LANDTEC

GEM-500

OPERATION MANUAL

For further information contact:

LANDTEC
850 S. Via Lata, Suite 112
Colton, CA 92324
Telephone: (909) 783-3636 / (800) LANDTEC
Fax: (909) 825-0591
www.CES-LANDTEC.com

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Chapter 1 - Getting Started

Unpacking the GEM™500

The GEM™500 unit is normally shipped in a special protective shipping unit. An optional protective hard case with a foam interior offers additional protection, transportation convenience and component hardware storage. When properly sealed, the hard case is watertight. The hard case is equipped with a pressure relief valve (located under the handle on the case) that is normally kept closed. If there is a change in elevation, the hard case may not open until internal pressure is equalized by turning the pressure relief valve. When shipping a GEM™500 back to LANDTEC for calibration or service, always ship it in the original packaging to protect unit from damage.

Carefully unpack the contents of the GEM™500, inspect and inventory them. The following items should be contained in your package:

- The GEM™500 unit
- GEM™500 Operation Manual
- Registration/Warranty Card and other instructional information
- Soft carrying case with replaceable protective window and carrying strap
- External (clear vinyl) sampling hose assembly (5 ft.) with external water trap filter assembly
- Blue ¼" vinyl sampling hose (5 ft.)
- Spare internal particulate filter element
- Polypropylene male connector (hose barb) connects to blue vinyl hose
- Spare external water trap filter element
- 110-volt Nickel-Cadmium battery charger
- GEM™500 download software on DataField CS CD
- RS-232 serial cable for computer/printer data downloading
- Temperature probe (optional)
- Hard carrying case (optional)

Immediately notify shipper if the GEM™500 unit or accessories are damaged due to shipping. Contact LANDTEC if any items are missing. If you have any questions, please contact CES- LANDTEC technical support at (800) 821-0496 or (800) LANDTEC. Complete the Registration/Warranty Card and return it to LANDTEC. The model and serial numbers are located on the back of the GEM™500 unit.

Attaching the Hose Assembly

The GEM™500 hose assembly comes fully assembled but it needs to be connected to the GEM™500. Connect the clear hose with the external filter/water trap assembly to the static pressure/ sampling port (top left corner) on the GEM™500 (See Figure 1.1). The shorter piece of hose (from the water trap filter hosing) should be connected to the GEM™500. This allows you to see any liquid entering the hose and shut the unit off before the liquid reaches the GEM-500™. Always connect the hose in the same direction. Connect the blue hose to the impact pressure port on the GEM™500 (See Figure 1.1). This port is located on the bottom left corner of the GEM™500. **DO NOT** block the exhaust port (See Figure 1.1).

Quick Connect Fittings

The quick connect fittings will simplify taking well field readings. They are easy to install on your landfill gas extraction system and on perimeter probes. Many different types are available. LANDTEC maintains a stock of fittings used on its equipment for your convenience.

The GEM™500 comes with quick connect fittings for the Accu-Flo wellhead. Insert the hose barb end of the male connector into the end of the clear and blue hoses.

GEM™500 Keyboard and Port Descriptions

1. **Red On/Off Key**—Turns unit on or off.
2. **Blue Number/Letter Toggle Key**—Enables well ID code to be entered by toggling between number and letter mode and toggles contrast on the gas read screens.
3. **Receptacle Port**—Used for battery recharging, RS232 serial communications, temperature probe or gas pod.
4. **Backspace/Exit Key**—Acts as backspace key when pressed and held for one second, to correct entry of wrong number/letter, returns to previous procedure or steps back one layer of menus (similar to pressing the ESCAPE key in many computer programs).

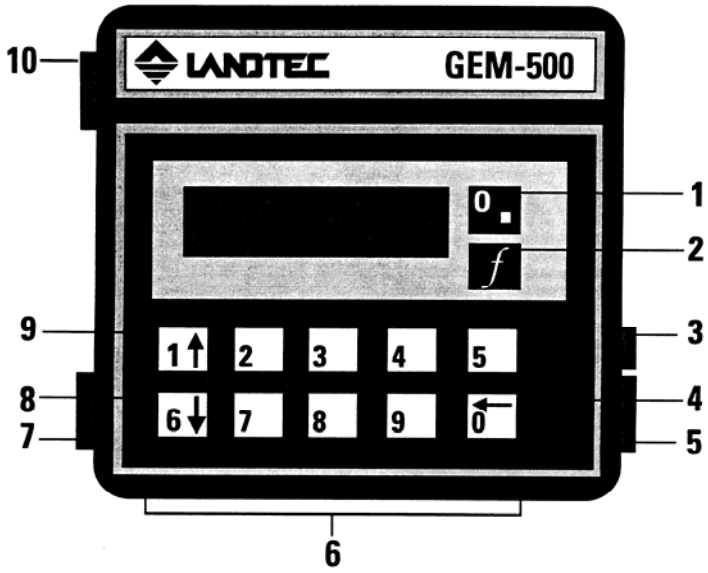


FIGURE 1.1

5. **Exhaust Port**—This port must be kept clear. If blocked while operating, over-pressurization may occur causing damage to internal components and case.
6. **Number Keys**—Enter numbers 0 through 9.
7. **Impact Pressure Port**—Measures impact pressure when connected to wellhead impact pressure port, pitot tube or orifice plate.
8. **Cursor-Down Key**—Enters number 6, scrolls down lines of information on display screens, and also scrolls down alphabetic character list.
9. **Cursor-Up Key**—Enters number 1, scrolls up lines of information on display screens, and also scrolls up alphabetic character list.
10. **Static Pressure/Sampling Port**—Measures static pressure and is inlet for gas sampling.

Must Do's Before Using the GEM™500

Proper operation of the GEM™500 requires the following functions to be completed before proceeding.

- Charge the unit with the battery charger
- Check the Time/Date
- Field Calibrate the unit

Calibration Gases

Calibration gases are required to field calibrate the GEM™500. Portable Calibration Gas Kits and 4-unit or 12-unit cylinder cases are available from LANDTEC. (See Chapter 2 -- *Field Calibration*)

Special Key Functions

Entering an ID code with Letters and Numbers
Use the blue toggle key (***ƒ***) to shift back and forth between number mode and letter mode. When in number mode, use number keys to enter numbers. When switched to letter mode, use the **1** KEY (**UP ARROW**) or the **6** KEY (**DOWN ARROW**) to scroll to desired letter, press **0** KEY to enter the letter on the display. Repeat this process for all letters. After entry, the first four characters will remain as a default for ease in entering the next ID. If different characters are desired, replace the defaults by using the backspace function described below.

Backspace Function
To change or correct an entry, use the **0** KEY (**BACK ARROW**) as a backspace key by holding it down for one second. In normal use, this key is quickly pressed and released.

Contrast Adjustment
Contrast can be adjusted when the unit is either first turned on or while taking a reading. While taking a reading, use the Blue *ƒ* KEY to enter the contrast adjustment screen. To adjust, use 1 KEY (UP ARROW) to darken the screen and the 6 KEY (DOWN ARROW) to lighten screen.

Chapter 2 – Using Menu Screens

Starting Up the GEM

This procedure is the same each time the GEM™500 is turned on by pressing the RED On/Off KEY.
The following steps will allow you to proceed to the Main Menu Screen of the GEM™500.

1. Turn unit on by pressing the RED **On/Off** KEY (see Figure 1.1)

   Note: If the GEM is turned on and no additional keys are pressed within 15 minutes, the unit will automatically shut off.

2. The Warning screen appears for five seconds. This is a reminder that the GEM™500 is not to be used in areas such as vaults, excavations or other confined spaces. An explosion could result causing serious injury or death.

FIGURE 2.1

3. The Service Contract screen may appear for five seconds if activated by LANDTEC. Otherwise, the Not Covered screen is displayed. The GEM™500 is a portable, scientific, field instrument that does require factory maintenance and calibration at recommended six-month intervals under normal landfill usage.

FIGURE 2.2

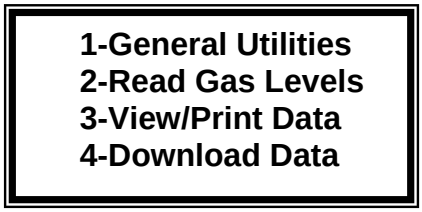
FIGURE 2.3

4. The LANDTEC/Contrast screen allows the user to adjust the contrast of the characters on the liquid crystal display screen. Press and hold the **1** KEY (**UP ARROW**) to increase contrast. Press and hold the **6** KEY (**DOWN ARROW**) to decrease the contrast. Adjust the contrast as necessary (contrast levels are **NOT** saved when the unit is turned off). Press the **0** KEY to proceed to the Main Menu screen.

FIGURE 2.4

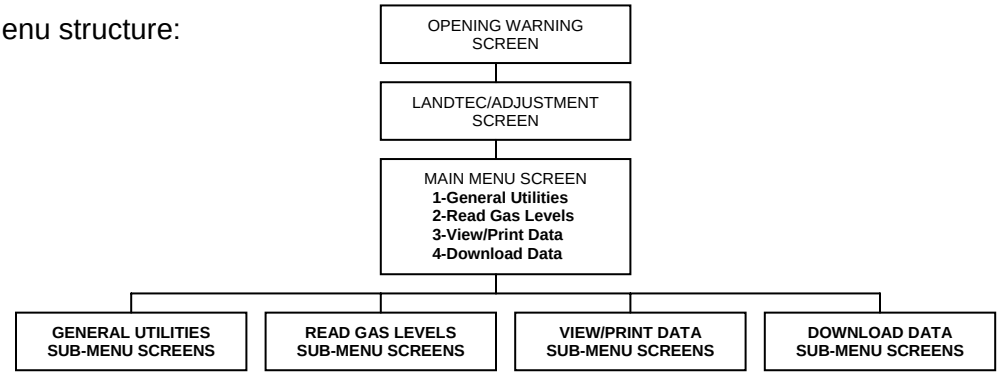
5. **The Main Menu Screen.** All the GEM™500 functions are accessed from the Main Menu Screen. All subsequent instructions about the GEM™500 functions will start from this screen.

FIGURE 2.5



GEM-500 Menu Tree

The overall menu structure:



Review of the Main Menu and Sub-Menu Screens

General Utilities
Refer to Chapter 4 for further information. The General Utilities function has sub-menu screens that allow housekeeping and other maintenance including:

1. CHECK TIME/DATE: Set or check time and date.
2. BATTERY STATUS: Graphic display of remaining power in batteries.
3. ZERO PRESSURES: Zero pressure transducers.
4. MEMORY: Check memory available or clear all data and ID information.
5. USA/METRIC UNITS: Select either USA standard or metric measurement units.
6. GAS CALIBRATION: Allow Methane, Carbon Dioxide and oxygen to be field calibrated by the user with calibration gas mixtures for increased accuracy (see Chapter 3).
7. GAS ALARM: Set gas alarm levels.
8. ID MAINTENANCE: View, enter, edit or delete ID information.

Read Gas Levels
Refer to Chapter 5 for further information. Read Gas Levels function allows gas, pressure, flow and BTU readings to be viewed and recorded. Sub-menu screens include:

1. Read GAS with Existing ID code.
2. Read GAS without ID code.

View/Print Data
For further information, refer to Chapter 6. The View/Print Data function allows previously stored data to be scanned on the GEM™500 display screen, individually displayed, or printed via the RS-232 cable to a serial printer.

Download Data
The Download Data function allows stored data to be downloaded via the RS-232 cable to a computer in a format that can be uploaded into DataField (LANDTEC database management program) or onto spreadsheets. See Chapter 7 for further information.

Note: The 0 KEY (BACKSPACE) acts as an exit or ESCAPE key at the end of each sub-menu by returning to the Main Menu.

Chapter 3 - Field Calibration

Field Calibration is menu guided and can be completed in about ten minutes. To streamline the procedure, the pump remains running during field calibration. The GEM™500 contains a calibration map accessed by its microprocessor for baseline reference data. This reference data was programmed into the GEM™500 during factory calibration using various traceable gas mixtures in an environmental chamber. At any time, the GEM™500 can be reset to factory settings which clears any user calibration settings and restores the GEM™500 to its original factory calibration.

The factory calibration has been designed to give the best possible results over a wide range of conditions. However, the instrument's accuracy can be improved in specific operating ranges by performing a field calibration. Most field instruments are calibrated or adjusted prior to taking a series of gas or pressure readings. They may also be checked for calibration during and after readings in order to verify the accuracy of the data collected.

It is important to field calibrate the GEM™500 on-site after the instrument has stabilized at working temperature. For this reason, a GEM™500 that was calibrated in the cool of the morning may not read as accurately during the hottest part of the day.

Note: Field calibration of the GEM™500 will improve the data collected in the range of the calibration gases used. Less accurate readings of concentrations outside the calibrated range may occur. For example, a GEM™500 that was field calibrated using 50% CH_4 and 35% CO_2 will give improved readings for most gas extraction systems. Recommended gas mixtures for reading migration probes are 15% Methane, 15% Carbon Dioxide with balance Nitrogen. A 4.0% oxygen with balance Nitrogen mixture may be used for both types of testing.

Calibration Gas/Span Gases

Field calibration requires two calibration gas mixtures. One gas mixture is used to span oxygen and zero Methane. The other is used to span Methane, Carbon Dioxide and zero oxygen. The oxygen has two curves: 0-5% and 0-25%. The zero point is the same for both curves; however, the span is different. The user need only span the instrument using calibration gas below 5% for the 0-5% range or calibration gas below 25% for the 0-25% range. Regardless of the ranges used, the instrument **must** be zeroed. Various calibration gas mixtures are available from LANDTEC.

Zero Methane

Calibration of the GEM™500 starts by establishing the bottom point of the Methane gas curve. The Methane (CH_4) is zeroed prior to taking readings at the start of each day. This function significantly improves the GEM™500's CH_4 accuracy over the entire range. **It is essential that the gas analyzer be clear of CH_4 when zeroed.** Care must be taken if the GEM™500 is to be zeroed using air near a landfill site because there are situations where Methane could be in the atmosphere.

Span Methane

A field calibration spans the Methane range prior to taking readings at the start of each day. The best results are obtained after the instrument has stabilized at its working temperature. This procedure alters the Methane calibration at all concentrations and stores the revised data in protected memory.

Note: Methane zero must be performed before setting the Methane Span.

Span Carbon Dioxide

Field calibration of CO_2 should be performed prior to taking readings at the start of each day after the instrument has stabilized at its working temperature. This procedure alters the calibration at all concentrations and stores the revised data in protected memory.

Zero Oxygen

This function is essential where low concentrations of oxygen are expected (below 5%). This establishes the zero point of an oxygen curve that is stored in the GEM™500 protected memory.

Span Oxygen

The oxygen calibration map contains two span curves, one for oxygen below 5% and one for oxygen above 5%. The proper curve is automatically selected. If a calibration gas with less than 5% oxygen is used, the lower span curve is set. If the calibration gas has more than 5% oxygen, the higher calibration curve is set.

Note: The Oxygen zero must be set before setting the Oxygen Span.

Equipment

The following items are required to perform a field calibration:

1. Cylinder of Methane and Carbon Dioxide span gas
2. Cylinder of 4/96 (4% O_2 and 96% N_2) calibration gas
3. Pressure regulators for the above cylinders capable of regulating in the range of 0 - 15 psig fitted with connectors suitable for ¼" hoses
4. LANDTEC regulator and flow meter preset to deliver the required flow of 399-500 cc per minute at 15 psig max. (See Figure 3.1.a)
5. Interconnecting lengths of ¼" hoses

This equipment is available from LANDTEC. The calibration equipment set up is shown in Figure 3.1.a and 3.1.b. The calibration cylinders sold by LANDTEC have a volume of 17 liters. The regulator, sold by same, is set to 0.5 liters per minute. A normal field calibration usually requires the gas to be running for about two minutes. Therefore you can expect to get between 14 and 18 calibrations per cylinder of calibration gas.

FIGURE 3.1.a Pressure/Flow Regulator

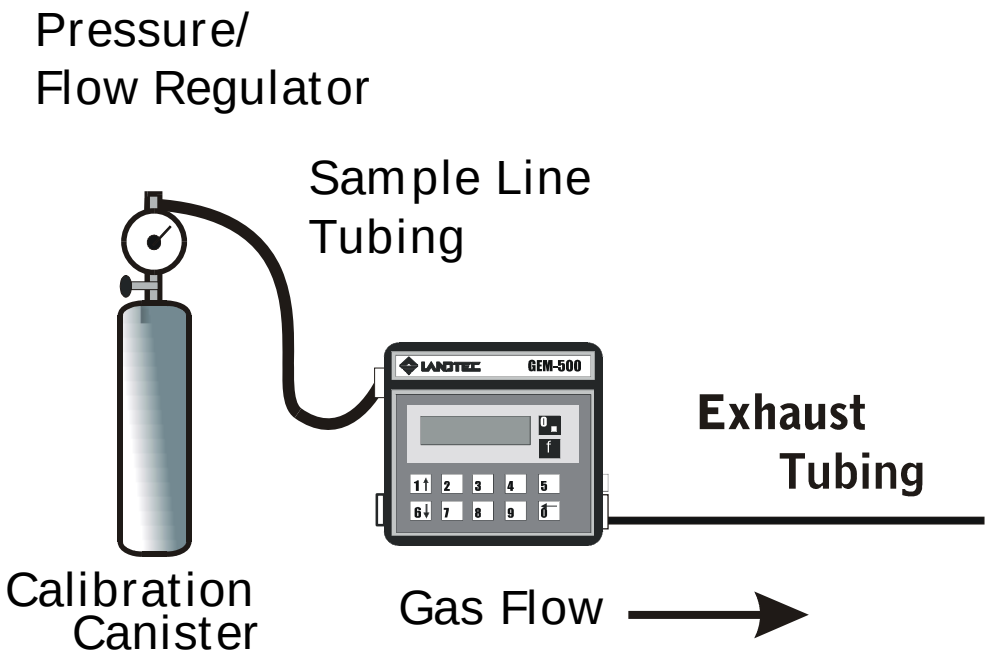
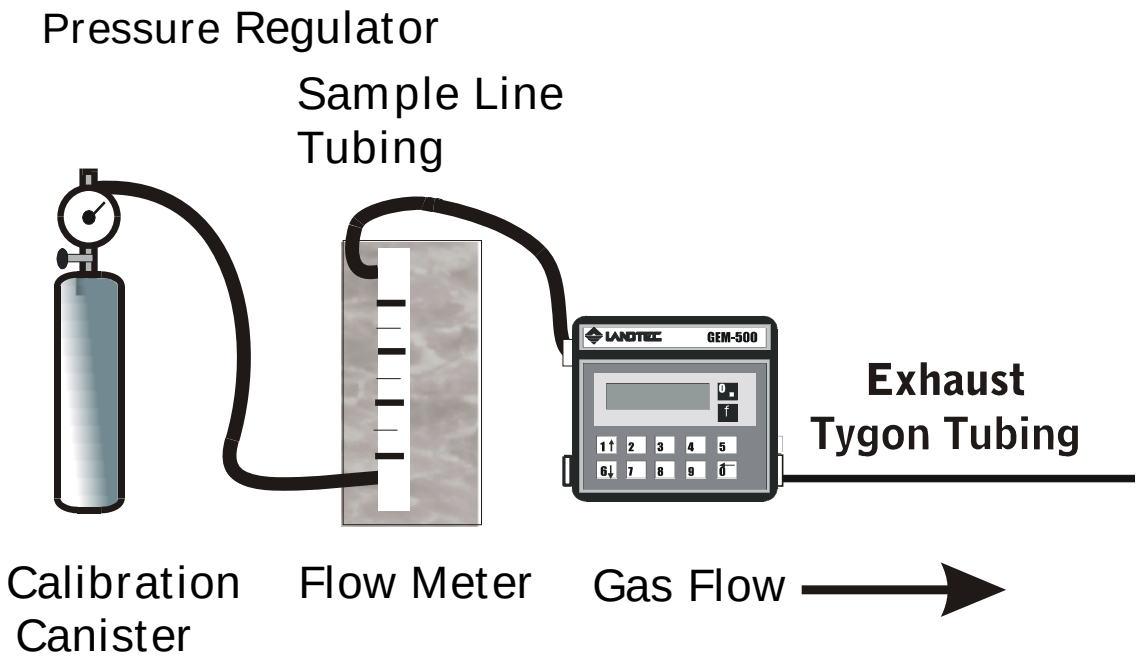


FIGURE 3.1.b Pressure Regulator with Flow Meter



Setting Up the Equipment

1. Connect the calibration gas cylinder to the pressure regulator.

2. Connect the sample input line to the regulator and to the GEM™500.

3. Connect the second 24" section of ¼" hose to the exhaust nozzle of the GEM™500. Direct exhaust away from you and out of the immediate area.

4. If using a LANDTEC regulator, no flow meter is required.

5. If **not** using the LANDTEC regulator, adjust the regulator discharge pressure to 5 psig and the flow meter to 500 cc per minute. Pinch the gas supply hose that will attach to the GEM™500 and verify the regulator discharge pressure does not exceed 10 psig. Turn off the cylinder valve.

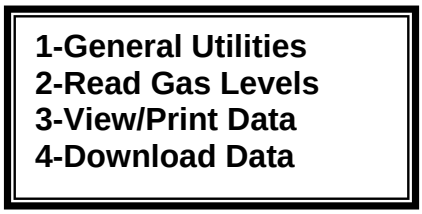
   Note: This procedure will be duplicated for the second span gas when oxygen is calibrated. The Oxygen/N_2 calibration gas cylinder will be substituted for the Methane/Carbon Dioxide calibration gas.

General Utilities KEY 5-Gas Calibration

The GEM™500 is factory calibrated. To improve accuracy, all standard landfill gas instruments should be field calibrated, zeroed, or in other ways adjusted prior to every use. Field calibration is performed from the General Utilities Menu of the GEM™500.

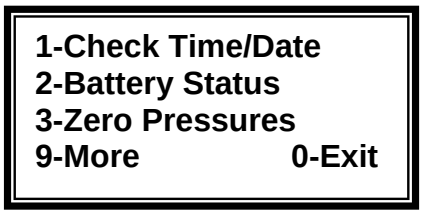
1. Press **1** KEY for **General Utilities** on the Main Menu Screen (See Figure 3.2).

FIGURE 3.2



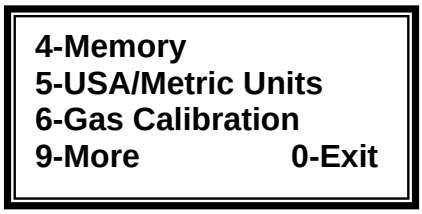
2. The General Utilities Screen appears as shown in Figure 3.3.

FIGURE 3.3



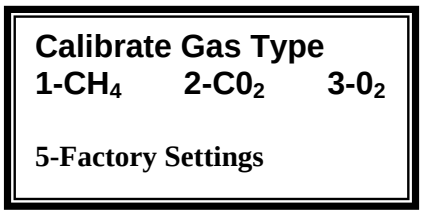
3. The gas calibration function is not on the first General Utilities screen. To reach this screen, press the **9** KEY for **More** and the **6** KEY for **Gas Calibration** (Figure 3.4). You may also press the **6** KEY while at the first General Utilities Screen to proceed directly to the Gas Calibration screen.

FIGURE 3.4



4. Pressing the **6** KEY for **Gas Calibration** on the General Utilities Sub-Menu screen, the first Gas Calibration screen is displayed as shown in Figure 3.5.

FIGURE 3.5



Methane (CH_4) Calibration - Zero CH_4

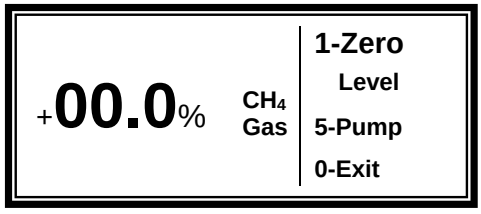
1. Press the **1** KEY, **CH_4 Calibration**, to start the calibration procedure. Pressing the **0** KEY will exit the screen without changing the previous calibration.

FIGURE 3.6

2. Pressing the **1** KEY, **Zero CH4**, initializes the Zero Methane procedure (Figure 3.7). A Methane percentage will not display until the Infrared (IR) Bench warms up. A plus or minus sign may appear on the far left of the display. This symbol may be ignored.

DO NOT PERFORM THIS PROCEDURE IN THE PRESENCE OF METHANE.

FIGURE 3.7



3. If using air to zero Methane, press the **5** KEY, **Pump**, to turn on the GEM™500 sample pump. Calibration gas hoses should not be attached to the GEM™500 during this procedure. Allow the pump to run for two minutes or until gas reading stabilizes. If using oxygen calibration gas to zero Methane, see step 3-6 in the Span Methane section then return to step 2 of this section.

4. Press **1** KEY, **Zero level**. One of the following screens (Figure 3.8 or Figure 3.9) will be displayed for three seconds before returning to the Zero Methane Screen shown in Figure 3.7.

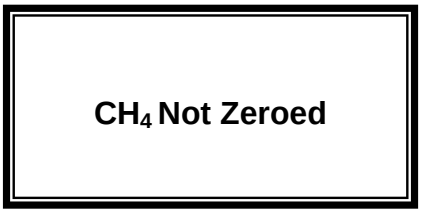


FIGURE 3.8

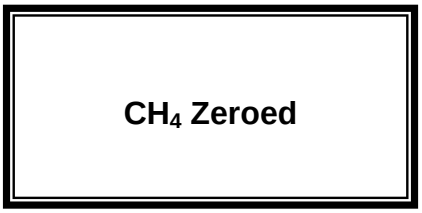
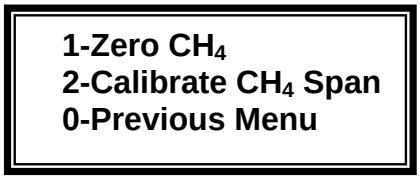


FIGURE 3.9

5. If the CH_4 Not Zeroed screen (Figure 3.8) is displayed, return to the Gas Calibration screen by pressing the **0** KEY, **Exit**. Verify Methane is not present and re-zero the Methane. If the problem continues, proceed to instructions contained in this section for Factory Settings.

6. If the CH_4 Zeroed OK screen (Figure 3.9) is displayed, press the **0** KEY, **Exit,** to return to the Methane Calibration Screen (Figure 3.10). Press the **2** KEY, **Calibrate CH_4 Span**, to proceed to the next section.

FIGURE 3.10



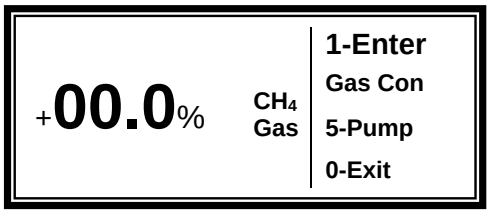
Methane (CH4) Calibration

1. Read the warning below before proceeding with the next steps.

> **WARNING! The GEM™500 is not certified intrinsically safe. The following procedure MUST NOT be performed in a confined area (such as well vaults, underground or indoors) or where there is any possibility of sparking or ignition. Ensure that the exhaust port is not blocked and is properly vented away from you. Ensure that no leaks are present. Unless all above conditions are maintained, an explosion could occur resulting in serious injury or death.**

2. After selecting the **2** KEY, **Calibrate CH_4 Span**, on the Methane Calibration screen, the following CH_4 Span screen appears (Figure 3.11).

FIGURE 3.11



3. Connect the ¼" hose from the calibration gas regulator/flow meter to the GEM™500 gas sample/impact port (Figure 1.1). It is **NOT** recommended to use the water trap sample hose for calibration. Attach hose to the exhaust port of the GEM™500 and direct the exhaust flow away from you and out of the immediate area.

4. Press the **5** KEY, **Pump**, on the CH_4 Span screen to turn on the sample pump.

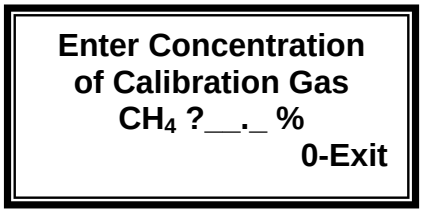
5. If not using LANDTEC supplied regulator, make sure the calibration gas flow is 500 cc and pressure is no greater than 2 psig.

6. Allow the calibration gas to flow into the GEM™500 for one minute or until instrument gas reading stabilizes.

7. After one minute, read the Methane gas concentration on the screen. It should be stable and not changing more than a few tenths of one percent at the 15% gas level or 2% at the higher gas level.

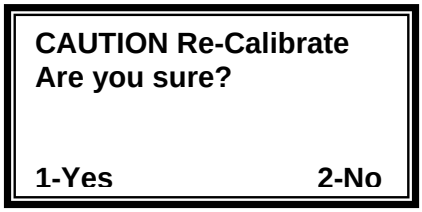
8. Press the **1** KEY, **Enter Gas Con**, and input the Methane concentration of the calibration gas using the keyboard of the GEM™500 (Figure 3.12). Enter the percentage as three digits XX.X%. (50% Methane would be input as 500.) The GEM™500 will automatically place a decimal point in the proper position. After the percentage is entered, press the **0** KEY, **Exit**.

FIGURE 3.12



9. The next screen is the Caution Re-Calibrate Screen (Figure 3.13).

FIGURE 3.13



10. Press the **1** KEY, **Yes**, and one of the two following messages will appear (Figure 3.14 or Figure 3.15).

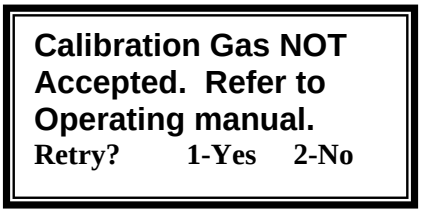


FIGURE 3.14

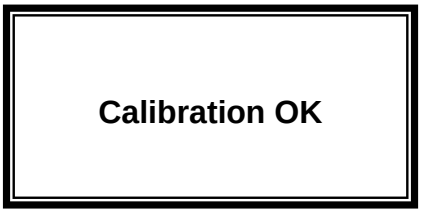


FIGURE 3.15

11. If the Calibration OK screen flashes (Figure 3.15), proceed to Step 13.

12. If the Calibration Gas Not Accepted screen appears (Figure 3.14), press the **1** KEY, **Yes**, and re-enter the Methane percentage. If the Calibration Gas Not Accepted screen still appears, press the **0** KEY, **No**, and start procedure again from zero Methane. If problem persists, proceed to Factory Settings, discussed later in this chapter.

13. If required, proceed to $C0_2$ calibration Step 1.

14. Press the **0** KEY twice. Turn off the calibration gas cylinder. Remove the calibration gas hose attached to the gas sample/static pressure port on the GEM™500. Leave the exhaust port hose connected and turn on the pump and allow it to purge the GEM™500 with air for 60 seconds. Press the **5** KEY, **Pump**, again. The pump turns off and automatically returns to the Calibrate Methane screen.

15. If there is no further calibration, press the **0** KEY, **Exit**, to return to the Gas Calibration screen. Field calibration has successfully been completed.

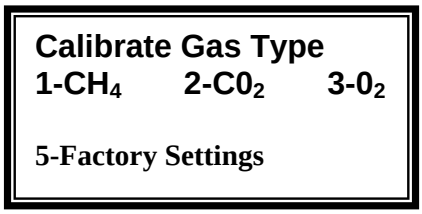
Carbon Dioxide (CO_2) Calibration

1. Because the cylinder used in this calibration contains Methane, the following warning must be adhered to before proceeding with the steps below.

WARNING! **The GEM™500 is not certified intrinsically safe. The following procedure MUST NOT be done in a confined area (such as well vaults, underground or indoors) or where there is any chance of sparking or ignition. No smoking, exposed lighting, or other sources of ignition should be in the area. On the GEM™500, ensure that exhaust port is not blocked and properly vented away from you. Ensure that no leaks are present. Unless all above conditions are maintained, an explosion could occur resulting in serious injury or death.**

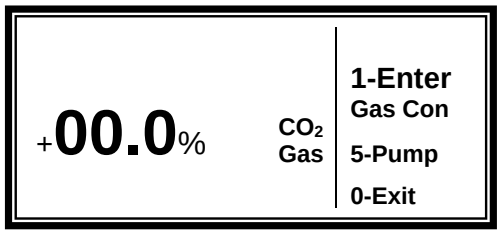
2. Press the **2** KEY, **CO_2 Calibration**, on the Gas Calibration screen (Figure 3.16).

FIGURE 3.16



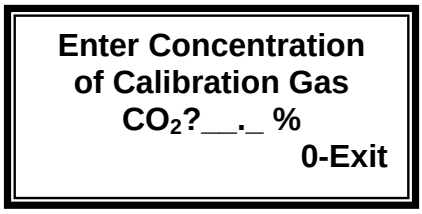
3. There is no Zero CO_2 function as there is in the Methane or oxygen calibration procedures. The following CO_2 Span screen appears (Figure 3.17).

FIGURE 3.17



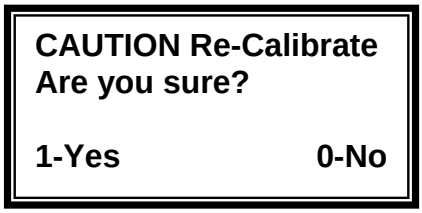
4. Press the **1** KEY, **Enter Gas Con**, to access the Enter Concentration screen (Figure 3.18). Input the percentage of Carbon Dioxide concentration of the calibration gas as three digits XX.X%. (40% Carbon Dioxide would be input as 400) The GEM™500 will automatically place a decimal point in the proper position. After the percentage is entered, press the **0** KEY, Exit.

FIGURE 3.18



5. The next screen is the Caution Re-Calibrate screen (Figure 3.19).

FIGURE 3.19



6. Press the **1** KEY, **Yes**, and one of the two following messages will appear (Figure 3.20 or Figure 3.21). If the Calibration OK screen appears, go to step 9 below.

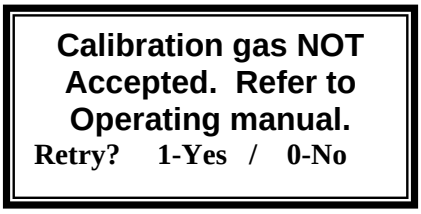


FIGURE 3.21

FIGURE 3.22

7. If the Calibration gas NOT Accepted screen appears, several things could have happened. Press the **1** KEY, **Yes,** and enter the percentage of Carbon Dioxide in the calibration gas. It is possible that the wrong percentage was input. If on a second attempt this does not work, press the **0** KEY, **No**, to return to the Gas Calibration screen and turn to the Factory Settings section for additional instructions.

8. If O_2 is to be zeroed, proceed to O_2 Calibration, step 1.

9. If no further calibration is needed, press the **0** KEY to **Exit** and return to the CO_2 Calibration screen shown on the prior page.

10. Turn off the calibration gas. Remove the calibration gas hose attached to the gas sample/static pressure port on the GEM™500. Leave the exhaust port hose connected. Allow the GEM™500 to purge with air for 60 seconds. Press the **5** KEY, **Pump**, to turn off the pump; then press the **0** KEY, **Exit**, to return to the Gas Calibration screen.

11. You have successfully completed a Carbon Dioxide Field Calibration. Immediately proceed to the next function, O_2 Calibration.

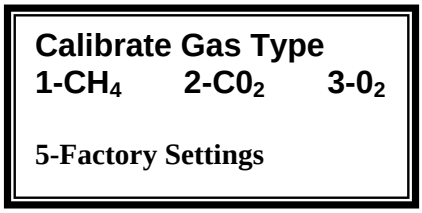
Oxygen (O_2) Calibration - Zero O_2

1. There are two calibration gas mixtures used for the calibration of oxygen. The Methane/ Carbon Dioxide calibration gas previously used to calibrate the Methane and Carbon Dioxide is used to Zero oxygen. A second calibration gas with a mixture of oxygen and Nitrogen is used to set the oxygen level in the next section. Because the calibration gas used contains Methane, the warning below must be followed before proceeding with the following steps.

WARNING! The GEM™500 is not certified as intrinsically safe. The following procedure MUST NOT be done in a confined area (such as well vaults, underground and indoors) or where there is any chance of sparking or ignition. No smoking, exposed lighting, or other sources of ignition should be in the area. On the GEM™500, ensure that exhaust gas port is not blocked and properly vented away from you. Ensure that no leaks are present. Unless all above conditions are maintained, an explosion could occur resulting in serious injury or death.

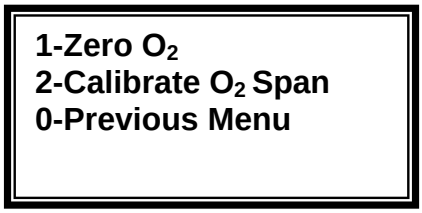
2. Press the Key **3**-O_2 Calibration on the Gas Calibration Screen (Figure 3.22).

FIGURE 3.22



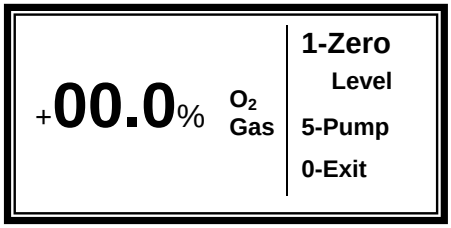
3. The Oxygen Calibration Screen will appear (Figure 2.23).

FIGURE 3.23



4. Pressing the **1** KEY, **Zero O_2**, will bring up the Zero Oxygen screen (Figure 3.24).

FIGURE 3.24



5. Read the oxygen Gas Concentration on the screen. It should be very near 00.0% and not changing more than a few tenths of one percent.

   Note: Even if the screen displays 00.0% oxygen, proceed with step 6 below; the Oxygen must be zeroed anyway.

6. Press the **1** KEY, Zero level, and one of the following screens (Figure 3.25 or Figure 3.26) will be displayed for three seconds before returning to the Zero Oxygen screen shown above.

FIGURE 3.25

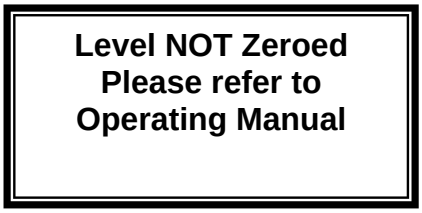


FIGURE 3.26

7. If the O_2 Zeroed screen displays, proceed to step 9 below.

8. If the Oxygen NOT Zeroed screen displays, return to the Oxygen Calibration screen. Check that the calibration gas contains no oxygen. Connect the correct gas and re-zero the oxygen. If the problem continues, proceed to instructions contained in this section for Factory Settings.

9. If the Oxygen Zeroed OK screen appears, turn off the calibration gas.

10. Remove the hose from the flow regulator to the GEM™500. Let the pump run for at least 60 seconds to purge the instrument with air. Press the **5** KEY, **Pump**, to turn off the pump.

11. Press the **0** KEY, **Exit**, to return to the Oxygen Calibration screen and proceed to oxygen span.

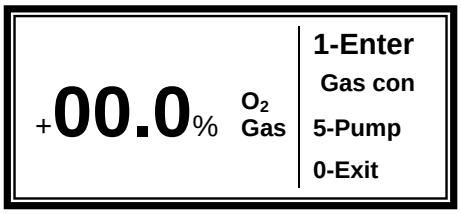
O_2 Calibration - O_2 Span

1. From the Gas Calibration screen, press the **3** KEY, **zero O_2**, and the Oxygen Calibration screen (Figure 3.27) will appear.

FIGURE 3.27

2. Press the **2** KEY, **Calibrate O_2 Span**, on the Oxygen Calibration screen will appear (Figure 3.28).

FIGURE 3.28



Note: The calibration gas used in this procedure is a mixture of oxygen and Nitrogen. The oxygen concentration by volume can be 2-5% with the remainder N_2.

3. Change the calibration gas mixture to Oxygen/Nitrogen. Install the regulator/flow meter on the new calibration gas mixture as directed previously in *Setting Up the Equipment*, page 4. Check and adjust the gas flow to 500 cc and pressure to 2 psig. Turn off the gas.

4. Connect the ¼" hose from the calibration gas regulator/flow meter to the GEM™500 gas sample/static pressure port (Figure 1.1). Attach hose to the exhaust port of the GEM™500, if not already attached, and direct the exhaust away from you and out of the immediate area.

5. Press the **5** KEY, **Pump**, displayed on the O_2 Span screen shown above. (Figure 3.28)

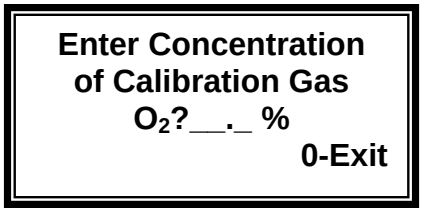
6. Turn on the calibration gas mixture of oxygen and Nitrogen.

7. Allow the calibration gas to flow into the GEM™500 for 60 seconds.

8. After 60 seconds, read the Oxygen Gas Concentration on the screen. It should be stable and not changing more than a few tenths of one percent.

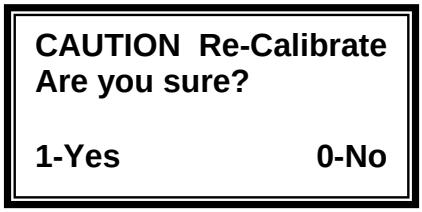
9. Press the **1** KEY, **Enter Gas Con**, and input the oxygen concentration of the calibration gas (typically 4%) using the keyboard of the GEM™500 (Figure 3.29). Enter the percentage as three digits XX.X%. (4% O_2 would be input as 040) The GEM™500 will automatically place a decimal point in the proper position. After the percentage is entered, press the **0** KEY to **Exit**.

FIGURE 3.29



10. The next screen to appear, Figure 3.30, is the Caution Re-Calibrate Screen.

FIGURE 3.30



11. Press the **1** KEY, **Yes**, and one of two screens will appear (Figure 3.31 or Figure 3.32).

12. If the Calibration OK Screen appears proceed to step 15.

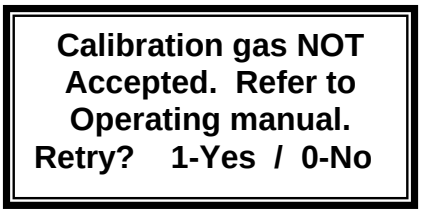


FIGURE 3.31

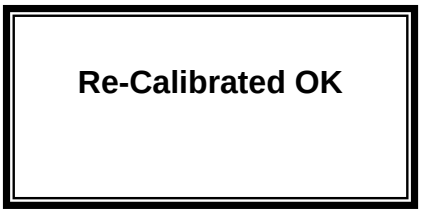


FIGURE 3.32

13. If the Calibration Gas NOT Accepted screen appears, press the **1** KEY, **Yes,** and re-enter the percentage of oxygen in the calibration gas. It is possible the wrong percentage was input. If, on a second attempt, this has not worked, press the **0** KEY, **No**, and return to the Oxygen Calibration Menu. Start the procedure over again. Zero and then calibrate the oxygen. If there are still problems, proceed to Factory Settings in this section.

14. Press the **0** KEY, **Exit**, to return to the Oxygen Calibration screen shown on the following page.

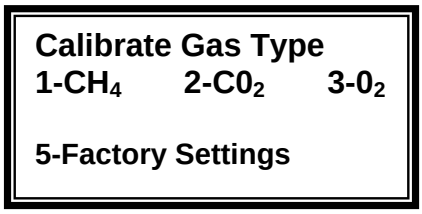
15. Turn off the calibration gas. Remove the calibration gas hose attached to the gas sample/static pressure port on the GEM™500.

Factory Setting Calibrations

As previously mentioned, it is sometimes necessary to return the GEM™500 to factory settings before trying to field-calibrate the unit. If for some reason sampling conditions change radically, overall accuracy of the GEM™500 can be improved by returning to factory settings and then re-calibrating. This procedure will overwrite previous field calibrations.

1. From the Gas Calibration screen, Figure 3.34, press the **5** KEY, **Factory Settings**.

FIGURE 3.34



2. The Caution screen, Figure 3.35, shown below will be displayed. If the **0** KEY, **No**, is pressed, the Not Set screen (Figure 3.36) appears for two seconds, then the Gas Calibration screen returns.

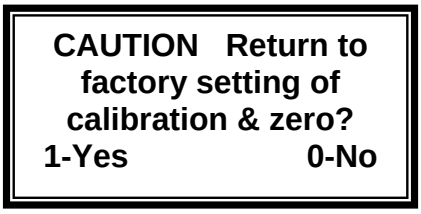


FIGURE 3.35

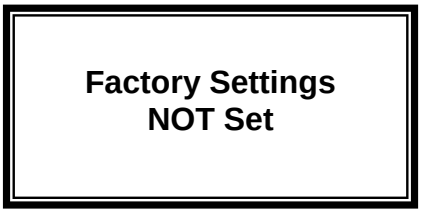


FIGURE 3.36

3. Press **1** KEY, **Yes**, and the Factory Setting Set OK screen (Figure 3.37) is displayed for three seconds before returning to the Gas Calibration screen shown in step 1.

FIGURE 3.37

4. After loading the factory settings, the Methane and oxygen calibration **MUST BE RE-ZEROED PRIOR TO USE.** After completing the gas calibrations, the GEM™500 is ready to read gas levels. Go to Chapter 5 of this manual, Read Gas Levels.

After Completing Gas Calibrations

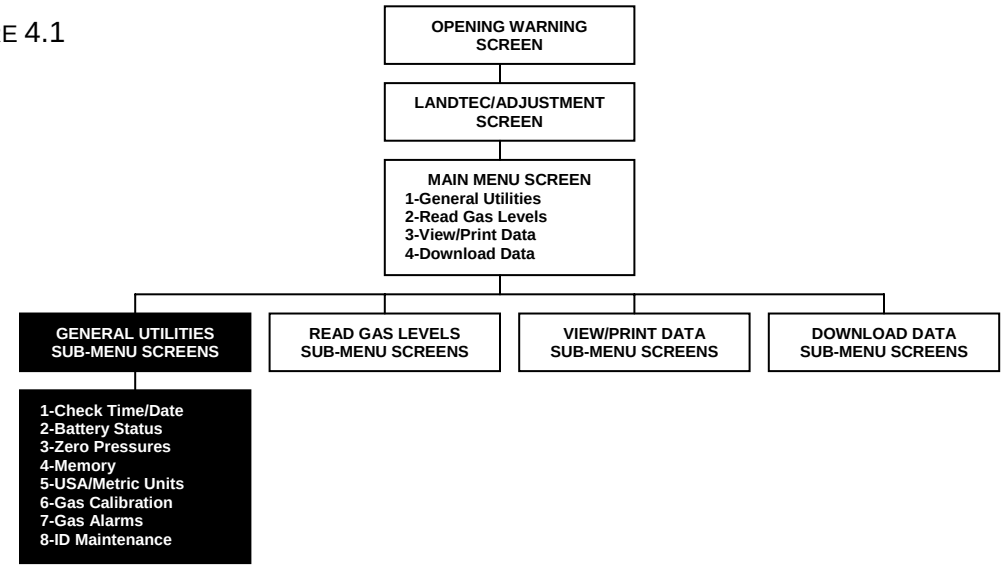
Additional general utilities functions should be addressed after the GEM™500 is field calibrated. These functions are available on the General Utilities menu and include:

- **Check Time/Date** assures that the data collected is properly time/date stamped.
- **Check Memory** assures that there is enough memory space in the GEM™500 to store the readings you plan to take. Otherwise the memory will need to be cleared. (See page 28, chapter 4)
- **Set Gas Alarms** alerts the user to unusual gas conditions.

Chapter 4 - General Utilities Functions

General Utilities Screen Tree Diagram

FIGURE 4.1



General Utilities Menu

The General Utilities functions are displayed on three subsequent screens. (Figures 4.2, 4.3, & 4.4) Any of the functions may be selected while any of the three screens is displayed. Use the **9** KEY, **More**, to move from one screen forward to the next. Press the **0** KEY, **Exit**, to return to the main menu.

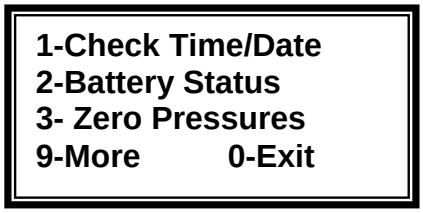


FIGURE 4.2

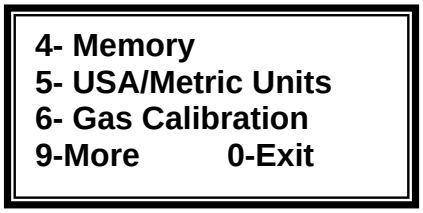


FIGURE 4.3

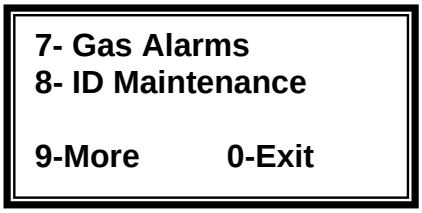


FIGURE 4.4

General Utilities Functions

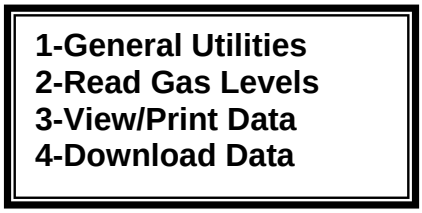
1. **CHECK TIME/DATE:** Set or check time and date.
2. **BATTERY STATUS:** Graphic display of the percentage of power remaining in the batteries.
3. **ZERO PRESSURES:** Zero pressure transducers.
4. **MEMORY:** Check available memory and facilitate clearing of all data and ID information.
5. **USA/METRIC UNITS:** Select either USA standard (Imperial) or metric (SI) measurement units.
6. **GAS CALIBRATION:** Field-calibrate Methane, Carbon Dioxide and oxygen with special gas mixtures for increased accuracy.
7. **GAS ALARMS:** Set gas alarm levels.
8. **ID MAINTENANCE:** View, enter, edit and delete well ID information.

Check Time/Date

There is an internal clock and calendar in the GEM™500 powered by a secondary battery that maintains the clock function when the GEM™500 is turned off. As each reading is stored in the GEM™500, it is time and date stamped. Both the clock and calendar are set by LANDTEC; however, they should be reset to the local time zone and checked weekly thereafter.

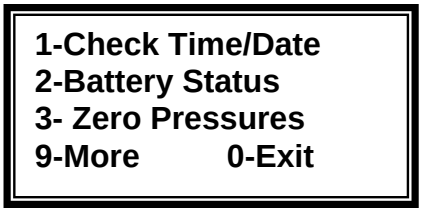
1. From the Main Menu, press the **1** KEY, **General Utilities**, for the General Utilities Sub-Menu screen.

FIGURE 4.5



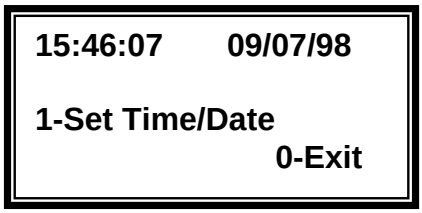
2. (Figure 4.6). Press the **1** KEY, **Check Time/Date**, on the General Utilities Sub-Menu screen to access the Check Time/Date function.

FIGURE 4.6



3. Press the **1** KEY, **Set Time/Date**, to proceed. (Figure 4.7)

FIGURE 4.7

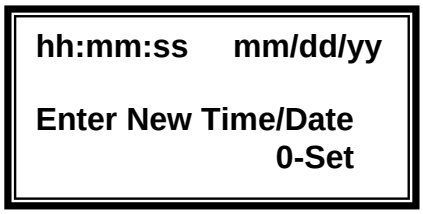


4. The time and date are displayed on the top line of the screen. A 24-hour clock or military time is used. If the time is after 12 noon, add 12 to the hour to convert it to the 24-hour format. Example: 3 p.m. is 12+3 = 15:00 hours. The time format is Hours: Minutes: Seconds. The date format used in the example is in U.S. calendar format with the month first and day second (mm/dd/yy).

5. If the time and date are accurate, end procedure by pressing the **0** KEY to **Exit** to the General Utilities Sub-Menu screen. If the time or date, or both, is wrong, press the **1** KEY, **Set Time/Date**.

6. Set the time and date by entering numbers from the GEM™500 keyboard. For setting the time hh = hours, mm = minutes, and ss = seconds. The date is entered in the U.S. calendar format where mm = months, dd = days, and yy = years. When finished, press the **0** KEY to **Set**.

FIGURE 4.8



NOTE: If it is necessary to correct an entry error, use the 0 KEY as a Backspace Key by holding it down for 1 second. In normal use, the 0 KEY is quickly pressed and released.

7. After setting, one of two screens displays. If the date is valid, Figure 4.9 displays for three seconds. If the time or date is invalid, Figure 4.10 displays. The time or date is invalid when impossible numbers are entered into the field. For example, mm=15 is an invalid month. Return to step 5 above and re-enter the correct time or date as instructed.

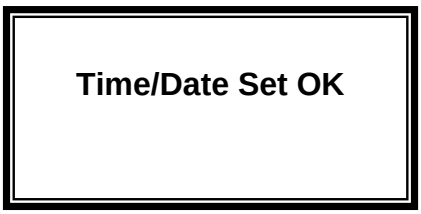


FIGURE 4.9

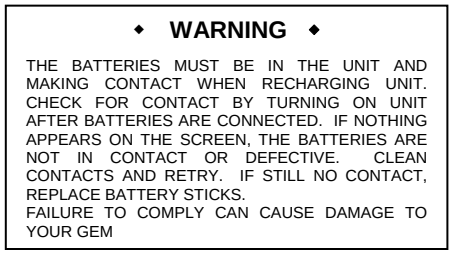
FIGURE 4.10

Battery Status

A Fast charger came with the GEM™500. The Fast charger takes approximately 2.5 hours for a 90% charge. The charger will automatically switch to a slow charge after this time to prevent damage to the batteries. The fast charger may be left connected overnight without damage to the NiCad batteries. When the GEM™500 is fully charged, it should be able to operate continuously for 6-8 hours depending upon the battery used and how it was charged. The GEM™500 may be operated with alkaline batteries, however, **ONLY** the NiCad batteries can be recharged. If the GEM™500 is without batteries for more than 30-45 minutes, memory/data loss will occur and the internal backup battery will run down. If this occurs, the unit will need to be returned to the lab for service.

WARNING! DO NOT TRY TO RECHARGE ALKALINE BATTERIES – DAMAGE TO THE UNIT WILL OCCUR. (Figure 4.11)

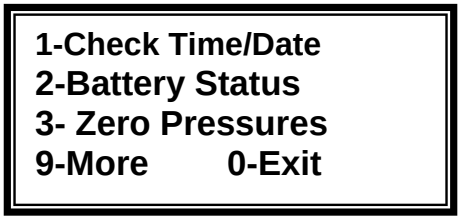
Figure 4.11



1. From the Main Menu, press the **1** KEY, **General Utilities**, for the General Utilities Sub-Menu screen.

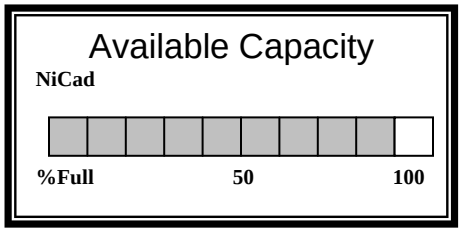
2. Press the **2** KEY, **Battery Status**, on the General Utilities Sub-Menu screen as shown in Figure 4.12.

FIGURE 4.12



3. The battery status graph displays the percentage of power remaining in the battery. When the graph reads 20-30%, a battery symbol indicator displays on the upper right of the screen, indicating approximately 1 hour of use remaining. When finished viewing the screen, press the **0** KEY to **Exit**.

FIGURE 4.13



Zero Pressures

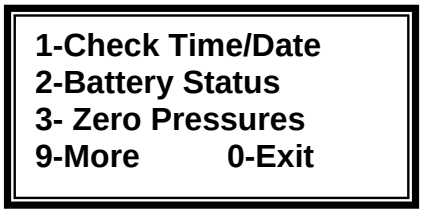
The GEM™500 measures atmospheric pressure as part of the LFG flow calculation. To properly measure pressure and the vacuum used in landfill gas extraction systems, the pressure transducers must be reset to zero each time before taking a pressure or vacuum reading.

This procedure may also be done prior to doing any **Read Gas Levels** because the **Zero Pressures** function is also contained on the **Read Gas Levels** Sub-Menu screen as shown in Chapter 5.

1. From the Main Menu, press the **1** KEY, **General Utilities**, for the General Utilities Sub-Menu screen.

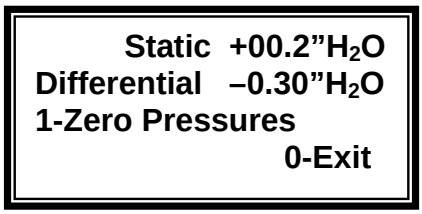
2. Press the **3** KEY, **Zero Pressures**, on the General Utilities Sub-Menu screen as shown in Figure 4.14.

FIGURE 4.14



3. Figure 4.15 displays the current readings of the static and differential pressure transducers. If both pressures do not read 00.0 **DISCONNECT ANY HOSES** ATTACHED TO THE GEM™500 and press the **1** KEY, **Zero Pressures**.

FIGURE 4.15



Note: Units displayed are inches of water column or (millibar) MB depending on measurement unit selected (USA or metric).

4. After the pressures have been zeroed, Figure 4.16 appears for three seconds. The Zero Pressures screen (Figure 4.15) then redisplays.

FIGURE 4.16

5. Press the **0** KEY, **Exit,** to return to the General Utilities Sub-Menu screen.

Memory

CAUTION: THIS FUNCTION CAN ERASE ALL STORED DATA. ONCE CLEARED, THE DATA CANNOT BE RECOVERED.

All well IDs and readings are stored in the GEM™500's memory. Eventually the memory becomes full. After each day's readings are completed, the remaining amount of memory should be checked. Normally, the readings for the day are downloaded to a computer. Downloading copies the information but does not clear it out of memory. That must be done manually, as described below. If the memory becomes full, a **MEMORY FULL** message displays. When this happens, the memory must also be manually cleared.

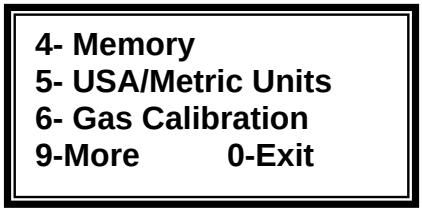
The GEM™500 can store many well IDs. It is, therefore, possible to use it on several landfills.

1. From the Main Menu, press the **1** KEY, **General Utilities**, for the General Utilities Sub-Menu screen.

2. Since the **Memory** function is not on the first General Utilities screen, press the **9** KEY, **More**, for the next screen, or enter **4** at this screen.

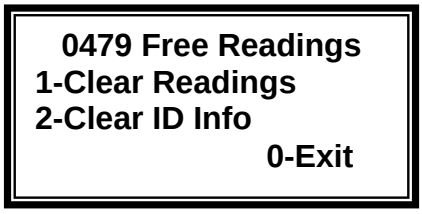
3. Press the **4** KEY**, Memory**, on the General Utilities Sub-Menu screen (Figure 4.17).

FIGURE 4.17



4. The amount of available memory left in the GEM™500 displays on The Number of Free Readings screen. (Figure 4.18) Three choices may be made on this screen. Press the **1** KEY, **Clear Readings**, to erase all gas/data readings but leave the IDs. Press the **2** KEY, **Clear ID Info**, to erase all ID numbers and the associated readings that have accumulated in the GEM™500 from the ID MAINTENANCE and READ GAS functions. Press the **0** KEY, **EXIT**, to ESCAPE from the procedure and return to the General Utilities Sub-Menu screen.

FIGURE 4.18



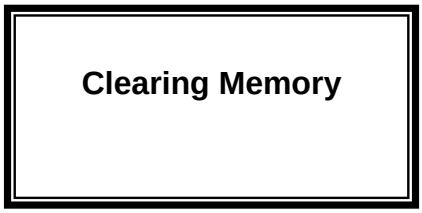
CAUTION: THIS STEP ERASES STORED DATA. YOU MAY WANT TO DOWNLOAD THE DATA FIRST SO IT IS NOT LOST.

5. After making your choice from the screen above, the Caution screen displays (Figure 4.19). As a final safety check, the code **0102** must be input from the GEM™500 keyboard to clear the memory. **IF YOU DECIDE NOT TO CLEAR THE MEMORY AT THIS POINT, TURN THE GEM™500 OFF BY PRESSING THE RED ON/OFF KEY** or enter an incorrect code then press the **0** KEY, **EXIT**, to return to the Memory screen. Do not input 0102 unless you want to clear the memory.

FIGURE 4.19

6. Enter 0102 from the keyboard and press the **0** KEY, Exit. The Clearing Memory screen displays for 3 seconds if the memory was erased.

FIGURE 4.20



After the Clearing Memory screen displays, the Number of Free Readings screen (Figure 4.18) redisplays. Press the **0** KEY to **Exit** to the General Utilities Menu screen.

USA/Metric Units

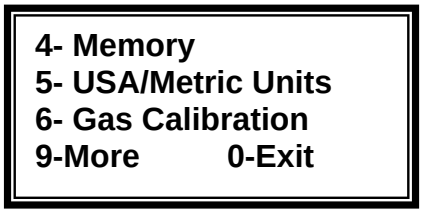
The GEM™500 can store and display data in 2 units of measure, Metric (SI) or Imperial (USA). This function allows setting the unit of measure.

1. From the Main Menu, press the **1** KEY, **General Utilities**, for the General Utilities Sub-Menu screen.

2. Since the **USA/Metric Units** function is not on the first General Utilities screen, press the **9** KEY, **More**, for the next screen, or enter **5** at this screen.

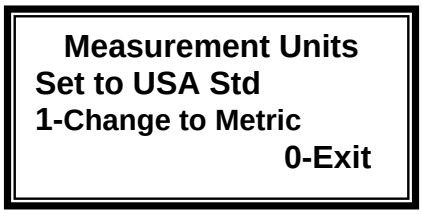
3. Press the **5** KEY, **USA/Metric Units**, on the General Utilities Sub-Menu screen (Figure 4.21).

FIGURE 4.21



4. The Measurement Units screen (Figure 4.22) displays how the GEM™500 is currently set (Set to USA Std or Set to Metric). Press the **1** KEY to change from USA Std to Metric. (This setting acts as a toggle switching from one to the other.) If the GEM™500 is currently displaying USA Std measurement units (Imperial — Btu's, Standard Cubic Feet, Fahrenheit temperatures, etc.) it switches to Metric and vice versa. When the GEM™500 is set to the correct measurement unit, press the **0** KEY, **Exit,** to return to the General Utilities Sub-Menu screen.

FIGURE 4.22



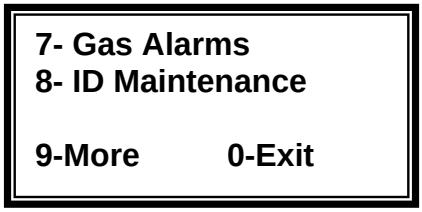
Gas Calibration
Please refer to Chapter 2 - Field Calibration for all information and instructions relating to the Gas Calibration function.

Gas Alarms
The GEM™500 has two alarm options that can warn the operator if a gas sample contains concentrations of **Methane below** established levels or **Oxygen above** preset levels. If the alarms are activated, there is a beeping and the affected gas blinks when displayed on the Read Gas Levels screen.

1. From the Main Menu, press the **1** KEY, **General Utilities**, for the General Utilities Sub-Menu screen.

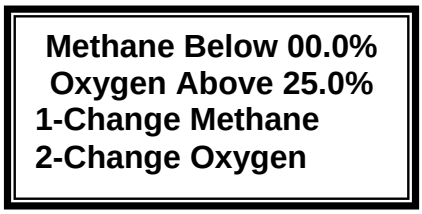
2. Since the **Gas Alarms** function is not on the first General Utilities screen, press the **9** KEY, **More**, for the next screen, or enter **7** at this screen. (Figure 4.23)

FIGURE 4.23



3. The Gas Alarm Set screen displays the alarm set point of both Methane and oxygen and presents the functions to change them. (Figure 4.24). Chose one to change the Methane alarm set point or two to change the oxygen alarm set point. If no change in alarm set points is required, press the **0** KEY, **Exit**, to return to the General Utilities Sub-Menu screen.

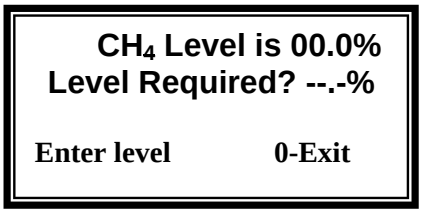
FIGURE 4.24



NOTE: To turn off alarms, set Methane alarm to 00.0% and oxygen alarm to 25.0%.

4. If the **1** KEY, **Change Methane**, is pressed, the Methane Alarm Set Point screen displays. (Figure 4.25) Using the numbered keys on the GEM™500 keyboard, input the new alarm level for Methane (CH_4). All three digits must be entered (XX.X%). The decimal point is automatically inserted. Press the **0** KEY to save and **Exit**.

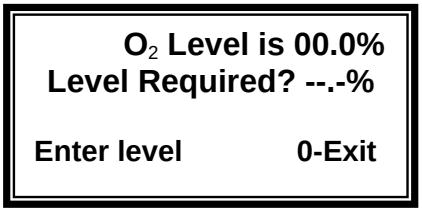
FIGURE 4.25



Note: If the GEM™500 receives CH_4 at or below this set point during the Read Gas Levels procedure, an audible alarm sounds to alert the operator.

5. If the **2** KEY, **Change Oxygen**, is pressed, the Oxygen Alarm Set Point screen displays. (Figure 4.26). Using the numbered keys on the GEM™500 keyboard input the new alarm level for oxygen (O_2). All three digits must be entered (XX.X%). The decimal point is automatically inserted. Press the **0** KEY to save and **Exit.**

FIGURE 4.26



Note: If the GEM™500 receives O_2 at or above this set point during the Read Gas Levels procedure, an audible alarm sounds to alert the operator.

6. Press the **0** KEY**, Exit,** to return to the General Utilities Sub Menu screen.

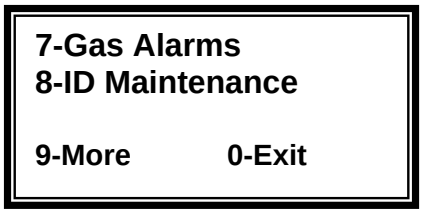
ID Maintenance

Each monitoring point on a site can be assigned a unique ID code using the ID Maintenance function. This code **must** be eight characters long. The characters can be any combination of letters and numbers. Typically, the landfill name or an abbreviation is used for the first four characters. After an ID code is entered (Step 4), the type of flow device (Accu-Flo, pitot tube, orifice plate or user defined) used at that ID location must also be entered (Step 5). Depending on the flow device selected, either no data, pipe ID (inner diameter), or both orifice and pipe ID size must also be entered.

1. From the Main Menu, press the **1** KEY, **General Utilities**, for the General Utilities Sub-Menu screen.

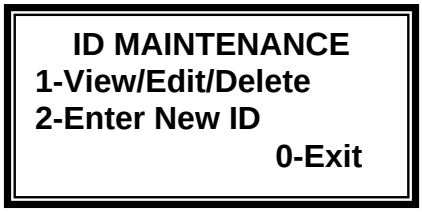
2. Since the **ID Maintenance** function is not on the first or second General Utilities screens, press the **9** KEY, **More**, twice or enter **8** at this screen. (Figure 4.27)

FIGURE 4.27



3. The ID Maintenance screen presents two options (*Figure 4.28)*. If a well already has an ID number, option one, View/Edit/Delete should be accessed. If a well has no ID assigned in the GEM™500, press the **2** KEY to **Enter New ID**.

FIGURE 4.28



4. Both numbers and letters can be input on the Enter ID screen. Use the **BLUE** *ƒ* KEY to switch (toggle) between numbers and letters. See Keyboard Information in the Getting Started Section at the beginning of this Manual.

   - For numbers, press the keypad **Number** KEYS (0-9). (Figure 4.29)

   - For letters, press the **1** KEY (**UP ARROW**) or **6** KEY (**DOWN ARROW**) to scroll through the alphabet until the letter of choice appears. Press the **0** KEY to select the letter. (Figure 4.30)

   After the final character is entered, the unit displays **0-Cont**. Press the **0** KEY if the ID is correct and ready to enter; otherwise, press and **hold** the **0** KEY to backspace and make corrections.

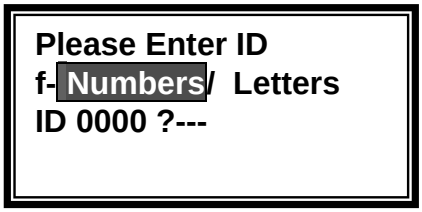


FIGURE 4.29

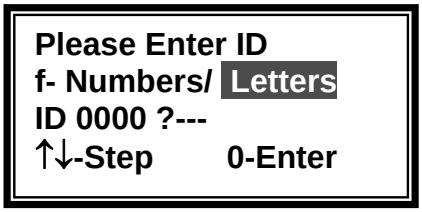
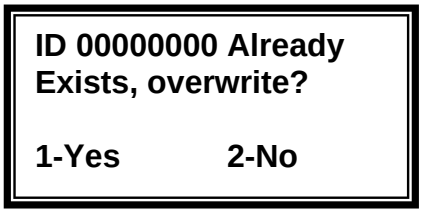


FIGURE 4.30

Note: When entering the very first well ID, four zeros will hold the first four places in the ID number. To replace these zeros with the well ID, use the 0 KEY to backspace over them by holding it down for more than a second. Then enter the first four characters of the well ID. These first four characters default to the second well ID entered, saving the user the time of reentering for each well.

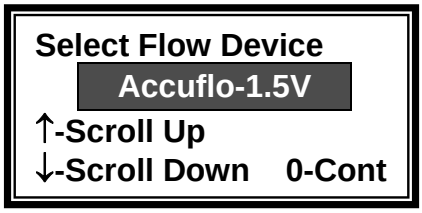
5. If an existing code is entered, the unit will ask if you want to overwrite. (Figure 4.31) If so, press the **1** KEY**, Yes**, to overwrite. If a mistake was made and an overwrite is not desired, press the **2** KEY, **No**, to return to the ID Maintenance screen. (Figure 4.28)

FIGURE 4.31



6. A well flow device is selected in the Flow Device screen. This selection is necessary for the GEM™500 to be able to calculate flow when readings are taken. Use the **1** KEY (**UP ARROW**) or the **6** KEY (**DOWN ARROW**) to scroll through the choices listed in Figure 4.33. Once the desired flow device is located in the shaded selection window, press **0** to select and **Continue**. (Figure 4.32)

FIGURE 4.32



Note: Selection of User Input allows the entry of flow in SCFM, if known. Those without a flow device may wish to use this selection to record velocity or other relevant data, (i.e. when using a Kurz meter).

FIGURE 4.33

Accuflo–1.5V (1½" Accu-Flo Model 150 Vertical Wellhead)
Accuflo–1.5H (1½" Accu-Flo Model 150 Horizontal Wellhead)
Accuflo–2V (2" Accu-Flo Model 200 Vertical Wellhead)
Accuflo–2H (2" Accu-Flo Model 200 Horizontal Wellhead)
Accuflo–3V (3" Accu-Flo Model 300 Vertical Wellhead)
Accuflo–3H (3" Accu-Flo Model 300 Horizontal Wellhead)
Orifice Plate (Orifice diameter and pipe inner diameter required)
Pitot Tube (Pipe ID required)
User Input (Pipe ID required)

7. If an Orifice Plate, Pitot Tube or User Input flow device is selected, additional information is required. If the pipe or orifice diameter screen appears, input the required size as necessary. Insert inches or centimeters (depending on whether U.S. or Metric Units were selected on the USA/Metric Units screen). The unit uses XX.XX as the format and automatically enters the decimal point. Press the **0** KEY to enter and **Continue**.

FIGURE 4.34

Enter Pipe ID

?-.-- Inches

8. The ID Stored OK Screen displays for three seconds (Figure 4.35) then the ID Maintenance displays so the next ID can be entered (Figure 4.36).

FIGURE 4.35

ID Stored OK

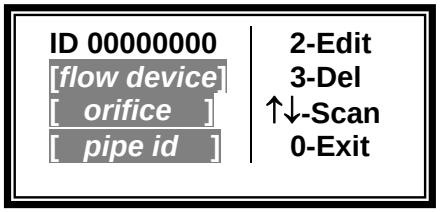
9. To View/Edit/Delete ID information, select the **1** KEY. (Figure 4.36)

FIGURE 4.36

ID MAINTENANCE
1-View/Edit/Delete
2-Enter New ID
0-Exit

10. The Well ID screen displays the Well ID and the associated flow device. The orifice and pipe data is also displayed if associated with a flow device. To scroll through the IDs stored in memory, use the **1** KEY, (**UP ARROW**) or the **6** KEY (**DOWN ARROW**). Press the **0** KEY to **Exit**.

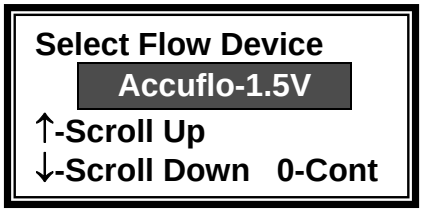
FIGURE 4.37



11. To edit the chosen Well ID information, press the **2** KEY, **Edit**. Use the **1** KEY (**UP ARROW**) or the **6** KEY (**DOWN ARROW**) to scroll through the choices listed in Figure 4.33. Once the desired flow device is located in the shaded selection window, press **0** to select and **Continue**. Press the **0** KEY, **Exit**, to return to the ID Maintenance screen. (Figure 4,38)

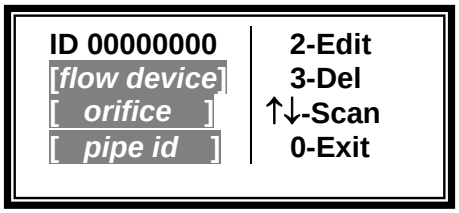
NOTE: Once the 2 KEY is pressed, the original flow device is erased and new data must be entered.

FIGURE 4.38



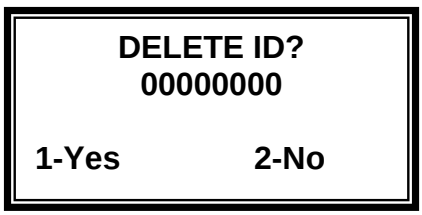
12. To delete a Well ID and the associated flow device, press the **3** KEY, **Delete**.

FIGURE 4.39



13. The Delete ID screen displays the Well ID chosen and asks for confirmation of the delete. If this Well ID ***should not*** be deleted, press the **2** KEY, **No**, (Figure 4.40). The unit cancels the delete command and returns to the Well ID screen (Figure 4.39). If this Well ID ***should*** be deleted, press the **1** KEY, **Yes**. The ID is deleted and the unit returns to the Well ID screen (Figure 4.39). Press the **0** KEY to **Exit** to the ID Maintenance screen.

FIGURE 4.40



14. Before leaving this section, store at least three IDs. These will be necessary for use in the following chapters.

Chapter 5 - Read Gas Levels

This section instructs the operator in how to use the GEM™500 to collect data from LFG extraction system wells and other monitoring points. Several things should be done prior to beginning to collect data readings with the GEM™500.

The operator should have performed the following:

- Check the TIME/DATE. (See Chapter 4 - General Utilities)
- Charge the unit's factory provided nickel cadmium batteries. (See Chapter 8 - Maintenance)
- Perform a Field Calibration on the unit. (See Section 3 - Field Calibration)

The GEM™500 is a sensitive measuring instrument. Vibration, shock, and great temperature changes can alter the field calibration. It is suggested that a field calibration be performed just prior to using the instrument at the site. Additional calibration is sometimes necessary in the field during the day.

WARNING! Review the warnings given in the beginning of this manual. The GEM™500 is NOT to be used in dangerous, explosive or confined atmospheres. Do NOT use the GEM™500 inside vaults, manholes, trenches or indoors. Do NOT block the exhaust port. If the exhaust port is blocked while the pump is operating, the pressure could force the unit to over-pressurize and damage the internal components and the case.

GEM™500 Hose and Wellhead

The proper hoses must be connected from the GEM™500 to the wellhead in order to collect data. As mentioned in the Getting Started Chapter, the clear hose with the external filter/water trap assembly is attached to the static pressure port on the GEM™500 (Figure 5.1). The almond colored male quick connect goes on the end of this hose to read the static pressure on the Accu-Flo Wellhead and the blue hose is connected to the impact port of the GEM™500.

On the following pages are examples of the Accu-Flo Wellhead, both vertical and horizontal models. Note the locations of the Static Pressure Port, Impact Pressure Port, Temperature Gauge, and Gas Sample Port.

Note: Five O-rings for quick disconnect fittings are supplied with Unit. Replace O-Rings when necessary because oxygen will be drawn into sample if O-rings are damaged. The GEM™500 pump will pull up to 80" of vacuum.

FIGURE 5.1

1. Static Pressure/Sampling Port—Measures static pressure when connected to wellhead static pressure port by hose. Always use water trap assembly.

2. Impact Pressure Port—Measures impact pressure when connected to wellhead impact pressure port by hose.

3. Exhaust Port—This port must be kept clear. If blocked while operating, over-pressurization and damage to internal components and case could occur.

4. Data Port - Used for Temperature Probe, POD, downloading data, and battery recharging.

LANDTEC Horizontal Accu-Flo Wellhead

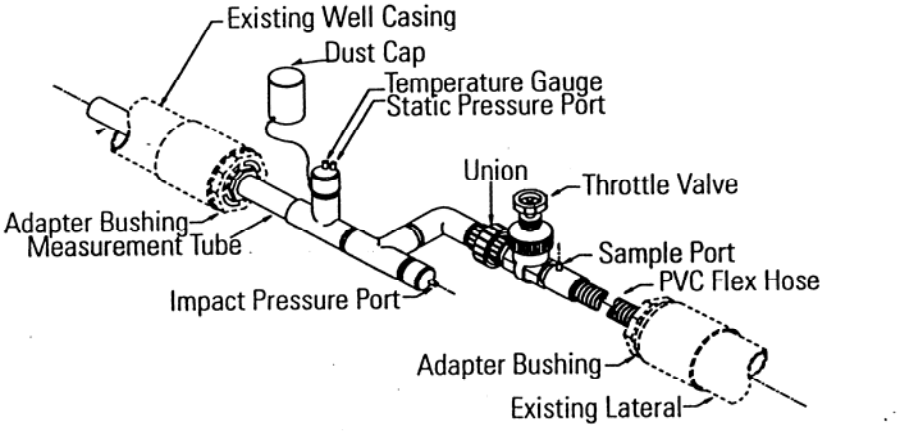


FIGURE 5.2

LANDTEC Vertical Accu-Flo Wellhead

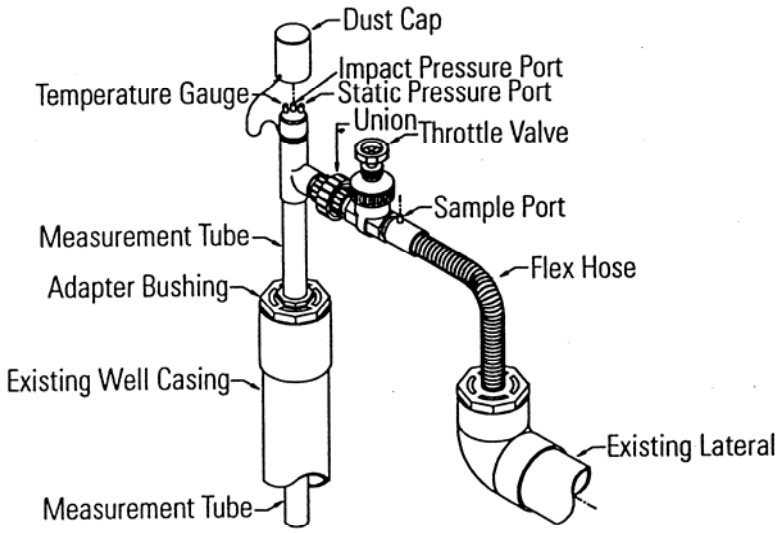
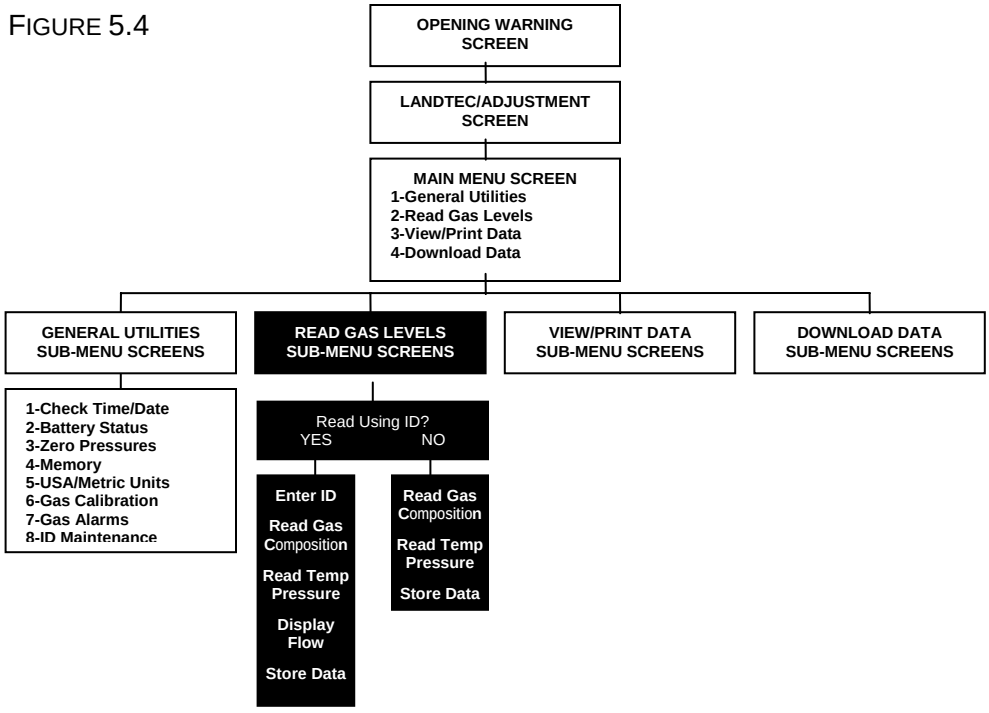


FIGURE 5.3

Read Gas Levels Screen Tree Diagram

FIGURE 5.4

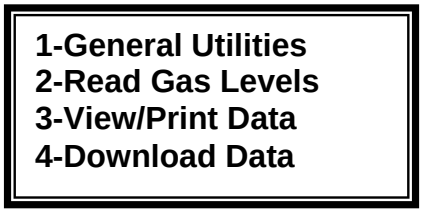


As shown in the screen tree diagram above (Figure 5.4), there are two menu paths that can be followed through the Read Gas Levels function. The path taken depends upon whether or not a well ID has been defined and stored in the GEM™500. Well IDs can be added at several points during this procedure.

Read Gas Levels Menu – Read Using ID? No

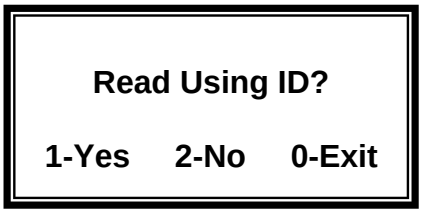
1. On the Main Menu screen press the **2** KEY (Figure 5.5) to initialize the Read Using ID screen.

FIGURE 5.5



2. The Read Using ID screen is displayed as shown in Figure 5.6. A choice needs to be made whether or not to read the well using an ID. If yes is chosen, a well ID is selected by scrolling through a list, or by entering the well ID manually. Typically, **NO** is chosen when a well only needs to be monitored or a well ID is not stored in memory in the unit.

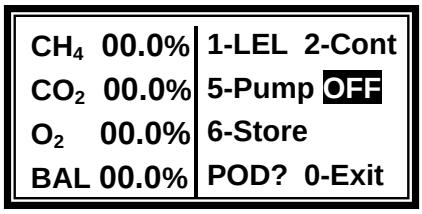
FIGURE 5.6



3. Select the **2** KEY, **No**.

4. Connect the GEM™500 to the wellhead with supplied hoses—Static Pressure/Sampling Port to the Static Pressure Port and Impact Pressure Port to Impact Pressure Port. The Gas Levels screen is divided into two parts. The left side of the screen displays current percentages of CH_4, CO_2, O_2, and BAL, which is the balance of all other gases excluding the CH_4, CO_2, and O_2. The right side of the screen displays functional choices for this reading (Lower Explosive Limit, Continue to temperature and pressure data, Pump On/Off, Last Data, Exit) and POD reminder.

FIGURE 5.7



POD refers to interchangeable electrochemical gas pods that are used to extend the measurement capabilities of the GEM™500 (Figure 5.8). These pods are available in seven different gases with nine different ranges and easily plug into the data port. The reminder lets the user know that if a pod were attached at this time, additional gas readings could be taken.

FIGURE 5.8

Interchangeable Electrochemical Gas Pods

Gas	Range (ppm)	Resolution (ppm)
H_2S	0 – 50	0.1
	0 – 200	1.0
CO	0 – 1000	1.0
SO_2	0 – 20	0.1
	0 – 100	1.0
NO_2	0 – 20	0.1
Cl_2	0 – 20	0.1
H_2	0 – 1000	1.0
HCN	0 – 100	1.0

5. Press the **5** KEY, **Pump**, to start the pump and draw a gas sample into the GEM™500. The **5** KEY, **Pump**, works as a toggle switch to turn the pump on and off. Once the pump is turned on, the readings are not considered to be accurate until the percentages on the left side of the display stabilize, typically within 30-45 seconds. A timer displays on the screen to monitor the pump running time.

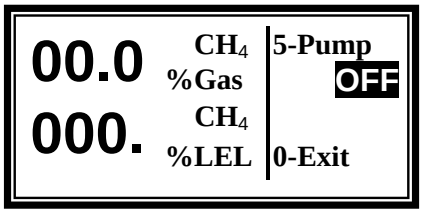
FIGURE 5.9

CH_4 00.0%	**1-LEL 2-Cont**
CO_2 00.0%	**5-Pump OFF**
O_2 00.0%	**9-Last Data**
BAL 00.0%	**POD? 0-Exit**

Note: The GEM™500 may sound an alarm (beeping) while taking gas readings. The alarm means that gas levels set in General Utilities Gas Alarms (page 31) have been reached or exceeded. In addition to the alarm, the screen display of the gas that set off the alarm will also blink.

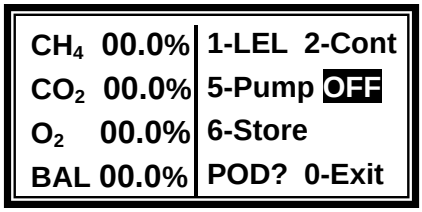
6. To monitor the LEL (Lower Explosive Limit), press the **1** KEY (Figure 5.9), to enter the LEL screen. If the LEL needs to be continuously monitored, just leave the pump running. When the LEL no longer needs to be monitored, press the **5** KEY again to toggle off the pump. Press the **0** KEY to Exit back to the Gas Levels screen.

FIGURE 5.10



7. To store the current readings press the **6** KEY, **Store**.

FIGURE 5.11



Since a well ID was not entered to begin with, one must now be entered. Use the **BLUE** *ƒ* KEY to switch (toggle) between numbers and letters. See Keyboard Information in the Getting Started Section at the beginning of this Manual.

- For numbers, press the keypad **Number** KEYS (1-0). (Figure 5.12)

- For letters, press the **1** KEY (**UP ARROW**) or **6** KEY (**DOWN ARROW**) to step through the alphabet until the letter of choice appears. Press the **0** KEY to select the letter. (Figure 5.13)

After the final character is entered, the unit displays **0-Cont**. Press the **0** KEY if the ID is correct and ready to enter; otherwise, press and **hold** the **0** KEY to backspace and make corrections.

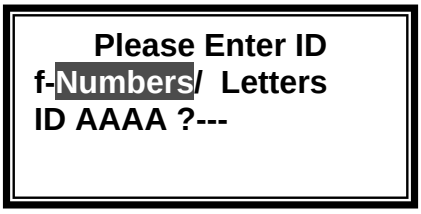


FIGURE 5.12

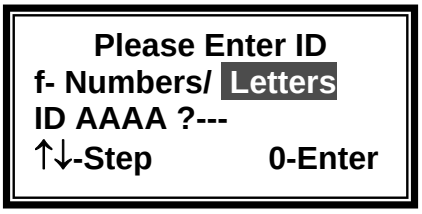


FIGURE 5.13

Note: Four letters from the previously entered ID default into the first four places of the ID number. To replace these letters, if needed, use the 0 KEY to backspace over them by holding it down for more than a second. Change the characters as needed.

9. On the Select Comments screen, use the **1** KEY to **Scroll Up** or the **6** KEY to **Scroll Down** through the comment list (Figure 5.15). When the correct comment appears in the comment display area, press the **2** KEY, to **Select**, then the **0** KEY to **Store** the readings.

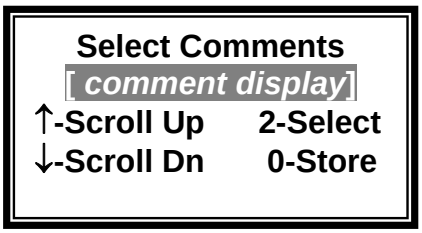


FIGURE 5.14

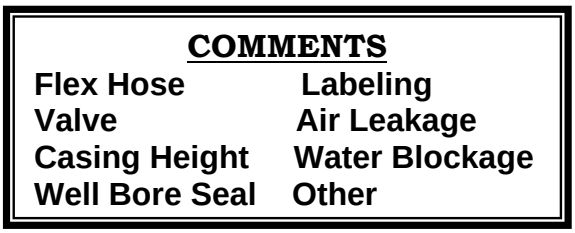


FIGURE 5.15

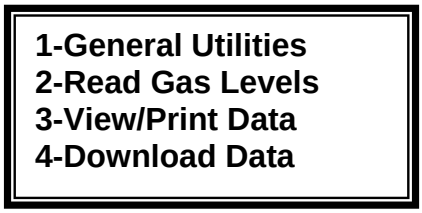
10. If the readings are successfully stored, the Readings Stored screen displays for three seconds (Figure 5.16). The Gas Levels screen (Figure 5.11) redisplays. The unit is now ready to accept another reading.

FIGURE 5.16

Read Gas Levels Menu – Read Using ID? Yes

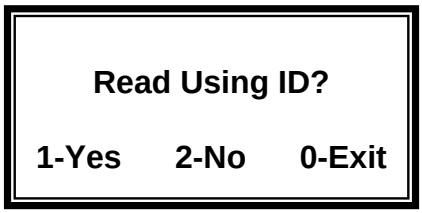
1. On the Main Menu screen, press the **2** KEY (Figure 5.17) to initialize the Read Using ID screen.

FIGURE 5.17



2. A choice needs to be made at the Read Using ID screen (Figure 5.18) whether or not to read the well using an ID. If **YES** is chosen, the well ID is selected by scrolling through a list or by entering the well ID manually. Typically, **NO** is chosen when a well only needs to be monitored or a well ID is not yet in memory.

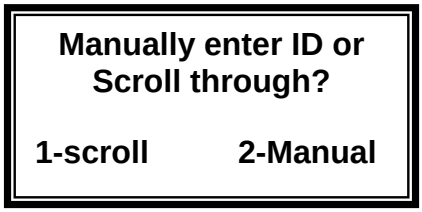
FIGURE 5.18



3. Select the **1** KEY **Yes**.

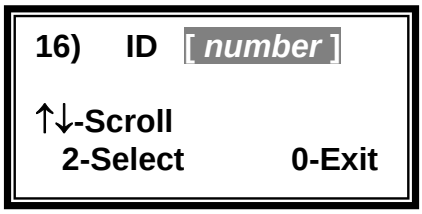
4. The Manually Enter ID screen allows the user to either scroll through a list of IDs that are already in memory or enter an ID manually. (Figure 5.19) If there are few IDs stored, it might be faster to use the scroll option; whereas the manual entry option might be faster to use if there are many IDs stored.

FIGURE 5.19



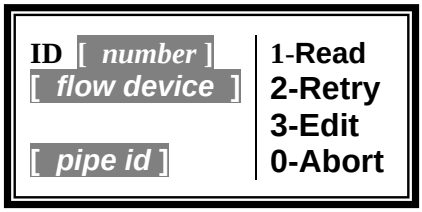
5. To scroll through the existing list of well IDs, press the **1** KEY, **Scroll**. The Select ID screen displays a single ID at a time. (Figure 5.20) Use the **1** KEY (**UP ARROW**) or the **6** KEY (**DOWN ARROW**) to scroll through the list. When the ID of choice is displayed, press the **2** KEY, **Select.**

FIGURE 5.20



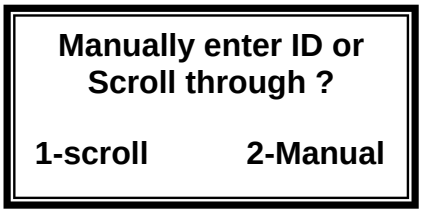
6. The chosen well ID and the type of flow device (Accu-Flo, Orifice Plate, Pitot Tube, or User Input) display on the left side of the screen and the Read, Retry, Edit, and Abort options display on the right. (Figure 5.21) Press the **1** KEY, **Read**, to continue to the Read Gas screen. (Skip to Step 14.)

FIGURE 5.21



7. To select manual entry press the **2** KEY, **Manual.**

FIGURE 5.22



8. Enter the well ID of choice. Use the **BLUE** *ƒ* KEY to switch (toggle) between numbers and letters.

   - For numbers, press the keypad **Number** KEYS (0-9). (Figure 5.23)
   - For letters, press the **1** KEY (**UP ARROW**) or **6** KEY (**DOWN ARROW**) to step through the alphabet until the letter of choice appears. Press the **0** KEY to select the letter. (Figure 5.24)

   After the final character is entered, the unit displays **0-Cont**. Press the **0** KEY if the ID is correct and ready to enter; otherwise, press and **hold** the **0** KEY to backspace and make corrections.

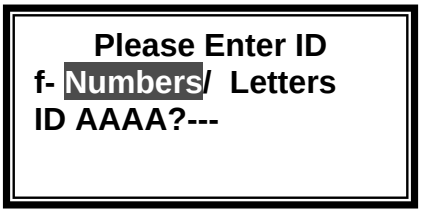


FIGURE 5.23

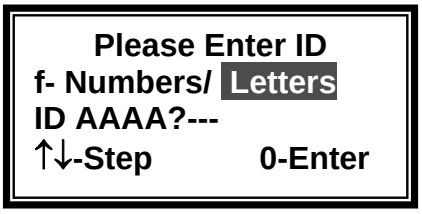
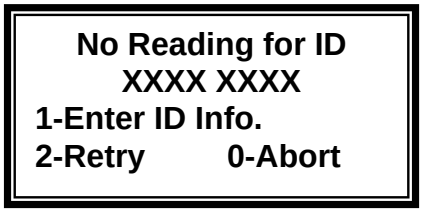


FIGURE 5.24

Note: Four letters from the previously entered ID default into the first four places of the ID number. To replace these letters, if needed, use the 0 KEY to backspace over them by holding it down for more than a second. Change the characters as needed.

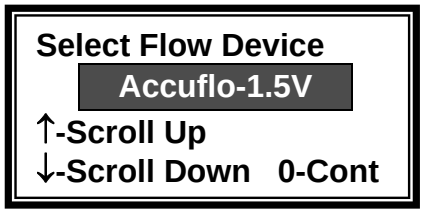
9. If the well ID is not yet entered into the unit, a No Reading screen appears. This screen provides three options. If the number is correct but has never been previously added, Enter ID Info. allows entry and flow device definition. If the well ID entered was in error, Retry takes the user back to the Manually Enter ID screen (Figure 5.22). The Abort command takes the user completely back out to the Main Menu (Figure 5.17). Press the **1** KEY, **Enter ID Info**.

FIGURE 5.25



10. A well flow device is selected in the Flow Device screen. This selection is necessary for the GEM™500 to be able to calculate flow when readings are taken. Use the **1** KEY (**UP ARROW**) or the **6** KEY (**DOWN ARROW**) to scroll through the choices listed in Figure 5.27. Once the desired flow device is located in the shaded selection window, press **0** to select and continue.

FIGURE 5.26



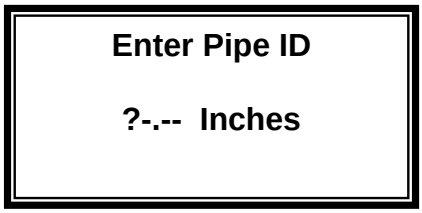
Note: Selection of User Input allows the eventual entry of flow in SCFM, if known (see Step 11). Those without flow devices may wish to use this selection to record velocity or other relevant data, (i.e. when using a Kurz meter).

FIGURE 5.27

Accuflo–1.5V (1½" Accu-Flo Model 150 Vertical Wellhead)
Accuflo–1.5H (1½" Accu-Flo Model 150 Horizontal Wellhead)
Accuflo–2V (2" Accu-Flo Model 200 Vertical Wellhead)
Accuflo–2H (2" Accu-Flo Model 200 Horizontal Wellhead)
Accuflo–3V (3" Accu-Flo Model 300 Vertical Wellhead)
Accuflo–3H (3" Accu-Flo Model 300 Horizontal Wellhead)
Orifice Plate (Orifice diameter and pipe inner diameter required)
Pitot Tube (Pipe ID required)
User Input (Pipe ID required)

11. If an Orifice Plate, Pitot Tube or User Input flow device is selected, additional information is required. If the pipe or orifice diameter screen appears, input the required size as necessary. Insert inches or centimeters (depending on whether USA or Metric Units were selected on the General Utilities USA/Metric units screen). The unit uses XX.XX as the format and automatically enters the decimal point. Press the **0** KEY to enter and continue.

FIGURE 5.28

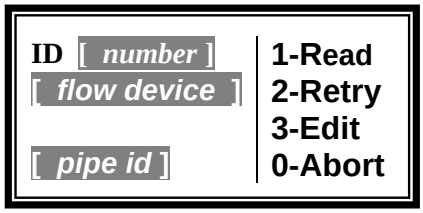


12. The ID Stored OK Screen displays for three seconds (Figure 5.29)

FIGURE 5.29

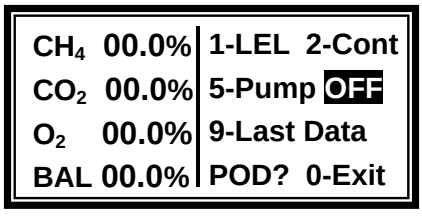
13. The chosen well ID and the type of flow device (Accu-Flo, Orifice Plate, Pitot Tube, or User Input) display on the left side of the screen and the Read, Retry, Edit, and Abort options display on the right. (Figure 5.30) Press the **1** KEY, **Read**, to continue to the Read Gas screen.

Figure 5.30



14. Connect the GEM™500 to the wellhead with the supplied hoses—Static Pressure/Sampling Port to the Static Pressure Port and Impact Pressure Port to Impact Pressure Port. The Gas Levels screen is divided into two parts. The left side of the screen displays current percentages of CH_4, CO_2, O_2, and BAL, which is the balance of all other gases excluding the CH_4, CO_2, and O_2. The right side of the screen displays functional choices for this reading (Lower Explosive Limit, Continue to temperature and pressure data, Pump On/Off, Last Data, Exit) and a POD reminder.

FIGURE 5.31



POD refers to interchangeable electrochemical gas pods that are used to extend the measurement capabilities of the GEM™500 (Figure 5.32). These pods are available in seven different gases with nine different ranges and easily plug into the data port. The reminder lets the user know that if a pod were attached at this time, additional gas readings could be taken.

FIGURE 5.32

Interchangeable Electrochemical Gas Pods

Gas	Range (ppm)	Resolution (ppm)
H_2S	0 – 50	0.1
	0 – 200	1.0
CO	0 – 1000	1.0
SO_2	0 – 20	0.1
	0 – 100	1.0
NO_2	0 – 20	0.1
Cl_2	0 – 20	0.1
H_2	0 – 1000	1.0
HCN	0 – 100	1.0

15. Press the **5** KEY, **Pump**, to start the pump and draw a gas sample into the GEM™500. The **5** KEY, **Pump**, works as a toggle switch to turn the pump on and off. Once the pump is turned on, the readings are not considered to be accurate until the percentages on the left side of the display stabilize, typically within 30-45 seconds. A timer displays on the screen to monitor the pump running time.

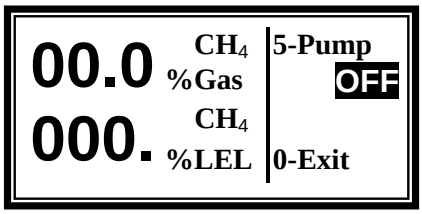
FIGURE 5.33

CH_4 00.0%	**1-LEL 2-Cont**
CO_2 00.0%	**5-Pump OFF**
O_2 00.0%	**9-Last Data**
BAL 00.0%	**POD? 0-Exit**

Note: The GEM™500 may sound an alarm (beeping) while taking gas readings. The alarm means that gas levels set in General Utilities Gas Alarms (page 31) have been reached or exceeded. In addition to the alarm, the screen display of the gas that set off the alarm also blinks.

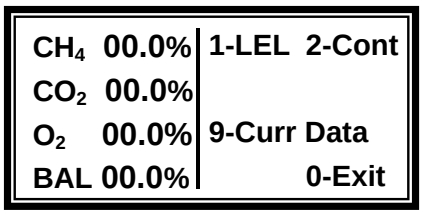
16. To monitor the LEL (Lower Explosive Limit), press the **1** KEY (Figure 5.33) to enter the LEL screen. If the LEL needs to be continuously monitored, just leave the pump running. When the LEL no longer needs to be monitored, press the **5** KEY again to toggle off the pump. Press the **0** KEY to Exit back to the Gas Levels screen (Figure 5.33).

FIGURE 5.34



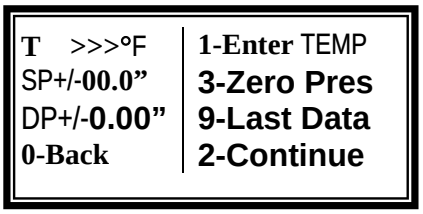
17. If at any time, while working on this screen, reference needs to be made to the prior reading on this wellhead, press the **9** KEY, **Last Data**. The unit displays the very last stored reading. The **9** KEY works as a toggle switch between the current reading and the last reading. From the Last Data (Figures 5.33 & 5.35) screen, the user can go directly into monitoring current LEL or continue directly to the current Temperature/Pressure screen.

FIGURE 5.35



18. From the Read Gas Levels screen (Figure 5.33), press the **2** KEY, Continue, for the Temperature and Pressure screen (Figure 5.36). This screen shows temperature, static pressure, differential pressure, and a number of functional options. If a temperature probe is used, it should be connected from the data port on the right side of the GEM™500 (Figure 5.1) to the temperature gauge port on the wellhead. When the temperature probe is connected to the GEM™500, the functional option Enter TEMP disappears as it displays only for manual entry. The temperature probe needs to remain in the wellhead until the entire reading is completed and stored. If a temperature probe is not used, the temperature can be read on a thermometer placed in the temperature gauge port on the wellhead and entered manually into the GEM™500. To enter the temperature manually, press the **1** KEY, **Enter TEMP**.

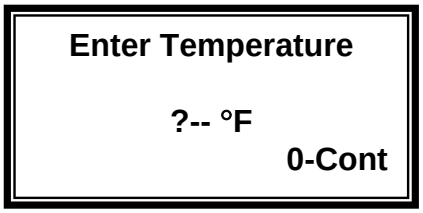
FIGURE 5.36



Note: If flow measurement is required, temperature must be entered either manually or with the optional temperature probe.

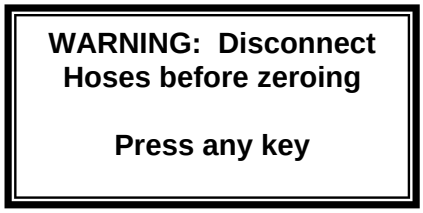
19. Temperature is entered in either Fahrenheit (F) or Celsius (C) depending on whether USA or Metric was chosen in the General Utilities USA/Metric Units screen (page 30). Number keys and leading zero(s) are used to enter a three digit temperature value, i.e., 78° is 078 and 5° is 005. Press the **0** KEY to Continue back to the Read Gas Levels screen (Figure 5.36).

FIGURE 5.37



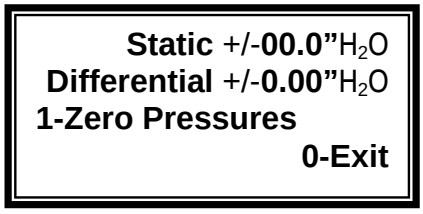
20. From the Read Gas Levels screen (Figure 5.36), press the **3** KEY, **Zero** Pressures, before proceeding. This is necessary because by taking a LFG sample, the impact port pressure transducers have been pressurized. The **Warning Disconnect hoses** screen displays before the Zero Pressure screen. (Figure 5.38). Disconnect all the hoses from the GEM™500 to the wellhead and press any key to continue.

FIGURE 5.38



21. The pressures displayed on the Static/Differential screen are displayed with either a positive or negative and need to stabilize (quit changing) before being zeroed. When stabilized, press the **1** KEY to **Zero Pressures**. (Figure 5.39)

FIGURE 5.39



Note: The units displayed are in inches of water column or MB depending on whether USA or Metric was chosen in the General Utilities USA/Metric Units screen (page 30).

22. The Zeroed OK screen (Figure 5.40) displays for 3 seconds, then the Static/Differential screen (Figure 5.41) redisplays. Occasionally the pressures will not zero completely. If this happens, press the **1** KEY, **Zero Pressures**, again until the pressures are completely zeroed. Once the static and differential pressures are zeroed, press the **0** KEY to **Exit.** The Temperature/Pressure screen then redisplays (Figure 5.42).

FIGURE 5.40

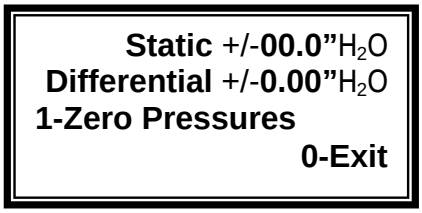


FIGURE 5.41

23. At the Temperature/Pressure screen, reconnect the hoses (Figure 5.43). Allow the instrument to read, then press the **2** KEY to Continue to the Flow/Btu screen.

FIGURE 5.42

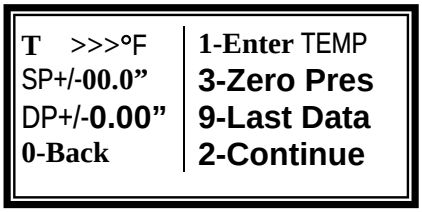


FIGURE 5.43

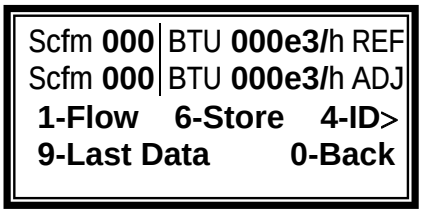
CONNECTIONS

1. **On an Accu-Flo wellhead, connect the Static Pressure/Sampling port (top left) on the GEM™500 to the Static Pressure Port on the wellhead, and the Impact Pressure Port on the wellhead. (Figures 5.1, 5.2, 5.3)**
2. **On a pitot tube, connect the hoses from the GEM™500 to the Impact and static Pressure ports.**
3. **On an orifice plate, connect the hoses on the GEM™500 to either side of the orifice plate.**

Note: To get a flow reading, the differential pressure (DP) must be positive with respect to the static pressure. If it is not, reverse the hoses.

The Flow screen displays the reference flow (REF) and adjusted flow (ADJ). The reference flow is static and will not change unless the Temperature/Pressure screen is re-accessed. Whereas the adjusted flow is active and is typically used to display changes in flow while adjustments are made. If an Accu-Flo, pitot tube, or orifice plate wellhead is in place, the GEM™500 automatically calculates the reference and adjusted flow. Other functions available here are the ability to store the data, go to the next wellhead ID, view the last data on this wellhead, or go back to the Temperature/Pressure screen. The units displayed on this screen, SCFM (Standard cubic feet per minute) and BTU (British Thermal Units, in thousands) are the USA units that are selected in the General Utilities USA/Metric Units screen (page 30).

FIGURE 5.44



If the flow needs to be changed, adjust the control valve on the wellhead. Within a few seconds the new flow is displayed on the GEM™500 as the adjusted value. When satisfied with the flow adjustment, press the **6** KEY to **Store** the information and continue to the Select Comments screen.

24. On the Select Comments screen, use the **1** KEY to **Scroll Up** or the **6** KEY to **Scroll Down** through a comment list (Figure 5.45). When the correct comment appears in the comment display area, press the **2** KEY, to **Select**, then the **0** KEY to store the readings.

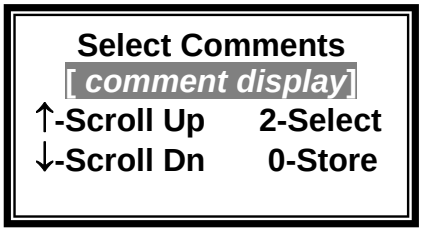


FIGURE 5.45

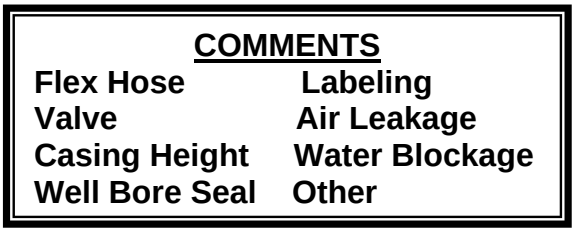


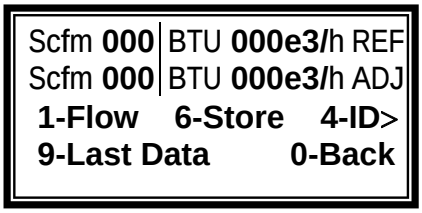
FIGURE 5.46

25. If the readings are successfully stored, the Readings Stored screen displays for three seconds (Figure 5.47). The Flow screen (Figure 5.44) redisplays.

FIGURE 5.47

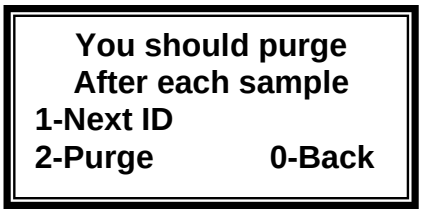
26. Press the **4** KEY, **ID** to advance to the next wellhead ID in memory. If the wellhead IDs were loaded into the GEM™500 in order, the unit will purge and the next ID will display after purge is completed.

FIGURE 5.48



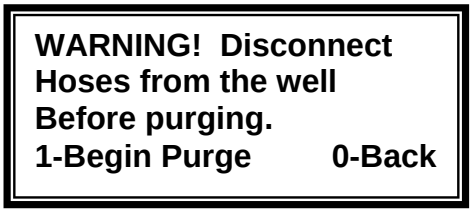
27. The Purge Prompt Screen (Figure 5.49) reminds the user that the GEM™500 needs to have any residual gases purged from its system to guarantee the accuracy of the next reading. Press the **2** KEY, **Purge,** to initialize the purge process.

FIGURE 5.49



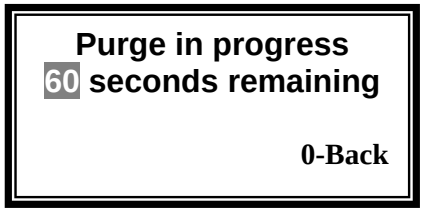
28. The Warning screen displays to remind the user to disconnect the hoses from the wellhead before starting the purge process. Once the hoses are removed, press the **1** KEY to begin the purge (Figure 5.50).

FIGURE 5.50



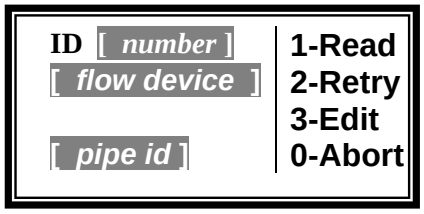
29. The pump starts and the Purge in Progress screen displays the number of seconds remaining in the purge (Figure 5.51). This purge process can be taking place while walking to the next wellhead.

FIGURE 5.51



30. The pump will run for 60 seconds and then shut off allowing the next well ID to be displayed. (Figure 5.52)

FIGURE 5.52



Cross-Gas Effects

Methane
The Methane reading is filtered to an infrared absorption frequency of 3.41μm (nominal), the frequency specific to hydrocarbon bonds. Instruments are calibrated using certified Methane mixtures and will give correct readings provided there are no other hydrocarbon gasses present within the sample (e.g. ethane, propane, butane, etc.). If there are other hydrocarbons present, the Methane reading will be higher (never lower) than the actual Methane concentration being monitored.

The extent to which the Methane reading is affected depends upon the concentration of the Methane in the sample and the concentration of the other hydrocarbons. The effect is non-linear and difficult to predict.

Carbon Dioxide
The Carbon Dioxide reading is filtered to an infrared absorption frequency of 4.29μm (nominal), the frequency specific to Carbon Dioxide. Therefore, any other gases usually found on landfill sites will not affect the Carbon Dioxide reading.

Oxygen
The Oxygen sensor is a newly developed galvanic cell type and suffers virtually no influence from CO_2, CO, H_2S, NO_2, SO_2 or H_2, unlike many other types of Oxygen cell.

The infrared sensors will not be "poisoned" by other hydrocarbons. Normal operation will resume as soon as the gas sample has been purged.

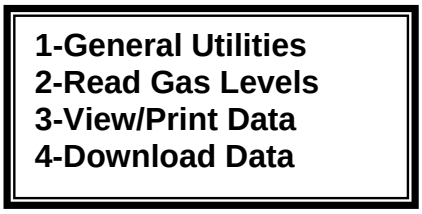
Note - there has been one reported incident of a high reading due to the presence of Carbon Disulphide, which has a similar absorption frequency to Carbon Dioxide.

Chapter 6 - View Data

View Data

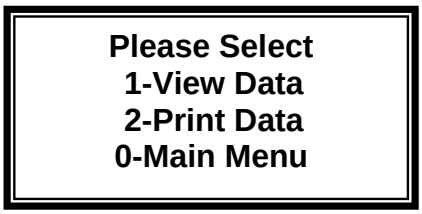
1. From the Main Menu, select the **3** KEY, **View Data** (Figure 6.1)

FIGURE 6.1



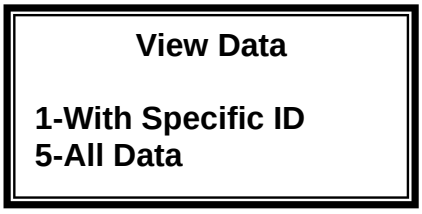
From the View/Print Select screen, the user can choose to view data, print data or return to the main menu. Press the **1** KEY, **View Data** to view data in memory in the GEM™500.

FIGURE 6.2



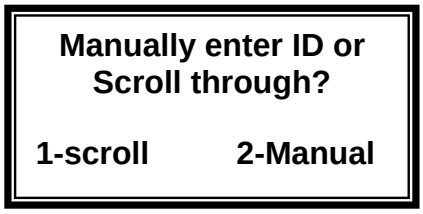
To view data from just one wellhead, press the **1** KEY, **With Specific ID**. This option allows manual entry of a single wellhead ID. If data from all wellheads needs to be viewed, press the **5** KEY, **All Data** and proceed to step 4.

FIGURE 6.3



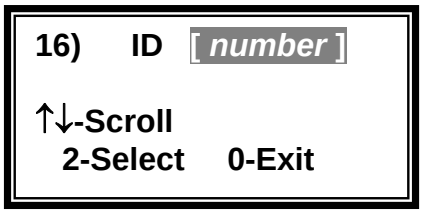
The Manually Enter ID screen allows the user to either scroll through a list of IDs that are already in memory or enter an ID manually. If there are few IDs stored, it might be faster to use the scroll option; whereas the manual entry option might be faster to use if there are many IDs stored (Refer to page 44 number 7). (Figure 6.4)

FIGURE 6.4



2. To scroll through the existing list of well IDs, press the **1** KEY, **Scroll**. The Select ID screen displays a single ID at a time. Use the **1** KEY (**UP ARROW**) or the **6** KEY (**DOWN ARROW**) to scroll through the list. When the ID of choice is displayed, press the **2** KEY, **Select.** (Figure 6.5)

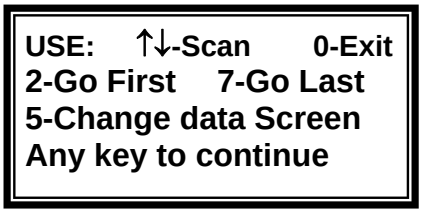
FIGURE 6.5



3. The following options are used to move around within the Data screens: (Figure 6.6)

- ↑↓-Scan – Use the **1** KEY (**UP ARROW**) or the **6** KEY (**DOWN ARROW**) to scroll through the list.
- 2-Go First – Use the **2** KEY to go to the first well ID in the list.
- 5-Change Data Screen – Use the **5** KEY to toggle between the Gas Concentrations screen (Figure 6.7) and the Flow screen (Figure 6.8).
- 7-Go Last – Use the **7** KEY to go to the last well ID in the list.
- 0-Exit – Use the **0** KEY to exit at any time.

FIGURE 6.6



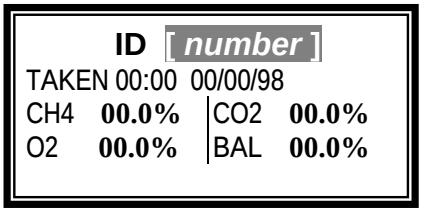


FIGURE 6.7

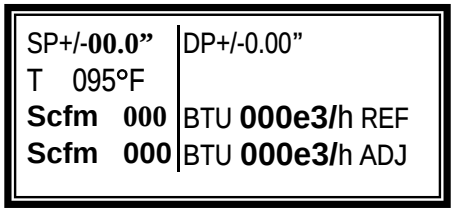


FIGURE 6.8

Chapter 7 – Communications

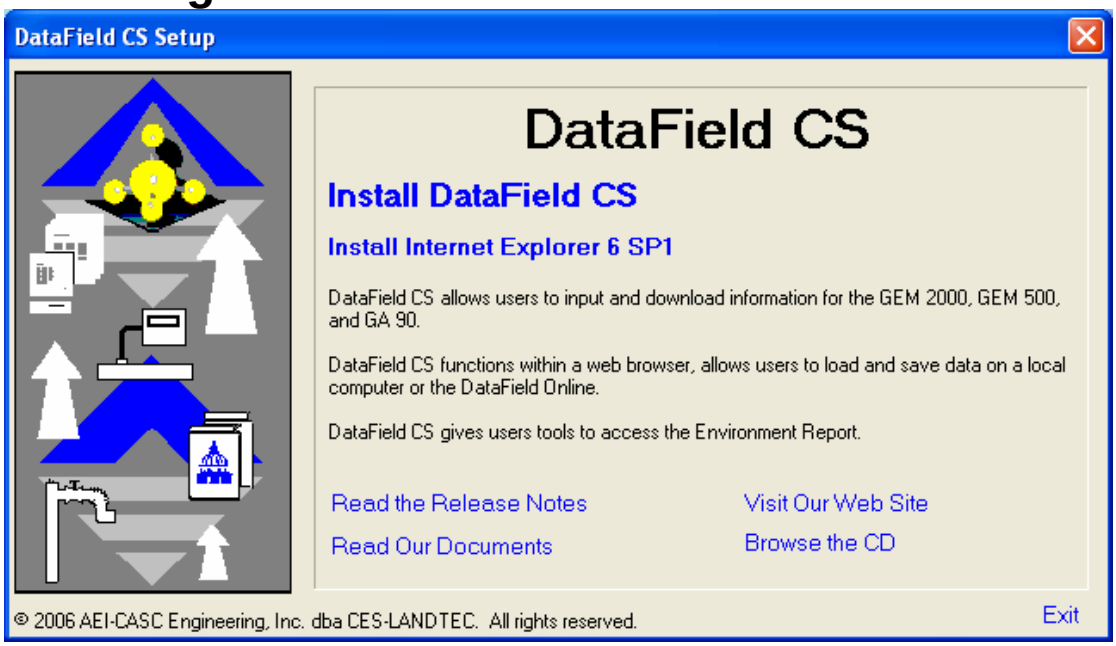
DataField CS Software

DataField CS is an integrated software program designed to communicate with the GEM™2000, GEM™500 and GA-90 instruments. The software will create files used for storing gas read data, ID data, comments and instrument configuration data. The files created are significantly different from the files created with GEM_COMM or GA_COMM software and are not compatible with these versions of software.

DataField CS is browser based (Java enabled) and will operate on Windows98 and higher Windows operating systems. Recommended hardware requirements are:

- Pentium III 500 MHz microprocessor or equal.
- 64 MB RAM.
- 120 MB of free hard disk space.
- CDROM drive.
- Mouse or pointer system.
- Standard keyboard.
- Installed printer.

Installing DataField CS



Be sure your computer is turned on and all software programs have been properly closed. Place the program disk in the CD ROM drive and close the tray. DataField CS will self start and display the DataField CS setup screen.*

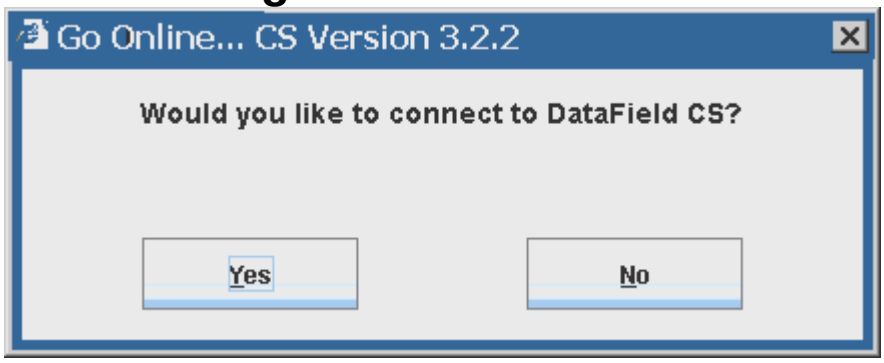
Install the Internet Explorer 6 SP1 by clicking on the corresponding link in the DataField CS set-up screen. If you are using Windows 95, install the Internet Explorer 5.5. Follow the onscreen instructions until the Internet Explorer is installed successfully.
Reboot the computer after the installation of the Internet Explorer is completed.
Re-insert CD Rom to start Autorun again.
Install the DataField CS by clicking on the corresponding link in the DataField CS set-up screen. Follow the onscreen instructions.

Other useful links on the DataField CS set-up screen:

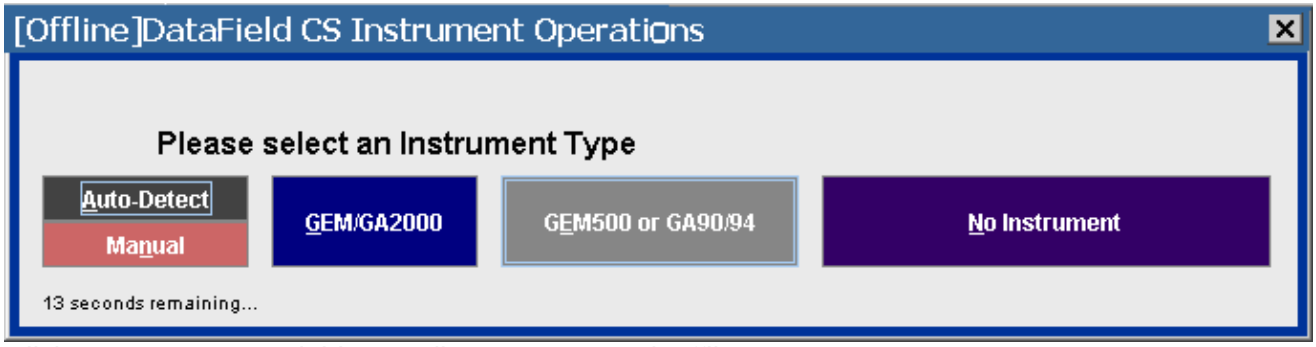
Read the DataField CS Overview link will open a presentation with an overview of DataField CS.
Read the Release Notes link has information on the system requirements, application compatibility and other important issues.
Visit Our Web Site link will open the LANDTEC web site.
Read Our Documents link will open a new window with manuals and user guides for GEM Instruments, as well as several viewers and 3rd party tools that can be downloaded.
Browse the CD link will open a file browser.
Information / Data Sheets set of links provides information on various Landfill instruments.

* If the DataField CS set-up screen hasn't appeared, open a file browser (ex. right-click on the Start button on your desktop and choose open) and navigate to your CD-ROM drive. Double-click on the **Autorun.exe**.

Establishing Communications



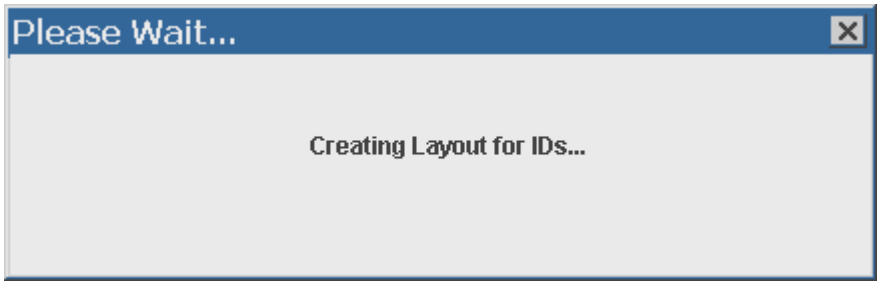
Click on the Start menu then Programs menu. Scroll to DataField and then DataField CS to start the software. The following screen will appear on the computer.

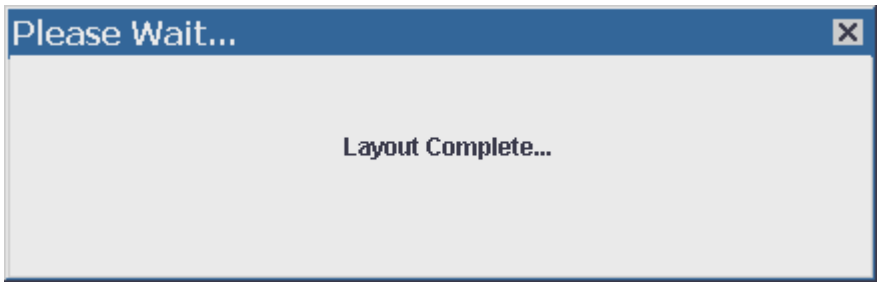


Click Yes to run DataField CS online or No to run it offline.

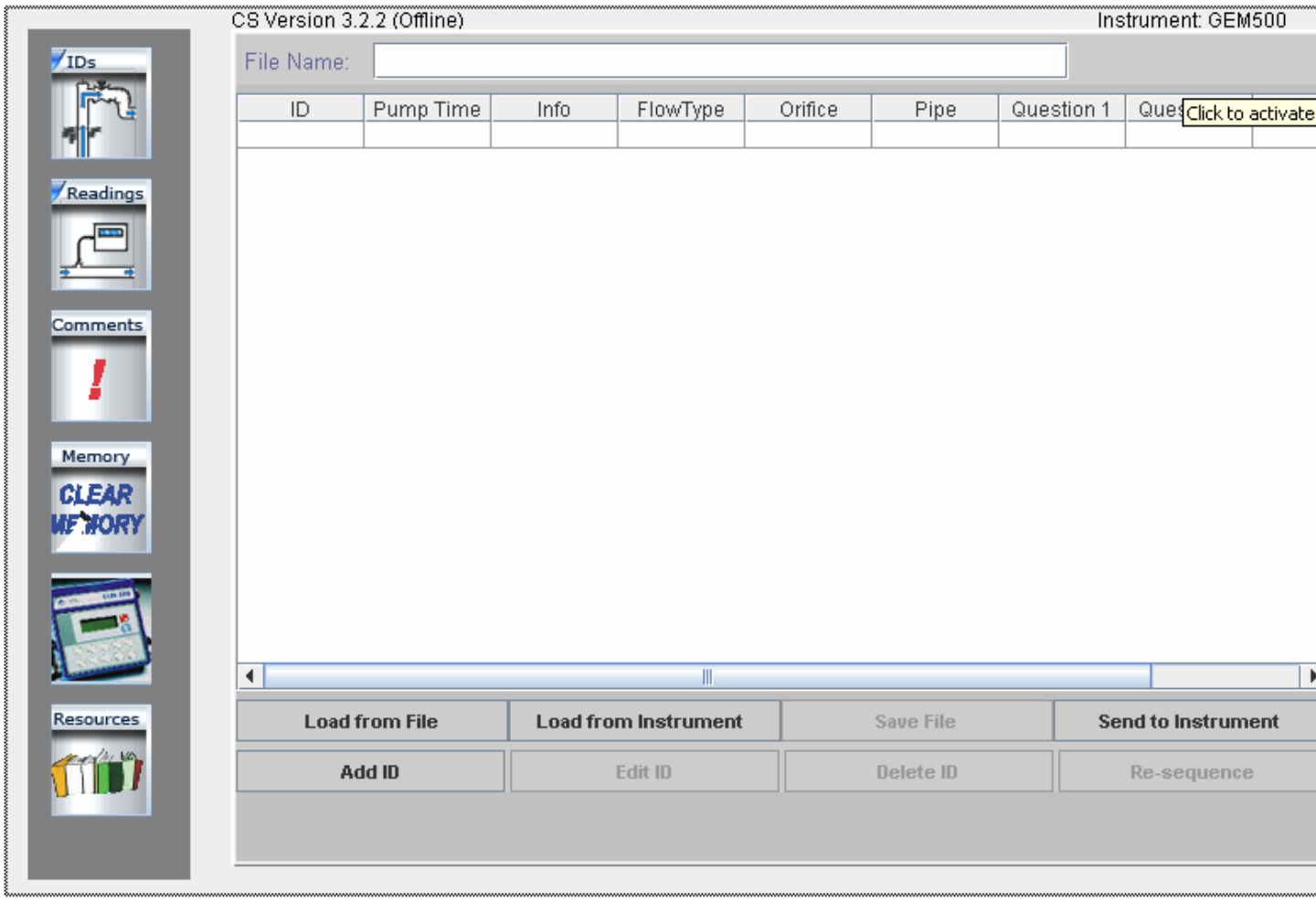
Now select "GEM500 or GA90/94". You can also click on the Auto-Detect button for the DataField CS to automatically detect the instrument.

Before clicking OK, connect the cable to the computer, plug the cable into the instrument, and turn on GEM500/GA90. Wait for self test. Then press “0” followed by “4” to go into the download mode. Now the instrument is ready to establish communications. Press “OK”.





Main Screen



Once DataField CS establishes communications with the instrument, the main software screen will appear.

Six main categories (buttons) are listed down the left side of the screen: ID Functions, Readings, Comments, Clear Memory, Instrument Settings and Resource Links. Clicking on any one of the buttons will take the user to that functionality of the application.

Close the program

Clicking on the **Close** button in the top right corner of the screen will exit the program. This will close all files and exit the program.

Communications

It is not possible to change instruments and establish communications without re-starting the software.

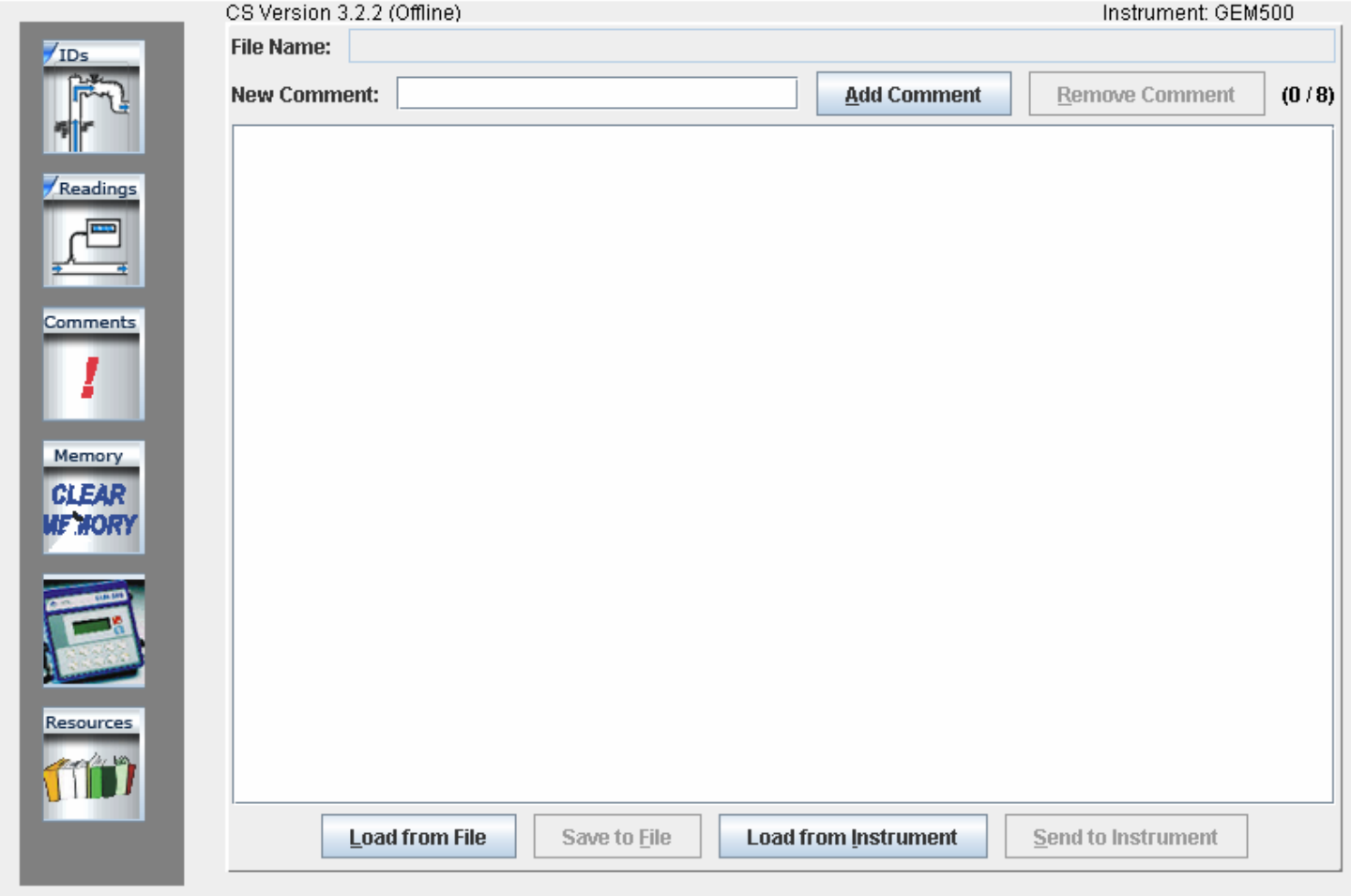
Functions

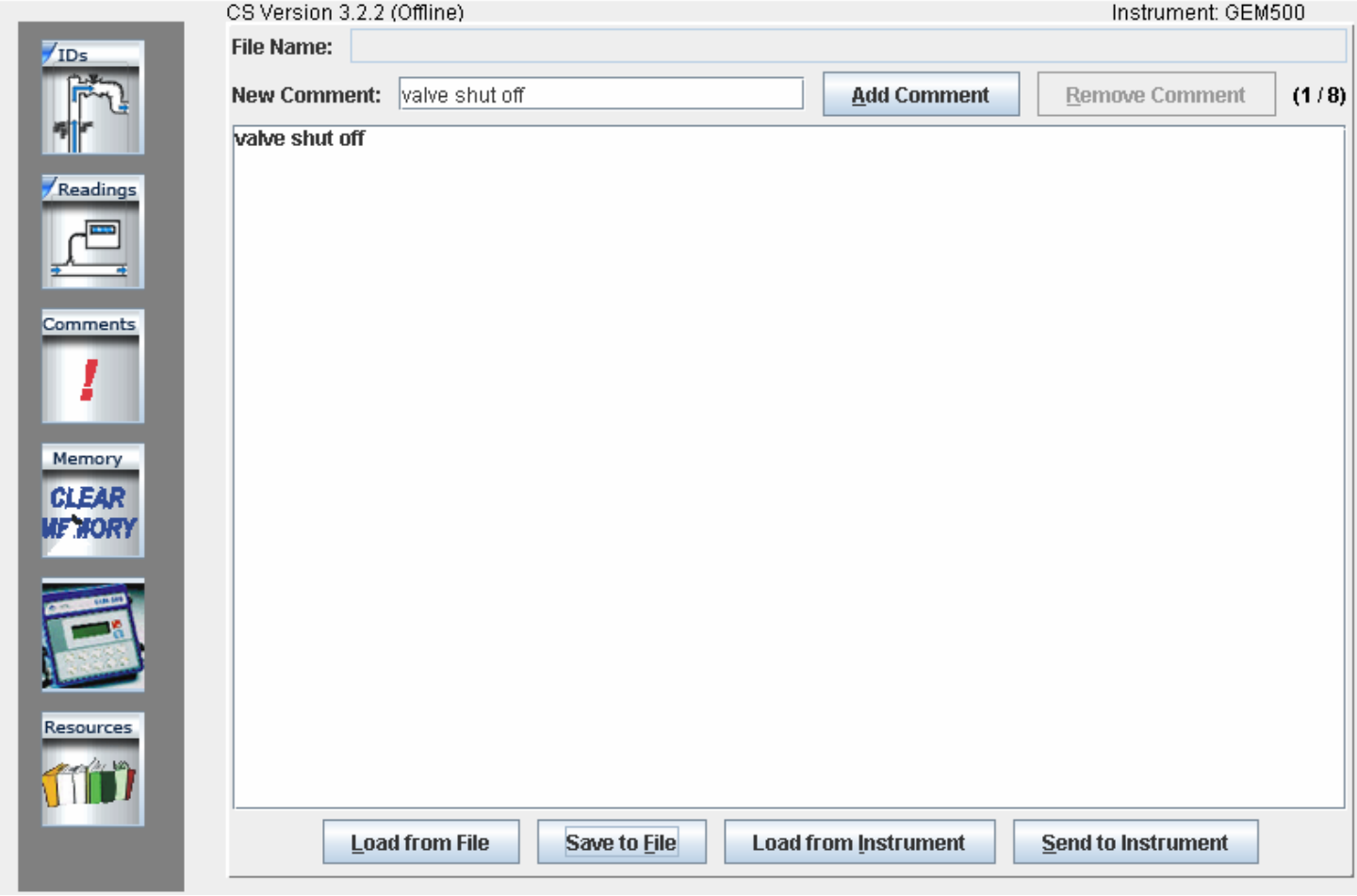
Each button has a specific function as listed below:

1. **Comments** – Allows entry of comments that may be selected for the IDs.
2. **IDs** – Used for adding new IDs, editing IDs or deleting IDs and entry of ID parameters such as pump run time, flow device, comments and questions for the ID.
3. **Readings** – Allows downloading and viewing data from instrument and uploading of previous data to the instrument.
4. **Clear Memory** – Allows the deletion if selective IDs, readings, comments, site questions or all memory loaded in instrument memory.
5. **Resource Links** – Allows the user to directly access information via the www.

Comments

DataField CS allows up to 64 comments to be created for upload to the GEM™500. Each comment may be 36 characters in length and may be alphanumeric or any character on the computer keyboard. From the opening screen, click on the **Comments** button to open the following screen.

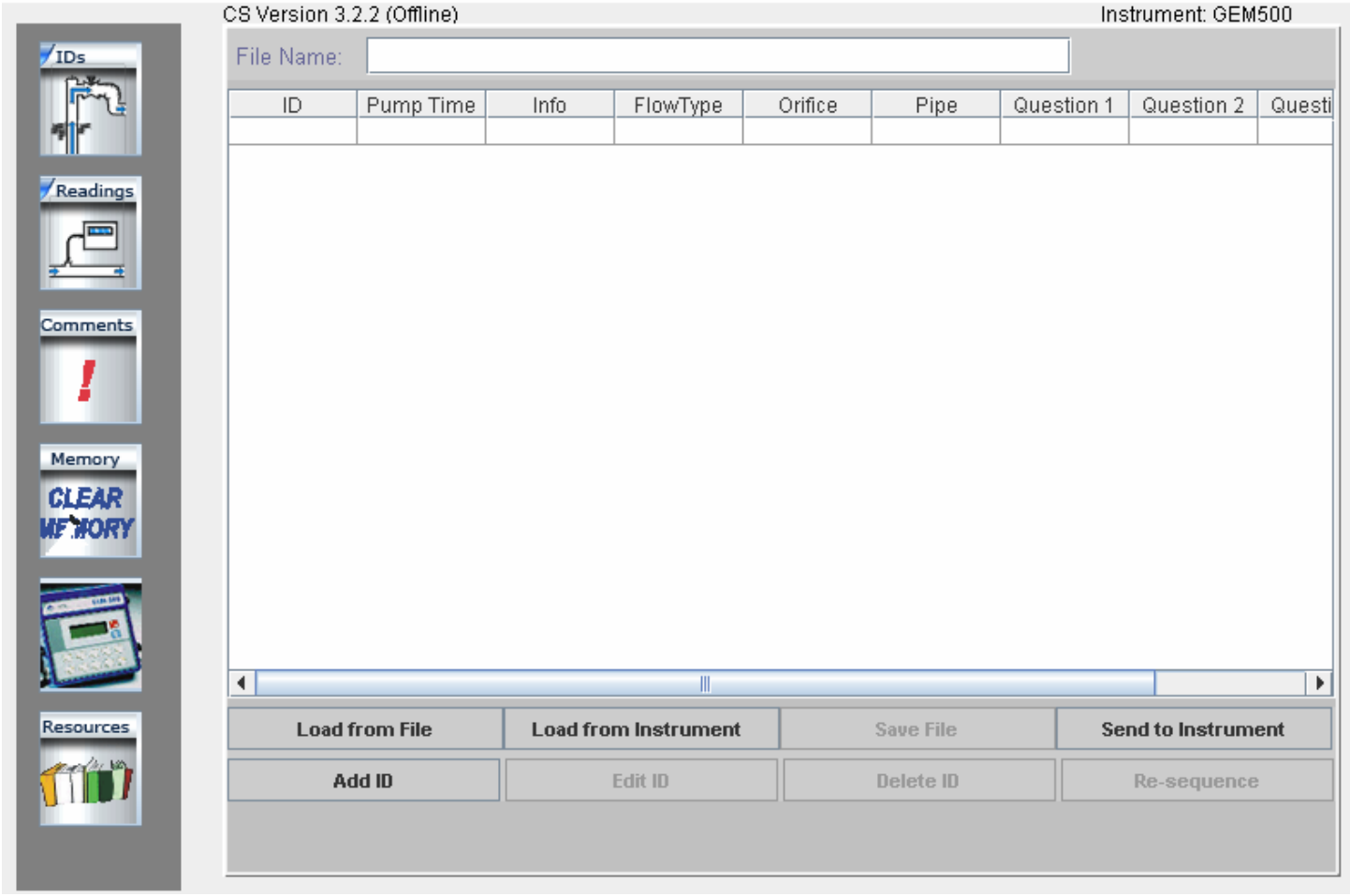




Enter the comment on the comment line and press **Enter** to continue entering comments until all the desired comments have been entered. Click on **Add Comment**. Click on **Save File** to save the data to the disk and then click on **Send to Instrument** to save the comments in the instrument. To delete a comment, click on the comment to highlight the comment and press the **Delete** key on the computer keyboard to remove the highlighted comment. It is always suggested to save the comment file because of the potential size and time required to recreate the comments. Once created, the comment file may be modified and saved under a different file name at any time.

Entering IDs

From the opening screen select the **ID** button. The following screen will open:

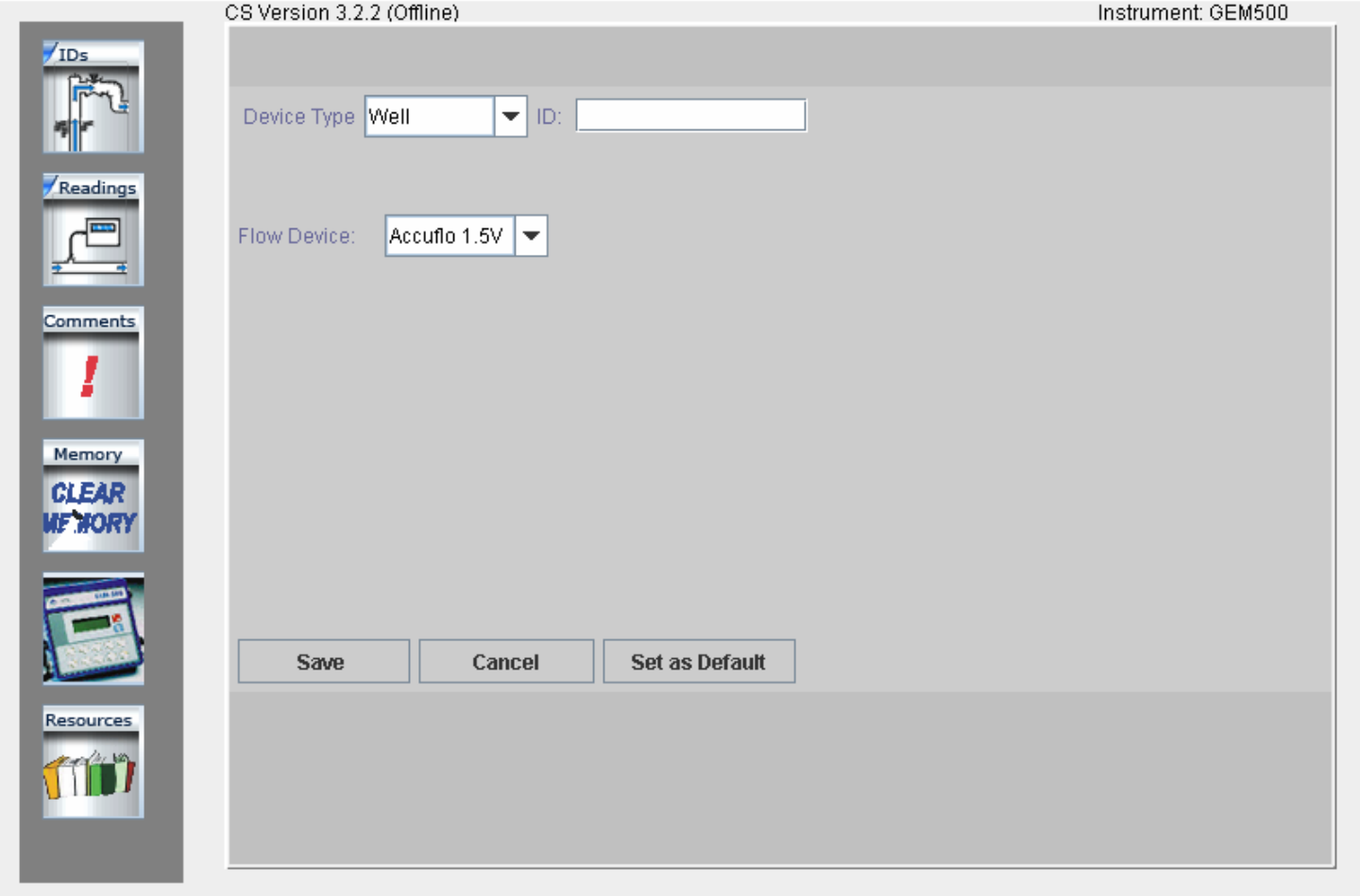


Selecting the **Save File** button will allow you to enter the name for the file you wish to save.

Selecting the **Load from File** button will allow a previously created file to be loaded from the computer disk drive.

Selecting the **Load from Instrument** button will allow previously loaded IDs in the instrument to be downloaded for modification such as increasing the pump run time or adding additional comments to a specific ID.

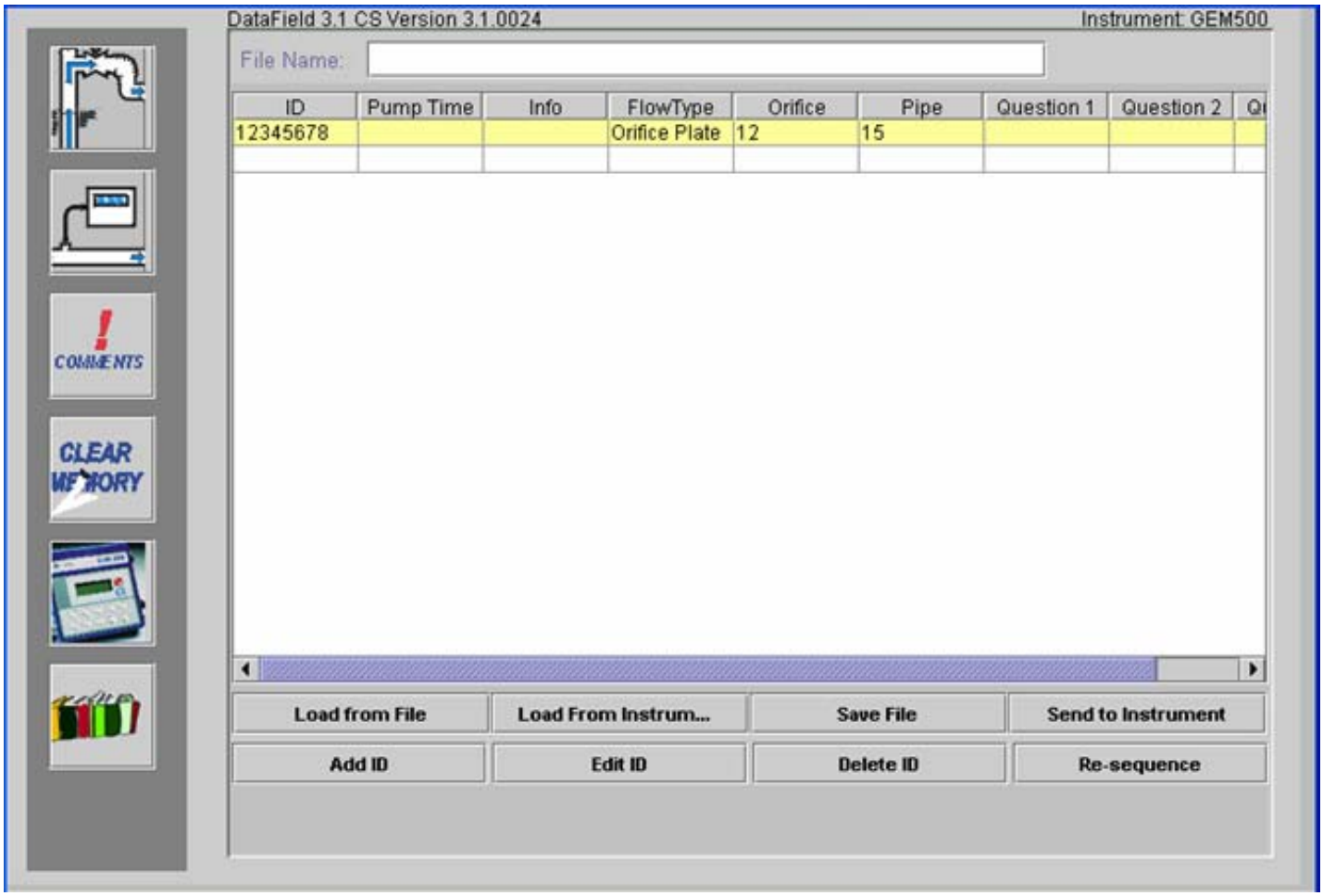
Add ID button is used for the creation of a new ID or multiple IDs that may be sent to the instrument or saved to a new file for later use.



To enter a new ID or create a new ID set, click on the **Add ID** button and the following screen will open:

Enter the Well ID in any combination of alpha or numeric characters for a maximum of eight characters. **All eight characters must be used**. Enter the type of flow device used with the well (Accu-Flo wellhead, Pitot tube, or orifice plate); user input may also be selected (GEM™500 only). If Pitot tube or orifice plate is selected, the **inside pipe diameter** and **orifice diameter** must be entered. If the flow device is going to be the same for multiple wells, click on **Set as Default** to lock the values.

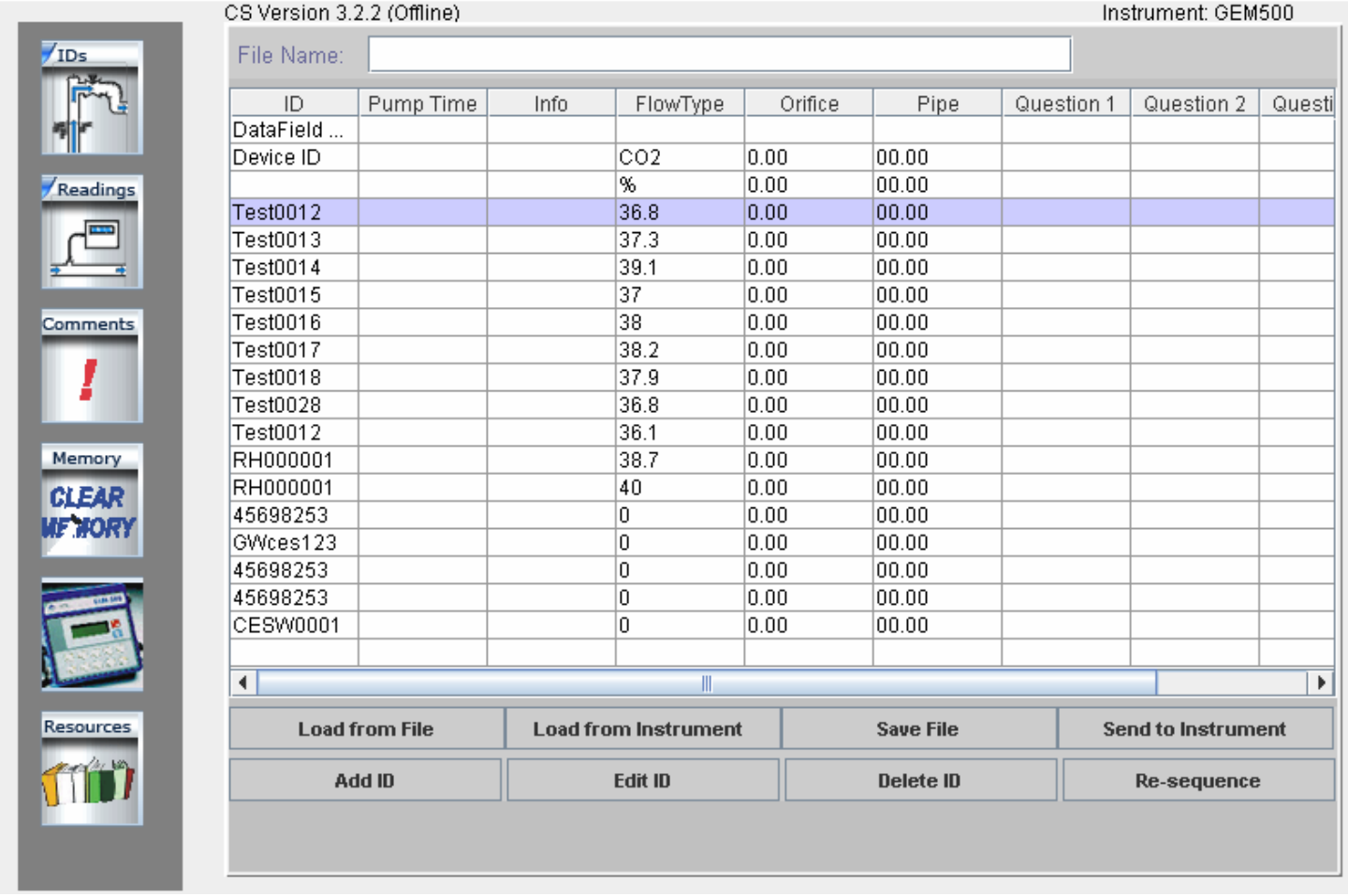
Click on **Save** to add this to the editor screen seen below. If additional IDs need to be entered, simply click on **Add ID** and enter the data as before.



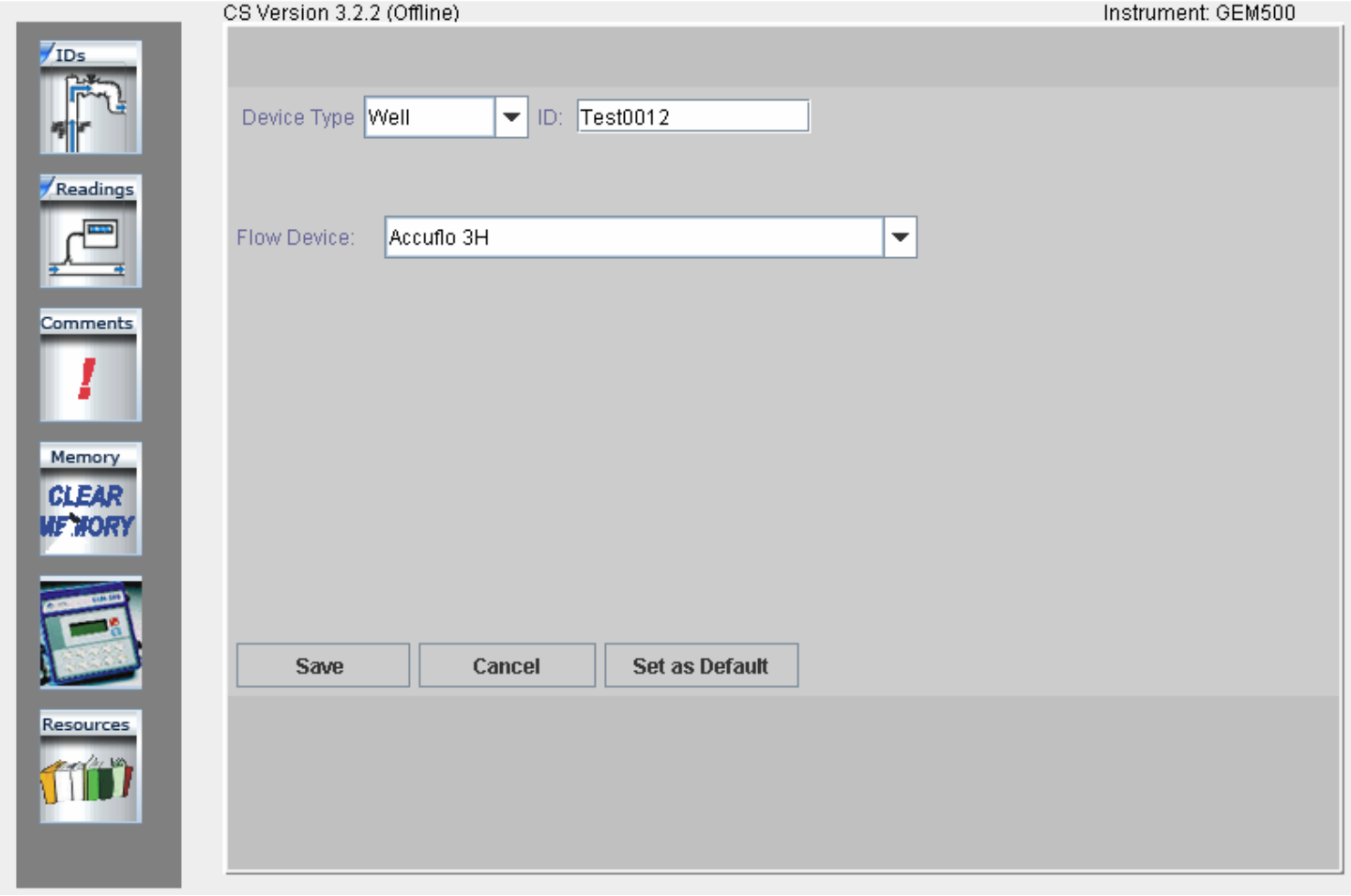
Once all the IDs have been entered, click **Save to File** button to save the ID data to a file or **Send to Instrument** button if data is to be uploaded to an instrument for field sampling.

Editing IDs

IDs may be edited in a similar manner to entering a new ID. Click on the **ID** button. Click on **Load from File** button if the IDs to be edited are in a saved file on disk or click on **Load from Instrument** if the IDs to be edited reside in the instrument. Once the IDs have been opened, the **ID Editor** screen will appear as below.



To select an ID for editing, click on the ID to highlight the ID, and then click on **Edit ID** at the bottom of the screen. The Edit ID screen will open and allow information for the selected ID to be changed. When finished with the changes, click on **Save** to save the edited ID to the ID list.



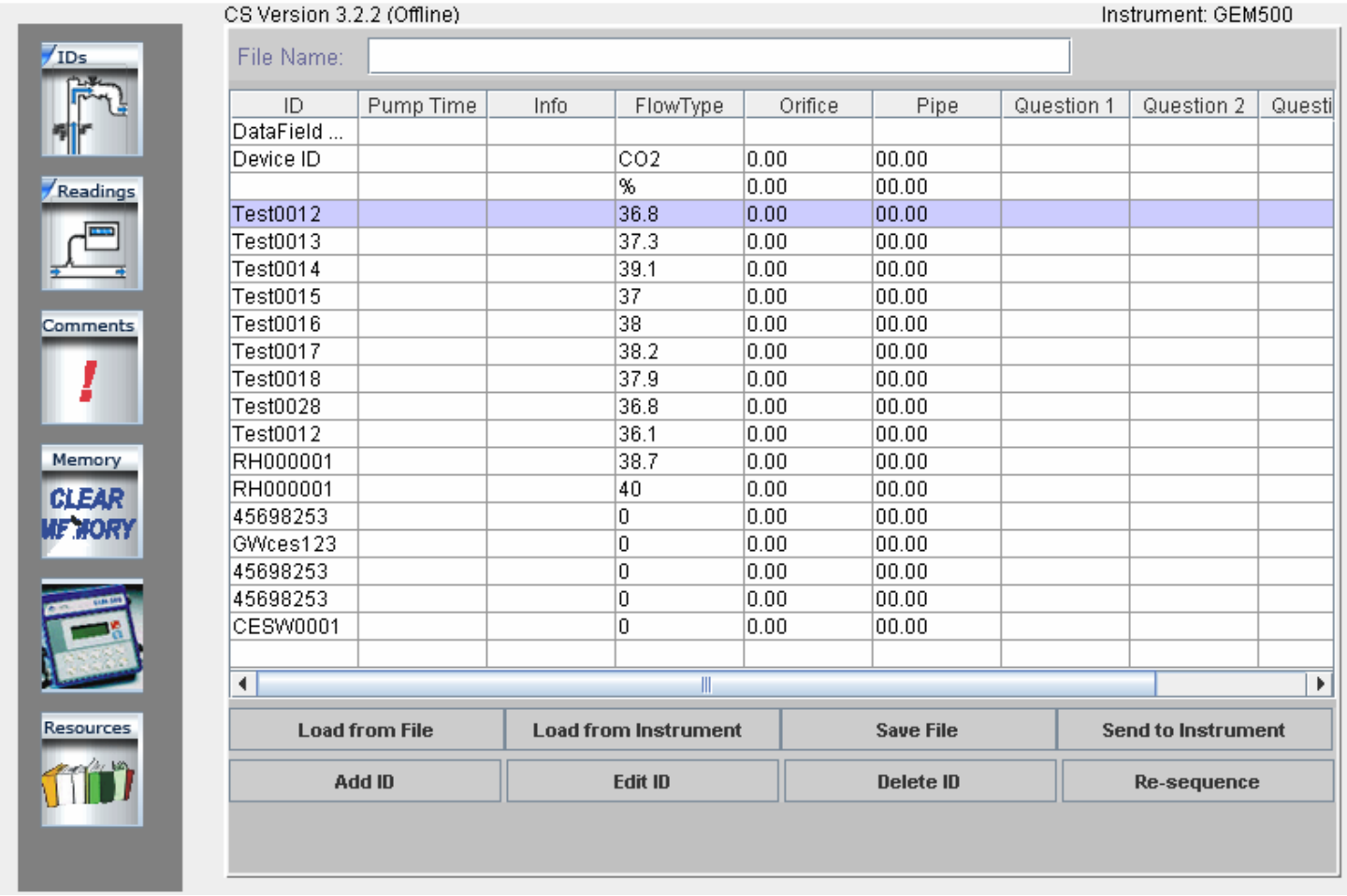
When editing is completed, click on the **Save** button and the previous screen will appear.

Note: IDs are appended to the unit, not over written. It is suggested to clear IDs before sending them to the unit.

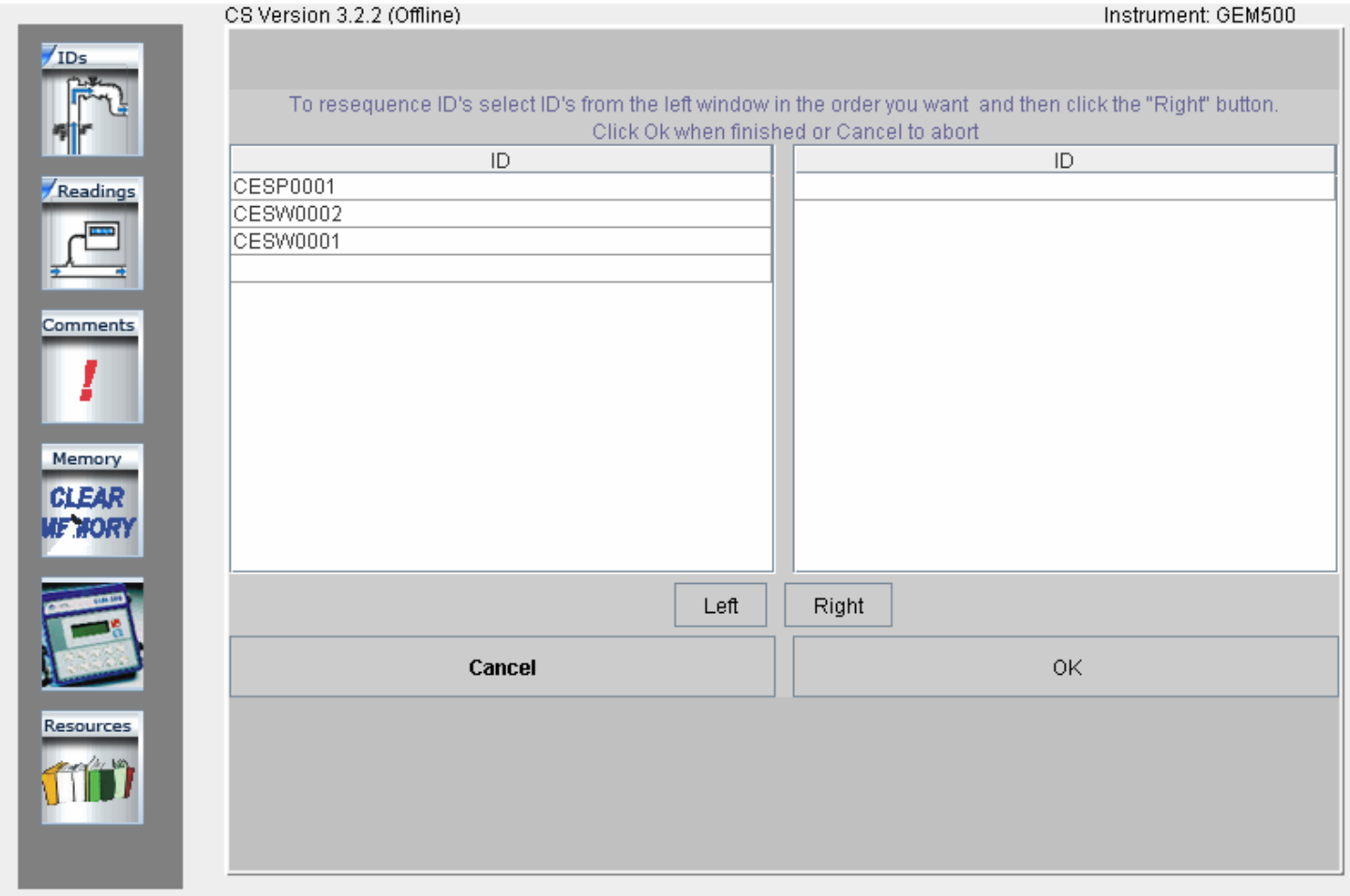
Delete IDs

Select an ID to delete and click on it to highlight it. Click on the **Delete ID** button. A prompt will appear to verify the action. Clicking **Yes** will delete the ID. To select multiple IDs use **Ctrl** and **Shift** buttons on your keyboard. When deleting multiple IDs after clicking on the **Delete ID** button a prompt will appear: "Would you like to verify each deletion?" Clicking **No** will delete all the selected IDs. Clicking **Yes** will prompt on the deletion of each ID in the selection. In this case the deletion of some IDs in the selection can be cancelled.

Click on **Save File** to save the updated file to disk or click on **Send to Instrument** to update the instrument for field sampling.

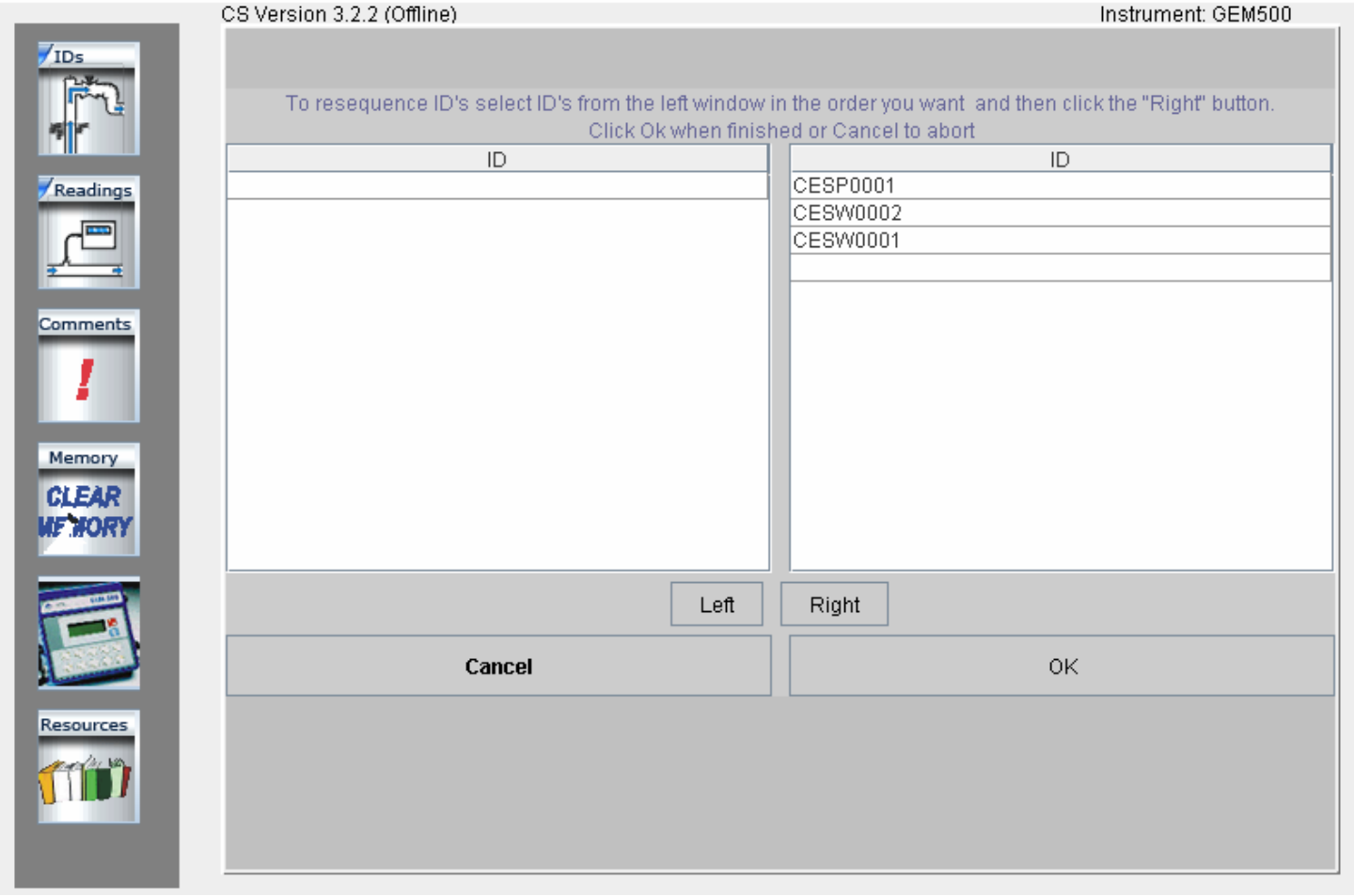


Re-sequencing



With DataField CS it is possible to change the order of the IDs in a file to be in the same order as they are sampled in the field. This is called **Re-sequencing**. To re-sequence an ID data set, click on the **ID** button to open the ID editor. Load the ID data set from a file or download the data set from the instrument. Click on the **Re-sequence** button to open the screen shown below.

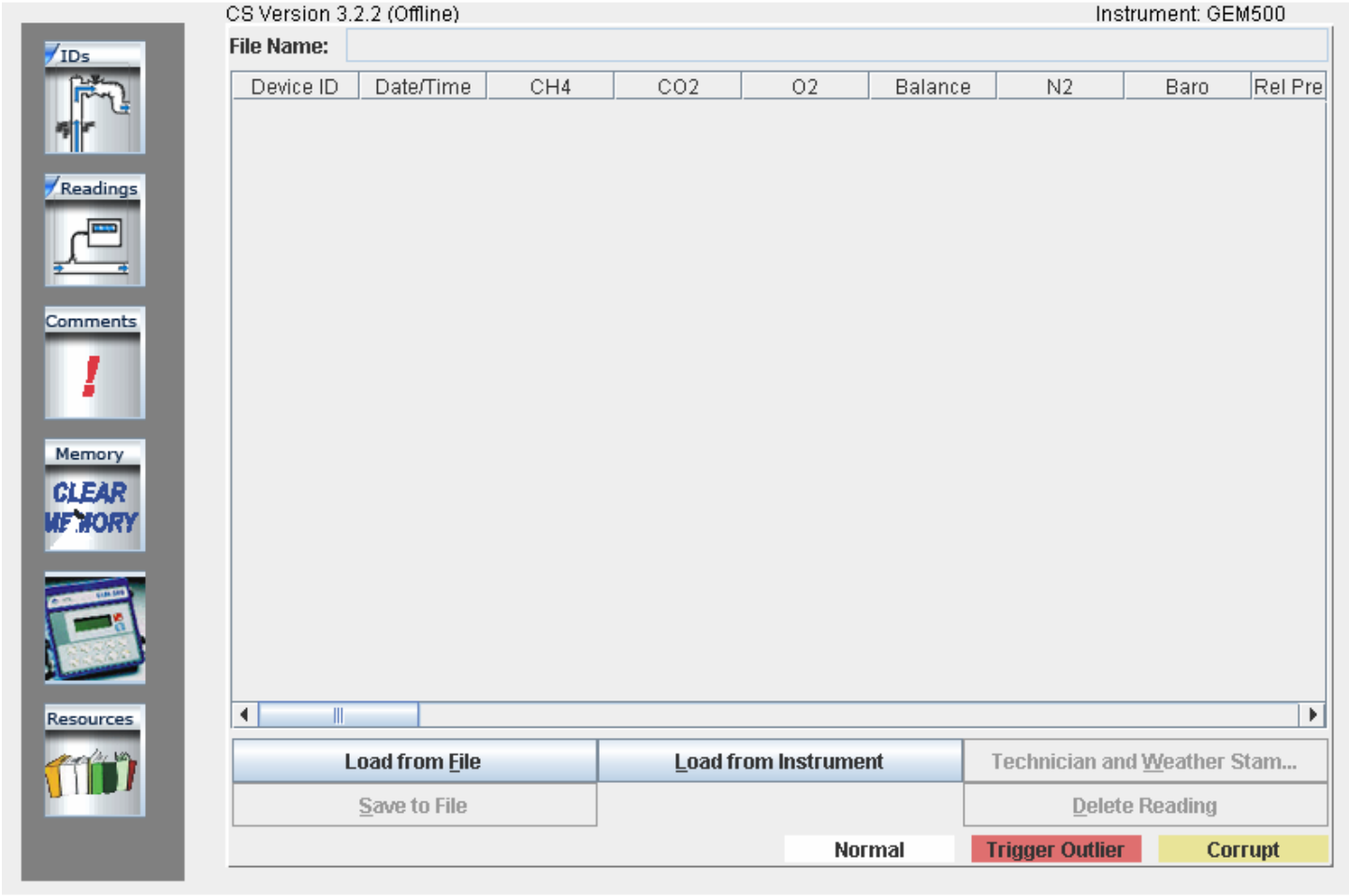
Select the ID from the left side window and click on the **Right** button to move ID to the right window to create the new sequence order. Repeat this process moving all IDs to the right side of the desired order.



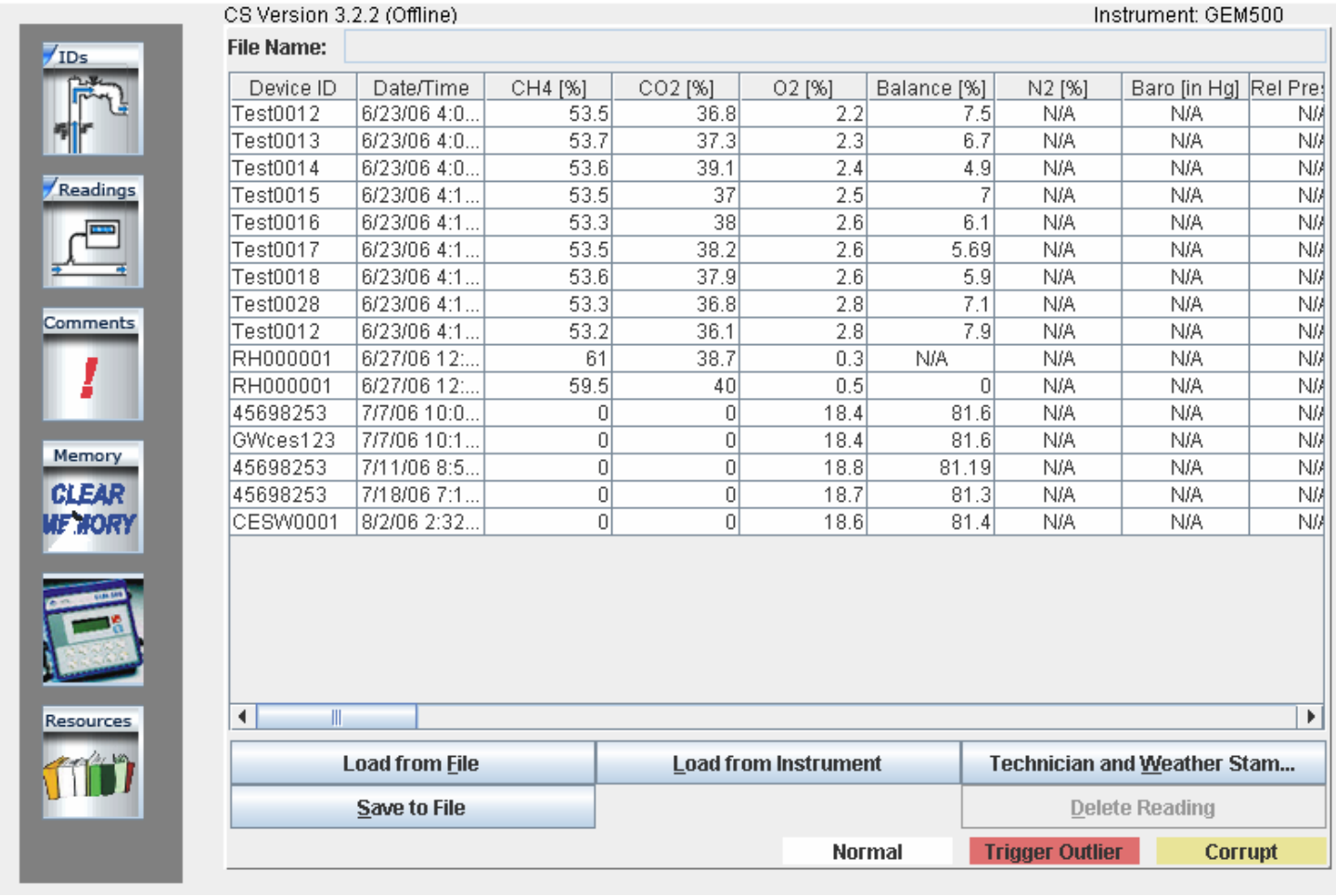
Click OK when the desired new sequence is obtained. Click on the **Save File** button to save the new data set to a file on disk or click on **Send to Instrument** to upload the new data to the instrument. Either action will overwrite the previous data.

Readings

The Readings screen provides the capability to download, upload, view, save data to a file and delete individual or multiple readings from a data set. Click on **Readings** to open the screen shown below.



Click on **Load from File** to open a file folder of saved data on the disk drive or click on **Load from Instrument** to download data from the instrument. Either action will open the following screen.

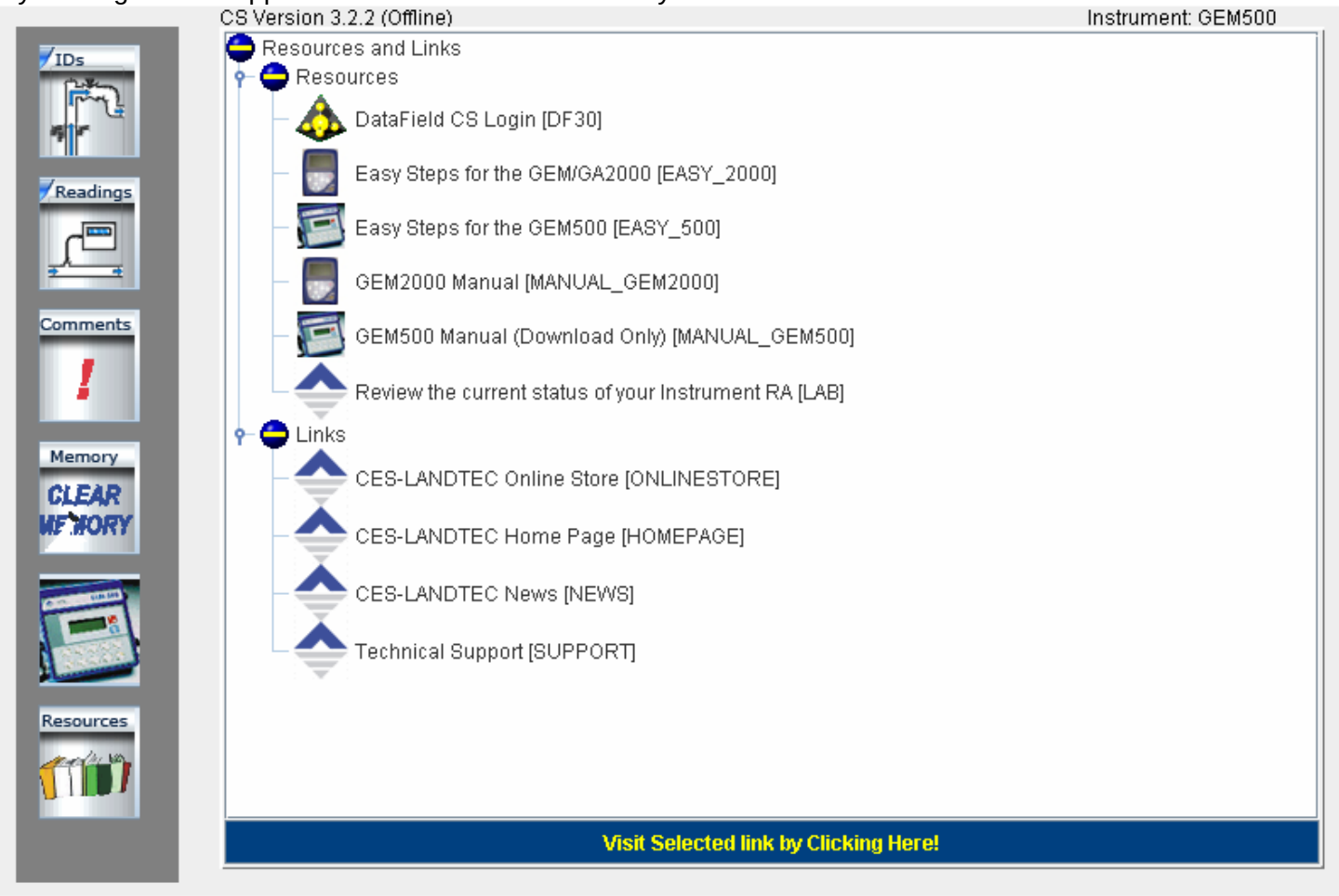


Once the file has been opened or data downloaded from the instrument, the readings can be either **stored online** (only with the online version) or **saved to a file** (only with the offline version). Readings can't be sent back to the instrument. **Send to Instrument** button will be always disabled.

To delete an ID from the data set, click on this ID to highlight it and then click on the **Delete Readings** button. Only one ID can be deleted at a time.

Resource Links

By clicking on the supplied link the user is taken directly to the www and the information listed.



Chapter 8 - Maintenance

Servicing

The GEM™500 has been electronically and functionally tested before leaving the factory. It is recommended that with normal usage, the unit should be serviced every **six months** for routine factory service and maintenance which includes:

- Replace all Filters and O-rings.
- Perform Bench Test with 10 Test Gases.
- Minor Adjustments.
- Check Overall Performance.
- If needed, run through Environmental Chamber.
- Check Charging Circuit and Battery Pack.
- Check Inlet Port Fittings.
- Calibrate Transducers.
- Check the Pump.
- Check the Flow Fail.
- Perform Leak Test.

LANDTEC is the ONLY authorized service center for the GEM™500 instruments in the Americas

Cleaning

Protect the GEM™500 by keeping it in its protective soft case. The keypad (polycarbonate membrane) should be wiped clean with soapy water and a damp cloth. Other cleaning agents may damage the membrane.

Sunlight and Heat

The GEM™500 should not be left out in direct sunlight for long periods of time as this raises the temperature inside the case and may cause damage to the components. The unit may not operate or may operate erratically if it gets too hot or cold. The operating temperature range may be extended by use of heat packs in extremely cold conditions or cold packs in extreme heat conditions, these packs may be placed in the rear pouch of the soft case.

Dust Cap

Always keep the protective dust cap in place when the data port is not in use.

Filters

The GEM™500 is equipped with two filters:

Water Trap Filter — This filter is external to the GEM™500 and is located in-line in the sample hose. Unscrewing the two halves of the filter holder gives easy access to the filter. This filter should be routinely changed every one hundred hours of use or when water is sucked through the filter. The filter should also be replaced when the sample pump has difficulty drawing a sample of gas through it and into the unit. When this happens, the GEM™500 sounds a continuous audible warning and a **Flow Fail** message appears on the screen.

Particulate Filter — This filter is inside the GEM™500 and is located just inside the Static Pressure/Sampling port. (Figure 1.1, Figure 5.1) This filter is accessed by unscrewing the port (counter-clockwise) using the wrench provided.

Both filter holders are sealed with o-rings. Periodically inspect the o-rings to check their condition. Replace the o-rings if they become nicked, cut, swollen, or otherwise damaged. The GEM™500 unit is shipped with a spare filter of each type. Only genuine LANDTEC filters should be used and can be purchased through the LANDTEC Sales Department by dialing 1-800-LANDTEC or on our web page at CES-LANDTEC.COM.

Travel and Storage

Travel – The GEM™500 is a delicate scientific instrument and should be stored in its optional protective hard case when carrying it from site to site. This case affords maximum protection for the unit and offers enough storage space to take along all of the required accessories for the GEM™500.

Storage – If the unit is to be stored for a long period, the internal batteries should be charged prior to storage. Recharge the unit every two weeks during storage.

When loading the GEM™500 into its protective hard case, place the unit with the keyboard facing out and the LANDTEC logo (upside down) closest to the handle on the front of the case. This will assure that the unit is stored right-side up when the case is closed and standing with its handle up in the carry position.

Battery Charging

The internal battery pack of the GEM™500 is designed to be recharged many times, but as with all nickel-cadmium cells, certain rules should be observed or the batteries might not provide their full power or operating time. Please follow these instructions carefully.

WARNING! ONLY CHARGE A GEM™500 WITH A LANDTEC BATTERY CHARGER (PROVIDED WITH THE UNIT).

1. Let the batteries almost fully discharge before recharging.

2. Do not top off an almost full battery charge because memory patterns can be established and the battery may not provide its full capacity.

   Note: If the GEM™500 is repeatedly given small "top-off" charges, the battery capacity can be reduced. To restore the battery to full capacity, totally discharge the unit and then charge it for a full 14 hour period.

   When charging the batteries, let them charge at least 12 to14 hours. If using the optional LANDTEC Smart Charger, batteries can be completely recharged in approximately 3 hours.

3. Never let the batteries charge for more than three or four days.

4. Disconnect the charger from the GEM™500 after the batteries have charged.

Note: Heat from the battery compartment makes the front of the GEM™500 (under the GEM™500 label) warm to the touch while the batteries are charging.

Battery Shut-Off

A circuit within the GEM™500 continuously monitors the battery voltage. If the battery voltage falls below a predetermined level, the unit automatically shuts itself off in order to prevent memory loss. If the unit shuts itself off, it requires a full charge of 14 hours (approximately 3 hours with the LANDTEC Smart Charger) to restore the battery to its maximum level.

Battery Low Symbol

This Battery Symbol displays in the top right corner of the display screen. It displays as the battery capacity reaches about 10% of full charge. There are only about 30-45 minutes of full pump power left in the GEM™500 when the symbol is displayed.

Automatic Power-Off

The GEM™500 has an automatic power-off timer to conserve battery power. If no key is pressed for 15 minutes, the unit automatically switches itself off (no stored readings are lost).

Emergency Battery Power

In emergencies, the GEM™500 may be operated with 6 “C” sized alkaline batteries. To use alkaline cells, remove the nickel-cadmium battery pack by using a Phillips screwdriver on the back battery compartment of the GEM™500. Insert the alkaline battery “C” cells in the correct direction.

WARNING! DO NOT USE THE BATTERY CHARGER FOR STANDARD ALKALINE BATTERIES AS THEY MAY EXPLODE.

WARNING! BE SURE TO REPLACE BATTERIES IN CORRECT DIRECTION OR UNIT WILL BE DAMAGED.

Chapter 9 - Troubleshooting

Problem	Corrective Action/Reason
Unit does not turn on or operation is erratic	Battery charge is too low-recharge batteries. Unit is too hot - cool down unit and try again. Contact the factory.
"Flow Fail" is displayed and an audible alarm is heard	The inlet is blocked - remove blockage and retry. The particulate filter or water trap filter needs replacing – see chapter 8 Maintenance.
Readings taken are not what was expected	Unit may be cut out of calibration – calibrate unit with known gas concentration. Water trap filter or particulate filter are clogged – replace filter.
Unit displays***** or >>>>>	These symbols are substituted when the measured reading is out of range of the instruments capabilities in some fields or when a value needs to be entered manually such as temperature.
Oxygen reading is high on all wells inset	Check that the water trap housing is screwed on tight. Check or replace o-rings on the water trap and instrument inlet. Check the wellhead for cracks, replace o-ring on insert. Field calibrate oxygen channel.
Unit will not download readings or an error occurs while downloading.	Verify that the communications software is the right version for the instrument being used. Check that the proper serial port is selected in the software (see chapter 7). Contact the factory.
Methane and Carbon Dioxide readings drift	Perform a field calibration and check well again. Verify cal gas is flowing when regulator is turned on. Verify all connections are tight and filters are not clogged. Contact the factory.
Oxygen readings drift	Perform a field calibration – zero and span (see chapter 3) Contact the factory
Black screen displayed when unit turned on	Charge unit over night and try again. Unit too hot – cool down and try again. Try adjusting contrast level (see chapter 2) Contact factory
Nothing happens when the Gas Pod is installed	Remove and re-seat the Gas Pod. Contact the factory.
Temperature does not update when temperature probe is installed	Check the probe fitting is fully seated. Check the probe plug is screwed together tightly. Contact the factory.

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Chapter 10 - Measurement Units & Technical Specifications

Measurement Units

Screen 1

Type	Displayed As	USA (Imperial)	Metric (SI)
Methane	CH_4%	% by volume	% by volume
Carbon Dioxide	CO_2%	% by volume	% by volume
Oxygen	O_2%	% by volume	% by volume
Balance	BAL	% by volume	% by volume

Screen 2

Type	Displayed As	USA (Imperial)	Metric (SI)
Methane	CH_4%	% by volume	% by volume
Lower Explosive Limit	CH_4% LEL	% of 5% CH_4	% of 5%CH_4

Screen 3

Type	Displayed As	USA (Imperial)	Metric (SI)
Static Pressure	SP"	"w.c. (H_2O)	mb (millibar)
Differential Pressure	DP"	"w.c. (H_2O)	mb (millibar)
Temperature	T °F/°C	°F (degrees Fahrenheit)	°C (degrees Celsius)

Screen 4

Type	Displayed As	USA (Imperial)	Metric (SI)
Ref. (past) energy	BTU / h	BTU per Hour	
Ref. (past) energy	KW		Kilowatts
Ref. (past) Gas Flow	SCFM	Std. cubic feet per min.	
Ref. (past) Gas Flow	m^3/h		Cubic meters per hour
Adj. (past) energy	BTU / h	BTU per Hour	
Adj. (past) energy	KW		Kilowatts
Adj. (past) Gas Flow	SCFM	Std. cubic feet per min.	
Adj. (past) Gas Flow	m^3/h		Cubic meters per hour

Physical

Weight	4.9 lbs.
Size (Excluding Fittings)	H 8.94" x W 8.90'' x D 2.00"
Case material	Anti-static ABS
Keys	Membrane panel
Display	Liquid Crystal Display
Filters	User replaceable integral fiber filter at inlet port and external PTFE water trap filter

General

Certifications	None
Audible alarm	User selectable CH_4 Minimum and O_2 Maximum alarm levels via General Utilities Menu.
Communications	RS232 protocol via download lead with variable baud rate.
Relative pressure	±250 mbar from calibration pressure

Power Supply

Battery type	Rechargeable Nickel Cadmium battery sticks (2 required)
Battery life	Typical use 6-8 hours from fully charged condition.
Battery charger	Separate intelligent battery charger powered from AC voltage supply (120V).
Charge time	Approximately 2-3 hours from complete discharge.
Battery lifetime	Up to 500 charge/discharge cycles, approximately 1 year normal use.

Gas Ranges

Detection principle	CO_2 and CH_4 by dual wavelength infrared cell with reference channel. O_2 by internal electrochemical cell.			
Oxygen cell lifetime	Approximately 18 months in air.			
Typical Accuracy 0 - Full Scale	**Gas**	**0-5% volume**	**5-15% volume**	**15%-FS**
	CH_4	±0.3%	±1%	±3% (100%)
	CO_2	±0.3%	±1%	±3% (60%)
	O_2	±1%	±1%	±1% (21%)
Response time, T90	CH_4	≤20 seconds		
	CO_2	≤20 seconds		
	O_2	≤20 seconds		
Range	CH_4	0-70% to specification, 0-100% reading.		
	CO_2	0-40% to specification, 0-100% reading.		
	O_2	0-25%		

Pump

Typical flow	300 cc/min.

Flow fail point	50 cc/min approximately.
Flow with 200 mbar vacuum	250 cc/min approximately.
Vacuum	70 inches H_20.

Operating Conditions

Operating temp range	32°F to 104°F.
Relative humidity	0-95% non-condensing.
Atmospheric pressure range	700-1200 mbar. Displayed in Inches of Mercury (5.9 – 35.4“Hg). Not corrected for sea level.
Atmospheric pressure accuracy	±5 mbar approximately.
Case seal	IP65.

Optional Gas Pods

Typical Accuracy (Subject to User calibration).	**Gas**	**0-Full Scale**
	CO	±10% FS
	H_2S	±10% FS
	SO_2	±10% FS
	NO_2	±10% FS
	CL_2	±10% FS
	H_2	±10% FS
	HCN	±10% FS
Response time, T90	CO	≤60 seconds
	H_2S	≤60 seconds
	SO_2	≤60 seconds
	NO_2	≤60 seconds
	CL_2	≤60 seconds
	H_2	≤60 seconds
	HCN	≤60 seconds
Range	CO	0-500ppm
	H_2S	0-50 or 0-200ppm
	SO_2	0-20 or 0-100ppm
	NO_2	0-20ppm
	CL_2	0-20ppm
	H_2	0-1000ppm
	HCN	0-100ppm

Chapter 11 - Field Operations

Landfill Gas Generation

A brief overview of the theory of landfill gas generation and Methane recovery follows. Initially, when decomposable refuse is placed into a solid waste landfill, the refuse is entrained with air from the surrounding atmosphere. Through a natural process of bacterial decomposition, the Oxygen from the air is consumed and an anaerobic (Oxygen free) environment is created within the landfill. This anaerobic environment is one of several conditions necessary for the formation of Methane- CH_4.

If oxygen is reintroduced into the landfill, those areas are returned to an aerobic (Oxygen present) state and the Methane producing bacteria population is destroyed. A period of time must pass before the productive capacity is returned to normal. Since there is some Methane of a given quality within the landfill void space, a decline in Methane quality is only gradually apparent depending upon the size of the landfill.

Carbon Dioxide is also produced under either an aerobic or anaerobic condition. Under static conditions, the landfill gas will be composed of roughly half Methane and half Carbon Dioxide with a little Nitrogen.

As air is introduced into the landfill, the oxygen is initially converted to Carbon Dioxide and residual Nitrogen remains. Measurement of residual Nitrogen is usually a good indicator of the anaerobic state of the landfill; however, it cannot be directly measured. It can, however, be assumed and estimated using a subtraction basis as the balance gas. Hence, the measurement of Carbon Dioxide is an intermediary step. Because Carbon Dioxide levels may fluctuate depending on the changing concentrations of the other constituent gases, Carbon Dioxide levels are not evaluated directly but are considered in light of other data.

In evaluation of residual Nitrogen, allowances must be made if there has been any air leakage into the gas collection system or if there has been serious over pull. If enough air is drawn into the landfill, not all oxygen is converted into Carbon Dioxide and the oxygen is apparent in the sample. It is ideal to perform routine analysis of individual wells, as well as an overall well field composite sample, by a gas chromatography. This is not always practical at every landfill.

Under some conditions there may be a small amount of hydrogen in the LFG, (about 1 percent, usually much less). This may affect field monitoring response factors, but otherwise it can be ignored.

Subsurface Fires

If very large quantities of air are introduced into the landfill, either through natural occurrence or overly aggressive operation of the LFG system, a partly unsupported subsurface combustion of the buried refuse may be initiated. Subsurface fire situations are difficult to control or extinguish once started, present health and safety hazards, and can be quite costly. Therefore, prevention by good operation of the collection system and maintenance of the landfill cover is the best course of action.

The presence of Carbon Monoxide, Carbon Dioxide, and Hydrogen Sulfide are indicators of poorly supported combustion within the landfill.

Techniques for Controlling Landfill Gas

There are many techniques for controlling landfill gas extraction. These techniques represent tools which are used together to control landfill gas. The Accu-Flo wellhead is designed to work with all of these techniques. Below is a discussion of the individual techniques, how to use them, and their limitations. Reliance on only a few of the techniques discussed can lead to misinterpretation of field data and improper operation of the well field. Later the best use of these techniques to optimize landfill gas control will be discussed.

Controlling by Wellhead Valve Position

Unless the valve handle is calibrated for a given flow rate, this method is unreliable. The position of the valve handle alone does not provide sufficient information about the well to control it. It is useful to note the relative position of the valve, and essential to know which valves are fully open or fully closed.

Controlling by Wellhead Vacuum

This technique relies on the relationship of well pressure/vacuum to flow for a given well. Reliance upon this method, however, can be misleading. This is because the square root relationship between flow and pressure is difficult to affect while performing day-to-day well field adjustments. As decomposition, moisture, and other conditions change, this method shows itself to be inadequate and imprecise.

Controlling by Gas Composition

This method determines Methane, Nitrogen (balance gas) and other gas composition parameters at wellheads and at recovery facilities using portable field instruments and, sometimes, analytical laboratory equipment. Complete knowledge of gas composition (i.e., major fixed gases: Methane, Carbon Dioxide, Oxygen and Nitrogen) is desirable. It is also necessary to check other gas parameters, such as Carbon Monoxide, to fully evaluate the condition of the well field. Reliance on this information can lead to improper operation of the well field. Indications of excessive extraction often do not show up right away. This method often leads to a cycle of damage to the Methane producing bacteria population and then to over-correction. This cycling of the well and producing area of the landfill is not a good practice. It leads to further misinterpretation of the condition of the well field and has a disruptive effect on the operation of the well field. The use of analytical laboratory instrumentation such as a gas chromatograph is a valuable supplementary tool to verify gas composition. This normally requires collection of samples at the wellhead and analysis at some fixed location where the equipment is located. The drawbacks of this method as a primary means of obtaining information for well field adjustment are the time expended, cost, and probably most important, responsiveness to the needs of the well field for timely adjustment. The laboratory equipment required is also very costly. Some analysis is recommended for verification of field readings from time to time. It is recommended a monthly sample of the composite gas be taken at the inlet to the flare or gas recovery facility.

Controlling by Flow Rate

This is a more exacting technique for determining and adjusting gas flow at individual wells. It requires using a fixed or portable flow measurement device at each wellhead to obtain the data needed to calculate volumetric (or mass) flow rates. It is normally convenient to use cubic feet per minute or per day, as a standard unit of measure for volumetric flow. It is important to distinguish between the volumetric quantity of landfill gas and the volumetric quantity of Methane extracted from each well and the landfill in total. The two variables are somewhat independent of each other and it is the total quantity of Methane extracted we are interested in. It is possible for the total quantity of landfill gas extracted to increase while the total quantity of Methane extracted decreases. To monitor this, the quantity of Methane extracted (LFG flow x percent Methane) or the quantity of BTUs recovered per hour (LFG flow x percent Methane x BTUs per cubic foot of Methane x 60 minutes per hour) can be calculated. It is conventional to measure BTUs per hour as a unit of time. There are approximately 1012 BTUs of heat per cubic foot of pure Methane (like natural gas), although this figure varies a little among reference texts.

Measuring flow is an essential part of monitoring and adjusting a well field. The well should be adjusted until the amount of Methane recovered is maximized for the long term. A greater amount of Methane or energy can usually be recovered over the short term; however, this ultimately leads to diminishing returns. This is seen in stages as increased CO_2 and gas temperature and later as increased oxygen from well over-pull. In time, the Methane will also decline. This is the result of a portion of the landfill, usually at the surface, being driven aerobic. In this portion of the landfill, the Methane producing bacteria will have been destroyed (due to the presence of oxygen). With the Methane-producing capacity of the landfill reduced, the pore space in the area no longer producing may become filled with landfill gas equilibrating (moving in) from an unaffected producing area. This leaves the impression that more gas can be recovered from this area, and may lead to the operator opening the well or increasing flow.

Well field Monitoring

The frequency of LFG well field monitoring varies depending upon field requirements and conditions. Normal monitoring frequency for a complete field monitoring session with full field readings (suggested normal and abbreviated field readings list follows) will vary from typically once a month to once a week. Well field monitoring should not normally be extended beyond one month. The importance of regular, timely monitoring can not be overemphasized.

Typical Field Readings

- Name of person taking readings
- Date/time of each reading
- Methane (CH_4)
- Oxygen (O_2)
- Carbon Dioxide (CO_2)
- Balance Gas (primarily Nitrogen N_2)
- Wellhead gas temperature (flowing)
- Ambient air temperature
- Static pressure (PS) (from GEM™500 or magnehelic) or other device (anemometer/velometer)
- Velocity head (P or PT) (from GEM™500 or pitot tube and magnehelic)

- Wellhead gas flow (from GEM™500 , or pitot tube & magnehelic, or anemometer/velometer)
- Wellhead adjustment valve position (initial and adjusted)
- New wellhead vacuum and flow information after adjustment
- Calculation of each well's LFG and Methane flow and sum total
- Observations/comments

Additionally, Carbon Monoxide (CO) or Hydrogen Sulfide (H_2S) readings may be taken if problems are suspected. Supplementary monitoring once to several times a week may be performed using an abbreviated form of field readings.

Abbreviated Field Readings

- Name of person taking readings
- Date/time of each reading
- Methane (CH_4)
- Oxygen (O_2)
- Wellhead gas temperature (flowing)
- Ambient air temperature
- Static pressure (PS) (from GEM™500 , GA-90 or magnehelic)
- Velocity head (P or Pt) (from GEM™500 or pitot tube and magnehelic)
- Wellhead gas flow (from GEM™500 , or pitot tube and magnehelic, or anemometer/velometer)
- Wellhead adjustment valve position (initial and adjusted)
- New wellhead vacuum and flow information after adjustment
- Observations/comments

Line vacuums and gas quality may be taken at key points along the main gas collection header and at subordinate branches. This helps to identify locations of poor performance, excessive pressure drop, or leakage. Perform systematic monitoring of the well field, taking and logging measurements at each wellhead and major branch junction in the collection system.

During monitoring, examine landfill and gas collection system for maintenance issues. Record needed maintenance or unusual conditions. Examples of unusual occurrences or conditions are unusual settlement, signs of subsurface fires, cracks and fissures, liquid ponding, condensate/leachate weeping from side slopes, surface emissions and hot spots, and liquid surging and blockage in the gas collection system. Field readings should be kept in a chronological log and submitted to management on a timely basis.

Well Field Adjustment Criteria

There are several criteria used in well field adjustment. The primary criterion is Methane quality. Methane quality is an indicator of the healthy anaerobic state of the landfill and thus proper operation of the LFG collection system. However, a decline in the healthy productive state of the landfill is usually not immediately apparent from Methane quality. Due to this several criteria must be considered at once.

Following are well field adjustment criteria for consideration.

- Methane quality (ranging from 26 percent upwards)
- The degree to which conditions within the landfill favor Methane production. Typical conditions include:
  - pH
  - temperature
  - general overall quality
  - moisture conditions
  - waste stream characteristics
  - placement chronology
  - Insulation characteristics
- Oxygen quality (ranging below 1 percent, preferably less then ½ percent)
- Landfill cover porosity and depth in the proximity of the well
- Landfill construction factors including:
  - type of fill
  - size and shape of refuse mass
  - depth of fill
  - compaction
  - leachate control methods
- Seasonal, climatic, geographical, and recent weather, or other considerations, including seasonally arid or wet conditions, precipitation, drainage, groundwater
- Surrounding topography and geologic conditions
- Proximity of the well to side slopes (within 150 to 200 feet and less may require conservative operation of the well)
- Nitrogen (typically 8 to 12 percent and less)
- Temperature (between ambient and about 130 °F)
- LFG and Methane flow from the wellhead
- Design of the gas collection system
- Landfill perimeter gas migration and surface emission control, or energy recovery objectives
- Diurnal fluctuation (day to night) of atmospheric pressure

Establishing Target Flows

The goal is to establish a target flow which will likely produce the best possible Methane quality and minimum Oxygen levels while maximizing the recovery of landfill gas. Typically, small adjustments are made in flow to achieve and maintain quality objectives. The well must not be allowed to over pull. High well temperatures, (130° to 140° F and greater), are an indication of aerobic activity and, thus, well over-pull. These effects may not be immediately apparent.

Well adjustment should be made in as small an increment as possible, preferably an increment of ten percent of the existing flow or less. There may be obvious conditions when this is not appropriate, such as when first opening up a well or when serious over-pull is recognized. Every effort should be made to make adjustments and operations as smooth as possible. Dramatic adjustments, or operating while switching between a high flow mode and a well shutoff mode, should be avoided.

Well field Optimization

Every effort should be made to continuously locate and correct or eliminate conditions (e.g., gas condensate, surging and blockage, settlement, etc.) which inhibit efficient operation of the gas collection system. This allows well monitoring and adjustment to be significantly more effective.

Migration Control—Dealing with Poor Methane Quality

If Methane and Oxygen quality objectives cannot be maintained at a given well, such as a perimeter migration control well, then an attempt should be made to stabilize the well as closely as is practical, avoiding significant or rapid down-trending of Methane or up-trending of Oxygen.

It is not uncommon for perimeter migration control wells to be operated at less than 40 percent Methane or greater than one-percent Oxygen. It should be recognized that these wells are likely in a zone where some aerobic action is being induced, and that there is some risk of introducing or enhancing the spread of a subsurface fire. Sometimes a judicious compromise is necessary to achieve critical migration control objectives or because existing conditions do not allow otherwise. Such situations should be monitored closely.

Well field Adjustment—Purpose and Objectives

The objective of well field adjustment is to achieve a steady state of operation of the gas collection system by stabilizing the rate and quality of extracted LFG in order to achieve one or several goals. Typical reasons for recovery of LFG and close control of the well field are:

- Achieve and maintain effective subsurface gas migration control.
- Achieve and maintain effective surface gas emissions control.
- Assist with proper operation of control and recovery equipment.
- Avoidance of well over pull and maintenance of a healthy anaerobic state within the landfill.
- Optimize LFG recovery for energy recovery purposes.
- Control nuisance landfill gases odors.
- Prevent or control subsurface LFG fires.
- Protect structures on and near the landfill.
- Meet environmental and regulatory compliance requirements.

Well field adjustment is partly subjective and can be confusing because it involves judgment calls based on simultaneous evaluation of several variables, as well a general knowledge of site specific field conditions and historical trends. Well field evaluation and adjustment consist of a collection of techniques, which may be used, in combination, to achieve a steady state of well field operation.

LANDTEC Technical Tips

Landfill Control Technologies regularly produces technical landfill related information and educational material. Please call LANDTEC at (800) LANDTEC, to receive the current series of these Technical Tips.