A Badger Meter® Brand

Water Quality Monitor

Model Q45D/60 Portable Dissolved Oxygen Measurement System



Badger Meter

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User Manual

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INTRODUCTION

General

The Model Q45D/60 is a highly versatile portable monitoring/recording system designed for the measurement of dissolved oxygen (D.O.) in solution. The full scale operating range of the system is 0…40.0 ppm and the sensing system operates on water streams with temperatures from 0…50° C.

The system operates on two AA batteries and runs continuously for approximately 240 hours.

⚠ WARNING

IF UNIT IS TO BE STORED FOR MORE THAN 6 MONTHS, REMOVE THE BATTERIES FROM THE HOLDER TO AVOID POTENTIAL DAMAGE FROM BATTERY LEAKAGE.

The basic sensing element used in the dissolved oxygen monitor is a galvanic membrane sensor that directly measures dissolved oxygen.

Features

- Standard Q45D electronic transmitters are designed to be a fully isolated, battery powered instrument. The monitor can be quickly converted to either a loop-power transmitter or line-powered analyzer.
- Two 10-bit, isolated, 0…2.5V DC analog outputs may be configured to track pH and temperature, or pH and pH. Both analog outputs can be individually programmed to specific ranges.
- Large high-contrast, custom Super-Twist display provides excellent readability. The secondary line of display uses 5 × 7 dot matrix characters for clear message display. Two of four measured parameters may be on the display simultaneously. An LED back light can be turned on if necessary for use in very low light conditions.
- Sensor diagnostics monitor glass breakage, sensor leaks and RTD condition. Diagnostic messages provide a clear description of any problem with no confusing error codes to look up. Messages are also included for diagnosing calibration problems.
- Quick and easy 2-point and sample calibration methods include auto-buffer recognition from 3 built-in buffer tables. To provide high accuracy, all calibration methods include stability monitors that check temperature and main parameter stability before accepting data.
- Pt1000 temperature input. Temperature element can be user calibrated.
- Security lock feature to prevent unauthorized tampering with transmitter settings. All settings can be viewed while locked, but they cannot be changed.

Q45D/60 Portable System Specifications

Displayed Parameters	Main input: 0.00…19.99 ppm, 20.0…40.0 ppm % Saturation: 0…200% Sensor temperature: 0…50.0° C (32…122° F) Sensor signal: –40…2000 mV DC Output values: 0…2.5V DC, Vout #1/#2 Sensor slope/offset Model number and software version
Display	0.75 in. (19.05 mm) high 4-digit main display with sign 12-digit secondary display, 0.30 in. (7.62 mm) 5 × 7 dot matrix Integral LED back-light
Keypad	4-key membrane type with tactile feedback, polycarbonate with UV coating
Enclosure	NEMA 4X, polycarbonate, stainless steel hardware, weatherproof and corrosion resistant HWD: 4.40 × 4.40 × 3.50 in. (111.76 × 111.76 × 88.90 mm)
Mounting Options	Handheld w/nylon carrying strap
Weight	1 lb (0.45 kg)
Ambient Temperature	Instrument service: –20…60° C (–4…140° F) Sensor Service: –5…55° C (23…131° F) Storage: –30…70° C (–22…158° F)
Ambient Humidity	0…95%, indoor/outdoor use, non-condensing to rated ambient temperature range
Altitude	Up…2000 m (6562 ft)
Electrical Certification	Ordinary location, cCSAus (CSA and UL standards - both approved by CSA), pollution degree 2, installation category 2
EMI/RFI Influence	Designed to EN 61326-1
Output Isolation	600V galvanic isolation
Filter	Adjustable 0…9.9 minutes additional damping to 90% step input
Temperature Input	Pt1000 RTD with automatic compensation
Sensor	2-electrode galvanic membrane sensor for direct measurement of dissolved oxygen
Sensor Materials	Noryl and stainless steel
Sensor Cable	25 ft (7.5 m) cable with 6-pin plug
Max. Sensor-to-Analyzer Distance	100 ft (30.5 m), with junction box
Instrument Power	Two generic AA batteries, low battery indication at 1.60V DC
Outputs	Two 0…2.5V DC isolated outputs are provided on for connection to data recorders, and more
Battery Life	Approximately 240 hours of operational use on a set of batteries (without backlight)

Q45D Performance Specifications

Accuracy	0.2% of span or better
Repeatability	0.05% of span or better
Sensitivity	0.05% of span
Non-Linearity	0.1% of span
Stability	0.05% of span per 24 hours, non-cumulative
Temperature Drift	Span or zero, 0.01% of span/°C
Warm-Up Time	3 seconds to rated performance
Instrument Response Time	6 seconds to 90% of step input, in a given range, at lowest setting

INSTRUMENT HANDLE/MOUNTING

General

The Q45D/60 portable dissolved oxygen system comes complete with a specially designed handle that allows the system to be comfortably carried or quickly strapped to a railing. Although the system is designed to be a portable system, it can be permanently mounted for longer term field use. This is possible due to the very long battery life spans that can be achieved with the system.

Portable Handle

A removable handle is included with each unit that provides not only comfortable transportation of the system, but the integral locking strap allows the system to be quickly mounted to pipes or rails for longer term use in one area.

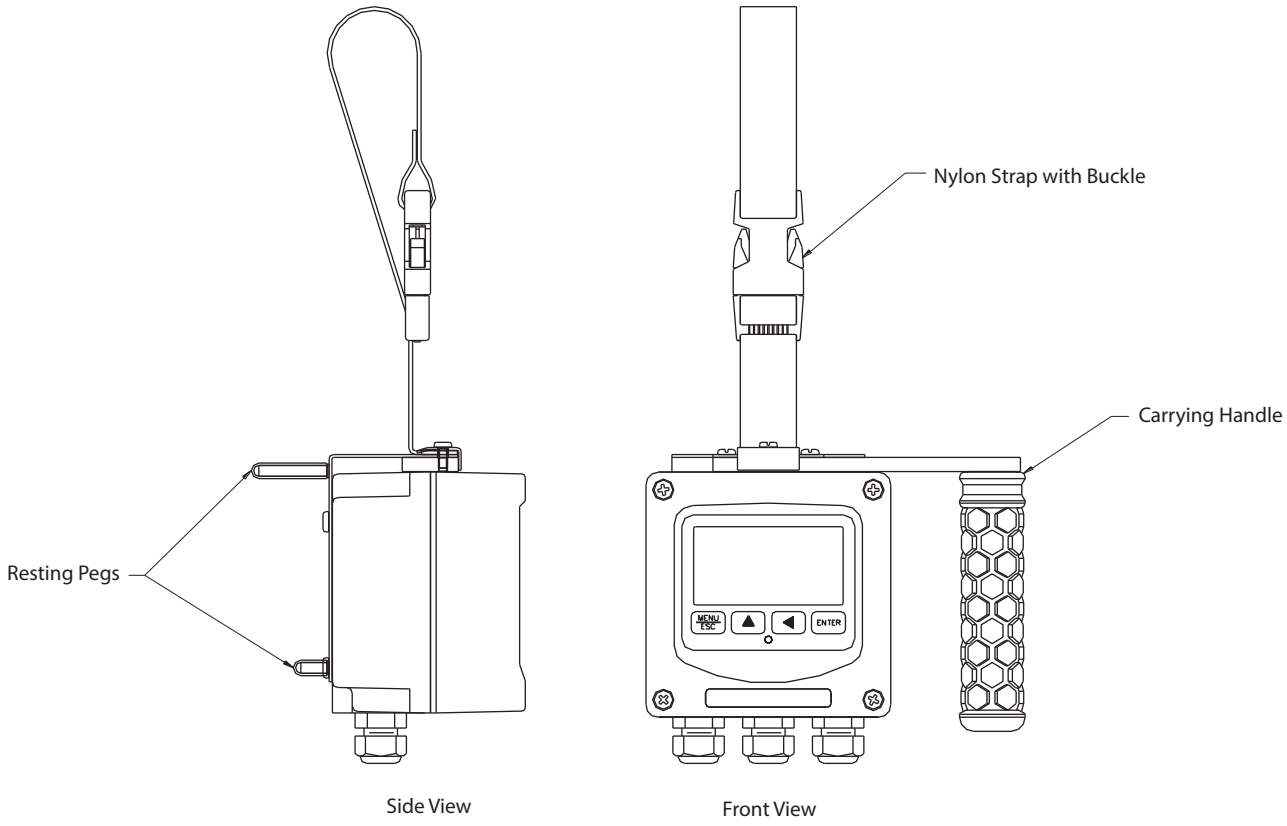


Figure 1: Portable handle views (Badger Meter - 0688)

ELECTRICAL CONNECTION

General

The sensor cable can be quickly connected to the Q45 terminal strip by matching the wire colors on the cable conductors. A junction box is also available to provide a quick-disconnect point for the sensor or a break point for very long sensor cable runs. Route signal cable away from AC power lines, adjustable frequency drives, motors or other noisy electrical signal lines. Do not run sensor or signal cables in conduit that contains AC power lines or motor leads.

Direct Sensor Connection

The sensor cable should be routed into the enclosure through the right-hand cord grip on the bottom of the enclosure. Make sure the cord grips are snugly tightened after electrical connections have been made to prevent moisture incursion. When stripping cables, leave adequate length for connections in the transmitter enclosure as shown in *Figure 2*.

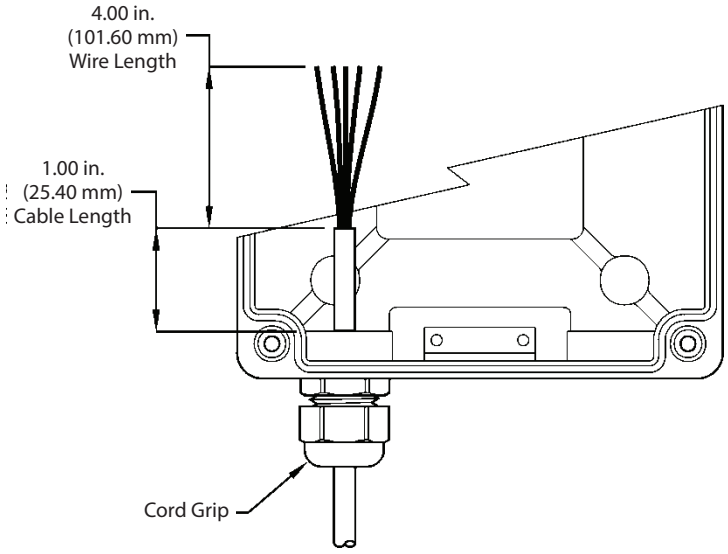


Figure 2: Sensor cable preparation

Sensor Connection

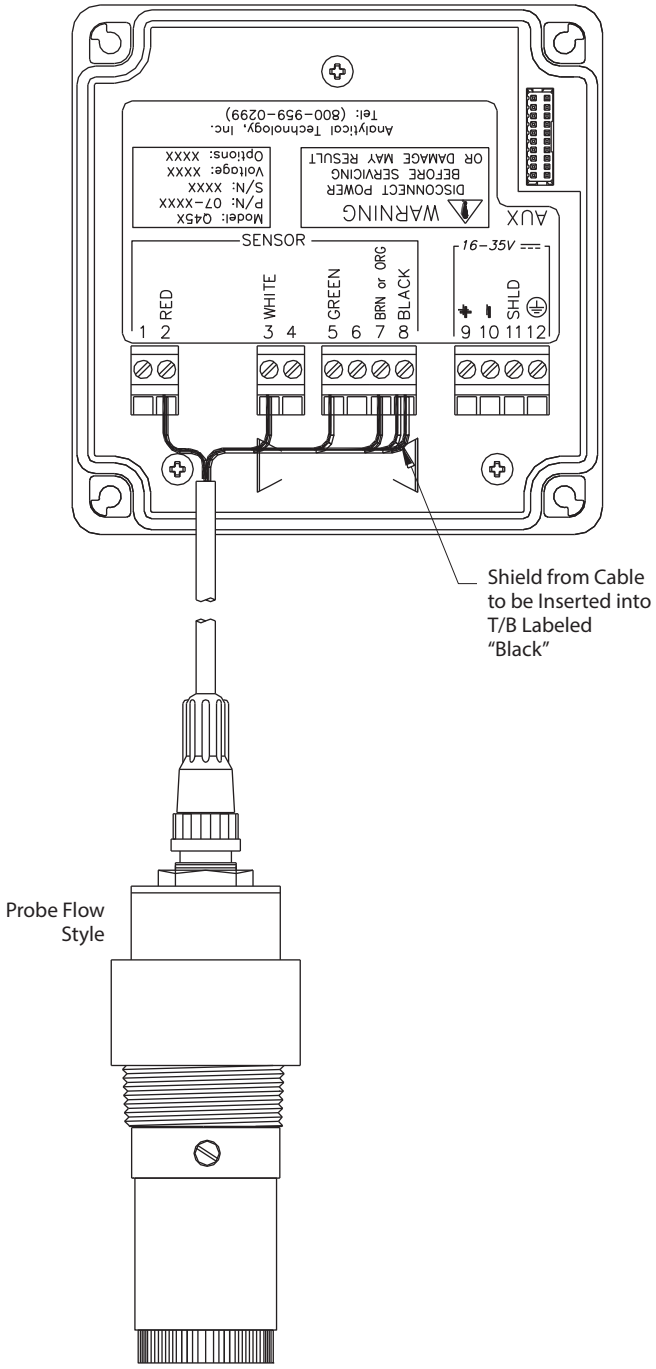


Figure 3: Flow type connections (Badger Meter - 0658)

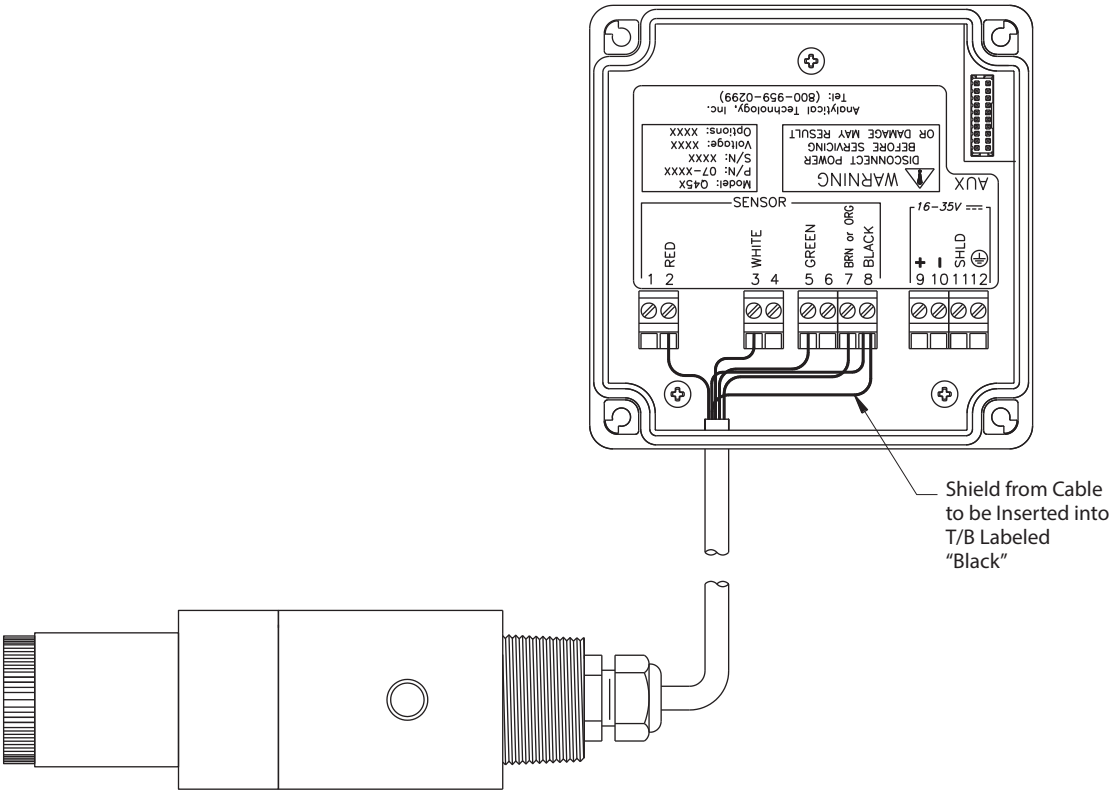


Figure 4: Submersible sensor connection (Badger Meter - 0671)

SENSOR ASSEMBLY

Oxygen Sensor Preparation

The oxygen sensor supplied with the Q45D is shipped dry. It does not operate until it is prepared by adding electrolyte and a membrane. Preparation of the sensor for operation must be done carefully. The procedure should be done by a qualified technician, and it should only be done when the system is ready for operation. Until then, it is best to leave the sensor in the condition in which it is received.

Submersible oxygen sensors are made up of two separate parts: a submersion holder that also contains the temperature compensating element and a sensing module. The sensing module screws into the holder with an O-ring providing a water tight connection. *Figure 5* shows the assembly.

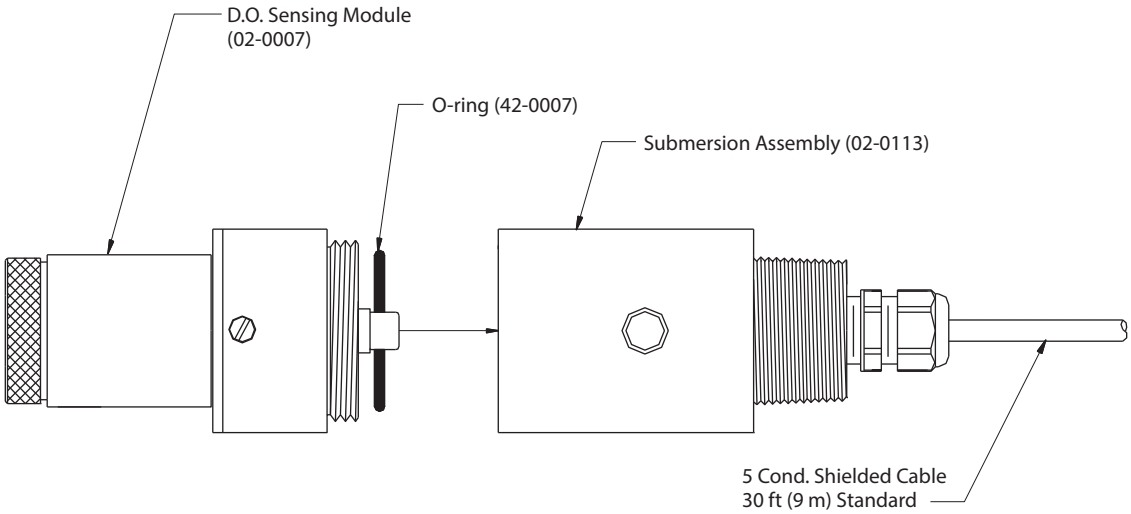


Figure 5: Submersible sensor assembly

Sensing modules contain the main measuring components and are the main component requiring service. *Figure 6* shows an exploded view of the D.O. sensing module.

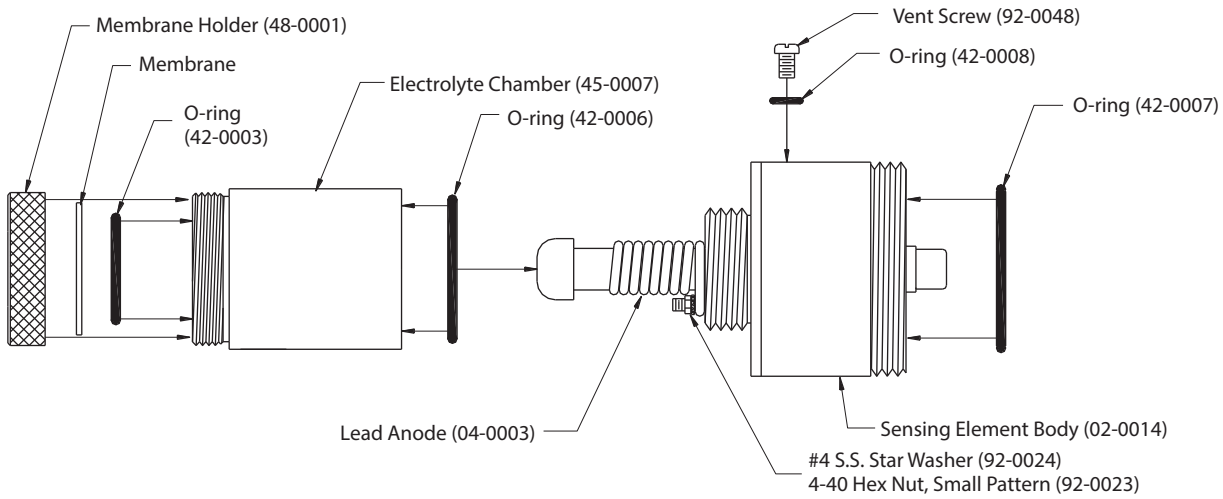


Figure 6: Submersible sensing module assembly

Follow the procedure below to prepare the D.O. sensor module for operation:

1. Unscrew the electrolyte chamber from the assembled sensor and also remove the vent screw from the side of the sensor body.
2. Remove the front nut from the bottom of the chamber and discard the protective membrane. O-rings are contained in grooves on both the bottom and top of the chamber. Be sure that these O-rings remain in place.
3. From the package of membranes (either 2 mil or 5 mil) supplied with the sensor, place a new membrane into the front nut, holding the membrane by its edge to avoid fingerprint oil from contaminating the membrane. The membrane is clear and is separated from other membranes by a light blue paper spacer.
4. Screw the front nut onto the chamber until you feel the O-ring compress. Hand-tight compression is all that is needed. Do not use tools to tighten. The membrane should be flat across the bottom of the chamber without wrinkles.
5. Fill the chamber with electrolyte until the level reaches the bottom of the internal threads.
6. Slowly screw the chamber onto the sensor body. A small amount of electrolyte runs out of the hole from which the vent screw was removed. Place a paper towel around the sensor to absorb the electrolyte overflow. The electrolyte is harmless and does not irritate skin. Tighten the chamber until the O-ring at the top of the chamber is compressed. Once again, do not use tools to tighten.
7. Shake excess electrolyte from the vent hole on the side of the sensor and replace the vent screw.

The sensor is now ready for operation. The membrane should be stretched tightly across the tip of the sensor.

⚠CAUTION

WHEN HANDLING THE ASSEMBLED SENSOR, DO NOT SET THE SENSOR ON ITS TIP OR DAMAGE TO THE MEMBRANE COULD RESULT. SEVERE IMPACTS ON THE TIP OF THE SENSOR FROM DROPPING OR OTHER MISUSE MAY CAUSE PERMANENT DAMAGE TO THE SENSOR.

Flow Type D.O. Sensor

The D.O. sensor designed for use in flow applications is similar in construction to *Figure 6 on page 12*. The method for sensor preparation is basically the same as described in *"Oxygen Sensor Preparation" on page 11*.

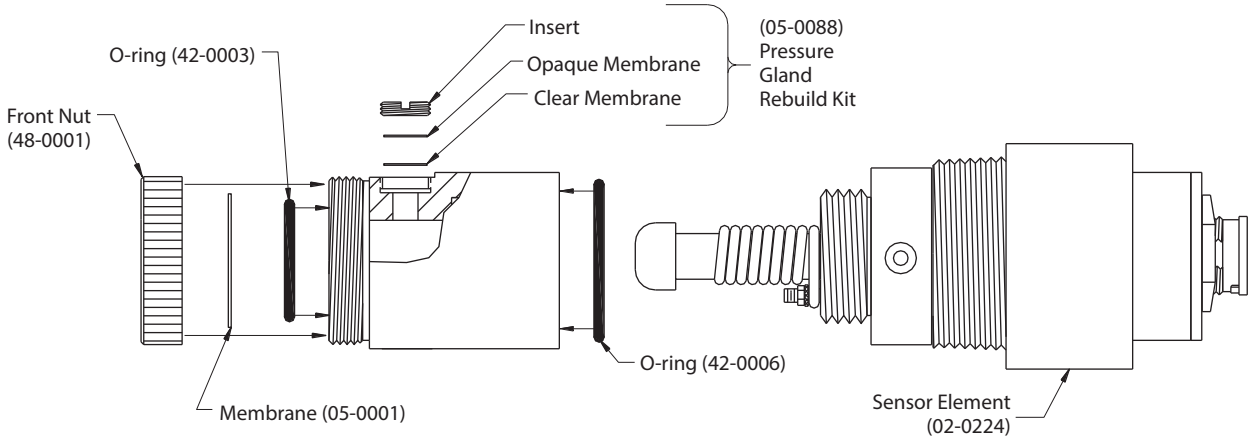


Figure 7: Flow type sensor assembly (Badger Meter - 0860)

OPERATION

General

To turn the system on, simply press and hold the **MENU** key for approximately 5 seconds and the display turns ON. To turn the unit off, press and hold the **ENTER** key until the display shuts off (about 3 seconds).

NOTE: The unit must be in the *MEASURE* menu in order for the 3-second key press to operate.

The instrument turns off automatically after 30 minutes if no keys are pressed – optimizing battery life. This mode of operation is ideal for portable operation where intermediate readings are being taken. Assuming the instrument is used perhaps an hour per day, this would result in a battery lifespan of about 240 hours. For continuous operation with no automatic shutoff, turn the *Auto-OFF* feature to *OFF* in the *DIAG* menu. This mode is intended for use when the instrument outputs are used for transmitting data. In this mode, the instrument runs continuously until the battery reaches the shutdown level (1.6V).

NOTE: Rechargeable AA batteries reduce operational times dramatically, as they typically contain much less energy than standard batteries.

The PWR switch disconnects the AA batteries and is only used to disconnect the battery if the system is not to be used for a long period of time (> 3 months of storage). Otherwise, leave this switch in the *ON* position. The red dip switch is only for factory use.

The "B" flashes on the display next to the main measurement indication when the instrument requires battery replacement. If the battery is not replaced, eventually the unit may not turn on in the normal operating mode. Once the low battery condition is indicated, the instrument only stays powered for 10 minutes.

Battery/Power Circuit Board

Q45D monitors are powered by internal AA alkaline batteries. *Figure 9 on page 16* shows this board assembly with batteries installed.

The battery circuit board contains 3 switch assemblies as shown in *Figure 8*.

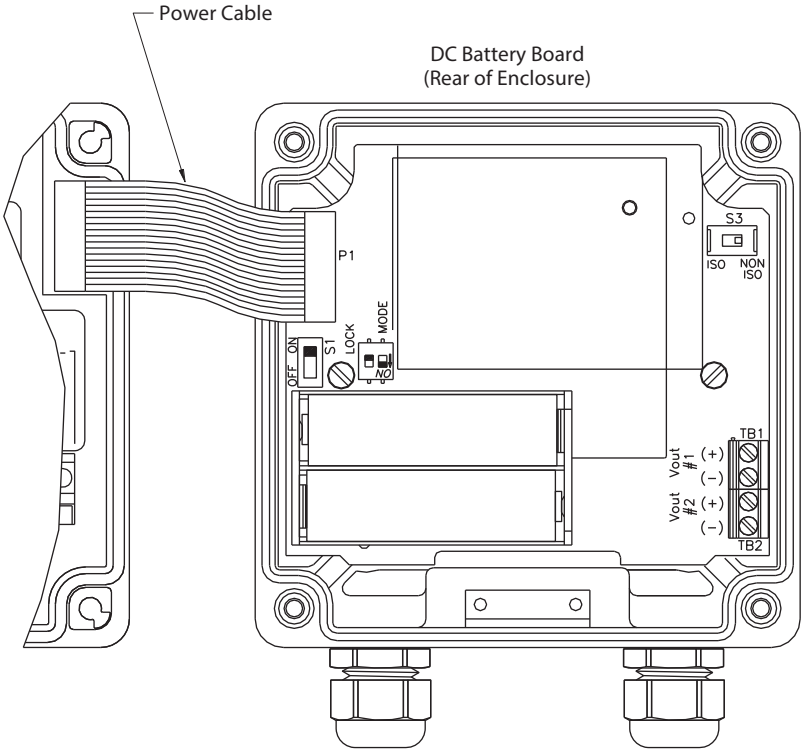


Figure 8: Battery board connections

The first **(S1)** is an On/Off slide switch. This switch must be in the *ON* position for operation. Turn it to *OFF* if you do not intend to operate the monitor in the next week or two.

The second switch assembly **(S2)** contains two switches, the one on the left marked *LOCK* and the one on the right marked *MODE*. The function of these two slide switches are as follows:

LOCK This switch is used to define how the monitor turns on and off. This switch is normally in the *OFF* position. With the lock switch off, the monitor turns on manually using the **MENU** key on the front of the monitor. With the lock switch in the *ON* position, the monitor is always on when there is enough power to run the monitor. The *ON* position is normally used when operating from an external power supply intended for continuous operation.

MODE This switch is used to set the voltage at which the monitor shuts off when powered by internal batteries. Alkaline batteries can normally be run down to about 0.8V. When using alkaline batteries, the mode switch is in the *OFF* position (factory default). If rechargeable NiMH batteries are substituted, place the *MODE* switch in the *ON* position.

NOTE: Rechargeable NiMH batteries have only about 35% of the capacity of alkalines. However, NiMH batteries can be recharged hundreds of times.

The third switch assembly is a single slide switch **(S3)** that defines whether the 0…2.5V DC signals from the monitor are isolated or non-isolated. Output isolation is not required when outputs are connected to the internal data logger. However, if the outputs are connected to external devices through the external connection cable, putting this switch in the *ISO* position protects against possible ground loops. The isolation circuit slightly increases the power requirement for the monitor, resulting in a bit less battery life.

Battery Power Circuit Board

The Q45 portable instrument is primarily operated by software settings; however, there are also a few hardware details on the battery circuit board to note.

The battery board is a circuit board that sits in the rear of the Q45 enclosure and connects to the Q45 AUX port through a ribbon cable. The battery board contains the battery clip for the two AA batteries and the output terminal strip for the two 0…2.5V DC outputs. Along the left side below the ribbon cable is an ON/OFF slide switch. This switch can be used to turn the instrument completely off when not intending to use the unit for an extended period.

Voltage Outputs

There are two sets of analog voltage outputs on the battery board that may be used to send isolated data back to remotely located recorders, PLCs and more. Output #1 is used only for dissolved oxygen information, and Output #2 can be used for an additional dissolved oxygen output channel or it can be selected to output temperature information.

Software Interface

The user interface for the Q45 Series instrument consists of a custom display and a membrane keypad. All functions are accessed from this user interface (no internal jumpers or pots, for example).

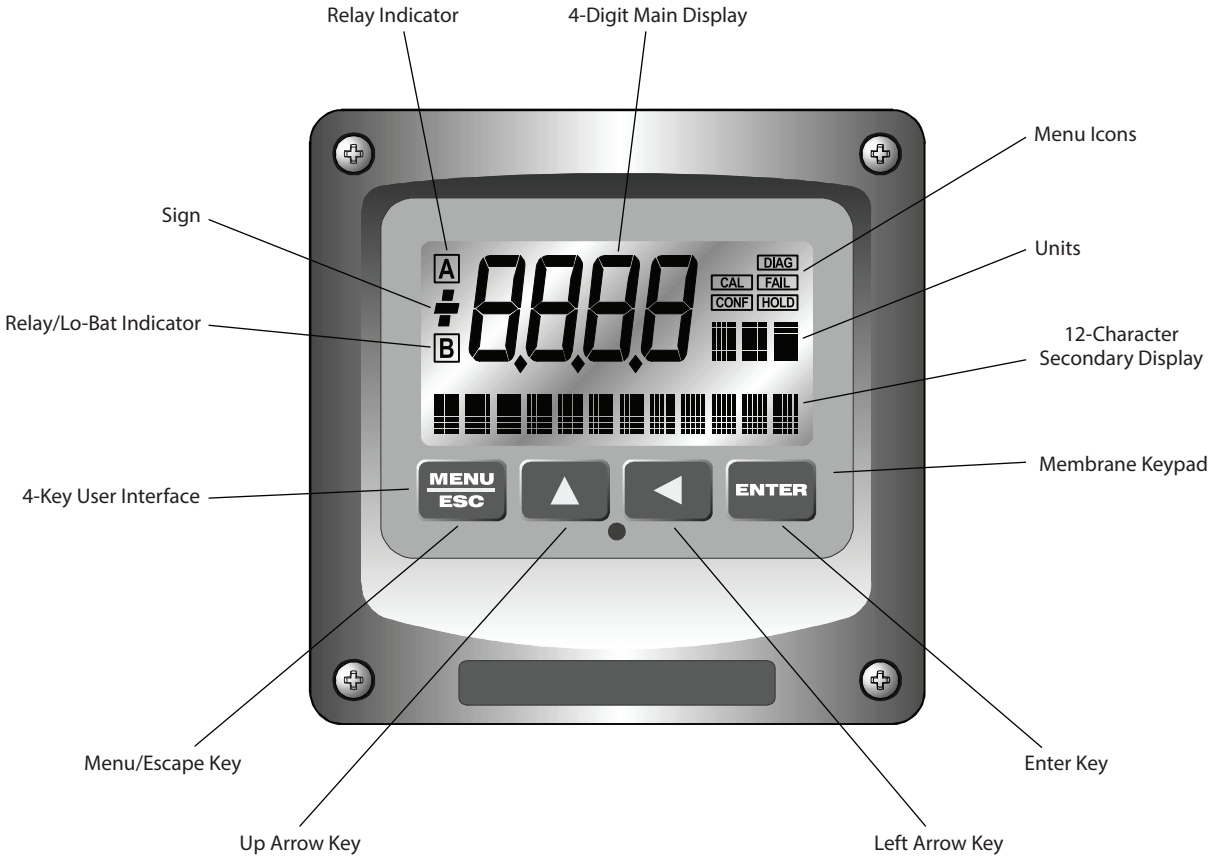


Figure 9: User interface (Badger Meter - 0654)

Keys

All user configurations occur through the use of four membrane keys. These keys are used as follows:

MENU/ESC	To scroll through the menu section headers or to escape from anywhere in software. The escape sequence allows the user to back out of any changes in a logical manner. Using the escape key aborts all changes to the current screen and backs the user out one level in the software tree. The manual refers to this key as either **MENU** or **ESC**, depending upon its particular function. In the battery-powered version of the Q45, this is also the ON button.
UP (arrow)	To scroll through individual list or display items and to change number values.
LEFT (arrow)	To move the cursor from right to left during changes to a number value.
ENTER	To select a menu section or list item for change and to store any change.

Display

The large custom display provides clear information for general measurement use and user configuration. There are three main areas of the display: the main parameter display, the secondary message line and the icon area.

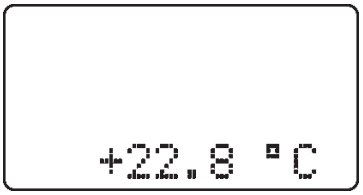
Main Parameter

During normal operation, the main parameter display indicates the present process input with sign and units. This main display may be configured to display any of the main measurements that the system provides. During configuration, this area displays other useful setup information to the user.



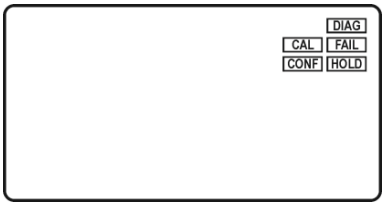
Lower Line

During normal operation, the lower line of the display indicates user-selected secondary measurements that the system is making. This also includes calibration data from the last calibration sequence and the transmitter model number and software version. During configuration, the lower line displays menu items and set-up prompts to the user. Finally, the lower line displays error messages when necessary. For a description of all display messages, see *"Display Messages" on page 29*.



Icon Area

The icon area contains display icons that assist the user in setup and indicate important states of system functions. The *CAL*, *CONFIG*, *CONTROL* and *DIAG* icons are used to tell the user what branch of the software tree the user is in while scrolling through the menu items. This improves software map navigation dramatically. Upon entry into a menu, the title is displayed (such as *CAL*), and then the title disappears to make way for the actual menu item. However, the icon stays on.



HOLD

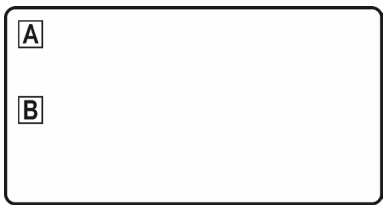
The *HOLD* icon indicates that the current output of the transmitter has been put into output hold. In this case, the output is locked to the last input value measured when the *HOLD* function was entered. *HOLD* values are retained even if the unit power is cycled.

FAIL

The *FAIL* icon indicates that the system diagnostic function has detected a problem that requires immediate attention. This icon is automatically cleared once the problem has been resolved.

Icon B

The left screen area contains one "B" icon that indicates the battery power is low.



Software

The software of the Q45D is organized in an easy to follow menu-based system. All user settings are organized under five menu sections: *Measure, Calibration [CAL], Configuration [CONFIG], Control [CONTROL]* and *Diagnostics [DIAG]*.

NOTE: The default *Measure* menu is display-only and has no menu icon.

Software Navigation

Within the *CAL, CONFIG, CONTROL* and *DIAG* menu sections is a list of selectable items. Once a menu section (such as *CONFIG*) has been selected with the **MENU** key, the user can access the item list in this section by pressing either the **ENTER** key or the **UP** arrow key. The list items can then be scrolled through using the **UP** arrow key. Once the last item is reached, the list wraps around and the first list item is shown again. The items in the menu sections are organized such that more frequently used functions are first, while more permanent function settings are later in the list. See *Figure 10 on page 19* for a visual description of the software.

Each list item allows a change to a stored system variable. List items are designed in one of two forms: simple single variable or multiple variable sequence. In the single variable format, the user can quickly modify one parameter. For example, changing temperature display units from °F to °C. In the multiple variable sequence, variables are changed as the result of some process. For example, the calibration of dissolved oxygen generally requires more than one piece of information to be entered. The majority of the menu items in the software consist of the single variable format type.

Any data that may be changed flashes. This flashing indicates *User Entry* mode and is initiated by pressing the **ENTER** key. The **UP** arrow key increases a flashing digit from 0…9. The **LEFT** arrow key moves the flashing digit from right to left. Once the change has been completed, pressing **ENTER** again stores the variable and stops the flashing. Pressing **ESC** aborts the change and also exits *User Entry* mode.

The starting (default) screen is always the *Measure* menu. The **UP** arrow key is used to select the desired display. From anywhere in this section the user can press the **MENU** key to select one of the four menu sections.

The *UP* arrow icon next to all list items on the display is a reminder to scroll through the list using the **UP** arrow key.

To select a list item for modification, first select the proper menu with the **MENU** key. Scroll to the list item with the **UP** arrow key and then press the **ENTER** key. This tells the system that the user wishes to perform a change on that item. For single item type screens, once the user presses the **ENTER** key, part or all of the variable begins to flash, indicating that the user may modify that variable using the arrow keys. However, if the instrument is locked, the transmitter displays the message "Locked!" and does not enter *User Entry* mode. The instrument must be unlocked by entering the proper code value to allow authorized changes to user entered values. Once the variable has been reset, pressing the **ENTER** key again causes the change to be stored and the flashing to stop. The message "Accepted!" displays if the change is within pre-defined variable limits. If the user decides not to modify the value after it has already been partially changed, pressing the **ESC** key aborts the modification and returns the entry to its original stored value.

In a menu item that is a multiple variable sequence type, once the **ENTER** key is pressed there may be several prompts and sequences that are run to complete the modification. The **ESC** key can always be used to abort the sequence without changing any stored variables.

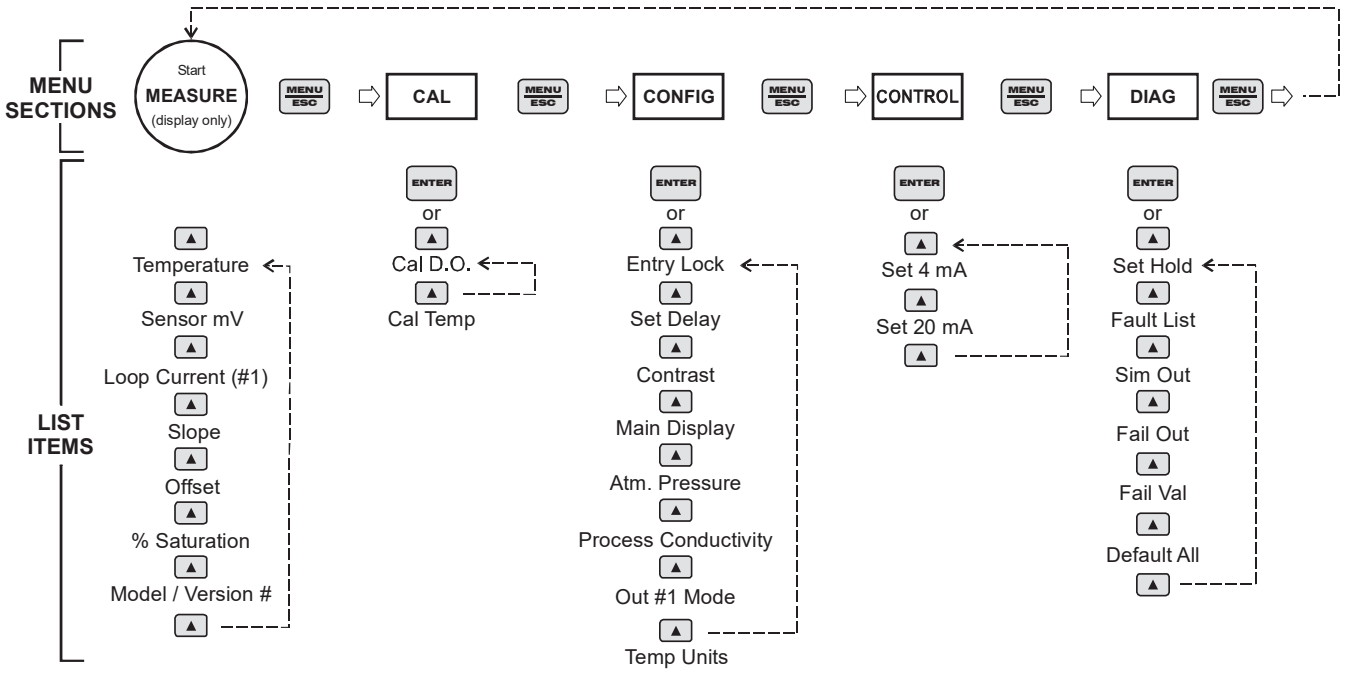


Figure 10: Software map

Measure Menu [MEASURE]

The default menu for the system is the display-only menu *MEASURE*. This menu is a display-only measurement menu and has no changeable list items. When left alone, the instrument automatically returns to this menu after approximately 30 minutes. While in the default menu, the UP arrow key allows the user to scroll through the secondary variables on the lower line of the display. A brief description of the fields in the basic transmitter version is as follows:

Transmitter Measure Screens

25.7° C Temperature display. Can be displayed in °C or °F, depending on user selection. A small "m" on the left side of the screen indicates the transmitter has automatically jumped to a manual 25° C setting due to a failure with the temperature signal input.

+350 mV Raw sensor output. Useful for diagnosing problems.

#1 1.05V DC Instrument output signal #1.

#2 0.66V DC Instrument output signal #2.

Slope = 100% Sensor output response vs. ideal calibration. This value updates after each calibration. As the sensor ages, the slope reading decays indicating sensor aging. Useful for resolving sensor problems.

Offset = 0 mV Sensor output signal at a zero ppm input. This value updates after a zero calibration has been performed. Useful for resolving sensor problems.

85.4 %sa Saturated dissolved oxygen value.

Q45D/50 v2.10 Transmitter software version number.

NOTE: A display test (all segments ON) can be actuated by pressing and holding the **ENTER** key while viewing the model/version number on the lower line of the display.

Calibration Menu [CAL]

The *Calibration* menu contains items for frequent calibration of user parameters. There are two items in this list: *Cal D.O.* and *Cal Temp*.

Cal D.O. The dissolved oxygen calibration function allows the user to adjust the transmitter zero/span reading to match a reference solution or to set the sensor zero point. See *"Calibration" on page 24* for more details.

Cal Temp The temperature calibration function allows the user to adjust the offset of the temperature response by a small factor of ±5° C. The temperature input is factory calibrated to very high accuracy; however, long cable lengths and junction boxes may degrade the accuracy of the temperature measurement in some extreme situations. Hence, this feature is provided as an adjustment. See *"Calibration" on page 24* for more details.

Configuration Menu [CONFIG]

The *Configuration* menu contains all of the general user settings:

Entry Lock This function allows the user to lock out unauthorized tampering with instrument settings. All settings may be viewed while the instrument is locked, but they cannot be modified. The *Entry Lock* feature is a toggle-type setting; that is, entering the correct code locks the transmitter and entering the correct code again unlocks it. The code is preset at a fixed value of 1454.

Press **ENTER** to initiate *User Entry* mode and the first digit flashes. Use the arrow keys to modify value. Press **ENTER** to toggle lock setting once code is correct. Incorrect codes do not change state of lock condition.

Set Delay The delay function sets the amount of damping on the instrument. This function allows the user to apply a first order time delay function to the dissolved oxygen measurements being made. Both the display and the output value are affected by the degree of damping. Functions such as calibration are not affected by this parameter. The calibration routines contain their own filtering and stability monitoring functions to minimize the calibration timing.

Press **ENTER** to initiate *User Entry* mode, and the value flashes. Use the arrow keys to modify value; range is 0.1…9.9 minutes. Press **ENTER** to store the new value.

Contrast This function sets the contrast level for the display. The custom display is designed with a wide temperature range, Super-Twist Nematic (STN) fluid.

The STN display provides the highest possible contrast and widest viewing angle under all conditions. Contrast control of this type of display is generally not necessary, so contrast control is provided as a means for possible adjustment due to aging at extreme ranges. In addition, the display has an automatic temperature compensation network.

Press **ENTER** to initiate *User Entry* mode, and the value flashes. Use the arrow keys to modify the value; range is 0…8 (0 being lightest). Press **ENTER** to update and store the new value.

Instr Type This function allows the user to change the type of measurement to be displayed in the primary display area. The user may select *1 ppm*, *2 mg/L* or *3 %Sat*. There is not a great deal of difference between type 1 and 2 settings as ppm and mg/L measurement units are pretty close to the same. However, programming for type 3 percent saturation changes the measured parameter to read a dissolved oxygen value that represents the percent of oxygen saturation at a given temperature. When this unit of measurement is selected, the main analog output and all alarm and control functions relates to this measurement. While a ppm measurement is displayed on the lower line, it is no longer the primary variable being measured by the system.

Press **ENTER** to initiate *User Entry* mode, and the selected value flashes. Use the **UP** arrow key to modify the desired display value. Press **ENTER** to store the new value.

Zero Filter The Q45D allows the user to program a value near zero below which the monitor reads zero. Because sensors rarely have a perfect zero stability, this zero filter eliminates occasional displays of numbers that are not meaningful. For instance, setting a zero filter at 0.03 PPM D.O. causes any measured values of 0.01 or 0.02 ppm to be displayed as 0.00 PPM.

AtmPres The Q45D instrument uses the atmospheric pressure value as an input for the calculation of a theoretical ppm value during a saturation calibration. The input default units are inHg (inches Mercury) since these units are easy to obtain from most local weather services. This value is only required to be entered during initial installation – it does not need to be modified at every calibration.

Press **ENTER** to initiate *User Entry* mode and the entire value flashes. Use the arrow keys to modify the value; range is 20.00…31.50 inHg.

A reference table is provided in *"Barometric Pressure Conversion" on page 31* to convert to inHg from several other common air pressure units. Press **ENTER** to store the new value.

Proc Cond The Q45D instrument also uses the process conductivity value as an input for the calculation of a theoretical ppm value during a saturation calibration. This value is only required to be entered during initial installation – it does not need to be modified at every calibration.

Press **ENTER** to initiate *User Entry* mode and the value flashes. Use the arrow keys to modify the value; range is 0.00…76.00 mS/cm. Press **ENTER** to store the new value.

NOTE: The solution conductivity does not change dramatically during the calibration process, leave a default setting of 00.50 mS/cm.

Out#2 Mode This function sets analog Output #2 to either track temperature (default) or dissolved oxygen.

Press **ENTER** to initiate *User Entry* mode, and the entire value flashes. Use the **UP** arrow key to modify the desired value; selections include *1* (°C/°F for temperature tracking) or *2* (ppm for dissolved oxygen tracking). Press **ENTER** to store the new value.

Temp Units This function sets the display units for temperature measurement.

Press **ENTER** to initiate *User Entry* mode, and the entire value flashes. Use the **UP** arrow key to modify the desired display value. The choices are *°F* and *°C*. Press **ENTER** to store the new value.

Control Menu

The *Control* menu contains all of the output control user settings.

Set 0V #1
Set 2.5V #1
Set 0V #2
Set 2.5V #2

These functions set the output range for each of the two instrument outputs. The value stored for the 0V point may be higher or lower than the value stored for the 2.5V point.

The entry values are limited to values within 40.00 ppm and must be separated by at least 1% of this range. Use the **LEFT** arrow key to select the first digit to be modified. Then use the **UP** and **LEFT** arrow keys to select the desired numerical value. Press **ENTER** to store the new value.

Output #1 is always in units of ppm, as it is fixed to track dissolved oxygen. Output #2 is in either units of ppm or °C/°F, depending on whether dissolved oxygen or temperature is set for Out#2 in the *CONFIG* menu.

NOTE: If the temperature units are changed between °C and °F (see *"Temp Units"*), the default settings for this output is stored (present data is not converted).

Diagnostics Menu [DIAG]

The *Diagnostics* menu contains all of the user settings that are specific to the system diagnostic functions, as well as functions that aid in troubleshooting application problems.

Set Hold

The *Set Hold* function locks the voltage output values on the present process value. This function can be used prior to calibration or when removing the sensor from the process to hold the output in a known state. Once *HOLD* is released, the outputs return to their normal state of following the process input. The transfer out of *HOLD* is bumpless on both analog outputs - that is, the transfer occurs in a smooth manner rather than as an abrupt change. An icon on the display indicates the *HOLD* state, and the *HOLD* state is retained even if power is cycled.

Press **ENTER** to initiate *User Entry* mode, and the entire value flashes. Use the **UP** arrow key to modify the desired value, selections are **ON** for engaging the *HOLD* function and **OFF** to disengage the function. Press **ENTER** to store the new value.

Fault List

The *Fault List* screen is a read-only screen that allows the user to display the cause of the highest priority failure. The screen indicates the number of faults present in the system and a message detailing the highest priority fault present.

NOTE: Some faults can result in multiple displayed failures due to the high number of internal tests occurring. As faults are corrected, they are immediately cleared.

Faults are not stored; therefore, they are immediately removed if power is cycled. If the problem causing the faults still exists, however, faults display again after power is re-applied and a period of time elapses during which the diagnostic system re-detects them. The exception to this rule is the calibration failure. When a calibration fails, no corrupt data is stored. Therefore, the system continues to function normally on the data that was present before the calibration was attempted.

After 30 minutes or if power to the transmitter is cycled, the failure for calibration clears until calibration is attempted again. If the problem still exists, the calibration failure reoccurs.

Press **ENTER** to initiate view of the highest priority failure. The display automatically returns to normal after a few seconds.

Sim Out

The *Sim Out* function allows the user to simulate the dissolved oxygen level of the instrument to check the output settings. The user enters a ppm value directly onto the screen, and the output responds as if it were actually receiving the signal from the sensor. This allows the user to check the function of attached monitoring equipment during setup or troubleshooting. Escaping this screen returns the unit to normal operation.

Press **ENTER** to initiate the *User Entry* mode, and the rightmost digit of the value flashes. Use the arrow keys to modify desired value. The starting display value is the last read value of the input. The output is under control of the *SIM* screen until the **ESC** key is pressed.

NOTE: If the *HOLD* function is engaged before the *Sim Output* function is engaged, the simulated output remains the same even when the **ESC** key is pressed. Disengage the *HOLD* function to return to normal output.

Auto-Off

Enables the automatic shut-off feature for the instrument. If **ON**, the instrument automatically shuts off in 30 minutes after no keys are pressed to save power. If **OFF**, the meter stays powered continuously until either the internal power switch on the battery board is turned **OFF** or the battery voltage drops to the cut-off point (approximately 8…10 days on a standard AA alkaline batteries).

Press **ENTER** to initiate *User Entry* mode, and the entire value flashes. Use the **UP** arrow key to modify the desired display value. The choices are *OFF* and *ON*. Press **ENTER** to store the new value

Set Default

The *Set Default* function allows the user to return the instrument back to factory default data for all user settings or for just the calibration default. It is intended to be used as a last resort troubleshooting procedure. All user settings or the calibration settings are returned to the original factory values. Hidden factory calibration data remains unchanged.

Press **ENTER** to initiate *User Entry* mode and select either *CAL* or *ALL* with the **UP** arrow key. The default *CAL* routine resets the zero offset to 0.0 nA and reset the slope to 100%. The default *ALL* routine resets all program variables to factory default and should be used with care since it changes any user settings that were programmed in the field.

CALIBRATION

Dissolved Oxygen Calibration

The instrument must be calibrated periodically to maintain a high degree of measurement accuracy. A complete calibration includes zeroing and spanning the sensor. It is generally unnecessary to set the zero at every calibration; however, it should be done during the initial installation.

The output of the dissolved oxygen sensor degrades over the cartridge lifetime as the electrolyte and electrodes are slowly consumed. Under normal conditions (3…5 ppm) the degradation occurs at a very slow rate. To account for this degradation, the Q45D system should be re-calibrated at regular intervals. In addition, the frequency of calibration must be determined by the application. High temperature applications or applications involving other extreme operating conditions may require more frequent calibration than those operating at more ambient levels. It is important for the user to establish a periodic cleaning and calibration schedule for sensor maintenance. Before calibrating with a new sensor for the first time, or whenever a sensor has been left unpowered for 10 days or more, first connect the sensor to the transmitter and allow the system to operate for at least 10 hours to properly polarize the cartridge electrodes. Failure to perform this conditioning can result in significantly higher than normal initial readings. Once the cartridge has been properly conditioned, the user must select the proper operating parameters, including atmospheric pressure and solution conductivity.

The system provides three methods of D.O. calibration: 1-point (sample), saturation (air cal) and zero. These three methods are significantly different.

Dissolved Oxygen Span Cal (1-spl)

The 1-Point (sample or comparison) method is intended to be primarily used as an online calibration; however, the sensor can be removed, cleaned and then calibrated in a bucket of clean water if necessary. During calibration, the system displays the current ppm reading and the user can manually enter a reference value from a lab sample or comparative reference instrument. In the Q45D system, the 1-point calibration adjusts the slope of the sensor output response.

1. Determine whether the calibration is done online or with the sensor removed and placed into a bucket of clean water. If the sensor is removed from the application, rinse and clean if necessary.
2. If the sensor has been removed and placed into a bucket of water, allow sensor to temperature equilibrate with the solution as much as possible. With the sensor coming from an application which differs greatly in temperature, the user may have to wait as much as 20 minutes. If the sensor is online, the user may want to set the output **HOLD** feature prior to calibration to lock out any output fluctuations.
3. Scroll to the *CAL* menu section using the **MENU** key and press **ENTER** or the **UP** arrow key. "Cal D.O." displays.
4. Press the **ENTER** key. The screen displays a flashing "1-spl" for 1-point, a "2-sat" for saturation calibration or a "3-zer" for zero calibration. Using the **UP** arrow key, set for a "1-spl" calibration and press **ENTER**.
5. The system now begins acquiring data for the calibration value. As data is gathered, the units for ppm and temperature may flash. Flashing units indicate that this parameter is unstable. The calibration data point acquisition stops only when the data remains stable for a pre-determined amount of time. This can be overridden by pressing **ENTER**. If the data remains unstable for 10 minutes, the calibration fails and the message "Cal Unstable" displays.
6. The screen displays the last measured ppm value and a message displays prompting the user for the lab value. The user must then modify the screen value with the arrow keys and press **ENTER**. The system then performs the proper checks.
7. If accepted, the screen displays the message "PASS" with the new slope reading, then it returns to the main measurement display. If the calibration fails, a message indicating the cause of the failure is displayed and the "FAIL" icon turns on.

Dissolved Oxygen Span Cal (sat)

This is the recommended method; however, it requires that the sensor be removed from the process and cleaned. Once cleaned, the sensor is placed in air known to be at 100% relative humidity. To accomplish this easily, Badger Meter recommends the use of a calibration bag to provide a stable high humidity environment. As the sensor temperature equilibrates in the air cal bag, the transmitter automatically calculates the new 100% saturation point using the temperature readings and the barometric pressure user data. This method therefore requires no user input during calibration.

NOTE: It is very important to allow enough time for the sensor to completely temperature equilibrate with the surrounding air. This time is at least 10 minutes.

This method requires that the sensor be removed from the process, cleaned and covered with a calibration bag. The sensor must also be wet for this procedure.

Though this method requires no user input during calibration, if this is the first time the system is being installed and calibrated, make sure to enter the proper atmospheric pressure data and process conductivity data prior to calibration.

1. Remove the sensor from the application. Rinse and clean if necessary.
2. Cover the sensor cartridge using one of the Badger Meter air calibration bags. The end of the sensor should be wet, and the membrane should not touch the sides of the bag. If there is water in the bag, the membrane must not be submerged, it must be in the air. Secure bag firmly around the sensor with a rubber band and let the sensor hang, membrane downward, while powered.
3. Allow the system to operate undisturbed for at least 20 minutes. If the system is stable, the value on the display increases to some ppm value and remains at that level. At that point, calibration can continue.
4. Scroll to the *CAL* menu section using the **MENU** key and press **ENTER** or the **UP** arrow key. "Cal D.O." displays.
5. Press the **ENTER** key. The screen displays a flashing "1-spl" for 1-point, a "2-sat" for saturation calibration or a "3-zer" for zero calibration. Using the **UP** arrow key, set for a "2-sat" span calibration and press **ENTER**.
6. The display prompts the user to hold the sensor in air and press **ENTER**. If the sensor has already been removed, reached temperature equilibrium and the calibration bag has been installed, press the **ENTER** key.
7. The system now begins acquiring data for the calibration value. As data is gathered, the units for ppm and temperature may flash. Flashing units indicate that this parameter is unstable.
8. The calibration data point acquisition stops only when the data remains stable for a pre-determined amount of time (approximately 15…20 seconds). This can be overridden by pressing **ENTER**. If the data remains unstable for 10 minutes, the calibration fails and the message "Cal Unstable" displays.
9. If accepted, the screen displays the message "PASS" with the new sensor slope reading, then it returns to the main measurement display. If the calibration fails, a message indicating the cause of the failure displays and the "FAIL" icon turns on.

The range of acceptable values for sensor slope is 20…250%. It may be necessary to rebuild the sensor as described in *"Sensor Assembly" on page 11*. Should the slope value remain out of range and result in calibration failures, review the *"Service" on page 28*, then contact the Service Department at Badger Meter for further assistance.

Dissolved Oxygen Zero Cal

Dissolved oxygen sensors have extremely low offset outputs at zero. For this reason, it is normally sufficient to simply leave the zero at the factory default of 0 mV. As an alternative, an electronic zero can be set by disconnecting the sensor from the cable and performing the steps below.

These steps below assume that the sensor has been prepared in accordance with *"Sensor Assembly" on page 11*.

NOTE: The 10 hour waiting time in step 2 below is not required if the monitor has been running for 24 hours prior to zeroing. If the unit has been running with the sensor connected, the sensor normally returns to a stable zero within 15 minutes.

1. Remove the sensor from the application if necessary. Clean and rinse if required.
2. Place about an inch of zero solution in a small beaker or other convenient container and immerse the tip of the sensor. Allow the sensor to sit undisturbed for at least 1 hour. Suspend sensor—DO NOT LET SENSOR SIT ON TIP.
3. Scroll to the *CAL* menu section using the **MENU** key and press **ENTER** or the **UP** arrow key. "Cal D.O." displays.
4. Press the **ENTER** key. The screen displays a flashing "1-spl" for 1-point, a "2-sat" for saturation calibration or a "3-zer" for zero calibration. Using the **UP** arrow key, set for a "3-zer" zero calibration and press **ENTER**.
5. The system now begins acquiring data for the sensor zero calibration value. As data is gathered, the units for sensor millivolts (mV) and temperature may flash. Flashing units indicate that this parameter is unstable. The calibration data point acquisition stops only when the data remains stable for a pre-determined amount of time. This can be overridden by pressing **ENTER**. If the data remains unstable for 10 minutes, the calibration fails and the message "Cal Unstable" displays.
6. If accepted, the screen displays the message "PASS" with the new sensor zero reading (offset), then it returns to the main measurement display. If the calibration fails, a message indicating the cause of the failure displays and the "FAIL" icon turns on. The range of acceptable value for sensor offset is –40…40 mV. Should a *FAIL* occur, carefully inspect the sensor for a tear in the membrane. It is probably necessary to rebuild the sensor. Should the offset value remain high and result in calibration failures, review the *"Service" on page 28*, and then contact the Service Department at Badger Meter for further assistance.

   The sensor offset value in mV from the last zero calibration displays on the lower line of the *Default* menus for information purposes.

Temperature Calibration

The temperature calibration sequence is essentially a 1-point offset calibration that allows adjustments of approximately ±5° C. The sensor temperature may be calibrated on line or the sensor can be removed from the process and placed into a known solution temperature reference.

In any case, it is critical that the sensor be allowed to reach temperature equilibrium with the solution in order to provide the highest accuracy.

When moving the sensor between widely different temperature conditions, it may be necessary to allow the sensor to stabilize as much as one hour before the calibration sequence is initiated. If the sensor is online, the user may want to set the output *HOLD* feature prior to calibration to lock out any output fluctuations.

1. Scroll to the *CAL* menu section using the **MENU** key and press **ENTER** or the **UP** arrow key.
2. Press the **UP** arrow key until "Cal Temp" displays.
3. Press the **ENTER** key. The message "Place sensor in solution then press ENTER" displays. Move the sensor into the calibration reference (if it hasn't been moved already) and wait for temperature equilibrium to be achieved. Press **ENTER** to begin the calibration sequence.
4. The calibration data gathering process begins. The message "Wait" flashes as data is accumulated and analyzed. The "°C" or "°F" symbol may flash periodically if the reading is too unstable.
5. The message "Adjust value - press ENTER" displays, and the rightmost digit begins to flash, indicating that the value can be modified. Using the **UP** and **LEFT** arrow keys, modify the value to the known ref solution temperature. Adjustments up to ±5° C from the factory calibrated temperature are allowed. Press **ENTER**.
6. Once completed, the display indicates "PASS" or "FAIL". If the unit fails, the temperature adjustment may be out of range, the sensor may not have achieved complete temperature equilibrium or there may be a problem with the temperature element. In the event of calibration failure, it is recommended to attempt the calibration again immediately.

SYSTEM MAINTENANCE

General

The Q45D/60 dissolved oxygen system generally provides unattended operation over long periods of time. With proper care, the system should continue to provide measurements indefinitely. For reliable operation, maintenance on the system must be done on a regular schedule. Keep in mind that preventive maintenance on a regular schedule is much less troublesome than emergency maintenance that always seems to come at the wrong time.

Analyzer Maintenance

No unusual maintenance of the analyzer is required if installed according to the guidelines of this operating manual. If the enclosure door is frequently opened and closed, it would be wise to periodically inspect the enclosure sealing gasket for breaks or tears.

Sensor Maintenance

Sensor maintenance is required for accurate measurements. The primary requirement is simply to keep the sensor membrane clean. The membrane is a polymer material that is resistant to anything that is encountered in water streams. However, deposits or biological growth can form on the surface of the membrane, and these deposits reduce the sensitivity to oxygen. Normally, these coatings can be removed by simply wiping the membrane with a soft cloth or paper towel.

Should a coating form on the membrane that does not wipe off, it is best to change the membrane. Chemical cleaning may work as well, but a new membrane is a more reliable solution. To change a membrane, follow the *"Sensor Assembly" on page 11*. Do not reuse the electrolyte from the sensor when changing a membrane. Always refill with fresh electrolyte. The electrolyte is stable and does not have a limited shelf life.

Even if no buildup is apparent on the membrane, it should be changed on a regular schedule. The recommended membrane change interval is every 6 months.

The actual membrane life is often in excess of one year, but periodic preventive maintenance simply avoids having to do service on an emergency basis.

While the sensor is disassembled for membrane changing, examine the condition of the O-rings on both ends of the electrolyte canister. If the O-rings show any signs of damage, replace them with new ones from the spare parts kit. It is good practice to change these O-rings once a year, regardless of their condition.

Lead Anode Replacement

Galvanic D.O. sensors consume the lead electrode during normal operation. As oxygen is measured, lead is converted to lead oxide, and after a period of time, the lead is expended. The lead electrode in Badger Meter's D.O. sensor cartridge can be easily replaced, and replacement should be done automatically every 12 months.

The lead electrode is the thick lead wire wrapped around the sensor body (see *Figure 6 on page 12*). It is connected through a stainless steel post with a nut and star washer. To change the lead electrode, remove the nut and washer and unwrap the old lead. Loop the end of a new lead electrode around the post and replace the nut and washer. Tighten the nut firmly but do not overtighten as damage to the sensing module can result. Wrap the remainder of the lead around the sensor body. There is no need to secure the other end of the lead.

SERVICE

General

The information included in this section is intended to be used in an attempt to quickly resolve an operational problem with the system. During any troubleshooting process, it saves the most time if the operator can first determine if the problem is related to the analyzer, sensor or some external source. Therefore, this section is organized from the approach of excluding any likely external sources, isolating the analyzer and finally isolating the sensor. If these procedures still do not resolve the operational problems, any results the operator may have noted here are very helpful when discussing the problem with the factory technical support group.

External Sources of Problems

To begin this process, review the connections of the system to all external connections.

1. Carefully examine sensor wiring connections for loose wiring or bad wire stripping.
2. Check sensor membrane for fouling. Look closely for any signs of grease or oil that may be present. Replace membrane and electrolyte, allow to stabilize and re-check. The procedure in *"Sensor Assembly" on page 11*, must be followed when replacing the membrane.

Analyzer Tests

1. Turn off power and remove sensor wiring. Re-apply power to the analyzer.
2. Using the *Simulate* feature, check operation of analog outputs with a DVM.
3. Check TC drive circuit. Connect a 1000 Ohms resistor across the BROWN and GREEN terminals. The temperature reading should display approximately 0° C and the dissolved oxygen reading should display approximately 0 ppm.

Display Messages

The Q45 Series instruments provide a number of diagnostic messages that indicate problems during normal operation and calibration. These messages appear as prompts on the secondary line of the display or as items on the *Fault List*.

The following messages appear as prompts:

Message	Description	Possible Correction
Max is 200	Entry failed, maximum value allowed is 200.	Reduce value to ≤ 200.
Min is 20	Entry failed, minimum value allowed is 20.	Increase value to ≥ 20.
Cal Unstable	Calibration problem, data too unstable to calibrate. Icons do not stop flashing if data is too unstable. User can bypass by pressing **ENTER**.	Clean sensor and allow sensor to equilibrate in ambient air. Check the mv display to see if sensor output is stable.
Out of Range	Input value is outside selected range of the specific list item being configured.	Check manual for limits of the function to be configured.
Locked!	Transmitter security setting is locked.	Enter security code to allow modifications to settings.
Unlocked!	Transmitter security has just been unlocked.	Displayed just after security code has been entered.
Offset High	The sensor zero offset point is out of the acceptable range of –40…40 mV.	Check wiring connections to sensor. Allow sensor to operate powered a minimum of 4 hours prior to first zero cal.
Sensor High	The raw signal from the sensor is too high and out of instrument range.	Check wiring connections to sensor.
Sensor Low	The raw signal from the sensor is too low.	Check wiring connections to sensor.
D.O. High	The dissolved oxygen reading is greater than the maximum of the user-selected range.	The dissolved oxygen reading is over operating limits. Set measuring range to the next highest level.
Temp High	The temperature reading is > 55° C.	The temperature reading is over operating limits. Check wiring and expected temp level. Perform RTD test as described in sensor manual. Recalibrate sensor temperature element if necessary.
Temp Low	The temperature reading is < –10° C.	Same as "Temp High" above.
TC Error	TC may be open or shorted.	Check sensor wiring and perform RTD test as described in sensor manual. Check junction box connections.
D.O. Cal Fail	Failure of dissolved oxygen calibration. *FAIL* icon does not extinguish until successful calibration has been performed or 30 minutes passes with no keys being pressed.	Clean sensor, redo zero and span calibration. If still failure, sensor slope may be less than 25% or greater than 500%. Perform sensor tests as described in *"Sensor Tests" on page 30*. Replace sensor if still failure.
T.C. Cal Fail	Failure of temperature calibration. *FAIL* icon does not extinguish until successful calibration has been performed or 30 minutes passes with no keys being pressed.	Clean sensor, check cal solution temperature and repeat sensor temp calibration. TC calibration function only allows adjustments of ±6° C. If still failure, perform sensor tests as described in *"Sensor Tests" on page 30*. Replace sensor if still failure. .

Sensor Tests

1. Check the membrane condition. A membrane that is not stretched smoothly across the tip of the sensor causes unstable measurements. If necessary, change membrane and electrolyte.
2. Dissolved oxygen sensors can be tested with a digital voltmeter (DVM) to determine if a major sensor problem exists. Follow the steps below to verify sensor integrity:
    a. Disconnect the five sensor wires from the back of the dissolved oxygen monitor. Those wires are color coded white, brown, red, black and green.

    NOTE: The brown wire may be replaced with an orange wire in some cables.

    b. Remove the electrolyte chamber from the sensor and dry the electrodes with a paper towel.

    c. Connect a DVM between the white and brown (or orange) wires. Reading resistance, you should find an open circuit value of infinite resistance. There must be no measurable resistance at all between these wires. Any resistance at all indicates either water in the cable connector or the breakdown in an electrode seal.

    d. Connect a DVM between the red and white wires. The red wire is part of the RTD circuit and the white wire is part of the measuring cell. There should be no connection. Reading resistance, you should find an open circuit value of infinite resistance. Any resistance at all indicates either water in the cable connector or the breakdown in an electrode seal.

    e. Connect the DVM between the red and black wires. These are the RTD leads, and you should find a resistance value that depends on the temperature. The table below lists the resistance values for various temperatures:

PT1000 RTD Table

Temperature	Resistance
0° C	1000 Ω
5° C	1019 Ω
10° C	1039 Ω
15° C	1058 Ω
20° C	1078 Ω
25° C	1097 Ω
30° C	1117 Ω
35° C	1136 Ω
40° C	1155 Ω
45° C	1175 Ω
50° C	1194 Ω

If you suspect that water has gotten into a cable connection on a flow type sensor or into the plug connection of a submersible sensor, disconnect the cable and allow the parts of the sensor to sit in a warm place for 24 hours. If water in the connector is the problem, it should dry out sufficiently to allow normal sensor operation. However, steps D and E above have to be repeated after drying to see if the problem is gone.

Barometric Pressure Conversion

Inches of Mercury (inHg)	Millimeters of Mercury (mmHg)	Feet Above Sea Level
22.00	558.8	8790
22.50	571.5	8053
23.00	584.2	7347
23.50	596.9	6671
24.00	609.6	6023
24.50	622.3	5402
25.00	635.0	4806
25.50	647.7	4233
26.00	660.4	3682
26.50	673.1	3156
27.00	685.5	2653
27.50	698.5	2150
28.00	711.2	1675
28.50	723.9	1217
29.00	736.6	776
29.50	749.3	349
30.00	762.0	–64
30.50	774.7	–463
31.00	784.4	–759

Water Saturated Concentration of O^2

Temperature		ppm Value	Temperature		ppm Value
°F	°C		°F	°C	
32	0.0	14.6	74	23.3	8.5
34	1.1	14.1	76	24.4	8.3
36	2.2	13.7	78	25.6	8.2
38	3.3	13.3	80	26.7	8.0
40	4.4	12.9	82	27.8	7.8
42	5.6	12.6	84	28.9	7.7
44	6.7	12.2	86	30.0	7.5
46	7.8	11.9	88	31.1	7.4
48	8.9	11.6	90	32.2	7.3
50	10.0	11.3	92	33.3	7.1
52	11.1	11.0	94	34.4	7.0
54	12.2	10.7	96	35.6	6.9
56	13.3	10.4	98	36.7	6.8
58	14.2	10.2	100	37.8	6.6
60	15.6	9.9	102	38.9	6.5
62	16.7	9.7	104	40.0	6.4
64	17.8	9.5	106	41.1	6.3
66	18.9	9.3	108	42.2	6.2
68	20.0	9.1	110	43.3	6.1
70	21.1	8.9	112	44.4	6.0
72	22.2	8.7	114	45.6	5.9

SPARE PARTS

Part No.	Description
*	Q45D D.O. Monitor Electronics Assembly, 3V DC
07-0078	Flow Type D.O. Sensor
07-0095	Submersion Type D.O. Sensor with 30 ft Cable
02-0007	Submersion Sensing Module (for #07-0095)
02-0014	Submersion Element Body (for #02-0007)
02-0113	Submersion Holder, 30 ft Cable (for #07-0095)
02-0224	Flow Type Sensor Element (for #07-0078)
03-0358	Electrolyte Chamber with Pressure Gland
48-0001	Membrane Holder, Type 316 Stainless Steel
04-0003	Replacement Lead Electrode
05-0001**	5-mil Membranes, pkg. of 10
05-0011**	Membranes, 2 mil., pkg. of 10
05-0014	Spare Parts Kit, Screw and O-ring
05-0015	Spare Parts Kit, Screw and O-ring (Flow Sensor)
05-0088	Pressure Gland Rebuild Kit
42-0014	Flowcell O-ring
09-0007**	Dissolved Oxygen Electrolyte, 4 oz (120 cc)

* Consult factory for electronic assembly part number.

NOTE: Instrument is supplied with sufficient spare parts for 6…12 months of operation. For 2 year spare parts inventory, 3 each of the items marked with an asterisk (**) should be ordered.

Lock/Unlock Code: 1454

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