature terminal)
9. DTC Flash Code LED Indicator
10. Unused

Power Module Electrical Evaluation

Several basic electrical tests can be performed on the Power Module. Failure of one of these evaluations is significant and may indicate that the device is physically damaged. If a Power Module is suspected to be faulty, thoroughly examine the rest of the system for possible damage.

Make all measurements with a voltmeter set to resistance scale (Ohms) (Refer to Section 9 - Figure 9-2., Resistance Measurement). Disconnect the Main Battery Disconnect and all cables from the Power Module during this analysis. Wait 60 seconds after power is disconnected to allow internal charge to dissipate (risk of hazard, improper readings otherwise).

1. **RESISTANCE >100K OHMS ALL TERMINALS TO HOUSING.**
   Ensure that there is an open-circuit between all terminals of the Power Module and the module's aluminum housing. The device is fully potted and all electronics are insulted from the housing. Place the Black meter lead on the housing and use the Red meter lead to probe all terminals.

2. **RESISTANCE < 2 OHMS BETWEEN +B AND M1.**
   Ensure that there is a short-circuit between the +B and M1 Terminals. Internally, there is a low-impedance current measurement shunt for the Armature portion of Traction. Place the Red meter lead on +B, and the Black meter lead on M1.

3. **RESISTANCE >1M OHMS BETWEEN F1 AND -B; F2 AND -B.**
   Ensure that there is an open-circuit between the two Field Terminals (F1 & F2) and -B. Internally, there are MOSFET transistors between these terminals that should be high-impedance when the module is unpowered. Place the Black meter lead on -B and the Red meter lead on F1 / F1.

4. **RESISTANCE >1M OHMS BETWEEN F1 AND +B; F2 AND +B.**
   Ensure that there is an open-circuit between the two Field Terminals (F1 & F2) and +B. Internally, there are MOSFET transistors between these terminals that should be high-impedance when the module is unpowered. Place the Black meter lead on +B and the Red meter lead on F1 / F1.

5. **RESISTANCE >100K OHMS BETWEEN P AND -B.**
   Ensure that there is an open-circuit between the P and the -B Terminals. Internally, there are MOSFET transistors between these terminals that should be high-impedance when the module is un-powered. Place the Black meter lead on -B, and the Red meter lead on P. Note that a measurement of increasing resistance (capacitor charge) is normal, but a persistently low impedance is not.

6. **RESISTANCE >1K OHMS BETWEEN M2 AND -B.**
   Ensure that there is an open-circuit between the M2 and -B Terminals. Internally, there are MOSFET transistors between these terminals that should be high-impedance when the module is unpowered. Place the Black meter lead on -B, and the Red meter lead on M2. Note that a measurement of increasing resistance (capacitor charge) is normal, but a persistently low impedance is not.

7. **RESISTANCE 120 OHMS BETWEEN PINS 10 & 11.**
   Ensure that the resistor that terminates the CANbus is within tolerance between pins 10 and 11 on the 12 position Mini-Fit Jr (Connector "B"). Place the Red meter lead on pin 10, and the Black meter lead on pin 11. The resistance should measure between 110 - 130 Ohms.

Power Module Diagnostics

The Power Module has the ability to detect many fault scenarios and communicate them to the JLG Analyzer. Useful diagnostic information can also be determined from the Green LED located on the Power Module.

1. **OPEN CIRCUIT LINE CONTACTOR (3-1)**
   - **a.** The Power Module's Line Contactor Drive Circuitry passed power-up self-tests, but the Line Contactor did not close when energized.
   - **b.** May signal an open-circuit between +B and the Line Contactor, a faulty Line Contactor, or an open-circuit between the Line Contactor and the Power Module +B Terminal.
   - **c.** 4 Flashes on Power Module.
   - **d.** Drive, Steer, & Lift Up Prevented.
2. **CONTACTOR DRIVER PERMANENTLY OFF (3-1)**
   - **a.** The Power Module's Line Contactor Drive Circuitry failed to energize during power-up self-tests.
   - **b.** May indicate a faulty Line Contactor, difficulty with Line Contactor coil wiring, or a faulty Power Module.
   - **c.** No Flash Code on Power Module.
   - **d.** Drive, Steer, & Lift Up Prevented.
3. **LINE CONTACTOR MISWIRED ON OR WELDED (3-2)**
   - **a.** The Power Module's Line Contactor Drive Circuitry passed power-up self-tests, but the Line Contactor was closed at power-up or failed to open when de-energized.
   - **b.** May indicate a faulty Line Contactor, difficulty with Line Contactor coil wiring, or difficulty with power wiring.
   - **c.** 4 Flashes on Power Module.
   - **d.** Drive, Steer, & Lift Up Prevented.
4. **CONTACTOR DRIVER PERMANENTLY ON (3-2)**
   - **a.** The Power Module's Line Contactor Drive Circuitry failed to de-energize during power-up self-tests.
   - **b.** May indicate difficulty with Line Contactor coil wiring, or a faulty Power Module.
   - **c.** No Flash Code on Power Module.
   - **d.** Drive, Steer, & Lift Up Prevented.
5. **POWER MODULE TOO HOT - PLEASE WAIT (4-2)**
   - **a.** The Power Module for Drive, Steer, and Lift Up has reached thermal cutout. Allow to cool by powering down.
   - **b.** May indicate that the vehicle is operating in extremely high ambient temperatures, or a faulty Power Module.
   - **c.** 8 Flashes on Power Module.
6. **DRIVING AT CUTBACK -- POWER MODULE CURRENT LIMIT (4-2)**
   - **a.** The Traction portion of the Power Module has reached thermal limit. Allow to cool by waiting for temperature to fall.
   - **b.** May indicate that the vehicle is operating on excessive grades, or there is a drive motor issue that causes high armature current (brake applied when driving, short-circuited armature, etc).
   - **c.** 8 Flashes on Power Module.
7. **LIFT UP AT CUTBACK -- POWER MODULE CURRENT LIMIT (4-2)**
   - **a.** The Pump portion of the Power Module has reached thermal limit. Allow to cool by waiting for temperature to fall.
   - **b.** May indicate that the vehicle's lift function is being used outside duty cycle considerations, or there is a pump motor issue that causes high current (worn brushes, worn commutator, etc).
   - **c.** 8 Flashes on Power Module.
8. **BATTERY VOLTAGE TOO LOW - SYSTEM SHUTDOWN (4-4)**
   - **a.** Battery Voltage momentarily dropped below 14.5V. With a low battery charge, this can occur during heavy current demand due to Drive, Steer, or Lift Up. Recharge batteries or check for damaged batteries.
   - **b.** May indicate low battery charge, a battery charger issue, or a power wiring issue.
   - **c.** 7 Flashes on Power Module.
   - **d.** Drive, Steer, & Lift Up Prevented.
9. **BATTERY VOLTAGE TOO HIGH - SYSTEM SHUTDOWN (4-4)**
   - **a.** The Power Module momentarily measured excessively high Battery Voltage (>37.0V) and the Ground Module de-energized the Ignition Relay to protect system devices. This may be due to improper battery charging or incorrect voltage batteries being used.
   - **b.** May indicate a battery charger issue, wrong battery type is installed, or a faulty Power Module.
   - **c.** 7 Flashes on Power Module.
   - **d.** Drive, Steer, & Lift Prevented.

10. CANBUS FAILURE: POWER MODULE (6-6)

- **a.** The control system failed to receive messages from the Power Module. Check wiring at the Ground Control Box and Power Module. Recycle power to clear difficulty.
- **b.** May indicate harness difficulty or a faulty Power Module.
- **c.** Resistance between CANH (Power Module Pin 10) and CANL (Power Module Pin 11) should be 60 ohms (+/- 5%) with the Power Module connected.
- **d.** Resistance between Power Module Pins 10 and 11 (harness disconnected) should be 120 ohms (+/- 5%).
- **e.** 10 Flashes on Power Module.
- **f.** Drive, Steer, & Lift Up Prevented.

11. OPEN-CIRCUIT DRIVE MOTOR WIRING (7-7)

- **a.** The Power Module detected an error in the Power Wiring (M1, M2, F1 & F2 Terminals) for the Drive Motors. Check power wiring and re-cycle power to clear difficulty. Alternately, there may be an issue (open field, armature, or brush) with one of the Drive Motors.
- **b.** May indicate field wiring or winding issues.
- **c.** 5 Flashes on Power Module.
- **d.** Drive & Steer Prevented.

12. POWER MODULE FAILURE: PERSONALITY RANGE ERROR (9-9)

- **a.** The Power Module detected an out-of-range or corrupt personality setting.
- **b.** Enter Access Level 1 on the JLG Analyzer, re-select Model, and cycle EMS after 5 seconds. May indicate a Power Module issue if it cannot be reset.
- **c.** 1 Flash on Power Module.

13. POWER MODULE FAILURE: INTERNAL ERROR (9-9)

- **a.** The Power Module detected an internal error via self-test.
- **b.** May indicate that the Line Contactor Coil is Open-Circuit in Power Module's prior to V1.10, a Power Wiring Issue, or a faulty Power Module.
- **c.** 11 Flashes on Power Module.

14. POWER MODULE FAILURE: CHECK POWER CIRCUITS OR MOSFET SHORT CIRCUIT (9-9)

- **a.** The Power Module detected an error in the Power Wiring for the Drive or Pump. Alternately, the Power Module has failed a self-test.
- **b.** 3 Flashes on Power Module may indicate a Short-Circuit in the Armature Wiring or a faulty Power Module.
- **c.** No Flashes on Power Module may indicate a faulty Power Module.

5.5 POWER MODULE - P/N-1001092456

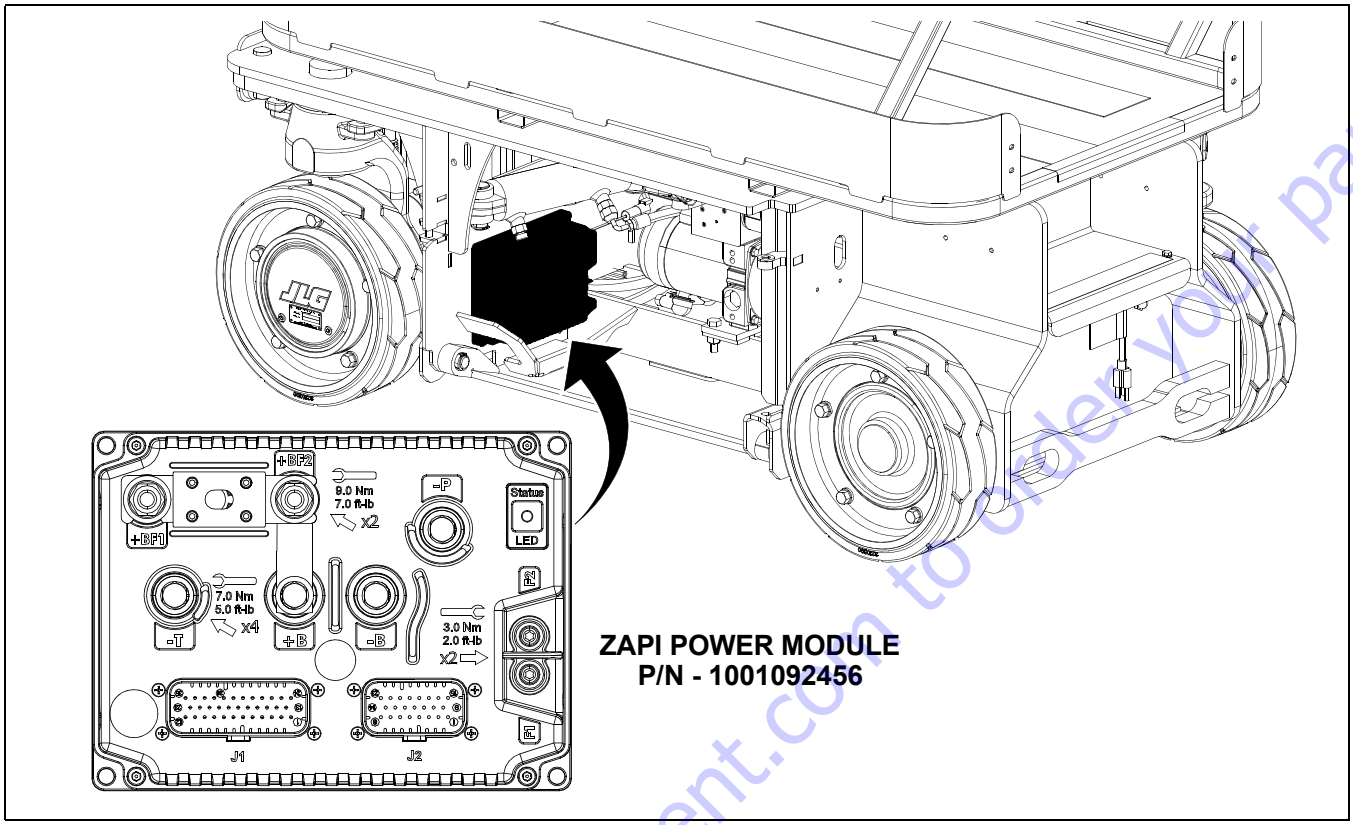


Figure 5-5. ZAPI Power Module Location

NOTICE

1230ES SCISSORS BUILT STARTING IN MID YEAR 2010 REPLACED THE SEVCON POWER MODULE (P/N-1600473) WITH THE ZAPI POWER MODULE (P/N-1001092456).

Table 5-1. ZAPI Power Module Specs

Operating Voltage (B+)	14.5 to 40 VDC
Maximum Current Limits: Armature Field Pump	 300 A 40 A 180 A
Standby Current	150 mA
Temperature Range: Operating Storage Thermal Limit	 -40°C to 75°C -40°C to 125°C 75°C to 90°C
Switching Frequency	16 kHz

The power module is located inside the left side access door as shown in Figure 5-5., ZAPI Power Module Location. Use the following instructions when replacing the power module.

1. Turn machine power off and disconnect the batteries.
2. Locate and remove the power module from the machine.
3. Note the wire terminal locations when removing the old power module.
4. Disconnect all wire connectors and cables from the old power module and remove it from the machine.
5. When installing the new power module, be sure that the terminals are oriented as shown in Figure 5-5.
6. After installing the new power module, begin connecting the wire connectors/cables to the module, refer to Figure 5-2. if necessary.
7. Where noted, torque all terminal bolts to torque specifications shown on the front of the module.
8. After all connections to the power module are made, the batteries can be reconnected.
9. Check for normal machine operation.

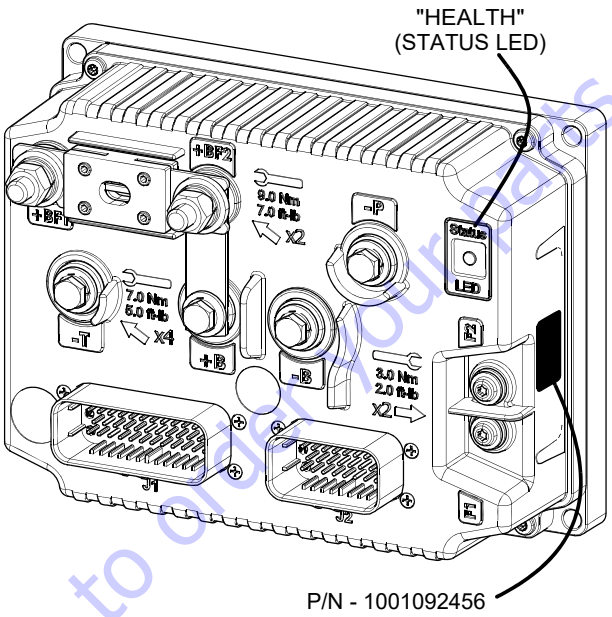
ZAPI Power Module Electrical Evaluation

INTEGRATED HEALTH INDICATOR

The ZAPI Power Module provides a green STATUS LED that shines through the cover to indicate module "health" status. The LED shall be illuminated when the device is powered on. The LED blinks (2Hz) when an internal issue is detected that cannot be repaired by a technician, this will trigger replacement of the device.

Table 5-2. Module Terminal Functions

+ BF1	Controller to Main Line Contactor
+ BF2	Positive Pump Connection
+ B	Left and Right Positive Armature (X7)
– B	Controll to Negative Battery
– T	Left and Right Negative Armature (X8)
– P	Negative Pump Connection
F1	To Motor Fields Wired in Series (X9)
F2	LT MFR Field Wires (X10)



ZAPI Power Module - "HEALTH" (Status LED)

5.6 GROUND CONTROL MODULE - SERVICE PROCEDURE

NOTE: *The Ground Control Station supplied with the ZAPI Power Module P/N-1001092456 (production start mid-year 2010) does not require use of the printed circuit board inside the ground control module.*
However box installation and removal instructions shown are exactly the same as the ground control box which does contain a printed circuit board and is used with previous machines supplied with the SEVCON Power Module.

Ground Control Station

(See Figure 5-6., Ground Control Station Assembly)

NOTICE

DO NOT ATTEMPT TO DISASSEMBLE THE GROUND CONTROL MODULE IF MACHINE IS STILL UNDER WARRANTY. OPENING THE GROUND CONTROL MODULE WHILE THE MACHINE IS UNDER WARRANTY WILL VOID THE WARRANTY. IF UNDER WARRANTY REQUEST A REPLACEMENT MODULE FROM THE FACTORY.

The Ground Control Module allows for field replacement of components internal to the module.

Printed Circuit Board (PCB) Replacement

NOTE: *Anytime the ground control box is removed the tilt sensor must be recalibrated. Refer to Section 7.4, TILT SENSOR CALIBRATION to recalibrate the tilt.*

1. Remove the three bolts at the bottom of the ground control station.

2. Remove the four screws where the control cable enters into the control box.
3. Remove plug and place control box face down on a suitable work bench..

4. Remove the six screws at the back of the ground control and separate.
5. Pull the pin connectors from the printed circuit board.

6. Remove the two screws inside the control box that affix the printed circuit board to the control box.
7. Replace the printed circuit board and reassemble the ground control box.

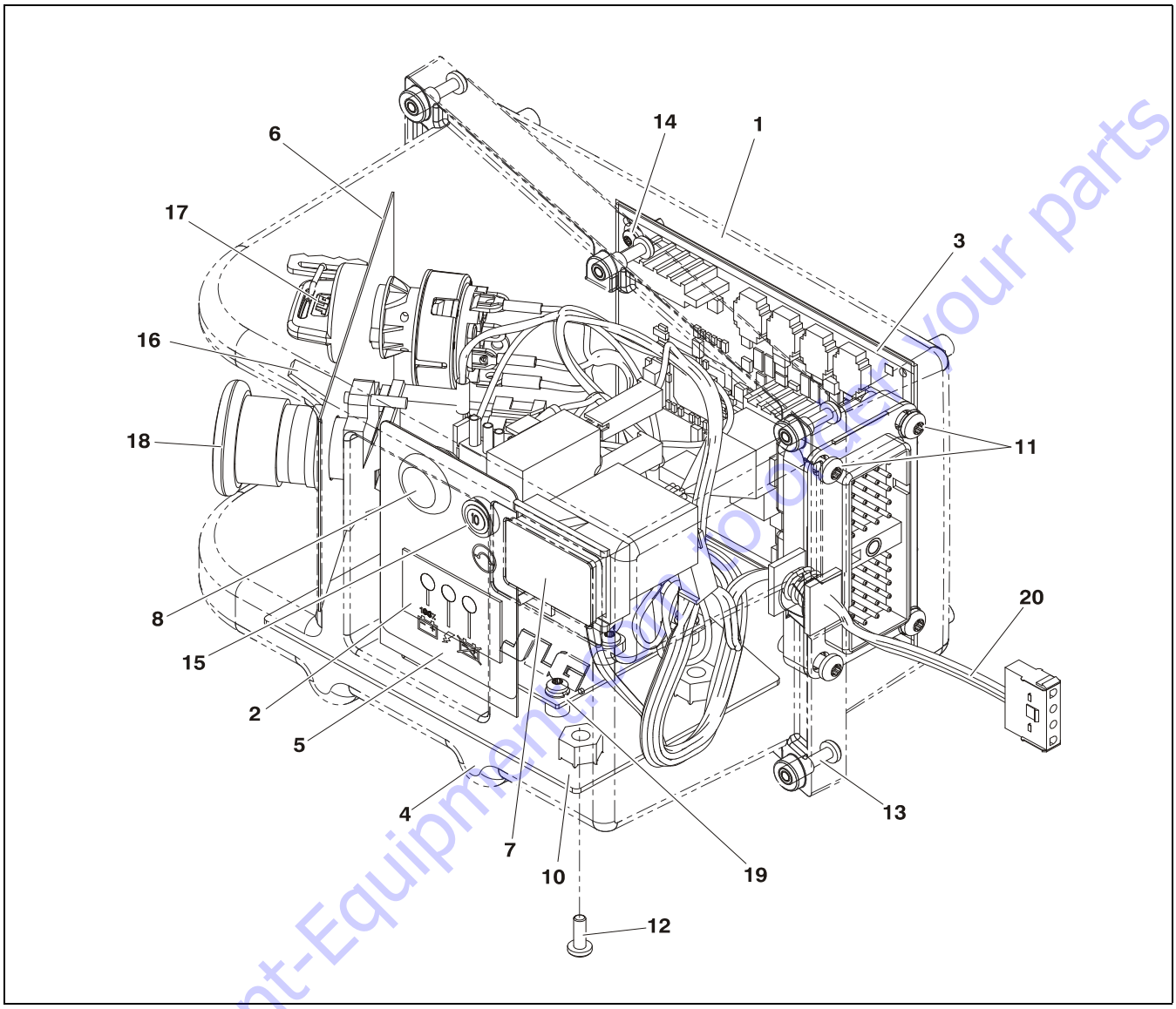
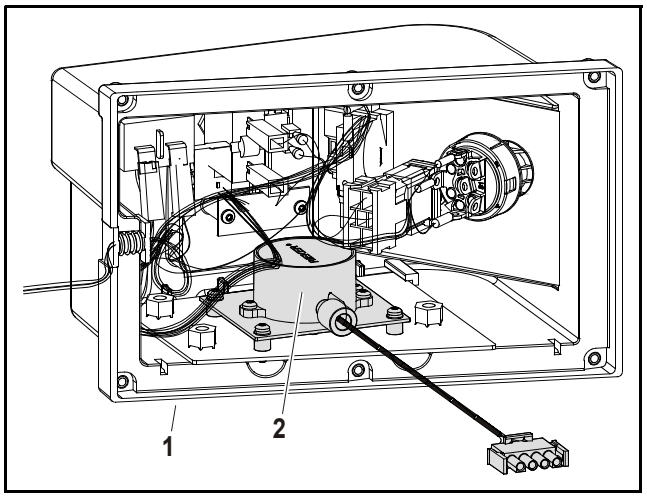


Figure 5-6. Ground Control Station Assembly

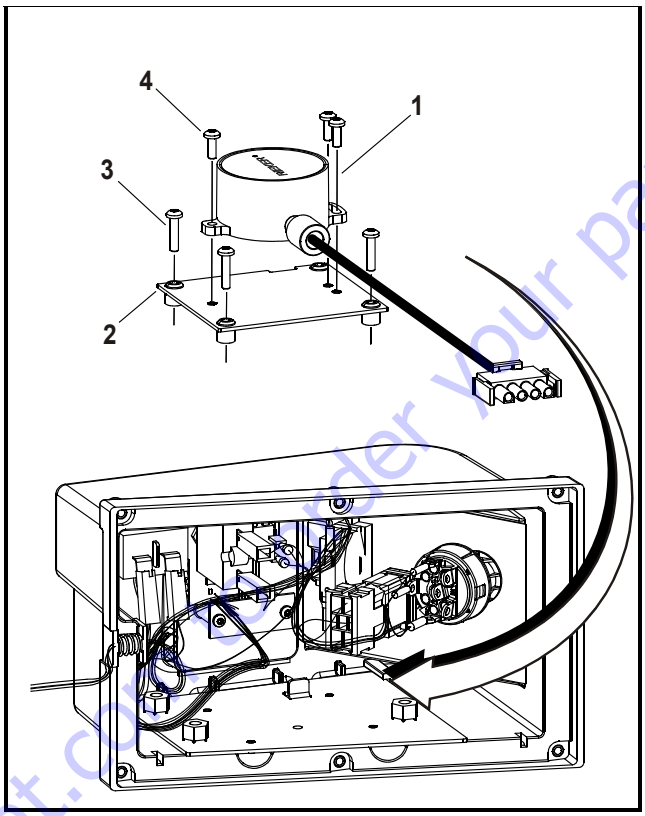
1. Rear Cover
2. Battery LED Circuit Board
3. Main Ground Control Circuit Board - (1600473 Drive Module Only)
4. Front Cover
5. LED Indicator Decal
6. Control Functions Decal
7. Hourmeter
8. Blank Plug
9. Unused
10. Controls/Indicators Mounting Plate
11. Torx Screws - Main Connector (X001)
12. Torx Screws - Controls/Indicators Mouting Plate
13. Torx Screws - Rear Cover to Front Cover
14. Plastite Screws - Main Board to Rear Cover
15. 10 Amp Circuit Breaker
16. Ground Control - Platform Lift UP/DOWN Switch
17. Keyswitch - Ground/Platform/OFF Control
18. Emergency Stop Switch
19. Tilt Module
20. Battery LED Indicator Connector Harness (X010)

Tilt Sensor, JLG P/N 1810140 and 1001114933:



1. Ground Control Station
2. Tilt Sensor (JLG P/N 1810140 or 1001114936)

Figure 5-7. Tilt Sensor Location



1. Tilt Sensor (JLG P/N 1810140 or 1001114936)
2. Sensor Mount
3. Screw, 3.5 x 0.6 x 16 LG
4. Screw, 3.5 x 0.6 x 10 LG

Figure 5-7. Tilt Sensor Removal

Tilt Sensor Removal:

NOTE: *Refer to Figure 5-7., Tilt Sensor Removal for numbers in parenthesis.*

1. Disconnect the batteries.
2. Open the Ground Control Station to gain access to the Tilt Sensor Assembly. (refer to prior mentioned procedures)
3. Remove the four Screws (3), to remove the Tilt Sensor (1) and Sensor Mount (2) from the Ground Control Box.
4. The Tilt Sensor (1) can be removed from the Sensor Mount (2) by removing the three Screws (4).

NOTE: *Follow the above procedures in reverse order when installing the tilt sensor assembly. After installing, be sure to calibrate the tilt sensor (refer to Section 7.4, TILT SENSOR CALIBRATION).*

Table 5-3. Tilt Sensor Harness for 1810140

Wire Color	Function	Connector Pin
Red	VCC	1
Green	PWMX	2
White	PWMY	3
Black	Ground	4

Table 5-4. Tilt Sensor Harness for 1001114936

Wire Color	Function	Connector Pin
Red	VCC	1
White	CANH	2
Green	CANL	3
Black	Ground	4

5.7 PLATFORM CONTROL STATION - SERVICE INFORMATION

Platform Control Station Assembly

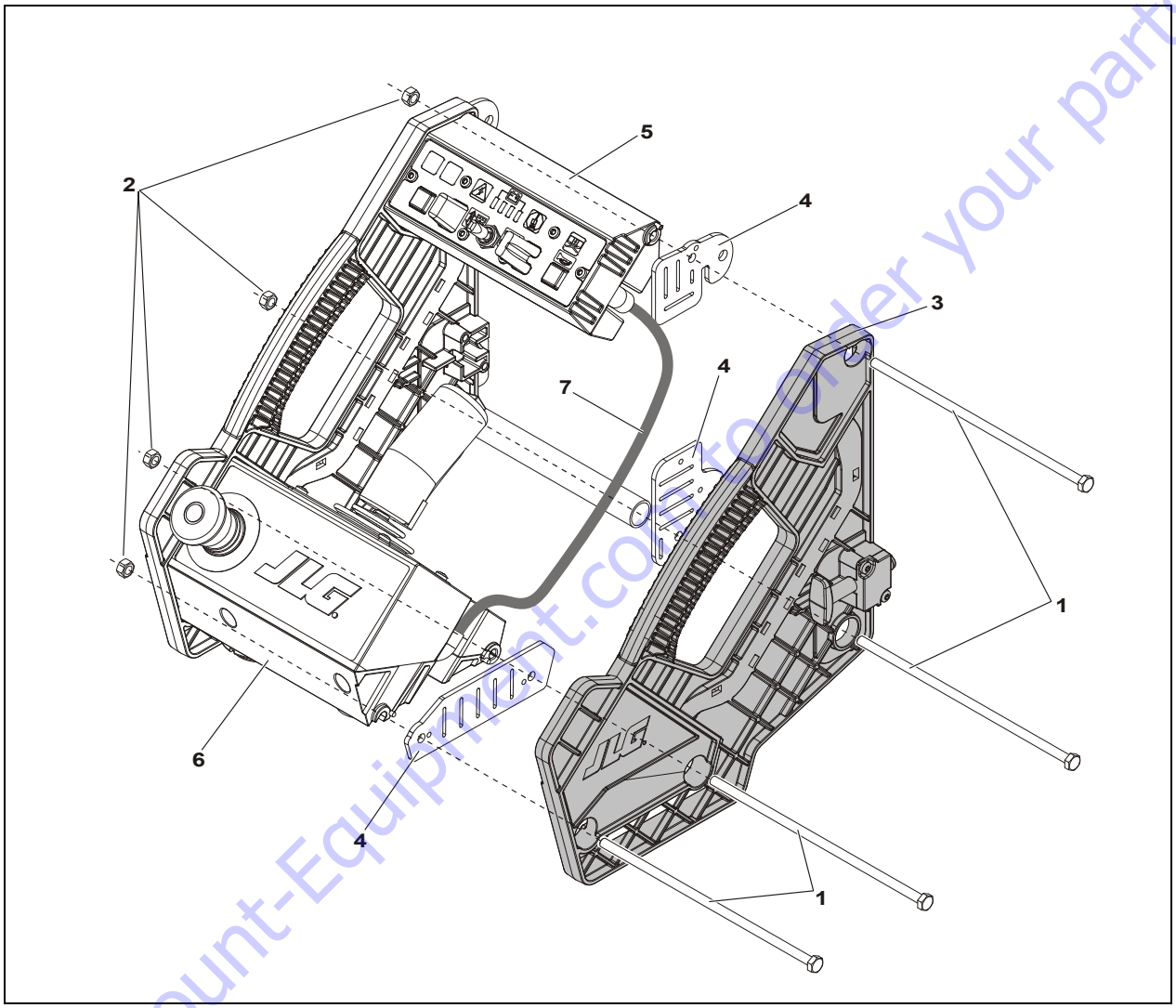


Figure 5-7. Platform Control Station Assembly

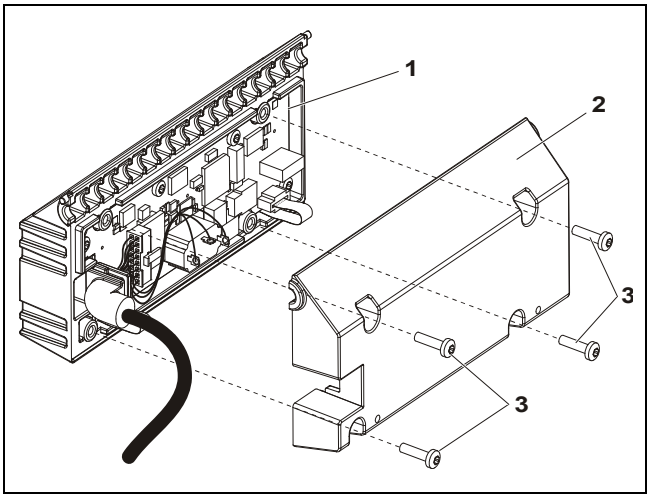
1. Assembly Bolts
2. Nuts
3. Side Panel
4. Mounting/Reinforcement Plates
5. Upper Control Box
6. Lower Control Box
7. Upper Control Box Wiring Harness

Upper Control Box - Component Replacement

1. Disconnect the platform control box and remove from the machine.
2. Place the platform control box on a suitable work bench.
3. Loosen and remove the long through bolts that hold the two side control housings together. *(See Figure 5-7.)*

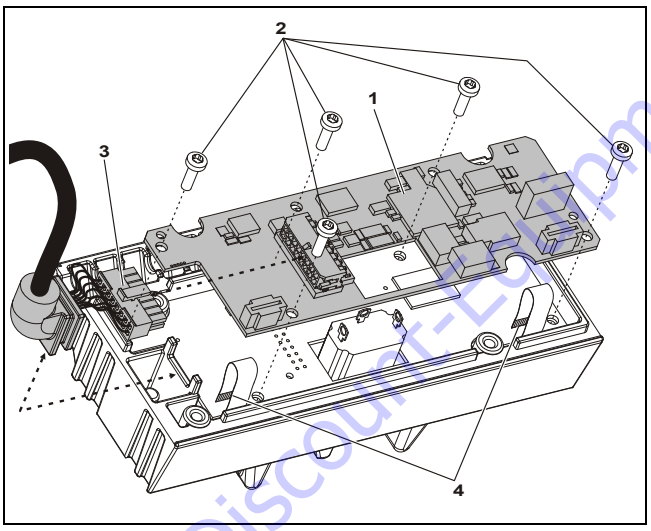
NOTE: *You may have to only loosen the two power bolts and remove the two closest the top in order to get to the printed circuit board located in the top of the control box where the drive/lift select switch is located.*

4. Loosen and remove the four (4) screws from the upper box assembly that hold the cover to the upper box.



Upper Control Box Cover - Installation

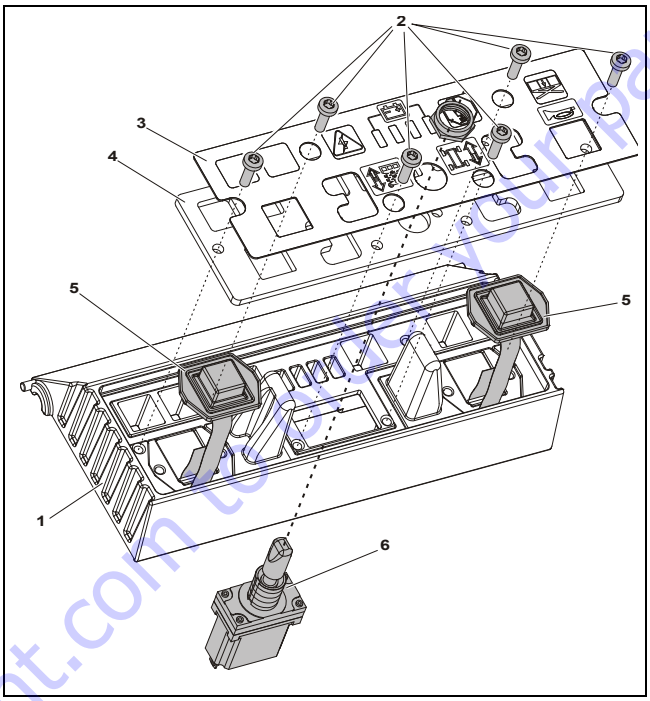
1. Upper Box Assembly
2. Upper Box Cover
3. Attach Screws



Upper Control Box Circuit Board - Installation

1. Circuit Board Assembly
2. Board Attach Screws
3. Upper to Lower Control Box Harness Connector
4. Front Button Switch to Circuit Board Ribbon Cables

1. Disconnect the upper to lower box harnness connector from the printed circuit board, and unplug the lift/drive switch blade terminals.
2. Disconnect the two (2) front button switch ribbon cables from the circuit board.
3. Remove the five (5) screws attaching the printed circuit board to the control box.
4. Replace board and reassemble upper control box.

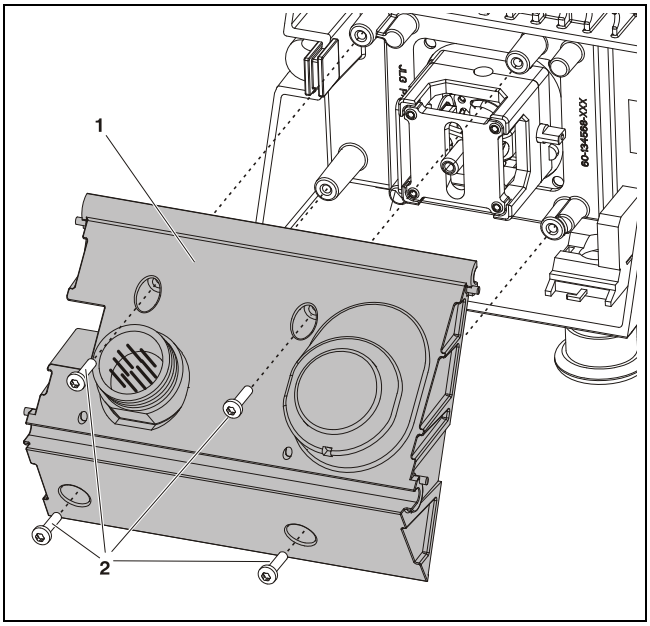


Upper Control Box Faceplate Component - Installation

1. Upper Control Box Housing
2. Face Plate Attach Screws
3. Face Plate Decal
4. Face Plate - Backing Plate
5. Button Switch
6. Drive/Lift Mode Select Switch

1. Remove the six (6) faceplate attach screws and the lift/drive mode selector switch attach nut.
2. Carefully lift the faceplate decal and backing plate out of the upper control box housing.
3. If replacing either of the button switches, the ribbon cable must be disconnected from the printed circuit board on the back, if not already done.
4. Replace component and reassemble.

Lower Control Box - Component Replacement

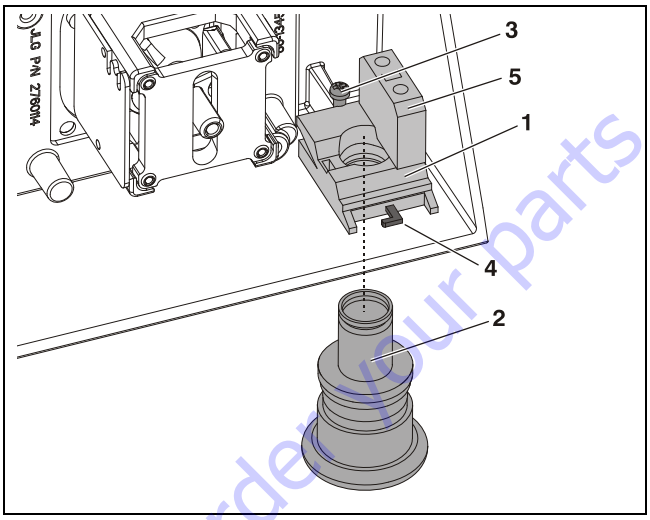


Lower Control Box Cover - Installation

1. Lower Control Box Cover
2. Attach Screws

1. Remove the four (4) attach screws and remove the cover from the other half.

NOTE: *Note wiring connections and routing when taking apart.*



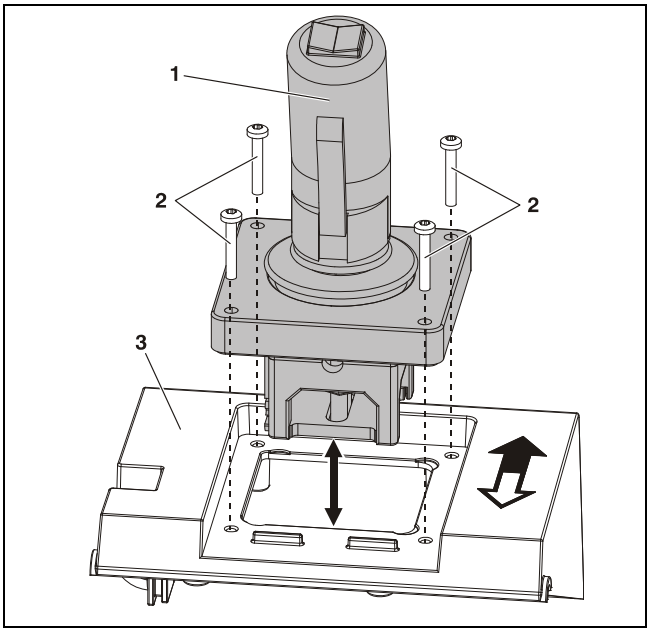
Emergency Stop/Shut-Down Switch - Installation

1. Switch Base
2. Switch Button/Barrel
3. Base Release Screw
4. Barrel Release Lever
5. Switch

1. Loosen the release screw, then spin the switch base if necessary to access the barrel release lever.

2. Pull the barrel release lever straight out with the blade of a screwdriver and pull barrel out of the switch base from the front of the control box.

3. Reverse steps to install.



Joystick Control - Installation

1. Joystick Assembly
2. Attach Screws
3. Lower Control Box

5.8 BATTERY/BATTERY CHARGER

NOTICE

JLG MACHINES EQUIPPED WITH DELTA Q BATTERY CHARGERS ARE DESIGNED FOR THE BEST PERFORMANCE WITH OEM FACTORY APPROVED BATTERIES.

APPROVED JLG REPLACEMENT BATTERIES ARE AVAILABLE THROUGH JLG'S AFTERMARKET PARTS DISTRIBUTION CENTERS OR JLG'S AFTERMARKET PROGRAMS. FOR ASSISTANCE WITH PROPER BATTERY REPLACEMENT, PLEASE CONTACT YOUR LOCAL JLG SUPPORT OFFICE.

BATTERIES APPROVED BY JLG HAVE BEEN TESTED FOR COMPATIBILITY WITH THE ALGORITHM PROGRAMMING OF THE DELTA Q BATTERY CHARGER TO OPTIMIZE BATTERY LIFE AND MACHINE CYCLE TIMES. THE USE OF NON APPROVED BATTERIES IN YOUR JLG EQUIPMENT MAY RESULT IN PERFORMANCE ISSUES OR BATTERY CHARGER FAULT CODES. JLG ASSUMES NO RESPONSIBILITY FOR SERVICE OR PERFORMANCE ISSUES ARISING FROM THE USE OF NON APPROVED BATTERIES.

NOTICE

BEFORE REMOVING ANY COMPONENT FROM THE ELECTRICAL SYSTEM, DISCONNECT THE BATTERIES USING THE QUICK-DISCONNECT LOCATED ON THE RIGHT SIDE BATTERIES.

Battery Maintenance and Safety Practices

⚠ CAUTION

ENSURE THAT BATTERY ACID DOES NOT COME INTO CONTACT WITH SKIN OR CLOTHING. WEAR PROTECTIVE CLOTHING AND EYEWEAR WHEN WORKING WITH BATTERIES. NEUTRALIZE ANY BATTERY ACID SPILLS WITH BAKING SODA AND WATER.

BATTERY ACID RELEASES AN EXPLOSIVE GAS WHILE CHARGING, ALLOW NO OPEN FLAMES, SPARKS OR LIGHTED TOBACCO PRODUCTS IN THE AREA WHILE CHARGING BATTERIES. CHARGE BATTERIES ONLY IN A WELL VENTILATED AREA.

ADD ONLY DISTILLED WATER TO BATTERIES. WHEN ADDING WATER TO THE BATTERIES, A NON-METALLIC CONTAINER AND/OR FUNNEL MUST BE USED.

⚠ WARNING

DO NOT REPLACE ITEMS CRITICAL TO STABILITY, SUCH AS BATTERIES, WITH ITEMS OF DIFFERENT WEIGHT OR SPECIFICATION. DO NOT MODIFY UNIT IN ANY WAY TO AFFECT STABILITY.

Check the electrolyte level of the batteries often, adding only distilled water when required. When fully charged, battery fluid level should be 1/8" below vent tubes. *(See Figure 5-8.)*.

- DO NOT fill to bottom of vent tubes.
- DO NOT allow fluid level to go below the top of the plates when charging or operating.

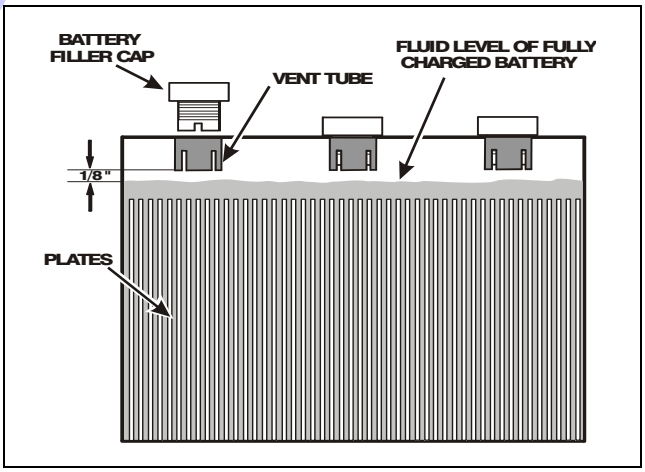
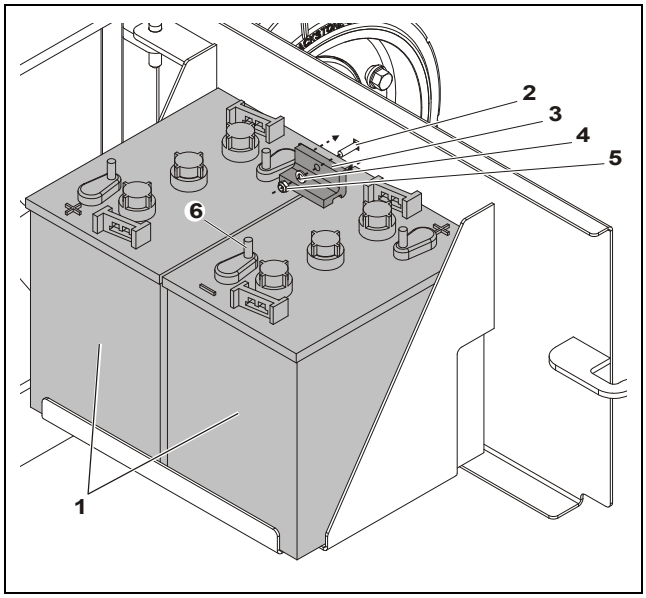


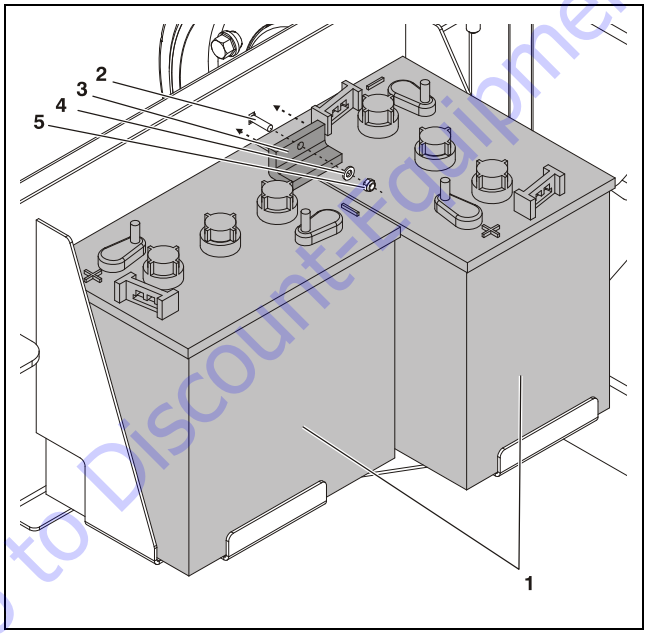
Figure 5-8. Battery Fluid Level.

Battery Installation



Left Side Battery Installation

1. Batteries
2. Bolt
3. Hold Down Clamp
4. Washer
5. Locking Nut
6. Attach Battery Temperature Sensor To This Terminal



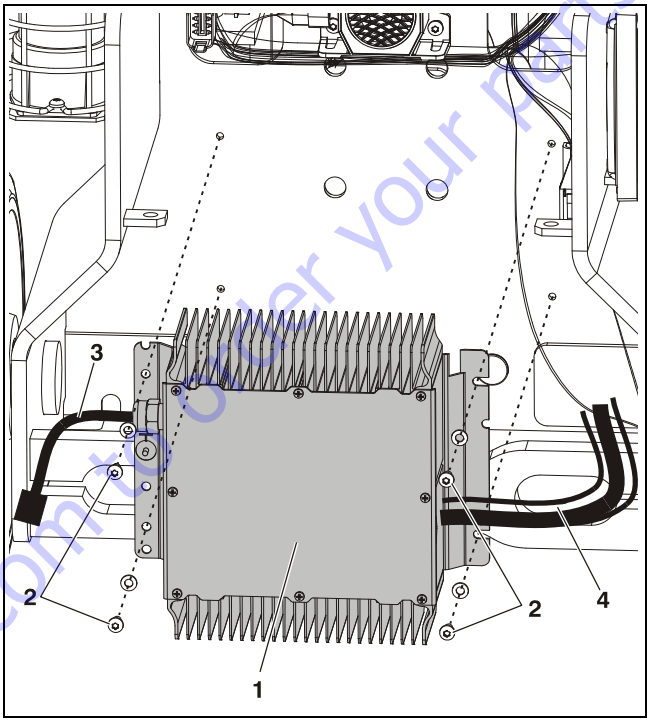
Right Side Battery Installation

1. Batteries
2. Bolt
3. Hold Down Clamp
4. Washer
5. Locking Nut

See Section-1 of this manual for battery specifications.

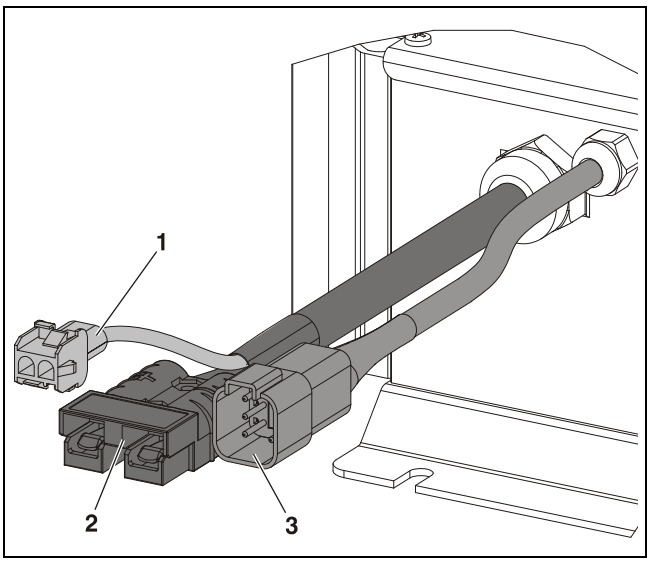
5.9 BATTERY CHARGER - INSTALLATION

The battery charger is located in the compartment at the rear of the machine, remove the charger/step-plate cover to gain access to the charger.



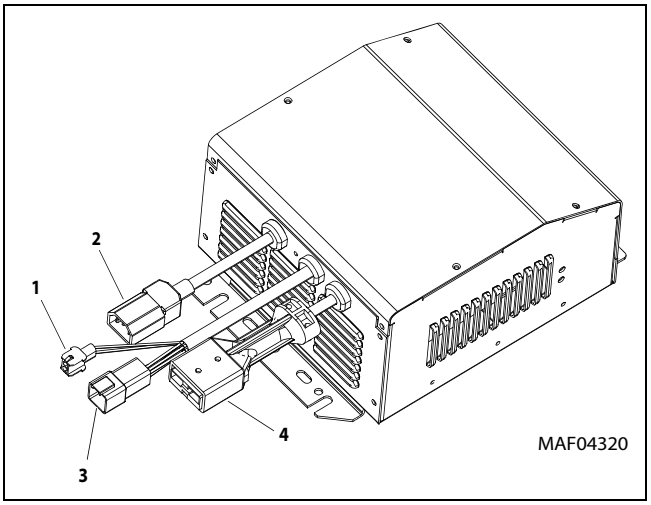
Battery Charger Assembly - Installation

1. Battery Charger Assembly
2. Attach Screws/Washers
3. AC Voltage - Input Cable
4. LED/Power/Interlock Cables



LED/Power/Interlock Cable - Identification(Delta-Q Charger)

1. Charger Interlock Cable
2. DC Power Cable to Batteries
3. LED Indicator, Battery Temp. Sensor Cable



LED/Power/Interlock Cable - Identification (Eagle Performance Charger)

1. Charger Interlock Cable
2. DC Power Cable to Batteries
3. LED Indicator, Battery Temp. Sensor Cable
4. IEC End

Also see Section 8 - Electrical Schematics for more detailed electrical connection information.

BATTERY CHARGER	SPECIFICATION Delta-Q 1001112111	SPECIFICATION Eagle Performance 1001177842
OUTPUT		
Nominal DC Output Voltage	24V	24V
Maximum DC Output Voltage	33.6V	31.92V
Maximum DC Output Current	25A	25A
Maximum Interlock Current	1A	–
INPUT		
AC Input Voltage	85-265VAC	108-132VAC
Nominal AC Input Voltage	120VAC - 230VAC RMS	120VAC RMS
AC Input Frequency	45-65 HZ	45-65 HZ
Maximum AC Input Current	12A RMS@108VAC	12A RMS@108VAC
OPERATION		
Battery type Indicator	–	Yellow LED
Charging Indicator	Yellow LED	Red - 30/60/90% LED
100% Charge Indicator	Green LED	Green LED
Fault Indicator	Red LED	Various LED Indications
PROTECTION		
Output Reverse Polarity	Electronic Protection - Automatic Reset	Electronic Protection - Automatic Reset
Output Short Circuit	Electronic Protection - Automatic Reset	Electronic Protection - Automatic Reset
AC Overload	Current Limited	Branch Circuit Protection
DC Overload	Current Limited	Current Limited
MECHANICAL		
Operating Temperature	–22°F to +122°F (–30°C to +50°C)	–30°C to +50°C (–22°F to +122°F)
Housing	Shock and Water Resistant Aluminum	Shock and Water Resistant Aluminum

Battery Charger Troubleshooting

No Lights at all

No Lights at all indicate that AC power to the charger is not connected or that the AC voltage is too low. It could also indicate an internal failure in the charger.

1. Check the connections to AC power. Check for AC voltage between 90 and 260 VAC at the charger.
2. If the AC voltage is verified to be correct at the connection to the charger, and the charger still displays no lights at all, return the charger for service.

FAULT LED Flashing

The Fault LED flashes to indicate the micro-controller inside the battery charger has detected a fault. The fault detected is indicated by the number of flashes. Count the number of flashes to determine the fault.

With any battery system, the most common problem will be a faulty battery connection. Because of the high likelihood of a battery connection problem, it is always worthwhile to confirm that all connections are good before checking for any other problems.

[1 Flash] - High Battery Voltage

1. Indicates a high battery voltage. Check that the battery charger voltage is consistent with the battery pack voltage. The first two digits of the four digit model name indicate the battery voltage the charger supports.
2. Check for wiring errors.
3. This fault will automatically clear and the charger will restart charging when this problem is removed.
4. High battery voltage could also occur if there is another source charging the battery. Disconnect any other sources during charging.
5. If this problem does not clear after the battery voltage is confirmed to be less than 2.4V per cell, return the charger for service.

[2 Flashes] - Low Battery Voltage

1. Indicates either a battery failure, no battery connected, or a lower than expected battery voltage. Check the battery and battery connections.
2. Check the nominal battery voltage. The first two digits of the four digit model name indicate the battery voltage the charger supports. Confirm that a nominal battery voltage is the same as the charger voltage.
3. This fault will clear automatically when the low battery voltage problem is rectified.
4. If this problem does not clear after the battery voltage is confirmed to be higher than 1.0V per cell and all connections are good, return the charger for service.

[3 Flashes] - Charge Time-out

Indicates the battery failed to charge within the allowed time. This could occur if the battery is of larger capacity than the algorithm is intended for. In unusual cases it could mean charger output is reduced due to high ambient temperature. It can also occur if the battery is damaged, old, or in poor condition.

1. Check the battery for damage such as shorted cells and insufficient water. Try the charger on a good battery.
2. If the same fault occurs on a good battery, check the connections on the battery and connection to AC, and the AC voltage itself.
3. Confirm that the nominal battery pack voltage is the same as the battery charger voltage.
4. This fault must be cleared manually by unplugging the AC, waiting 30 seconds and reconnecting the AC power.
5. If a charger displays this fault on a battery pack, and the pack is of questionable status, reset the charger by disconnecting AC for 30 seconds, and then reconnect the AC to start a new charge cycle. After a few charge cycles, this problem could stop occurring as the pack "recovers."

[4 Flashes] - Check Battery

This fault indicates the battery pack could not be trickle charged up to the minimum level required for the normal charge cycle to be started.

1. Check that none of the battery pack connections between modules are reversed or incorrectly connected.
2. Check that one or more cells in the battery are no shorted.
3. Confirm that the nominal battery pack voltage is the same as the battery charger voltage.
4. Try the charger on a good battery.
5. If this fault occurs, the battery is likely in poor condition. Try to recover the pack with a charger that can charge the individual cells - such as an automotive charger. Be sure to set this charger to the appropriate voltage - 6V per 6V battery, 12V per 12V string/battery.

[5 Flashes] - Over Temperature

This fault indicates the charger has become too hot during operation. Though not damaging to the charger, charge time will be extended significantly.

1. This fault indication will not clear automatically, but the charger will restart charging automatically when the temperature drops. The fault indication must be cleared manually by unplugging the AC, waiting 30 seconds and reconnecting the AC power.
2. If possible, move the machine to a cooler location.
3. Confirm that dirt or mud is not blocking the cooling fins of the charger. Clean the charger. Rinse the charger with a low pressure hose if required. Do no use high pressure. Do not us a pressure washer.

[6 Flashes] - Over Load/Over Temperature

This fault indicates that the batteries will not accept charge current, or an internal fault has been detected in the charger. This fault will nearly always be set within the first 30 seconds of operation. If it occurs after the charger has started charging normally, be sure to make a note of it.

1. Remove excessive AC loads from inverter if installed.
2. Try to clear the fault by unplugging the AC, waiting 30 seconds and reconnecting the ac power.
3. Check all battery connections. Look for a high resistance connection.The most likely reason for this fault is a fault in the battery such as a bad battery connection, an open cell, or insufficient water.
4. This fault will occur if an internal fuse inside the charger blows. If the green wire is shorted to ground even momentarily, this fuse will blow. To check the fuse, measure with an ohmmeter between the green and red wires with the AC disconnected. If a short circuit is not measured, the fuse has blown. Return unit to a service depot to have this fuse replaced.
5. If this fault occurs after battery charging has started, confirm that AC power was not interrupted and that all battery connections are good.
6. If all battery connections are good, an internal fault has been detected and the charger must be brought to a qualified service depot.

Excessive Battery Watering Requirements or Strong Sulphur (Rotten Egg) Smell

These symptoms indicate over-charging or high battery temperature. These symptoms are unlikely to be caused by too high a charge current since the maximum charge current of the charger will be small compared to even a moderately sized battery pack. The most likely cause for this problem is incorrect charge algorithm setting and/or high ambient temperatures.

1. Confirm that the battery pack is not too small - usually > 50Ah.
2. Confirm that the nominal battery voltage matches the charger output voltage.
3. Confirm the correct battery charge algorithm. If the battery pack is new, the algorithm will need to be changed if the pack is not the same as the old one. for instructions on how to determine and change the battery charge algorithm see the following sub-section.
4. If the output voltage of the charger seems excessive, return the charger for service. Contact JLG to get the expected battery voltage settings for the charger in question. Be sure to have the charger's serial number and charge algorithm setting available when calling.

Checking/Changing the Battery Charge Algorithm

The charger is pre-loaded with programming algorithms for the specific batteries detailed in Table 5-5, Battery Algorithms. Contact JLG if your specific battery model is not listed.
Each time AC power is applied with the battery pack not connected, the charger enters an algorithm select/display mode for approximately 11 seconds. During this time, the current Algorithm # is indicated on the Yellow Charging LED. A single digit Algorithm # is indicated by the number of blinks separated by a pause. A two digit Algorithm # is indicated by the number of blinks for the first digit followed by a short pause, then the number of blinks for the second digit followed by a longer pause.

To check / change the charging algorithm:

1. Disconnect the charger positive connector from the battery pack. Apply AC power and after the LED test, the Algorithm # will display for 11 seconds.
2. To change the algorithm, touch the connector to the battery's positive terminal for 3 seconds during the 11 second display period and then remove. The Algorithm # will advance after 3 seconds. Repeat this procedure until the desired Algorithm # is displayed. A 30 second timeout is extended for every increment. Incrementing beyond the last Algorithm will recycle back to the first Algorithm. When the desired Algorithm is displayed, touch the charger connector to the battery positive terminal until the output relay makes a clicking noise (approx. 10 seconds). The algorithm is now in the permanent memory.

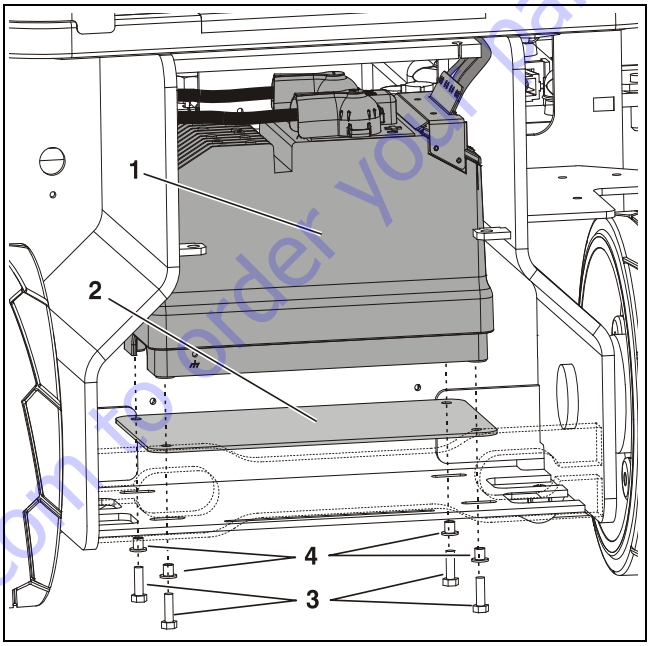
3. Remove the AC power from the charger and reconnect the charger's positive connector to the battery. It is recommended to check a newly changed algorithm by repeating the above steps 1 and 3.

Table 5-5. Battery Algorithms

Algorithm #	Battery Type
43	Harris Battery Discover EVGC6A-A
35	JLG P/N 0400242
23	Douglas Flooded (JLG default) GES Battery A1055 Trojan T105 East Penn GC-110-WNL Trojan T105 PLUS Champion CHGC2 GC2 US BATT EV-145-WNL US BATT 2200 XC
8	Concorde 10xAh AGM
7	J305 DV/DT CP
6	DEKA 8G31 Gel
5	Trojan 30/31XHS
4	US Battery USB2200
3	T105 DV/DT CP
2	Trojan T105 tapped
1	Trojan T105

5.10 BATTERY CHARGER/INVERTER (OPTION) - INSTALLATION

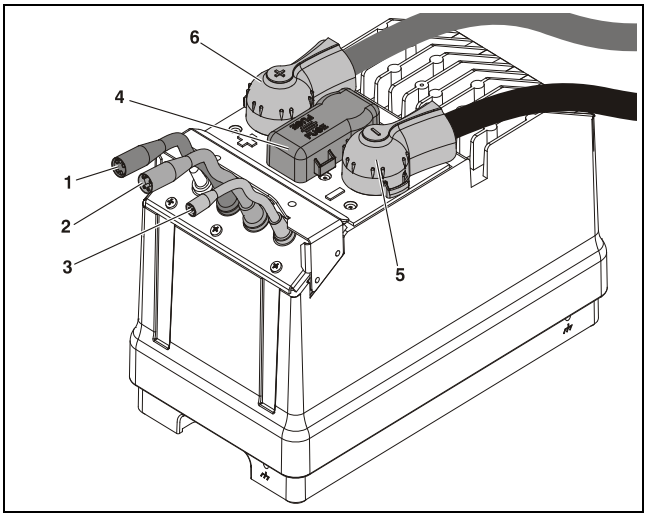
The battery charger-AC-inverter is located in the compartment at the rear of the machine, remove the charger/step-plate cover to gain access to the charger.



Battery Charger/Inverter Assembly - Installation

1. Charger/Inverter Assembly
2. Insulate Mounting Pad
3. Attach Screws (a)
4. Nylon Shoulder Washers

NOTE: *(a) On final assembly apply Loctite #242 to screw threads*



LED/Power/Interlock Cable - Identification

1. AC Output Connector
2. AC Input Connector
3. Remote On/Off Switch Cable
4. External DC Fuse Location
5. DC (–) Connection
6. DC (+) Connection

BATTERY CHARGER/AC INVERTER	SPECIFICATION
AC INVERTER - SPECS	
Output Power (Continuous)	1000 W
Output Power (Surge)	3000 W
AC Output Current	36 A
AC Output Voltage	115 to 125 VAC
Output Frequency	60 Hz
DC Input Voltage	21.2 to 29 VDC
Remote ON/OFF	Yes
CHARGER - SPECS	
Nominal DC Output Voltage	28 VDC
Maximum DC Output Voltage	33 VDC
Maximum DC Output Current	23 to 27 ADC
Required Interlock Current	1 A
Input Voltage (AC)	100 to 130 VAC
Nominal Input Voltage (AC)	120 VAC
Input Frequency	54 to 66 Hz
OPERATION	
Charging Indicator	Yellow LED
100% Charge Indicator	Green LED
Fault Indicator	Red LED
PROTECTION	
Output Reverse DC Polarity	125 A Replaceable Fuse
Output AC Short Circuit	Electronic Protection - Automatic Reset
AC Overload	20 A Internal Slow Blow Charger Fuse
DC Overload	Voltage Limited - Internally Controlled
MECHANICAL	
Operating Temperature	–40°F to +185°F (–40°C to +85°C)
Housing	Shock and Water Resistant Aluminum

For further specification and troubleshooting information refer to the manufacturers' Charger/Inverter Owner's Guide shipped with the machine. Publication - RM1024-JLG - Part # 3128406.

Also see Figure 9-21., Battery Charger/Inverter Electrical Connection Schematic for more detailed connection information.

SECTION 6. MAST COMPONENTS

6.1 MAST COMPONENTS OVERVIEW

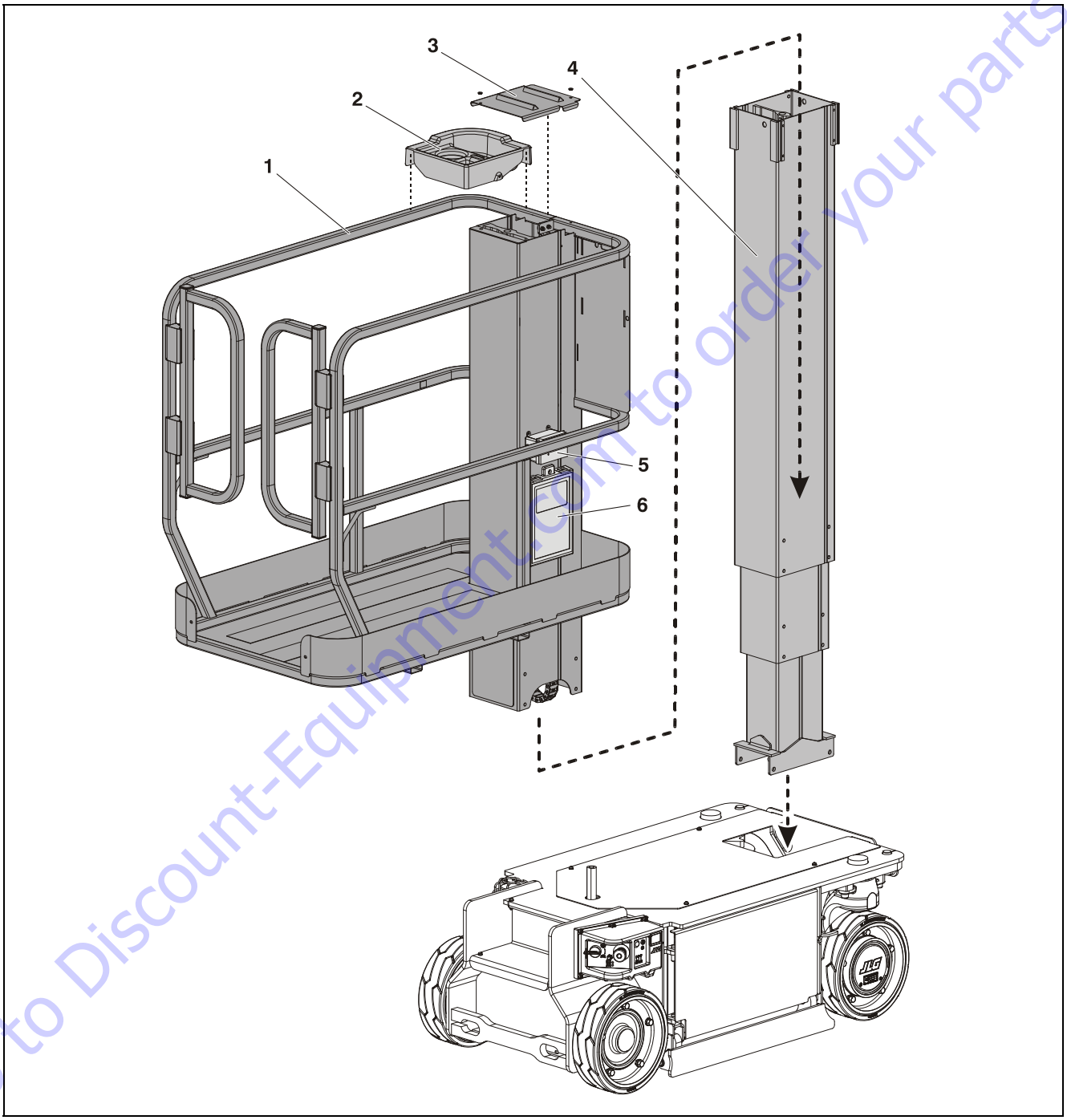


Figure 6-1. Mast Components.

1. Platform Assembly
2. Tool Tray
3. Mast Cover Plate
4. Mast Assembly
5. AC Power Receptacle
6. Manual Storage Box

PARTS FINDER

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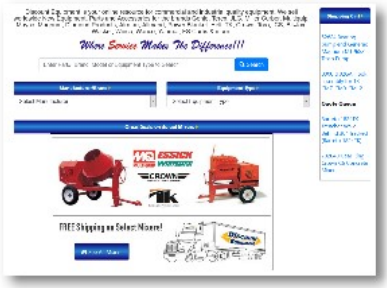

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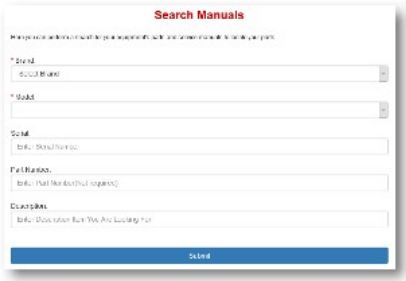

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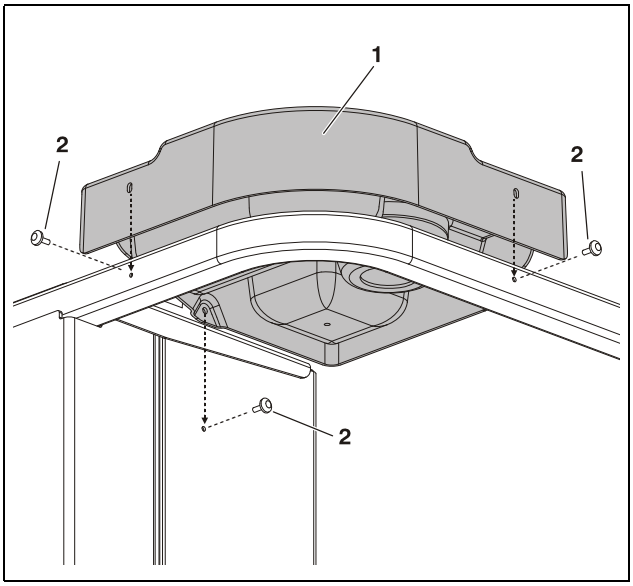
We sell worldwide for the brands: Genie, Terex, JLG, MultiQuip, Mikasa, Essick, Whiteman, Mayco, Toro Stone, Diamond Products, Generac Magnum, Airman, Haulotte, Barreto, Power Blanket, Nifty Lift, Atlas Copco, Chicago Pneumatic, Allmand, Miller Curber, Skyjack, Lull, Skytrak, Tsurumi, Husquvarna Target, , Stow, Wacker, Sakai, Mi-T- M, Sullair, Basic, Dynapac, MBW, Weber, Bartell, Bennar Newman, Haulotte, Ditch Runner, Menegotti, Morrison, Contec, Buddy, Crown, Edco, Wyco, Bomag, Laymor, Barreto, EZ Trench, Bil-Jax, F.S. Curtis, Gehl Pavers, Heli, Honda, ICS/PowerGrit, IHI, Partner, Imer, Clipper, MMD, Koshin, Rice, CH&E, General Equipment, ,AMida, Coleman, NAC, Gradall, Square Shooter, Kent, Stanley, Tamco, Toku, Hatz, Kohler, Robin, Wisconsin, Northrock, Oztec, Toker TK, Rol-Air, Small Line, Wanco, Yanmar

6.2 PLATFORM TOOL TRAY - INSTALLATION

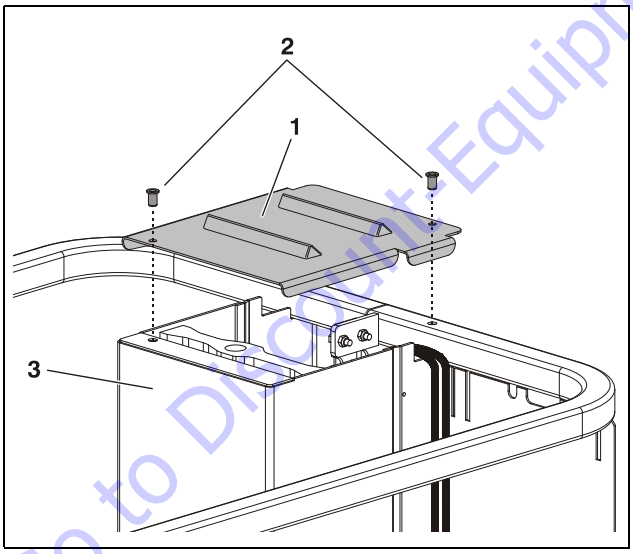


Platform Tool Tray - Installation

1. Tool Tray
2. Attach Screws (a)

NOTE: *(a)Do not use a screw with the threaded portion longer than 1/2 in. (12mm) when attaching to the side of the mast.*

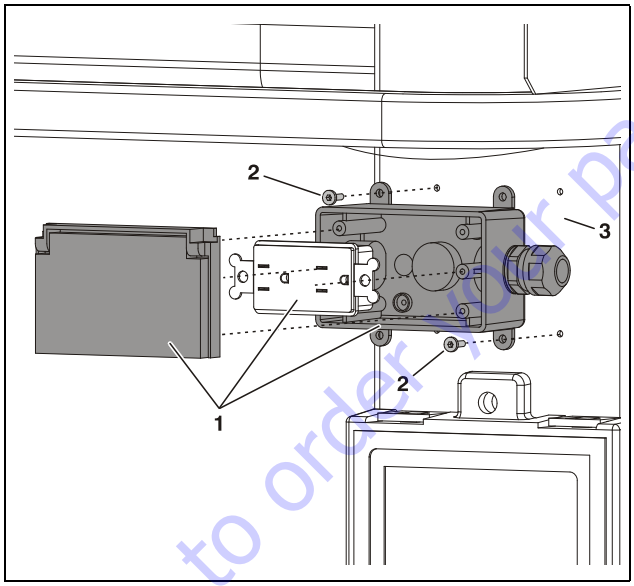
6.3 MAST COVER PLATE - INSTALLATION



Mast Cover Plate Installation

1. Mast Cover Plate
2. Rivet Nuts
3. Top of Mast Assembly

6.4 PLATFORM AC RECEPTACLE BOX - INSTALLATION



AC Receptacle Box - Installation

1. AC Voltage - Receptacle Box Components
2. Attach Screws
3. Platform/Mast Assembly

NOTE: *(See AC POWER RECEPTACLES AND WIRING (PLATFORM) - CE SPEC MACHINES ONLY on page 9-40) for receptacle wiring connections of available AC plug types.*

6.5 MAST ASSEMBLY - COMPONENTS

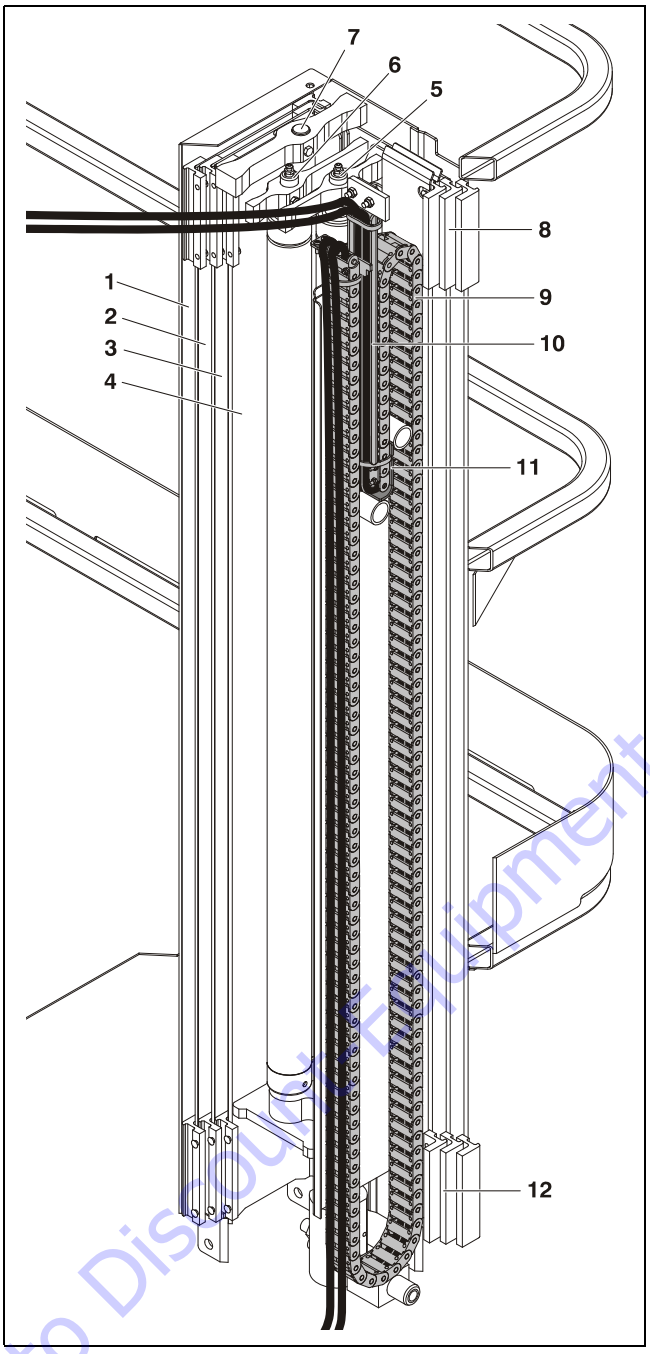


Figure 6-2. Mast Assembly - Components
(Mast shown cutaway for illustrative purposes only)

1. Platform/Outer Mast Section
2. Outer Mid Mast Section
3. Inner Mid Mast Section
4. Mount/Inner Mast Section
5. Hydraulic Cylinder #1
6. Hydraulic Cylinder #2
7. Hydraulic Cylinder #3
8. Top (External) Slide Pads
9. Power-Trak System
10. Power-Trak Guide
11. Power-Trak Shield Assy
12. Bottom (Internal) Slide Pads

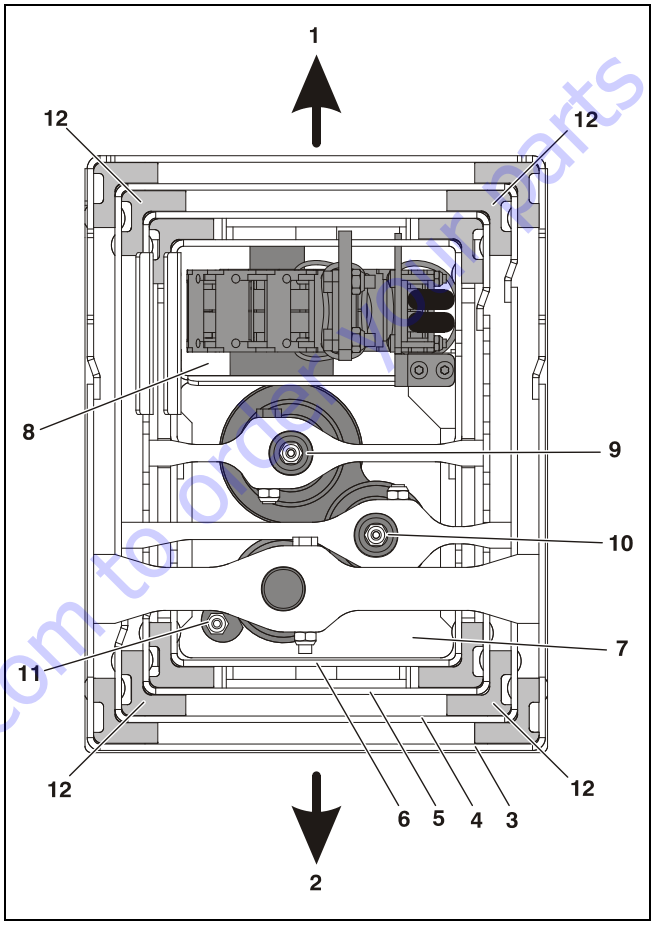


Figure 6-3. Mast Assembly - Orientation (Top View)

1. Front of Machine
2. Rear of Machine
3. Platform/Outer Mast Section
4. Outer Mid Mast Section
5. Inner Mid Mast Section
6. Mount/Inner Mast Section
7. Hydraulic Cylinder Compartment
8. Power-Trak Compartment
9. Cylinder #1 Bleeder Valve
10. Cylinder #2 Bleeder Valve
11. Cylinder #3 Bleeder Valve
12. Corner Slide Pads (a)

NOTE: *(a)Always mount slide pads with the groove oriented to the side of the mast not the front or rear, for clearance of the pad mounting rivets during operation.*
The slide pads are available in two thicknesses:
JLG P/N-1001092165 - 9,7mm thick - round notch on ends
JLG P/N - 4700042 - 8,7mm thick - NO round notch on end
Always use the 1001092165 slide pad unless mast tube clearances prevent installation.

6.6 PLATFORM ASSEMBLY

Platform - Extending Mast Unpowered

NOTICE

IF LIFT IS DISABLED AND THE MAST CANNOT BE EXTENDED UNDER THE MACHINE'S OWN POWER, THE PLATFORM MUST BE HOISTED OR LIFTED BY OTHER MEANS - LIFT PER ILLUSTRATION BELOW - BEFORE EXTENDING THE MAST, PRESS AND HOLD THE MANUAL DESCENT VALVE BUTTON ON THE FRONT OF THE MACHINE - WHEN DESIRED PLATFORM HEIGHT IS REACHED, RELEASE THE MANUAL DESCENT VALVE. THIS PROCEDURE SHOWS THE PLAT

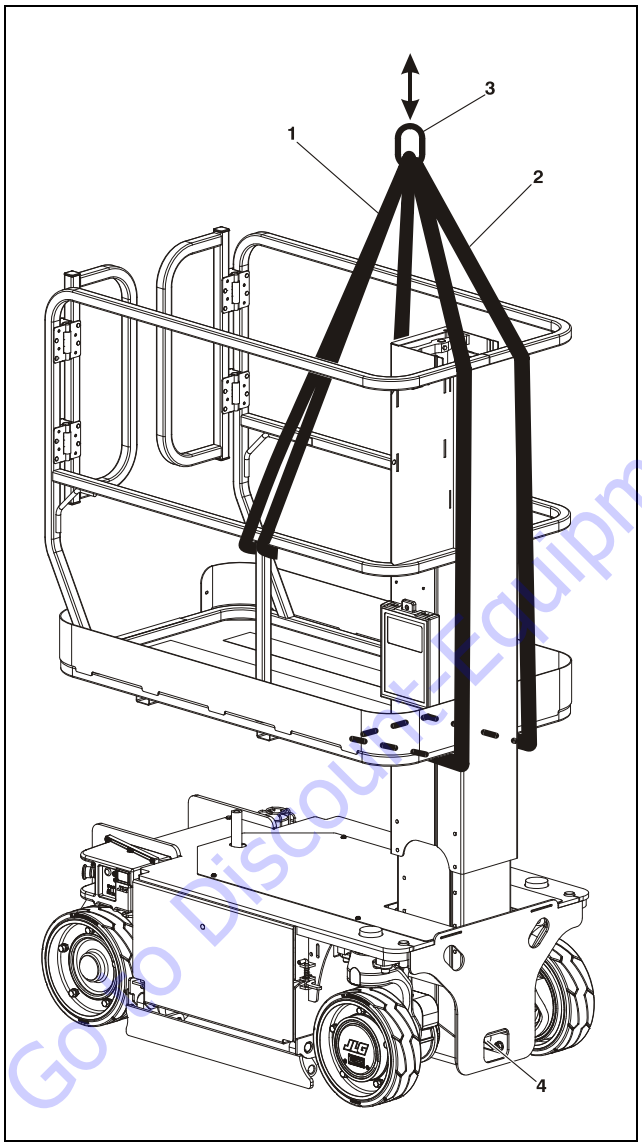


Figure 6-4. Extending Mast Unpowered

1. Sling Position - 1
2. Sling Position - 2
3. Lifting Ring/Hook
4. Manual Descent Valve Location

This Procedure shows the platform assembly (only) removal/ installation to the mast assembly. The platform and outer mast section are a one piece manufactured weldment.

Platform Removal

1. Extend the mast and raise the platform far enough out of the base assembly to allow access to the slide pads on the bottom corners of the outer mast section, but not to high that you cannot easily get to the top of the mast to work on it.

2. Support platform for later liting, with either an overhead crane or a fork truck attaching a lifting strap to remove the platform once the following steps are completed. *(See Figure 6-5.)*

3. Disconnect machine power at the right side battery tray using the quick disconnect.

4. At the four bottom corners of the outer mast section, remove the pop rivets securing each slide pad to the mast section. *(See Figure 6-5.) - Item 1*. Two (2) rivets per slide pad. The pads may not slide out of the mast section until the platform is lifted later and the upper slide pads on outer-mid section pushes them out.

5. Disconnect the platform control box main harness connector from the bottom of the platform control box and allow to hang loose for now. Remove the platform control box from the platform.

6. Remove the AC outlet receptacle box from the outside of the outer mast section. Allow the receptacle box to hang loose for now.

7. Remove the screws holding the cover plate consealing the cables for the receptacle box and platform box to the right side of the mast.

8. At the top of the mast, *(See Figure 6-5.) - Item 2)* the cylinder rod for hydraulic cylinder #3 is attached to platform mast section cross support with a bolt and nut through a detent on the side of the rod. Remove the locking nut from the hex head bolt holding the cylinder rod in place to the mast cross support. Remove the bolt from the cross support. It may be necessary to lift or lower slightly on the platform assembly with the lifting strap to remove the bolt.

9. Also at the top of the mast opening, *(See Figure 6-5.) - Item 3)* remove the two (2) bolts and nuts attaching the power-trak cable guide to the platform rail for the AC receptacle and platform control station electrical cables.

NOTE: *It may be necessary to pull down or push up on the rear of the platform to keep the platform level while lifting it off of the mast assembly.*

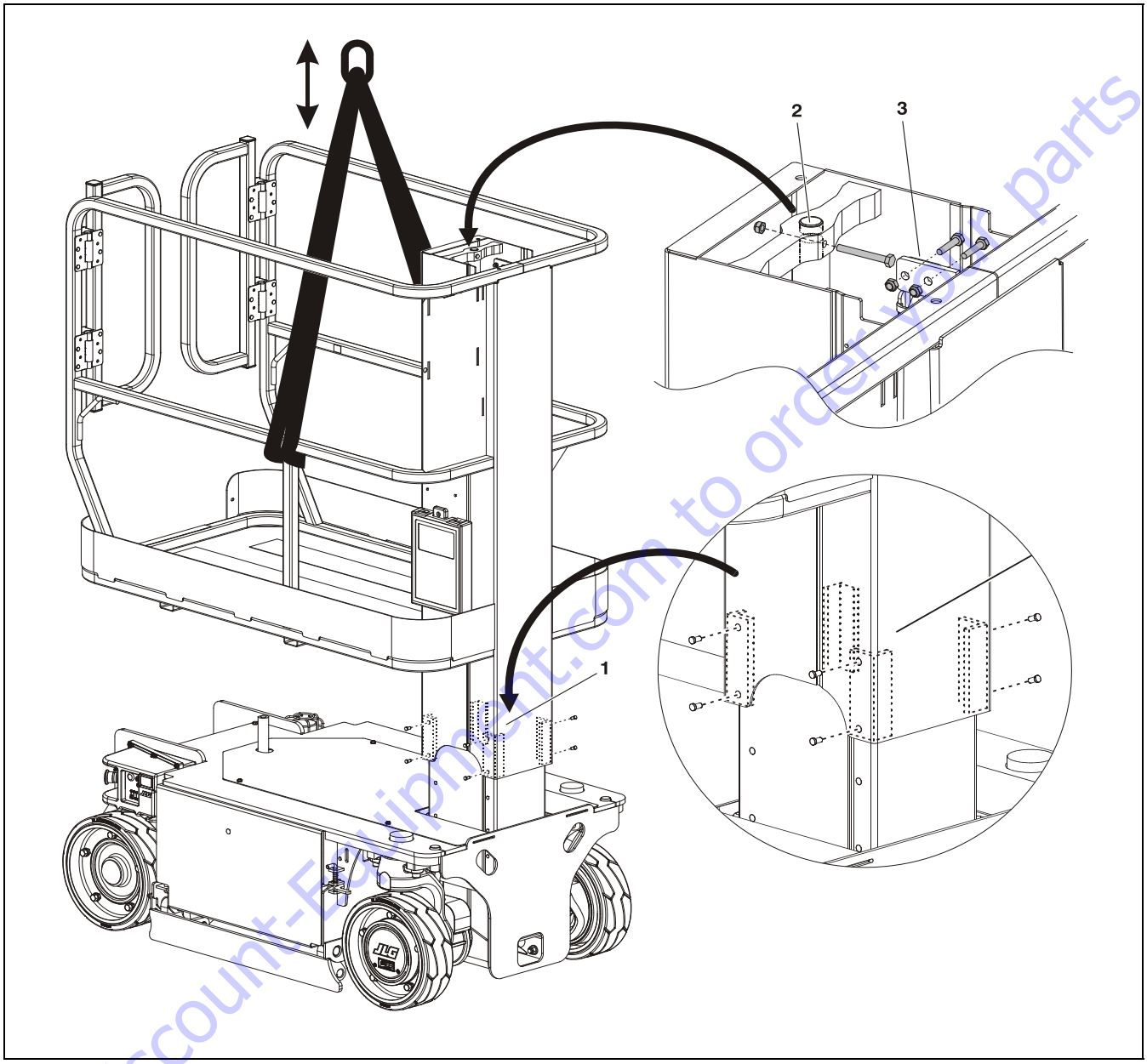


Figure 6-5. Platform to Mast - Installation

1. Platform Outer Mast Section - Lower Slide Pad Location
2. Lift Cylinder #3 - Attach Bolt and Nut Location
3. Power-Trak Guide Plate Attach Bolts and Nuts

10. While feeding the electric harness cables for both the AC receptacle box and the platform control station into the top of the mast, carefully start to lift the platform sliding it up off of the mast assembly. Once clear of the mast assembly, move to a suitable area for later assembly.

Platform Installation

1. Using an overhead crane with lifting strap, lift the platform assembly up over the main mast assembly.

2. Before lowering the platform assembly onto the mast, be certain the electrical cables for the AC receptacle box and platform control station are within the top of the mast assembly to prevent damage to the cables.

NOTE: *It may be necessary to pull down or push up on the rear of the platform to keep the platform level while lifting it off of the mast assembly.*

3. Lower the platform assembly approximately half way down the mast, then reinstall the slide pads at the bottom corners of the platform mast section. *(See Figure 6-5.) - Item 1.*
4. Continue to lower the platform assembly, at the top of the mast guide the cylinder rod of hydraulic cylinder #3 into the cross support located at the top of the platform assembly mast section. Install the detent bolt and nut, tighten securely. *(See Figure 6-5.) - Item 2.*
5. Pull the electrical harness cables out through the top of the platform mast section and lay over the right side of the mast.
6. Reattach the power-trak cable guide using the two (2) bolts and nuts to the lug at the top of the platform mast section. *(See Figure 6-5.) - Item 2.*
7. Route the electrical cables down the right side of the mast section and reinstall the metal cable cover using the two (2) screws previously removed.
8. Reattach the AC receptacle box to the side of the mast and install the platform control box to the platform control box mounting plate. Attach the platform control box - cable harness to the bottom of the control box.
9. Reconnect machine power at the right side batteries quick-disconnect connector.
10. Power machine up and cycle the mast up and down a few times, look inside the top of the mast to be certain the power-trak and harness cables are free of interference and not being pinched in any way.
11. If operation is OK, reinstall the mast section top cover.

6.7 MAST ASSEMBLY

It is recommended that the platform assembly be removed *(See Section 6.6)* before removing the mast assembly separately.

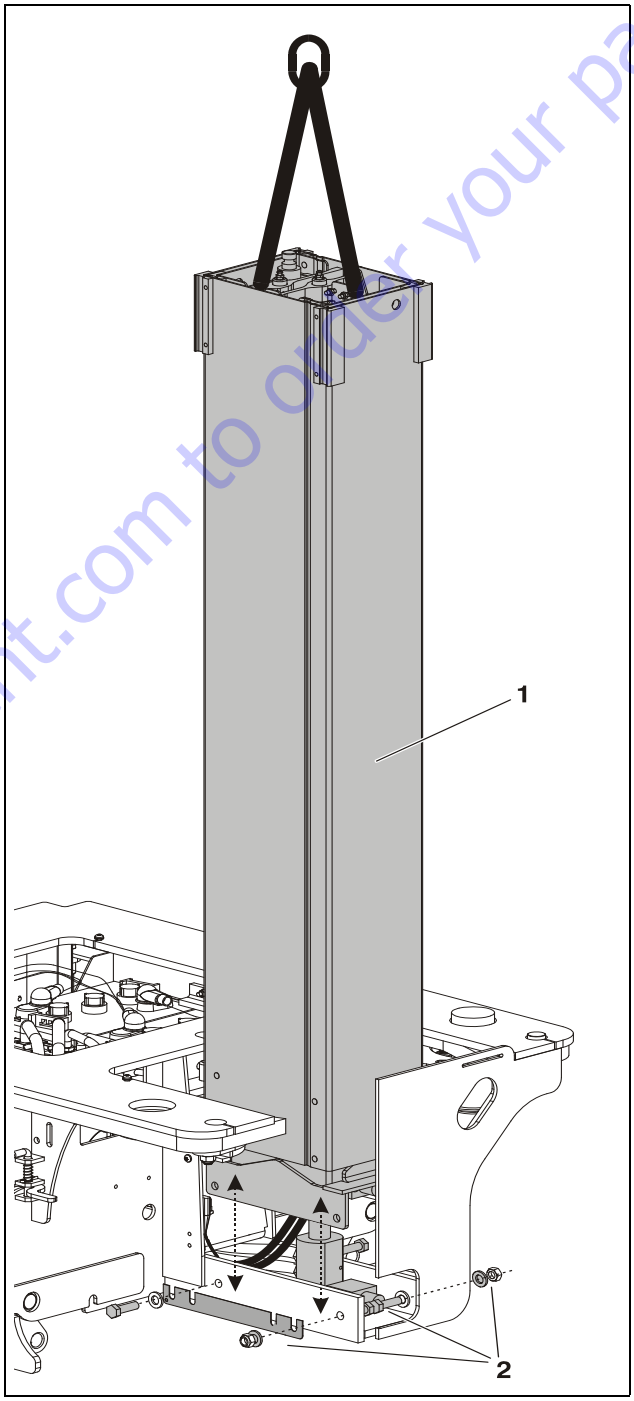


Figure 6-6. Mast - Installation
(Front of frame shown cutaway for illustrative purposes only)

1. Mast Assembly
2. Fastening Hardware

Mast Removal

NOTE: *To ease removal and installation of the mast assembly it is recommended that the complete machine be elevated on suitable stands to allow easy access to the mounting bolts on the base of the mast assembly.*

1. Lower the mast assembly completely before beginning the mast removal process to ensure no residual pressure remains in the lift cylinder.

2. Attach an overhead crane by strap through the cross supports on the top of mast sections.

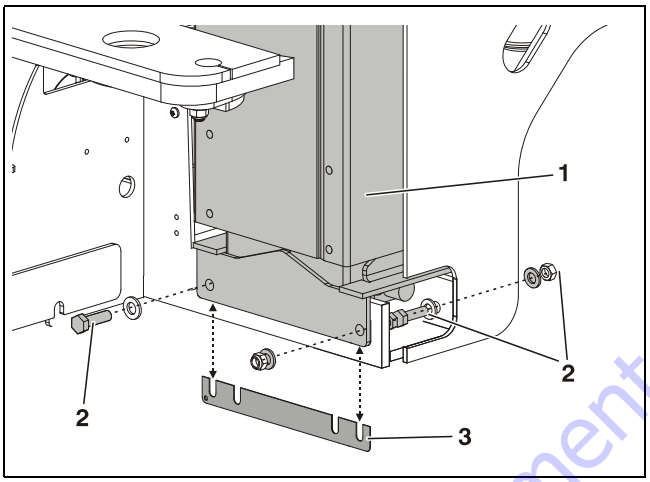


Figure 6-7. Mast Base Mounting Hardware
(Front of frame shown cutaway for illustrative purposes only)

1. Mast Assembly
2. Fastening Hardware
3. 20 Ga. (.0359 in.)- Mounting Shim

3. Remove the four (4) bolts, nuts, washers, and shims from the base mount of the mast. Access the bolts and nuts through the access holes in the bottom and front of the base frame.

NOTE: *Before removing the mast off the machine, you must decide which way you want to disconnect the harness cables to the AC receptacle box and platform control box running through the power-trak in the mast.*
You can either disconnect the cables from their source at the rear of the machine in the charger compartment and free the cables through to the front of the machine so the cables come out with the mast.
Or disconnect the power-trak from the top of the mast and allow it slide out through the bottom of the mast as it is lifted off of the machine. This method also requires the AC receptacle box and the platform control box cable to be disconnected and feed down through the mast with the power-trak.

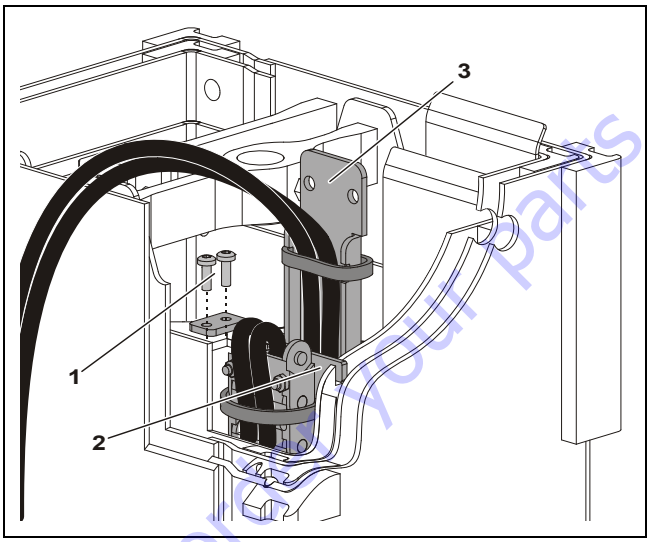


Figure 6-8. Power-Trak - Removal

1. Attach Screws
2. Power-Trak Hanger Bracket (a)
3. Power-Trak Guide (b)
4. Hyd. Cyl. #1 Bleeder Valve

NOTE: *(a)Remove hanger bracket from slot in mast and push down into the mast.*
(b)If platform has already been removed this will be hanging loose.

4. If removing the power-trak from the mast use the following steps; *(See illustration above)*

   a. Remove the attach screws from the power-trak guide bracket.

   b. Push the power track and cables down into the mast past the hanger bracket slot in the side of the mast.

5. At the top of the mast, carefully open the bleeder valve on the top of the main hydraulic cylinder #1 attached to the base frame.

NOTE: *While lifting the mast assembly out of the frame, hydraulic cylinder #1 will still be attached to the base frame, lift slowly straight up ONLY, do not attempt to lift on an angle or the hydraulic cylinder may be damaged.*

NOTE: *Also when lifting the mast assembly, if you detached the power-trak from the top of the mast it will need to be lowered out the bottom of the mast as the mast is lifted upwards.*

6. Carefully lift the mast assembly up out of the frame far enough to gain access to the wire harness connector for the lift down selenoid, and the hydraulic lines connected to hydraulic cylinder- #1, still attached to the base frame.

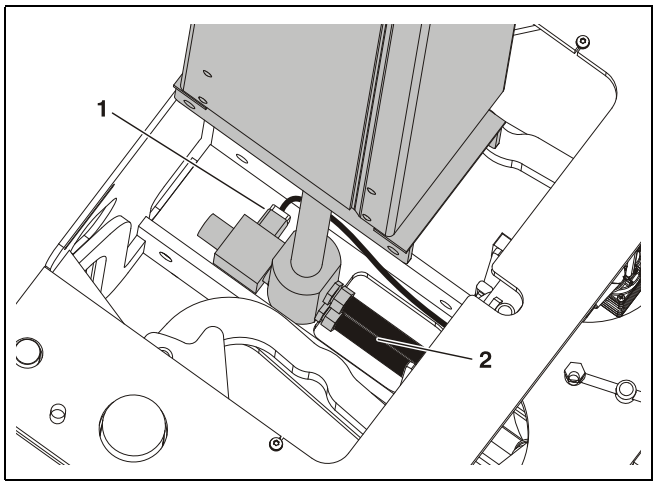


Figure 6-9. Hydraulic Cylinder Connections - Removal

1. Lift Down Valve Selenoid Harness
2. Extend and Return Hydraulic Lines (a)

NOTE: *(a)Open hydraulic lines carefully, have a container ready to catch draining oil, cap ports and lines immediately once lines are removed.*

7. Disconnect the wire harness connector from the lift down valve selenoid. Disconnect and cap the extend and return hydraulic lines on the bottom of hydraulic cylinder #1.

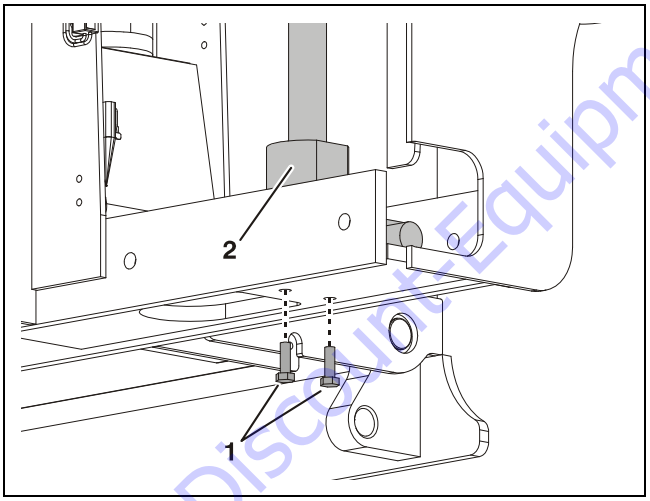


Figure 6-10. Hydraulic Cylinder Bottom End Bolts - Removal

1. Cylinder Attach Bolts
2. Hydraulic Cylinder #3

8. Remove the two (2) bolts attaching hydraulic cylinder #1 to the underside of the base frame.

9. Lift the mast assembly free of the frame, place on a suitable workbench for disassembly.

Mast Disassembly

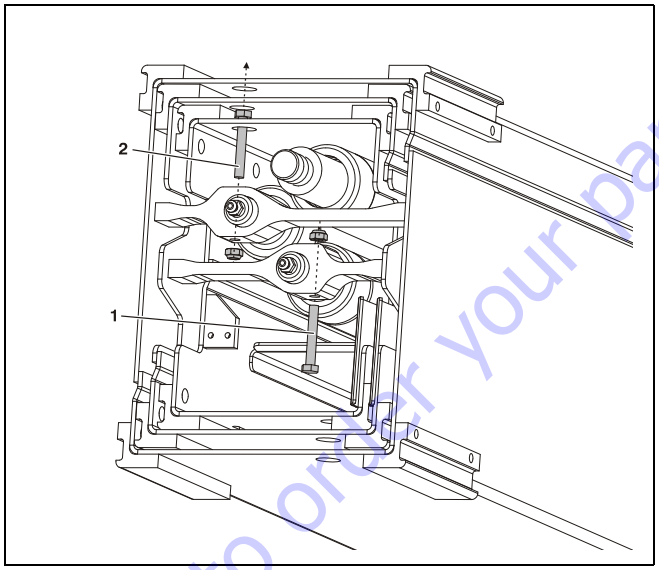


Figure 6-11. Hydraulic Cylinder Top End Bolts - Removal

1. Cylinder #1 Attach Bolt/Nut
2. Cylinder #2 Attach Bolt/Nut

1. At the top of the mast, remove the bolts and nuts attaching the cylinder rods for cylinder #1 and #2 to their cylinder anchor cross bars.

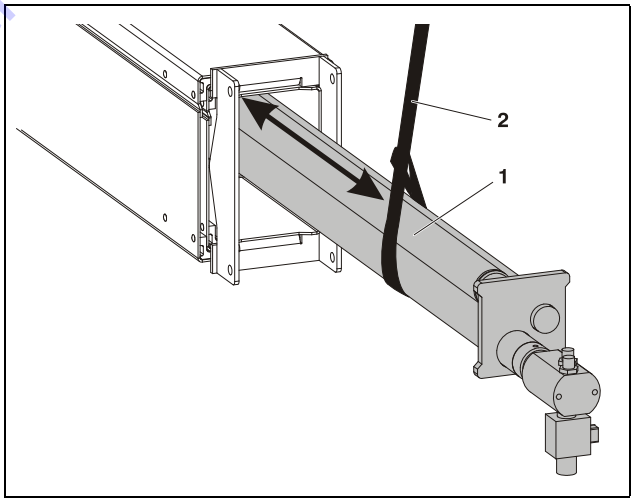


Figure 6-12. Hydraulic Cylinder - Removal

1. Multi-stage Hydraulic Cylinder Assembly
2. Lifting Strap

2. Using suitable lifting equipment and strap, slide the cylinder assembly out the bottom of the mast assembly, place on a suitable workbench.

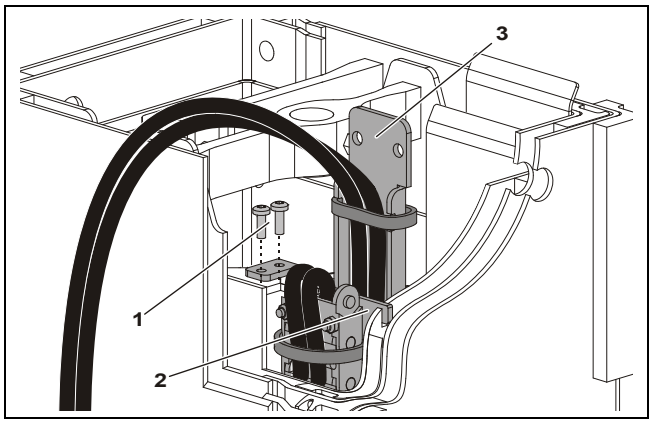


Figure 6-13. Power-Trak - Removal

1. Attach Screws
2. Power-Trak Hanger Bracket (a)
3. Power-Trak Guide

NOTE: *(a) Remove bracket from slot in mast and remove power-trak harness from the mast.*

3. If the power-trak assembly was left attached to the mast assembly, to remove it now, remove the two (2) screws attaching the power-trak guide to the mounting lug at the top of the mast. Slide the hanger bracket out of the slot in the front of the mast section. Now slide the complete power-trak assembly with cables out of the top of the mast assembly.

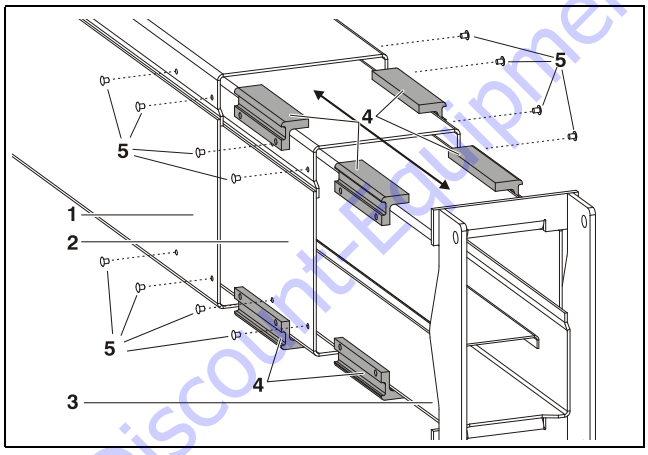


Figure 6-14. Mast Sections - Disassembly

1. Outer-Mid Mast Section
2. Inner-Mid Mast Section
3. Mount/Inner Mast Section
4. Slide Pads
5. Pad Attach Rivets

4. To remove the mast sections from each other, slide the mast sections apart until the rivets attaching the slide pads to the bottom corners of the mast sections are exposed. Remove the rivets from the slide pads on the mast sections you want to remove at the bottom of the outer-mid and inner-mid mast sections, then slide the mast section out the bottom.

Mast - Reassembly

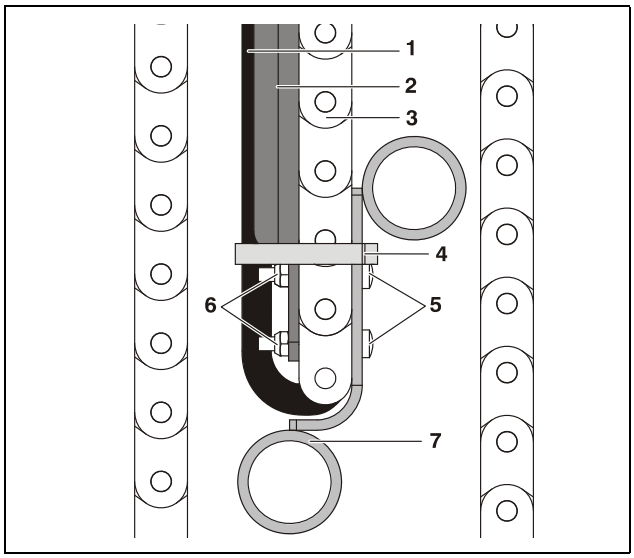
(Refer to the Mast Disassembly illustrations when required)

1. If required, assemble the external slide pads to the top of the outer-mid, inner-mid and mount/inner mast section. Orient the groove in the pads to the side of the mast and attach with the proper rivets from the inside of the mast. *(See Figure 6-3.)*

NOTE: *Always mount slide pads with the groove oriented to the side of the mast not the front or rear, for clearance of the pad mounting rivets during operation.(See Figure 6-3.)*
The slide pads are available in two thicknesses:
JLG P/N-1001092165 - (9,7 mm thick) - round notch on ends
JLG P/N - 4700042 - (8,7 mm thick) - NO round notch on end
Always use the 1001092165 slide pad unless mast tube clearances prevent installation.

2. Slide the inner-mid and the mount/inner mast sections into the outer-mid mast section. Allow the mounting holes for the bottom slide pads of the inner-mid mast section to be exposed. *(See Figure 6-14.)*

3. Push the bottom slide pads into the bottom of the outer-mid and the inner-mid mast sections, mount with the groove in the pad towards the side of the mast. Attach with the proper rivets. *(See Figure 6-14.)*



Power-Trak Shield - Installation

1. Power-Trak Cable
2. Power-Trak Guide
3. Power-Trak Assy.
4. Tie Strap
5. Shield Mounting Bolts
6. Mounting Nuts
7. Power-Trak Shield Assy.

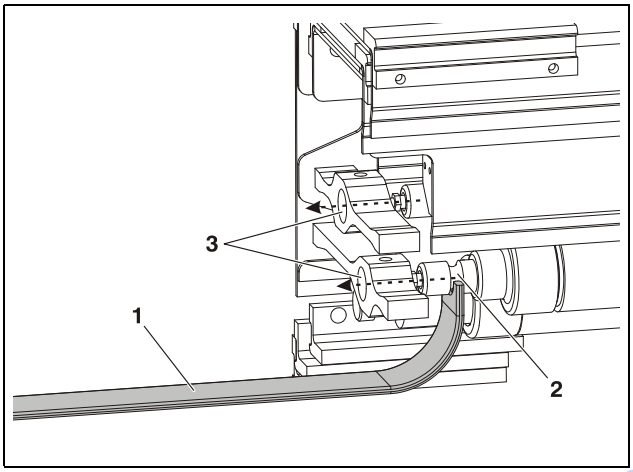
4. Slide the inner-mid and the mount/inner mast sections into the outer-mid mast section.

5. At the top of the mast assembly, install the power-trak assembly into the power-trak compartment of the mount/inner mast section. *(See Figure 6-13.)*

6. Attach the power-trak hanger bracket to the mount/inner mast section. *(See Figure 6-13.)*

7. Slide the multi-stage hydraulic cylinder into the hydrauliccylinder compartment of the mast assembly. *(See Figure 6-12.)*

8. Attach the cylinder rod of cylinder #1 and 2 into their anchor cross bars at the top of the mast assembly. Secure using the proper bolt and nut assembly. *(See Figure 6-11.)*



Hydraulic Cylinder - Installation

1. Tool (Simular/Fabricate)
2. Detent in Cylinder Rod
3. Rod Anchor Brackets

Mast Installation

1. Move the mast assembly near the machines base frame. At the top of the mast assembly attach a lifting strap and lift the mast assembly into a vertical position.

2. Open the bleeder valve at the top of hydraulic cylinder #1, then pull the cylinder rod out the bottom of the cylinder approximately 2 ft. (61cm).

3. Carefully lift the mast assembly over the machine and center it into the opening where the mast is mounted on the machine.

4. If the power-trak assembly harness was left attached to the base frame when the mast was removed, lift it off the base frame and hold it vertically. As the mast assembly is lowered take the top end of the power-trak assembly and feed it into the power-trak compartment on the front side of the mast assembly.

5. Lower mast assembly down or pull cylinder rod out of cylinder #1 and align the holes in the bottom of the rod assembly with the holes in the base frame. Secure using the proper bolts, apply Loctite #242 to the threads of the rod attach bolts on final assembly. *(See Figure 6-10.)*

6. Re-connect the lift down valve harness connector to the lift down valve mounted on the front of the cylinder rod assembly.

7. Re-connect the extend and return lines to the back of the cylinder rod assembly. *(See Figure 6-9.)*

8. Carefully lower the mast assembly, while lowering feed the power-trak assembly into the mast and lift the power-trak assembly till it is completely over top of the lift down valve assembly. *(See Figure 6-2.)*

9. Feed the control cables through the notch in the baffle plate inside the mast. Install the P-clamp onto the control cables for attachment to the right-rear mast mounting bolt.

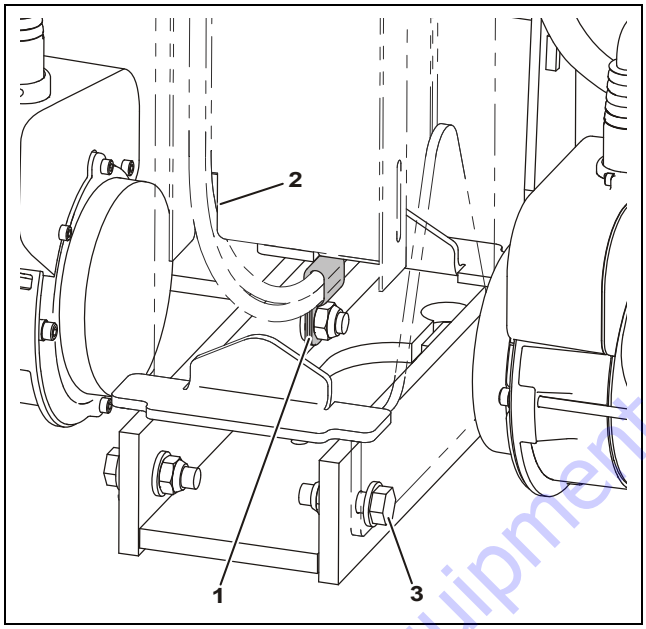
10. Continue to lower the mast until the holes in the mount/inner mast section mounting plates are aligned with the holes in the base frame mounting plates. *(See Figure 6-7.)* Check the side to side play between the mast mount and the frame mount, shim equally to both sides until side to side play is removed. Install the mast mounting bolts, nuts, and washers, with the nuts inboard.

11. Before tightening the mast mounting bolts/nuts, check mast for vertical front/rear and left/right plumb. Per following table:

Plumb, maximum - Front/Rear	3 in. (76mm)
Plumb, maximum - Left/Right	2 in. (50mm)

Tighten the mast mounting bolts/nuts as required in the following sequence:

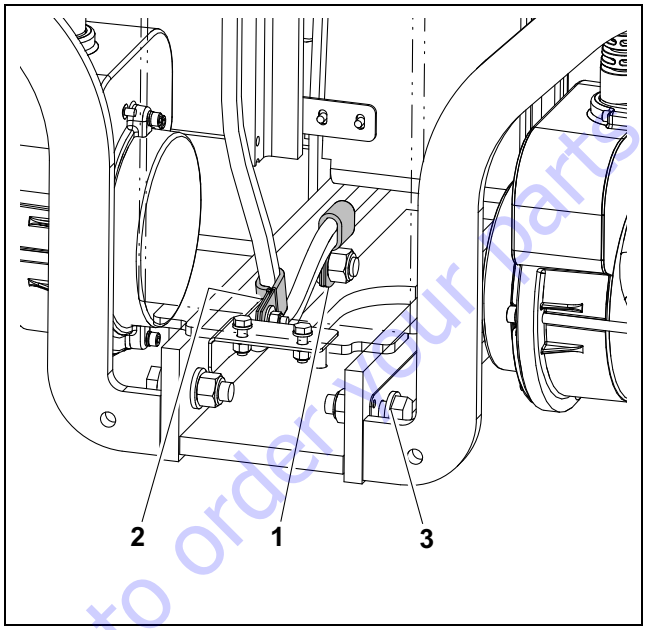
1. Left Front
2. Right Rear
3. Left Rear
4. Right Front



This installation applies to machines with "A2-" prefix serial numbers and machines prior to SN 0200230157.

1. Control Cable P-Clamp **(a)**
2. Route Cable Through Notch in Mast Baffle Plate
3. Left-Front Mast Mounting Bolt (M12 - Class 8.8) **(b)**

NOTE: ***(a)*** *Install clamp between washer and nut of the right-rear mast mounting bolt.* ***(b)*** *An extra washer may be required to space the screw away from the RED manual descent button on the lift cylinder. Apply Loctite #271 to mast mounting bolt threads. Torque as required, tightening in an X (cross) pattern.*



This installation applies to machines with "013-" prefix serial numbers and machines from SN 0200230158 to present.

1. Control Cable Frame P-Clamp **(a)**
2. Control Cable Mast P-Clamp - Attach to Bracket
3. Left-Front Mast Mounting Bolt (M12 - Class 10.9) **(b)**

NOTE: ***(a)*** *Install clamp between washer and nut of the right-rear mast mounting bolt.* ***(b)*** *An extra washer may be required to space the screw away from the RED manual descent button on the lift cylinder. Apply Loctite #271 to mast mounting bolt threads. Torque as required, tightening in an X (cross) pattern.*

1. At the top of the mast, if reinstalling the power-trak, reach down into the power-trak compartment and pull the power-trak assembly up, attach the hanger bracket to the top of the mast assembly. *(See Figure 6-13.)*

2. Re-install the platform assembly *(See Platform Installation on page 6-5).*

Multi-Stage Hydraulic Cylinder - Cylinder Bleeding Procedure

NOTICE

THE THREE STAGE CYLINDER MUST BE BLED IN THE SEQUENCE OF CYL. #1, THEN CYL. #2, THEN CYL. #3.

1. First check that hydraulic oil level is between the min./max. markings on the side of the pump reservoir.
2. In the platform, if necessary, remove the mast cover from the top of the mast assembly.
3. Place the proper size 90° angled line wrench on the bleeder valve of cylinder #1. *(See Figure 6-3.)* for orientation of bleeder valves.
4. Attach a plastic tube to the bleeder valve on cylinder #1, use a tube long enough to hang over the side of the mast assembly and place the loose end into a container to catch the hydraulic fluid.
5. Power up the machine.
6. Loosen the bleeder valve on the cylinder being bled. Be certain the other end of the bleeder tube is in the catch container.
7. Set the platform control station to platform lift mode and push the joystick to lift the platform. Do not allow the platform to lift to far off the stowed position, re-lower and lift again if necessary.
8. Watch the bleeder tube, when a constant flow of oil (no bubbles) is visible, close the bleeder valve.
9. Remove the bleeder tube and line wrench and move to the next cylinder in sequence. Repeat steps 6 through 8 until all three cylinders are bleed.
10. It is recommended that the platform be cycled up and down a few full lifts. Then repeat step 1.
11. Finally repeat steps 6 through 10 again then cylinder bleeding is completed.

Mast Installation Completion

Once mast is installed and properly bled to remove the air from the hydraulic lift system, wipe off any excess hydraulic oil from accessible surfaces of the mast and hydraulic cylinder. If necessary, check the lift system hydraulic pressure setting. Cycle the mast up and down a few times then check at the top and bottom of the mast for any hydraulic oil leaks.

6.8 MULTI-STAGE HYDRAULIC CYLINDER - SERVICING

Refer to Section 3.6, PUMP/LIFT/MAST - Theory of Operation for more detailed information on Hydraulic System.

Overview

The hydraulic cylinder for this machine is a multi-stage - three cylinder design.

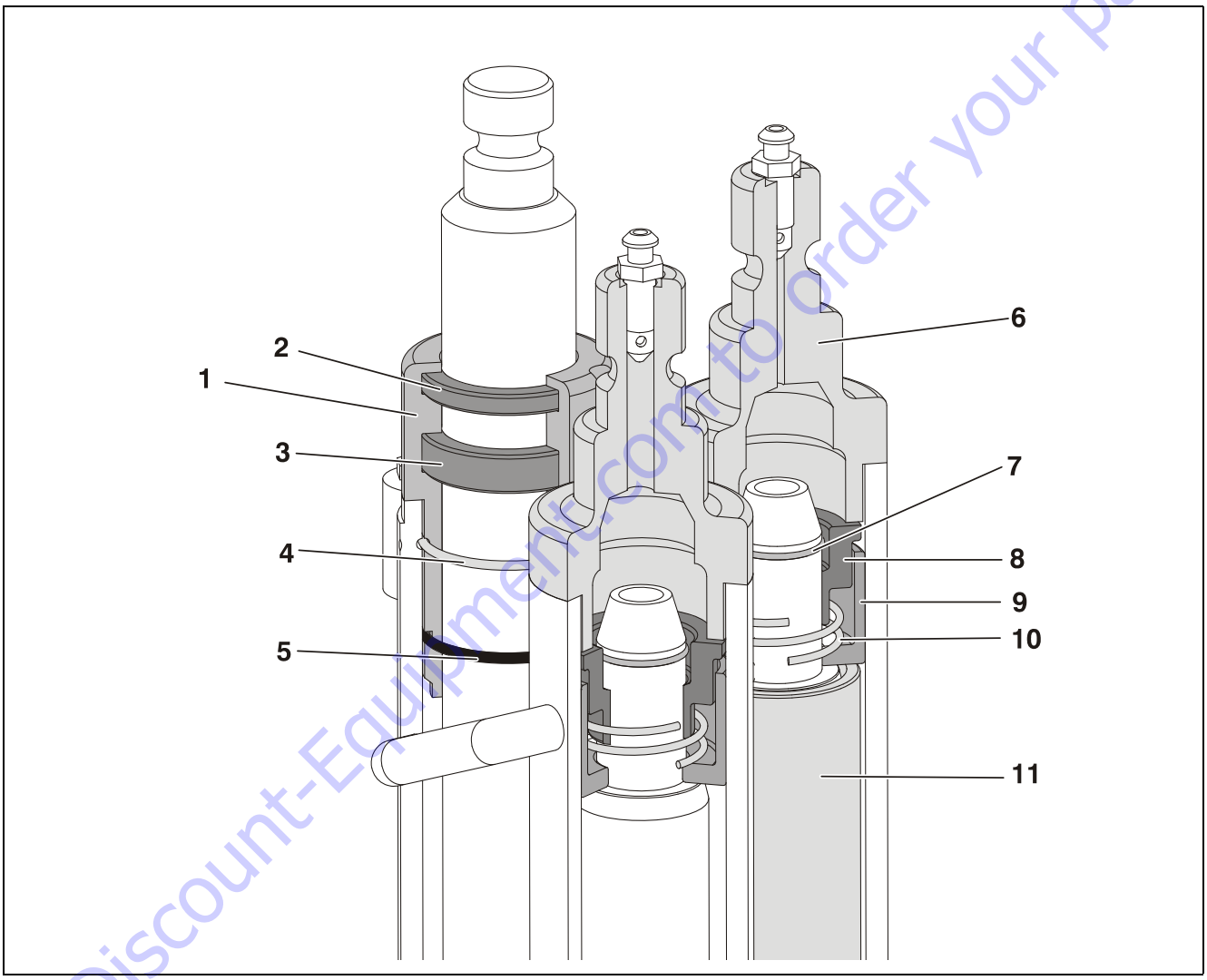


Figure 6-15. 1230ES Lift Cylinder Internal Components - Top End

1. Cyl. #3 - Gland
2. Cyl. #3 - Wiper Seal
3. Cyl. #3 - Main Seal
4. Cyl. #3 - Gland Wire Retaining Ring
5. Cyl. #3 - Gland O-Ring Seal
6. Cyl. #1 - End Cap (a)
7. Cyl. #1 - Piston Retaining Ring
8. Cyl. #1 - Piston
9. Cyl. #1 - Piston Guide Ring
10. Cyl. #1 - Piston Damping Spring
11. Cyl. #1 - Rod Guide/Spacer

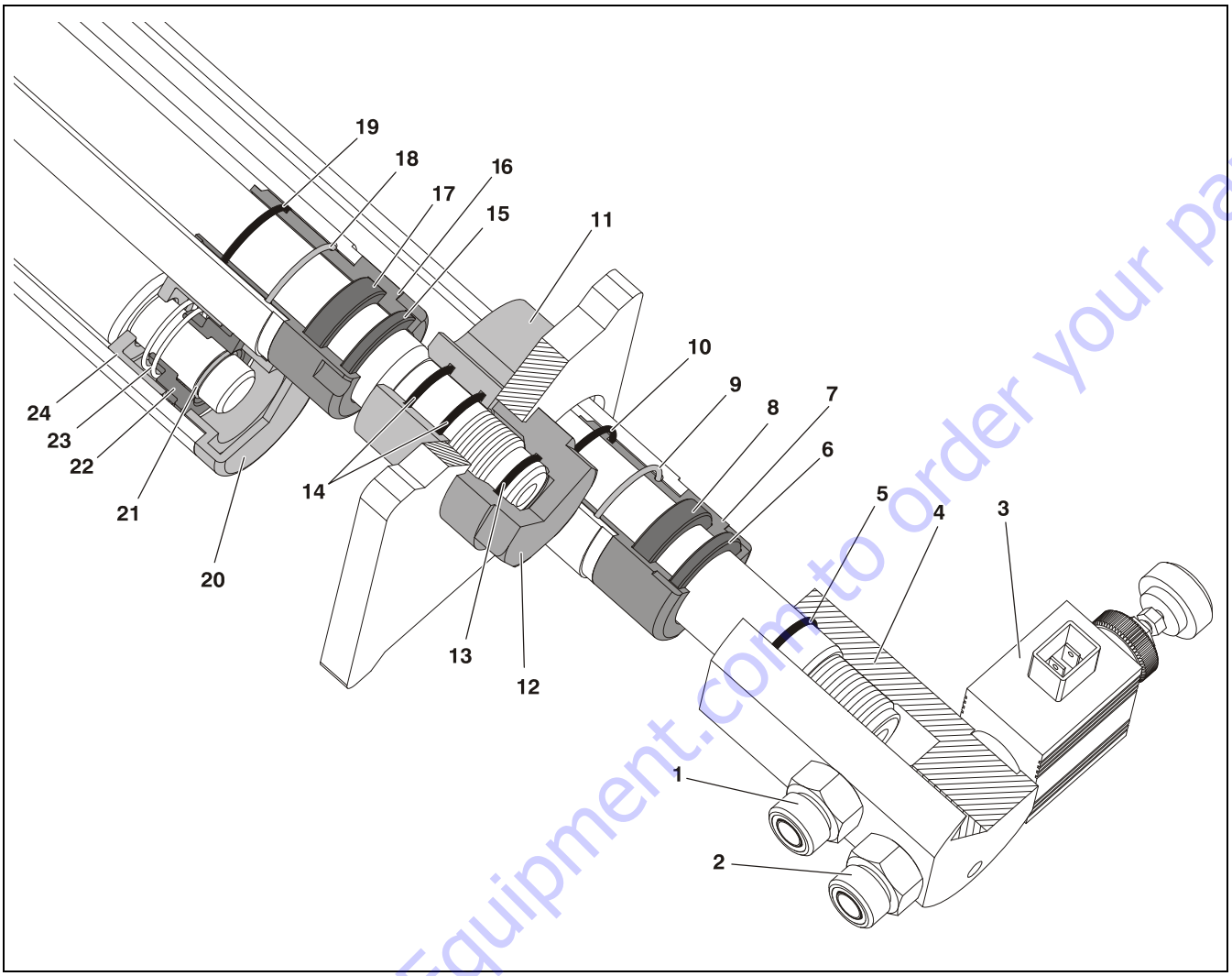


Figure 6-16. 1230ES Lift Cylinder Internal Components - Lower End

1. Extend Port (a)
2. Return Port
3. Proportional Lift Selenoid (b)
4. Valve Port Block (c)
5. O-Ring Seal
6. Cyl. #1 - Rod Wiper Seal
7. Cyl. #1 - Gland (d)
8. Cyl. #1 - Main Seal
9. Cyl. #1 - Gland Wire Retaining Ring
10. Cyl. #1 - O-Ring Seal
11. Cylinder Joint
12. Cyl. #2 and #3 - End Attach Cap (c, d)
13. Cyl. #2 - Cap O-Ring Seal
14. Cyl. #2 - Joint O-Ring Seals
15. Cyl. #2 - Rod Wiper Seal
16. Cyl. #2 - Gland (d)
17. Cyl. #2 - Main Seal
18. Cyl. #2 - Gland Wire Retaining Ring
19. Cyl. #2 - O-Ring
20. Cyl. #3 - Barrel End Cap (e)
21. Cyl. #3 - Piston Retaining Ring
22. Cyl. #3 - Piston
23. Cyl. #3 - Piston Damping Spring
24. Cyl. #3 - Piston Guide Ring

NOTE: *(a) Small orifice rated at 4 GPM (115 Liters/minute).*
(b) The proportional selenoid coil has a 28 ohm rating.
(c) Apply Loctite #242 to the threads of the cylinder rod on final assembly to the valve port block. Torque to 200 Nm (148 ft. lb.).
(d) Removeable.
(e) Fixed Non-Removeable - Welded to cylinder barrel.

Hydraulic Cylinder - Disassembly

The following disassembly procedures shows the complete disassembly sequence of the cylinder assembly. However, your situation may not require complete disassembly, choose which procedures are required to repair the cylinder assembly for your situation.

NOTICE

DISASSEMBLY OF THE CYLINDER SHOULD BE PERFORMED ON A CLEAN WORK SURFACE IN A DIRT FREE WORK AREA.

Removing the Valve Block Assembly

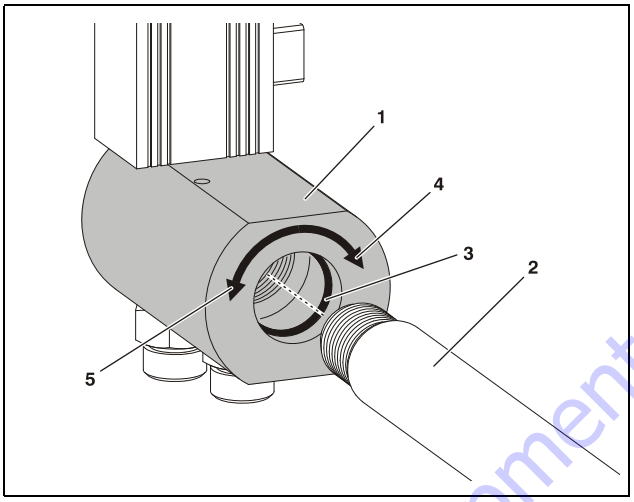


Figure 6-17. Valve Block - Removal

1. Valve Block
2. Cyl. #1 - Cylinder Rod
3. O-Ring Seal
4. Direction for Removing
5. Direction for Installing

NOTICE

PROTECT THE CYLINDER ROD SURFACE. DAMAGE TO THE CYLINDER ROD CHROME FINISH DUE TO SCRATCHING, INDENDATION, CHIPPING OR OTHERWISE WILL CAUSE EVENTUAL GLAND SEAL FAILURE. THE CYLINDER ROD MUST BE REPLACED IF DAMAGED.

1. Wrap the cylinder rod to protect it from damage, then clamp the cylinder rod into a vise or device to keep it from turning while removing the valve block assembly.
2. Using the proper size wrench, (approx. 55mm - 2.165"), turn the valve block assembly counterclockwise to remove it from the end of the cylinder rod.

Cylinder #2 and #3 - Removal from Stack

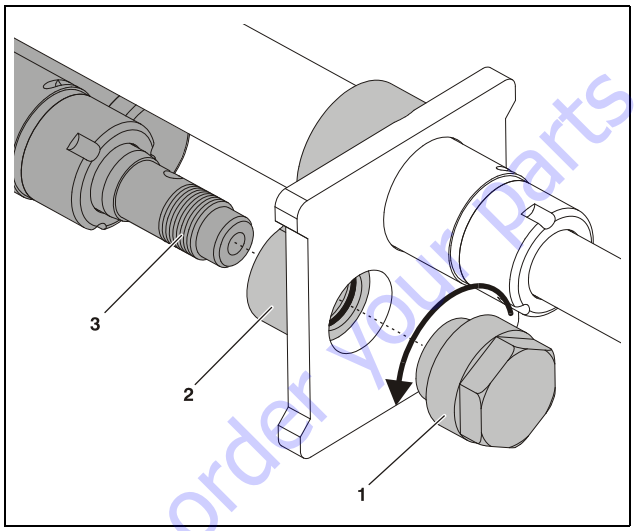


Figure 6-18. Cylinder #2 and #3 Assembly - Removal

1. Rod Attach Cap
2. Cylinder Joint
3. Cyl. #2 and #3 Assembly

1. Using the proper size wrench, (44mm - 1.732") remove cylinder #2 rod attach cap by turning the cap counterclockwise to remove.
2. Once the attach cap is removed from cylinder #2 rod, slide the cylinder #2 and #3 assembly out of the joint sleeve. Move the cylinder #2 and #3 assembly to a suitable workbench for disassembly.

Cylinder Rod Assembly - Removal from the Cylinder Barrel

The following disassembly procedure for removing the gland end of the cylinder is the same for cylinders 1, 2, and 3.

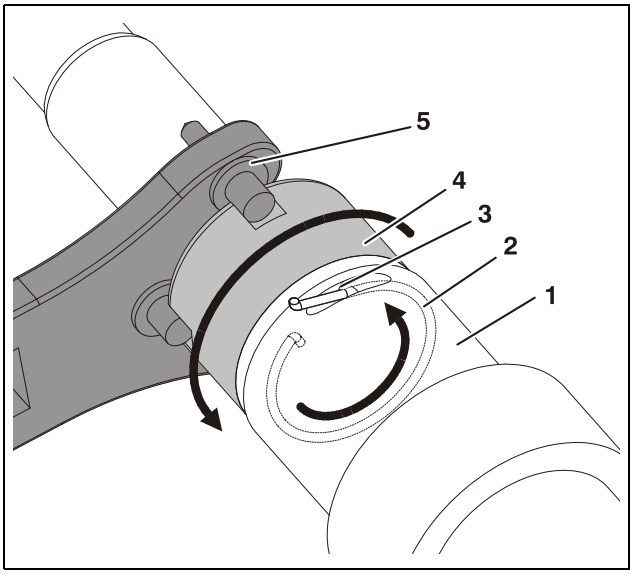


Figure 6-19. Cylinder Rod/Gland - Removal

1. Cylinder Barrel
2. Gland Wire Retaining Ring
3. Retaining Ring Slot/Hole
4. Cylinder Gland
5. Spanner Wrench Tool (48mm - 1.889" Dia.)

1. Using pliers and small screwdriver fish the end of wire retaining ring out of the slot on the gland end of the cylinder barrel.
2. Place the spanner wrench pins (48mm - 1.889" diameter) into the slots in the end of the gland.
3. Now slowly rotate the gland pulling the gland retaining ring out of the slot in the side of the cylinder barrel. Keep rotating gland until the hood end of the retaining ring is aligned with the hole in the slot and lift the retaining ring completely free of the cylinder barrel.
4. Place a container below the end of the cylinder barrel and carefully pull the gland out of the end of the cylinder barrel. Allow any hydraulic oil to drain.

NOTICE

EXTREME CARE SHOULD BE TAKEN WHEN REMOVING THE CYLINDER ROD, HEAD, AND PISTON. AVOID PULLING THE ROD OFF CENTER, WHICH COULD CAUSE DAMAGE TO THE PISTON AND CYLINDER BARREL SURFACES.

5. Carefully slide the rod assembly out of the cylinder barrel and place on a clean surface preferably a workbench.

Piston - Removal from Cylinder Rod

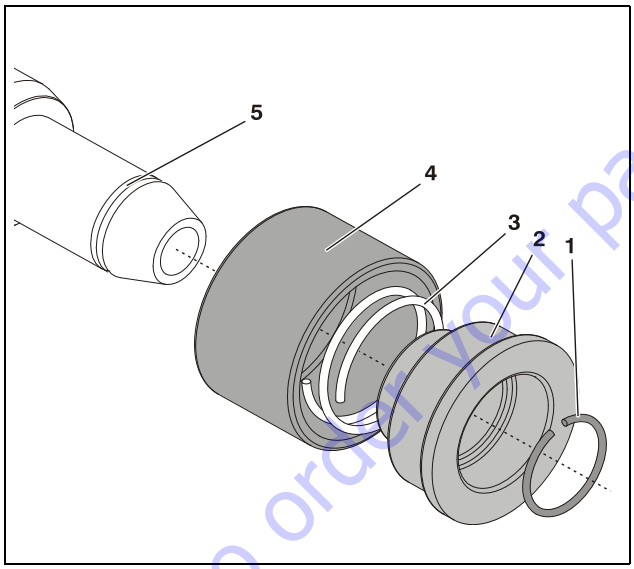


Figure 6-20. Cylinder Rod Piston - Removal

1. Piston Retaining Ring
2. Piston
3. Compression Spring
4. Piston Guide Ring
5. Retaining Ring Slot on Cylinder Rod

1. Remove the piston retaining ring from slot in the end of the cylinder rod.
2. Slide piston, compression spring and piston guide ring off the end of the cylinder rod.

Hydraulic Cylinder Component Inspection

Cylinder Rod

There should be no scratches or pits deep enough to catch the fingernail. Pits that go to the base metal are unacceptable. Scratches that catch the fingernail but are not to the base metal, less than 0.5 inch long and primarily in the circumferential direction are acceptable provided they cannot cut the rod seal. Chrome should be present over the entire surface of the rod and the lack thereof is unacceptable. In the event that an unacceptable condition occurs, the rod should be repaired or replaced.

Cylinder Head (Gland)

Visually inspect the inside bore for scratches or polishing. Deep scratches are unacceptable. Polishing indicates uneven loading and when this occurs, the bore should be checked for out-of-roundness. If out-of-roundness exceed 0.007", this is unacceptable. Check the condition of the dynamic seals (wiper, rod seals) looking particularly for metallic particles embedded in the seal surface. It is normal to cut the static seal on the retaining ring groove upon disassembly. Remove the rod seal, static o-ring and backup and rod wiper. Damage to the seal grooves, particularly on the sealing surfaces, is unacceptable. In the event that an unacceptable condition occurs, the head should be replaced.

Piston

Visually inspect the outside surface for scratches or polishing. Deep scratches are unacceptable. Polishing indicates uneven loading and when this occurs, the diameter should be checked for out-of-roundness. If out-of-roundness exceeds 0.007", this is unacceptable. Check the condition of the dynamic seals and bearings looking particularly for metallic particles embedded in the bearing and in the piston seal surface. Remove the seals and bearings. Damage to the seal grooves, particularly on the sealing surfaces, is unacceptable. In the event that an unacceptable condition occurs, the piston should be replaced.

Tube Assembly

Visually inspect the inside bore for scratches and pits. There should be no scratches or pits deep enough to catch the fingernail. Scratches that catch the fingernail but are less than 0.5 inch long and primarily in the circumferential direction are acceptable provided they cannot cut the piston seal. The roughness of the bore should be between 10 and 20 µ inches RMS. Significant variation (greater than 8 µ inches difference) are unacceptable. In the event that an unacceptable condition occurs, the tube assembly should be repaired or replaced.

Hydraulic Cylinder - Assembly

NOTE: *Prior to cylinder assembly, ensure the proper JLG seal kits are used, see the JLG Parts Manual.*

NOTICE

APPLY A LIGHT FILM OF THE HYDRAULIC OIL TO BE USED FOR OPERATION TO ALL COMPONENTS TO BE ASSEMBLED, EXCEPT THE THREADED AREAS WHERE LOCTITE IS TO BE APPLIED.

Cylinder Assembly

This procedure is same for all three cylinders.

1. Reassemble the piston/compression spring/piston guide onto the end of the cylinder rod secure using the piston retaining ring. *(See Figure 6-20.)*

NOTICE

EXTREME CARE SHOULD BE TAKEN WHEN INSTALLING THE CYLINDER ROD, HEAD, AND PISTON INTO THE CYLINDER BARREL. AVOID PULLING THE ROD OFF CENTER, WHICH COULD CAUSE DAMAGE TO THE PISTON AND CYLINDER BARREL SURFACES.

2. Lubricate the piston assembly and rod with hydraulic oil, slide the rod assembly into the cylinder barrel.
3. Install new o-rings and seals into the cylinder head gland.
4. Lubricate the o-rings and seals with hydraulic oil then carefully slide the gland assembly onto the end of the cylinder rod and into the end of the cylinder barrel.
5. Rotate the gland until the hole for the retaining ring is lined up with the hole in the cylinder barrel.
6. Insert a new retaining ring into the slot with the hook end of the retaining ring facing down and inserted into the hole in the gland. *(See Figure 6-19.)*
7. Using the proper spanner wrench (48mm - 1.889" diameter) slowly rotate the gland 360° until all the retaining ring has pulled into the slot. Fill the open slot with a silicone sealant to prevent dirt from entering.

Cylinder #2 and #3 Assembly to Cylinder #1

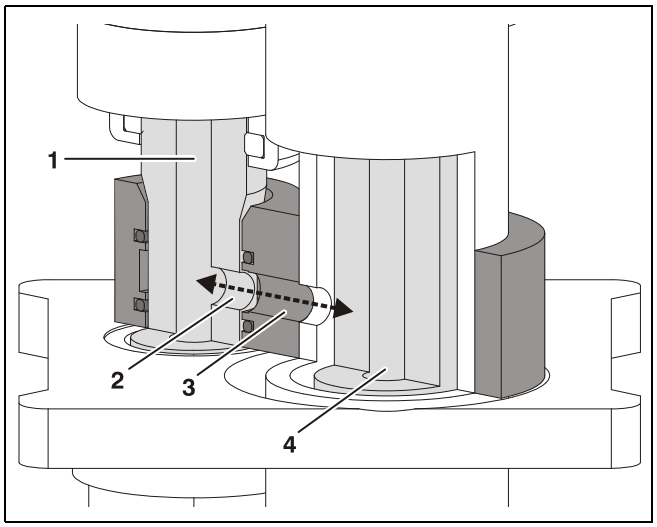


Figure 6-21. Cyl. #2/3 to Cylinder Joint Assembly

1. Cyl. #2 - Cylinder Rod
2. Cyl. #2 - Hole in Rod
3. Passage Hole in Joint
4. Cyl. #1 - Cylinder Rod

1. Replace the o-rings in the cylinder joint and rod attach cap. Lubricate the o-rings with hydraulic oil, however keep any oil off of the threads in the rod attach cap.

NOTE: *The attach cap threads need to be clean and free of oil when assembled to the cylinder rod, so the loctite applied to the cylinder rod threads will set properly.*

2. Lay cylinder #1 assembly and cylinder #2/3 assembly on the workbench in their approximate assembled position.
3. At the bottom end of the cylinder #2/3 assembly, locate the hole on the side of the tapered cylinder rod end on cylinder #2. This hole should be closely aligned with the hole passage inside the cylinder joint of cylinder #1 assembly when assembled. *(See Figure 6-21.)*
4. Just before final assembly apply Loctite #242 to the threads on the tapered end of the cylinder rod of the cylinder #2/3 assembly. Slide the cylinder #2/3 assembly tapered cylinder rod end into the cylinder joint attached to cylinder #1 aligning the hole in the tapered cylinder rod end to the hole in the cylinder joint.
5. Install the rod attach cap to the tapered end of the cylin-der rod and torque the cap to 200 Nm (148 ft. lb.).

Valve Body Installation

NOTICE

PROTECT THE CYLINDER ROD SURFACE. DAMAGE TO THE CYLINDER ROD CHROME FINISH DUE TO SCRATCHING, INDENTATION, CHIPPING OR OTHERWISE WILL CAUSE EVENTUAL GLAND SEAL FAILURE. THE CYLINDER ROD MUST BE REPLACED IF DAMAGED.

1. Lubricate and place a new o-ring in the groove on the tapered end of cylinder rod #1.

NOTE: *The cylinder rod and valve body threads need to be clean and free of oil when the valve body is assembled to the cylinder assembly, so the loctite applied to the cylinder rod threads will set properly.*

2. Clean the threads of the tapered end of the cylinder rod of cylinder #1 and apply Loctite #242 to the threads.
3. Apply a light film of hydraulic oil to the rod surface above the threaded area to lubricate the o-ring when installing the valve body to the cylinder rod end.
4. Be certain the threads inside the valve body are clean and dry of any debris or oil.
5. Using the proper fixture to keep the cylinder rod from turning and protect the cylinder rod from damage, insert the valve body onto the end of the cylinder rod and tighten, then torque to 200 Nm (148 ft. lb.).

Hydraulic Cylinder Assembly Testing

If a hydraulic cylinder testing fixture is not available to fully pressurize the cylinder, then the cylinder must be checked for proper operation and leaks after installation of the mast assembly to the machine.

NOTICE

IF A TEST FIXTURE IS USED TO TEST THE HYDRAULIC CYLINDER, DO NOT EXCEED THE MAXIMUM RATED PRESSURE SETTING OF THE HYDRAULIC SYSTEM. (SEE SECTION-1 SPECIFICATIONS FOR MAXIMUM HYDRAULIC SYSTEM PRESSURE SETTINGS.)

SECTION 7. JLG CONTROL SYSTEM

7.1 ELECTRONIC CONTROL SYSTEM

To Connect the Hand Held Analyzer:

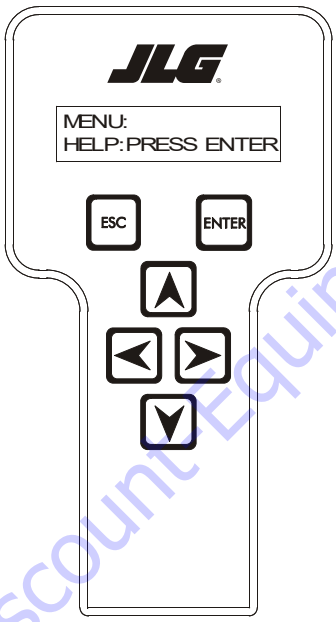
1. Connect the four pin end of the cable supplied with the analyzer, to the four position connector on the PCB and connect the remaining end of the cable to the analyzer.

NOTE: *The cable has a four pin connector at each end of the cable; the cable cannot be connected backwards.*

2. Power up the Control System by turning the lower key to the platform position and pulling both emergency stop buttons on.

Using the Analyzer:

With the machine power on and the analyzer connected properly, the analyzer will display the following:



HELP:

PRESS ENTER

At this point, using the **RIGHT** and **LEFT** arrow keys, you can move between the top level menu items. To select a displayed menu item, press **ENTER.** To cancel a selected menu item, press **ESC**; then you will be able to scroll using the right and left arrow keys to select a different menu item.

The top level menus are as follows:

(Also see menu flow charts - Figure 7-1. and Figure 7-2.)

HELP

DIAGNOSTICS

ACCESS LEVEL

PERSONALITIES (See Table 7-3 on Page 7-14)

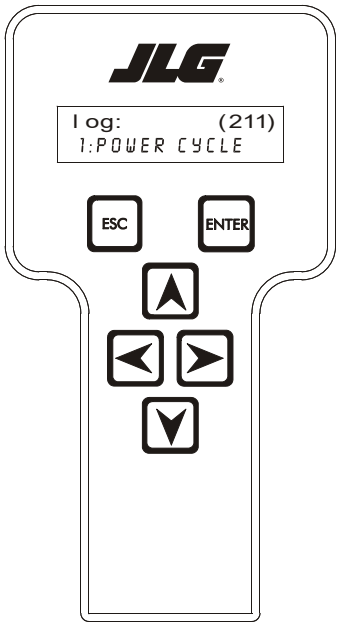
MACHINE SETUP (See Table 7-1 on Page 7-11)

ACTIVATE TESTS

CALIBRATION

If you press **ENTER**, at the HELP:PRESS ENTER display, and a fault is present during power up, the analyzer display will scroll the fault across the screen. If there was no fault detected during power up, the display will read:
In platform mode**,**
HELP: (001)
EVERYTHING OK,
In ground mode**,**
HELP: (002)
GROUND MODE OK

If **ENTER** is pressed again, the display moves to the following display:



LOGGED HELP

LOG: (211)
1: Power Cycle (Or last recorded fault)

At this point, the analyzer will display the current fault, if any are present. You may scroll through the fault logs to view what

the last fifteen faults were. Use the right and left arrow keys to scroll through the fault logs. To return to the beginning, press **ESC** two times.

When a top level menu is selected, a new set of menu items may be offered;
If for example you choose Personalities:

DRIVE

LIFT

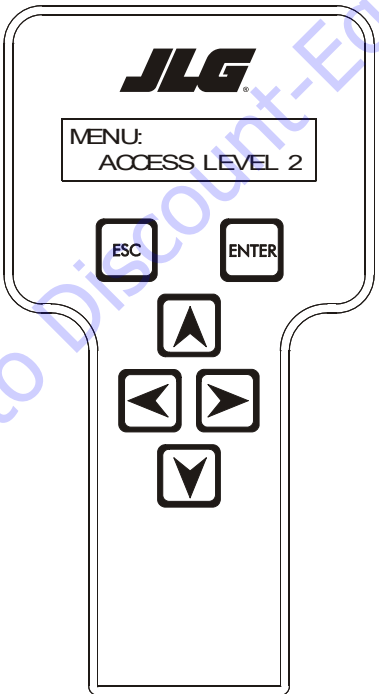
STEER

GROUND

Pressing **ENTER** with any of the above displayed menus, will display additional sub-menus within the selected menu. In some cases the next level is the parameter or information to be changed. Refer to the flow chart for what menus are available within the top level menus. You may only view the personality settings for selected menus while in access level 2. Remember, you may always cancel a selected menu item by pressing the **ESC** key.

Changing the Access Level of the Hand Held Analyzer:

When the analyzer is first connected, you will be in access level 2 which enables you to only view most configuration settings which cannot be changed until you enter a password to advance to a lower level. This ensures that a setting cannot be accidentally altered. To change the access level, the correct password must be entered. To enter the password, scroll to the **ACCESS LEVEL** menu.



For example:

MENU:

ACCESS LEVEL 2

Press **ENTER** to select the **ACCESS LEVEL** menu.

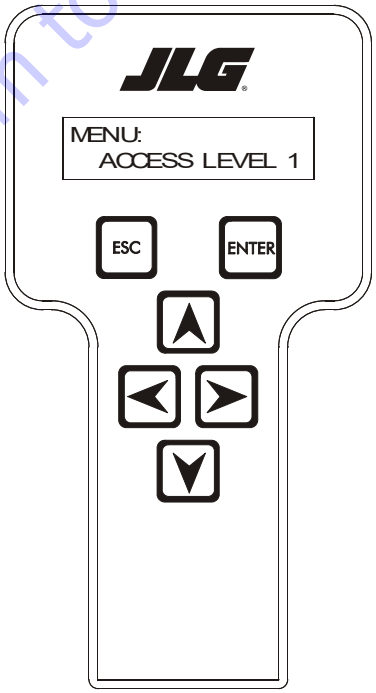
Using the **UP** or **DOWN** arrow keys, enter the first digit of the password, 3.

Then using the **RIGHT** arrow key, position the cursor to the right one space to enter the second digit of the password.

Use the **UP** or **DOWN** arrow key to enter the second digit of the password which is 3.

Repeat this process until you have entered all five digits of the password which is **33271**.

Once the correct password is displayed, press **ENTER**. The access level should display the following, if the password was entered correctly:



MENU:

ACCESS LEVEL 1

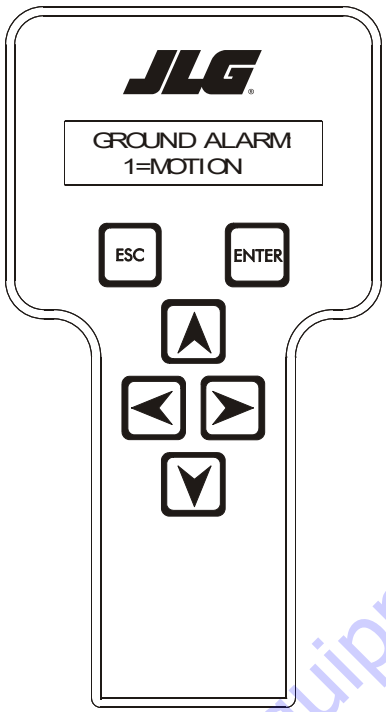
Repeat the above steps if the correct access level is not displayed or you can not adjust the personality settings:

Machine Setup

When a machine digit item is selected, press the **UP** or **DOWN** arrow keys to adjust its value.

⚠ WARNING

FAILURE TO MAKE THE PROPER SETTINGS FOR THE PARTICULAR MACHINE CAN RESULT IN IMPROPER OPERATION.



For example:

GROUND ALARM:

1=MOTION

The effect of the machine digit value is displayed along with its value. The above display would be selected if the machine was equipped with a ground alarm and you wanted it to sound when driving. There are certain settings allowed to install optional features or select the machine model.

When selecting the machine model to match the size of the machine, the personality settings will return to default settings.

NOTE: *Refer to the appropriate Machine Personality Settings Table, and the Machine Setup Table on the following pages in this Service Manual for the default settings.*

Password 33271 will give you access to level 1, which will permit you to change all machine personality and/or machine setup settings.

⚠ WARNING

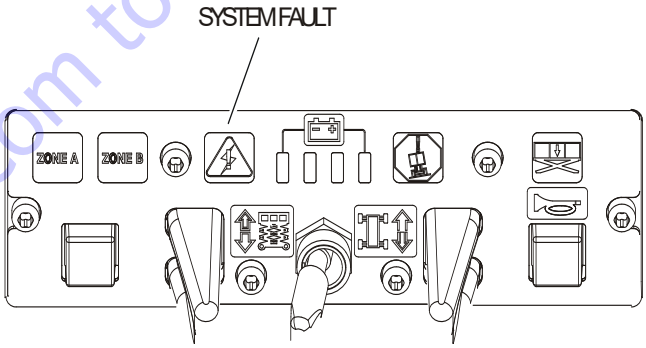
CHANGING THESE SETTINGS MAY ADVERSELY AFFECT THE PERFORMANCE OF YOUR MACHINE.

NOTICE

IT IS A GOOD PRACTICE TO AVOID PRESSURE-WASHING ELECTRICAL/ELECTRONIC COMPONENTS. SHOULD PRESSURE-WASHING BE UTILIZED TO WASH AREAS CONTAINING ELECTRICAL/ELECTRONIC COMPONENTS, JLG INDUSTRIES, INC. RECOMMENDS A MAXIMUM PRESSURE OF 750 PSI (52 BAR) AT A MINIMUM DISTANCE OF 12 INCHES (30.5 CM) AWAY FROM THESE COMPONENTS. IF ELECTRICAL/ELECTRONIC COMPONENTS ARE SPRAYED, SPRAYING MUST NOT BE DIRECT AND BE FOR BRIEF TIME PERIODS TO AVOID HEAVY SATURATION.

Diagnostic Trouble Codes (DTC)

DTC (Diagnostic Trouble Codes) are indicated on the face of the platform control box as shown:



NOTE: *Flash codes are also displayed on the handheld analyzer. For descriptions see Section 8, DIAGNOSTIC TROUBLE CODES*

ANALYZER SCREEN LAYOUT

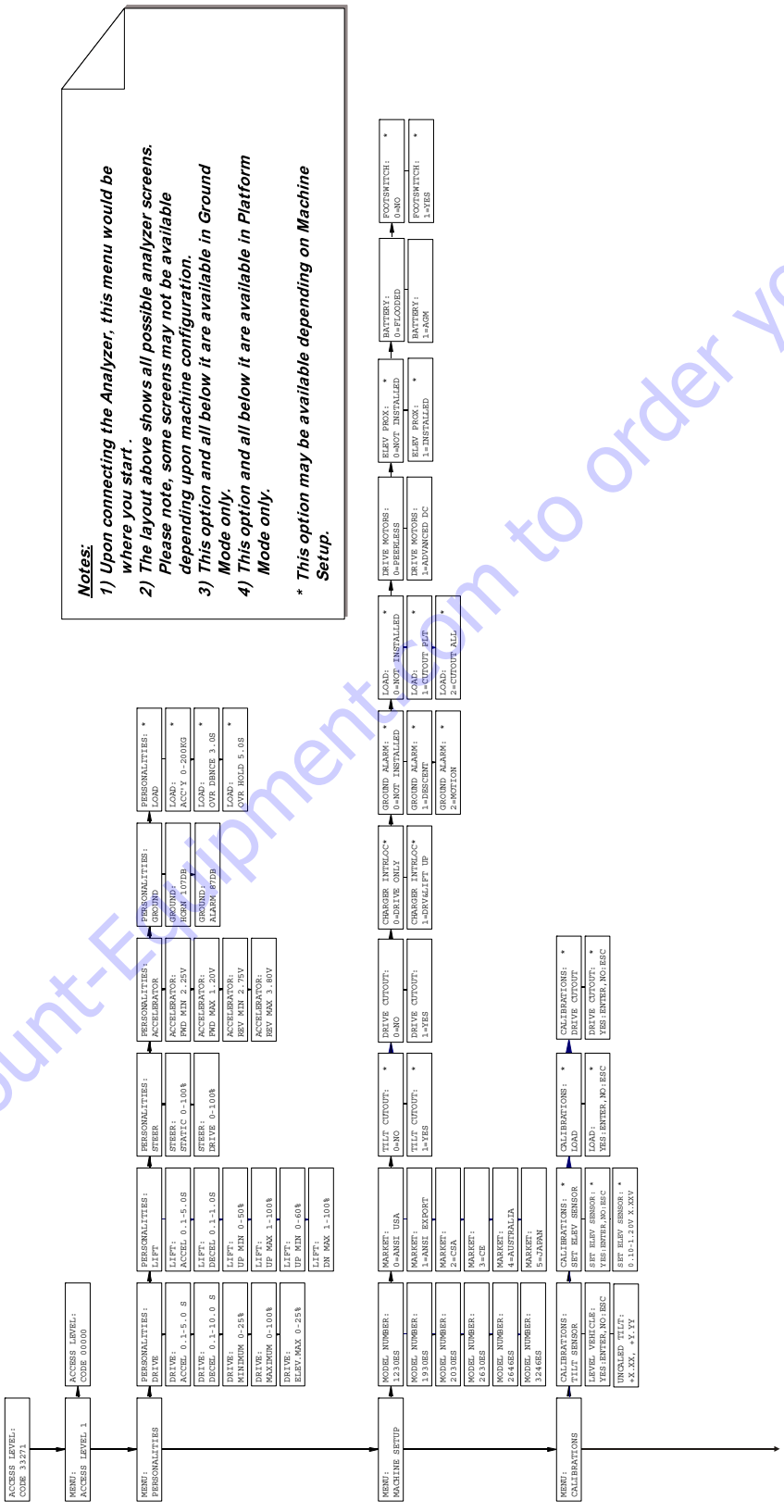


Figure 7-1. Analyzer Menu Flow Chart - Sevcon vP1.14 - Sheet 1 of 2 - (4170032 -15)

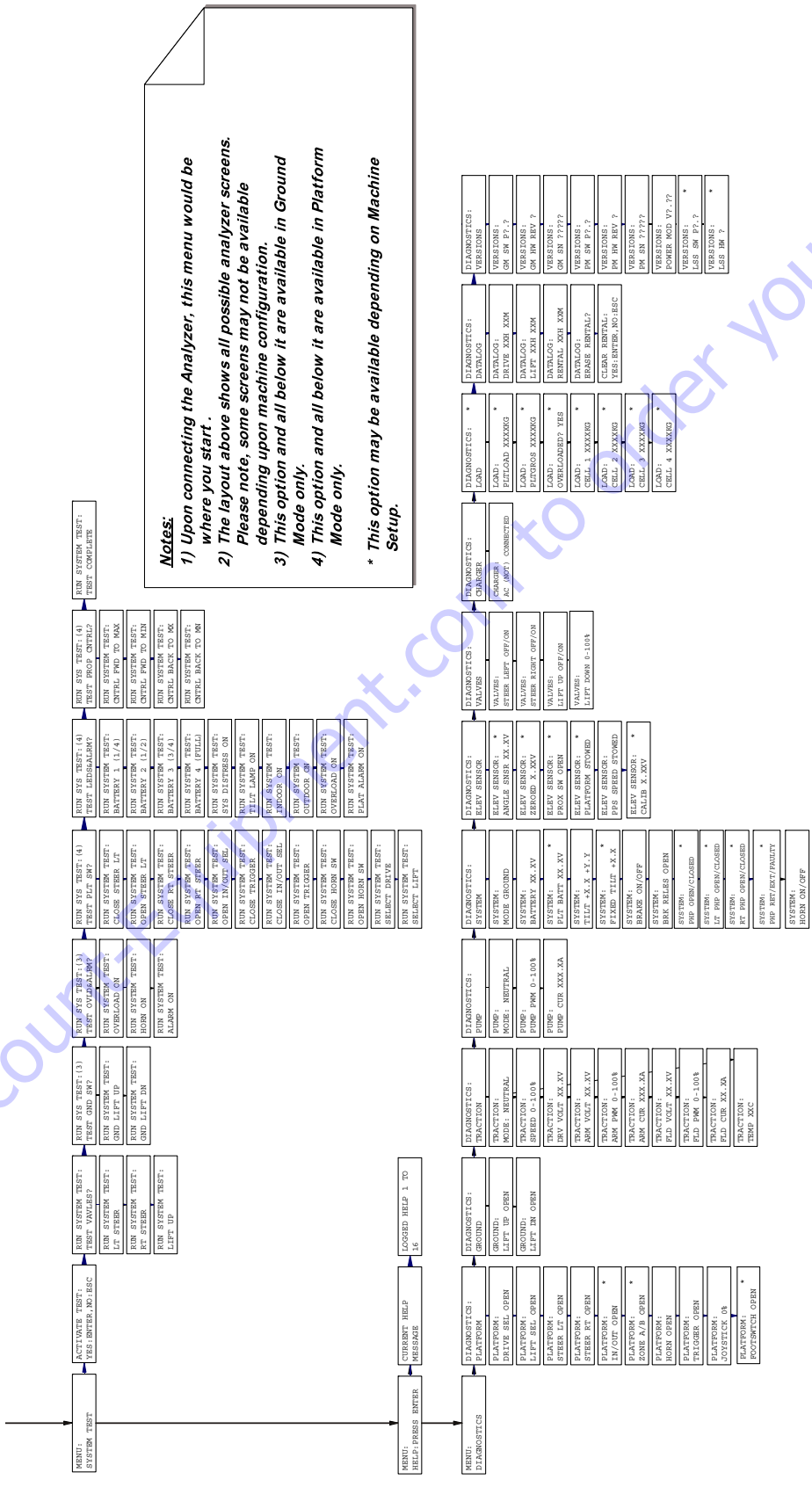


Figure 7-2. Analyzer Menu Flow Chart - Sevcon vP1.14 - Sheet 2 - (4170032 - 15)

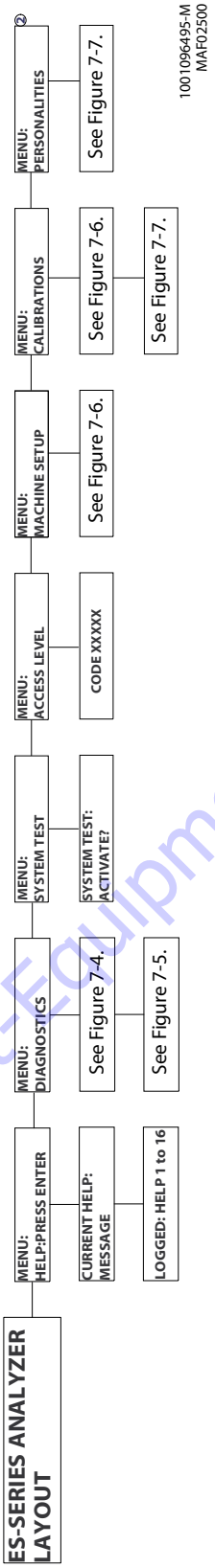


Figure 7-3. Analyzer Menu Flow Chart (Software Version P1.12) - Sheet 1 of 5 (Machines Equipped with ZAPI - 1001092456 Power Module Only)

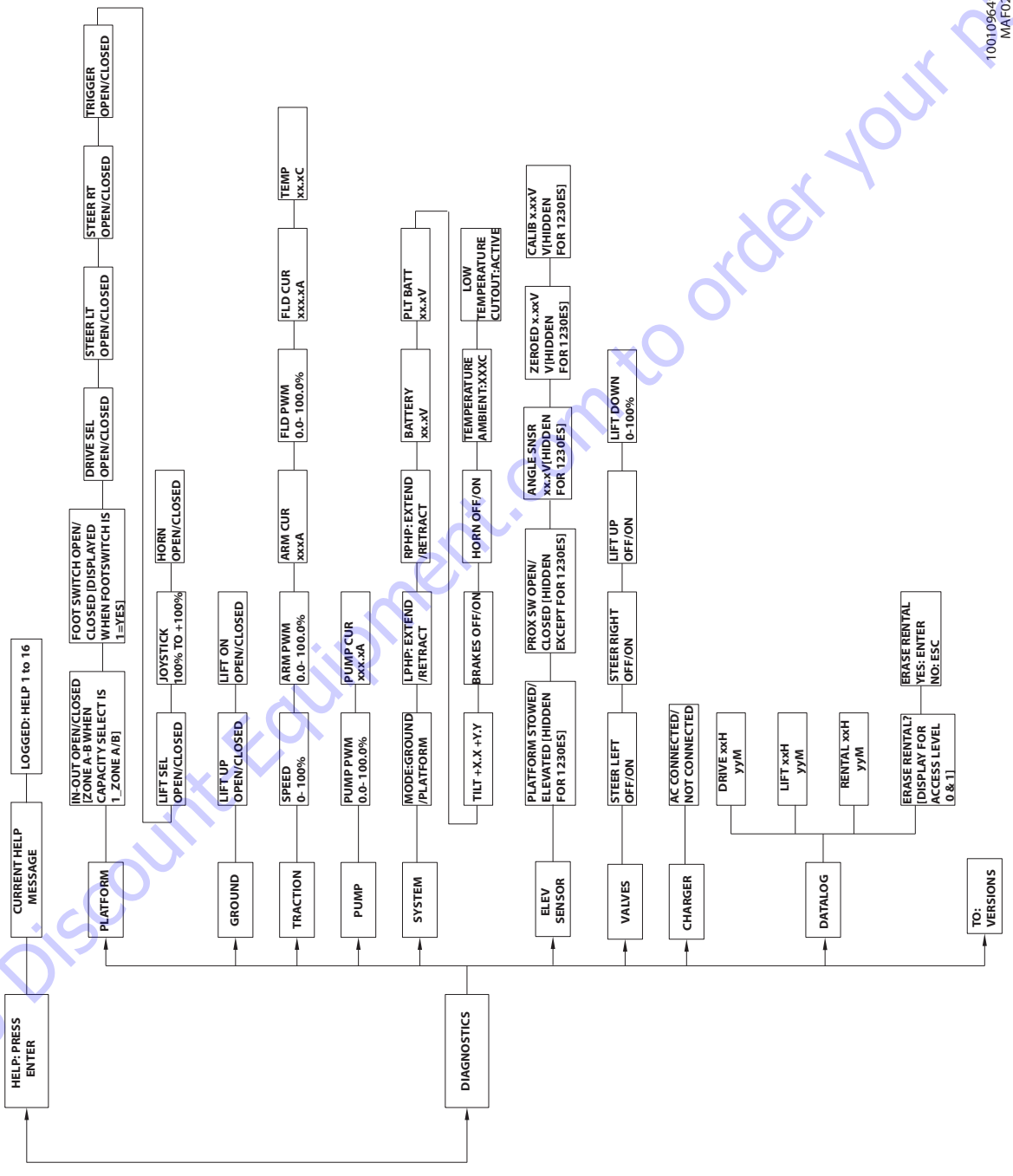


Figure 7-4. Analyzer Menu Flow Chart (Software Version P1.12) - Sheet 2 of 5 (Machines Equipped with ZAPI - 1001092456 Power Module Only)

Figure 7-5. Analyzer Menu Flow Chart (Software Version P1.12) - Sheet 3 of 5 (Machines Equipped with ZAPI - 1001092456 Power Module Only)

Figure 7-6. Analyzer Menu Flow Chart (Software Version P1.12) - Sheet 4 of 5 (Machines Equipped with ZAPI - 1001092456 Power Module Only)

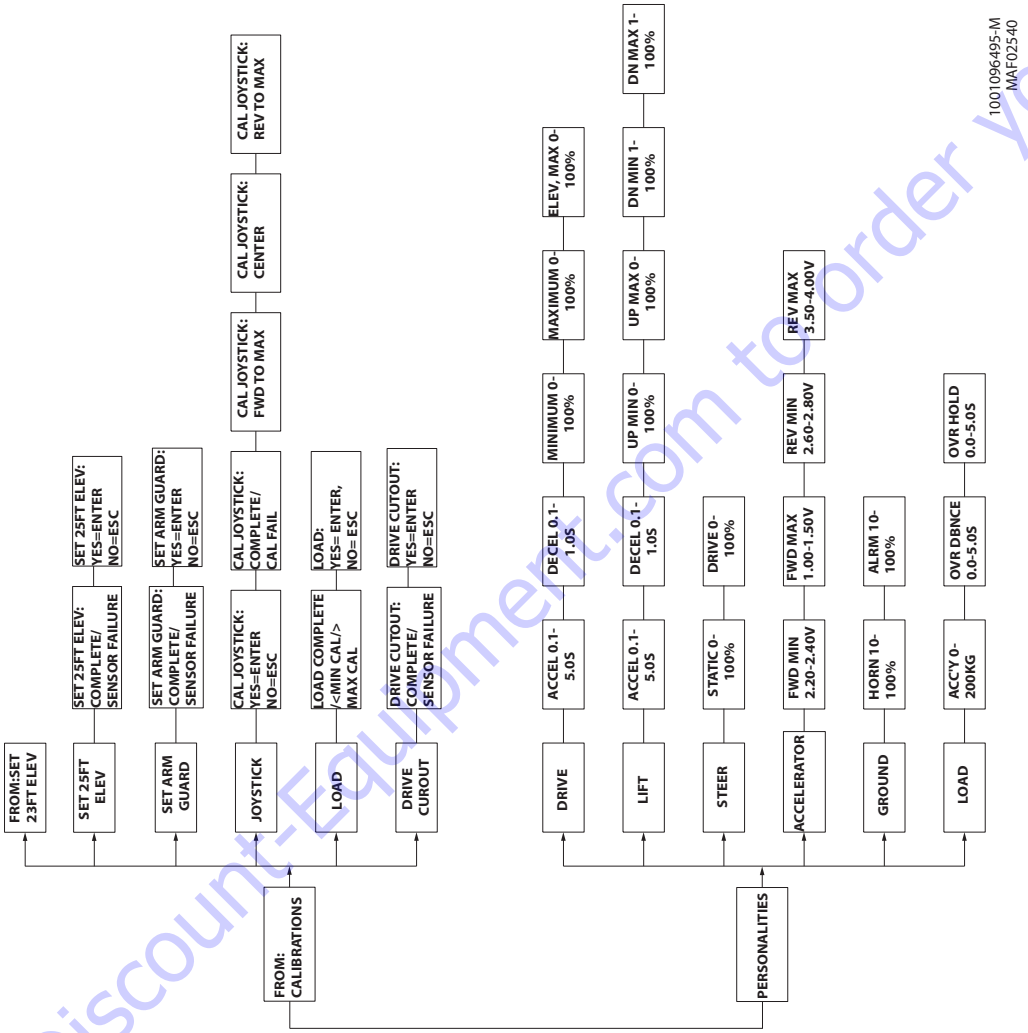


Figure 7-7. Analyzer Menu Flow Chart (Software Version P1.12) - Sheet 5 of 5 (Machines Equipped with ZAPI - 1001092456 Power Module Only)

7.2 MACHINE CONFIGURATION PROGRAMMING INFORMATION

NOTE: *When configuring an 1230ES machine, the machine configuration must be completed before any personality settings can be changed. Changing the personality settings first and then changing the model number of the machine configuration will cause the personality settings to return to default.*

Shaded entries are not available for the selected market.

Table 7-1. Machine Configuration Programming Information(Software Version P1.14)
Machines Equipped with Sevcon (1600346) Power Module ONLY

Configuration Digit	Setting Range	Description	Model Default Setting per Market					
			0	1	2	3	4	5
1 (Model #)	0 1 2 3 4 5	1230ES 1930ES 2030ES 2630ES 2646ES 3246ES	0	0	0	0	0	0
2 (Market)	0 1 2 3 4 5	ANSI USA ANSI EXPORT CSA CE AUSTRALIA JAPAN	0	0	0	0	0	0
3 (Tilt Cutout)	0 1	NO - Drive and lift up NOT PREVENTED while tilted (Ground and Platform Mode). YES - Drive and lift up PREVENTED while tilted (Ground and Platform Mode).	1	1	1	0	1	1
4 (Drive Cutout)	0 1	NO - Drive and lift up NOT PREVENTED while elevated. YES - Drive and lift up PREVENTED while elevated.	0	0	0	0	0	0
5 (Charger Interlock)	0 1	DRIVE ONLY - Drive motion PREVENTED while vehicle is charging. DRIVE AND LIFT UP - Drive and lift up motions ARE PREVENTED while vehicle is charging. Required for CE.	0	0	0	0	0	0
6 (Ground Alarm)	0 1 2	NOT INSTALLED - Vehicle alarm will function for Arm Guard (if enabled), Overload (if LSS enabled), and as a horn. DESCENT - Vehicle alarm will function for Arm Guard (if enabled), Overload (if LSS enabled), as a horn and during Lift Down motion. MOTION - Vehicle alarm will function for Arm Guard (if enabled), Overload (if LSS enabled), as a horn and during Drive and Lift motion.	2	2	2	0	2	2
7 (Load)	0 1 2	NOT INSTALLED – Load Sensing System (LSS) is not fitted to the vehicle CUTOUT PLT – Load Sensing System (LSS) is fitted, and Platform Controls are prevented in the event of an Overload. Ground Controls remain functional. This is the default setting for CE machines. CUTOUT ALL – Load Sensing System (LSS) is fitted. Platform and Ground Controls are prevented in the event of an Overload.	o	1	0	1	0	1
8 (Drive Motors)	0 1	PEERLESS - Vehicle is fitted with Peerless drive motors. ADVANCED DC - Vehicle is fitted with Advanced DC drive motors.	1	1	1	1	1	1
9 (Elev. Prox.)	0 1	0=NOT INSTALLED – Vehicle is not fitted with an Elevation Prox Sensor. Vehicle has Left & Right Brake Release Outputs, and Maintained Brake Release functionality. 1=INSTALLED – Vehicle is fitted with an Elevation Prox Sensor (original ES-Series). Vehicle has a single Brake Release Output, and Momentary Brake Release functionality.	0	0	0	0	0	0
10 (Battery)	0 1	0=FLOODED – Batteries are conventional lead-acid type. 1=AGM – Batteries are absorbed glass mat type.	0	0	0	0	0	0
11 (Footswitch)	0 1	NO - Vehicle is not fitted with a footswitch YES - Vehicle is fitted with a footswitch	0	0	0	0	0	1

Table 7-2. Machine Configuration Programming Information (Software Version P1.12)
(Machines Equipped with ZAPI - 1001092456 Power Module Only)

Configuration Digit	Setting Range	Description	Model Default Setting per Market						
			0	1	2	3	4	5	6
1 (Model 1)	0 1 2 3 4 5	1230ES 1930ES 2030ES 2630ES 2646ES 3246ES	0						
2 (Market)	0 1 2 3 4 5 6	ANSI USA ANSI EXPORT CSA CE AUSTRALIA JAPAN KOREA	0						
3 (Tilt Cutout)	0 1	NO - Drive and lift up NOT PREVENTED while tilted (Ground and Platform Mode). YES - Drive and lift up PREVENTED while tilted (Ground and Platform Mode).	1	1	1	1	1	1	1
4 (Drive Cutout[3])	0 1	NO - Drive and lift up NOT PREVENTED while elevated. YES - Drive and lift up PREVENTED while elevated.	0						
5 (Charger Interlock)	0 1	DRIVE ONLY - Drive motion PREVENTED while vehicle is charging. DRV & LIFT UP - Drive and lift up motions are PREVENTED while vehicle is charging. Required for CE.	0	0	0	0	0	0	0
6 (Ground Alarm)	0 1 2	NOT INSTALLED - Vehicle alarm will function for Arm Guard (if enabled), Overload (if LSS enabled), and as a horn. DESCENT - Vehicle alarm will function for Arm Guard (if enabled), Overload (if LSS enabled), as a horn and during Lift Down motion. MOTION - Vehicle alarm will function for Arm Guard (if enabled), Overload (if LSS enabled), as a horn and during Drive and Lift motion.	2	2	2	0	2	2	2
7 (Load[3])	0 1 2	NOT INSTALLED – Load Sensing System (LSS) is not fitted to the vehicle CUTOUT PLT – Load Sensing System (LSS) is fitted, and Platform Controls are prevented in the event of an Overload. Ground Controls remain functional. This is the default setting for CE machines. CUTOUT ALL – Load Sensing System (LSS) is fitted. Platform and Ground Controls are prevented in the event of an Overload.	1	1	1	2	1	1	1
8 (Battery)	0 1	0=FLOODED – Batteries are conventional lead-acid type. 1=AGM – Batteries are absorbed glass mat type.	0						
9 (Footswitch)	0 1	NO - Vehicle is not fitted with a footswitch YES - Vehicle is fitted with a footswitch	0	0	0	0	0	1	1
10 (WHT. Noise Alarm)	0 1	0=NO – Vehicle is not fitted with a White Noise Alarm. 1=YES– Vehicle is fitted with a White Noise Alarm.	0	0	0	0	1	0	0
11 (Low Temp Cutout)	0 1	NO - Vehicle is not fitted with a Low Temperature Cutout. YES - Vehicle is fitted with a Low Temperature Cutout.	0	0	0	0	0	0	0

Table 7-2. Machine Configuration Programming Information (Software Version P1.12)
(Machines Equipped with ZAPI - 1001092456 Power Module Only)

Configuration Digit	Setting Range	Description	Model Default Setting per Market						
			0	1	2	3	4	5	6
12 (Beacon)	0 1 2	0 = NO-Vehicle is not configured for the Beacon Option. 1=YES- Vehicle is configured for the Beacon Option. 2= NO RELAY- Vehicle does not have a beacon relay and is configured to work PRE-EN280.	0	0	0	0	0	0	0
13 (PHP Alarm)	0 1	0 = NO-Vehicle is not configured for PHP Alarm when Pothole bar is blocked. 1=YES- Vehicle is configured for PHP Alarm when Pothole bar is blocked.	0	0	0	0	0	0	0

1001115626-H

7.3 MACHINE PERSONALITY - ADJUSTMENT SETTINGS

Table 7-3. Machine Personality Adjustment - Machines Equipped with Sevcon (1600346) Power Module

Function	Adjustment Range	1230ES (Factory Setting)
DRIVE		
ACCEL	0.1 - 5.0 (Sec)	0.8
DECEL	0.1 - 1.0 (Sec)	1.0
MINIMUM	0 - 25%	0
MAXIMUM	0 - 100%	100
ELEV. MAX.	0 - 25%	18
LIFT		
ACCEL	0.1 - 5.0 (Sec)	0.5
DECEL	0.1 - 1.0 (Sec)	0.1
UP MIN	0 - 50%	10
UP MAX	0 - 100%	100
DN MIN	1 - 60%	42
DN MAX	0 - 100%	61
STEER		
STATIC	0 - 100%	100
DRIVE	0 - 100%	60
ACCELERATOR		
FWD MIN	2.20 - 2.40 V	2.25
FWD MAX	1.00 - 1.50 V	1.20
REV MIN	2.60 - 2.80 V	2.75
REV MAX	3.50 - 4.00 V	3.80
GROUND		
HORN	87 - 107 dB	107
ALARM	87 - 107 dB	87
LOAD		
ACCY	0 - 200 Kg	N/A
OVR DBNCE	0.0 - 5.0 Sec	N/A
OVR HOLD	0.0 - 5.0 Sec	N/A

NOTE: *These settings may change in order to achieve optimal performance on a machine by machine basis.*

Table 7-4. Machine Personality Adjustment - Machines Equipped with ZAPI (1001092456) Power Module

Function	Adjustment Range	1230ES (Factory Setting)
DRIVE		
ACCEL	0.1 - 5.0 (Sec)	0.8
DECEL	0.1 - 1.0 (Sec)	1.0
MINIMUM	0 - 25%	0
MAXIMUM	0 - 100%	100
ELEV. MAX.	0 - 30%	25
LIFT		
ACCEL	0.1 - 5.0 (Sec)	0.5
DECEL	0.1 - 1.0 (Sec)	0.1
UP MIN	0 - 50%	20
UP MAX	0 - 100%	100
DN MIN	1 - 60%	45
DN MAX	0 - 100%	85
STEER		
STATIC	0 - 100%	100
DRIVE	0 - 100%	60
ACCELERATOR		
FWD MIN	2.20 - 2.40 V	2.23
FWD MAX	1.00 - 1.50 V	1.19
REV MIN	2.60 - 2.80 V	2.74
REV MAX	3.50 - 4.00 V	3.78
GROUND		
HORN	87 - 107 dB	107
ALARM	87 - 107 dB	87
LOAD		
ACCY	0 - 200 Kg	0
OVR DBNCE	0.0 - 5.0 Sec	3.0
OVR HOLD	0.0 - 5.0 Sec	5.0

NOTE: *These settings may change in order to achieve optimal performance on a machine by machine basis.*

7.4 TILT SENSOR CALIBRATION

Be sure that the machine is parked and stowed on level ground.

Ground Module Software Version 1.5

1. Enter Access Level 1 and go to the CALIBRATION/TILT SENSOR/LEVEL VEHICLE screen.
2. Choose the right arrow key to view the raw, uncalibrated tilt sensor values. If either raw angle reads ±5.0 or more, the machine is too unlevel and the software will prohibit calibration. Therefore, attempt to dissect the three areas of error to find the primary contributor:
   - **a.** Machine mounting and/or grade:
     Try to measure the top of the Ground Control box for levelness. If unable to get a good reading, unbolt the Ground Control box and check the box's mounting surface for levelness.
   - **b.** Tilt sensor mounting on machine or wedged crooked in control box:
     If the machine mounting/grade appears acceptable, remove and open the Ground Control box carefully. Observe whether the tilt sensor is properly seated in its grooves.
   - **c.** Tilt sensor has developed an offset shift: Remove the tilt sensor from the Ground Control box but keep both the tilt sensor and Ground Control box electrically connected. Level one axis of the tilt sensor and observe the raw reading (should be within ± 2.0). Do the same for the other axis. If either axis is greater than ±2.0, replace the tilt sensor.

Ground Module Software Version 1.4

3. Enter Access Level 1 and go to the CALIBRATION/TILT SENSOR/LEVEL VEHICLE screen.
4. Choose the right arrow key to view the raw, uncalibrated tilt sensor values. If either raw angle reads ±5.0 or more, the machine is too unlevel and the software will prohibit calibration. Therefore, attempt to dissect the three areas of error to find the primary contributor:
   - **a.** Machine mounting and/or grade:
     Try to measure the top of the Ground Control box for levelness. If unable to get a good reading, unbolt the Ground Control box and check the box's mounting surface for levelness.
   - **b.** Tilt sensor mounting on machine or wedged crooked in control box.:
     If the machine mounting/grade appears acceptable, remove and open the Ground Control box carefully. Observe whether the tilt sensor is properly seated.
   - **c.** Tilt sensor has developed an offset shift:
     Remove the tilt sensor from the Ground Control box but keep both the tilt sensor and Ground Control box electrically connected. Level one axis of the tilt sensor and observe the raw reading (should be within ± 2.0). Do the same for the other axis. If either axis is greater than ± 2.0, replace the tilt sensor.

Calibration Failures

Some possible reasons that the tilt sensor won't calibrate are:

- **a.** The surface the machine is sitting on is off level by a few degrees (flat doesn't imply level; parking lots are often not level).
- **b.** The tilt sensor has failed one or both of the channels (X axis and Y axis).
- **c.** Tilt sensor has moisture intrusion that has shifted its output.
- **d.** Water and/or corrosion in the box has corrupted electrical connections or caused a tilt sensor or ground control board failure (observe any cracks in the box)
- **e.** The Ground Control Box, as mounted on the machine, does not allow the tilt sensor to be level.

For the following troubleshooting steps, a bubble level (smaller is better) will be needed and the machine must be on a level surface:

1. On the Analyzer, go the Diagnostics/System and read the tilt angle. If either angle reports +20.0°, there is an electrical/electronic failure (tilt sensor, control board, electrical connections).
   - **a.** Take the Ground Control box off of the machine and open.
   - **b.** Disconnect the sensor and clean any corrosion off of the tilt sensor and control board connections.
   - **c.** Reassemble and test. If fault persists, replace tilt sensor.
2. If the Analyzer displays angles other than +20.0°, attempt to calibrate. If machine won't calibrate, note the reason displayed on Analyzer:
   - **a.** SENSOR FAILURE – tilt sensor internal frequency is out of range (replace sensor).
   - **b.** NOT LEVEL - tilt sensor has either developed an offset or it is too unlevel as mounted on the machine.

7.5 TILT SENSOR ELECTRICAL EVALUATION

This basic check using the JLG Analyzer can be used to test the Tilt Sensor.

- **If angle measurements read +20.0, then a sensor/wiring/connector fault exists.** If the readings intermittently display expected angles, then there is likely a wiring/connector problem and not a failed sensor. In either case, open the ES Ground box. Disconnect the sensor, check the wire terminations, and clean any corrosion on the tilt sensor and control board connections. Reconnect and test. If the fault persists, replace the tilt sensor and return the faulty tilt sensor to JLG with a detailed description of the diagnostic steps taken.

7.6 ELEVATION ANGLE SENSOR ELECTRICAL EVALUATION

These basic checks using the JLG Analyzer can be used to test the Elevation Atrecrqwetngle Sensor. If the problem is still occurring, perform the Tilt vs. Allowed Height Evaluation described below.

- **On a level surface, with the Analyzer under DIAGNOSTICS/ELEV SENSOR, verify that the elevation angle sensor voltage increases (ranges from 0.2V-0.8V to 3.6V-4.2V) with platform height.** If not, check the sensor mounting. If necessary, unbolt sensor and rotate by hand while monitoring with the Analyzer to check the integrity of the sensor output.
- **For machines equipped with an elevation proximity switch, if the Elevation Sensor appears satisfactory, verify that the Elevation Prox switch is opening and closing appropriately** by watching the change of state between the stowed and elevated positions (monitor PROX SWITCH under DIAGNOSTICS/ELEV SENSOR). If a change of state is not observed, check prox mounting and operability by placing metal in front of the prox sensor face.

Tilt vs. Allowed Height Evaluation

First, find a level surface (not just flat like a parking lot; must be level). The surface should be a plane in which the wheels are within 0°±0.2°. Find this surface by taking a digital level and measuring the areas on which the wheels would rest in both the X and Y directions. Mark the locations and drive the machine to these points. If a level surface can not be found, flat shims or plates may be place under the wheels to create a level plane for the wheels.

In determining the existing tilt angle, read the angle on the Analyzer under DIAGNOSTICS/SYSTEM. Do not place a handheld level on the machine to determine whether the machine is level and lifting to the appropriate height. Such a measurement will likely be different than the Ground box/tilt sensor angle reading due to manufacturing and mounting tolerances. The tilt angle in both directions should read within ±0.5° while on a level surface. If not, then either the machine has a drifting tilt sensor or has been erroneously re-calibrated since the original factory calibration.

Check the service records to determine whether a re calibration has been performed. If so, re-calibrate on the level surface. If there is no record of an earlier calibration, we must assume that the sensor output has drifted. Therefore, replace the sensor and return to JLG with a detailed troubleshooting description.

NOTE: *There is a rare case in which an attempted calibration will be unsuccessful for machines with Ground module software version P1.5 or earlier. If this occurs while performing a calibration, the Analyzer will display:*

LEVEL VEHICLE
TILT +20.0 +20.0

and the following fault will also be logged**.**

TILT SENSOR NOT CALIBRATED (2/3) [DTC 811]

If no other faults have been logged since the last startup, this fault indicates that the software needs to be updated to P1.6 or later. Update the software and continue troubleshooting evaluation before replacing any components.

If the tilt sensor readings are within range for a level machine, compare the allowed Tilt vs. Height in the chart below. Being within 6" of the target height is considered acceptable.

Table 7-5. Tilt Cutout Settings

1230ES	Tilt Setting (front to back)	Tilt Setting (side to side)
ANSI/CSA	3°	1.5°
CE/AUS	3.4°	3.4°

NOTE: *For Japanese specification machines labeled "Ministry of Labor Notification #70," the Tilt Setting is 5 degrees (front to back and side to side) regardless of elevated platform height.*

If the machine does not appear to track the lift cutout heights and no fault exists as described above, stow the machine and re-calibrate the Elevation Sensor.

7.7 ELEVATION SENSOR CALIBRATION

1. Be sure that the machine is parked and stowed on level ground.
2. Attach the analyzer near the ground control station.
3. Go to Access Level 1 and scroll through to CALIBRATION.
4. Under Calibrations go to SET ELEV SENSOR.
5. Press enter for Yes and the Elevation Sensor will set.

NOTE: *Check the elevation sensor by lifting the scissor arms, from the platform, and driving until the drive speed cuts back. Refer to the Maximum High Drive Cut Out Height table in section 1 of this manual for proper speed cut out height.*

NOTES:

PARTS FINDER

Search Website by Part Number

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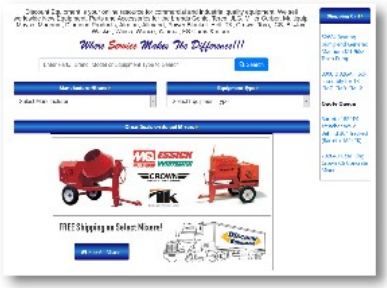

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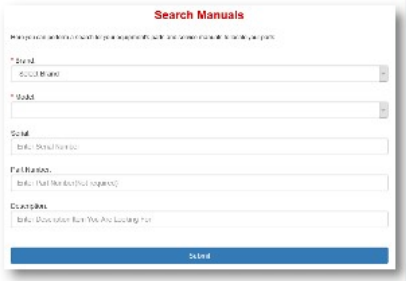

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SECTION 8. DIAGNOSTIC TROUBLE CODES

8.1 INTRODUCTION

This section provides a reference for Diagnostic Trouble Codes (DTC) read from the Multifunction Digital Indicator (MDI). This section should only be used for machines equipped with a SEVCON Power Module-(ground board software version P1.13 or higher) or ZAPI Power Module-(ground board software version P1.0 or higher). For more information on any sensors or indicators, refer to the appropriate section for the machine area. Many of the checks below require configuring and using a multimeter. Refer to Section 7: General Electrical Information & Schematics for multimeter basics. DTCs are sorted in groups by the first two digits, which is also the system distress lamp flash code. To troubleshoot multiple DTCs, start with the DTC with the higher first two digits. The machine is powered by four 6 Volt batteries in series, providing a nominal 24 Volts to the control system. Some procedures below refer to this nominal voltage (VMN) as 24V. Actual voltage measurements may differ based on the charge of the batteries. **If a correction is made during a check, conclude the check by cycling the machine power, using the emergency stop switch.** It may also be helpful to run a system test, ANALYZER -> SYSTEM TEST for intermittent or difficult problems.

8.2 X-CONNECTOR REFERENCES

Throughout the following DTC troubleshooting procedures, electrical connectors are given a three digit identifier number preceded with an “X” for identifying and locating the specific connector on the machine.

See Section 9.8, X-CONNECTOR ID INDEX for description of "X" connectors and Figure 9-12. on page 9-20, and Figure 9-13. on page 9-21 for location of "X" connectors on the machine.

Example of "X" connector usage nomenclature:

[X006.21] refers to terminal 21 (pin and socket) of connector X006.

[X006.21.soc] refers to the socket side of terminal 21, connector X006.

[X006.21.pin] refers to the pin side of terminal 21, connector X006.

8.3 DTC INDEX

8.4 DTC CHECK TABLES

0-0 Help Comments

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
001	EVERYTHING OK	The normal help message in platform mode. Displays on the analyzer only.	
002	GROUND MODE OK	The normal help message in ground mode. Displays on the analyzer only.	
003	ALARM SOUNDING - TILTED & ABOVE ELEVATION	Control system senses that the platform is elevated and the vehicle is tilted, and the machine not configured to cutout.	• Check that the machine is tilted. If so, lower the platform and reposition the machine to a level surface. • Fully stow the platform. • The tilt sensor is part of the ground control box. Check that the ground control box is secured to the machine. • Check that the pothole protection switches are securely mounted. • Check that the elevation angle sensor is securely mounted. • Check the ANALYZER -> MACHINE SETUP -> MARKET configuration. • If MARKET is set to CE, ensure ANALYZER -> MACHINE SETUP -> TILT CUT-OUT parameter is set as desired. • Backprobing ground board J1-18 should show about 0 volts. • Backprobing ground board J1-10 should show about 0 volts. • Check pothole protection switch adjustment. • Calibrate the elevation sensor, see Section 5.5. • Calibrate the tilt sensor, see Section 5.2.
004	DRIVING AT CUTBACK - ABOVE ELEVATION	The platform is elevated and the machine is driving.	• Fully stow the platform. • Check that the elevation angle sensor is securely mounted. • Check that the pothole protection switches are securely mounted. • Check the lift/drive switch. • Backprobing ground board J1-18 should show about 0 volts. • Backprobing ground board J1-10 should show about 0 volts. • Check function of elevation angle sensor. ANALYZER -> DIAGNOSTICS -> ELEV SENSOR -> ZEROED should be about 0V when stowed and about 0.15V at cutback.
005	DRIVE & LIFT UP PREVENTED - TILTED & ELEVATED	Driving is not possible since the platform is elevated and the chassis is not level.	• Check that the machine is tilted. If so, lower the platform and reposition the machine to a level surface. • Fully stow the platform. • The tilt sensor is part of the ground control box. Check that the ground control box is secured to the machine. • Check that the pothole protection switches are securely mounted. • Check that the elevation angle sensor is securely mounted. • Check the ANALYZER -> MACHINE SETUP -> MARKET configuration. • If MARKET is set to CE, ensure ANALYZER -> MACHINE SETUP -> TILT CUT-OUT parameter is set as desired. • Check pothole protection switch adjustment. • Backprobing ground board J1-18 should show about 0 volts. • Backprobing ground board J1-10 should show about 0 volts. • Calibrate the elevation sensor, see Section 5.5. • Calibrate the tilt sensor, see Section 5.2.

0-0 Help Comments

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
006	LIFT UP PREVENTED - MAX HEIGHT ZONE A	The vehicle has reached the maximum height and further lift up motion is not possible. Applicable to 2630ES or 3246ES.	• Check that the zone is set appropriately for the platform load. • Check that the platform height is at the rated maximum height specification (20' for 2630 or 26' for the 3246). • Check that the elevation angle sensor is securely mounted. • If there are any elevation sensor faults (DTC 251, 252, 2511, or 2512), troubleshoot those first. • Check that ANALYZER -> MACHINE SETUP -> MODEL setting is correct. • Check that ANALYZER -> MACHINE SETUP -> MARKET setting is correct. • Check ANALYZER -> DIAGNOSTICS -> ELEV SENSOR -> ZEROED is about 1.53V for the 3246 or about 1.22V for the 2630 when at full height. If not, repair or replace the elevation angle sensor.
007	DRIVING AT CUTBACK - POTHOLE STILL ENGAGED	While stowed, drive speed is reduced since the control system detected that the pothole protection mechanism failed to retract.	• Check for obstructions around the pot-hole protection mechanisms. • Check that the PHP switches are securely mounted. • Check PHP switches wiring from the ground board and for proper operation. The left PHP input (24V) is from J1-9 and its output (24V when deployed) is to J1-10. The right PHP input (24V) is from J1-17 and its output (24V when deployed) is to J1-18.
008	FUNCTIONS LOCKED OUT - SYSTEM POWERED DOWN	After 2 hours without activity, the control system enters a low-power state to preserve battery charge.	• Normal operation should resume after a power cycle. • Check batteries charge, condition, etc.
009	DRIVE PREVENTED - ELEVATED ABOVE DRIVE CUTOUT HEIGHT	The platform is elevated above the calibrated cutout height.	• Check that the elevation angle sensor is securely mounted. • Check the ANALYZER -> MACHINE SETUP -> MARKET configuration. • If MARKET is set to Japan, ensure ANALYZER -> MACHINE SETUP -> DRIVE CUTOUT parameter is set as desired.

2-1 Power-Up

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
211	POWER CYCLE	This help message is issued at each power cycle. Displays on the analyzer only.	Normal operation. No check necessary.
212	KEYSWITCH FAULTY	Both platform and ground modes are selected simultaneously. Defaults to ground mode.	• Check key switch function. • Backprobe J2-3 with the keyswitch in the ground position. Voltage should be under 6V. Otherwise, keyswitch or wiring faulty. • Backprobe J2-4 with the keyswitch in the platform position. Voltage should be under 6V. Otherwise, keyswitch or wiring faulty. • Check key switch wiring to ground board J2-3 and J2-4 and to emergency stop switch. • Replace ground board.

2-2 Platform Controls

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
221	FUNCTION PROBLEM - HORN PERMANENTLY SELECTED	The horn switch was closed during power-up in platform mode.	• Check if the horn switch is damaged, obstructed or jammed. • Disconnect the horn switch ribbon cable on the platform board. If DTC still present, replace the platform board. If DTC 221 is no longer present, replace the horn switch or platform board.
222	FUNCTION PROBLEM - INDOOR / OUTDOOR PERMANENTLY SELECTED	The indoor / outdoor (zone A / zone B) switch was closed during power-up in platform mode.	• Check if the indoor/outdoor (zone A / zone B) capacity switch is damaged, obstructed or jammed. • Replace platform board.

2-2 Platform Controls

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
223	FUNCTION PROBLEM - DRIVE & LIFT ACTIVE TOGETHER	The drive and lift inputs are closed simultaneously in platform mode.	• Check drive/lift switch for visible damage. • Check switch continuity. There should only be continuity from the center post to one of the outer posts at a time. Otherwise, replace the switch. • Check drive/lift switch signal and wiring to the platform board. Its input (0V) is from platform board terminal J1-11. "Lift" selection output (0V when selected) is to platform board terminal J1-9. "Drive" selection output (0V when closed) is to platform board terminal J1-10. • Replace platform board.
224	FUNCTION PROBLEM - STEER LEFT PERMANENTLY SELECTED	The steer left switch was closed during power-up in platform mode.	• Check if the steer left switch is obstructed or jammed. • Check steer left switch and its wiring. The steer left switch input (24V) is from platform board terminal J1-1, and its output (24V when closed) is to platform board terminal J1-15. • Replace platform board.
225	FUNCTION PROBLEM - STEER RIGHT PERMANENTLY SELECTED	The steer right switch was closed during power-up in platform mode.	• Check if the steer right switch is obstructed or jammed. • Check steer right switch and its wiring to the platform board. The steer right switch input (24V) is from platform board terminal J1-1, and its output (24V when closed) is to platform board terminal J1-16. • Replace platform board.
226	ACCELERATOR FAULTY - WIPER OUT OF RANGE	The joystick signal is outside the acceptable range of 0.50V - 4.5V, or is unstable.	• Center joystick and check to see if a power cycle will clear DTC. • Check the joystick signal and its wiring. The joystick input (5V) is from the platform board terminal J1-5, its output (2.5V with joystick at center) to the platform board terminal J1-6, and its ground (0V) is to the platform board terminal J1-7. Observe output signal while slowly operating joystick. • Replace platform board.
227	STEER SWITCHES FAULTY	The steer left and steer right inputs were closed simultaneously.	• Check if the steer switches are damaged, obstructed or jammed. • Check the steer switch signals and wiring to the platform board. The steer switch input (24V) is from platform board terminal J1-1, outputs (24V when closed) are to platform board terminals J1-15 and J1-16 (left and right). • Replace platform board.
228	FUNCTION LOCKED OUT - ACCELERATOR NOT CENTERED	The joystick was not centered at power-up.	• Release joystick and allow to center. • Check if the joystick is obstructed or jammed. • Check the joystick signal and its wiring. The joystick input (5V) is from the platform board terminal J1-5, its output (2.5V with joystick at center) to the platform board terminal J1-6, and its ground (0V) is to the platform board terminal J1-7. Observe output signal while slowly operating joystick. • Replace platform board.
229	FUNCTION PROBLEM - TRIGGER PERMANENTLY CLOSED	The trigger switch was closed during power-up in platform mode.	• Check if the trigger switch is obstructed or jammed. • Check the trigger switch signal and wiring to the platform board. The trigger input (24V) is from platform board terminal J1-1, and its output (24V when closed) is to platform board terminal J1-8. • Replace platform board.
2210	TRIGGER CLOSED TOO LONG WHILE IN NEUTRAL	The trigger switch was closed for more than five seconds while the joystick was centered.	• Check if the trigger switch is obstructed or jammed. • Check the trigger switch signal and wiring to the platform board. The trigger input (24V) is from platform board terminal J1-1, and its output (24V when closed) is to platform board terminal J1-8. • Replace platform board.

2-2 Platform Controls

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
2232	FUNCTION PROBLEM - DRIVE & LIFT BOTH OPEN	The drive and lift inputs are both de-energized in Platform Mode.	• Check if either function is active, if Yes; • Repair the wiring or switch to clear the message. • ZAPI - HEALTH (Status LED) - ON

2-3 Ground Controls

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
231	FUNCTION PROBLEM - LIFT PERMANENTLY SELECTED	The ground control box lift switch was closed up or down, during power-up in ground mode.	• Check if the lift switch is obstructed or jammed. • Check the lift switch signal and wiring to the ground board. The lift switch input (24V) is from ground board terminal J2-4, and its outputs (24V when closed) are to ground board terminals J2-6, J2-7 (up and down). • Replace ground board.
232	GROUND LIFT UP / DOWN ACTIVE TOGETHER	The lift up / down inputs are closed simultaneously.	• Check if the lift switch is obstructed or jammed. • Check the lift switch signal and wiring to the ground board. The lift switch input (24V) is from ground board terminal J2-4, and its outputs (24V when closed) are to ground board terminals J2-6 (up), J2-7 (down). • Replace ground board.
233	FUNCTION PROBLEM - BRAKE RELEASE PERMANENTLY SELECTED	The manual brake release switch was closed during power-up.	• Check if the brake release switch is obstructed or jammed. • Check the brake release switch signal and wiring to the ground board. The brake release switch input (24V) is from ground board terminal J1-19, and its output (24V when closed) is to ground board terminal J1-20. • If the brakes are released, the machine can be pushed or moved without drive motor power. • Replace ground board.

2-5 Function Prevented

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
251	ELEV ANGLE SENSOR FAULTY - VOLTAGE OUT OF RANGE	The elevation angle sensor input voltage is outside the acceptable range of 0.10V - 4.50V.	• Check that the platform elevation sensor is securely mounted and undamaged. • Check voltage as displayed on ANALYZER -> DIAGNOSTICS -> ELEV SENSOR -> ANGLE SNSR. Backprobe ground board J1-15. If this voltage disagrees with the ANGLE SNSR voltage, replace the ground board. • Backprobe the elevation angle sensor connector. Terminal A should be 4.7V, terminal C should be 0V. • Check the elevation angle sensor signal and wiring to the ground board. The elevation angle sensor input is from ground board terminal J1-14 (4.7V), its output (0.1 - 1.2V when stowed) is to ground board terminal J1-15, and its ground is to ground board terminal J1-16. • Replace the ground board.
252	ELEV ANGLE SENSOR HAS NOT BEEN CALIBRATED	The elevation angle sensor has not been calibrated.	• Calibrate the elevation angle sensor to clear fault. See Section 5.5.
253	DRIVE PREVENTED - CHARGER CONNECTED	Driving is not possible while the vehicle is charging.	• Check if the charger is connected to off board power source and disconnect if desired. • Check ANALYZER -> MACHINE SETUP -> CHARGER INTERLOC is set as desired. • Check that charger's red (positive) battery wire connector terminal is receiving power (24V) from batteries. • Check signal from charger interlock connector terminal 2 to ground board terminal J1-29, where 0VDC indicates charging in process.

2-5 Function Prevented

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
254	DRIVE & LIFT UP PREVENTED - CHARGER CONNECTED	Drive or lift is not possible while the vehicle is charging AND is configured to prevent all motion.	• Check if the charger is connected to off board power source and disconnect if desired. • Check ANALYZER -> MACHINE SETUP -> CHARGER INTERLOC is set as desired. (Must be in ACCESS LEVEL 1 to change.) • Check that charger's red (positive) battery wire connector terminal is receiving power (24V) from batteries. • Check signal from charger interlock connector terminal 2 to ground board terminal J1-29, where 0VDC indicates charging in process.
255	PLATFORM OVERLOADED	The load sensing system measured platform load is excessive.	• Remove excess weight from the platform. • Check that the platform is not caught on something, preventing up or down movement. • If any CAN bus faults are active, troubleshoot those first. • Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.
256	DRIVE PREVENTED - POTHOLE NOT ENGAGED	Driving is not possible while elevated since the pot-hole protection system failed to deploy.	• Check for obstructions or mechanical problems around the pot-hole protection mechanisms. • Check that the PHP switches are securely mounted. • Adjust pot-hole protection switches. • Check the pothole protection switches signal and wiring to the ground board. The left pot-hole protection switch input (24V) is from ground board terminal J1-9, and its output (24V when deployed) is to ground board terminal J1-10. The right pot-hole protection switch input (24V) is from ground board terminal J1-17, and its output (24V when deployed) is to ground board terminal J1-18.
257	ELEV PROX PERMANENTLY CLOSED - CHECK PROX AND ANGLE ADJUSTMENT	The elevation proximity switch shows the platform to be stowed, while the elevation angle sensor shows the platform to be raised. The elevation proximity switch is only found on certain older lifts. This switch is not used on current machines so this DTC should not occur.	• Verify that an elevation proximity switch is present on the machine. If not, ensure ANALYZER -> MACHINE SETUP -> ELEV PROX is set to NOT INSTALLED. If the switch is present, set ELEV PROX to INSTALLED and check switch continuity. The switch should close when placed in close proximity to ferrous metal.
258	DRIVE & LIFT PREVENTED - BRAKES ELECTRICALLY RELEASED FOR TOWING	Manual brake release mode is activated with the switch in the battery box near the ground control box. Drive or lift is not possible.	• Push manual brake release switch again or cycle power to clear manual brake release mode. • Check if the brake release switch is obstructed or jammed. • Check the brake release switch signal and wiring to the ground board. The switch input (24V) is from ground board terminal J1-19, and its output (24V when closed) is to ground board terminal J1-20. • Replace ground board.
259	MODEL CHANGED - HYDRAULICS SUSPENDED - CYCLE EMS	The model selection has been changed.	• Check ANALYZER -> MACHINE SETUP -> MODEL NUMBER. • Replace ground board.
2510	DRIVE PREVENTED - BRAKES NOT RELEASING	While driving on a level surface, armature current was > 150A for five seconds. Brakes assumed to not be releasing properly.	• Ensure vehicle is not stuck on something preventing movement. • Check / repair drive motor wiring, brakes or mechanical issues.
2511	ELEV ANGLE SENSOR FAULTY - NOT MOUNTED	The input voltage from the elevation angle sensor indicates the elevation angle sensor is not mounted.	• Check that the elevation angle sensor is securely mounted. • Check that the elevation angle sensor mechanisms are intact. • Replace elevation angle sensor.
2512	ELEV ANGLE SENSOR NOT DETECTING CHANGE	The input voltage from the elevation angle sensor did not change while vehicle was lifting up.	• Check that the elevation angle sensor is securely mounted. • Check elevation angle sensor is not jammed or obstructed. • If there are any other elevation angle sensor, joystick, or lift up faults, troubleshoot them before continuing. • Replace elevation angle sensor.

3-1 Line Contactor Open Circuit

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
311	OPEN CIRCUIT LINE CONTACTOR	The power modules line contactor did not close when energized. Drive, steer and lift up prevented.	• Check contactor main contact wiring to battery (+) terminal and power controller terminal B+. • Contactor solenoid resistance should measure about 52 Ohms. • Check contactor solenoid wiring to power module 12 position connector terminal 8 and ground board terminal J1-19. • Check that power module 12 position connector terminal 8 goes from 24V to near 0V while contactor should be closing. If this happens replace contactor. • Replace the line contactor.
312	CONTACTOR DRIVER PERMANENTLY OFF	The power modules line contactor drive circuitry failed to energize when requested. Drive, steer and lift up prevented.	• Check continuity between contactor connector pin 1 and ground board socket J1-19. • Contactor solenoid resistance should measure about 52 Ohms. • Check continuity between contactor connector pin 2 and power module connector socket 8. • Replace power module.

3-2 Line Contactor Short Circuit

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
321	LINE CONTACTOR MISWIRED ON OR WELDED	Battery voltage was present at the power module B+ terminal at power up. Drive, steer and lift up prevented.	• Check wiring of contactor. • Check resistance between the studs of the contactor while disconnected from the machine. • Check contactor main contact wiring to battery (+) terminal and power module terminal B+. • Check continuity between contactor connector pin 1 and ground board socket J1-19. • Check continuity between contactor connector pin 2 and power module 12 position connector terminal 8. • Measure voltage between power model B+ and B- terminals. If 24V is present, replace line contactor. • Replace power module.
322	CONTACTOR DRIVER PERMANENTLY ON	The power modules line contactor drive circuitry failed to de-energize when requested. Drive, steer and lift up prevented.	• Check continuity between contactor connector pin 1 and ground board socket J1-19. • Check continuity between contactor connector pin 2 and power module 12 position connector terminal 8. • Replace power module.

3-3 Ground Output Driver

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
331	BRAKE SHORT TO BATTERY	The ground board detected voltage while the brake solenoid was commanded off.	• Ensure ANALYZER -> MACHINE SETUP -> ELEV PROX is set to NOT INSTALLED.
332	BRAKE OPEN CIRCUIT	The ground board did not detect current flow to the brake solenoid during normal operation.	• Ensure ANALYZER -> MACHINE SETUP -> ELEV PROX is set to NOT INSTALLED.
333	LIFT UP SHORT TO BATTERY	The ground board detected voltage while the lift up solenoid was commanded off at power up.	• Check for continuity through this circuit. The lift up solenoid resistance should measure about 30 Ohms. The lift up solenoid is powered with 24V from ground board J1-25, and its ground is to ground board J1-30, 37. • Inspect the wiring for physical damage. • Replace ground board.

3-3 Ground Output Driver

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
334	LIFT UP OPEN CIRCUIT	The ground board did not detect current flow to the lift up solenoid during power up.	• Check for continuity through this circuit. The lift up solenoid resistance should measure about 30 Ohms. The lift up solenoid is powered with 24V from ground board J1-25, and its ground is to ground board J1-30, 37. • Inspect the wiring for physical damage. • Replace ground board.
335	LIFT DN SHORT TO BATTERY	The ground board detected voltage while the lift down solenoid was commanded off.	• Check ANALYZER -> MACHINE SETUP -> ELEV PROX is set to NOT INSTALLED • Check for continuity through this circuit. The lift down solenoid resistance should measure about 20 Ohms. The lift down solenoid is powered (PWM) by ground board J1-26, and its ground is to ground board J1-27. • Inspect the wiring for physical damage. • Replace ground board.
336	LIFT DN OPEN CIRCUIT	The ground board did not detect current flow to the lift down solenoid during normal operation.	• Check for continuity through this circuit. The lift down solenoid resistance should measure about 20 Ohms. The lift down solenoid is powered (PWM) by ground board J1-26, and its ground is to ground board J1-27. • Inspect the wiring for physical damage. • Replace ground board.
337	STEER LEFT SHORT TO BATTERY	The ground board detected voltage while the steer left solenoid was commanded off at power up.	• Check for continuity through this circuit. Steer left solenoid resistance should measure about 30 Ohms. The steer left solenoid is powered with 24V from ground board J1-21, and its ground is to ground board J1-30, 37. • Inspect the wiring for physical damage. • Replace ground board.
338	STEER LEFT OPEN CIRCUIT	The ground board did not detect current flow to the steer left solenoid during normal operation.	• Check for continuity through this circuit. Steer left solenoid resistance should measure about 30 Ohms. The steer left solenoid is powered with 24V from ground board J1-21, and its ground is to ground board J1-30, 37. • Inspect the wiring for physical damage. • Replace ground board.
339	STEER RIGHT SHORT TO BATTERY	The ground board detected voltage while the steer right solenoid was commanded off.	• Check for continuity through this circuit. Steer right solenoid resistance should measure about 30 Ohms. The steer right solenoid is powered with 24V from ground board J1-22, and its ground is to ground board J1-30, 37. • Inspect the wiring for physical damage. • Replace ground board.
3310	STEER RIGHT OPEN CIRCUIT	The ground board did not detect current flow to the steer right solenoid during normal operation.	• Check for continuity through this circuit. Steer right solenoid resistance should measure about 30 Ohms. The steer right solenoid is powered with 24V from ground board J1-22, and its ground is to ground board J1-30, 37. • Inspect the wiring for physical damage. • Replace ground board.
3311	GROUND ALARM SHORT TO BATTERY	The ground board detected voltage while the ground alarm was commanded off.	• Check for continuity through this circuit. The ground alarm solenoid is powered with 24V from ground board J1-19, its PWM signal is from ground board J1-28, and its ground is to ground board J1-30, 37. There should be about 1500 Ohms between ground alarm connector pin 1 and pin 3. • Inspect the wiring for physical damage. • Replace ground board.

3-3 Ground Output Driver

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
3312	LEFT BRAKE SHORT TO BATTERY	The ground board detected voltage while the left brake was commanded off.	• Check for continuity through this circuit. The left brake is powered with 24V from ground board J1-23, and its ground is to ground board J1-30, 37. Brake solenoid resistance should measure about 20 Ohms. • Inspect the wiring for physical damage. • Replace ground board.
3313	RIGHT BRAKE SHORT TO BATTERY	Voltage was detected on the right brake solenoid when the ground board output was commanded off during power-up.	• Check for continuity through this circuit. Brake solenoid resistance should measure about 20 Ohms. The right brake is powered with 24V from ground board J1-24, and its ground is to ground board J1-30, 37. • Inspect the wiring for physical damage. • Replace ground board.
3314	LEFT BRAKE OPEN CIRCUIT	Current flow to the left brake solenoid was not detected during normal left brake operation.	• Check for continuity through this circuit. The left brake is powered with 24V from ground board J1-23, and its ground is to ground board J1-30, 37. Brake solenoid resistance should measure about 20 Ohms. • Inspect the wiring for physical damage. • Replace ground board.
3315	RIGHT BRAKE OPEN CIRCUIT	The ground board did not detect current flow to the right brake during normal operation.	• Check for continuity through this circuit. Brake solenoid resistance should measure about 20 Ohms. The right brake is powered with 24V from ground board J1-24, and its ground is to ground board J1-30, 37. • Inspect the wiring for physical damage. • Replace ground board.
33297	LEFT BRAKE - SHORT TO GROUND	Drive and Steer Prevented	• Excessive current flow to the Left Brake Solenoid was detected (J1-34 NLB). • ZAPI - HEALTH (Status LED) - ON
33298	STEER LEFT VALVE - SHORT TO GROUND	Drive, Steer and Lift Up Prevented	• Excessive current flow to the steer left solenoid detected (J2-9 NLV). • ZAPI - HEALTH (Status LED) - ON
33299	LINE CONTACTOR COIL - SHORT TO BATTERY	Drive, Lift and Steer Prevented	• Voltage from an external source was detected on the Negative Main Line Contactor. • ZAPI - HEALTH (Status LED) - ON
33302	NEGATIVE SUPPLY - SHORT TO BATTERY	Drive, Lift, and Steer Prevented	• At power-up, the system module detected an external short on J1-12, J1-17, J1-23, J2-14 or J2-15. Normally these pins are grounded by the System Module. All functions are prevented to protect the control system. • ZAPI - HEALTH (Status LED) - ON
33303	NEGATIVE SUPPLY - SHORT TO GROUND	Drive, Lift and Steer Prevented	• At power-up, the System Module detected an external short on J1-12, J1-17, J2-14 or J2-15. Normally these pins are grounded by the System Module. Since the external ground may compromise integrity, all functions will be prevented. • ZAPI - HEALTH (Status LED) - ON
33304	RIGHT BRAKE - SHORT TO GROUND	Drive, and Steer Prevented	• Excessive current flow to the Right Brake solenoid was detected (J1-33 NRB). • ZAPI - HEALTH (Status LED) - ON
33305	STEER RIGHT VALVE - SHORT TO GROUND	Drive, Steer, and Lift Up Prevented	• Excessive current flow to the Steer Right Solenoid was detected (J2-18 NRV). • ZAPI - HEALTH (Status LED) - ON
33406	LiFT UP VALVE - SHORT TO GROUND	Drive, Steer, and Lift Up Prevented	• Excessive current flow to the Lift Up Solenlid was detected at (J2-2 PDV or J2-16 NDV). • ZAPI - HEALTH (Status LED) - ON

3-3 Ground Output Driver

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
33407	LIFT DN VALVE - SHORT TO GROUND	Lift Up and Down Prevented	• Excessive current flow to the Lift Down Solenoid was detected (J2-16 NDV). • ZAPI - HEALTH (Status LED) - ON

4-2 Thermal Limit (SOA)

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
421	POWER MODULE TOO HOT - PLEASE WAIT	The power module has reached thermal cut-out.	• Power down and allow to cool. • Do not operate in ambients over 140° F (60° C). • Check for jammed or obstructed drive motors. • Check for excessively high current consumption in the pump, ANALYZER -> DIAGNOSTICS -> PUMP -> PUMP CUR over 130 Amps with an empty deck. • Check for excessively high traction current consumption, ANALYZER -> DIAGNOSTICS -> TRACTION -> ARM CUR over 120 Amps while driving on the level.
422	DRIVING AT CUTBACK - POWER MODULE CURRENT LIMIT	The drive portion of the power module has reached thermal limit.	• Check for jammed or obstructed drive motors. • Check for excessively high traction current consumption, ANALYZER -> DIAGNOSTICS -> TRACTION -> ARM CUR over 120 Amps while driving on the level.
423	LIFT UP AT CUTBACK - POWER MODULE CURRENT LIMIT	The lift up portion of the power module has reached thermal limit.	• Check for jammed or obstructed arm stack or pivot bushing. • Check for excessively high current consumption in the pump, ANALYZER -> DIAGNOSTICS -> PUMP -> PUMP CUR over 130 Amps with an empty deck. • Refer to Pump Motor Electrical Evaluation in Section 4.8.

4-4 Battery Supply

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
441	BATTERY VOLTAGE TOO LOW - SYSTEM SHUTDOWN	The power module momentarily measured battery voltage under 14.5V between ground board J1-39 and ground board J1-40.	• Recharge batteries or check for damaged batteries. • Check battery charger function.
442	BATTERY VOLTAGE TOO HIGH - SYSTEM SHUTDOWN	The power module momentarily measured battery voltage > 37.0V.	• May be due to improper battery charging or incorrect voltage batteries being used.
443	LSS BATTERY VOLTAGE TOO HIGH	The load sensing system module momentarily measured battery voltage > 34.0V.	• May be due to improper battery charging or incorrect voltage batteries being used. • Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.
444	LSS BATTERY VOLTAGE TOO LOW	The load sensing system module momentarily measured battery voltage < 9V.	• Recharge batteries or check for damaged batteries. • Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.
446	LOGIC SUPPLY VOLTAGE OUT OF RANGE	The system module logic supply voltage was measured to be out of normal operating range by the interface PCB (<11V).	• This may be caused by a loose battery terminal, severely discharged batteries, damaged battery, or an improper wire harness connection. • Drive, Steer, and Lift Prevented • ZAPI - HEALTH (Status LED) - ON
4421	LOGIC SUPPLY VOLTAGE OUT OF RANGE	The system module logic supply voltage was measured by the power PCB to be more than 34V for 10uS.	• This may be caused by a loose battery terminal, severely discharged batteries, damaged battery, or an improper wire harness connection. • Drive, Steer, and Lift Prevented • ZAPI - HEALTH (Status LED) - ON

4-4 Battery Supply

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
4422	LOGIC SUPPLY VOLTAGE OUT OF RANGE	The system module logic supply voltage was measured by the power PCB to be less than 11V for 10uS.	• This may be caused by a loose battery terminal, severely discharged batteries, damaged battery, or an improper wire harness connection. • Drive, Steer, and Lift Prevented • ZAPI - HEALTH (Status LED) - ON

6-6 Communication

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
661	CANBUS FAILURE - POWER MODULE	The control system failed to receive messages from the power module.	• Check for 24V between power module 12 position connector terminal 1 and the power module B- terminal. If this is the problem, the line contactor may be cycling on and off, making a clicking noise when the machine is powered. • Disconnect ground board J1 and power module connector. Ground board socket J1-31 to power module connector socket 10 should have continuity. Ground board socket J1-32 to power module connector socket 11 should have continuity. • Turn on machine in platform mode. If DTC 662 is present, troubleshoot that DTC before continuing.

6-6 Communication

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
662	CANBUS FAILURE - PLATFORM MODULE	In platform mode, the control system failed to receive messages from the platform board.	• Turn on machine in ground mode. If DTC 661 is not present check for 24V between platform box connector terminals D and A. If not 24V, test continuity from platform box connector socket A to ground board connector socket J1-6 and test continuity from platform box connector socket D to ground board connector socket J1-7. • If DTC 661 was present in the previous check, disconnect armstack passthru connector located near the ladder on the left. Turn on in ground mode. If DTC 661 is not present then there is a problem in armstack harness. Armstack passthru socket 5 to platform box terminal E should have continuity. Armstack passthru socket 6 to platform box connector terminal F should have continuity. Armstack passthru socket 7 to platform box connector terminal G should have continuity. Armstack passthru socket 5 to armstack passthru socket 6 resistance should be 120 Ohms +/- 5%. Armstack passthru socket 5 to armstack passthru socket 7 should measure open circuit. Armstack passthru socket 6 to armstack passthru socket 7 should measure open circuit. • Disconnect armstack passthru and ground board J1. Armstack passthru pin 5 to ground board socket J1-11 should have continuity. Armstack passthru pin 6 to ground board socket J1-12 should have continuity. Armstack passthru pin 7 to ground board socket J1-13 should have continuity. Armstack passthru pin 5 to armstack passthru pin 6 should measure open circuit. Armstack passthru pin 5 to armstack passthru pin 7 should measure open circuit. Armstack passthru pin 6 to armstack passthru pin 7 should measure open circuit. • Disconnect ground board J1 and power module connector. Ground board socket J1-31 to power module connector socket 10 should have continuity. Ground board socket J1-32 to power module connector socket 11 should have continuity. Ground board socket J1-31 to J1-32 should measure open circuit. Ground board socket J1-31 to J1-33 should measure open circuit. Ground board socket J1-32 to J1-33 should measure open circuit. • Ensure all connections opened above are reconnected. Disconnect power module connector. Turn on in platform mode. If DTC 662 is no longer present replace power module. • If DTC 661 and 662 have been present through above steps replace ground board. *Continued Next Page*
662 (Cont.)	CANBUS FAILURE - PLATFORM MODULE (Continued)	In platform mode, the control system failed to receive messages from the platform board.	• Disconnect platform box connector. Open platform box. Disconnect platform board connector. Platform box socket E to platform board J1-3 should have continuity. Platform box socket F to platform board J1-4 should have continuity. Platform box pin E to pin F should measure open circuit. Platform box pin E to pin G should measure open circuit. Platform box pin F to pin G should measure open circuit. If these checks are OK replace platform board.
663	CANBUS FAILURE - LOAD SENSING SYSTEM MODULE	With load sensing system enabled, the control system failed to receive messages from the load sensing system module.	• Check ANALYZER -> MACHINE SETUP -> MODEL NUMBER is correct. • Check ANALYZER -> MACHINE SETUP -> MARKET is correct. • Check ANALYZER -> MACHINE SETUP -> LOAD is correct. • Check for 24V between load sense system module connector J1-1 and J1-2. • Turn on machine in platform mode. If DTC 662 is present, troubleshoot that DTC before continuing. • Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.

6-6 Communication

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
664	CANBUS FAILURE - ACCESSORY MODULE	An accessory module has stopped communication.	• Turn on machine in platform mode. If DTC 662 is present, troubleshoot that DTC before continuing. • See accessory module documentation for troubleshooting.
6635	CANBUS FAILURE - CHASSIS TILT SENSOR	Chassis Tilt Sensor messages not received for 1000 mS while B+ is present on J1-28	• The control system failed to receive messages from the Chassis Tilt Sensor located inside the Ground Control Box. • Ensure that +B is present on pin 1 of the sensor, and -B is present on pin 4. Check the CANbus wiring to pins 2 and 3 of the sensor. • ZAPI - HEALTH (Status LED) - ON

6-7 Accessory

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
671	ACCESSORY FAULT	An accessory module is reporting a fault.	• See accessory module documentation for troubleshooting.

7-7 Electric Motor

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
771	OPEN CIRCUIT DRIVE MOTOR WIRING	The power module detected a problem in the drive motors' power circuit wiring.	• Refer to Drive Motor Electrical Evaluation in Section 3.5. • Refer to Power Module Electrical Evaluation in Section 3.6.
772	STALLED TRACTION MOTOR OR POWER WIRING ERROR	Drive, Steer, and Lift Prevented	• The System Module detected armature current feedback > 4.5V or < 0.5V. This is mostly likely caused by a stalled traction motor or power wiring issue. Alternately, it could be an internal fault. • ZAPI - HEALTH (Status LED) - ON
773	CAPACITOR BANK FAULT - CHECK POWER CIRCUITS	Drive, Steer, and Lift Prevented	• There is an internal or external fault that prevents the System Module's capacitor bank from charging. • The System Module detected that the VMN of the pump and traction has not increased more than 1.3V in 1000mS. Alternately, the VMN of the pump or traction is less than 20% of battery voltage. • If this message persists after disconnecting the drive and pump wiring, there is an internal fault. • ZAPI - HEALTH (Status LED) - ON
774	SHORT CIRCUIT FIELD WIRING	Drive, Steer, and Lift Prevented	• The field wiring passed System Module power-up diagnostics. However, an external short circuit was detected when current was applied to F1 / F2. This situation is caused by improper field wiring or a damaged motor. • ZAPI - HEALTH (Status LED) - ON
775	OPEN CIRCUIT FIELD WIRING	Drive, Steer, and Lift Prevented	• The System Module applied field current, but could regulate the desired current. The situation is caused by improper field wiring or a damaged motor. • ZAPI - HEALTH (Status LED) - ON
776	STALLED PUMP MOTOR OR POWER WIRING ERROR	Drive, Steer, and Lift Prevented	• The System Module measured improper pump current feedback (>4.5V or <0.5V) for 240mS. This is caused by a stalled pump motor, a power wiring issue, or a System Module malfunction. • ZAPI - HEALTH (Status LED) - ON
777	OPEN CIRCUIT PUMP MOTOR WIRING	Drive, Steer, and Lift Prevented	• The System Module measured pump current less than 8A while the motor voltage was greater than 7V for 1200mS. This indicates there is an open-circuit between the System Module's –P terminal and the pump motor. • ZAPI - HEALTH (Status LED) - ON

7-7 Electric Motor

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
778	TRACTION T HIGH - CHECK POWER CIRCUITS	Drive, Steer, and Lift Prevented	• While driving, the voltage measured at the System Module's T terminal did not agree with the predicted value for at least 300mS. This issue may be caused by a power wiring error or an internal fault. • ZAPI - HEALTH (Status LED) - ON
779	TRACTION T LOW - CHECK POWER CIRCUITS	Drive, Steer, and Lift Prevented	• While driving, the voltage measured at the System Module's T terminal did not agree with the predicted value for at least 1000mS. This issue may be caused by an opencircuit of the armature wiring (+B and –T terminals) or an internal fault. • VMN does not increase more than 1.3V • VMN is less than 20% Battery Voltage • Battery Voltage . VMN is greater than 4V • ZAPI - HEALTH (Status LED) - ON
7710	PUMP P HIGH - CHECK POWER CIRCUITS	Drive, Steer, and Lift Prevented	• While steering or lifting up, the voltage measured at the System Module's P terminal did not agree with the predicted value for at least 240mS. This issue may be caused by a power wiring error or an internal fault. • Pump Feedback . Predicted >7V • ZAPI - HEALTH (Status LED) - ON
7711	PUMP P LOW - CHECK POWER CIRCUITS	Drive, Steer, and Lift Prevented	• While steering or lifting up, the voltage measured at the System Module's P terminal did not agree with the predicted value for at least 1000mS. This issue may be caused by an open-circuit of the pump wiring (+BF2 and –P terminals) or an internal fault. • Pump feedback does not increase more than 1.3V • Pump feedback is less than 20% Battery Voltage • Battery Voltage - pump feedback is greater than 4V • ZAPI - HEALTH (Status LED) - ON
7741	ARMATURE BRAKING CURRENT TOO HIGH	Drive, Steer, and Lift Prevented	• The System Module detected excessive braking current for more than 5000mS. This can be caused by transporting an excessive load on a steep grade. Alternately, this may indicate an internal fault. • ZAPI - HEALTH (Status LED) - ON
7742	FIELD VOLTAGE IMPROPER	Drive, Steer, and Lift Prevented	• The System Module voltage at the F1 and F2 terminals was improper at power-up (expected to be ½ Battery Voltage). This is caused by an open- or short-circuit in the field wiring or motor. Disconnect the field and motor wiring from the System Module and connect F1 / F2 with a short wire. If the situation persists after a power cycle, it may be an internal issue. • ZAPI - HEALTH (Status LED) - ON

8-1 Tilt Sensor

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
811	TILT SENSOR NOT CALIBRATED	The tilt sensor calibration has not been performed.	• Calibrate the tilt sensor, see Section 5.2. • Replace then calibrate tilt sensor, see Section 5.2.
812	NO DATA FROM TILT SENSOR - NOT CONNECTED OR FAULTY	No signal from tilt sensor.	• Check tilt sensor connections and wiring in ground control box. • Calibrate the tilt sensor, see Section 5.2. • Replace then calibrate tilt sensor, see Section 5.2.

8-2 Platform Load Sense

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
821	LSS CELL #1 ERROR	A problem has been detected with the load sense system.	• Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.
822	LSS CELL #2 ERROR	A problem has been detected with the load sense system.	• Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.
823	LSS CELL #3 ERROR	A problem has been detected with the load sense system.	• Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.
824	LSS CELL #4 ERROR	A problem has been detected with the load sense system.	• Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.
825	LSS HAS NOT BEEN CALIBRATED	The load sensing system module has not been calibrated	• Empty platform. Calibrate LSS, see Section 2.2: Calibration in the LSS manual, 3124288. • Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.

9-9 Hardware

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
991	LSS WATCHDOG RESET	A problem has been detected with the load sense system.	• Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.
992	LSS EEPROM ERROR	A problem has been detected with the load sense system.	• Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.
993	LSS INTERNAL ERROR - PIN EXCITATION	A problem has been detected with the load sense system.	• Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.
994	LSS INTERNAL ERROR - DRDY MISSING FROM A/D	A problem has been detected with the load sense system.	• Refer to Section 2.3: Troubleshooting in the LSS manual, 3124288.
995	POWER MODULE FAILURE - PERSONALITY RANGE ERROR	The power module detected an out-of-range or corrupt personality setting	• Record all personality settings in ANALYZER -> PERSONALITIES and ANALYZER -> MACHINE SETUP. Reset control system personalities to default settings by selecting a different model than indicated, cycle power then select proper model. Then, enter personality settings recorded above.
996	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module's analog to digital converter does not respond for the power PCB. This is an internal failure. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING
997	POWER MODULE FAILURE - CHECK POWER CIRCUITS OR MOSFET SHORT CIRCUIT	The power module detected an error in the power wiring for the drive or pump.	• Refer to Drive Motor Electrical Evaluation in Section 3.5. • Refer to Pump Motor Electrical Evaluation in Section 4.8. • Refer to Power Module Electrical Evaluation in Section 3.6.
998	EEPROM FAILURE - CHECK ALL SETTINGS	The control system detected an EEPROM failure.	• Replace ground board.
999	FUNCTION LOCKED OUT - POWER MODULE SOFTWARE VERSION IMPROPER	The power module software version is not compatible with the rest of the system.	• Replace power module to clear fault.
9910	FUNCTION LOCKED OUT - PLATFORM MODULE SOFTWARE VERSION IMPROPER	The platform board software version is not compatible with the rest of the system.	• Reprogram platform board.
9911	FUNCTION LOCKED OUT - LSS MODULE SOFTWARE VERSION IMPROPER	The load sensing system module software version is not compatible with the rest of the system.	• Replace LSS module to clear fault.

9-9 Hardware

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
9912	POWER MODULE FAILURE - SYSTEM MONITOR	The ground board detected armature, field, or pump current while function was not commanded.	• Refer to Drive Motor Electrical Evaluation in Section 3.5. • Refer to Pump Motor Electrical Evaluation in Section 4.8. • Refer to Power Module Electrical Evaluation in Section 3.6.
9924	FUNCTIONS LOCKED OUT - MACHINE NOT CONFIGURED	The control system's memory indicates that the vehicle has not been configured (new control system components).	• Use the JLG analyzer to adjust all machine setup and personality settings, refer to 5.7 Machine Configuration Programming Information.
9950	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module's armature power circuitry is driven without PWM command for 100mS. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING
9951	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module's pump power circuitry is driven without enable from the interface PCB for 100mS. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING
9952	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module's pump power circuitry is driven without PWM command for 100mS. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING
9953	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module's field power circuitry is driven without enable from the interface PCB for 100mS. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING
9954	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module's field power circuitry is driven without reverse direction from the power PCB for 100mS. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING
9955	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module's field power circuitry is driven without forward selection from the power PCB for 100mS. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING
9956	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module's field current control or MOSFET's are malfunctioning. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING
9957	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module's hardware that generates an interrupt at 36V and 12V did not respond properly at power-up. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING
9958	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module's pump current measurement or MOSFET are malfunctioning. • Pump current measurement >2.74V or <2.26V for 200mS while idle. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING
9960	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module detected an issue with the traction current measurement or the MOSFET's. • Armature current feedback >2.74V or < 2.26V while idle • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING

9-9 Hardware

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
9962	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module's temperature feedback is >4.9V or <0.1V. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING
9963	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module detected a mismatch in the redundant RAM information stored in the power PCB. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - ON
9964	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module's analog to digital converter does not respond for the interface PCB. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING
9969	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module's MC/EB/EV/DV Enable is always on. This is internal fault. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING
9970	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module detected a mismatch in the redundant RAM information stored in the interface PCB. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - ON
9971	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module's MC/EB valve activation pin is shorted. This is an internal fault. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING
99143	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module's power and interface PCB digital inputs do not agree. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING
99144	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module's MC feedback from the interface PCB disagrees with the feedback from the power PCB. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING
99145	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module's enable for the power PCB requested a drive motor or valve activation when not expected. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING
99146	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module's lift down feedback voltage to the interface and power PCB's disagrees. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING
99147	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module's VMN feedback voltage to the interface and power PCB's disagrees. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING
99148	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module's setpoint request from the interface PCB does not match the input state. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING

9-9 Hardware

DTC	FAULT MESSAGE	DESCRIPTION	CHECK
99149	POWER MODULE FAILURE - INTERNAL ERROR	Drive, Steer, & Lift Prevented	• The System Module encountered an unexpected software issue. • Cycle machine, if error still exists, replace System Module. • ZAPI - HEALTH (Status LED) - FLASHING

NOTES:

SECTION 9. GENERAL ELECTRICAL INFORMATION & SCHEMATICS

9.1 GENERAL

This section contains schematics to be used for locating and correcting most of the operating problems which may develop. If a problem should develop which is not presented in this section or which is not corrected by listed corrective actions, technically qualified guidance should be obtained before proceeding with any maintenance.

NOTICE

IT IS A GOOD PRACTICE TO AVOID PRESSURE-WASHING ELECTRICAL/ELECTRONIC COMPONENTS. SHOULD PRESSURE-WASHING BE UTILIZED TO WASH AREAS CONTAINING ELECTRICAL/ELECTRONIC COMPONENTS, JLG INDUSTRIES, INC. RECOMMENDS A MAXIMUM PRESSURE OF 750 PSI (52 BAR) AT A MINIMUM DISTANCE OF 12 INCHES (30.5 CM) AWAY FROM THESE COMPONENTS. IF ELECTRICAL/ELECTRONIC COMPONENTS ARE SPRAYED, SPRAYING MUST NOT BE DIRECT AND BE FOR BRIEF TIME PERIODS TO AVOID HEAVY SATURATION.

9.2 MULTIMETER BASICS

A wide variety of multimeters or Volt Ohm Meters (VOM) can be used for troubleshooting your equipment. A digital meter with reasonable accuracy (within 7%) is recommended for the measurements in these procedures. This section shows diagrams of a common, digital VOM configured for several different circuit measurements. Instructions for your VOM may vary. Please consult the meter operator's manual for more information.

Grounding

"Grounding the meter" means to take the black lead (which is connected to the COM (common) or negative port) and touch it to a good path to the negative side of the voltage source.

Backprobing

To "backprobe" means to take the measurement by accessing a connector's contact on the same side as the wires, the back of the connector. Readings can be done while maintaining circuit continuity this way. If the connector is the sealed type, great care must be taken to avoid damaging the seal around the wire. It is best to use probes or probe tips specifically designed for this technique, especially on sealed connectors. Whenever possible insert probes into the side of the connector such that the test also checks both terminals of the connection. It is possible to inspect a connection within a closed connector by backprobing both sides of a connector terminal and measuring resistance. Do this after giving each wire a gentle pull to ensure the wires are still attached to the contact and contacts are seated in the connector.

Min/Max

Use of the "Min/Max" recording feature of some meters can help when taking measurements of intermittent conditions while alone. For example, you can read the voltage applied to a solenoid when it is only operational while a switch, far from the solenoid and meter, is held down.

Polarity

Finding a negative voltage or current reading when expecting a positive reading frequently means the leads are reversed. Check what reading is expected, the location of the signal and that the leads are connected to the device under test correctly. Also check that the lead on the "COM" port goes to the ground or negative side of the signal and the lead on the other port goes to the positive side of the signal.

Scale

M = Mega = 1,000,000 * (Displayed Number)
k = kilo = 1,000 * (Displayed Number)
m = milli = (Displayed Number) / 1,000
µ = micro = (Displayed Number) / 1,000,000
Example: 1.2 kΩ = 1200 Ω
Example: 50 mA = 0.05 A

Voltage Measurement

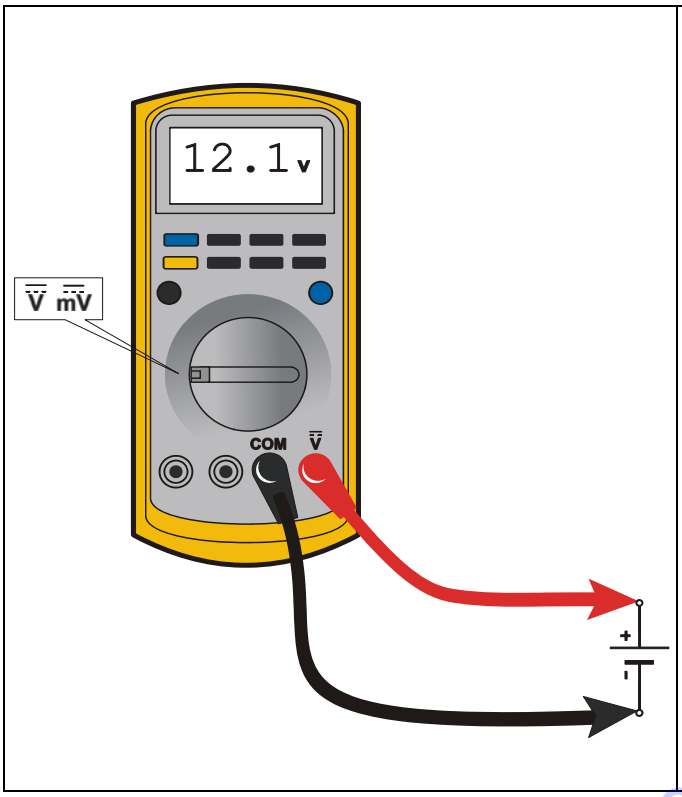


Figure 9-1. Voltage Measurement (DC)

- If meter is not auto ranging, set it to the correct range (See multimeter's operation manual)
- Use firm contact with meter leads

Resistance Measurement

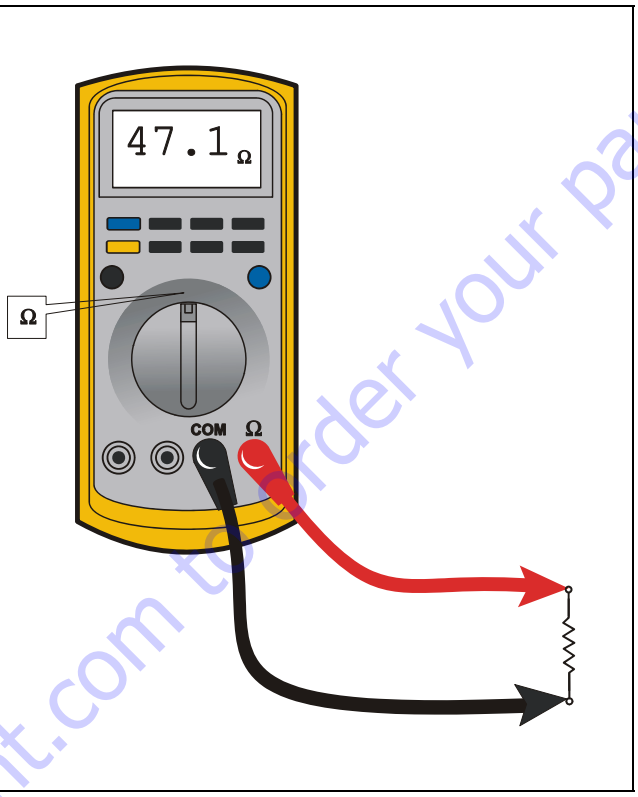


Figure 9-2. Resistance Measurement

- First test meter and leads by touching leads together. Resistance should read a short circuit (very low resistance)
- Circuit power must be turned OFF before testing resistance
- Disconnect component from circuit before testing
- If meter is not auto ranging, set it to the correct range (See multimeter's operation manual)
- Use firm contact with meter leads

Continuity Measurement

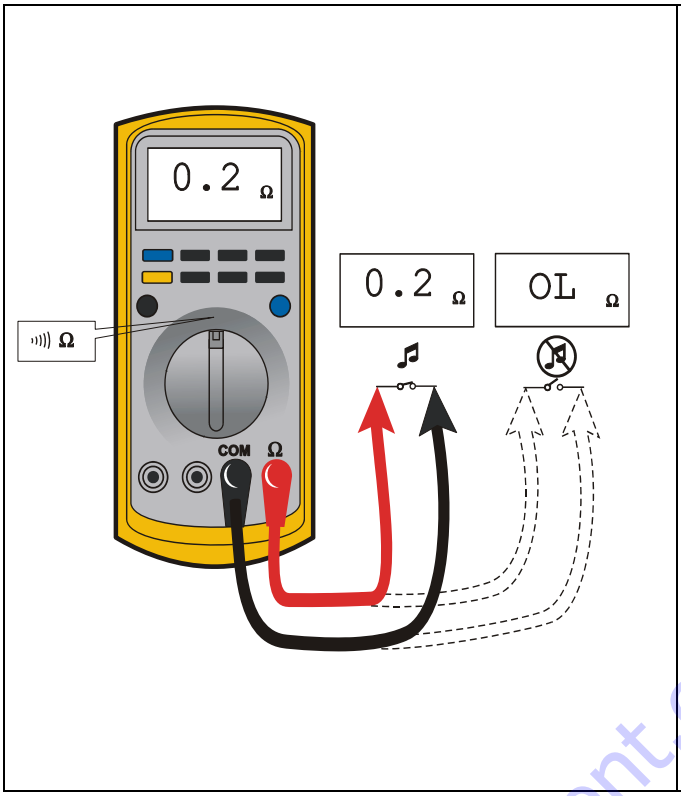


Figure 9-3. Continuity Measurement

- Some meters require a separate button press to enable audible continuity testing
- Circuit power must be turned OFF before testing continuity
- Disconnect component from circuit before testing
- Use firm contact with meter leads
- First test meter and leads by touching leads together. Meter should produce an audible alarm, indicating continuity

Current Measurement

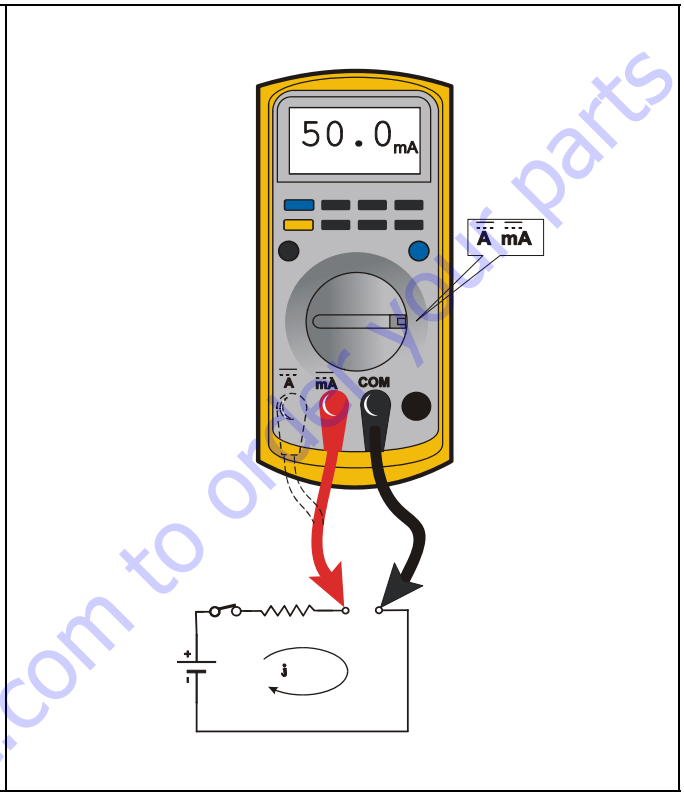


Figure 9-4. Current Measurement (DC)

- Set up the meter for the expected current range
- Be sure to connect the meter leads to the correct jacks for the current range you have selected
- If meter is not auto ranging, set it to the correct range (See multi meter's operation manual)
- Use firm contact with meter leads

Continuity Measurement Over Long Distances

When trying to determine continuity of a harness or wire, longer than the reach of standard instrument leads, is possible to perform the check without excessively long leads. Using the other wires in the harness one can determine the condition of a particular wire in the harness.

Requirements:

- Harness with at least three separate wires including the wire under test.
- These wires must be able to be isolated from other wires, etc.
- Jumper or method to connect contacts on one side of harness.
- Meter that can measure resistance or continuity.

Procedure

Test multimeter leads resistance. Subtract this value from the measured resistance of the wires to get a more accurate measurement.

Consult the circuit schematic to determine which wires to use in addition to wire under test, here called wire #1 and wire #2, and how to isolate these wires. These wires should appear in the same connectors as the wire under test or are within reach of the jumper.

1. Disconnect all connections associated with the wire under test and the two additional wires. If harness is not completely isolated disconnect battery terminals also, as a precaution.
2. Measure continuity between all three wires, the wire under test, wire #1 and wire #2. These should be open. If not, repair the shorted wires or replace the harness.
3. On one side, jumper from contact of wire #1 and wire #2.
4. Measure continuity between wire #1 and wire #2. If there is continuity, both wires are good and can be used for this test. If there is not continuity, either wire could be bad. Check connections and measurement setup. Redo measurement. If still no continuity, repair wires or consult schematic for other wires to use for test.
5. Jumper from wire under test to wire #1.
6. Measure continuity. If there is continuity, the wire under test is good. Resistance of a wire increases as the length increases and as the diameter decreases.

One can find the continuity of two wires, here #1 and #2, at once by following steps 1 through 4. If there is a problem the third wire is used to troubleshoot the other wires. To find the problem, start at step 1 and use the entire procedure.

9.3 ELECTRICAL SWITCH TESTING

Basic Check

The following check determines if the switch is functioning properly, not the circuit in which the switch is placed. A switch is functioning properly when there is continuity between the correct terminals or contacts only when selected.

1. De-energize the circuit.
2. Isolate the switch from the rest of the circuit if possible. If not possible, keep in mind it may affect readings.
3. Access the terminals to the switch.
4. If the switch has two terminals:
   a. Measure resistance across the terminals.
   b. Change the switch position.
   c. Measure resistance again with the leads in the same positions. If the meter was reading short, it should read an open. If the meter was reading open it should read short.
5. If the switch has more than two terminals, consult the schematic or switch diagram to determine what terminals will be connected. The test is similar to testing a switch with two terminals.
   a. Place one meter lead on the common contact and the other on a different contact in the same circuit.
   b. Cycle through all positions of the switch. The meter should read short only when the switch connects the two terminals and open otherwise.
   c. If the switch has more than one common contact repeat the process for that circuit.

Limit Switches

Limit switches are used to control movement or indicate position. Mechanical limit switches are just like manually operated switches except that the moving object operates the switch. These switches can be tested the same way as a standard switch by manually operating the sensing arm.

Another type of limit switch used by JLG is the inductive proximity switch, also referred to as a "prox switch". Inductive proximity switches are actuated only by ferrous metal (metal that contains Iron, such as steel) near the switch. They do not require contact, and must be energized to actuate. These types of switches can be used to detect boom or platform position, for example. These switches have a sensing face where the switch can detect ferrous metal close to it. To find the sensing face, take note how the switch is mounted and how the mechanisms meet the switch. Test this type of switch as follows:

1. Remove prox switch from its mount.
2. Reconnect harness if it was disconnected for step 1, and turn on machine.
3. Hold switch away from metal and observe switch state in the control system diagnostics using the Analyzer. See vehicle or control system documentation on how to do this.
4. Place sensing face of switch on the object to be sensed by the switch. If that is not available, use a piece of ferrous metal physically similar to it. The switch state in the control system diagnostics should change.
5. When reinstalling or replacing switch be sure to follow mounting instructions and properly set the gap between the switch and object sensed.

Automatic Switches

If the switch is actuated automatically, by temperature or pressure for example, find a way to manually actuate the switch to test it. Do this either by applying heat or pressure, for example, to the switch. These switches may need to be energized to actuate.

1. Connect instrumentation to monitor and/or control the parameter the switch is measuring.
2. Observe switch state in control system with the Analyzer. See vehicle or control system documentation on how to do this.
3. Operate system such that the switch actuates. This could be going over a certain pressure or temperature, for example. The state indicated in the control system should change.

Switch Wiring - Low Side, High Side

When controlling a load, a switch can be wired between the positive side of the power source and the load. This switch is called a "high side" switch. The switch supplies the power to the load. When a switch is wired between the negative side of the power source and the load, it is a "low side" switch. The switch provides the ground to the load.

A low side switch will allow voltage to be present on the load. No power is applied because the switch is stopping current flow. This voltage can be seen if the measurement is taken with one test lead on the load and the other on the battery negative side or grounded to the vehicle. What is actually being measured is the voltage drop across the switch. This could mislead a technician into thinking the load is receiving power but not operating. To produce an accurate picture of power or voltage applied to the load, measure voltage across the load's power terminals. Also, the technician can measure the voltage at both power terminals with respect to battery ground. The difference between those two measurements is the voltage applied to the load.

9.4 APPLYING SILICONE DIELECTRIC COMPOUND TO AMP CONNECTORS

Silicone Dielectric Compound must be used on the AMP connections for the following reasons:

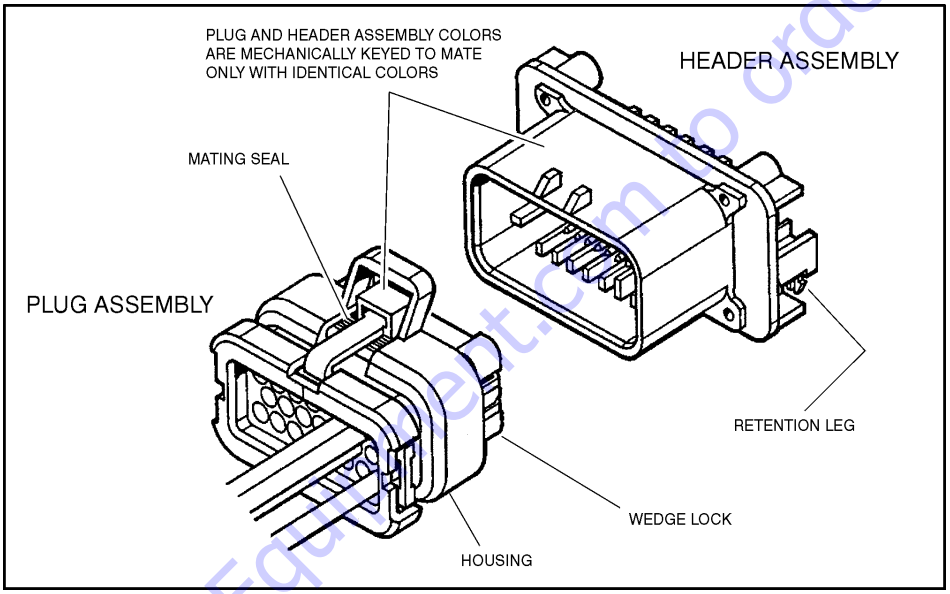
- To prevent oxidation at the mechanical joint between male and female pins.
- To prevent electrical malfunction caused by low level conductivity between pins when wet.

Use the following procedure to apply Silicone Dielectric Compound to the electrical connectors.

1. To prevent oxidation and low level conductivity, silicone dielectric grease must be packed completely around male and female pins on the inside of the connector after the mating of the housing to the header. This is easily achieved by using a syringe to fill the header with silicone dielectric compound, to a point just above the top of the male pins inside the header. When assembling the housing to the header, it is possible that the housing will become air locked, thus preventing the housing latch from engaging.

2. Pierce one of the unused wire seals to allow the trapped air inside the housing to escape.

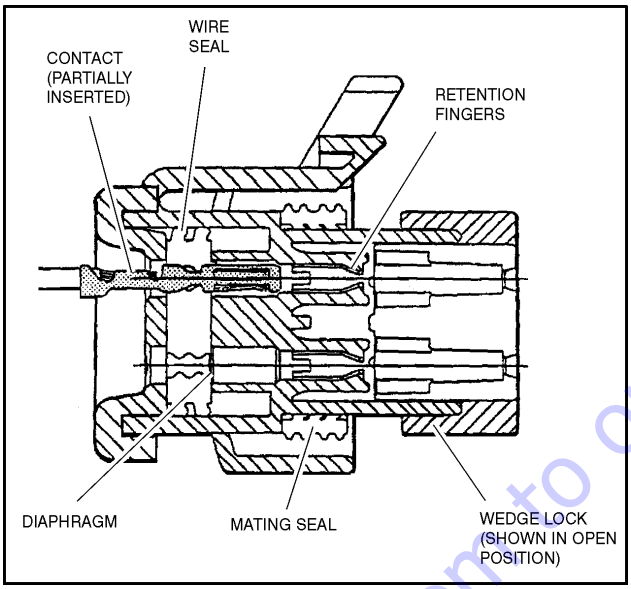
3. Install a hole plug into this and/or any unused wire seal that has silicone dielectric compound escaping from it.



AMP Connector

Assembly

Check to be sure the wedge lock is in the open, or as-shipped, position (See Connector Assembly Figure 1). Proceed as follows:



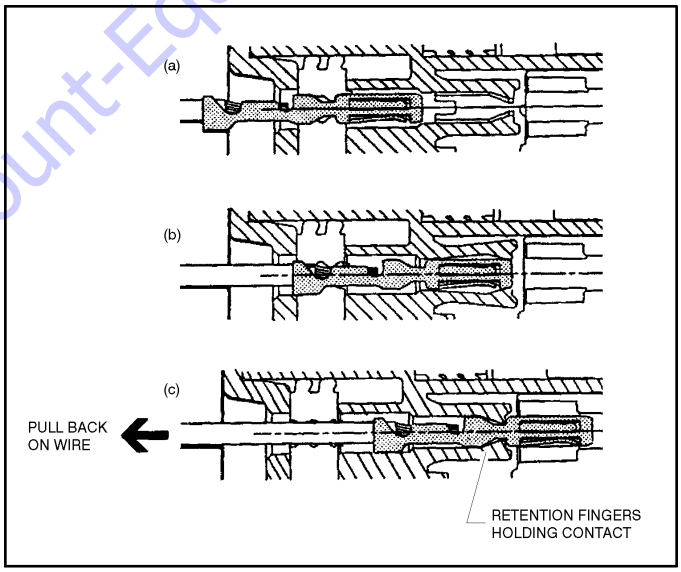
Connector Assembly Figure 1

1.To insert a contact, push it straight into the appropriate circuit cavity as far as it will go (See Connector Assembly Figure 2).

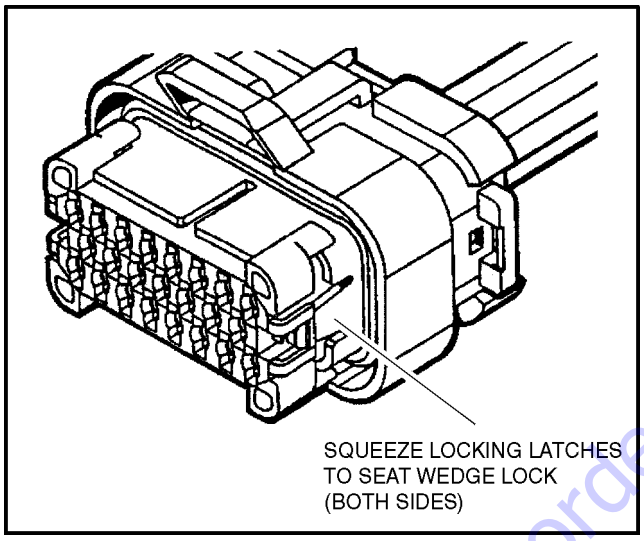
2.Pull back on the contact wire with a force of 1 or 2 lbs. to be sure the retention fingers are holding the contact (See Connector Assembly Figure 2).

3.After all required contacts have been inserted, the wedge lock must be closed to its locked position. Release the locking latches by squeezing them inward (See Connector Assembly Figure 3).

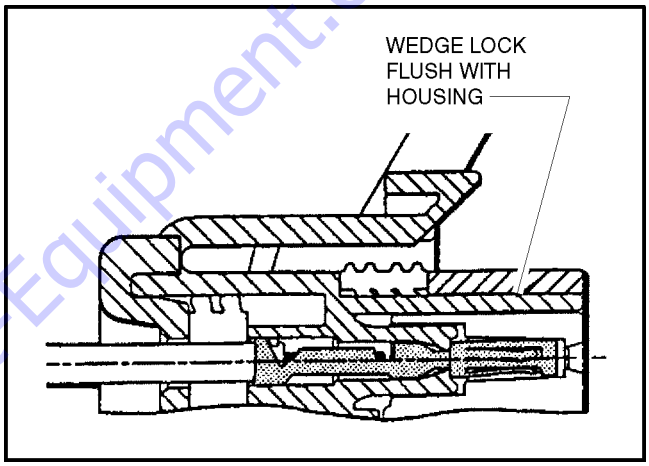
4.Slide the wedge lock into the housing until it is flush with the housing (See Connector Assembly Figure 4).



Connector Assembly Figure 2



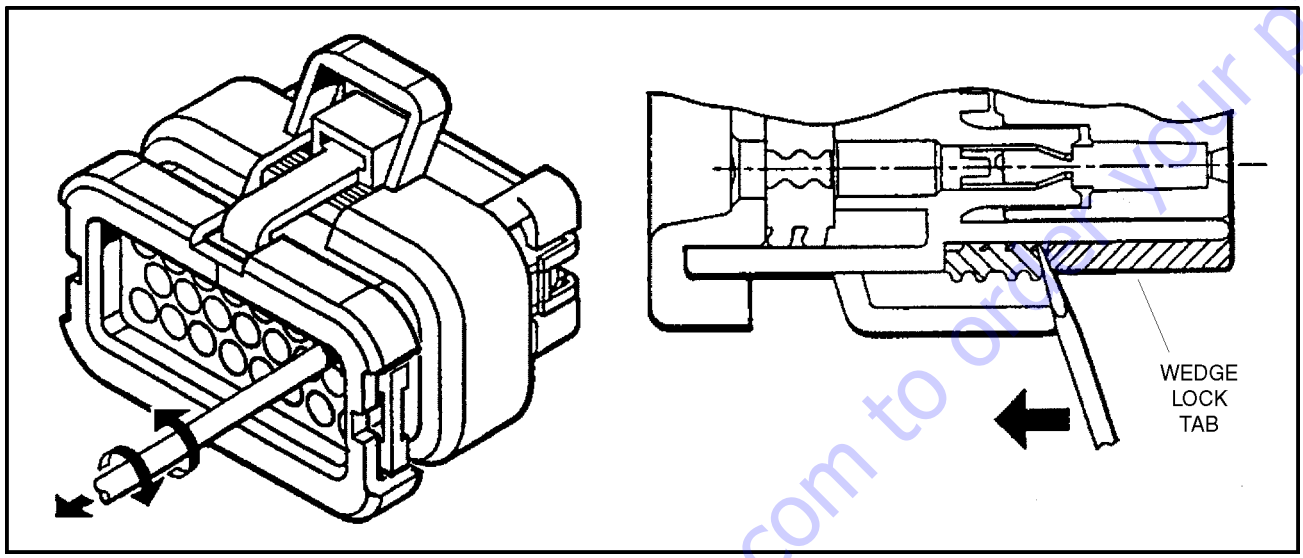
Connector Assembly Figure 3



Connector Assembly Figure 4

Disassembly

1. Insert a 4.8 mm (3/16") wide screwdriver blade between the mating seal and one of the red wedge lock tabs.
2. Pry open the wedge lock to the open position.
3. While rotating the wire back and forth over a half turn (1/4 turn in each direction), gently pull the wire until the contact is removed.



Connector Disassembly

NOTE: *The wedge lock should never be removed from the housing for insertion or removal of the contacts.*

Wedge Lock

The wedge lock has slotted openings in the forward, or mating end. These slots accommodate circuit testing in the field, by using a flat probe such as a pocket knife. DO NOT use a sharp point such as an ice pick.

Service - Voltage Reading

⚠ CAUTION

DO NOT PIERCE WIRE INSULATION TO TAKE VOLTAGE READINGS.

It has been common practice in electrical troubleshooting to probe wires by piercing the insulation with a sharp point. This practice should be discouraged when dealing with the AMPSEAL plug assembly, or any other sealed connector system. The resulting pinholes in the insulation will allow moisture to invade the system by traveling along the wire strands. This nullifies the effectiveness of the connector seals and could result in system failure.

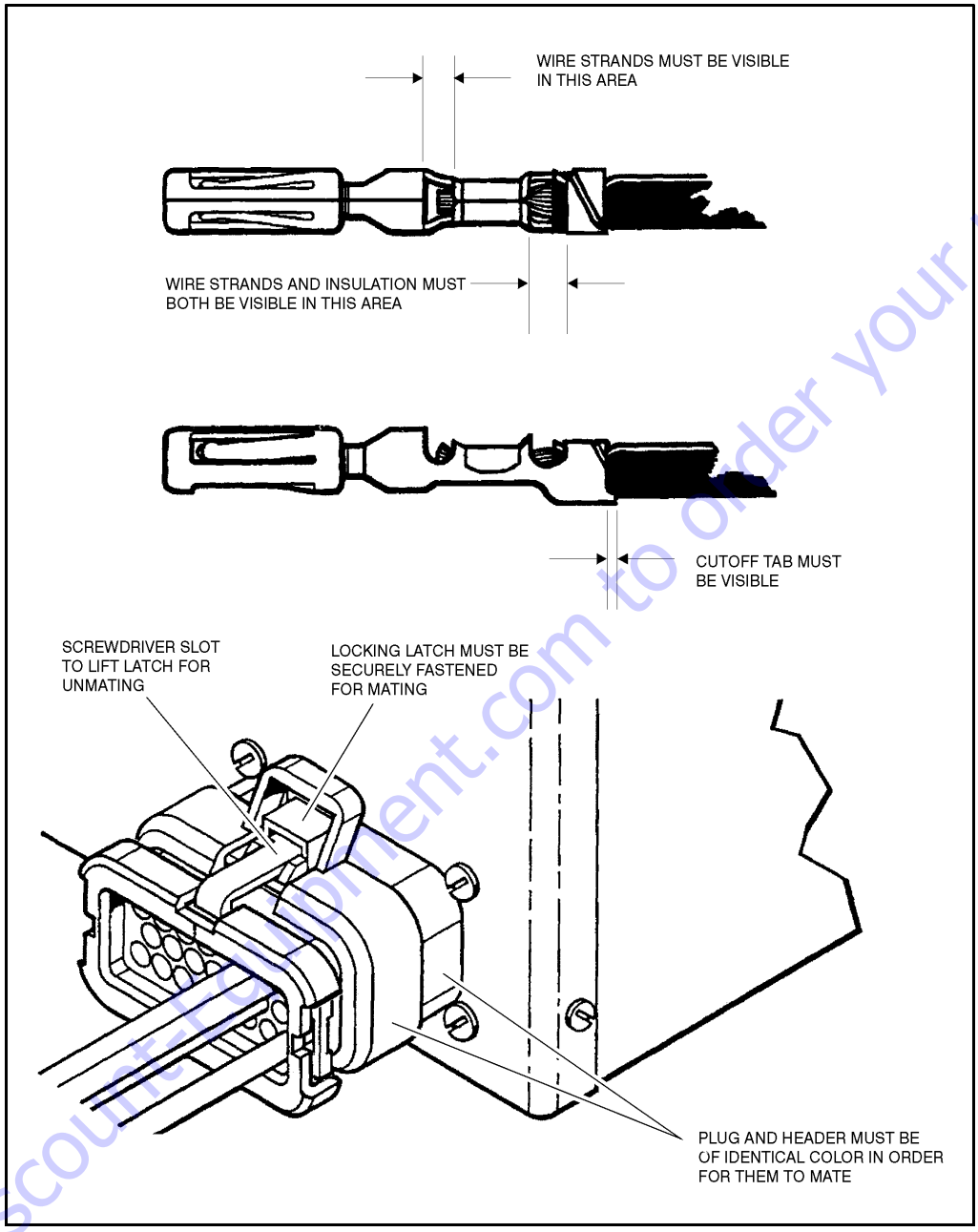


Figure 9-5. Connector Installation

9.5 WORKING WITH DEUTSCH CONNECTORS

DT/DTP Series Assembly

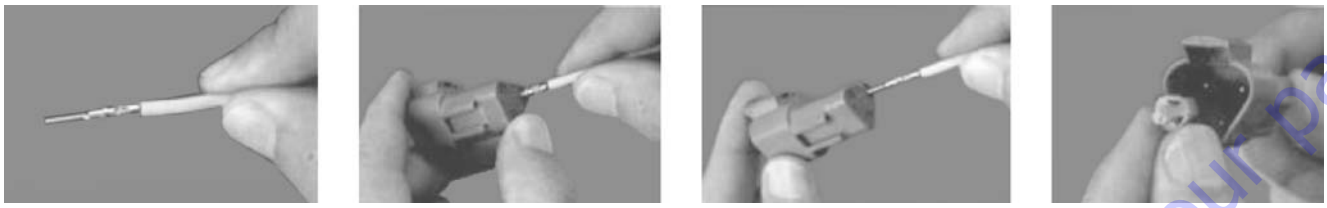


Figure 9-6. DT/DTP Contact Installation

1. Grasp crimped contact about 25mm behind the contact barrel.
2. Hold connector with rear grommet facing you.
3. Push contact straight into connector grommet until a click is felt. A slight tug will confirm that it is properly locked in place.
4. Once all contacts are in place, insert wedgelock with arrow pointing toward exterior locking mechanism. The wedgelock will snap into place. Rectangular wedges are not oriented. Thy may go in either way.

NOTE: *The receptacle is shown - use the same procedure for plug.*

DT/DTP Series Disassembly

Figure 9-7. DT/DTP Contact Removal

1. Remove wedgelock using needlenose pliers or a hook shaped wire to pull wedge straight out.
2. To remove the contacts, gently pull wire backwards, while at the same time releasing the locking finger by moving it away from the contact with a screwdriver.
3. Hold the rear seal in place, as removing the contact may displace the seal.

HD30/HDP20 Series Assembly

Figure 9-8. HD/HDP Contact Installation

1. Grasp contact about 25mm behind the contact crimp barrel.
2. Hold connector with rear grommet facing you.
3. Push contact straight into connector grommet until a positive stop is felt. A slight tug will confirm that it is properly locked in place.

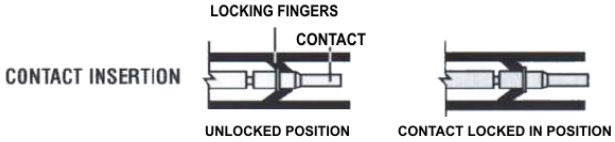


Figure 9-9. HD/HDP Locking Contacts Into Position

NOTE: *For unused wire cavities, insert sealing plugs for full environmental sealing*

HD30/HDP20 Series Disassembly

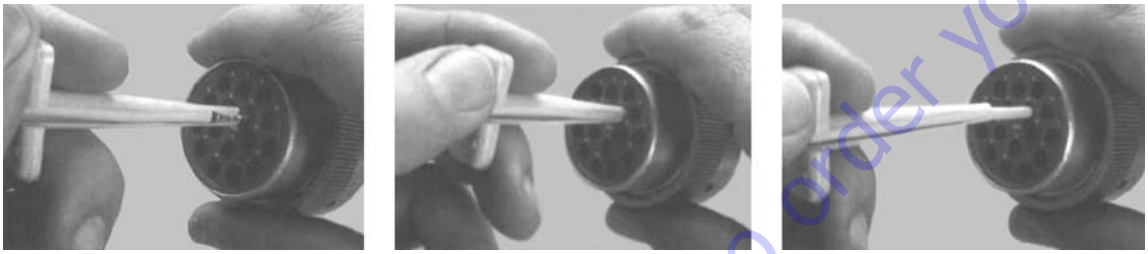


Figure 9-10. HD/HDP Contact Removal

1.With rear insert toward you, snap appropriate size extractor tool over the wire of contact to be removed.

2.Slide tool along into the insert cavity until it engages contact and resistance is felt.

3.Pull contact-wire assembly out of connector.

Figure 9-11. HD/HDP Unlocking Contacts

NOTE: *Do Not twist or insert tool at an angle.*

9.6 X-CONNECTOR REFERENCES

Throughout this Service Manual, electrical connectors are given a three digit identifier number preceded with an “X” for identifying and locating the specific connector.

See Section 9.8, X-CONNECTOR ID INDEX for description of "X" connectors and Figure 9-12. on page 9-20, and Figure 9-13. on page 9-21 for location of "X" connectors on the machine.

Example of "X" connector usage nomenclature:

[X006.21] refers to terminal 21 (pin and socket) of connector X006.

[X006.21.soc] refers to the socket side of terminal 21, connector X006.

[X006.21.pin] refers to the pin side of terminal 21, connector X006.

9.7 CONNECTOR LOADING DIAGRAMS

Table 9-1. Connector Loading Diagrams

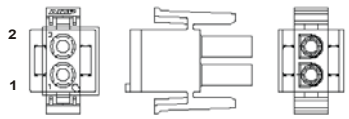
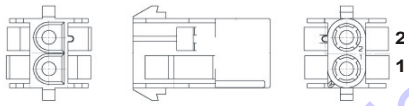
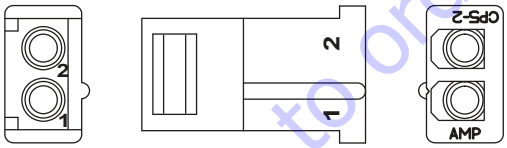
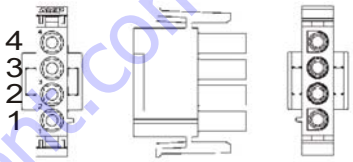
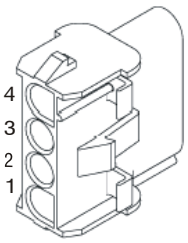
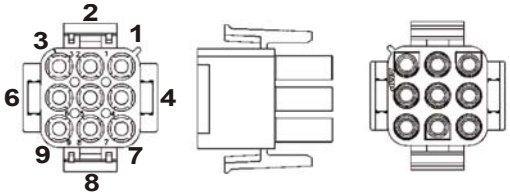
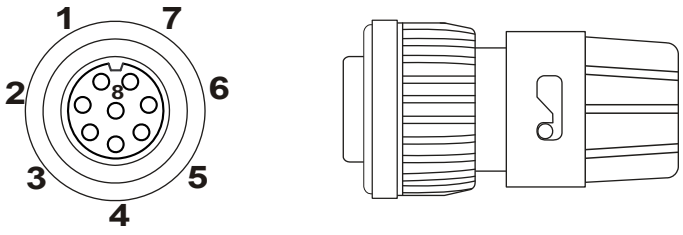
ID	Description	Diagram
AMP02P	Amp 2 position plug	
AMP02R	Amp 2 position receptacle	
AMPC02P	Amp Commercial 2 position plug	
AMP04P	Amp 4 position plug	
AMP04R	Amp 4 position receptacle	
AMP09P	Amp 9 position plug	
CXA08P	Conxall 8 position plug	

Table 9-1. Connector Loading Diagrams (Continued)

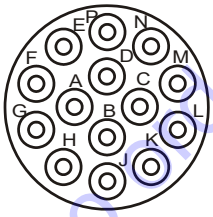
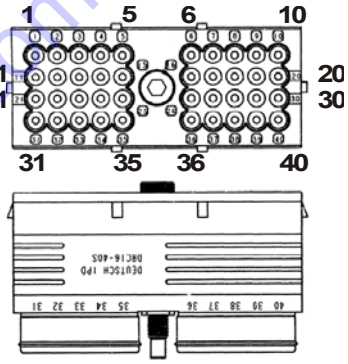
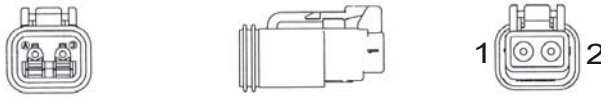
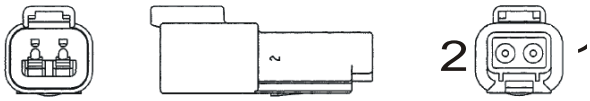
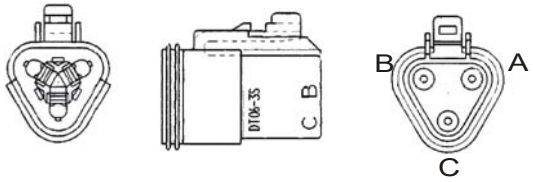
ID	Description	Diagram
DHD14P	Deutsch 14 position HD series alum. Plug	 REAR VIEW
DHD14R	Deutsch 14 position HD series alum. Receptacle	 REAR VIEW
DRC40P	Deutsch 40 position plug	
DT02P	Deutsch 2 position DT series plug	
DT02R	Deutsch 2 position DT series receptacle	
DT03P	Deutsch 3 position DT series plug	

Table 9-1. Connector Loading Diagrams (Continued)

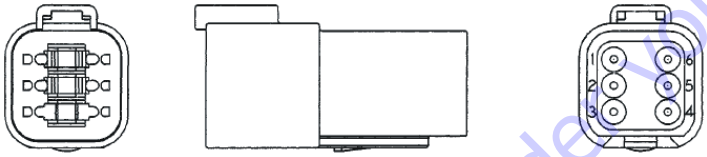
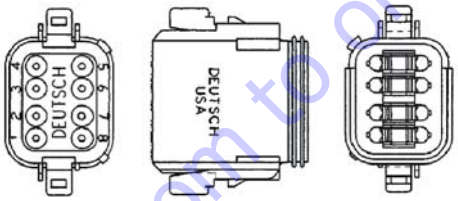
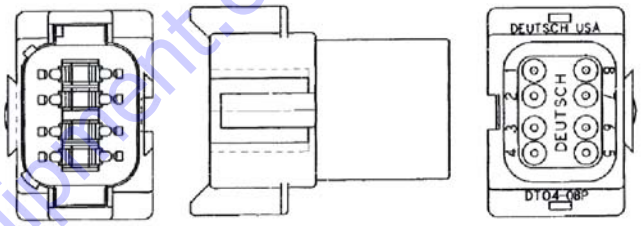
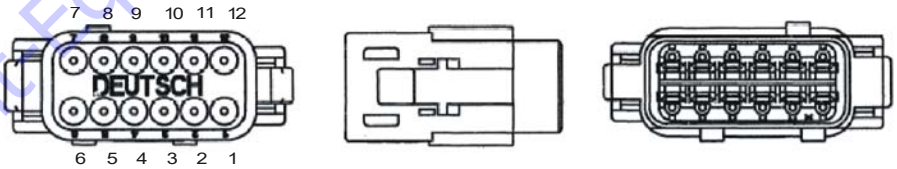
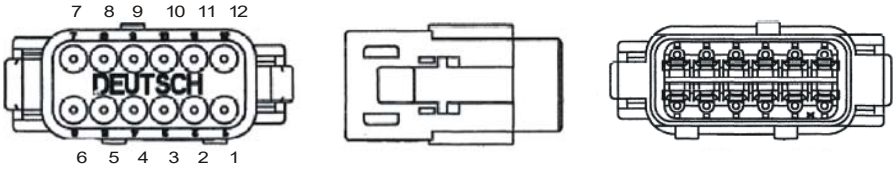
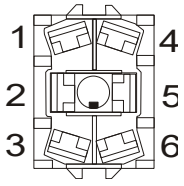
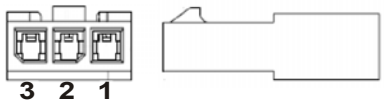
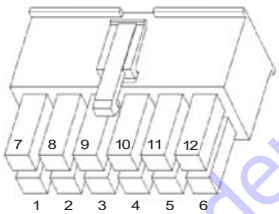
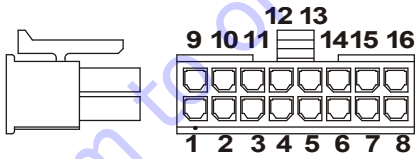
ID	Description	Diagram
DT06AP	Deutsch 6 position DT series plug	
DT06R	Deutsch 6 position DT series receptacle	
DT08AP	Deutsch 8 position DT series plug with A keys	
DT08AR	Deutsch 8 position DT series receptacle with A keys	
DTM12AP	Deutsch 12 position DT series mini plug with A key	
DTM12BP	Deutsch 12 position DT series mini plug with B key	
E06P	Eaton Toggle Switch	

Table 9-1. Connector Loading Diagrams (Continued)

ID	Description	Diagram
MMF03P	Molex 3 position plug	
MMF12P	Molex Mini Fit 12 position plug	
MMF16P	Molex Mini Fit 16 position plug	

9.8 X-CONNECTOR ID INDEX

Table 9-2. X-Connector ID Index

ID	Description	End 1 ID	End 2 ID
X001	Ground Module J1		DRC40P
X002	Ground Module J2		AMP09P
X003	Ground Module J3		AMP04P
X008	Battery +		
X009	RH Pothole Switch		
X010	Ground Passthru	AMP04P	AMP04R
X011	Diagnostic Port	AMP04R	
X012	Brake Release Power		
X013	Brake Release Ign		
X014	Beacon	DT02R	
X017	Arm Stack Passthru	DT08AR	DT08AP
X018	Charger Interlock	AMP02P	AMP02R
X019	Charger Plug		
X020	Charger	DT06AP	DT06R
X021	Battery -		
X022	Ground Alarm	DT03P	
X023	LH Pothole Switch		
X024	Left Brake	DT02R	DT02P
X025	Right Brake	DT02R	DT02P
X026	Contactor	DT02R	
X027	Power Module	MMF12P	

Table 9-2. X-Connector ID Index

ID	Description	End 1 ID	End 2 ID
X028	LED Display	AMP04R	
X029	Overload +		
X030	Overload -		
X031	Hourmeter -		
X032	Hourmeter +		
X033	Circuitbreaker Out		
X034	Circuitbreaker In		
X035	Gnd E-Stop In		
X036	Gnd E-Stop Out		
X037	Lift Switch	E06P	
X038	Key Common		
X039	Key Ground		
X040	Key Platform		
X041	Lift Down Valve	DT02P	
X042	Steer Right Valve	DT02P	
X043	Lift Up Valve	DT02P	
X044	Steer Left Valve	DT02P	
X046	Platform Box	DHD14P	DHD14R
X047	Platform E-Stop Out		
X048	Platform E-Stop In		
X049	Joystick	AMP09P	
X050	Platform Module J1	MMF16P	
X051	Platform Lift Drive Switch	MMF03P	
X052	Platform Alarm +		
X053	Platform Alarm -		
X054	Platform Horn Switch		
X056	Inverter Switch Out		
X057	Inverter Switch In		
X058	Contactor Supply		
X059	Contactor Out		
X060	Power Module B-		
X061	Power Module F1		
X062	Power Module F2		
X063	Left Motor Power Mod M1		
X064	Power Module P		
X065	Power Module B+ from Contactor		
X066	Left Motor Power Mod M2		
X069	Pump Motor +		
X070	Pump Motor -		
X071	Battery 1 + to Contactor		
X072	Battery 1 -		
X073	Battery 2 +		
X074	Battery 2 -		

Table 9-2. X-Connector ID Index

ID	Description	End 1 ID	End 2 ID
X075	Battery Disconnect		
X076	Battery 3 +		
X077	Battery 3 -		
X078	Battery 4 +		
X079	Battery 4 - to Power Mod		
X080	Right Motor Field Cross		
X081	Left Motor Field Cross		
X082	Inverter Control	CXA08P	
X083	Right Motor Power Mod M1		
X084	Power Mod B + to Pump Motor		
X085	Right Motor Power Mod M2		
X086	Battery 1 + to Inverter +		
X087	Inverter +		
X088	Battery 4 - to Inverter -		
X089	Inverter -		
X090	Right Wheel Brake Solenoid	AMPC02P	
X091	Left Wheel Brake Solenoid	AMPC02P	
X092	Right Wheel +		
X093	Left Wheel +		
X094	Right Wheel -		
X095	Left Wheel -		
X096	Right Wheel Field from F1		
X097	Left Wheel Field from F2		
X098	Right Wheel Field Common		
X099	Left Wheel Field Common		
X104	1230 Footswitch Chassis		DT08AP
X105	1230 Footswitch Platform	DT08AR	
X106	1230 Footswitch J1	DTM12BP	
X107	1230 Footswitch J2	DTM12AP	
X108	1230 Mast Passthru		DT08AP
X109	1230 Proximity Switch	DT02P	
X110	Inverter AC input		
X111	Inverter AC output		
X112	Charger AC input		

9.9 MACHINE LOCATION OF COMPONENT X-CONNECTORS

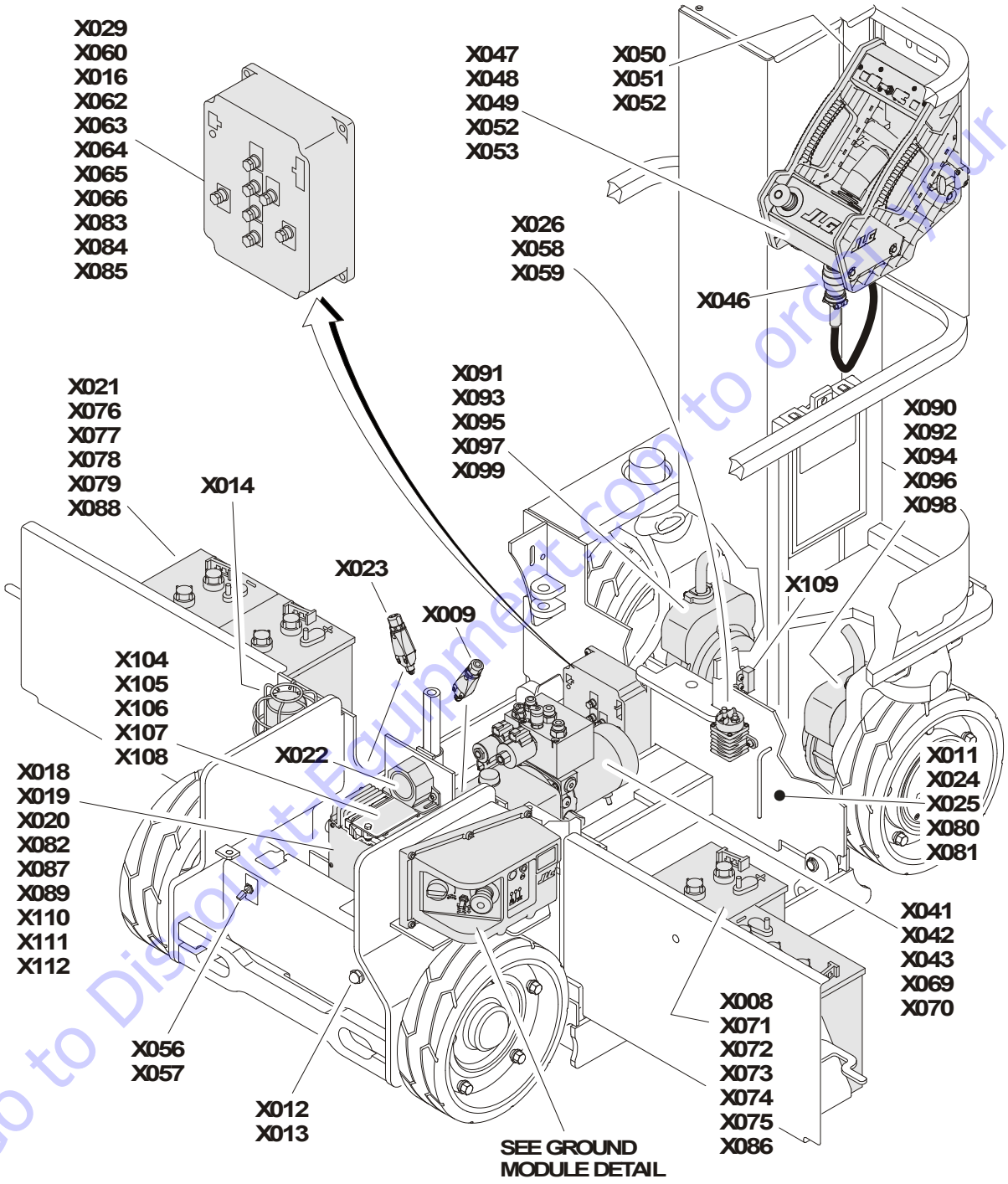


Figure 9-12. 1230ES - Location of Component X-Connectors on Machine.

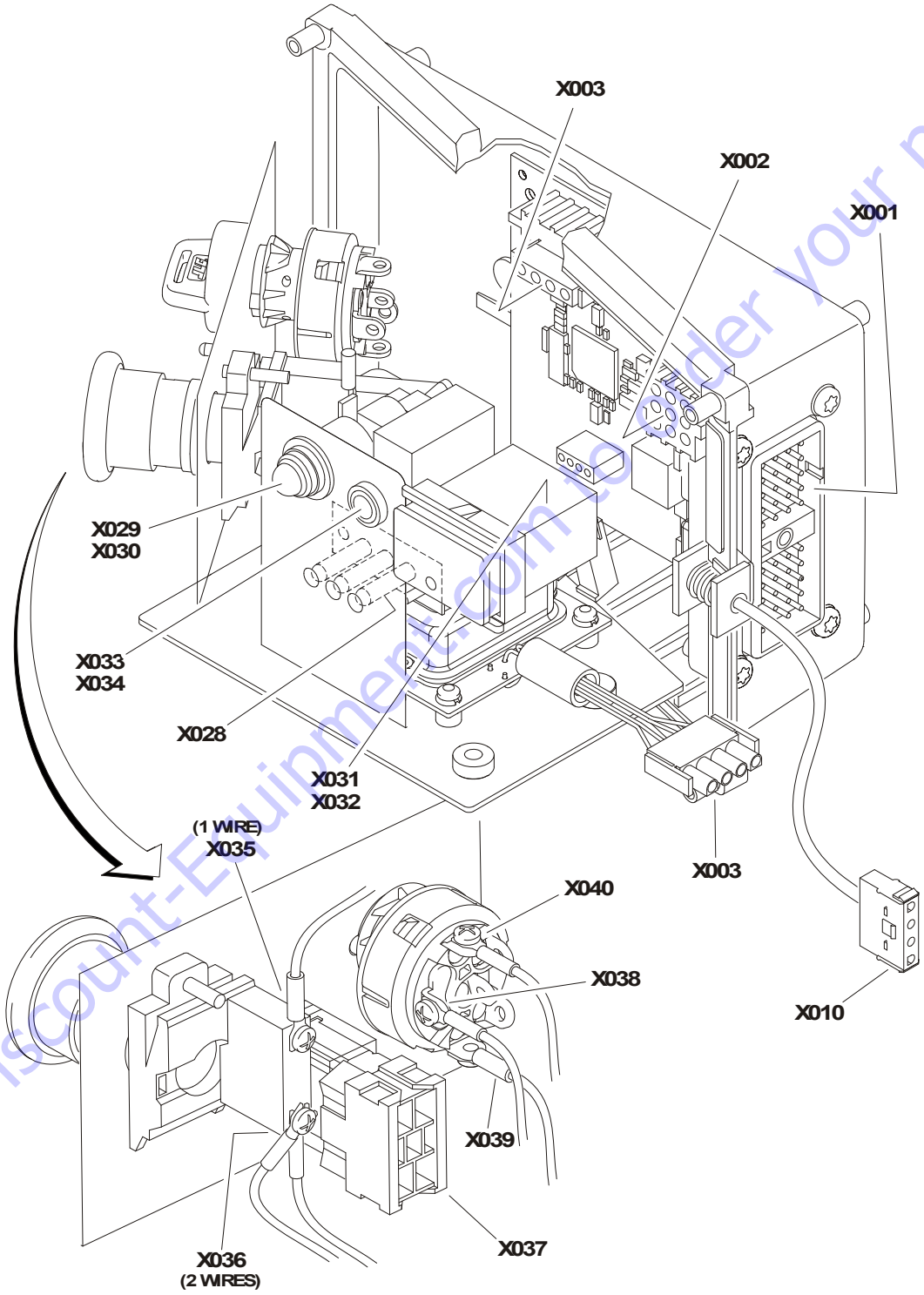


Figure 9-13. 1230ES - Location of Component X-Connectors on Ground Control Module.

9.10 ELECTRICAL LAYOUT AND SCHEMATICS

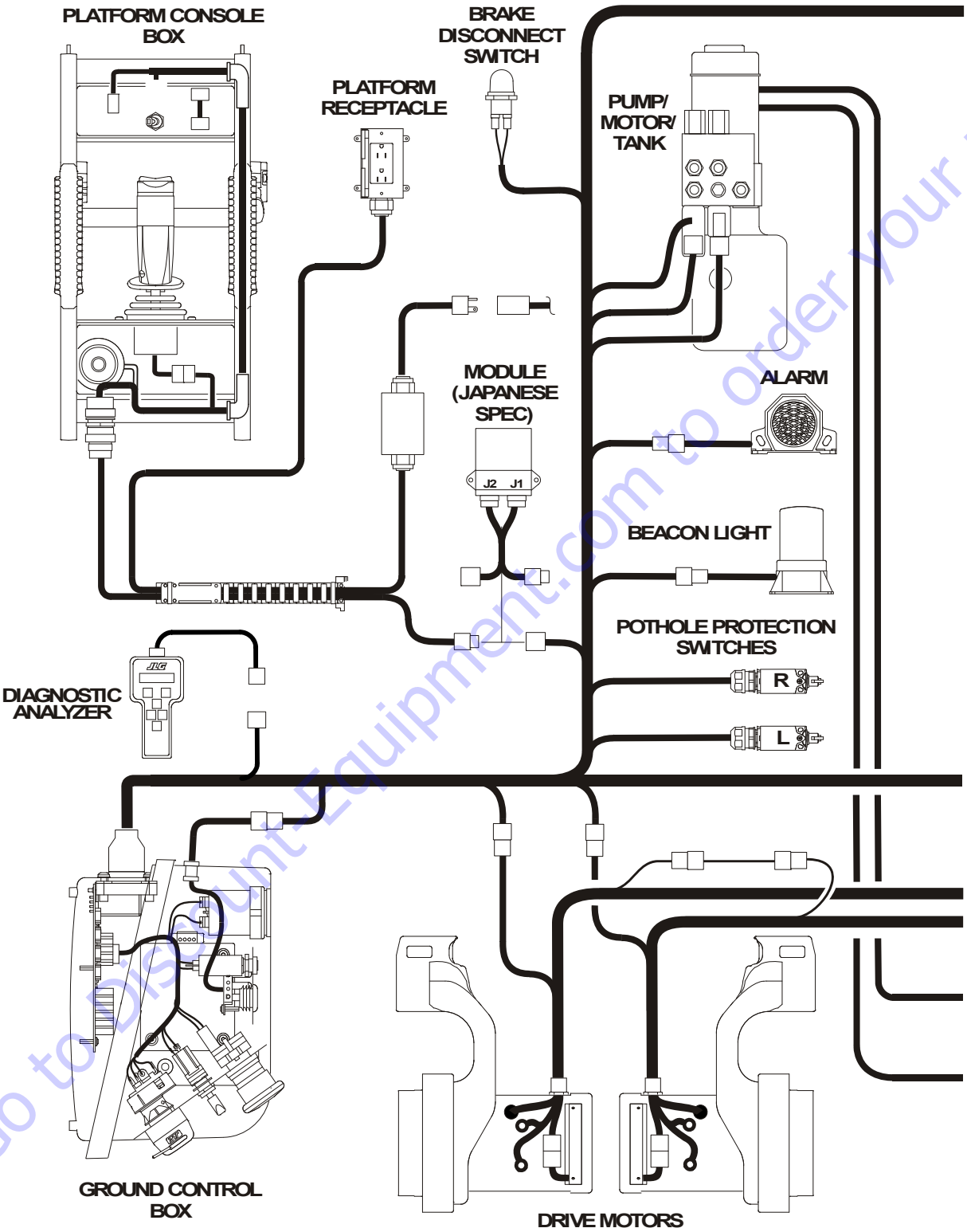


Figure 9-14. 1230ES - Overview of Electrical System Components. (1600346 Drive Module)

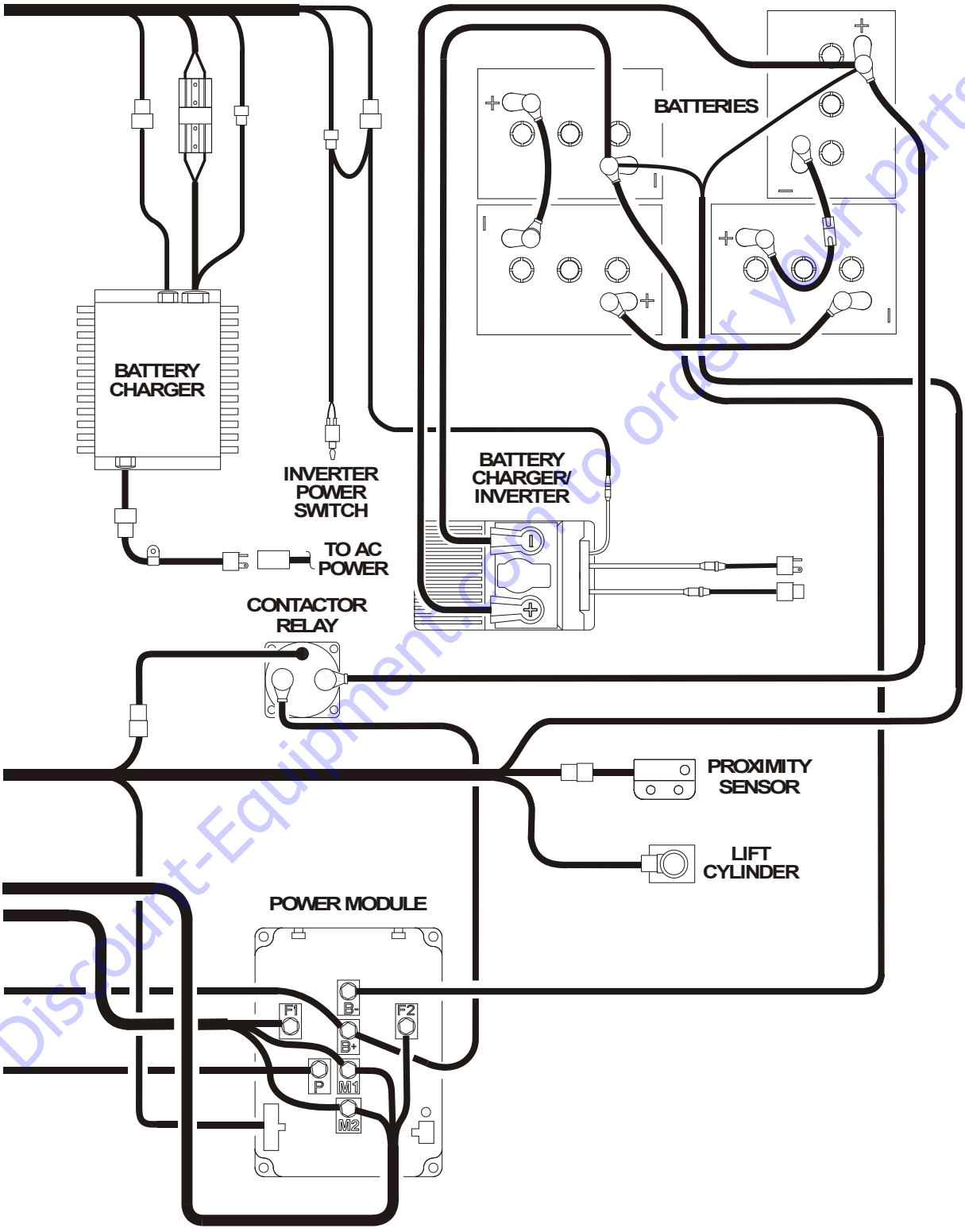


Figure 9-14., 1230ES - Overview of Electrical System Components. (1600346 Drive Module)

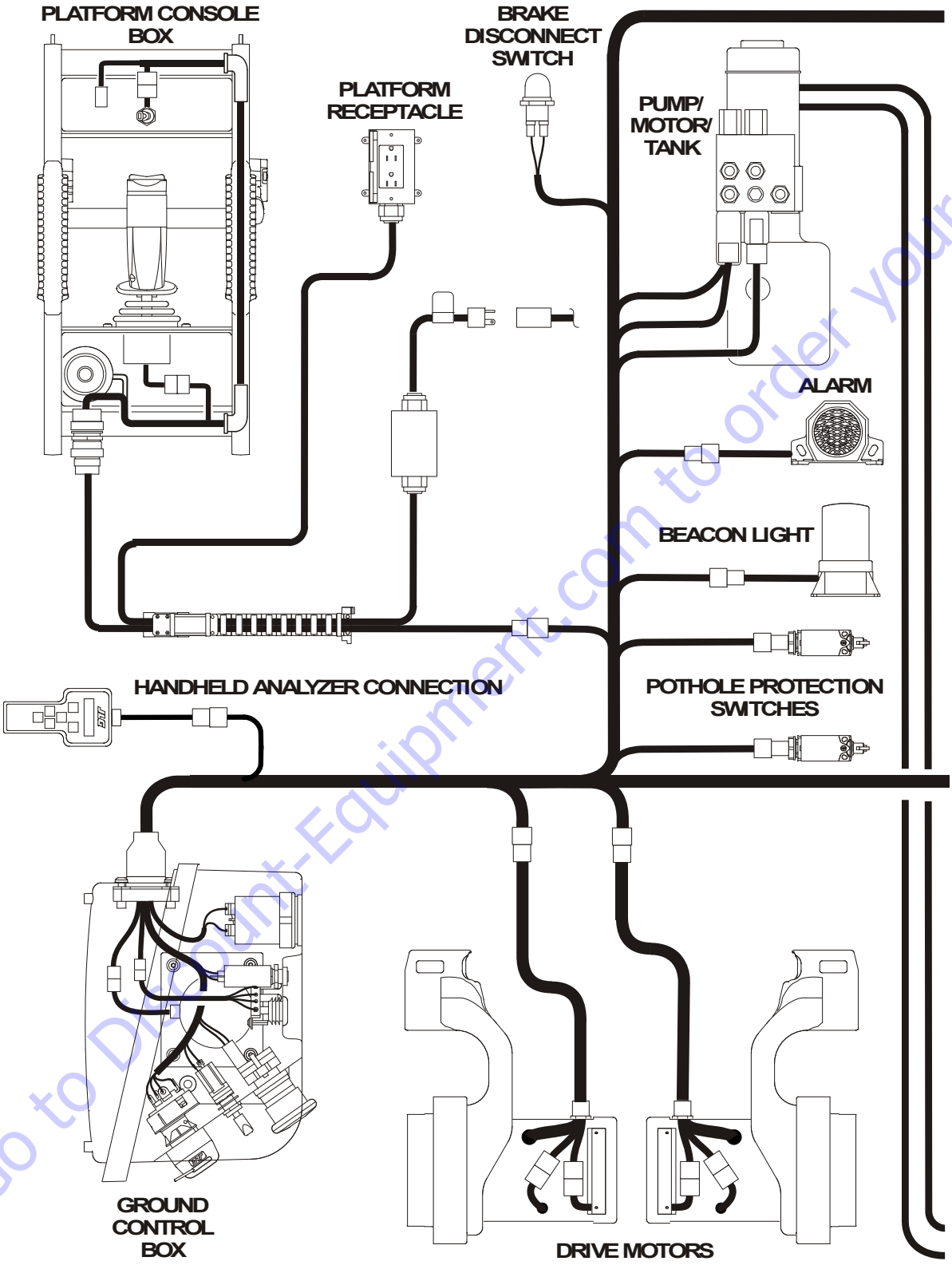


Figure 9-15. 1230ES - Overview of Electrical System Components. (1001092456 Drive Module)

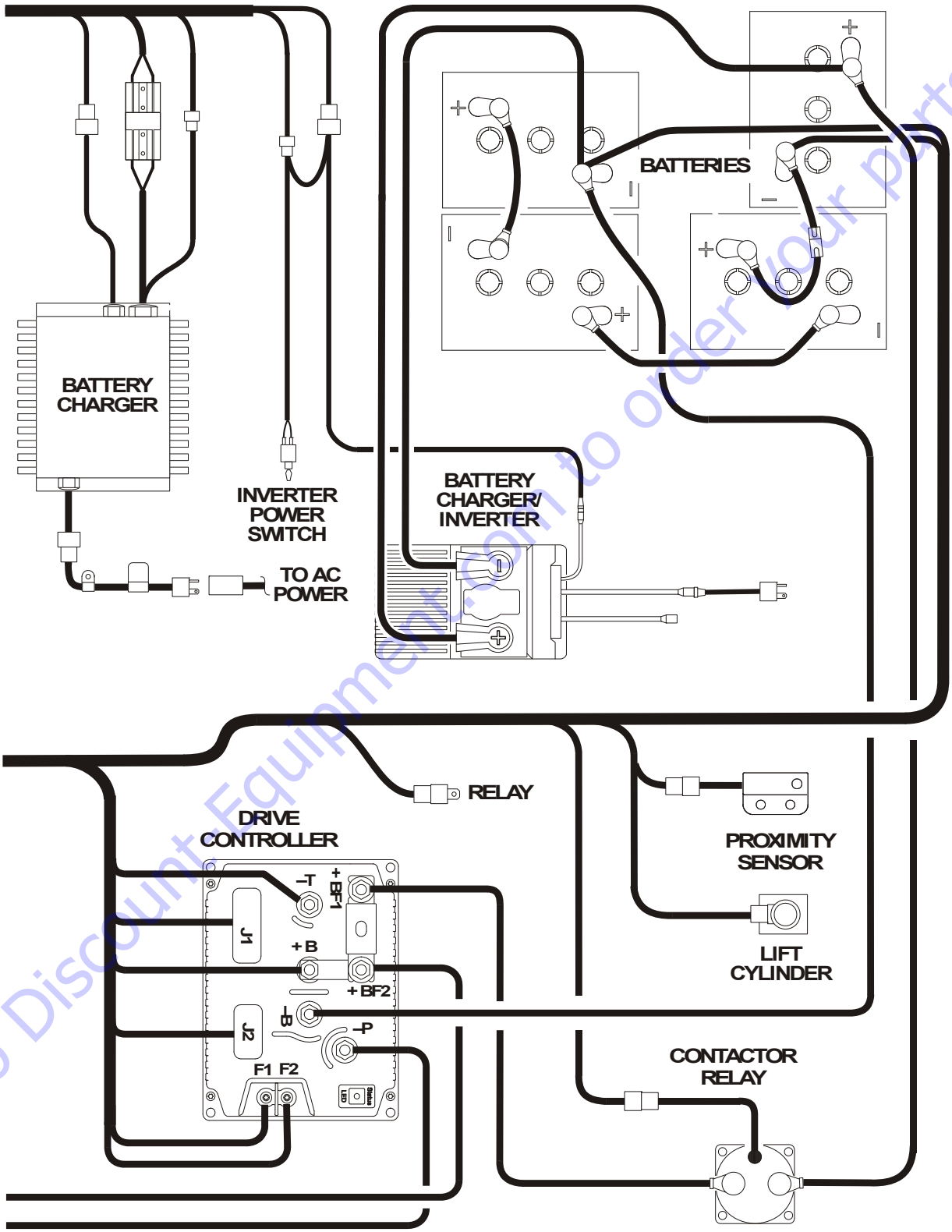


Figure 9-15., 1230ES - Overview of Electrical System Components. (1001092456 Drive Module)

9.11 ELECTRICAL SCHEMATICS

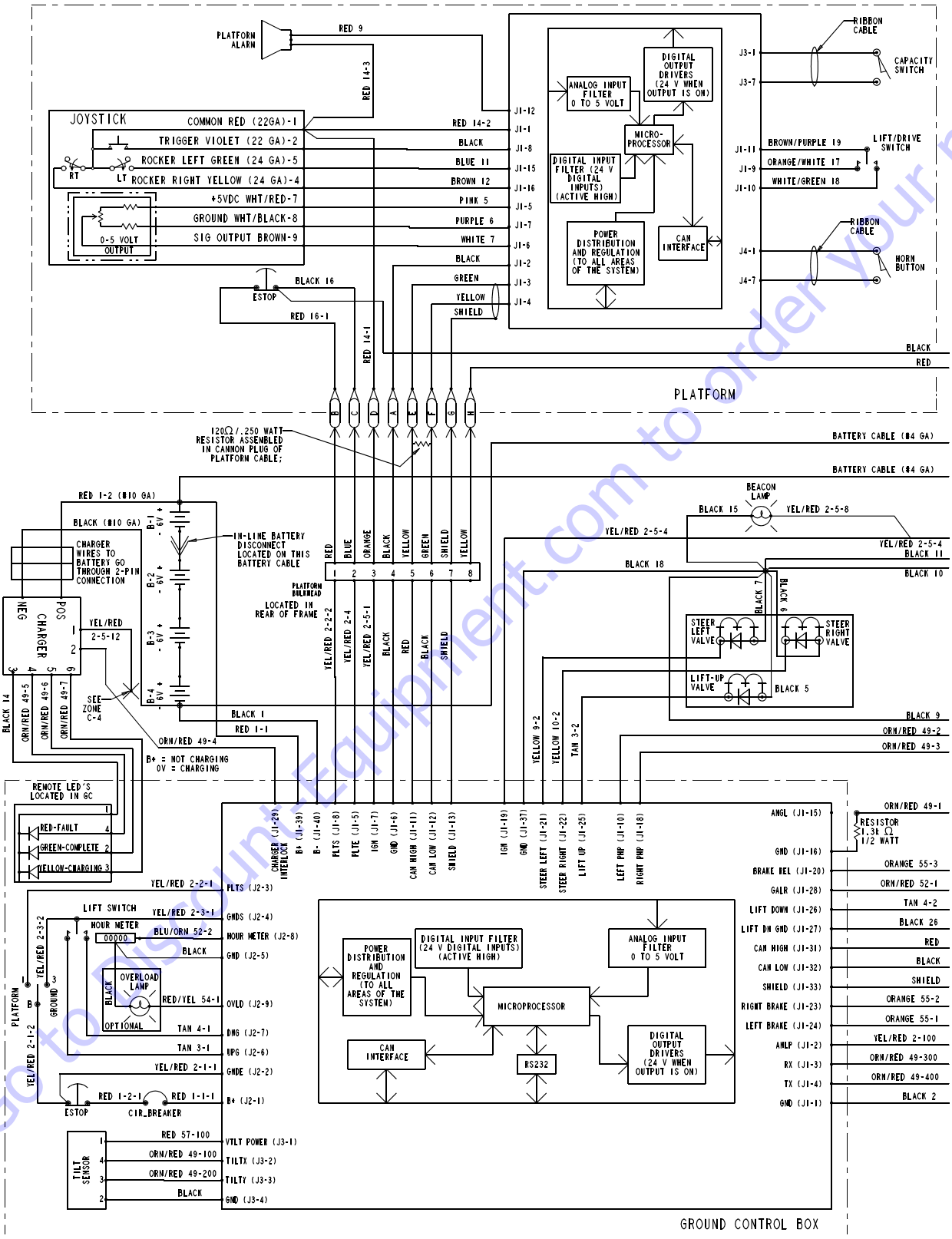
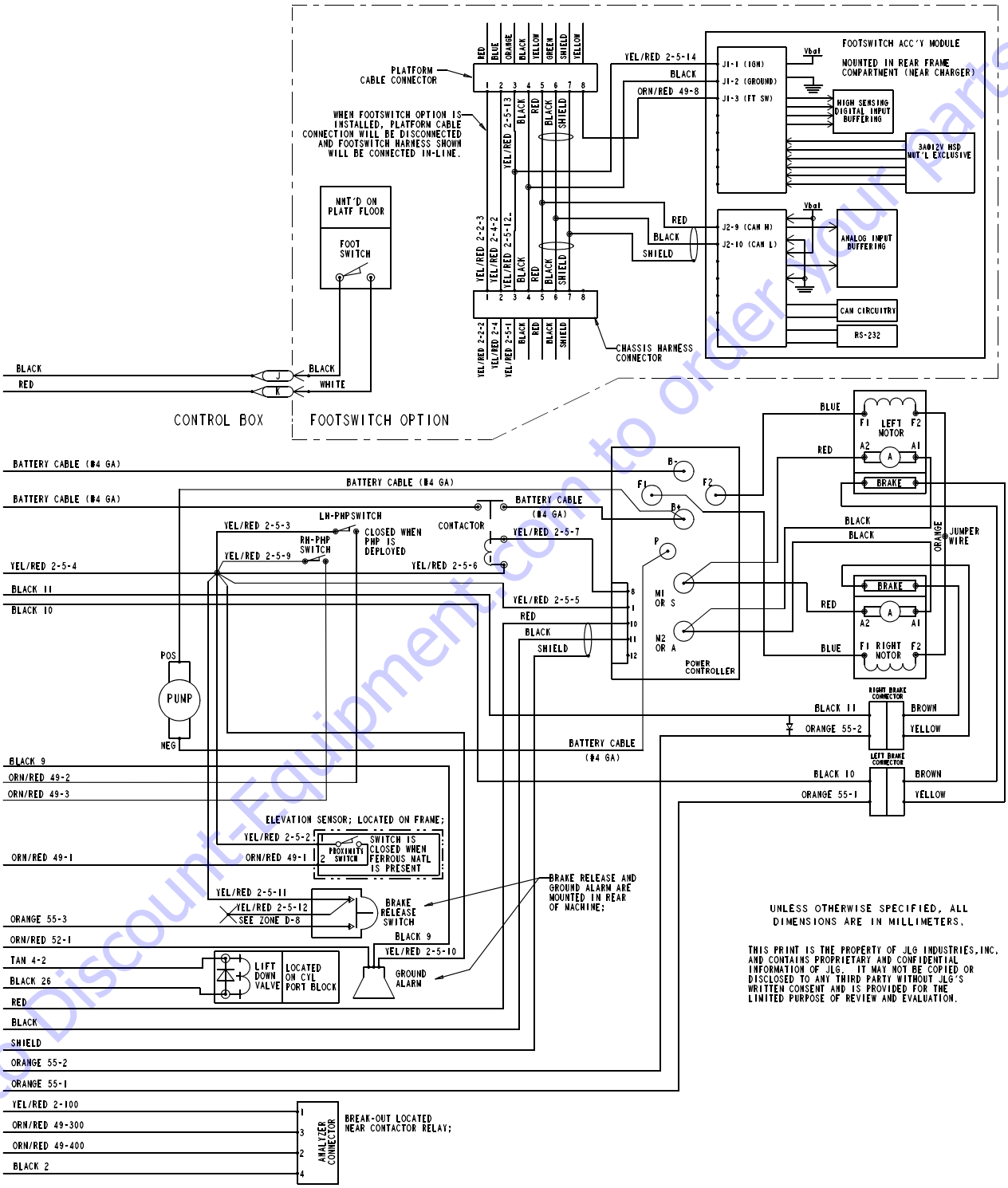


Figure 9-16. Electrical Schematic - (Machines with 1600346 Drive Module)



1870188_E

Figure 9-16., Electrical Schematic - (Machines with 1600346 Drive Module)

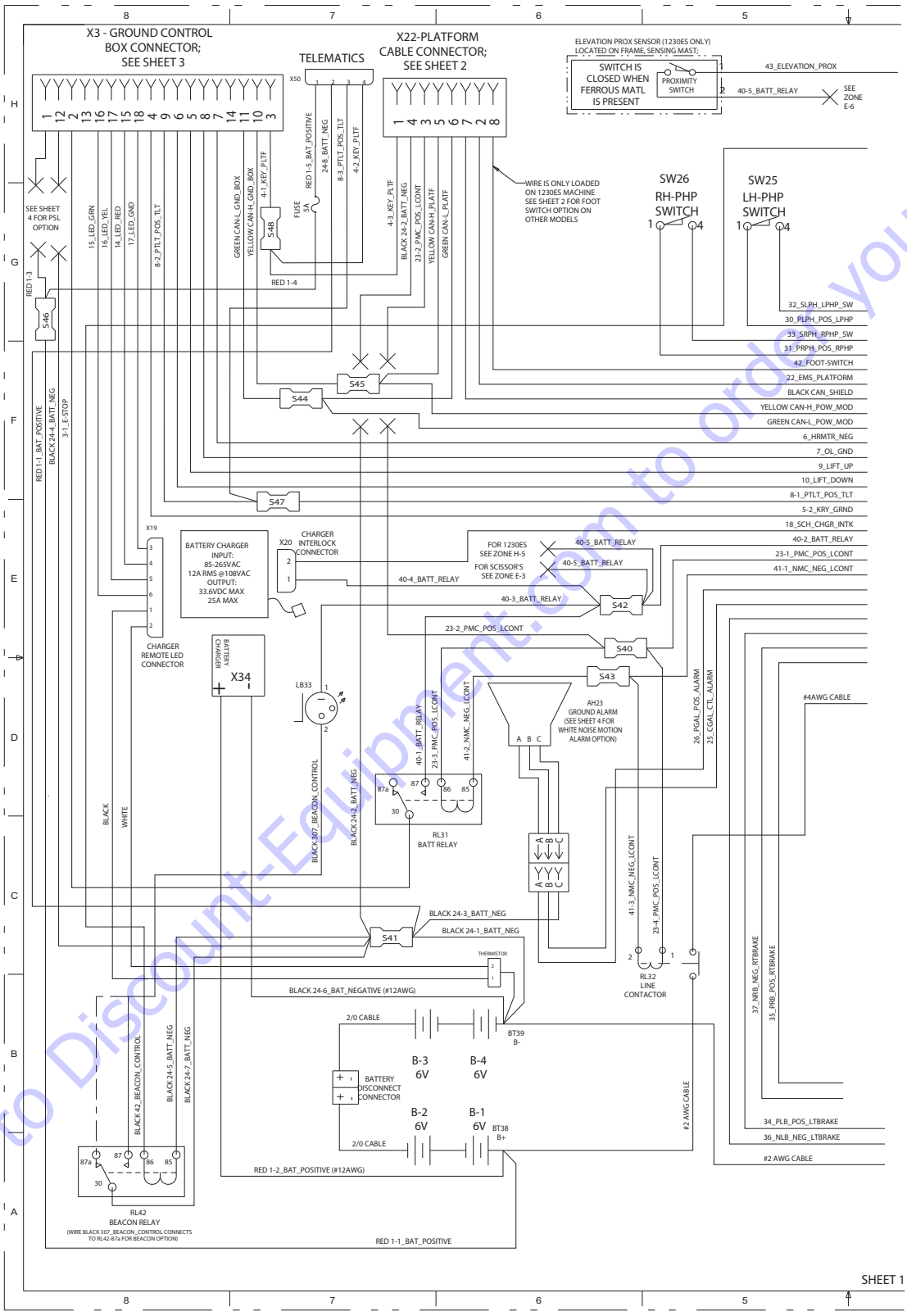


Figure 9-17. Electrical Schematic - (Machines with 1001092546 Drive Module)

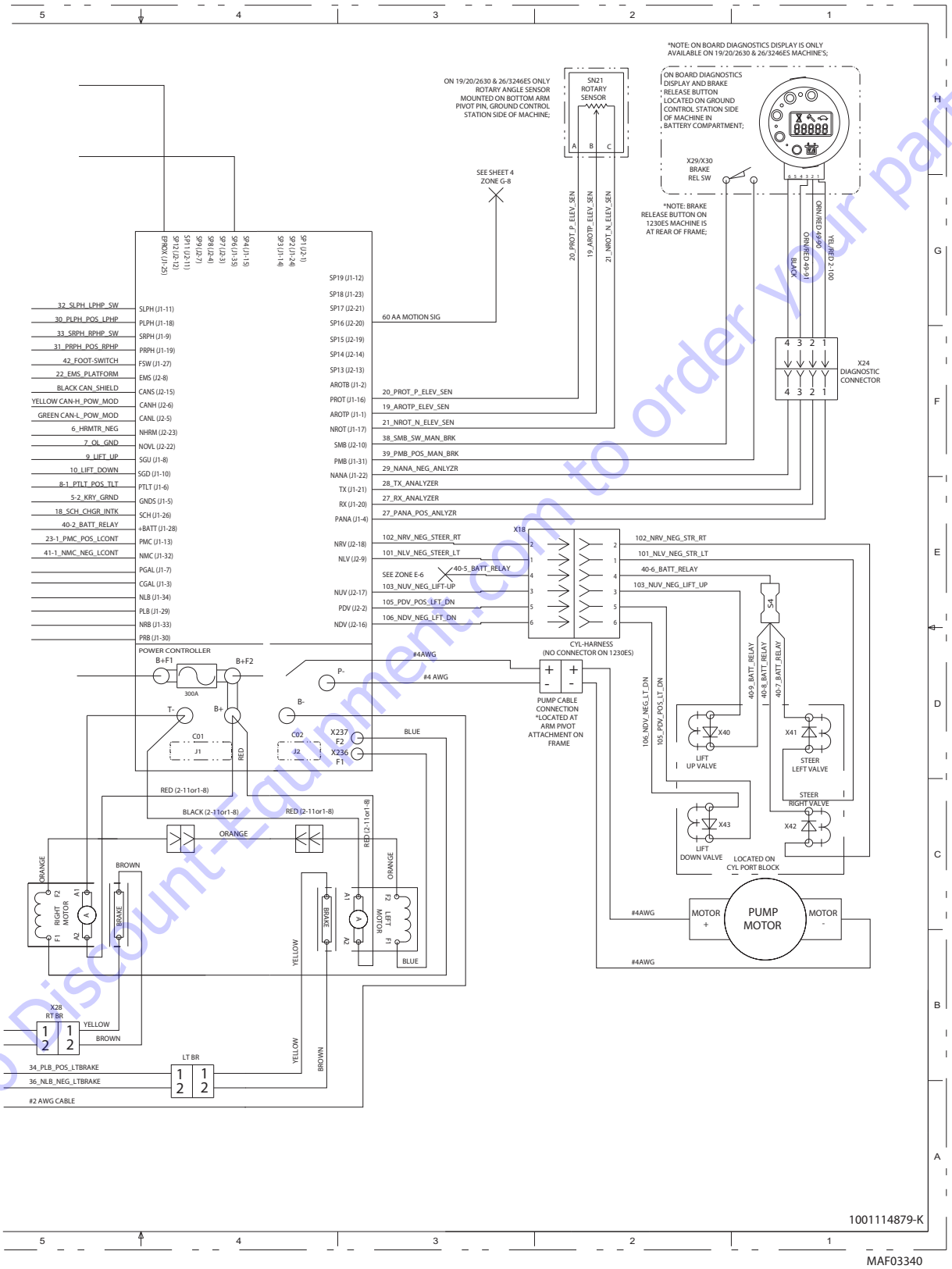


Figure 9-17., Electrical Schematic - (Machines with 1001092546 Drive Module)

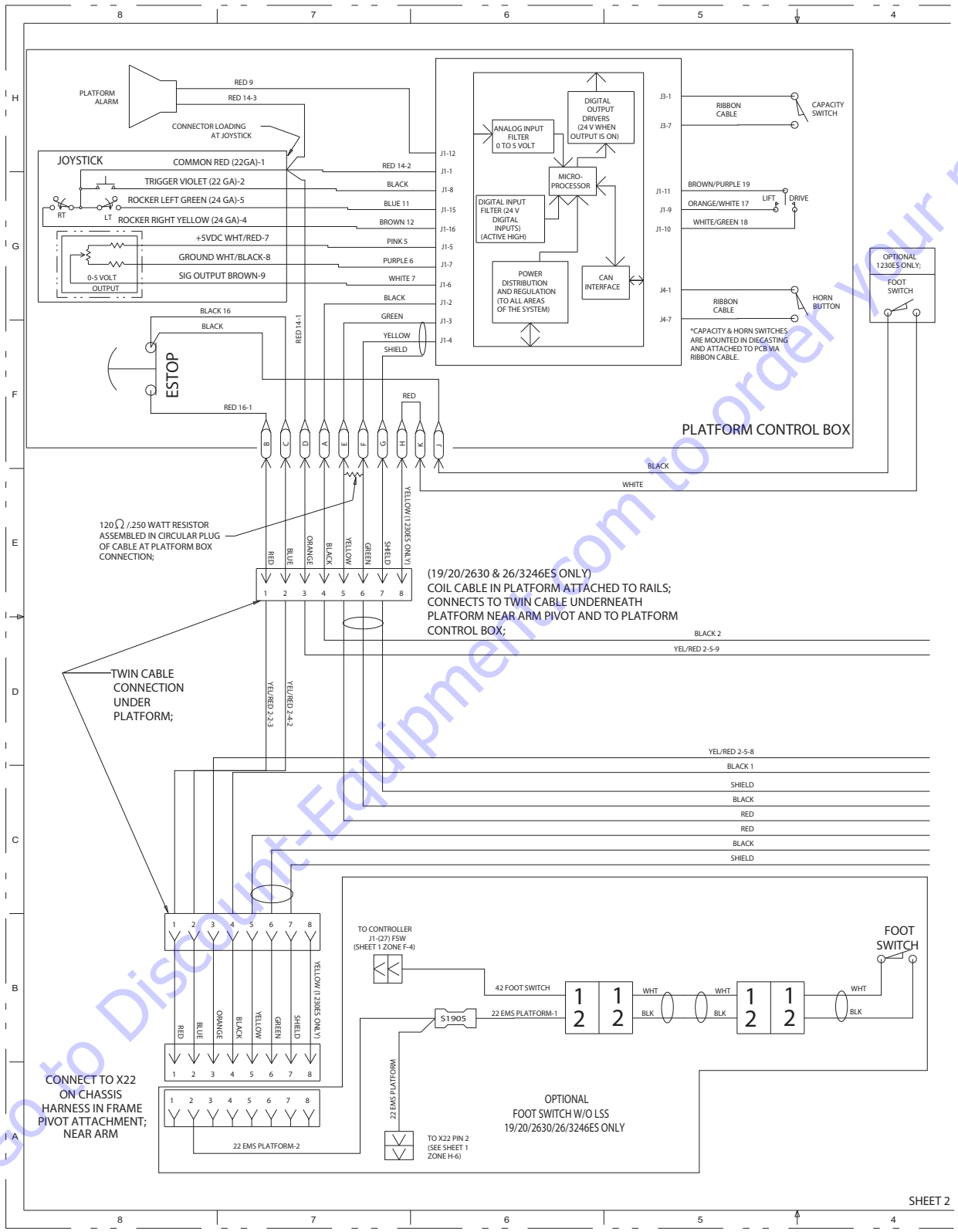


Figure 9-18. Electrical Schematic - (Machines with 1001092546 Drive Module)

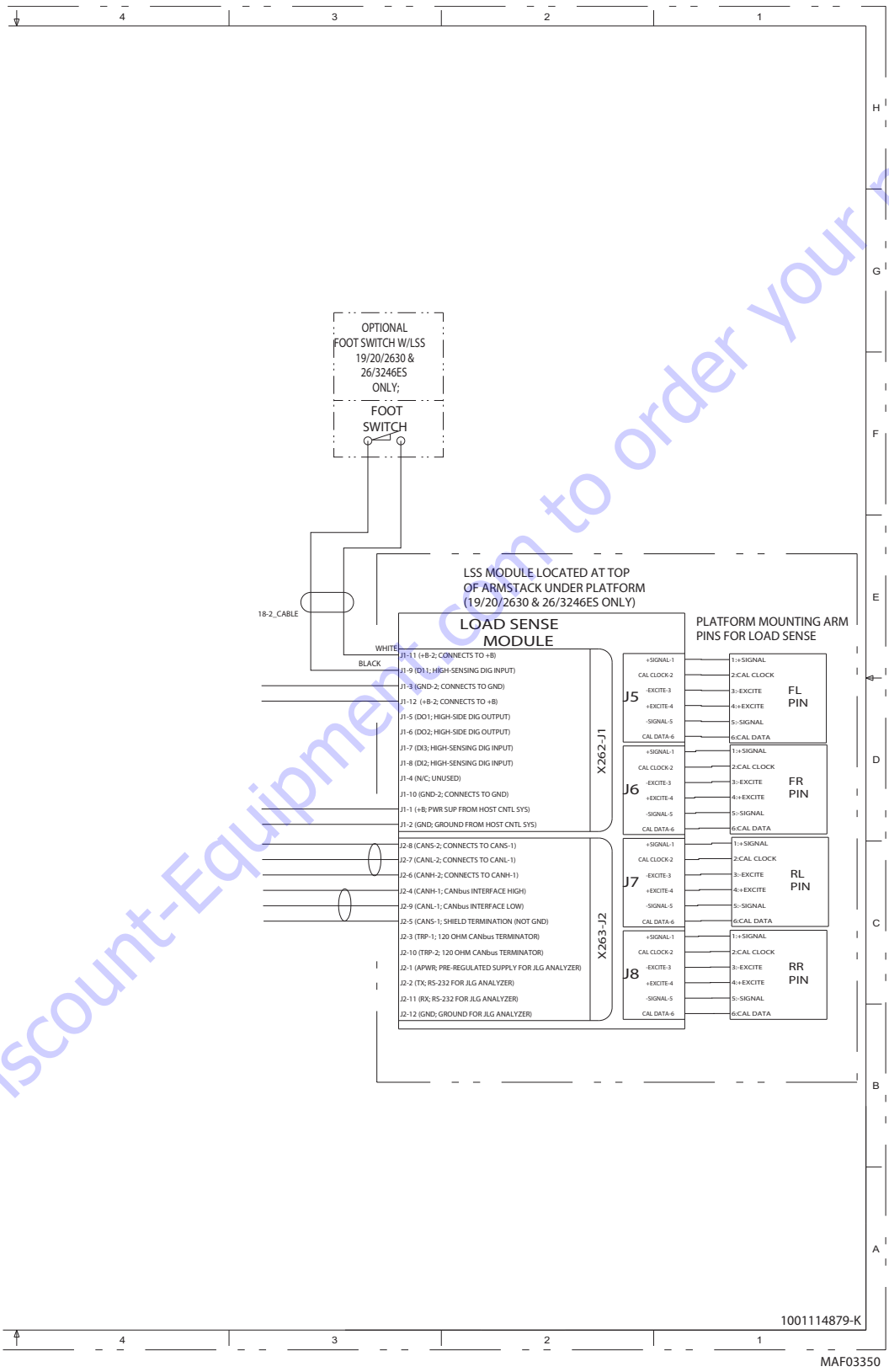


Figure 9-18., Electrical Schematic - (Machines with 1001092546 Drive Module)

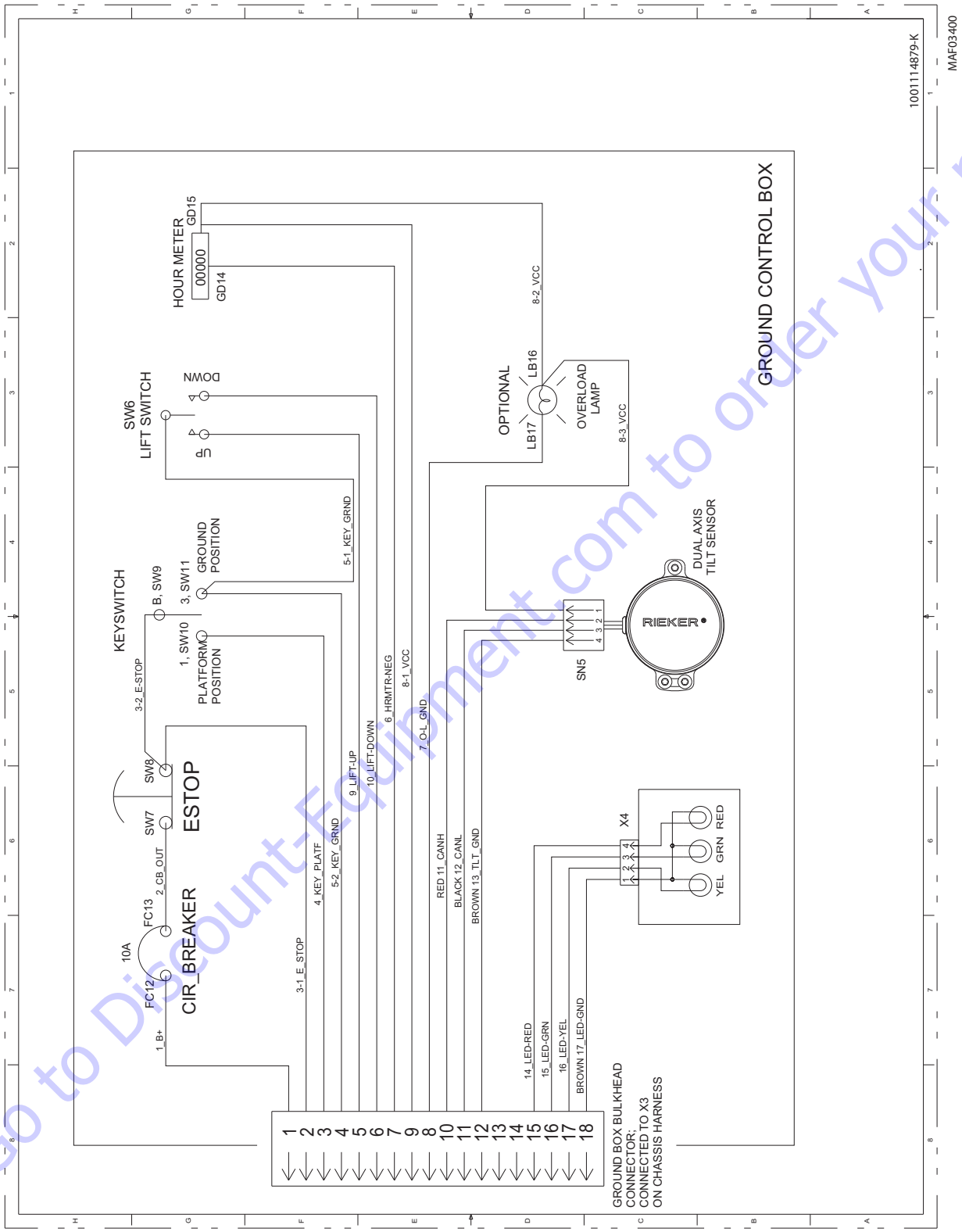


Figure 9-19. Electrical Schematic (Ground Control Module) - (Machines with 1001092546 Drive Module)

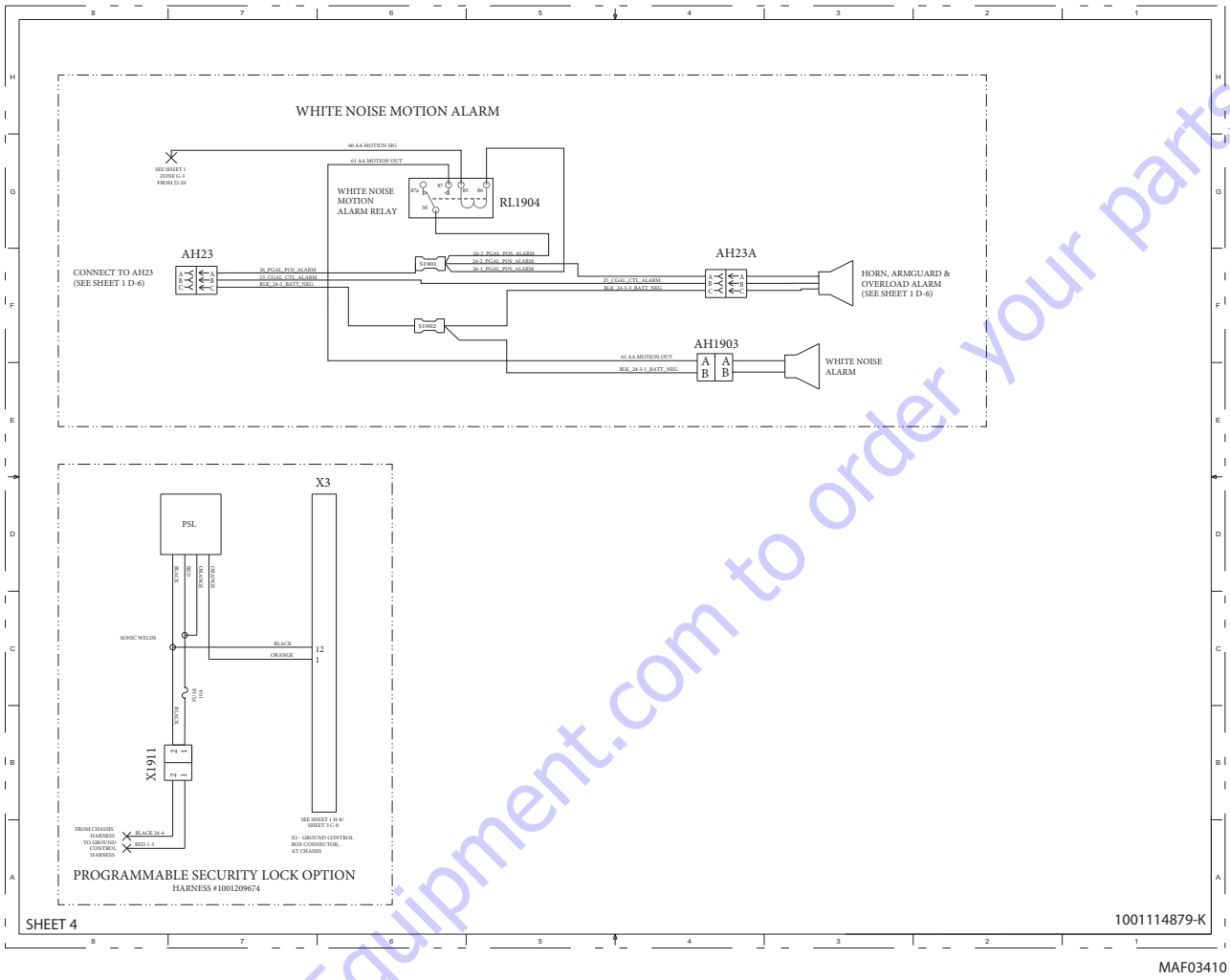


Figure 9-20. Electrical Schematic (Ground Control Module) - (Machines with 1001092546 Drive Module)

9.12 PIN INPUT/OUTPUT TYPES

Table 9-3. Ground Board J1 - Connector X001 (1600346 Power Module ONLY)

Pin	Function	Type	Range (V)
1	Ground	Power Output	0
2	Analyzer Power	Power Output	12
3	RS-232 Receive	Input/Output	Comm
4	RS-232 Transmit	Input/Output	Comm
5	Platform EMS	Input	Vbatt
6	Ground	Power Output	0
7	Ignition	Power Output	Vbatt
8	Platform EMS Source	Power Output	Vbatt
9	Not Used	--	--
10	Left PHP Switch	Input	Vbatt
11	CAN Bus high	Input/Output	Comm
12	CAN Bus Low	Input/Output	Comm
13	CAN Bus Shield	Power Output	0
14	Not Used	--	--
15	Elevation Prox Switch	Input	5
16	Ground	Power Output	0
17	Not Used	--	--
18	Right PHP Switch	Input	Vbatt
19	Ignition	Power Output	Vbatt
20	Brake Release Swtich	Input	Vbatt
21	Steer Left Coil	Output	Vbatt
22	Steer Right Coil	Output	Vbatt
23	Right Brake Release	Output	Vbatt
24	Left Brake Release	Output	Vbatt
25	Lift Up Coil	Output	Vbatt
26	Lift Down Coil	Output	PWM
27	Ground	Power Output	0
28	Ground Alarm	Output	PWM
29	Charger Interlock	Input	Vbatt
30	Not Used	--	--
31	CAN Bus High	Input/Output	Comm
32	CaN Bus Low	Input/Output	Comm
33	CAN Bus Shield	Output	0
34	Not Used	--	--
35	Not Used	--	--
36	Not Used	--	--
37	Ground	Power Output	0
38	Not Used	--	--
39	Master Ignition Connection	Power Input	Vbatt
40	Master Ground Connection	Power Input	0

Table 9-4. Ground Board J2 - Connector X002

Pin	Function	Type	Range (V)
1	Ignition	Power Output	Vbatt
2	Ground EMS	Power Input	Vbatt
3	Platform EMS Source	Power Input	Vbatt
4	Ground Mode Select	Input	Vbatt
5	Ground	Power Output	0
6	Ground Lift Up	Input	Vbatt
7	Ground Lift Down	Input	Vbatt
8	Hour Meter	Output	Vbatt
9	Ground Overload Lamp	Output	Vbatt

Table 9-5. Ground Board J3 - Connector X003

Pin	Function	Type	Range (V)
1	Tilt Sensor Power	Power Output	12
2	Tilt Sensor X-Axis (PWM)	Input	12
3	Tilt Sensor Y-Axis (PWM)	Input	12
4	Ground	Power Output	0

Table 9-6. Platform Board J1 - Connector X050

Pin	Function	Type	Range (V)
1	Master Ignition	Power Input	Vbatt
2	Master Ground	Power Input	0
3	CAN Bus High	Input/Output	Comm
4	CAN Bus Low	Input/Output	Comm
5	Joystick Power Supply	Power Output	5
6	Joystick Signal	Input	5
7	Ground	Power Output	0
8	Trigger Switch	Input	Vbatt
9	Lift Select Switch (Active Low)	Input	Vbatt
10	Drive Select Switch (Active Low)	Input	Vbatt
11	Ground	Power Output	0
12	Platform Alarm (Active Low)	Output	Vbatt
13	Not Used	--	--
14	Not Used	--	--
15	Steer Left Switch	Input	Vbatt
16	Steer Right Switch	Input	Vbatt

Table 9-7. Platform Board J3

Pin	Function	Type	Range (V)
1	Ground	Power Output	0
2	Not Used	--	--
3	Not Used	--	--
4	Not Used	--	--
5	Not Used	--	--
6	Not Used	--	--
7	Indoor/Outdoor Select Switch (Active Low)	Input	Vbatt

Table 9-8. Platform Board J4

Pin	Function	Type	Range (V)
1	Ground	Power Output	0
2	Not Used	--	--
3	Not Used	--	--
4	Not Used	--	--
5	Not Used	--	--
6	Not Used	--	--
7	Horn Switch (Active Low)	Input	Vbatt

Table 9-9. Power Module - Connector X027 (1600346 Power Module)

Pin	Function	Type	Range (V)
1	Ignition	Power Input	Vbatt
2	Not Used	--	--
3	Not Used	--	--
4	Not Used	--	--
5	Not Used	--	--
6	Not Used	--	--
7	Not Used	--	--
8	Line Contactor High Side	Power Output	Vbatt
9	Not Used	--	--
10	CAN Bus High	Input/Output	Comm
11	CAN Bus Low	Input/Output	Comm
12	Not Used	--	--

Table 9-10. Power Module - J1 (1001092456 Power Module ONLY)

Pin	Function	Type	
1	Primary Elevation Sensor Analog Input (0-5V)	Analog	Input
2	Spare - Analog Input	Analog	Input
3	Control for Ground Alarm (PWM)	Digital	Output
4	Positive for Analyzer (+12V)	Power	Output
5	Ground Select (Logic Supply for Ground Mode)	Power	Input
6	Positive for Tilt Sensor (Connect to +BATT)	Power	Output
7	Positive for Ground Alarm (Connect to +BATT)	Power	Output
8	Ground Lift Up Switch (High-Sensing)	Digital	Input
9	Right Pothole Switch (High Sensing)	Digital	Input
10	Ground Lift Down Switch (High-Sensing)	Digital	Input
11	Left Pothole Switch (High-Sensing)	Digital	Input
12	Spare Negative Reference	Power	Output
13	Positive Main Line Contactor (Connect to GNDS diode OR'd with EMS)	Power	Output
14	Spare Digital Input (High-Sensing)	Digital	Input
15	Spare Digital Input (High-Sensing)	Digital	Input
16	Positive Rotary Sensor Reference (+5V)	Power	Output
17	Negative for Rotary Sensor	Power	Output
18	Positive Left Pothole Switch Reference (Connect to +BATT)	Power	Output
19	Positive Right Pothole Switch Reference (Connect to +BATT)	Power	Output
20	RS-232 Receive	Serial	Input
21	RS-232 Transmit	Serial	Output
22	Negative for Analyzer (Connect to -B)	Power	Output
23	Spare Negative Reference (Connect to -B)	Power	Output
24	Spare Digital Input (High-Sensing)	Digital	Input
25	Elevation Proximity Switch (High-Sensing; 1230ES only)	Digital	Input
26	Charger Interlock (High-Sensing)	Digital	Input
27	Foot Switch (High-Sensing; 1230ES only)	Digital	Input
28	Battery Supply from External Relay	Power	Input
29	Positive Left Brake Release (Connect to +BATT)	Power	Output
30	Positive Right Brake Release (Connect to +BATT)	Power	Output
31	Positive Manual Brake Release (Connect to +BATT)	Power	Output
32	Negative Main Line Contactor (Low-Side Driver)	Digital	Output
33	Negative Right Brake Solenoid (Low-Side Driver)	Digital	Output
34	Negative Left Brake Solenoid (Low-Side Driver)	Digital	Output
35	Spare Digital Output (Low-Side Driver) / Digital Input (High-Sensing)	Digital	Output

Table 9-11. Power Module - J2 (1001092456 Power Module ONLY)

Pin	Function	Type	
1	Spare - (Connect to +BATT)	Power	Output
2	Positive Lift Down Valve (High-Side Driver)	Power	Output
3	Spare Digital Input (High-Sensing)	Digital	Input
4	Spare Digital Input (High-Sensing)	Digital	Input
5	CANbus Low	Serial	I/O
6	CANbus High	Serial	I/O
7	Spare Positive Analog Reference (+5V)	Power	Output
8	Platform EMS (Logic Supply for Platform Mode)	Power	Input
9	Negative Steer Left Solenoid Valve (Low-Side Driver)	Digital	Output
10	Switch Manual Brake Release (High-Sensing)	Digital	Input
11	Spare Digital Input (High-Sensing)	Digital	Input
12	Spare Digital Input (High-Sensing)	Digital	Input
13	Spare Digital Input (High-Sensing)	Digital	Input
14	Spare Negative Analog Reference (Connect to -B)	Power	Output
15	CANbus Shield (Connect to -B)	Power	Output
16	Negative Lift Down Valve (Low-Side Driver)	Power	Output
17	Negative Lift Up Solenoid Valve (Low-Side Driver)	Digital	Output
18	Negative Steer Right Solenoid Valve (Low-Side Driver)	Digital	Output
19	Spare Analog Input (0-5V)	Analog	Input
20	Spare Digital Output (Low-Side Driver)	Digital	Output
21	Spare Digital Output (Low-Side Driver)	Digital	Output
22	Negative for Overload Lamp (Low-Side Driver)	Digital	Output
23	Negative for Hourmeter (Low-Side Driver)	Digital	Output

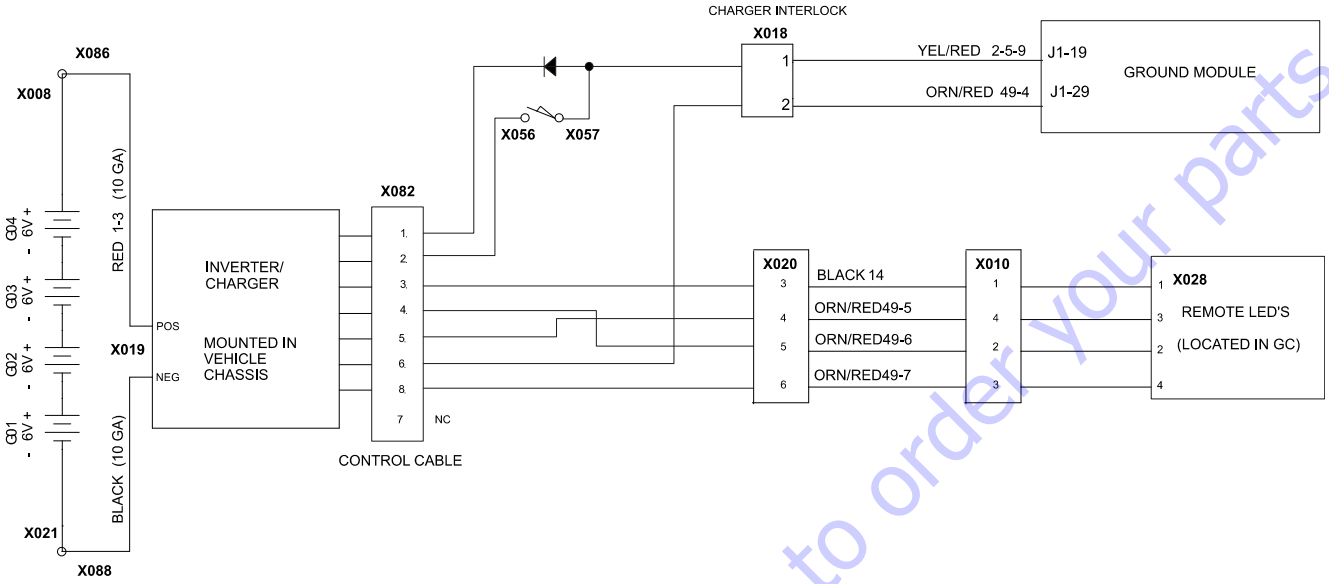
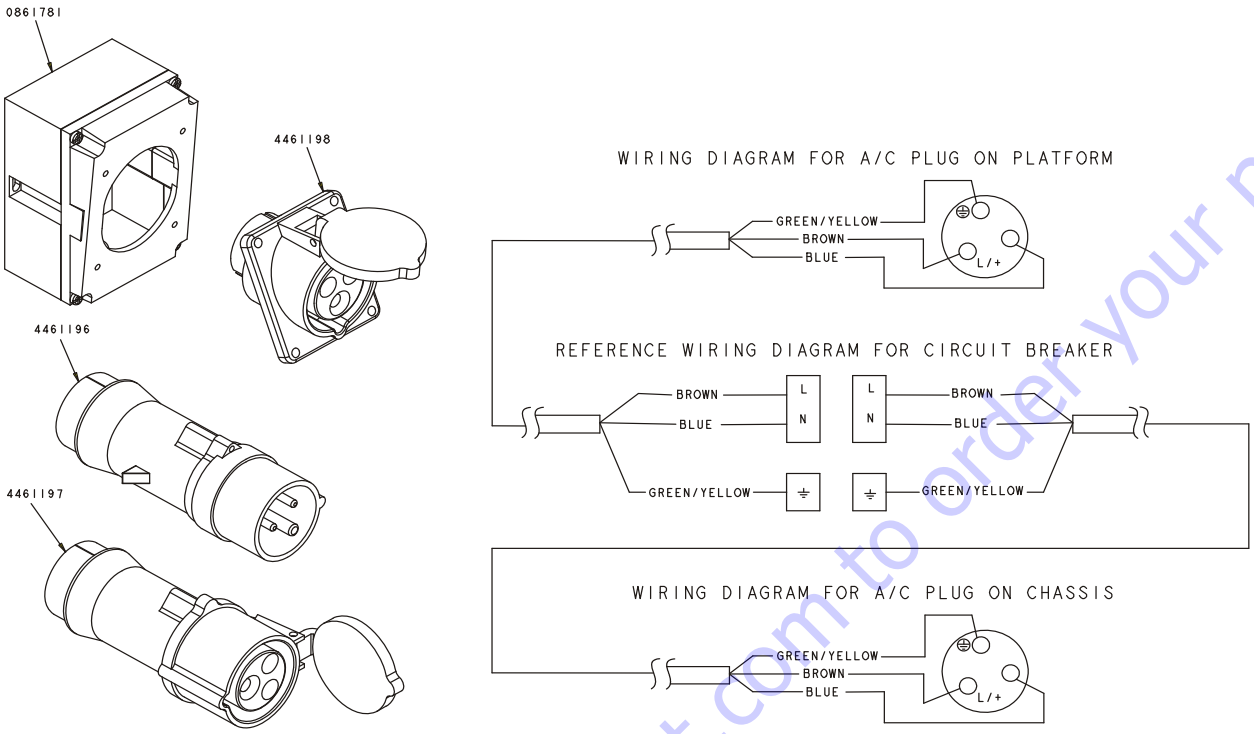
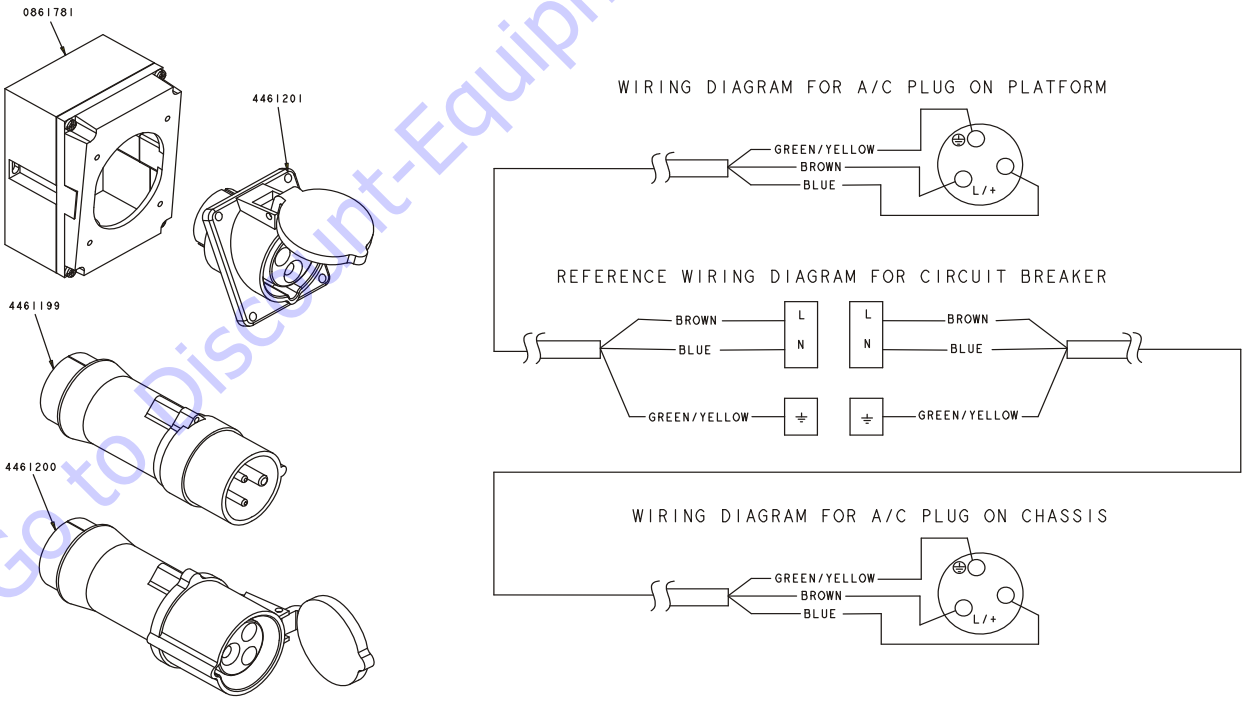


Figure 9-21. Battery Charger/Inverter Electrical Connection Schematic

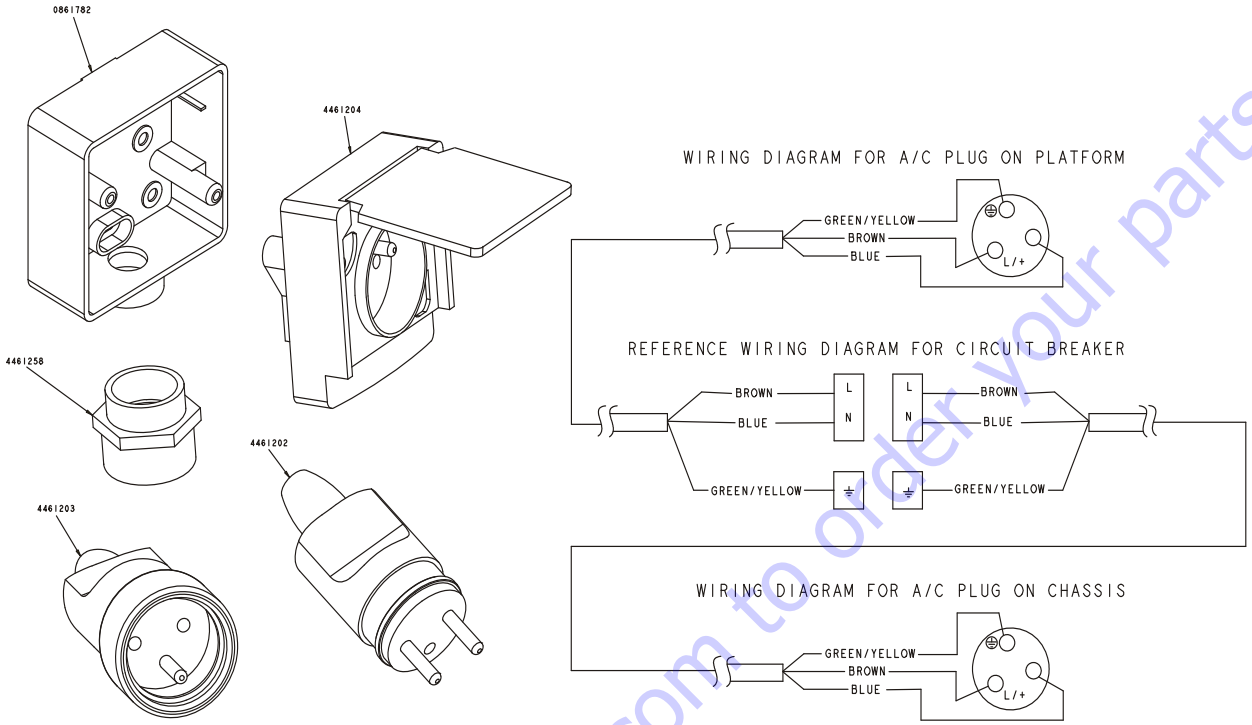
9.12 AC POWER RECEPTACLES AND WIRING (PLATFORM) - CE SPEC MACHINES ONLY



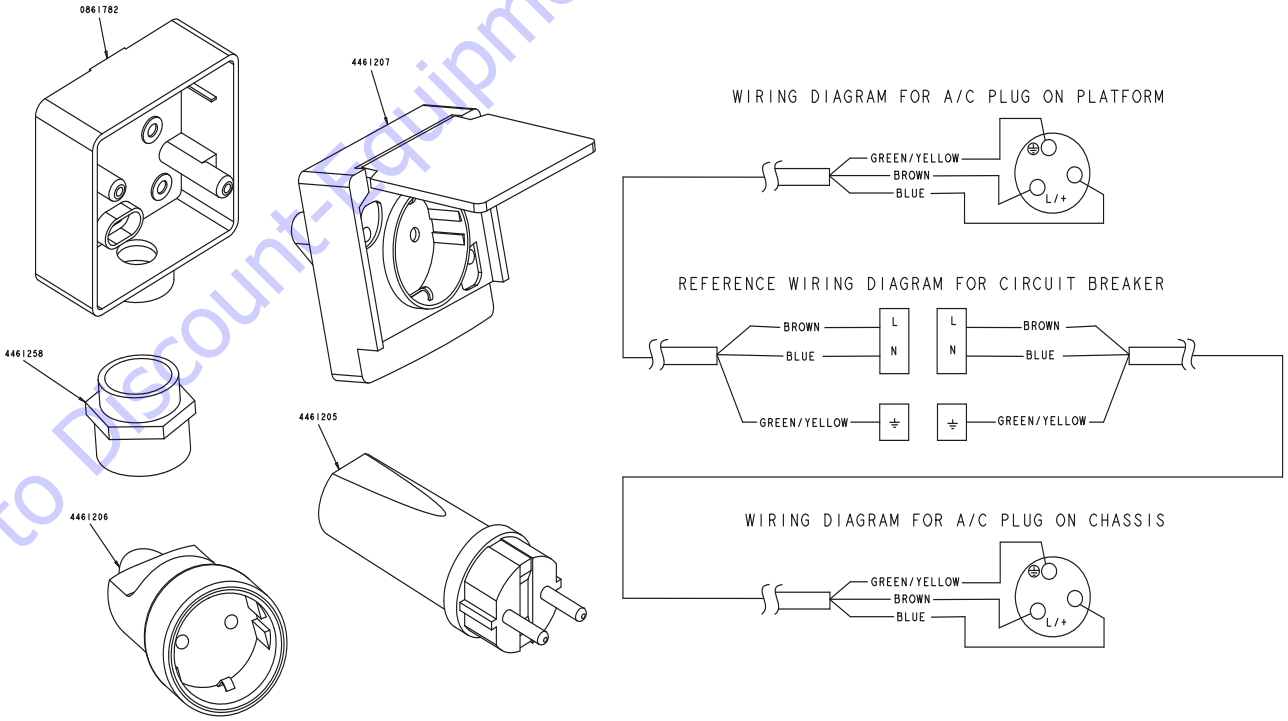
IEC 60309 PLUGS & SOCKETS / 100V TO 130V / YELLOW / P/L 0275216



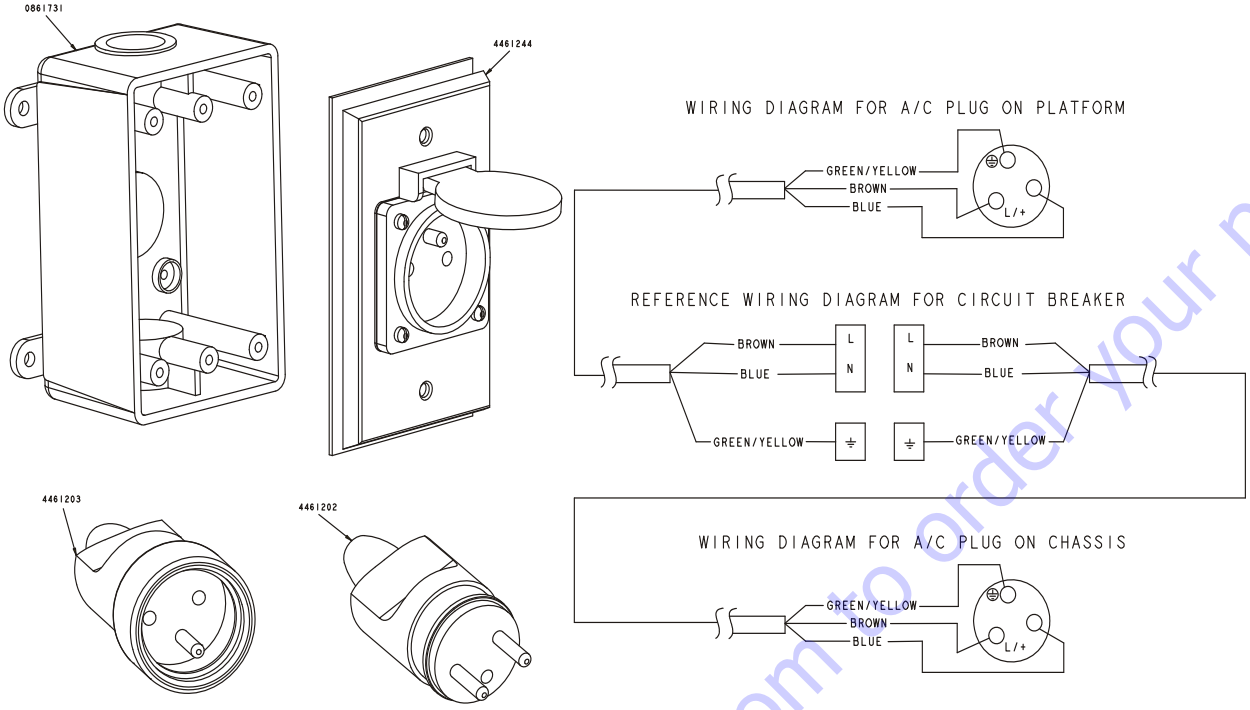
IEC 60309 PLUGS & SOCKETS / 200V TO 250V / BLUE / P/L 0275217



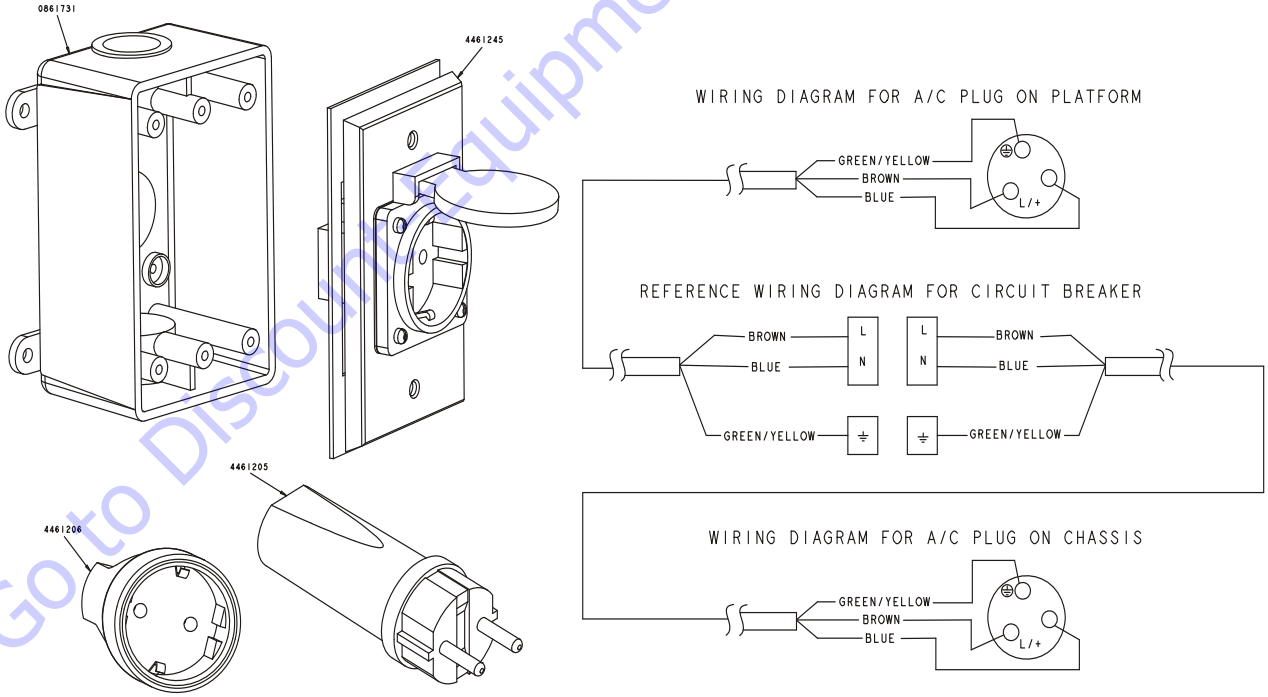
CEE 7 PLUGS & SOCKETS / GROUND PIN / 200V TO 250V / P/L 0275218



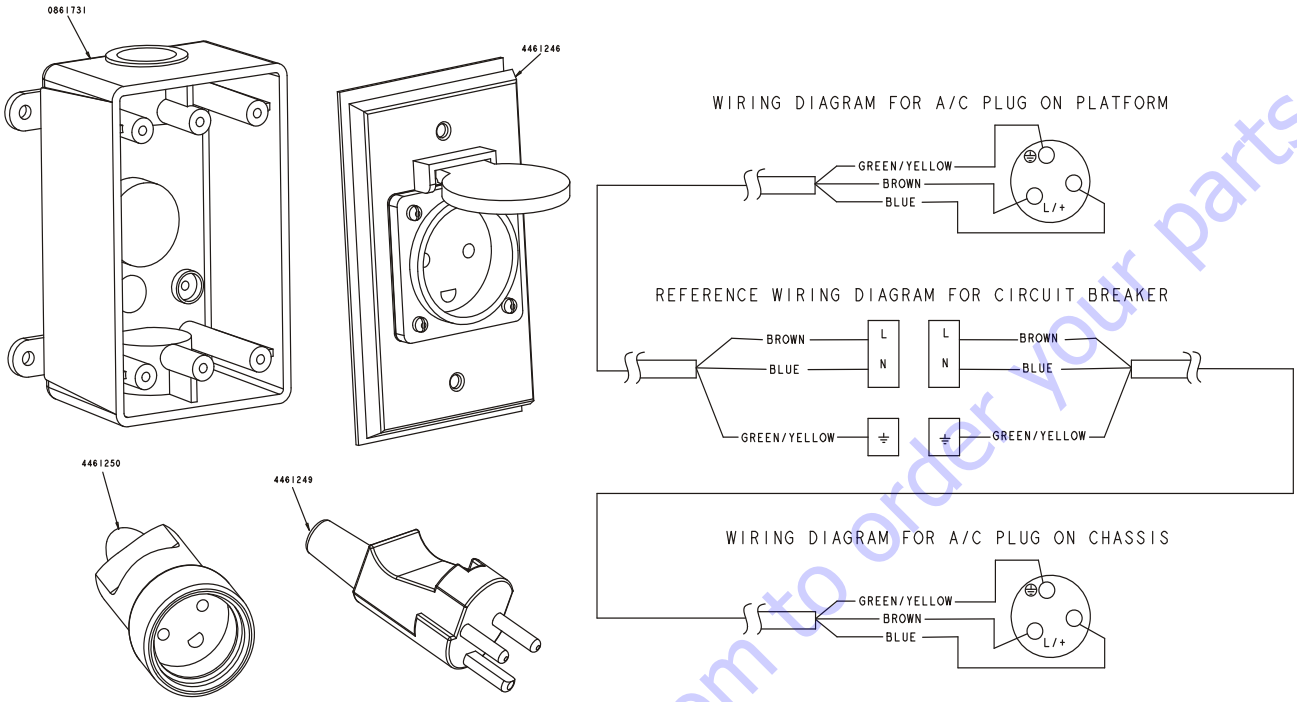
CEE 7 PLUGS & SOCKETS / SIDE GROUND / 200V TO 250V / P/L 0275219



CEE 7 PLUGS & SOCKETS / GROUND PIN / AMERICAN 2" X 4" WALL BOX
200V TO 250V / P/L 0275452



CEE 7 PLUGS & SOCKETS / SIDE GROUND / AMERICAN 2" X 4" WALL BOX
200V TO 250V / P/L 0275453



AFSNIT 107-2-01 PLUGS & SOCKETS / GROUND PIN / KEYED AMERICAN 2" X 4" WALL BOX
200V TO 250V / P/L 0275454

9.13 HYDRAULIC SCHEMATIC

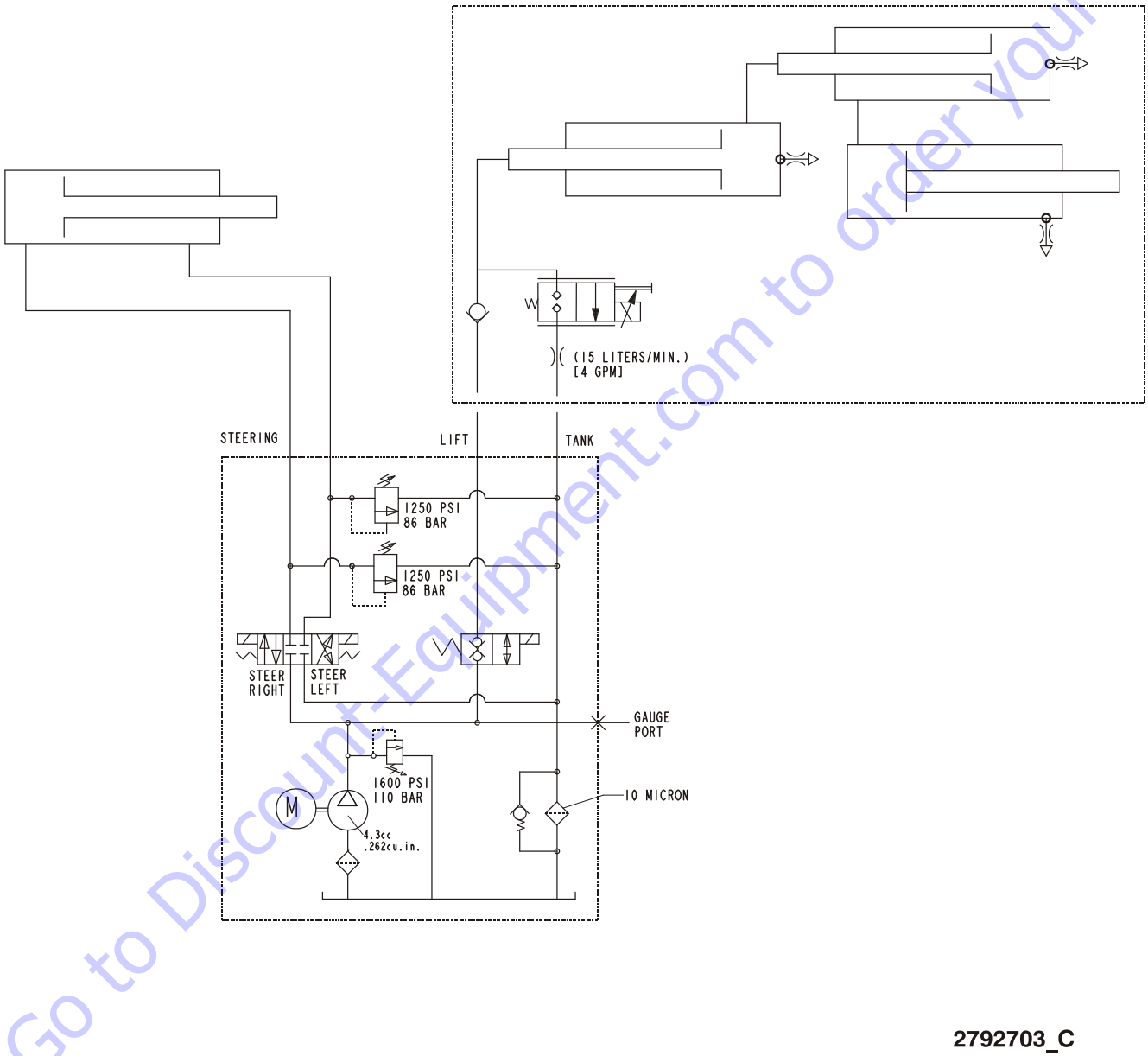


Figure 9-22. Hydraulic Diagram - (2792703_C)

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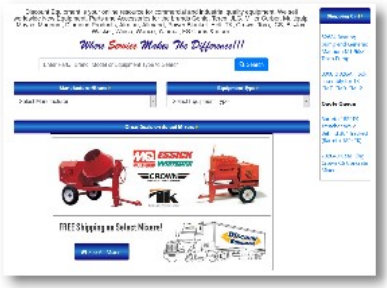

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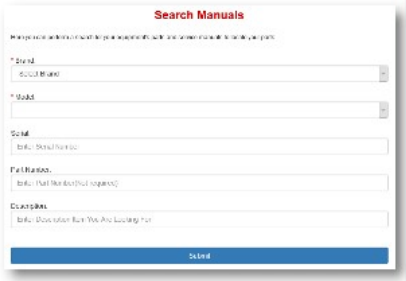

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