



SERVICE MANUAL

3000 Series

T31 Indicators



T31P



T31XW



SERVICE MANUAL

3000 Series T31 Indicators:

T31P & T31XW

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1.1 INTRODUCTION

This service manual contains the information needed to perform routine maintenance and service on the Ohaus T31 Indicators. The contents of this manual are contained in five chapters:

Chapter 1 Getting Started – Contains information regarding service facilities, tools and test equipment, measuring masses, specifications, hardware setup or disassembly, operating the Indicator, scale setup and calibration, and configuring the Indicator's communication and Legal-for-Trade menus.

Chapter 2 Troubleshooting – Contains a diagnosis/diagnostics chart and error code table.

Chapter 3 Maintenance Procedures – Contains preventive maintenance procedures and disassembly, repair and replacement procedures.

Chapter 4 Testing – Contains an operational test, segment display test, performance tests and adjustments.

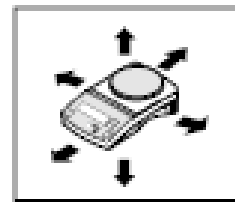
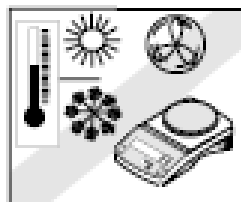
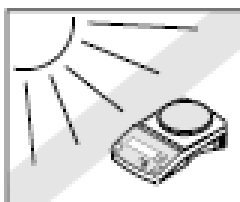
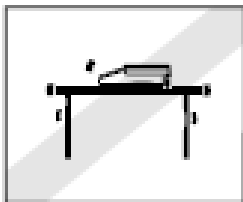
Chapter 5 Drawings and Parts Lists – Contains exploded views of T31 Indicators, identifying all serviceable components.

Before servicing the indicator, you should be familiar with the Instruction Manual which is packed with every indicator.

1.2 SERVICE FACILITIES

To service an indicator, the service area should meet the following requirements:

- Must be protected from electrostatic discharge.
- Should be temperature controlled and meet the indicator specifications for temperature environmental requirements. See specifications for temperature range.
- Must be free of vibrations such as fork lift trucks close by, large motors, etc.
- Must be free of air currents or drafts from air conditioning/heating ducts, open windows, people walking by, fans, etc.
- Area must be clean and air must not contain excessive dust particles.
- Work surface must be stable and level.
- Work surface must not be exposed to direct sunlight or radiating heat sources.



1.3 TOOLS AND TEST EQUIPMENT REQUIRED

In order to properly service the Indicator, certain special tools and test items are required in addition to standard electronic tool kits. These items are listed as follows:

1.3.1 Special Tools and Test Equipment List

1. Ohaus Scale Base.
2. Load Cell Simulator optional.
3. Computer with RS232 Interface for testing the RS232 communications.
4. RS232 Interface cable.
5. Data Printer for use with RS232 communications.
6. ESD work station or mat.

1.3.2 Standard Tools and Test Equipment List

1. Standard Electronics Tool Kit
2. Digital Voltmeter (DVM), with clip on probes. Input impedance of at least 10 megohms in the 1 Volt dc position.
3. Soldering Iron, solder and flux remover.

1.4 SPECIFICATIONS

TABLE 1-1. SPECIFICATIONS

Model	T31P	T31XW
Capacity Range	5 to 20,000 kg or lb	
Maximum Displayed Resolution	1:20,000	
Approved Resolution	1:6,000	
Maximum Avg. Piece Weight	1d	
Weighing Units	Kg, lb, g, oz, lb:oz	
Functions	Weighing, Parts Counting	
Display	1 in/2.5 cm digit height, 6-digit, 7-segment 1.5 in/3.8 cm high x 4.9 in/12.5 cm wide backlit LCD	
Backlight	White LED	
Keypad	4-button mechanical switches	4-button membrane switches
Ingress Protection	---	IP66
Load Cell Excitation Voltage	5V DC	
Load Cell Drive	Up to 4 x 350 ohm load cells	
Load Cell Input Sensitivity	Up to 3mV/V	
Stabilization Time	Within 2 seconds	
Auto-Zero Tracking	Off, 0.5, 1 or 3 divisions	
Zeroing Range	2% or 100% of capacity	
Span Calibration	5 kg or 5 lb to 100% capacity	
Interface	RS232	
Overall Dimensions (W x D x H) (in/mm)	8.2 x 2.8 x 6.5 / 210 x 71 x 168	8.3 x 2.8 x 5.8 / 212 x 71 x 149
Net Weight (lb/kg)	3.6 / 1.6	6.6 / 2.9
Shipping Weight (lb/kg)	5.7 / 2.6	8.8 / 4.0
Operating Temperature Range	-10°C to 40°C // 14°F to 104°F	
Power	9 – 12 VDC, 0.5A, AC Adapter Internal rechargeable, Sealed Lead-Acid Battery (100-hour typical life) (T31P) 100-240 VAC / 50-60 Hz, Internal Power Supply (T31XW)	

CHAPTER 1 GETTING STARTED

1.5 HARDWARE SETUP OR DISASSEMBLY

Both the T31P and T31XW connect to a scale base through a Load Cell Cable that connects to the Indicator's Main Printed Circuit Board (PCB). When supplied as part of a scale, each model has a mounting bracket that attaches to the column bracket of the base scale. To remove the mounting bracket, remove the threaded knobs, holding the Indicator by hand.



CAUTION:
ELECTRICAL SHOCK HAZARD. REMOVE ALL POWER CONNECTIONS TO THE INDICATOR BEFORE SERVICING OR MAKING INTERNAL CONNECTIONS.

The process of opening the Housing varies slightly for each model:

T31P:

1. Remove the four Phillips head screws from the rear housing.
2. Open the housing, being careful not to disturb the internal connections.

T31XW:

1. Remove the four hex head screws from the rear housing.
2. Open the housing by carefully pulling the top of the front housing forward.

Below is a diagram of the T31's Main PCB, with connectors, jumpers, terminals and switches indicated. The Load Cell Cable connects to Terminal Block J5.

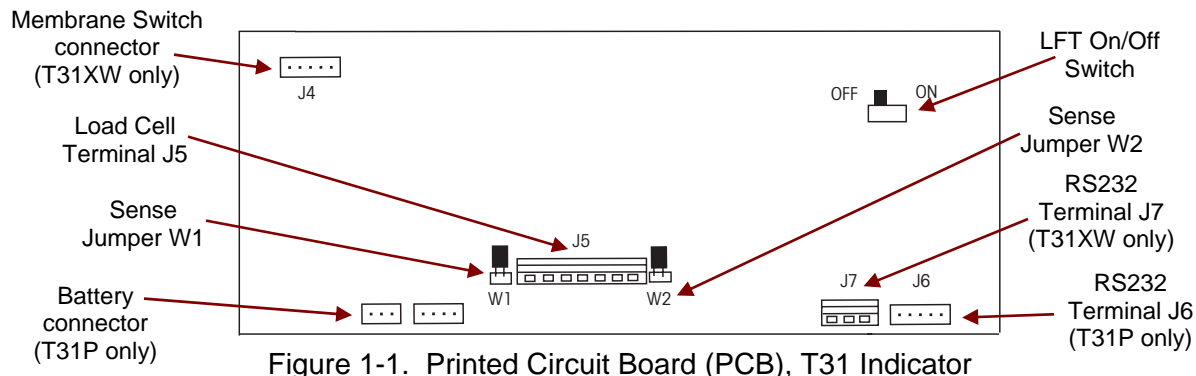


Figure 1-1. Printed Circuit Board (PCB), T31 Indicator

1.5.1 Jumper Connections

For a 4-wire load cell with no sense wires, short Jumpers W2 and W3.

For a 6-wire load cell that includes sense wires, open Jumpers W2 and W3.

For load cells with an extra ground shield wire, connect the shield to the center position (GND).

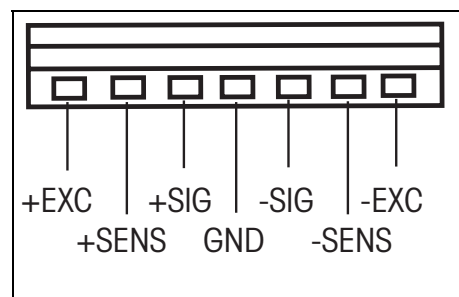


Figure 1-2. Load Cell wiring.

Pin Connection

J5-1	+Excitation
J5-2	+Sense
J5-3	+Signal
J5-4	GND
J5-5	-Signal
J5-6	-Sense
J5-7	-Excitation

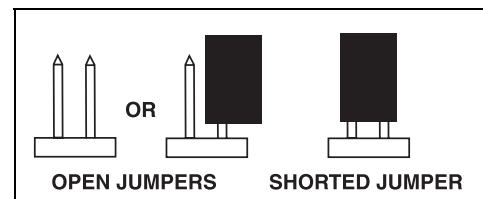


Figure 1-3. Open/shorted jumpers.

1.5.2 RS232 Interface

Each model (T31P and T31XW), has RS232 communication. The T31P uses a standard 9-pin D-style connector, with a pin configuration as illustrated in Figure 1-5, connecting to its female counterpart on the back of the T31P Housing. The T31XW has a water-tight strain relief outlet on its rear panel. (See Figure 1-4.) To connect an RS232 cable, pass it through the strain relief and attach it to terminal block J7. (See Figure 1-1.) Re-tighten the strain relief to ensure a water-tight seal.

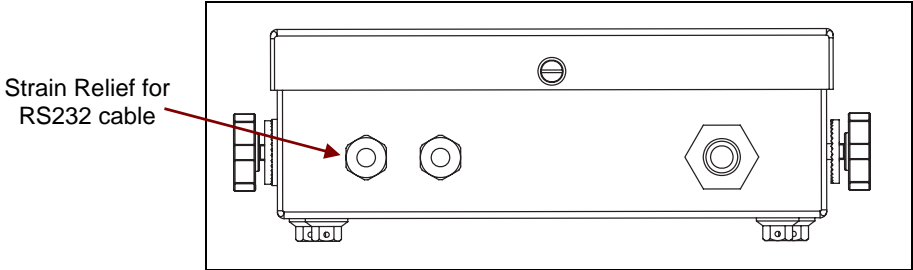


Figure 1-4. Rear panel, T31XW.

The RS232 wiring on the T31XW's Terminal J7 is labeled (J7-1=TXD, J7-2=RXD, J7-3=GND), to facilitate connecting the RS232 cable. The RS232 pin configuration for the T31P is illustrated in Figure 1-5, below.

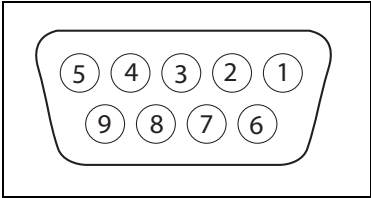


Figure 1-5. RS232 Pins.

<u>Pin</u>	<u>Connection</u>
1	N/C
2	TXC
3	RXD
4	N/C
5	GND
6-9	N/C

To adjust RS232 settings, see Section 1.9, page 1-11, or the Instruction Manual packed with the Indicator.

1.6 OPERATION

This section contains information on the basic operation of the Indicator. An exploded view drawing is included in Chapter 5 which identifies all components of the indicator. The descriptions in this manual refer to the names of the components identified in the exploded view drawing with the numbered callout.

1.6.1 Power Supply

The T31XW has an Internal Universal Power Supply, 100-240 VAC / 50-60 Hz, and plugs into a standard, properly grounded electrical outlet. Power to the T31P indicator is supplied by a 9 – 12 V dc, 500mA Power Adapter, or by a 6V 5Ah internally rechargeable sealed lead acid battery. The indicator will automatically switch to battery operation if there is a power failure or the power cord is removed.



NOTE

Before using the T31P Indicator for the first time, the battery should be fully charged for up to 12 hours. The Indicator can be operated during the charging process. The battery is protected against over-charging and the Indicator can remain connected to the AC power line.

Connect AC power to the indicator and allow it to charge. While the battery is charging, the triangle above the battery function symbol will light. When the battery is fully charged, this triangle will disappear.

The indicator can operate up to 100 hours on a fully charged battery. It automatically enters standby mode after one minute of no activity.

During battery operation, a flashing triangle above the battery function symbol indicates the battery is low and requires recharging. Approximately 60 minutes of operation will remain when the battery symbol starts to blink. The indicator will display Lo.BAT and automatically turn off when the battery is fully discharged.

1.7 OVERVIEW OF THE CONTROLS

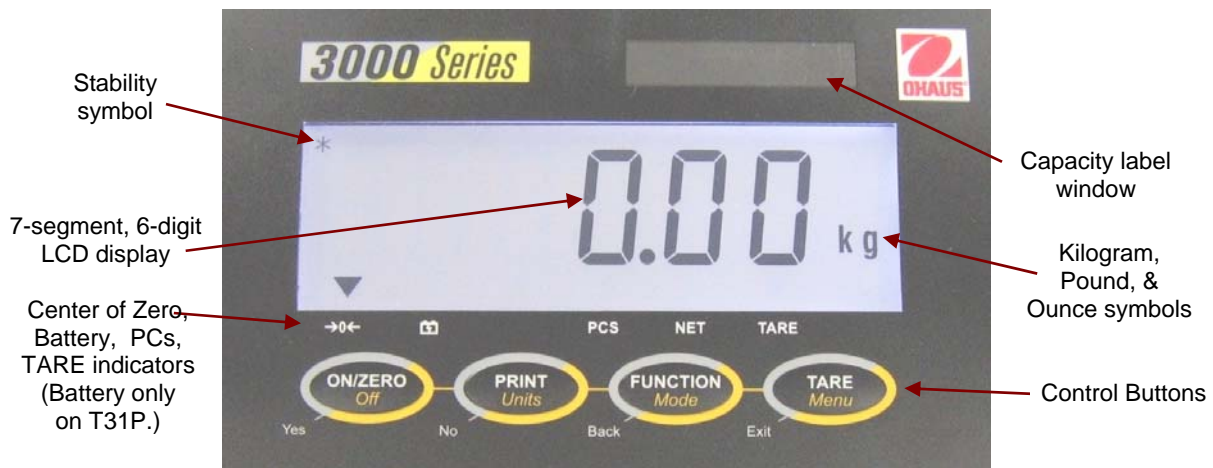






Figure 1-6. T31 Display.

1.7 OVERVIEW OF THE CONTROLS

TABLE 1-2. FUNCTIONS OF DISPLAY CONTROLS

Button	 Yes	 No	 Back	 Exit
Primary Function (Short Press)	ON/ZERO Turns the Indicator on.	PRINT Sends the current value to the COM port if AUTOPRINT is set to Off.	FUNCTION Initiates an application mode.	TARE Performs a tare operation.
Secondary Function (Long Press)	Off Turns the Indicator off.	Units Changes the weighing unit.	Mode Allows changing the application mode. Press and hold allows scrolling through modes.	Menu Enter the User menu.
Menu Function (Short Press)	Yes Accepts the current setting on the display.	No Advances to the next menu or menu item. Rejects the current setting on the display and advances to the next available setting. Increments the value.	Back Moves back to previous menu item. Decrements the value.	Exit Exits the User menu. Aborts a calibration in progress.

1.7.1 Power ON

To turn the indicator on, press **ON/ZERO/Off** (short press). The indicator performs a display test, momentarily displays software version, and then enters the active weighing mode.

1.7.2 Power OFF

To turn the power off, press **ON/ZERO/Off** (long press). The indicator shuts down.

CHAPTER 1 GETTING STARTED

1.7 OVERVIEW OF THE CONTROLS

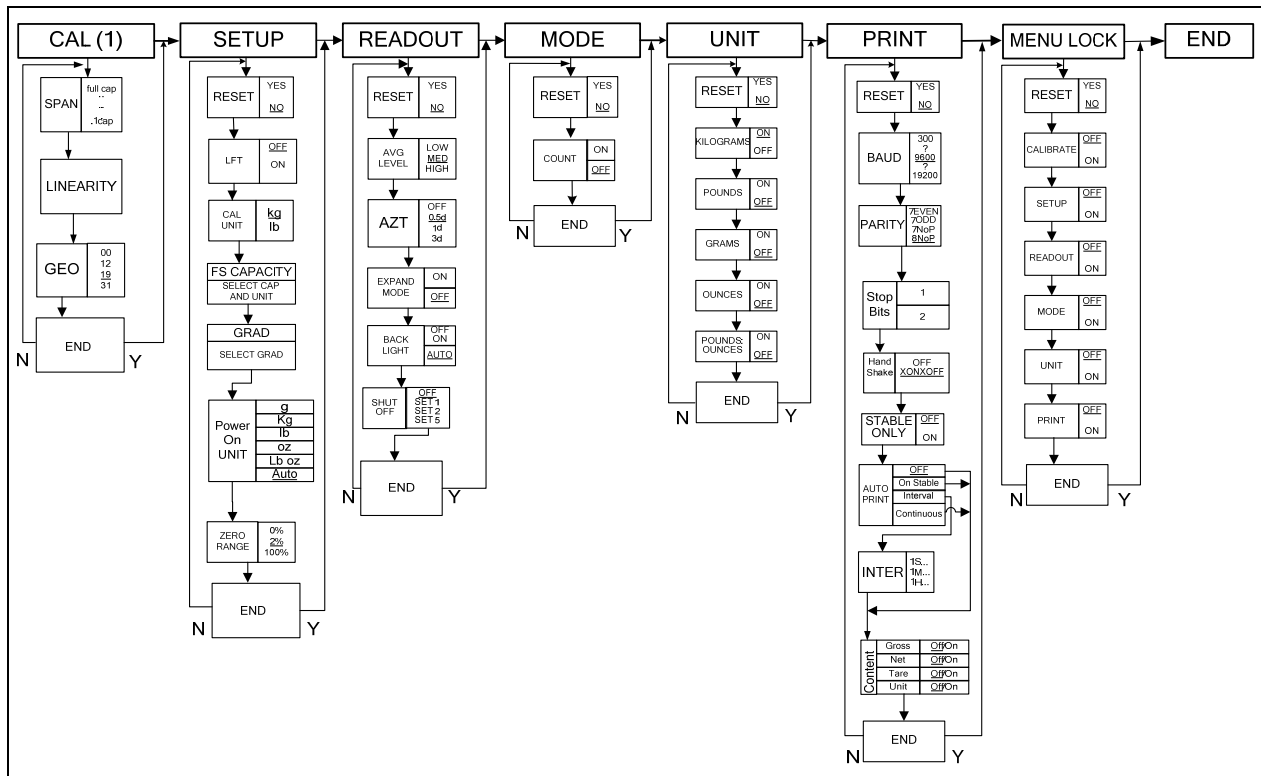
1.7.3 Menu Setup

To enter the Menu Mode, press and hold the **TARE/Menu** button until MENU appears on the display. The first upper level menu appears on the display.

Use **Yes**, **No**, **Back**, and **Exit** to navigate in Menu Mode:

- **Yes** Allows entry into the displayed menu.
Accepts the displayed setting and advances to the next menu item.
- **No** Skips by the displayed menu.
Rejects the displayed setting or menu item and advances to the next available item.
- **Back** Moves backwards through the upper and middle level menus.
Backs out of a list of selectable items to the previous middle level menu.
- **Exit** Exits from menu directly to the active weighing mode.

Table 1-3. T31 MENU STRUCTURE



1.8 SCALE SETUP & CALIBRATION

Two calibration processes are available: Span Calibration and Linearity Calibration.

Preliminary Steps:

1. Be sure appropriate calibration masses are available before beginning calibration.
2. Be sure the scale base is level and stable during the entire calibration process.
3. If LFT is set to On, calibration is unavailable.
To set LFT to OFF, see Section 1.10, page 1-13.

Note: To use the LFT mode again after turning it off, it is necessary to have the Indicator locked and sealed by local Weights and Measures authorities.

4. If the Calibration Menu is locked in the Menu Lock submenu, turn it back on:
 - Press and hold **TARE/Menu** until **C.A.L.** appears, then press **No**.
 - **SETUP** appears. Press **No**. **READOUT** appears. Press **No**.
 - **MODE** appears. Press **No**. **UNIT** appears. Press **No**.
 - **PRINT** appears. Press **No**.
 - **MENU LOCK** appears. Press **Yes**. **RESET** appears. Press **No**.
 - **CALIBRATE** appears. Press **Yes**. Then press **No** continuously until **End** appears.
 - Press **Yes** twice to exit menu mode.
5. Allow the Indicator to warm up for approximately five minutes after stabilizing to room temperature.
6. To abort calibration, press the **Exit** button anytime during the calibration process.

1.8.1 Geographical Adjustment Factor

The Geographical Adjustment Factor (GEO) is used to compensate for variations in gravity. Local gravity variance (depending on distance from the equator and altitude above sea level) is compensated for by entering a Geocode (conversion factor). See Appendix B to determine the Geocode conversion factor that corresponds to your location.

Note: Changing the GEO Factor alters the calibration. The GEO value was set at the factory and should only be changed if the location of use varies from the default setting.

To adjust the GEO Factor, press and hold **TARE/Menu** until **C.A.L.** appears. Press **Yes**. **SPAN** appears. Press **No**. **Linearity** appears. Press **No**. **GEO** appears. Press **Yes**. The default GEO setting appears. Press **No** to increment the number, or **Back** to decrement, until the desired number appears. Then press **Yes**.

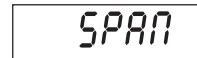
GEO appears again. Press **No** to exit the **GEO** menu. **End** appears. Press **Yes** to return to the **CAL** menu. Press **No** continuously until **E.n.d** appears. Press **Yes** to return to weighing mode.

1.8.2 Span Calibration

Span Calibration uses two points: the first point is the zero value, with no weight on the scale. The second point is the Span value, with a calibration mass placed on the scale.

Press and hold **TARE/Menu** until **C.A.L.** appears, then press **Yes**.

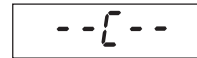
SPAN appears. Press **Yes** to access the Span Calibration menu.



The display flashes **0**. With no weight on the scale, press **Yes** to establish the zero point.



The display shows **--C--** while the zero point is established.

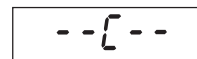


The display flashes the span calibration point. Place the specified weight on the scale and press **Yes**.



To choose a different span point, press **No** to increment the selections, or **Back** to decrement the selections. (See Appendix A for available span points.) When the desired value is displayed, place the specified weight on the scale and press **Yes**.

The display flashes **---C---** while the span point is established.



If span calibration was successful, the scale exits to the active weighing mode and displays the actual weight value.



1.8.3 Linearity Calibration

Linearity calibration uses three calibration points: the first with no weight on the scale, the second at approximately half capacity, the third at capacity. The Linearity calibration points are fixed and cannot be altered user during the procedure. See Appendix A for the linearity points.

Press and hold **TARE/Menu** until **C.A.L.** appears, then press **Yes**.

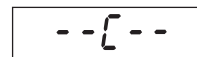
SPAN appears. Press **No**. **Linearity** appears. Press **Yes** to access the Linearity Calibration menu.



The display flashes **0**. With no weight on the scale, press **Yes** to establish the zero point.



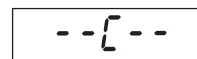
The display shows **--C--** while the zero point is established.



The display flashes the mid-calibration point. Place the specified weight on the scale and press **Yes**.



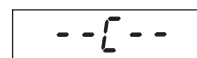
The display shows **--C--** while the mid-calibration point is established.



The display flashes the full calibration point. Place the specified weight on the scale and press **Yes**.



The display shows **--C--** while the full calibration point is established.



After successful calibration, the scale exits to the active weighing mode and displays the actual weight value.



1.9 RS232 INTERFACE CONNECTION

The T31 has a bi-directional RS232 interface for communication with printers and computers. When communication is used, data can be output various ways, depending on PRINT menu settings.

For RS232 cable connections, see Section 1.5.2, page 1-5.

1.9.1 Setting Communications Parameters

The T31 Indicator’s default communication parameters are baud rate 9600 bits per second (bps), 8 databits, no parity, Handshake XON/XOFF, Stable Only Off, and Autoprint Off.

To change these settings use the PRINT menu, as follows:

1. Press and hold **TARE/Menu** until **C.A.L.** appears. Press **No**. **S.E.t.U.P** appears. Press **No**. **r.E.A.d** appears. Press **No**. **M.O.d.E** appears. Press **No**. **U.N.I.t** appears. Press **No**. **P.r.i.n.t** appears. Press **Yes**. **rESEt** appears. Press **No**.

2. **bAUd** appears. Press **Yes**. bAUd
3. The default Baud rate setting, **9600** bps, appears. To change the setting, press **No**. The menu cycles to the next setting each time you press No: first 9600, then 300, 600, 1200, 2400, 4800, and 9600 again. Press Yes when the desired setting appears. **bAUd** appears again. Press **No**.

4. **PARitY** appears. Press **Yes**. The default Parity setting, **8 NONE**, appears. To change the setting, press **No**. PARitY

5. The menu cycles to the next setting each time you press No: first 7 Even, then 7 Odd, 7 None, and 8 None again. Press **Yes** to accept a setting. **PARitY** appears again. Press **No**. StOP

6. **StOP** appears. Press **Yes**. The default Stop Bit setting, **1**, appears. To change the setting, press **No**.

7. The menu toggles to the next setting each time you press No: first 1, then 2, then 1 again. Press **Yes** when the desired setting appears. **StOP** appears again. Press **No**. HAND

8. **HANd** appears. Press **Yes**. The default Handshake setting, **On-Off** (Xon/Xoff), appears. To change the setting, press **No**.

9. The menu toggles to the next setting each time you press No: first Off, then On-Off, then Off again. Press **Yes** when the desired setting appears. **HANd** appears again. Press **No**. StABLE

10. **StAbLE** appears. Press **Yes**. The Stable setting allows the Indicator to print values only when the stability criteria are met. To choose **ON**, press **Yes**. If you press **No**, **Off** appears. Press **Yes** to accept a setting. Then **StAbLE** appears. Press **No**.

11. **A.Print** appears. Press **Yes**. Auto Print sets printing to occur each time stability criteria are met (**ON.StAB**), or at a defined interval (**INtEr**), or continuously (**CONt**). The default setting is **Off**. Press **No** until the preferred setting appears. Then press **Yes**. **A.Print** appears. Press **No**. **INtEr** appears. APr int

12. If **INtEr** was selected, use the **INtEr** sub-menu to set the interval, from 1 to 3600 seconds. Press **No** to advance, **Back** to regress, and **Yes** to accept a setting. After you press **Yes**, **INtEr** appears again. Press **No** twice, then **Yes** when **End** appears, **No** when **P.r.i.n.t** appears, **No** again, and **Yes** when End appears again to exit menu mode.

CHAPTER 1 GETTING STARTED

1.9.2 Interface Commands

The RS232 Interface enables a computer to be used to control some functions of the Indicator using the commands listed in Table 1-4.

TABLE 1-4. SERIAL INTERFACE COMMAND TABLE.

Command	Function
IP	Immediate Print of displayed weight (stable or unstable).
P	Print stable displayed weight (according to stability setting).
CP	Continuous Print
SP	Print when stable.
xP	Interval Print x = Print Interval (1-3600 sec)
Z	Same as pressing Zero button
T	Same as pressing Tare button
xT	Download Tare value in grams (positive values only). Sending 0T clears tare (if allowed)
PU	Print current unit: g, kg, lb, oz, lb:oz
xU	Set scale to unit x: 1=g, 2=kg, 3=lb, 4=oz, 5=lb:oz
PV	Version: print name, software revision and LFT ON (if LFT is set ON).
Esc R	Global reset to reset all menu settings to the original factory defaults

NOTES:

- Commands sent to the Indicator must be terminated with a carriage return (CR) or carriage return-line feed (CRLF).
- Data output by the Indicator is always terminated with a carriage return-line feed (CRLF).

1.9.3 Output Format

The default serial output format is shown below.

TABLE 1-5. DEFAULT SERIAL OUTPUT FORMAT

Field:	Polarity	Space	Weight	Space	Unit	Stability	Legend	CR	LF
Length:	1	1	7	1	5	1	3	1	1

Definitions:

Polarity, “-” sign if negative, blank if positive.

Weight, up to six numbers and one decimal, right justified, leading zero blanking.

Units, up to five characters.

Stability, “?” character is printed if not stable, blank if stable.

Legend, up to 3 characters: G = gross weight, NET = net weight, T = tare

1.10 LEGAL FOR TRADE (LFT)

NOTE: When LFT is set to ON through the LFT sub-menu, and the LFT switch on the Main PCB is set to ON (see Figure 1-1, page 1-4), the following menu settings cannot be changed:

Span Calibration, Linearity Calibration, Calibration Unit, GEO, LFT, Capacity, Graduation, Zero Range, Stable Range, AZT, Modes, and Units.

To enable editing of these menu settings, open the Indicator and return the LFT switch on the Main PCB to the OFF position. Then set the LFT menu item to OFF, as follows:

1. Press and hold **TARE/Menu** until **C.A.L.** appears, then press **No**.
2. **S.E.t.U.P** appears. Press **Yes**.
3. **rESEt** appears. Press **No**.
4. **LfT** appears. Press **Yes**.
5. **OFF** appears. Press **Yes**.
6. **LfT** appears again. Press **No**. Continue to press **No** until **END** appears. Press **Yes**. (Or simply press **Exit** after leaving the LFT menu.)
7. The Indicator returns to weighing mode. It is now possible to use the abovementioned menus.

After the LFT/CAL Lock setting has been turned off, the scale must be inspected in accordance with local weights and measures regulations before it can be used in LFT mode again.

The weights and measures official may apply a wire or paper security seal as shown below.

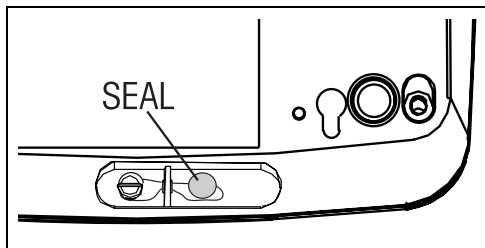


Figure 1-7. T31P Wire Seal.

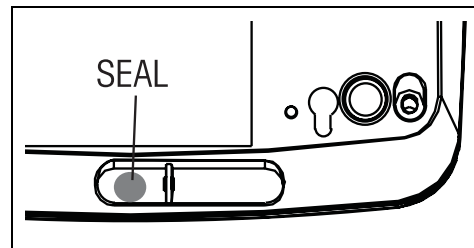


Figure 1-8. T31P Paper Seal.

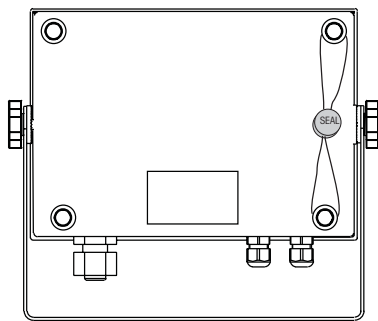


Figure 1-9. T31XW Wire Seal

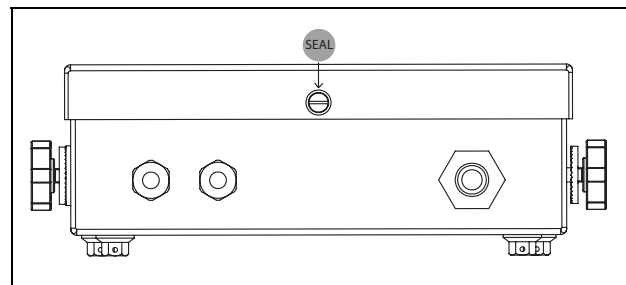


Figure 1-10. T31XW Paper Seal

2.1 INTRODUCTION

This section of the manual covers visual inspection of the Indicator, troubleshooting, and a Diagnostic Guide, Table 2-1. For setup and connection to either a known good base or simulator, see Chapter 1. Follow all directions step by step. Make certain that the work area is clean and use care when handling components of the Indicator.

2.2 VISUAL INSPECTION

Carefully remove the Indicator from its packing container and remove any packing material fastened to the unit. Note all items supplied with the unit such as AC power supply, cables, instruction manual, weights, etc. Keep a record of all items and note their condition.

1. Examine the Indicator for signs of abuse such as a cracked top cover or base, damage from liquids, cracks on corners, which may suggest the unit was dropped.
2. Open the Indicator by removing the four screws in the rear housing. Be careful not to stretch the cables that connect the main Printed Circuit Board (PCB) to the outlets (RS232 and Load Cell ports) and power supply.
3. Examine the top of the main PCB for cracks or signs of corrosion.
4. If it appears that corrosion may have affected the board and you want to examine the bottom of the PCB, remove the four screws holding it to the housing.
5. Carefully lift out the main PC board. If it is cracked or shows signs of corrosion, it requires replacement. See Chapter 3, Maintenance Procedures, for board replacement and testing. If the Indicator shows no sign of physical damage, continue with procedures.

See chart below for visual checking procedures.

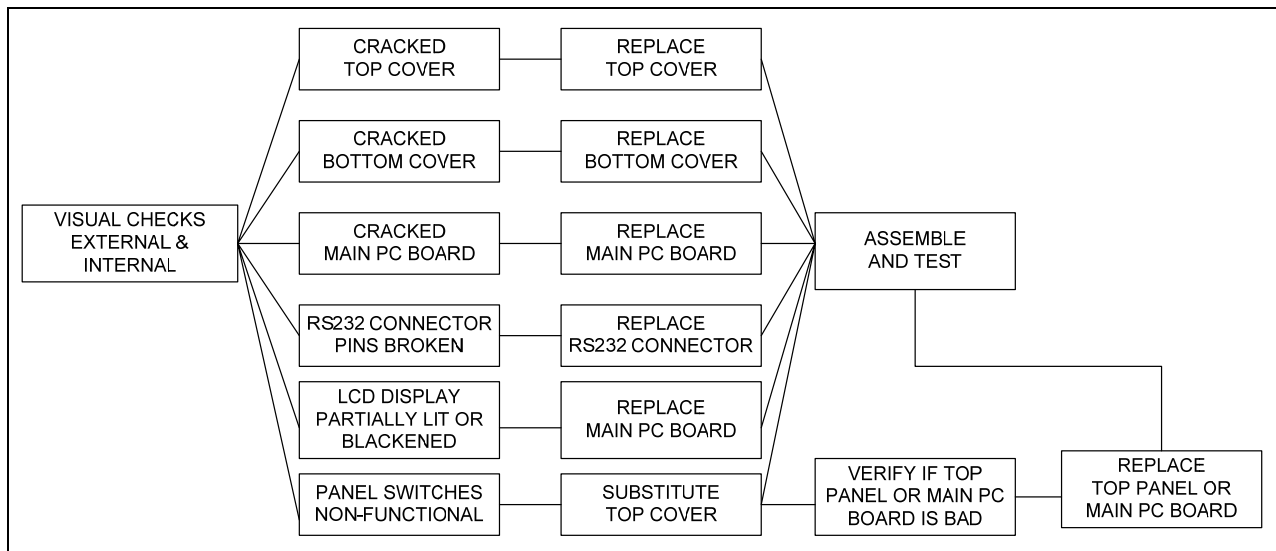


Figure 2-1. Visual Checking Procedures.

2.3 DIAGNOSTIC GUIDE

Table 2-1 is a Diagnostic Guide designed to help locate the problem area quickly and easily. The probable causes are listed with the most common cause first. If the first remedy does not fix the problem, proceed to the next remedy. Before attempting any repairs, read all chapters of this manual to be familiar with overall operation and all components.

2.2.1 Diagnosis

1. Isolate and identify the symptom
2. Refer to Table 2-1, Diagnostic Guide and locate the symptom.
3. Follow the suggested remedies in the order they appear.
4. Perform the indicated checks, or see the appropriate section of the manual.
5. Repair or replace the defective part.

NOTE:

If more than one symptom is observed, approach one area at a time, and remember that the symptoms may be interrelated.

If a problem arises that is not covered in this manual, contact Ohaus Corporation for further information.

2.2.1 Diagnosis

TABLE 2-1. DIAGNOSTIC GUIDE

Symptom	Possible Cause(s)	Remedy
Unit will not turn on	Power cord not plugged in or properly connected. Power outlet not supplying electricity. Battery discharged (T31P only).	Check power cord connections. Make sure power cord is plugged in properly into the power outlet. Check power source. Reconnect AC power to charge the battery.
Cannot zero the Scale, or will not zero when turned on.	Load on Scale exceeds allowable limits. Load on Scale is not stable. Load Cell is damaged. PCB is damaged.	Remove load on Scale. Wait for load to become stable. Replace Load Cell. Replace PCB.
Poor accuracy	Improper calibration Unstable environment Load Cell is damaged. PCB is damaged.	Perform calibration. Move scale to suitable location. Replace Load Cell. Replace PCB.
Unable to calibrate	Unstable environment Incorrect calibration mass Lock Calibration Menu set to On. Lock switch on PCB is "on". LFT menu set to On.	Move the scale to suitable location. Use correct calibration mass. Set Lock Calibration Menu to Off. Set the Lock switch on PCB to Off. Set LFT menu to Off.
Battery indicator is flashing (T31P only)	Battery discharged	Connect indicator to power and charge battery.
Battery fails to charge fully (T31P only)	Battery is defective.	Replace battery.
Error 7.0	Unstable weight reading when defining reference weight.	Unstable Error, check platform location.
Error 8.1	Weight reading exceeds Power On Zero limit.	Remove load from scale. Recalibrate scale.
Error 8.2	Weight reading below Power On Zero limit.	Add load to scale. Recalibrate scale.
Error 8.3	Weight reading exceeds Overload limit.	Reduce load on scale.
Error 8.4	Weight reading below Underload limit.	Add load to scale. Recalibrate scale.
Error 9.0	Internal fault.	Cycle power. Replace PCB.

CHAPTER 2 TROUBLESHOOTING

Symptom	Possible Cause(s)	Remedy
Error 9.5	Calibration data not present.	Calibrate scale. Replace PCB.
Error 53	EEPROM data incorrect.	Cycle power on and off. If error continues, replace PCB.
CAL E	Calibration Error. Calibration value outside allowable limits.	Repeat calibration using correct calibration weights.
LOW rEF	In Pieces mode, the average piece weight of the parts is small (warning).	You may continue to weigh, but results may not be accurate, because average piece weight is smaller than can be accurately counted.

3.1 PREVENTIVE MAINTENANCE

Ohaus Indicators are precision instruments and should be carefully handled, stored in a clean, dry, dust-free area, and cleaned periodically. Follow these precautionary steps:

- When an Indicator has had chemicals or liquids spilled on it, all exterior surfaces should be cleaned as soon as possible with warm water on a damp cloth.
- Allow at least 10 minutes for the Indicator to stabilize after moving it from an area which is at a different temperature than the area where it is to be operated.

3.1.1 Preventive Maintenance Checklist

The Indicator should be inspected and checked regularly, as follows:

1. Unplug the AC Adapter before cleaning.
2. For the T31P, clean the outside using a cloth dampened with a mild detergent.
3. For the T31XW, use approved cleaning solutions for the stainless-steel Indicator housing and rinse with water.



CAUTION

DO NOT USE CHEMICAL CLEANERS OR SOLVENTS OF ANY TYPE.
SOME CLEANERS ARE ABRASIVE AND MAY AFFECT THE SCALE'S FINISH.

4. Check the Power Cord for broken or damaged insulation.
5. Make a visual inspection for faulty connectors, wiring, and loose hardware.

3.2 REPLACEMENT OF MAJOR COMPONENTS

The decision to replace any component should only be made after thoroughly diagnosing the problem. If, after the replacement of any component, the Indicator is still non functional and no other information on the subject is available in the manual, contact Ohaus Corporation by visiting www.ohaus.com. In the United States call Ohaus Aftermarket toll free, 800-526-0659 between 8:00 a.m. and 4:00 p.m. EST.

3.2.1 Printed Circuit Board (PCB) Replacement

Repairs are not recommended on the PCB. Component parts of the PCB are not stocked by Ohaus. Replacement is recommended rather than repairing.

Replace the PCB for any of the following reasons:

- Display is defective; characters missing or partial display.
 - Indicator fails to calibrate properly.
 - Display is erratic or unstable.
 - Certain functions are not operational.
 - Indicator does not operate at all.
1. Unplug the Indicator from the AC power source.
 2. Remove the four screws from the Bottom Housing.
 3. Carefully separate the Top Housing and Bottom Housing.
 4. On the T31XW:
 - Remove the Keypad connector ribbon cable by pulling it out.
 - If the RS232 Interface is connected, disconnect its wire leads from the PCB's RS232 Terminal Block J7. (See Figure 1-1.)
 5. On the T31P:
 - Disconnect the battery.
 - Pull the horizontal white-tab plug connecting the RS232 Interface to the PCB's Terminal J6. (See Figure 1-1.)
 6. On both models:
 - Pull the white-tab wire plugs connecting the PCB to the unit's power supply.
 - Disconnect the wire leads connecting the scale's load cell to the PCB's Load Cell Terminal Block J5. (See Figure 1-1.)
 7. Remove the four screws from the PCB. (...and, on the T31XW, the grounding cable screwed to the PCB near the Keyboard connector.)



CAUTION

When handling the PCB, grasp it by the edges only!
Do not touch the foil side. Static discharge may damage some components.

8. Lift out the PCB.
9. Carefully re-position the replacement PCB over the screw holes in the Top Cover. Re-insert and tighten the screws.
10. Reconnect the Cable Sets removed in Steps 4 – 6.
11. Perform calibration procedures. (See Section 1.8.)
12. Perform testing procedures. (See Chapter 4.)

3.2.2 Cable Set Replacement

Note: The cables that connect the PCB to the Load Cell connector, the RS232 connector, the AC power outlet, and (in the case of the T31P) the Lead Acid Battery, are all sold as a single set. Replace them singly or together, as follows:

1. Open the Housing.
2. Disconnect the cables from any of the connectors (RS232, Load Cell, AC outlet) for which the cable set is to be replaced. In the case of the T31P's battery, remove the quick-connect tabs that hold the cables in place.
3. Reconnect the wires to the PCB.

3.2.3 Function Label & Membrane Switch Replacement

1. On the T31XW, open the Housing and disconnect the plastic ribbon cable that connects the Membrane Switch to the PCB.
2. Carefully remove the old Function Label or Membrane Switch. It is held in place with a strong adhesive.
3. Clean the Top Cover and remove all traces of adhesive.
4. Remove the protective backing from the back of the new Function Label or Membrane Switch. Carefully position it on the Top Housing, starting at the bottom of the cover. Use a rolling motion to smooth it into position.
5. On the T31XW, connect the plastic ribbon cable that connects the Membrane Switch to the PCB.
6. Close the Housing (if opened previously), re-insert and tighten the four screws previously removed.
7. Perform calibration procedures. (See Section 1.8.)
8. Perform testing procedures. (See Chapter 4.)

3.2.4 Power Supply Replacement (T31XW Only)

9. Unplug the Indicator from the AC power source.
10. Remove the four screws from the Bottom Housing and separate the Top Housing and Bottom Housing.
11. Pull the white tab plug that connects the power cord to the 3-post receptacle on the side of the Power Supply.
12. Remove the screws that secure the Power Supply Cover, and lift it off.
13. Pull the white tab plug that connects the Power Supply to the PCB.
14. Remove the screw holding the grounding wire from the white plug to the Power Supply's base.
15. Lift out the Power Supply.
16. Position the replacement Power Supply with the screw holes aligned.
17. Position the grounding wire over the screw hold on the right side, insert the screw and tighten it.
18. Attach the white tab plug that connects the Power Supply to the PCB.
19. Carefully position the Power Supply Cover, with the wires from the smaller white tab plug coming through the gap in the front.
20. Attach the white tab plug that connects the Power Supply to the AC power cord.
21. Insert and tighten the screws that secure the Power Supply Cover.
22. Re-connect the Top and Bottom Housing, insert and tighten the four screws.
23. Connect the Indicator to AC power and test it.

3.2.5 Battery Replacement (T31P only)

1. Unplug the Indicator from the AC Adapter.
2. Remove the four screws from the Bottom Housing.
3. Carefully separate the Top Housing and Bottom Housing.
4. Remove the quick-connect tabs that hold the Battery Cables in place.
5. Remove the four screws, each with a washer, that secure the Battery to the Bottom Housing.
6. Carefully lift away the bracket that holds the Battery in place.
7. Position the replacement Battery in the place of the old one
8. Reposition the bracket that holds the Battery in place, and insert the four screws, each with a washer, that secure the Battery to the Bottom Housing.
9. Insert the quick-connect tabs as they were before.
10. Reassemble the Top Housing and Bottom Housing, and reconnect the Load Cell Cable to the Load Cell Connector on the Bottom Housing.
11. Perform calibration procedures. (See Section 1.8.)
12. Perform testing procedures. (See Chapter 4.)

4.1 TESTING

Before and after servicing the Indicator, operational and performance tests should be made to determine if it meets specifications. Turn the Indicator ON and allow it to warm up for at least 10 minutes before performing these checks. The masses used for calibration should be ASTM Class 4 or OIML F2 tolerance or better.



NOTE:

Make sure the test area is free from drafts and that the base rests on a level and vibration-free surface.

4.2 Power Test

The purpose of this test is to determine if the electronic circuitry of the Indicator is functioning properly. In some cases, the AC Adapter or line cord supplied with the Indicator may have become defective.

1. For the T31P, first be sure the AC Adapter is functioning properly, then connect it to the Indicator power plug. (For the T31XW, check that the power cord is not damaged.)
2. Plug the AC Adapter or power cord into a suitable power source.
3. With the Indicator connected to an appropriate power supply, press the **ON/ZERO Off** button. The Indicator performs a self-test, indicates the software revision and then goes into weighing mode.
4. If all of the displays appear normal in this test, continue with the next test. If the display did not appear, check the AC adapter output and repeat the test with a good adapter. If the display was erratic, the PC board is defective and requires replacement.

4.3 Performance Tests Using a Scale Base

These tests are performed on the Indicator using a known good scale base and test mass. At this point, the Indicator has been checked for full display, menu setup and calibrated.

If a Load Cell Simulator is being used, proceed to paragraph 4.4.

4.3.1 Overload/Underload Test

This test determines if the Indicator displays the proper indication when an underload or overload condition exists on the scale base.

1. With the Indicator ON and no mass on the scale base, lift up on the scale base platform and observe the display. The display should indicate Error 8.2. Release the platform. The display should return to zero.



Note: Do not exceed Load Cell capacity when testing the Indicator.

2. Place a mass on the scale base platform which slightly exceeds the capacity of the scale base, and observe the Indicator display. The display should indicate Error 8.1. Remove the mass from the scale base. The display should return to zero.

4.4 Performance Tests Using a Load Cell Simulator

A simulator can be used in place of a scale base if available.

- Connect the simulator to Terminal Block J5 (the Load Cell terminal block) on the PCB, so that EX+, EX-, S+ and S- are matched at each end of the cable. (See Figures 1-1 and 1-2, page 1-4.)

Test the Indicator as follows:

1. Set the simulator to zero. Power on the Indicator. Perform a Span Calibration, with zero at the simulator's zero setting, and 100% capacity at the simulator's 2.0 milli-volt setting.
2. Following calibration, check that the Indicator's display reading is stable at each simulator level, up to the maximum set in the calibration. If the readings are stable, the Indicator is functioning properly.

4.5 Calibration Retention Test

This test checks that the Indicator retains calibration after power is removed and then restored.

1. Turn the Indicator OFF and disconnect the AC Adapter or power cord.
2. Wait one minute, then reconnect the AC Adapter or power cord to the Indicator.
3. Check to insure that the Indicator retained calibration settings.

4.6 RS232 Interface Test / Print Test

The RS232 Interface performance can be monitored using an external printer or computer connected to the Indicator.

To set up communication parameters, see Section 1.9.1.

Once the communications parameters match between the Indicator and either a computer or printer, it is possible to test the Indicator's print function.

- Press the **Print/Units** button. Printing to an external printer or computer should occur each time the button is pressed.

This section of the manual contains exploded views for the 3000 Series T31 Indicators. The exploded view drawings are designed to identify the parts which can be serviced on the Indicator in the field.

NOTE:

In all cases where a part is replaced, the balance must be thoroughly checked after the replacement is made. The balance **MUST** meet the parameters of all applicable specifications in this manual.

If further technical information is needed, please contact your local Ohaus distributor, or:

Ohaus Corporation, www.ohaus.com
19A Chapin Road
P.O. Box 2033
Pine Brook, NJ 07058-2033 USA

Tel: 973-377-9000
Fax: 973-593-0359

In the United States call toll free, 800-526-0659 between 8:00 a.m. and 6:00 p.m. EST.

5.1 3000 SERIES T31P INDICATOR: HOUSING & INTERNAL PARTS

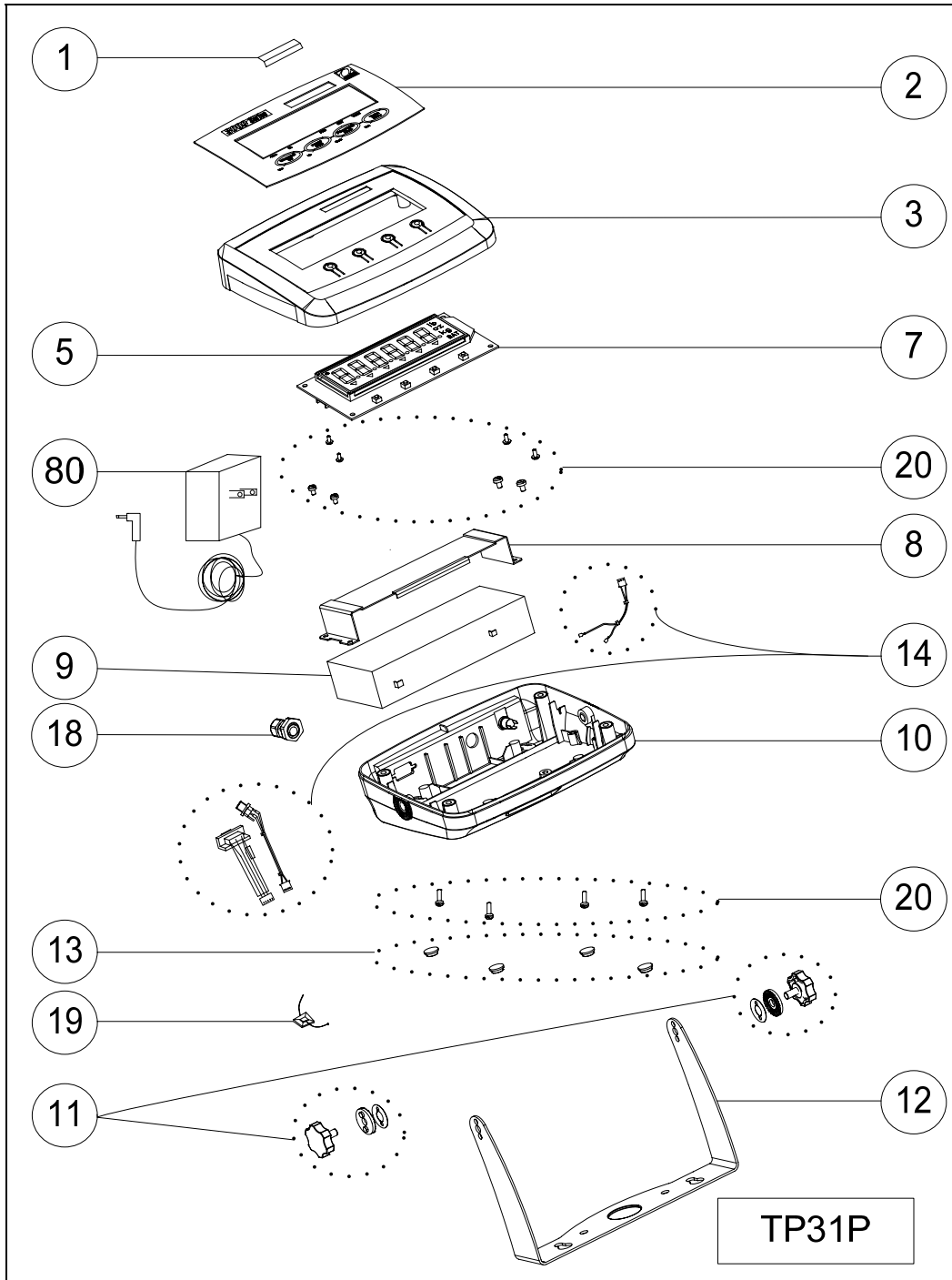


Figure 5-1. Series 3000 T31P Indicator: Housing & Internal Parts.

5.1 3000 SERIES T31P INDICATOR: HOUSING & INTERNAL PARTS

TABLE 5-1. T31P INDICATOR: HOUSING & INTERNAL PARTS

Drawing Item	Description
1	Capacity and Readability Label
2	Function Label
3	Top Housing
5	LCD Display with backlight,
7	Main PCB
8	Battery Bracket Kit
9	Rechargeable Lead Acid Battery
10	Bottom Housing
11	Knobs (Set of 2)
12	Wall Mount Kit
13	Rubber Feet (Set of 4)
14	Cable Kit
18	Cable Fitting
19	Internal Cable Mounts
20	Hardware Kit
80	Adapter

5.2 3000 SERIES T31XW INDICATOR: HOUSING & INTERNAL PARTS

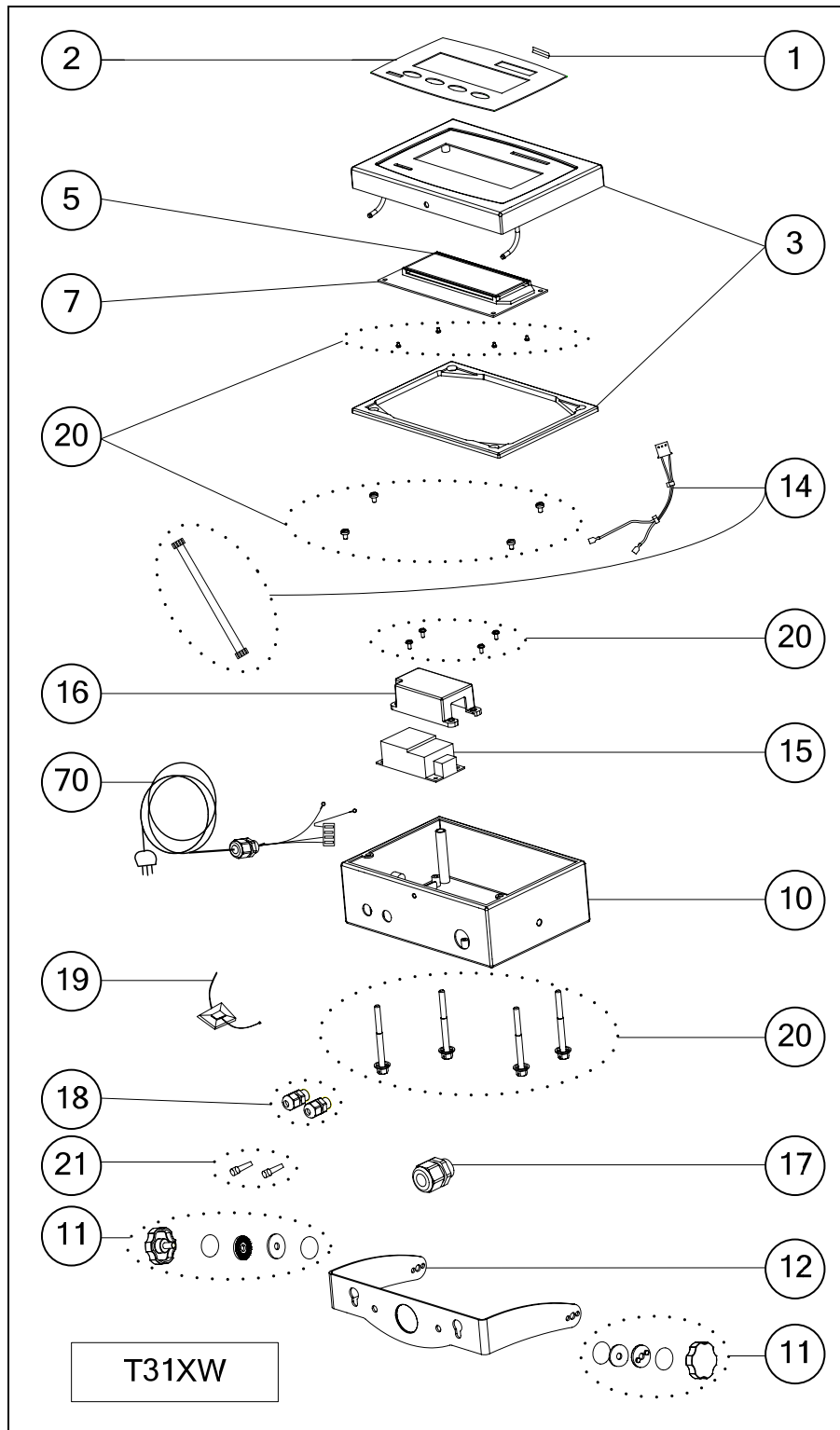


Figure 5-1. Series 3000 T31XW Indicator: Housing & Internal Parts.

5.1 3000 SERIES T31XW INDICATOR: HOUSING & INTERNAL PARTS

TABLE 5-1. T31XW INDICATOR: HOUSING & INTERNAL PARTS

Drawing Item	Description
1	Capacity and Readability Label
2	Membrane Switch
3	Top Housing, with Gasket
5	LCD Display with backlight,
7	Main PCB
10	Bottom Housing
11	Knobs, with seals (Set of 2)
12	Wall Mount Kit
14	Cable Kit
15	Power Supply PCB
16	Power Supply Cover
17	Cable Fitting for AC Power Cord
18	Cable Fittings for RS232 and Load Cell cables
19	Internal Cable Mounts
20	Hardware Kit
21	I/O Filler Plugs for Cable Fittings
70	Line Cord

APPENDIX A SETUP & CALIBRATION VALUES

APPENDIX A. SETUP & CALIBRATION VALUES

TABLE A-1. SETUP & CALIBRATION VALUES

Capacity	Graduation size with LFT OFF	Graduation size with LFT ON	Span calibration points	Linearity calibration points
5	0.0005, 0.001, 0.002, 0.005	0.001, 0.002, 0.005	5	2, 5
10	0.0005, 0.001, 0.002, 0.005, 0.01	0.002, 0.005, 0.01	5, 10	5, 10
15	0.001, 0.002, 0.005, 0.01	0.005, 0.01	5, 10, 15	5, 15
20	0.001, 0.002, 0.005, 0.01, 0.02	0.005, 0.01, 0.02	5, 10, 15, 20	10, 20
25	0.002, 0.005, 0.01, 0.02	0.005, 0.01, 0.02	5, 10, 15, 20, 25	10, 25
30	0.002, 0.005, 0.01, 0.02	0.005, 0.01, 0.02	5, 10, 15, 20, 25, 30	15, 30
40	0.002, 0.005, 0.01, 0.02	0.01, 0.02	5, 10, 15, 20, 25, 30, 40	20, 40
50	0.005, 0.01, 0.02, 0.05	0.01, 0.02, 0.05	5, 10, 15, 20, 25, 30, 40, 50	25, 50
60	0.005, 0.01, 0.02, 0.05	0.01, 0.02, 0.05	5, 10, 15, 20, 25, 30, 40, 50, 60	30, 60
75	0.005, 0.01, 0.02, 0.05	0.02, 0.05	5, 10, 15, 20, 25, 30, 40, 50, 60, 75	30, 75
100	0.005, 0.01, 0.02, 0.05, 0.1	0.02, 0.05, 0.1	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100	50, 100
120	0.01, 0.02, 0.05, 0.1	0.02, 0.05, 0.1	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120	60, 120
150	0.01, 0.02, 0.05, 0.1	0.05, 0.1	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120, 150	75, 150
200	0.01, 0.02, 0.05, 0.1, 0.2	0.05, 0.1, 0.2	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120, 150, 200	100, 200
250	0.05, 0.1, 0.2	0.05, 0.1, 0.2	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120, 150, 200, 250	120, 250
300	0.02, 0.05, 0.1, 0.2	0.05, 0.1, 0.2	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120, 150, 200, 250, 300	150, 300
400	0.02, 0.05, 0.1, 0.2	0.1, 0.2	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120, 150, 200, 250, 300, 400	200, 400
500	0.05, 0.1, 0.2, 0.5	0.1, 0.2, 0.5	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120, 150, 200, 250, 300, 400, 500	250, 500
600	0.05, 0.1, 0.2, 0.5	0.1, 0.2, 0.5	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120, 150, 200, 250, 300, 400, 500, 600	300, 600
750	0.05, 0.1, 0.2, 0.5	0.2, 0.5	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120, 150, 200, 250, 300, 400, 500, 600, 750	300, 750
1000	0.05, 0.1, 0.2, 0.5, 1	0.2, 0.5, 1	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120, 150, 200, 250, 300, 400, 500, 600, 750, 1000	500, 1000
1200	0.1, 0.2, 0.5, 1	0.2, 0.5, 1	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120, 150, 200, 250, 300, 400, 500, 600, 750, 1000, 1200	600, 1200
1500	0.1, 0.2, 0.5, 1	0.5, 1	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120, 150, 200, 250, 300, 400, 500, 600, 750, 1000, 1200, 1500	750, 1500
2000	0.1, 0.2, 0.5, 1, 2	0.5, 1, 2	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120, 150, 200, 250, 300, 400, 500, 600, 750, 1000, 1200, 1500, 2000	1000, 2000

APPENDIX A SETUP & CALIBRATION VALUES

Capacity	Graduation size with LFT OFF	Graduation size with LFT ON	Span calibration points	Linearity calibration points
2500	0.2, 0.5, 1, 2	0.5, 1, 2	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120, 150, 200, 250, 300, 400, 500, 600, 750, 1000, 1200, 1500, 2000, 2500	1200, 2500
3000	0.2, 0.5, 1, 2	0.5, 1, 2	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120, 150, 200, 250, 300, 400, 500, 600, 750, 1000, 1200, 1500, 2000, 2500, 3000	1500, 3000
5000	0.5, 1, 2, 5	1, 2, 5	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120, 150, 200, 250, 300, 400, 500, 600, 750, 1000, 1200, 1500, 2000, 2500, 3000, 5000	2500, 5000
6000	0.5, 1, 2, 5	1, 2, 5	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120, 150, 200, 250, 300, 400, 500, 600, 750, 1000, 1200, 1500, 2000, 2500, 3000, 5000, 6000	2500, 5000
7500	0.5, 1, 2, 5	2, 5	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120, 150, 200, 250, 300, 400, 500, 600, 750, 1000, 1200, 1500, 2000, 2500, 3000, 5000, 6000, 7500	3000, 7500
10000	0.5, 1, 2, 5, 10	2, 5, 10	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120, 150, 200, 250, 300, 400, 500, 600, 750, 1000, 1200, 1500, 2000, 2500, 3000, 5000, 6000, 7500, 10000	5000, 10000
12000	1, 2, 5, 10, 20	2, 5, 10	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120, 150, 200, 250, 300, 400, 500, 600, 750, 1000, 1200, 1500, 2000, 2500, 3000, 5000, 6000, 7500, 10000, 12000	5000, 10000
15000	1, 2, 5, 10	5, 10	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120, 150, 200, 250, 300, 400, 500, 600, 750, 1000, 1200, 1500, 2000, 2500, 3000, 5000, 6000, 7500, 10000, 12000, 15000	7500, 15000
20000	2, 5, 10, 20	5, 10, 20	5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 120, 150, 200, 250, 300, 400, 500, 600, 750, 1000, 1200, 1500, 2000, 2500, 3000, 5000, 6000, 7500, 10000, 20000	10000, 20000

APPENDIX B GEOGRAPHICAL ADJUSTMENT VALUES

APPENDIX B. GEOGRAPHICAL ADJUSTMENT VALUES

TABLE B-1. GEOGRAPHICAL ADJUSTMENT VALUES.

Geographical latitude away from the equator (North or South), in degrees and minutes.	Elevation above sea level in meters										
	0 325	325 650	650 975	975 1300	1300 1625	1625 1950	1950 2275	2275 2600	2600 2925	2925 3250	3250 3575
	Elevation above sea level in feet										
	0 1060	1060 2130	2130 3200	3200 4260	4260 5330	5330 6400	6400 7460	7460 8530	8530 9600	9600 10660	10660 11730
0°00' - 5°46'	5	4	4	3	3	2	2	1	1	0	0
5°46' - 9°52'	5	5	4	4	3	3	2	2	1	1	0
9°52' - 12°44'	6	5	5	4	4	3	3	2	2	1	1
12°44' - 15°06'	6	6	5	5	4	4	3	3	2	2	1
15°06' - 17°10'	7	6	6	5	5	4	4	3	3	2	2
17°10' - 19°02'	7	7	6	6	5	5	4	4	3	3	2
19°02' - 20°45'	8	7	7	6	6	5	5	4	4	3	3
20°45' - 22°22'	8	8	7	7	6	6	5	5	4	4	3
22°22' - 23°54'	9	8	8	7	7	6	6	5	5	4	4
23°54' - 25°21'	9	9	8	8	7	7	6	6	5	5	4
25°21' - 26°45'	10	9	9	8	8	7	7	6	6	5	5
26°45' - 28°06'	10	10	9	9	8	8	7	7	6	6	5
28°06' - 29°25'	11	10	10	9	9	8	8	7	7	6	6
29°25' - 30°41'	11	11	10	10	9	9	8	8	7	7	6
30°41' - 31°56'	12	11	11	10	10	9	9	8	8	7	7
31°56' - 33°09'	12	12	11	11	10	10	9	9	8	8	7
33°09' - 34°21'	13	12	12	11	11	10	10	9	9	8	8
34°21' - 35°31'	13	13	12	12	11	11	10	10	9	9	8
35°31' - 36°41'	14	13	13	12	12	11	11	10	10	9	9
36°41' - 37°50'	14	14	13	13	12	12	11	11	10	10	9
37°50' - 38°58'	15	14	14	13	13	12	12	11	11	10	10
38°58' - 40°05'	15	15	14	14	13	13	12	12	11	11	10
40°05' - 41°12'	16	15	15	14	14	13	13	12	12	11	11
41°12' - 42°19'	16	16	15	15	14	14	13	13	12	12	11
42°19' - 43°26'	17	16	16	15	15	14	14	13	13	12	12
43°26' - 44°32'	17	17	16	16	15	15	14	14	13	13	12
44°32' - 45°38'	18	17	17	16	16	15	15	14	14	13	13
45°38' - 46°45'	18	18	17	17	16	16	15	15	14	14	13
46°45' - 47°51'	19	18	18	17	17	16	16	15	15	14	14
47°51' - 48°58'	19	19	18	18	17	17	16	16	15	15	14
48°58' - 50°06'	20	19	19	18	18	17	17	16	16	15	15
50°06' - 51°13'	20	20	19	19	18	18	17	17	16	16	15
51°13' - 52°22'	21	20	20	19	19	18	18	17	17	16	16
52°22' - 53°31'	21	21	20	20	19	19	18	18	17	17	16
53°31' - 54°41'	22	21	21	20	20	19	19	18	18	17	17
54°41' - 55°52'	22	22	21	21	20	20	19	19	18	18	17

APPENDIX B GEOGRAPHICAL ADJUSTMENT VALUES

TABLE B-1. GEOGRAPHICAL ADJUSTMENT VALUES.

Geographical latitude away from the equator (North or South), in degrees and minutes.	Elevation above sea level in meters										
	0 325	325 650	650 975	975 1300	1300 1625	1625 1950	1950 2275	2275 2600	2600 2925	2925 3250	3250 3575
	Elevation above sea level in feet										
	0 1060	1060 2130	2130 3200	3200 4260	4260 5330	5330 6400	6400 7460	7460 8530	8530 9600	9600 10660	10660 11730
55°52' - 57°04'	23	22	22	21	21	20	20	19	19	18	18
57°04' - 58°17'	23	23	22	22	21	21	20	20	19	19	18
58°17' - 59°32'	24	23	23	22	22	21	21	20	20	19	19
59°32' - 60°49'	24	24	23	23	22	22	21	21	20	20	19
60°49' - 62°09'	25	24	24	23	23	22	22	21	21	20	20
62°09' - 63°30'	25	25	24	24	23	23	22	22	21	21	20
63°30' - 64°55'	26	25	25	24	24	23	23	22	22	21	21
64°55' - 66°24'	26	26	25	25	24	24	23	23	22	22	21
66°24' - 67°57'	27	26	26	25	25	24	24	23	23	22	22
67°57' - 69°35'	27	27	26	26	25	25	24	24	23	23	22
69°35' - 71°21'	28	27	27	26	26	25	25	24	24	23	23
71°21' - 73°16'	28	28	27	27	26	26	25	25	24	24	23
73°16' - 75°24'	29	28	28	27	27	26	26	25	25	24	24
75°24' - 77°52'	29	29	28	28	27	27	26	26	25	25	24
77°52' - 80°56'	30	29	29	28	28	27	27	26	26	25	25
80°56' - 85°45'	30	30	29	29	28	28	27	27	26	26	25
85°45' - 90°00'	31	30	30	29	29	28	28	27	27	26	26



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