FORWARD

The purpose of this manual is to provide the customer with the operating procedures essential for the promotion of safe and proper machine operation for its intended purpose. It is important to over-stress proper usage. All information in this manual should be READ and UNDERSTOOD before any attempt is made to operate the machine.

SINCE THE MANUFACTURER HAS NO DIRECT CONTROL OVER MACHINE APPLICATION AND OPERATION, CONFORMANCE WITH GOOD SAFETY PRACTICE IN THIS AREA IS THE RESPONSIBILITY OF THE USER AND HIS OPERATING PERSONNEL.

ALL PROCEDURES HEREIN ARE BASED ON THE USE OF THE MACHINE UNDER PROPER OPERATING CONDITIONS, WITH NO DEVIATIONS FROM THE ORIGINAL DESIGN. ALTERATION AND/OR MODIFICATION OF THE MACHINE IS STRICTLY FORBIDDEN WITHOUT WRITTEN APPROVAL FROM MANITOWOC BOOM TRUCKS, INC.

REMEMBER, EQUIPMENT IS ONLY AS SAFE AS THOSE WHO OPERATE IT!
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MANUAL REVISIONS

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1 MECHANICAL DESCRIPTION OF THE SYSTEM COMPONENTS

Pressure Transducer: The pressure transducer transforms hydraulic pressure into an electric analog voltage signal. Two pressure transducers are connected, one to the rod side and one to the piston side of the lift cylinder. The pressure transducer is connected to the central unit with a four-conductor, double-shielded cable.

The power supply voltage is ±5V.
The output signal is 0.00V under 0 pressure to -1.00V at max. pressure (4410psi)

The Length-Angle Transducer: The length-angle sensor (LWG) is a combination of two transducers in one box, fitted at the base section of the boom. It measures the length and angle of the boom.

A reeling drum drives a potentiometer, which is the length transducer. Part of the length transducer is the length cable on the drum, which is a two-conductor cable (screen and live). It is connected to the anti-two-block switch at the boom head and to a slip ring body in the reel. The angle transducer is fitted into a small box filled with oil. A pendulum drives the axle of the angle potentiometer.

The power supply voltage for both is -5.00V
The output signal for the length transducer is: -0.500V up to -4.500V
The output signal for the angle transducer is: -1.875V up to -3.125V

Anti-Two-Block Switch: The anti-two-block switch monitors the load block and its relationship with the head of the boom. In working condition, the switch is closed. When the hook block strikes the weight, the circuit opens, disengaging a relay output to the lockout solenoid valves, where applicable. To check the cable for damage, (short circuit to ground) there is a 4.7k resistor between ground and the contact of the switch. The weight at the anti-two-block switch keeps the switch closed until the hook block strikes it.

Console: The console displays the geometrical information such as length and angle of main boom, working radius and head height of the boom. It also displays the actual load and the maximum load permitted by load chart. Furthermore, it has an alarm horn and a warning light for overload, and a pre-warning light. The analog instrument shows a percentage of the total permissible moment. The console has a switch for the operating modes (duty-selection switch for crane configurations) and a switch for the Reeving of the hook block. It also has a warning light for anti-two-block conditions and an override switch for overload or anti-two block condition.

Duty Selection Switches (Digital Inputs): The system has to be programmed for the lifting area configuration. The crane is going to be worked in (e.g. main boom) on outriggers over front, or rear, or over the side for 360 degrees. For obtaining this information from the crane, micro switches are installed in the electrical swivel that tells the system the exact location of the boom. Micro switches are also located on the counterweight which tells the system if the counterweight is installed or not, where applicable.
2 MECHANICAL AND ELECTRICAL DESCRIPTION OF THE CENTRAL UNIT

All the data of the crane is stored inside the central unit in EPROM’s. The central unit receives all actual information of the crane. This is computed against the reference data and the crane status is continuously monitored.

**Description of the Housing:** The central unit DS150 is a rugged, waterproof sheet steel housing. It is mounted on the left side of the turn table weldment or on the counterweight. The cables are led into the central unit via strain reliefs and connected with fast-ons. An override switch is mounted on the housing, which overrides the LMI function. The system is protected by a 2-AMP fuse, which is mounted on the lower right side. The output signal is protected by a 10-AMP fuse, mounted on the lower mid.

**Description of the Boards:** Inside the central unit (CU) there is a main board. The main board and CPU is the heart of the system, and it contains the processor and the system and data EPROMs. The system EPROM holds the operating system and data EPROM hold the crane and calibration information. The wires from the various components are connected with fast-ons to the main board. The main board holds the electronics necessary to receive, evaluate, and direct the continuous flow of data from the sensors to the processor.

**Main board components:**
- **Power supply:** Provides all the necessary voltages for the transducers and the electronics on the main board.
- **Analog input part:** Receives and prepares all the signals from the transducers for further processing.
- **Relays, an overload and anti-two-block relay:** Controls the Bosch relay for lever lockout.

**Incoming Signals:** Signals from the transducers are connected to the main board. The signals vary depending on the sensor:
- **Angle transducer** signal is between -1.875V and -3.125V.
- **Length transducer** signal is between -0.500V and -4.500V.
- **Pressure transducer** signals are between 0.00V and -1.00V. (measured between the negative and positive outputs)
- **Anti-two-block switch** resistance is 4.7Kohms.
- **Digital inputs** for the duty selection switches are on or off.

**Outgoing Signal:** The outgoing signal of the main board is the signal for lever lockout of connection #48. In normal working conditions there are 12 volts at this connection. If there is an overload or anti-two-block condition the signal becomes 0 volts. Furthermore, all voltages for the transducers are going out through the main board.
2.1 Basic System Component Layout
2.2 Basic Adjustment Of The Components

**Length:** Ensure that the length cable tension is correct with fully retracted boom and no tension on the cable reel. Turn the cable drum 5 to 8 turns counter clockwise. Then remove cover from cable reel and adjust the potentiometer counter clockwise to end stop. See Procedure 3.

**Angle:** Set the boom between 0 and 5 degrees and set the inclinometer to the boom angle. Adjust the angle sensor to the same angle as the boom. Check the angle at 20 degrees, 45 degrees, and 70 degrees. Angle display should be less than ± .5 degrees of the value of the inclinometer. See Procedure 3.

**Pressure Channel:** Rest the boom and disconnect hydraulic hoses from the pressure transducers. Measure and record the zero-points of both pressure transducers on the main board. Adjust P1 and P2 on the main board to 500mV at test points MP11 and MP12. Connect hydraulic hoses back to the pressure transducers. See Procedure 2.

**Duty Selection Switches Digital Inputs:** Check the duty selection switches for correct operation. Check the voltage on digital input connections.

Check the function of the hoist limit switch (anti-two-block)
Check function of lever lockout.

Measure and record the power supply voltages. See Addendum A.
3 DEFINITIONS

BOOM LENGTH: The straight line through the centerline of boom pivot pin to the centerline of the boom point load hoist sheave pin, measured along the longitudinal axis of the boom. (Indicator ± 2%)

BOOM ANGLE: The angle between the longitudinal centerline of the boom base section and the horizontal plane. (Indicator 65° to 90° boom angle + 0°/2°; less than 65° boom angle + 0°/-3°)

RADIUS OF LOAD The horizontal distance from a vertical projection of the crane’s axis of rotation to the supporting surface, before loading, to the center of the vertical hoist line or tackle with rated load applied. (Indicator 100% to 110%)

RATED LOAD The load value shown on the applicable load-rating chart of the crane for the particular crane configuration, boom length, boom angle, or functions or these variables. For radii outside those shown on the load-rating chart, the rated load is to be considered as zero.

ACTUAL LOAD The weight of the load being lifted and all additional equipment such as blocks, slings, sensors, etc. Also referred to as working load. (Indicator 100% to 110%)

CRANE CONFIGURATION The physical arrangement of the crane which is prepared for a particular operation in conformance with the manufacturer’s operating instructions and load rating chart.

TWO-BLOCKING Contact of the lower load block or hook with the upper load block, boom point, or boom point machinery.

ANALOG: Electrical signals that vary in proportion to the quantities they represent. (Boom length, angle, and pressure transducer)

DIGITAL: Electrical signals of an on-and-off state (two different voltage levels) to represent some quantity of operation. (A2B, area definition switch)
4 DRAWINGS

4.1 SYSTEM Electrical Diagram

NOTES:

1. TAPE AND STORE ALL WIRES NOT CONNECTED

2. OUTER SHEILD CONNECTED TO STRAIN RELIEF INSERT

3. INNER SHEILD INSULATED AND CONNECTED AS SHOWN

4. INNER SHEILD CUT AND INSULATED

5. COIL ASSY IS PREWIRED. INSTALL AS SHOWN

6. SWITCH PREWIRED AND POTTED

7. REFER TO Crane MANUFACTURER OR PAT SERVICE FOR DIGITAL INPUT WIRING
4.2 Central Unit

Spare Parts List
# PART NO. 024-150-060-002 CENTRAL UNIT, DS150/0002 STANDARD PARTS LIST

<table>
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<tr>
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<th>PART NO.</th>
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<th>DESCRIPTION</th>
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<td>01</td>
<td>024-150-300-001</td>
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<td>BOARD, MAIN, DS150, CU, 12V</td>
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<td>02</td>
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<td>CENTRAL UNIT ACCY, SCREW SET, DS150</td>
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<td>03</td>
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<td>CENTRAL UNIT ACCY, GROUNDING KIT FOR COVER</td>
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<td>CENTRAL UNIT ACCY, WALL MOUNT SET, DS150/350</td>
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<td>KEYSWITCH, CENTRAL UNIT, NEW STATIONARY</td>
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<td>08</td>
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<td>FUSE HOLDER, CENTRAL UNIT, MAIN BOARD</td>
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<td>RELAY, SHUT-OFF 12 V (BOSCH)</td>
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4.3 Console  

Spare Parts List

To change DS150/0006 (12V) to DS150/0036 (24V) a jumper wire must be soldered on main board, J3 added, and the light bulbs changed. When ordering spare part please specify 12 or 24 volt machine.
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To change DS150/0008 (12V) to DS150/0012 (24V) a jumper wire must be soldered on main board, J3 added, and the light bulbs changed. When ordering spare part please specify 12 or 24 volt machine.
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<td>19</td>
<td>050-150-110-002</td>
<td>1</td>
<td>SWITCH ACCY, KNOB WITH SCALE DISK 1-63</td>
</tr>
<tr>
<td>20</td>
<td>050-150-110-002</td>
<td>1</td>
<td>SWITCH ACCY, KNOB WITH SCALE DISK 1-16</td>
</tr>
<tr>
<td>21</td>
<td>050-150-110-049</td>
<td>1</td>
<td>ALARM, BUZZER, DS150 &amp; DS350C CONSOLE</td>
</tr>
<tr>
<td>22</td>
<td>050-150-110-049</td>
<td>1</td>
<td>FACEPLATE, DS150 CONSOLE, LARGE DISPLAY (STD.)</td>
</tr>
<tr>
<td>23</td>
<td>050-150-110-049</td>
<td>1</td>
<td>GASKET, HOUSING</td>
</tr>
<tr>
<td>24</td>
<td>050-150-110-049</td>
<td>1</td>
<td>SCREW, 3mm x 10mm, PANHEAD, PHILLIPS FACEPLATE</td>
</tr>
</tbody>
</table>
4.5 Cable Reel

Spare Parts List
<table>
<thead>
<tr>
<th>NO.</th>
<th>PART NO.</th>
<th>QTY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>006-710-006-002</td>
<td>1</td>
<td>SENSOR, LENGTH TRANS. LGE 100 (KT200/LWG208)</td>
</tr>
<tr>
<td>02</td>
<td>068-000-110-038</td>
<td>1</td>
<td>SENSOR ACCY, GEAR WHEEL, KT200 CABLE REEL</td>
</tr>
<tr>
<td>03</td>
<td>067-000-050-065</td>
<td>1</td>
<td>SENSOR ACCY, GEAR WHEEL, T=50 CENTER SHAFT</td>
</tr>
<tr>
<td>04</td>
<td>064-103-060-002</td>
<td>1</td>
<td>SENSOR, ANGLE WG103</td>
</tr>
<tr>
<td>05</td>
<td></td>
<td>2</td>
<td>SCREW, 6M X 12 SOCKET CAP</td>
</tr>
<tr>
<td>06</td>
<td></td>
<td>3</td>
<td>WASHER, FLAT 6MM</td>
</tr>
<tr>
<td>07</td>
<td></td>
<td>1</td>
<td>SCREW, 6M x 100M SOCKET CAP</td>
</tr>
<tr>
<td>08</td>
<td></td>
<td>1</td>
<td>WASHER, LOCK 6MM</td>
</tr>
<tr>
<td>09</td>
<td></td>
<td>1</td>
<td>SLIPRING, 2 CONDUCTOR</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>1</td>
<td>CONNECTION STRIP</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>1</td>
<td>CABLE REEL, KT200 HOUSING,BKT,CABLE DRUM &amp; NYLON CABLE COVER</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>1</td>
<td>CABLE REEL ACCY, CABLE DRUM,KT 200/ LWG208</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>139'</td>
<td>CABLE, LENGTH SENSOR, 1 CORE W/SHEILD (per ft)</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>1</td>
<td>BRACKET, MTG. CABLE REEL ARM, ONE SLOT</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>4</td>
<td>SCREW, 12mm x 30MM HEX HEAD</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>1</td>
<td>BRACKET, MTG. CABLE REEL ARM, TWO SLOTS</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td>1</td>
<td>COVER, CABLE REEL, KT200</td>
</tr>
<tr>
<td>18</td>
<td></td>
<td>10</td>
<td>CABLE REEL ACCY, SCREW CABLE REEL COVER</td>
</tr>
<tr>
<td>19</td>
<td></td>
<td>10</td>
<td>WASHER, LOCK 6mm</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>1</td>
<td>STRAIN RELIEF, PG 13.5, 8-12mm RED+ WHITE</td>
</tr>
<tr>
<td>21</td>
<td></td>
<td>1</td>
<td>STRAIN RELIEF, PG 7 BLACK</td>
</tr>
</tbody>
</table>
4.6 Central Unit Board Layout And Measuring Points

Measuring Points
MP1: AGND
MP2: +9V
MP3: -9V
MP4: 5V TTL
MP5: 5V REF
MP6: +5V/+UPS sensors supply
MP7: -5V/-UPS sensors supply
MP8: +9V HES
MP10: AGND
MP11: DAV1 piston pressure signal
MP12: DAV2 rod pressure signal
MP13: LW1 length signal
MP14: WG1 angle signal #1
MP15: WG2 angle signal #2

LED's
LOAD: Overload relay ON(energized/normal conditions)/OFF (de-energized)
A2B: A2B relay ON(energized/normal conditions)/OFF (de-energized)
5 PROCEDURE

5.1 EPROM replacement in Central Unit
Follow this procedure when changing EPROM’s in the DS150 central units.

1. Remove cover, from central unit.

CAUTION: Before handling the EPROM, discharge any static electricity from your body by touching a ground source. The EPROM could be damaged if this procedure is not followed.

Use the central unit main board layout and measuring point drawing to locate the system and data EPROM’s.

2. Remove the old EPROM from the main board using an EPROM puller. Be careful not to bend the legs of the EPROM when removing it.

3. Installing the new EPROM:
• Ensure the notch is in the correct direction. The direction of the EPROM is determined by the notch on the end of the EPROM.
• The DATA and TLK EPROM’s fill the bottom of the socket as shown by the arrows.
• Place EPROM in the correct EPROM socket as shown.

4. Inspect gasket and install cover using the following procedures to prevent any moisture from entering the central unit.

Reference material:
031-300-340-002 Central Unit Cover Installation and Tightening Procedure; Rev A.
031-300-340-003 Central Unit Gasket Recommendations; Rev -.

5.2 Piston & Rod Pressure Channel Zero Point Adjustment

Use the central unit main board layout and measuring point drawing to make the following adjustments.

1. Lower boom all the way down (no rest pressure) then disconnect hydraulic hose from the piston side pressure transducer.

2. Connect a digital voltmeter to main board
   A) black (-) lead to mp10
   B) red (+ ) lead to mp11

3. Adjust P1 to obtain a reading of 0.500 volts (500mv) on meter.

4. Disconnect hydraulic hose from the rod side pressure transducer.

5. Connect a digital voltmeter to main board
   A) BLACK (-) lead to MP10
   B) RED (+ ) lead to MP12

6. Adjust P2 to obtain a reading of 0.500 volts (500mv) on meter.

7. Reconnect hydraulic hoses to pressure transducers, and then bleed the air from hydraulic lines.
5.3 Length & Angle Adjustments

ADJUST LENGTH POTENTIOMETER, WITH BOOM FULLY RETRACTED
TURN THE CENTER SCREW COUNTER CLOCKWISE TO A SOFT STOP.

ADJUST TOP OF ANGLE SENSOR PARALLEL WITH BOOM.
5.4 Main Board Replacement

Refer to Drawing 1, central unit parts list for board location.
1. Turn system power off.
2. Remove the central unit lid.
NOTE: Take care not to damage the boards with the screwdriver, when removing and inserting screws.
3. Remove the system and data software from the main board.
4. Remove the relay from the main board.
5. Mark all connection wires before removing, to identify location for reconnecting. Disconnect all X1 terminal wires from the main.
6. Remove the 9 large Philips screws holding the main board in place.
7. Note the orientation of the main board in the central unit. Remove main board and place it in the same packing material that the replacement in which the main board came.
8. Carefully insert the new main board in place.
9. Insert the 9 Philips mounting screws.
10. Insert the relay into the main board.
11. Insert the system and data software into the main board.
12. Connect the X1 terminal wires to the main board. Refer to Wiring Diagram.
13. Zero pressure transducers using the zeroing procedure in this section.
14. Inspect the gasket for nicks, cuts, or damages. Refer to 031-300-340-003 DS 350 Central Unit Gasket Recommendations, Revision A and 031-300-340-002 Central Unit Cover Installation and Tightening Procedure, Revision A
6 THEORY

6.1 Anti-Two Block & Shutoff Circuit

6.2 Length Measuring Channel
6.3 Piston Side Pressure Measuring Channel

6.4 Rod Side Pressure Measuring Channel
6.5 Main Boom Angle Measuring Channel

6.6 Second Angle Measuring Channel
7 TROUBLESHOOTING FLOW CHARTS

7.1 General Flowchart

This section explains how to handle a problem that may arise with the PAT Load Moment Indicator System-PAT DS150. The procedures are easy to follow and are given in flowcharts on the following pages. Start with the general flowchart below, which will guide you to one of the detailed flowcharts shown in this section.

START

What's Wrong?

- Lever Lockout Activated → Go to Flow Chart 2
- Broken Length Cable → Go to Flow Chart 3
- No display → Go to Flow Chart 4
- Anti-Two Block Problem → Go to Flow Chart 5
- Length Reading Problem → Go to Flow Chart 6
- Load Reading Problem → Go to Flow Chart 7
- Bad Data Transfer Between Console & Central Unit → Go to Flow Chart 8
- Interference Problem → Go to Flow Chart 9
- Angle Problem → Go to Flow Chart 10
7.2 Lever Lockout Activated

PROBLEM: The lever lockout system of the crane is activated. Crane movements “hoist up”, “telescope out”, and “boom down” are stopped. Crane is not in overload or two-block condition.

Start

Set the override key switch in central unit into upper position to override LMI. Refer to Operator’s Handbook for LMI override instructions.

Fixed

Yes

NO

Does console indicate Anti-Two-block warning?

NO

Fault in crane electric or hydraulic system.

Check lever lockout system in crane.

YES

Fault in Anti-Two Block system.

Go to Flow Chart 5

If Load Moment Limit Light displays fault, it is located in LMI, cables, wiring, fuses, or console.

Read error code displayed on console and go to Section 6.

If console display is blank fault is located in power supply, wiring or fuses.

Go to Flow Chart 4

Go to Flow Chart 5
7.3 Broken Length Cable

PROBLEM: Damaged or broken length cable.

Refer to cable reel parts list and system wiring diagram.

Replace length cable using the following procedure:

1. Cut old cable at cable drum.
2. Disconnect damaged length cable from junction box at the boom nose.
3. Open cable reel cover and disconnect wiring from connection block. Pull 7 conductor cable out of strain relief.
4. Remove cable reel from mounting brackets.
5. Remove damaged length cable, which is mounted to the slip rings in the cable reel, from slip ring connection.
6. On the backside of the cable reel, open the strain relief attached to the axle in the center of the drum. Pull existing length cable out of the cable reel.
7. Pull new length cable through the hole, pipe and strain relief and push it through the axle of the reeling drum. Tighten strain relief to ensure sealing.
8. Reconnect the length cable to the slip ring.
9. Remount cable reel to the boom.
10. Turn reeling drum clockwise to spool the new cable neatly onto the drum.
11. Set preload on cable reel by turning the drum counter-clockwise 5 to 8 turns.
12. Wrap the new length cable around the boom tip anchor pin (4 or 5 wraps) and secure with tie wraps. Leave enough length cable to connect into the boom tip junction box.
13. Connect the length cable into the boom tip junction box.
14. Reset length potentiometer in length angle transducer (screw is located in center of white gear); with boom fully retracted, turn potentiometer carefully counter-clockwise until it stops. Recheck length and angle display.
7.4 No Display

**PROBLEM:** Blank console display with no warning light shown. All crane moments have been stopped.

1. **Start**
2. **Check fuses on CPU box.**
   - **Correct?**
     - No → **Replace fuses.**
     - Yes → **Measure crane voltage on connection board between X1-2 (+12V) and X1-4 (ground).** Refer to system wiring diagram.
       **NOTE:** If crane voltage is measured below 10V system will switch off.
       - **Correct?**
         - No → **Check crane power supply for faulty crane electric or if supply is too low.**
         - Yes → **Measure voltage on the connection board between X1:30 (+12/24V) and X1:33 (ground).** This is an output voltage to the console. Refer to system wiring diagram.
           - **Correct?**
             - No → **Replace connection board and reset pressure channel.** Refer to system wiring diagram and main board replacement procedure.
             - Yes → **Next Page**
Measure voltage in the console between X1:1 (+12/24V) and X1:2 (ground). Refer to system wiring diagram.

Check connections of the cable between console and central unit. Replace cable if necessary. Refer to system wiring diagram.

Correct?

NO

YES

Display is defective. Refer to console parts list.

YES

END
7.5 Anti Two Block Problem

PROBLEM: Function of Anti-Two-Block System is faulty.

START

Check to see whether or not crane is in two-block condition.

Correct? No → Lower hook down into safe position

Yes

Check if jumper/dummy plug in receptacle at boom nose is plugged in.
Refer to system wiring diagram.

Correct? No → Plug appropriate plug into socket of junction box.

Yes

Turn power off or disconnect wire from connection board X1:35 in central unit. Remove bypass plug and check function of Anti-Two Block switches with ohmmeter between wires 2 and 3 of switches or between terminals 1 and 6 at boom nose box. This checks the function of the Anti-Two Block switch. Install bypass plug.
Switch closed = 0 Ohm (weight installed)
Switch open => 1 Megaohm (weight removed)
Refer to system wiring diagram.

Correct? No → Replace Anti-Two-Block switch.

Yes

Next Page
Measure the A2B signal in the cable reel between X1:Brown and X2:Red wires on the slip ring with an ohmmeter.
   - Switch closed = 4700 ± 500 Ohms
   - Switch open => 1 Megaohm
   - Reconnected slip ring wires.
   - Refer to system wiring diagram.

If broken length cable, Refer to length cable replacement.

Measure the A2B signal in the cable reel between terminal 7 and 8 with an ohmmeter.
   - Switch closed = 4700 ± 500 Ohms
   - Switch open => 1 Megaohm
   - Reconnected slip ring wires.
   - Refer to system wiring diagram.

Measure the A2B signal in the boom base 10 pin receptacle between terminal 5 and 6 with an ohmmeter.
   - Switch closed = 4700 ± 500 Ohms
   - Switch open => 1 Megaohm
   - Reconnected slip ring wires.
   - Refer to system wiring diagram.

Fault in 7 conductor cable between cable reel and boom base box.
Refer to system wiring diagram.

Correct?
No

Fault in wiring between boom nose box and cable reel. Check for damaged length cable and wiring.
   - Refer to system wiring diagram.
   - If broken length cable, Refer to length cable replacement.

Correct?
No

Replace slip ring
Refer to cable reel parts list.

Correct?
No
Connect wire #5 back to the terminal X1:35 on the connection board. Refer to system wiring diagram.

Turn system power off. Check Anti-Two-Block signal in central unit with ohmmeter measure between X1:34 and X1:35.
Anti-Two-Block switch closed = 4700 Ohms ±50 0Ohms
Anti-Two-Block switch open => 1 Megaohm.
Refer to system wiring diagram.

Correct? NO
Faulty wiring between cable reel and central unit. Check cable.

Correct? YES
Disconnect X1:34 and X1:35. Check main board function by installing a temporary resistor, 4700 Ohms between X1-34 and X1-35 in central unit. With resistor connected alarm should be inactive.
Refer to system wiring diagram.

Correct? NO
Replace main board and reset pressure channel. Refer to main board replacement procedure.

Reconnect Wire #6 to X1:34 and Wire #5 to X1:35
Refer to system wiring diagram.

End
7.6 Length Reading Problem

PROBLEM: Length reading incorrect. Crane is not in “out of load chart” condition.

START

Check mechanical adjustment of length potentiometer in cable reel. When main boom is fully retracted, adjust length potentiometer counter-clockwise until it stops. Refer to length/angle adjustments procedure.

Correct?

Yes

Correct?

No

Replace length potentiometer assembly. Remove slip ring body from shaft and remove gear wheel from potentiometer axle. Unscrew mounting plate and remove potentiometer assembly from mounting plate. Remove assembly wires form terminal block. Connect new assembly to terminal block. Reinstall mounting plate, gear wheel and slip rings. With boom fully retracted, reset potentiometer by turning counter-clockwise until it stops. Refer to Cable Reel Parts List.

Check out clutch in big gear wheel of length transducer. Extend and retract boom to ensure that clutch is not sipping on potentiometer axle.

Correct?

Yes

Correct?

No

Replace the gear wheel, clean potentiometer axle. Reset length potentiometer. Refer to length/angle adjustments procedure.

Check power supply to length transducer on connection board, terminal X1:8 (ground) and X1:11 (-5V) Refer to system wiring diagram.

Correct?

Yes

Correct?

No

Replace connection board and reset pressure channel. Refer to system wiring diagram and main board replacement procedure.

NEXT PAGE
Measure supply to length transducer in cable reel at terminal between Pin 1 (ground) and Pin 3 (-5v)  
Refer to system wiring diagram.

Correct?  
Yes  
No  
Faulty wiring between central unit and length transducer. Check wiring.

Measure signal from length transducer in cable reel at terminal between pin 2 (signal) and pin 1 (ground). Retract boom - 0  
Potentiometer turn = -0.5v 10 Potentiometer turn = -4.5v

Correct?  
Yes  
No  
Replace length potentiometer assembly. Remove slipring body from shaft and remove gear wheel from potentiometer axle. Unscrew mounting plate and remove potentiometer assembly from mounting plate. Remove assembly wires from terminal block. Connect new assembly to terminal block. Reinstall mounting plate, gear wheel and slip rings. With boom fully retracted, reset potentiometer by turning counter-clockwise until it stops.

Measure signal from length transducer in central unit main board between X1:8 (ground) and X1:10 (signal: -0.5 and -4.5v) Refer to system wiring diagram.

Correct?  
Yes  
No  
Faulty wiring between central unit and length transducer. Check wiring.

NEXT PAGE
Measure length signal of amplified output on connection board between test point MP10 and test point MP13. (+5V)
NOTE: Negative signal at terminal X1:11 will be converted into positive signal at MP13 (i.e.: input at terminal X1:11 = -0.5V and gnd).
Refer to system wiring diagram.

Correct?  
Yes  
No  
Replace connection board and reset pressure channel. Refer to system wiring diagram and main board replacement Procedure.

END
7.7 Load Reading Problem

PROBLEM: Load reading incorrect.

START

Check selected operating mode (code on operating mode switch).

Correct?

No

Select operating mode switch to correct position (see operating mode in load chart).

Yes

Check boom length reading on display.

Correct?

No

Reset length potentiometer. With fully retracted boom, turn potentiometer axle counter-clockwise until it stops (see Section 3 and 6). Refer to length & angle adjustments procedure.

Yes

Measure radius and check with the displayed radius.

Correct?

No

Check mechanical adjustment of angle transducer is correct. Angle transducer box should be in line with boom and adjusted to actual boom angle should match displayed boom angle. Refer to length & angle adjustments procedure.

Yes

Check power supply to pressure transducer (rodside). Unplug transducer cable from transducer. Measure connection board between X1:14 to X1:13 (-5.0v) and X1:14 to X1:15 (+5.0) for rod side

Check power supply to pressure transducer (piston side). Unplug transducer cable from transducer. Measure connection board between X1:19 to X1:20 (-5.0v) and X1:19 to X1:18 (+5.0)

Refer to system wiring diagram.

NEXT PAGE
Check power supply at transducer plugs.
Measure between B (ground) and A = +5V.
Measure between B (ground) and C = -5V.

Check power supply and measure between test point MP10 (ground) to MP7(+5.0v) and between test point MP10 (ground) to MP6(-5.0v)
Refer to main board layout.

Correct?

Yes

Correct?

Check power supply and measure between test point MP10 (ground) to MP2(+9.0v) and between test point MP10 (ground) to MP3(-9.0v)
Refer to main board layout.

Correct?

Power supply on connection board faulty. Replace connection board and reset pressure channel. Refer to system wiring diagram and main board replacement procedure.

Check power supply at transducer plugs.
Measure between B (ground) and A = +5V.
Measure between B (ground) and C = -5V.

Correct?

Faulty wiring. Check wiring of pressure transducer cable.

Correct?

Yes

NEXT PAGE
Check transducer signals in central unit. Connect pressure transducers to cable. Disconnect wire No. 4 of transducer cable from X1:21 (signal piston side). Measure transducer signals (0...-1V) between Pin 19 (ground) and wire No. 4 of piston cable. Disconnect wire No 4 of transducer cable from terminal block X1: Pin 16 (single rod side). Measure transducer signals (0...-1V) between Pin 19 (ground) and wire No. 4 of rod cable. Refer to system wiring diagram.

Correct? No

Check wiring in pressure transducer cable. Continuity Good?

No

Correct?

Yes

Transducer defective-replace transducer and reset pressure channel.

Yes

Connect wire No. 4 from transducer cables back to terminal X1:16 (rod side) and terminal X1:21 (piston side). Without pressure in pipes or hydraulic pipes disconnected from transducer, check 0-point adjustment on connection board. Measure between test point MP10 (ground) and test point MP11. Signal should be 0.50V (piston side). Measure between test point MP10 (ground) and test point MP12. Signal should be 0.50V (rod side). Refer to system wiring diagram.

Correct? No

Measure voltage between test point MP10 (ground) and test point MP11 and reset with P1 to 0.50V (piston side). Measure voltage between test point MP10 (ground) and test point MP12 and reset with P2 to 0.50V (rod side). If not adjustable, replace transducer. Refer to system wiring diagram and zeroing transducer procedure.

END
7.8 Bad Data Transfer Between Console & Central Unit

PROBLEM: Error Code “E93/E94” No data transfer to and from console.

START

Make sure that the eproms are plugged into the correct socket and orientated. Refer to EPROM replacement procedure.

Correct? No → Place EPROM in correct socket.

Yes

Check crane supply voltage for console in central unit at connection board X: 33 (ground) and X1:30 (+12V). Make sure external and internal power supply is correct. Refer to Section 4. Refer to system wiring diagram.

Correct? No → Replace main board and reset pressure channel. Refer to system wiring diagram and transducer replacement procedure.

Yes

NEXT PAGE
Troubleshooting Flow Charts

Continued from previous page

Check power supply to console between console terminal 2 (ground) and terminal 1 (+12v)
Refer to system wiring diagram.

Correct? No

Faulty wiring in cable from central unit to console.
Replace cable.

Yes

Ensure that wires are properly connected between CU X1:31 and console terminal 4 and
between CU X1:32 and console terminal 3.
Refer to system wiring diagram.

Correct? No

Replace main board and reset pressure channel.
Refer to system wiring diagram and transducer replacement procedure.

Yes

END
7.9 Interference Problem


START

Refer to Section 8 - Bad Data Transfer Between Console & Central Unit.

Correct?

No

Replace or repair part which is defective.

Yes

Check if additional ground link between main board terminal X1:3 and central unit box mounting bracket is in place.

Correct?

No

Install ground line - single cable minimum of AWG14 (2.0mm) between terminal X1:3 and central unit box mounting bracket. Refer to system wiring diagram.

Yes

Ensure that cable shields are connected correctly. Refer to connection and wiring diagrams, Refer to system wiring diagram.

Correct?

No

Make correct shield connection. Refer to system wiring diagram.

Yes

Find out which component of the crane electric is spiking out (e.g. dump valve, outrigger relay). Install a diode or resistor across terminals of spiking component. Diode type such as 1N4001 can be used, however, ensure the correct plus and minus connections for diode.

END
7.10 Angle Problem

PROBLEM: Displayed Angle Incorrect. Actual measured angle is different from displayed angle.

START

Use a calibrated inclinometer to measure the actual main boom angle and compare with displayed angle on console. Refer to length/angle adjustments procedure.

Check the supply voltage to angle sensor on connection board between X1:11 (+5VDC) and X1:8 (ground). Refer to system wiring diagram.

Correct? No

Check system power supply voltage. Refer to Section 7.4 No Display, this manual.

Yes

Check the voltage at angle sensor between connector pins A (AGND) and C (+5V). Refer to system wiring diagram.

Correct? No

Cable defective, replace cable or cable assembly. Refer to system wiring diagram.

Yes

Check the voltage between X1:8 (ground) and X1:9 (signal/output voltage). Voltage should be 3.125V (0°), 2.5V(45°), 1.875V (90°). Refer to angle sensor theory.

Replace Angle Sensor. Refer to length/angle adjustments procedure.

END
## 8 ERROR CODE TABLE

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Error</th>
<th>Cause</th>
<th>Elimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>E01</td>
<td>Fallen below radius range or angle range exceeded</td>
<td>• Fallen below the minimum radius or gone past the maximum angle specified in the respective load chart due to luffing up the boom too far</td>
<td>• Luff down the boom to a radius or angle specified in the load chart.</td>
</tr>
<tr>
<td>E02</td>
<td>Radius range exceeded or fallen below angle range</td>
<td>• Gone past the maximum radius or fallen below the minimum angle specified in the respective load chart due to luffing down the boom too far</td>
<td>• Luff up the boom to a radius or angle specified in the load chart.</td>
</tr>
<tr>
<td>E03</td>
<td>Non-permitted slewing zone (no load area)</td>
<td>• The slewing zone with load is not permitted</td>
<td>• Slew to permitted area</td>
</tr>
<tr>
<td>E04</td>
<td>Operating mode not acknowledged or non permitted slewing zone</td>
<td>• A non existing operating mode has been selected • The boom is in a non-permitted slewing zone</td>
<td>• Set the correct operating mode for the operating state in question • Slew the boom to a permitted area.</td>
</tr>
<tr>
<td>E05</td>
<td>Prohibited length range</td>
<td>• Boom has been extended either too far or not far enough, e.g. if it is prohibited to go beyond a certain maximum boom length or with load curves for jibs where the main boom has to be extended to a certain length</td>
<td>• Extend/retract boom to the correct length • Length sensor adjustment has changed, e.g. the cable slid off the length sensor reel. • Retract boom. Check the pre-stress of the cable reel (cable must be taut). Open the length sensor and carefully turn the length sensor pot counter clockwise until loosened by using a screw driver</td>
</tr>
<tr>
<td>Error Code</td>
<td>Error</td>
<td>Cause</td>
<td>Elimination</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>E06</td>
<td>Radius range exceeded or fallen below angle range with luffing jib</td>
<td>• Maximum radius as specified in the load chart exceeded or fallen below minimum angle due to</td>
<td>• Luff the jib to a radius or angle specified in the load chart.</td>
</tr>
<tr>
<td></td>
<td>operation</td>
<td>luffing down the luffing jib too far</td>
<td></td>
</tr>
<tr>
<td>E07</td>
<td>Faulty acknowledgment of the overload relay on the main board.</td>
<td>• Overload relay or main board are defective</td>
<td>• Replace main board</td>
</tr>
<tr>
<td></td>
<td>The relay should be energized, the 2nd contact however is indicated</td>
<td>• Processor board defective</td>
<td>• Replace processor board.</td>
</tr>
<tr>
<td></td>
<td>to be off, or the 2nd contact is indicated to be on while the relay</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>should be de-energized.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E08</td>
<td>No acknowledgement from the anti-two-block relay</td>
<td>• Refer to E07</td>
<td>• Refer to E07</td>
</tr>
<tr>
<td>Error Code</td>
<td>Error</td>
<td>Cause</td>
<td>Elimination</td>
</tr>
<tr>
<td>------------</td>
<td>-------</td>
<td>-------</td>
<td>-------------</td>
</tr>
</tbody>
</table>
| E11        | Fallen below lower limit value for measuring channel "length main boom" | - Cable between central unit and length sensor is defective or disconnected. Water inside the plug of the length/angle sensor  
- Length potentiometer is defective  
- Electronic component in the measuring channel is defective | - Check cable as well as plugs, replace, if need be.  
- Replace length potentiometer  
- Replace LMI main board or processor board. |
| E12        | Fallen below the lower limit value in the measuring channel "pressure piston side" | - Cable between the central unit and pressure transducers defective or water inside the plugs  
- Pressure transducer is defective.  
- Electronic component in the measuring channel is defective. | - Check cable as well as plugs, replace, if need be.  
- Replace pressure transducer  
- Replace LMI main board or processor board. |
| E13        | Fallen below lower limit value in the measuring channel "pressure rod side" | - Refer to E12 | - Refer to E12 |
| E15        | Fallen below lower limit value in measuring channel "angle main boom" | - Cable between central unit and the length/angle sensor defective or loose. Water inside the plug of the length/angle sensor.  
- Angle potentiometer defective  
- Electronic component in the measuring channel defective. | - Check cable as well as plugs, replace, if need be.  
- Replace angle sensor  
- Replace LMI main board or processor board. |
| E16        | Fallen below lower limit value in measuring channel "angle 2" | - Cable between the central unit and the angle sensor defective or loose. Water inside the plug of the angle sensor.  
- Angle potentiometer defective  
- Electronic component in the measuring channel defective. | - Check cable as well as plugs, replace, if need be.  
- Replace angle sensor  
- Replace LMI main board or processor board. |
<table>
<thead>
<tr>
<th>Error Code</th>
<th>Error Description</th>
<th>Cause</th>
<th>Elimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>E19</td>
<td>Reference and/or supply voltage defective</td>
<td>• The supply voltage is falsified by one of the sensors (DAV, LWG)</td>
<td>• Check the voltages on the LMI main board. Check sensors, plugs and cable, replace, if need be. Replace LMI main board</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Electronic component is defective</td>
<td></td>
</tr>
<tr>
<td>E20</td>
<td>Analog and/or supply voltage defective</td>
<td>• The analog voltage is falsified by one of the sensors</td>
<td>• Check the voltages on the LMI main board. Check sensors, plugs and cable, replace, if need be. Replace LMI main board</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Electronic component is defective</td>
<td></td>
</tr>
<tr>
<td>E21</td>
<td>Upper limit value in measuring channel &quot;main boom length&quot; has been exceeded.</td>
<td>• Refer to E11</td>
<td>• Refer to E11</td>
</tr>
<tr>
<td>E22</td>
<td>Upper limit value in measuring channel &quot;pressure piston side&quot; has been exceeded.</td>
<td>• Refer to E12</td>
<td>• Refer to E12</td>
</tr>
<tr>
<td>E23</td>
<td>Upper limit value in measuring channel &quot;pressure rod side&quot; has been exceeded.</td>
<td>• Refer to E12</td>
<td>• Refer to E12</td>
</tr>
<tr>
<td>E25</td>
<td>Upper limit value in measuring channel &quot;main boom angle&quot; has been exceeded.</td>
<td>• Refer to E15</td>
<td>• Refer to E15</td>
</tr>
<tr>
<td>E26</td>
<td>Upper limit value in measuring channel &quot;angle 2&quot; has been exceeded.</td>
<td>• Refer to E16</td>
<td>• Refer to E16</td>
</tr>
<tr>
<td>E29</td>
<td>Reference and/or supply voltage defective</td>
<td>• Refer to E19</td>
<td>• Refer to E19</td>
</tr>
<tr>
<td>E31</td>
<td>Error in the system program</td>
<td>• The system program PROM is defective</td>
<td>• Replace system program PROM (PROM No. 0)</td>
</tr>
<tr>
<td>E37</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E38</td>
<td>System program and data EPROM do not match.</td>
<td>• The system program in the LMI does not match to the programming in the data EPROM</td>
<td>• Replace the system program PROM or the data EPROM (PROM No. 1)</td>
</tr>
<tr>
<td>Error Code</td>
<td>Error</td>
<td>Cause</td>
<td>Elimination</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| E41        | Error in the internal write/read memory (RAM) of the computer component 80C537 | - Computer component 80C537 defective  
- CPU module defective  
- Processor board defective. | • Replace computer component 80C537.  
• Replace CPU module.  
• Replace processor board with CPU module. |
| E42        | Error in the external write/read memory, 1st part (RAM)              | - Write/read memory (CMOS RAM) or processor board defective.          | • Replace processor board with CPU module.                                  |
| E43        | Error in the external write/read memory, 2nd part (RAM)              | • Refer to E42                                                        | • Refer to E42                                                              |
| E45        | Redundancy error in the A/D conversion                               | • The A/D converter on the processing board and the redundant A/D converter in the CPU 80C537 provide different results. | • Replace processor board.                                                 |
| E46        | Error in the A/D converter uPD 7004 of the processor board.          | • No acknowledgment of the A/D converter uPD 7004                    | • Replace processor board.                                                 |
| E48        | Cyclic RAM test: error in the internal write/read memory (RAM) of the computer component 80C537 | - Computer component 80C537 defective  
- CPU module defective  
- Processor board defective. | • Replace computer component 80C537.  
• Replace CPU module  
• Replace processor board with CPU module. |
| E49        | Cyclic RAM test: error in the internal write/read memory (RAM) of the computer component 80C537 | - Computer component 80C537 defective  
- CPU module defective  
- Processor board defective. | • Replace computer component 80C537.  
• Replace CPU module  
• Replace processor board with CPU module. |
| E51        | Error in the crane data EPROM or EEPROM.                             | - No valid data in the crane data EEPROM.  
- Memory module wrongly bridged.  
- Crane data EPROM defective | • Load crane data EEPROM containing valid data.  
• Bridge memory module acc. to memory type  
• Replace crane data EPROM |
<table>
<thead>
<tr>
<th>Error Code</th>
<th>Error</th>
<th>Cause</th>
<th>Elimination</th>
</tr>
</thead>
</table>
| E91        | No data transmission form the console to the central unit | • 24 V supply of the console is interrupted  
• Interruption or accidental ground in the line between console electronics and central unit  
• Transmitter/receiver module is defective | • Check 24 V at terminal X1 of the console electronics  
• Check the main console electronics - central unit. In case of an accidental ground, the transmitter module of the console electronics might be damaged. Therefore, replaces the console electronics.  
• Exchange console electronics or LMI main board |
| E92        | Error in the data transmission from console to central unit | • Loose connection in the line between console electronics and central unit  
• Transmitter/receiver module is defective | • Check the connection between console electronics and central unit  
• Exchange console electronics or LMI main board |
| E93        | Error in the data transmission from the central unit to the console | • Refer to E92 | • Refer to E92 |
| E94        | No data transmission from the central unit to the console | • Interruption or accidental ground in the line central unit - console  
• 5 V supply of the computer in the central unit is missing  
• 5 V supply is too low  
• Transmitter/receiver module is defective  
• Computer module is defective  
• Electro-magnetic interferences (e.g. when switching contacts or valves) | • Check line to the console (in case of accidental ground, replace console electronics, too).  
• Check connection to the power unit  
• Exchange the LMI main board  
• Replace console electronics or LMI main board  
• Replace processor board.  
• Eliminate the source of interference by inverse diodes or varistors. |

**Note:** If an error message is displayed which is not contained in above list, please contact PAT America, Inc. service department.
ADDENDUM A BASIC ADJUSTMENT AND VOLTAGE CHECKS

MODEL:________________________
S/N:________________________

PAT DS150 P/N 024-150-060-002 central unit / 024-150-300-001 main board

1. Crane Supply Voltage @ X1-1 (+) & X1-4 (GND) = VDC

   
   + 9V @ Mp2 = ____________ VDC Mp 10 Ground - Piston & Rod Pressure
   - 9V @ Mp3 = ____________ VDC Mp 10 Ground - Piston & Rod Pressure
   5V @ Mp4 = ____________ VDC Mp 10 Ground - TTL on Board
   5V @ Mp5 = ____________ VDC Mp 10 Ground - Reference on Board
   + 5V @ Mp6 = ____________ VDC Mp 10 Ground - Internal on Board
   - 5V @ Mp7 = ____________ VDC Mp 10 Ground - Length and Main/Jib Angle

3. Boom Length: (MP10 Ground for Meter)
   
   Fully Retracted ____________ Ft. ____________VDC @ X1:10 ____________DC @ MP13
   Fully Extended ____________ Ft. ____________VDC @ X1:10 ____________DC @ MP13
   -5 Volt Reference Voltage ____________ VDC @ X1:11

4. Boom Angle: (MP10 Ground for Meter)
   
   Minimum Angle __________ ° __________ VDC @ X1:9 __________ VDC @ Mp14
   Maximum Angle __________ ° __________ VDC @ X1:9 __________ VDC @ Mp14
   -5 Volt Reference Voltage ____________ VDC @ X1:11

5. Pressure Transducers: (MP10 Ground for Meter)
   
   Piston Zero Point ________ VDC @ X1:21 ________ VDC @ Mp11
   Rod Zero Point ________ VDC @ X1:16 ________ VDC @ Mp12
   + 5 Volt Reference Voltage ____________ VDC @ X1:13 & 18
   -5 Volt Reference Voltage ____________ VDC @ X1:15 & 20
# ADDENDUM B Reference Tables for measuring supply and signal voltages for sensor channels

Use the table as a quick reference for measuring supply and signal voltages for the sensor channels that are specific to the error code listed.

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Channel</th>
<th>Pin ‘ground’</th>
<th>Pin ‘supply’</th>
<th>Nominal Voltage (VDC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E11/21</td>
<td>2 Length</td>
<td>8</td>
<td>11</td>
<td>-5</td>
</tr>
<tr>
<td>E12/22</td>
<td>1 Pressure Piston side</td>
<td>19</td>
<td>20</td>
<td>-5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19</td>
<td>18</td>
<td>+5</td>
</tr>
<tr>
<td>E13/23</td>
<td>0 Pressure Rod side</td>
<td>14</td>
<td>15</td>
<td>-5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14</td>
<td>13</td>
<td>+5</td>
</tr>
<tr>
<td>E15/25</td>
<td>3 Angle Main boom</td>
<td>8</td>
<td>11</td>
<td>-5</td>
</tr>
<tr>
<td>E16/26</td>
<td>4 Angle Jib</td>
<td>23</td>
<td>25</td>
<td>-5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Channel</th>
<th>Pin ‘ground’</th>
<th>Pin ‘supply’</th>
<th>Amplified Signal on main board use MP10 - GND and MP supply voltage 0.5...4.5V</th>
</tr>
</thead>
<tbody>
<tr>
<td>E11/21</td>
<td>2 Length</td>
<td>8</td>
<td>10</td>
<td>-0.5...-4.5 MP13</td>
</tr>
<tr>
<td>E12/22</td>
<td>0 Pressure Piston side</td>
<td>8</td>
<td>21</td>
<td>0...-1 MP11</td>
</tr>
<tr>
<td>E13/23</td>
<td>1 Pressure Rod side</td>
<td>8</td>
<td>16</td>
<td>0...-1 MP12</td>
</tr>
<tr>
<td>E15/25</td>
<td>3 Angle Main boom</td>
<td>8</td>
<td>9</td>
<td>-1.875...-3.125 MP14</td>
</tr>
<tr>
<td>E16/26</td>
<td>4 Angle Jib</td>
<td>8</td>
<td>24</td>
<td>-1.875...-3.125 MP15</td>
</tr>
</tbody>
</table>