Linear Swell Meter, Model 2100

Instruction Manual

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Fann Instrument Company

Linear Swell Meter 2100 Instruction Manual

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1 Introduction to the Linear Swell Meter 2100

Fann's Linear Swell Meter, Model 2100 is designed to test shale hydration or dehydration. Operators apply the information from this test to predict and correct shale problems encountered during oil well drilling. Having this information helps operators develop a drilling program that minimizes drilling risks and costs associated with shale.

The Linear Swell Meter (LSM), Model 2100 includes an automatic measuring system, compactor unit, and software.

The LSM software records the measurements and summarizes the results in a real-time graph that shows the percentage of swelling versus time.

1.1 Background and Application

Much research and development has gone into developing chemical and mechanical tests and methods that can measure the reactivity of shale. Currently, tests are available for measuring shale properties, such as specific surface area (SSA), total cation exchange capacity (methylene blue test), dispersibility and/or erosion potential, swelling potential, and strength.

Interest in the swelling potential of shales (absorption of water) is reflected in a variety of experimental procedures. For many years, soil engineers have used simple field tests to measure swelling. The Linear Swell Meter uses the same principle.

Shale samples may come from drilled cuttings, core samples, or another source. Drilled cuttings are ground to a suitable particle size and then compressed under pressure using a hydraulic compactor. This compacted material is wrapped in a porous sleeve to minimize radial swelling during the test. This sleeve's design keeps the sample intact, minimizing crumbling or sloughing that is common with shale.

Temperature can significantly affect the shale reactivity. Increasing the temperature will increase the reactivity and reduce the swelling test time.

Swelling reactivity in reconstituted shale core samples is also dependent on the shale type, its moisture content, and the pressure and duration of compaction loading.

1.2 Document Conventions

The following icons are used as necessary in this instruction manual.

NOTE Notes emphasize additional information that may be useful to the reader.

CAUTION Describes a situation or practice that requires operator awareness or action in order to avoid undesirable consequences.

MANDATORY ACTION Gives directions that, if not observed, could result in loss of data or in damage to equipment.

WARNING! Describes an unsafe condition or practice that if not corrected, could result in personal injury or threat to health.

ELECTRICITY WARNING! Alerts the operator that there is risk of electric shock.

HOT SURFACE! Alerts the operator that there is a hot surface and that there is risk of getting burned if the surface is touched.

2 Safety

Safe laboratory practices and procedures should be observed while operating and maintaining the Linear Swell Meter. This section lists some precautions to follow. For safe operation of the vacuum pump, drying oven and dessicator, see the manufacturer's instruction manuals.

2.1 Compactor

Make sure that the hydraulic pressure has been released and both pressure gauges read zero before performing the following practices:

- Removing the core chambers
- Moving the compactor
- Refilling the hydraulic pump
- Performing any maintenance on the compactor

When refilling or repairing the hydraulic system, clean any spilled oil. Oil on the floor makes the floor slippery and can cause someone to fall or be injured. Oil spills on the bench or the compactor can cause dirt accumulation and can be a fire hazard.

2.2 Measuring Unit

The electrical power cables to the LSM and the computer used with it should be three-wire grounding cables and should be plugged into a grounded receptacle in the laboratory. Make sure that the instrument power switch is turned OFF when connecting the power cable.

2.3 Sample Preparation

Handle the Pyrex® evaporation dishes with care to avoid breaking them and being cut by broken glass.

Avoid spilling the sample fluid when pouring it into the evaporation dish. If the sample fluid is spilled on the instrument, it could get into the electrical parts and damage the electrical components. If the sample is spilled, quickly clean the area. If the spill is near any electrical components, unplug the instrument from the power source before cleaning the spill.

2.4 Electrical Safety

Unplug the instrument from the electrical power source before disassembling or repairing the instrument. Usually, maintenance operations require removing the bottom plate and back plate in order to access the inside. With these items removed, the user is exposed to the electrical terminals and the risk of electrical shock unless the instrument has been unplugged. If the power must be turned back on during troubleshooting, please contact a qualified technician who has been trained in safely testing electrical circuits.

2.5 Ergonomic Considerations

The Linear Swell Meter and compactor are large and heavy. Handle them carefully when moving them during installation or maintenance.

The instruments can be easily moved within a lab, but because they are delicate, avoid moving them. Two people should help move it.

2.6 Environmental Considerations

Follow proper handling and disposal practices for your samples.

3 Features and Specifications

The Linear Swell Meter system features an automated measuring system with four measuring heads. Four cores can be analyzed at the same time. The system is also configured for connecting three additional four place measuring units. The operator can start and stop any of the individual swelling tests at any time during the sequence.

Data from these measurements is processed by customized software that features real-time data logging and graphics. The software is Windows®-based and uses menus for loading constants, configuration details, data files, and other information.

This section describes the system's components in detail. To perform this test, you will need the additional laboratory supplies listed in Table 3-2. Laboratory supplies are not included, but they are available for purchase.

The complete Linear Swell Meter 2100 system includes these items:

- a four-head measuring unit
- the compactor unit
- LSM 2100 software for Windows®

Figure 3-1 shows the measuring unit with a computer (not included).

Figure 3-1 Linear Swell Meter 2100

An additional four-place head unit can be connected to the existing head assembly via a connector cable. No additional hardware or software is required for that arrangement.

Specifications for the LSM are listed in Table 3-1.

Table 3-1 Linear Swell Meter, Model 2100 Specifications

Category		Specification
Maximum Operating Environment Temperature		120°F (49°C)*
Maximum Sample Temperature		180°F (82°C)
Transducer Travel		± 0.2 in. (0.5 cm)
Measuring Unit, 4 Head	Dimensions (Width x Depth x Height)	33 x 13.25 x 15.5 inches 83.8 x 33.65 x 39.3 centimeters
	Weight	60 lb (27 kg)
Compactor, 2 Head	Dimensions (Width x Depth x Height)	14.5 x 16.5 x 16.75 inches 36.8 x 41.9 x 42.5 centimeters
	Weight	64 lb (34 kg)
Electrical		115 VAC, single phase, 50/60 Hz, 2 A

*Prolonged temperature above 130°F can damage interior electronic components .

3.1 Measuring System

The Fann LSM 2100 system measures swelling by linear displacement using an automated linear variable differential transformer (LVDT). It has multiple measuring heads, allowing four cores to be analyzed simultaneously. The LSM 2100 software collects and processes the data from these measurements. It also keeps a record of the data and graphs it in real-time. See Figure 3-1 for the system and computer. The components of the measuring system are shown in Figure 3-2.

This measuring system offers independent dead-weight sample loading and simultaneous automatic operation during the swelling phase of the test.

The LVDT has a maximum displacement of +/- 0.2 inches and measures the vertical displacement of the sample within 0.1% accuracy. The mechanical restraining force (pre-load) that is applied to the shale core sample during the swell test is 1.21 lb (548.8 g). Additional pre-load can be applied using auxiliary weight. Adding this weight brings the total pre-load to 4.41 lb (2000 g). See Figure 3-2.

To obtain accurate measurements, core samples are held in a snug-fitting porous sleeve (60 mesh core holder) during the swelling test. This sleeve minimizes radial swelling, sloughing, and crumbling of the core sample.

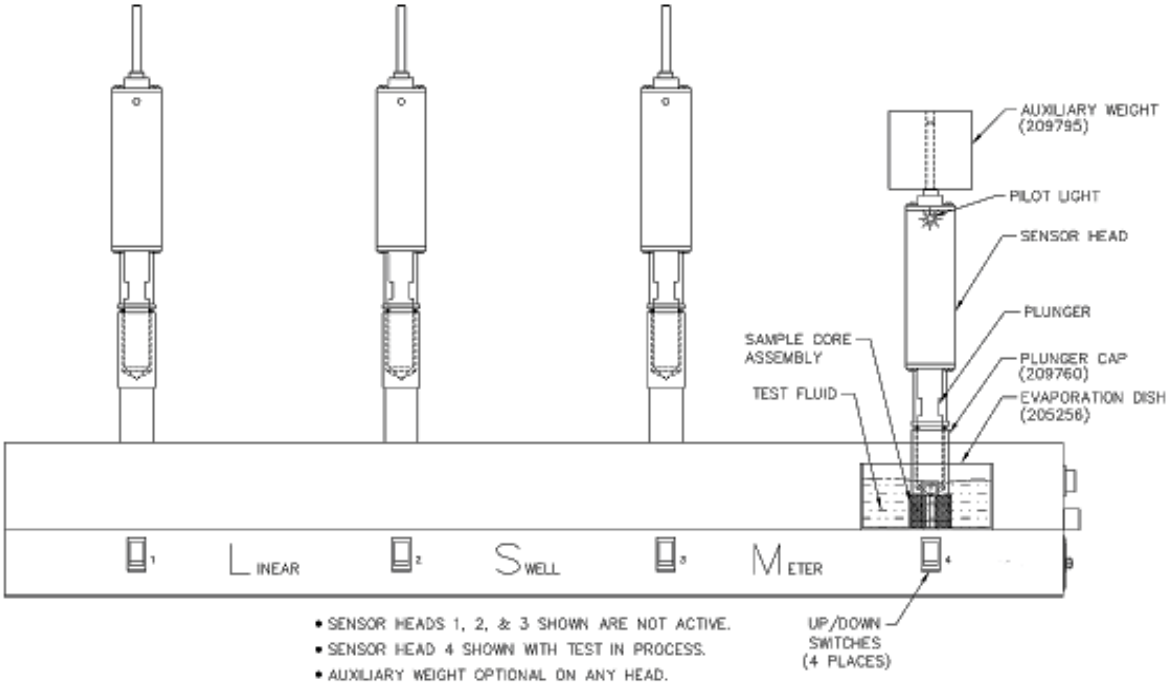


Figure 3-2 Active Measuring Head with Auxiliary Weight

3.2 Compactor

A two-cell, hand-operated hydraulic compactor is used to compact the pulverized core samples from drilled cuttings. Applying constant pressure up to 10,000 lb_f for several hours to the core sample will form a satisfactory shale core plug.

Crushed shale is placed in the cylindrical mold (core chamber) that connects to the compactor cell (hydraulic cylinder), where compaction (reconstitution) occurs.

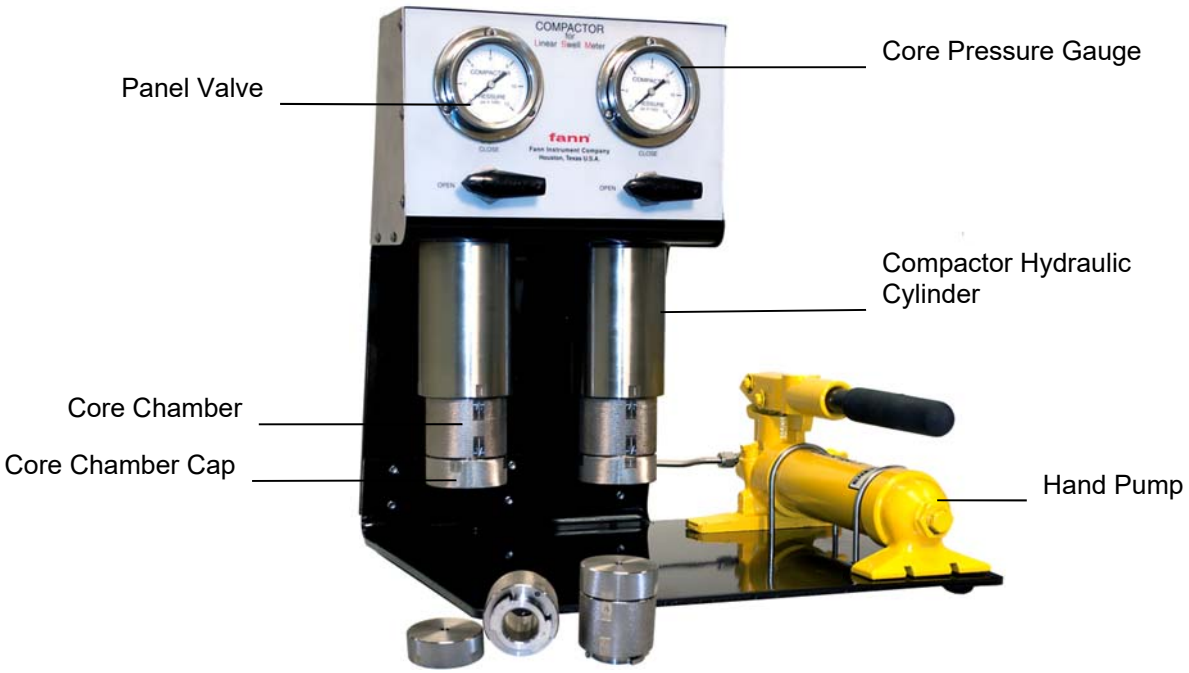


Figure 3-3 Compactor, Cell, and Pump

3.3 Laboratory Supplies

Table 3-2 lists the laboratory equipment and supplies that are required to compact samples into a core plugs and to perform a swell test. (See Table 3-2 for a complete list of optional equipment available for separate purchase.)

Table 3-2 Laboratory Supplies and Equipment for Swell Measurements

Item	Use
Vacuum desiccator Vacuum pump	To normalize the reconstituted core plug
Drying oven	Temperature range 105ºC or higher
Scale	Weigh to 25 g
Mortar and pestle	To pulverize shale
Caliper, 0-1 inch	Measure to ±0.001 inch accuracy
Sieve, 60 mesh	To wash the shale
Sieve, 200 mesh	To separate crushed shale
Spatula (2)	To mix moist shale
Evaporation dish	To contain sample during the swell test
Container with lid	To store shale test samples
Calcium chloride brine solution	To control sample humidity
Isopropanol Synthetic sea water	To wash shale
Xylene	To wash shale from oil based drilling fluids
Type D Durometer	To measure shale plug hardness before test
Type A Durometer	To measure shale plug hardness after test

3.4 Computer Requirements

A computer that operates on Windows® XP or Windows® 7 is required. The LSM 2100 does not include a computer and monitor.

Please disable the sleep mode on your computer. When a test is running, the computer is collecting data. If the computer goes into sleep mode, data will not be collected.

3.5 LSM 2100 Software

This software provides data acquisition from one to eight channels. The main display is shown in Figure 3-4.

From the main display, the user can start and stop a test using the menu options. The main display shows the graphs and test data. Also, the swelling time (minutes) and percentage of swelling appears in the top right corner when the cursor is placed along a graph line.

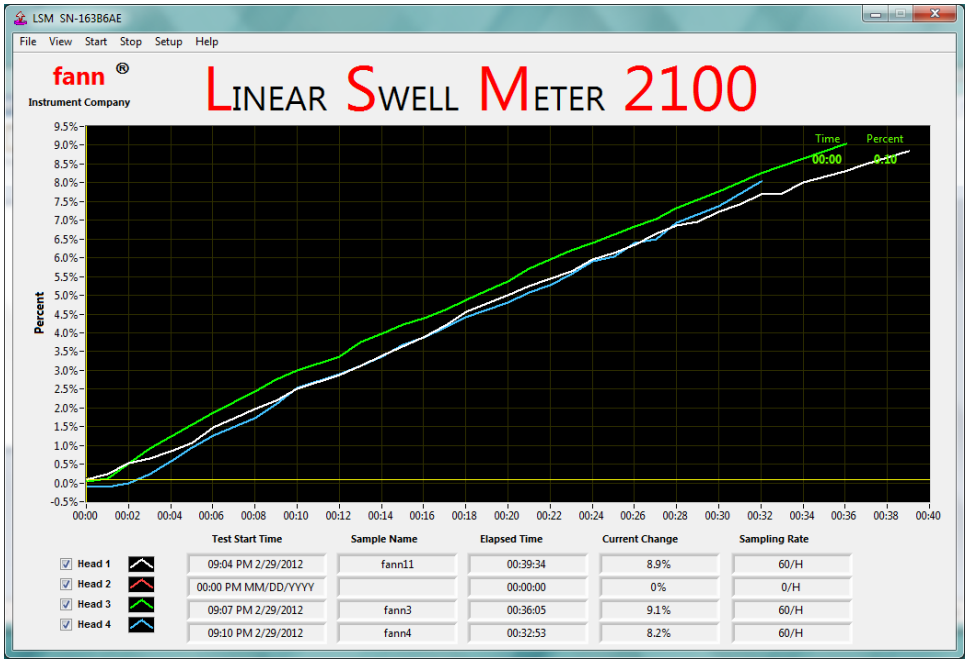


Figure 3-4 LSM Control and Status Screen

The program can be configured to automatically send an email report for all eight channels for any of these conditions:

- Pre-set times of day
- When pre-set swell percentages have been crossed
- When pre-set slopes have been exceeded

If the program is shut down or the power fails, any tests in progress will resume when the program is restarted.

4 Installation

This section explains how to set up the equipment and install the software.

4.1 Measuring Unit

Select a suitable location for the LSM measuring unit. A suitable location is one where the measuring unit can operate with minimum disturbance, has suitable electrical power, and is near the measurement computer.

1. Connect one end of the cable to the USB port on the right side of the measuring unit.

Figure 4-1 Computer Connection on LSM

2. Install the proper fuses for the supply voltage.
3. Connect a power cord to the power receptacle on the measuring unit and to the power source.

Do NOT connect anything to the USB port.

4. Turn the unit on.

4.2 Compactor

Carefully unpack the compactor and move it to the desired location. The compactor does not have to be next to the LSM, but having it nearby is desirable.

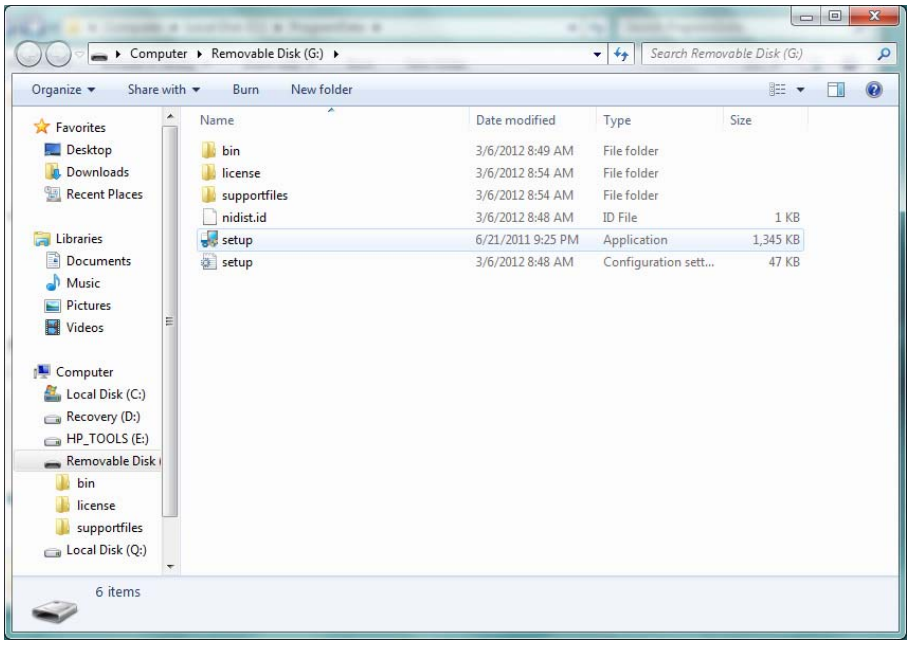
It should be placed on a sturdy table, counter, or stand. Make space for the core chamber, sample preparation, and clean up after the test ends.

4.3 Software Installation

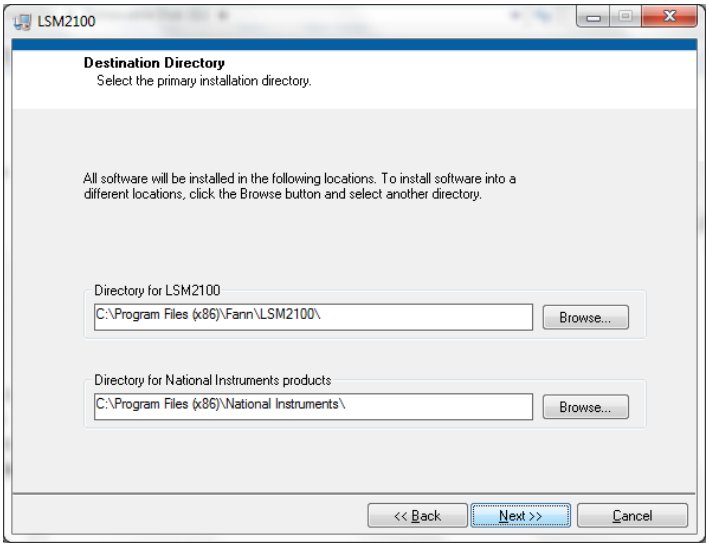
To install the LSM software, follow these steps.

1. Insert the LSM software install the USB flashdrive into the computer.

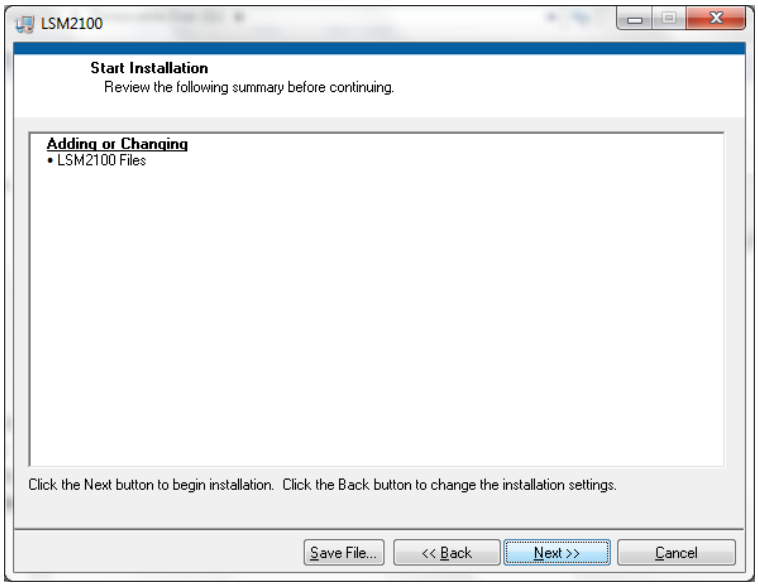
2. If the installation process does not automatically begin, click **Start**, and then **Run**. Browse to find the setup program on the USB flashdrive. Select the setup program, and then click to open.



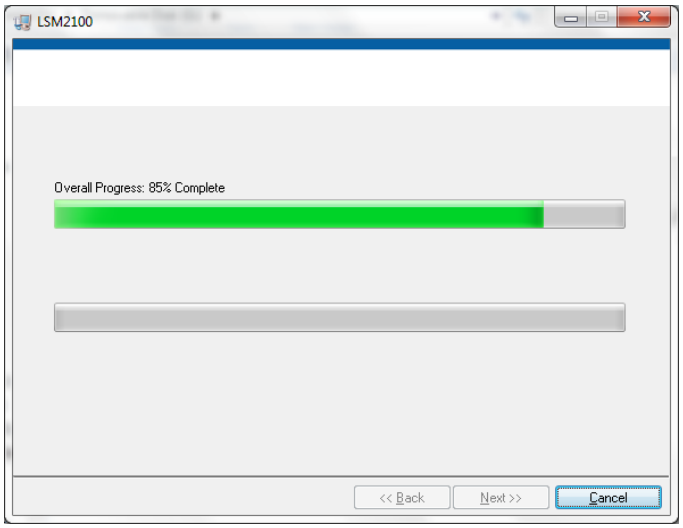
3. When the setup program appears in the **Run** dialog box, select **OK**.
4. Wait for the software to install.
5. Select where you want to install the software.



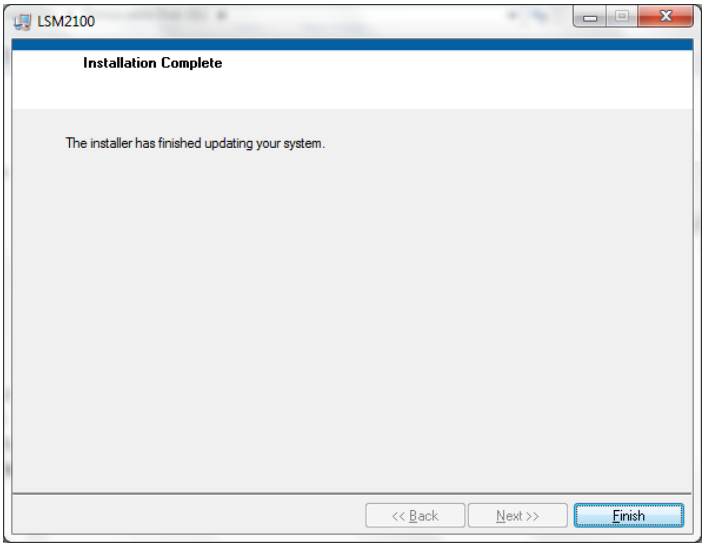
6. When prompted, accept the End User License Agreements (EULA) and the default installation paths. Click **Next**.
7. Continue with the installation process, following the prompts, and clicking **Next** when required.



Start Installation



Installation in progress



Installation complete

8. When the software installation is complete, the system will require restart. Follow the prompt on the screen and restart the computer.

9. After the computer restarts, the LSM software will start automatically. The prompt will say, “Machine is not connected. Please restart the program.” Click **OK**. The program will close.

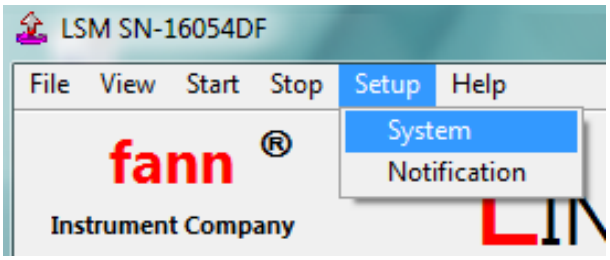
10. After the program closes, connect the computer to the instrument via USB cable.

4.4 User Configuration

Before the LSM 2100 program can be used, it must be properly configured.

1. Start the LSM software by clicking on the LSM.exe shortcut on the computer desktop.

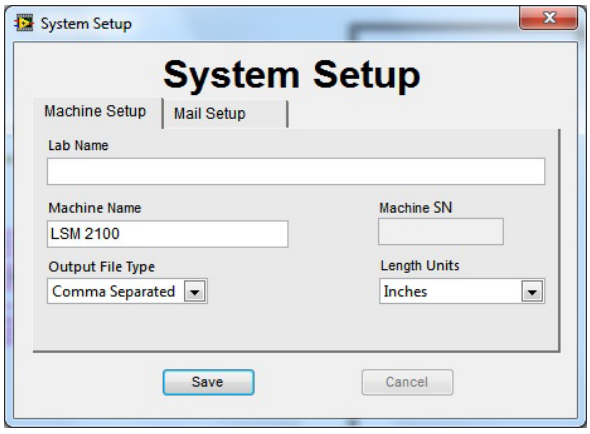
2. From the top menu bar, select the **Setup** button, then **System**.



LSM Setup Menu

3. Adjust these **System Setup** values:

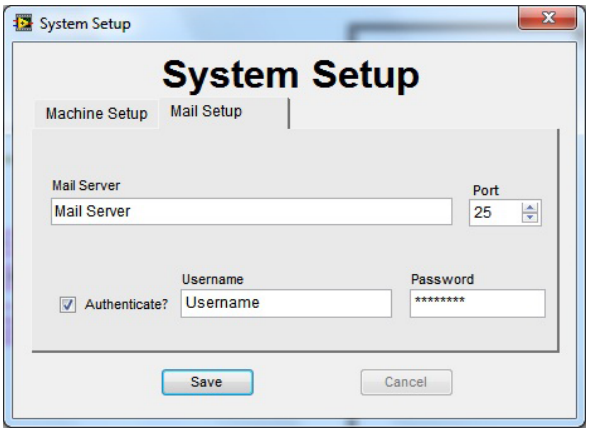
   - Lab Name — this name will appear on the test reports
   - Machine Name — a unique identifier for each LSM instrument in the lab
   - Output File Type — Comma Separated (CSV) or Tab Separated (TSV)
   - Length Units — Inches or Millimeters
   - Machine SN — Serial Number for the machine that the software connects



System Setup – Machine Setup

4. Select the **Save** button when complete, or select the **Mail Setup** tab.

5. Configure the **Mail Setup** as instructed by the facility's information technology group. Select **Save** when finished.

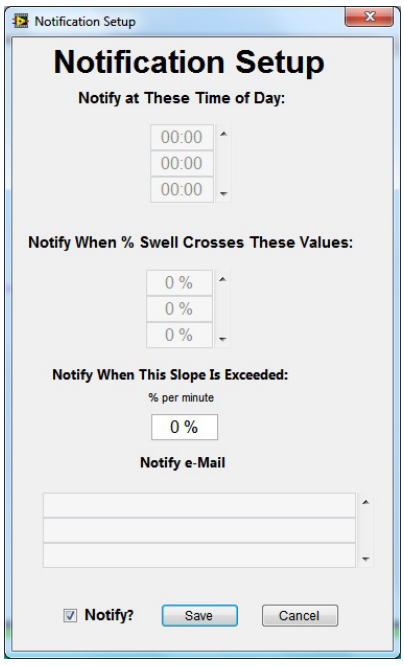


System Setup – Mail Setup

6. From menu, select the **Setup** button, then **Notification**.

7. Adjust and save these **Notification Setup** values:

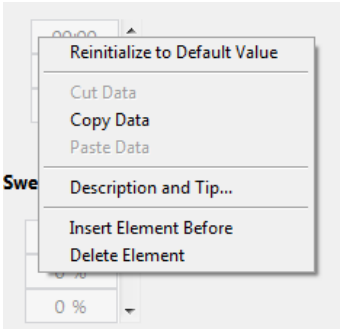
   - Notify at These Time of Day
   - Notify When % Swell Crosses These Values
   - Notify When This Slope Is Exceeded
   - Notify E-Mail - enter the E-mail addresses to receive these notification messages.



Notification Setup

8. Enable all notifications by clicking **Notify?**.

9. Right click and select **Delete Element** to clear the values and disable individual notification types.



Notification Setup Menu

The email notifications report the values for all measuring heads.

5 Operation

This section describes the operations involved in using the Linear Swell Meter. It is organized in these subsections:

- Sample Preparation
- Calibration
- Shale Core Plug Installation
- Test Start-up
- Test Shutdown

Disable the sleep mode on your computer. When a test is running, the computer is collecting data. If the computer goes into sleep mode, data will not be collected.

5.1 Sample Preparation

Shale core samples for these tests are compacted (reconstituted) using the two cell hydraulic compactor. Pulverized shale is placed in a cylindrical mold, and then compacting pressure is applied and maintained during compaction.

Tests indicate that a constant pressure of 10,000 lb_f applied for 1.5 hours results in satisfactory shale core plugs. Approximately 20 grams of 200-mesh material will yield a cylindrical core plug of 1-1/8 inch (28.6 mm) diameter and 5/8 inches (15.9 mm) height. The material quantity and length will vary with the type of shale or clay.

This procedure shows how to prepare a reconstituted shale core sample suitable for testing. It is recommended that you prepare all samples that are needed for an investigation at the same time. Several steps require considerable processing time which will be the same whether one or a group of samples are being prepared.

5.1.1 Prepare the shale

Determine the source of the shale to be used for the test – drilled cuttings, core samples, or other source.

If the shale comes from drilled shale cuttings, collect these cuttings from rig shaker. These cuttings are usually contaminated with drilling fluids and have been exposed to the atmosphere.

1. Obtain sufficient sample to reconstitute the number of shale cores required. Allow about 30 grams for each core sample plug needed.

   A. Drilled Cuttings

      1) Wash the cuttings with water on a 60-mesh sieve.

      2) If the cuttings sample is very dispersed, use synthetic seawater or isopropanol to wash them.

Isopropanol is highly flammable and has strong vapors. Keep away from heat, sparks, or open flame. Avoid skin and eye contact. Provide good ventilation and avoid inhalation.

      3) Wash oily cuttings with xylene first, and then wash with isopropanol.

Xylene is flammable and has strong vapors. Keep away from heat, sparks, or open flame. Avoid skin and eye contact. Provide good ventilation. Avoid inhalation.

      4) Dry the sample in an oven at 220ºF (105ºC) for 4 hours.

      5) Store the clean cuttings in a vacuum desiccator containing saturated calcium chloride brine solution. This solution is needed to maintain a constant humidity of 29.5%.

   B. Core Samples

      If the shale sample comes from a core or other source, it probably does not need cleaning. Store the sample in a vacuum desiccator as previously described.

2. Obtain approximately 25 grams of the shale sample from the desiccator.

3. Grind the shale sample to a particle size that will pass through a 200-mesh (75-micrometer opening) sieve. Repeat this step until all the shale sample passes through the screen.

If the shale sample came from drilled cuttings and was washed, it will contain sufficient moisture. Therefore, you can skip the next step.

5.1.2 Measure the moisture content

1. If the shale sample is from a core or other source, determine its moisture content. Weigh approximately 5 grams of the ground sample and then dry this sample in an oven at 220ºF (105º C) for two hours.

2. Weigh the sample after it has cooled to room temperature, and then calculate the moisture content. If the moisture content of sample is approximately 5%, go to step 4. If the moisture content is greater than 5%, then dry the sample in the oven and weigh it again after is has cooled to room temperature.

3. If the moisture content is less than 5%, add sufficient deionized water to make up a total of 5% water by weight.

    a. Mix thoroughly by kneading the mixture with two spatulas.

    b. Transfer the mixture into mortar and grind the mixture gently with a pestle until the sample passes through a 200-mesh screen.

Do NOT exceed 5% water in the sample. Samples with moisture content greater than 5% may not compact sufficiently.

4. Transfer the mixture from the mortar to a container with tight lid for storage until needed for compaction.

5.1.3 Compact the shale

1. Align the “O” on the cap with the arrow on the core chamber. See Figure 5-1.

Figure 5-1 Compactor Cell with Core Sample

The cap can only be installed or removed when the “O” on the cap is in line with the arrow on the chamber. See Figure 5-1.

2. Turn the cap 1/4 turn until the detent snaps into place and the arrow on the core chamber is aligned with the "I" on the cap as shown in Figure 5-1.

3. Place the core stop in place in the cap, point down, then place the acrylic spacer disk on top of the core stop. See Figure 5-2.

4. Pour 20.0 grams of the prepared shale powder sample into the cell. Place the second acrylic spacer disk on top of sample and press firmly. Refer to Figure 5-2.

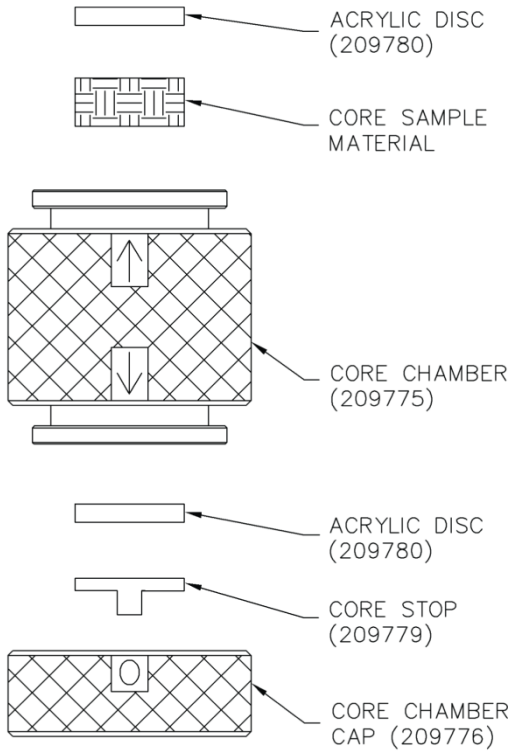


Figure 5-2 Core and Core Chamber Layout

5. Attach the core chamber assembly to the cylinder of the compactor unit. Rotate the core chamber assembly, as a unit, 1/4 turn until the detent snaps into place and the arrow on the core chamber is aligned with the "I" on the cylinder. See Figure 5-3.

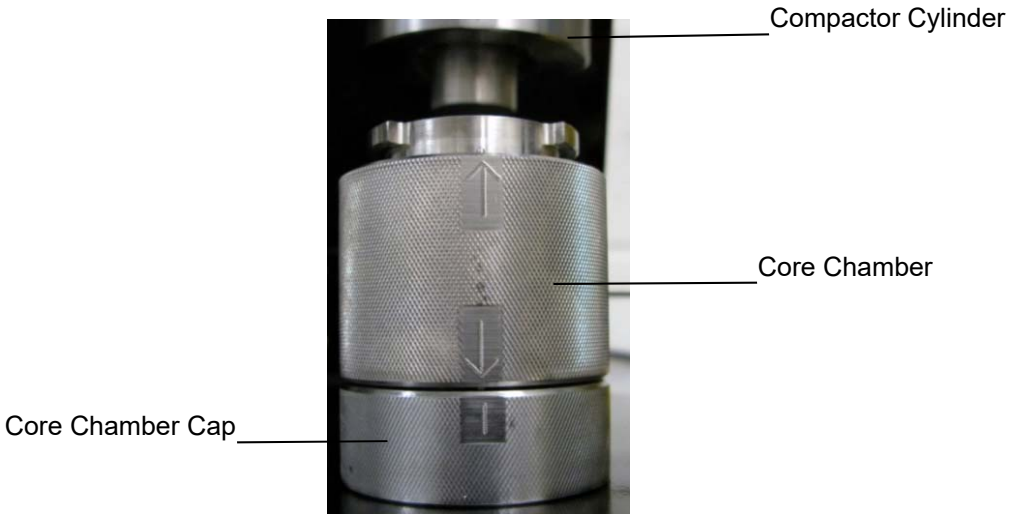


Figure 5-3 Core Chamber Assembly onto Compactor Cylinder

Make sure that the core chamber cap is assembled properly onto the core chamber and that the core chamber assembly is assembled properly onto the compactor cylinder. Separation of these parts while pressure is applied can cause injury.

6. Close the pressure release valve on the hydraulic pump and open the cell panel valve for the cell (Figure 5-4) to be pressurized.

Figure 5-4 Panel Valve And Pressure Gauge on Compactor Cell

7. Using the hand-operated hydraulic pump, apply hydraulic pressure until the pressure reaches 10,000 lb_f on the shale (until the pressure gauge reads compactor pressure of 10,000).

Note: due to the geometry of the compactor cell, the pounds force x 1000 (lbf) value reading on the gauge can be read as an approximately interchangeable reading for psi.

The pressure will drop when compacting begins. Maintain the pressure at 10,000 lb_f by operating the hand pump.

8. At approximately 10 minute intervals, readjust the pressure to 10, 000 lb_f until it remains constant. After each pressure adjustment, close the panel valve to avoid bleed off to the pump.

9. Maintain the pressure for 1.5 hours. Open the panel valve and adjust pressure at ten minute intervals as necessary. Close the panel valve after adjusting the pressure.

10. Release the pressure by turning the panel valve to open, and then turn the release valve on the hand pump.

11. Screw the extractor tool into the bottom cell cap and tighten it to force the core slightly upward and release the pressure on the bottom cell cap.

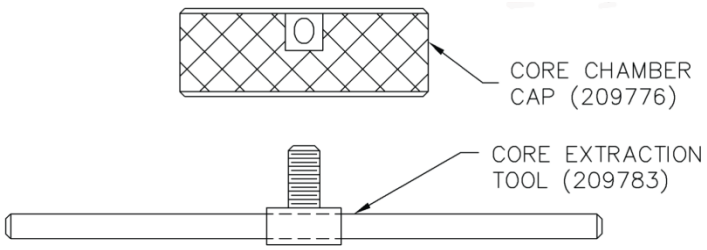


Figure 5-5 Core Extraction Tool

12. Remove the bottom cap from the cell.

13. With the pump release valve closed and the panel valve open for the cell being disassembled, slowly apply enough pressure to expel the core stop, the lower acrylic spacer, and the core from the compaction cell.

14. Immediately weigh the reconstituted core plug and place it in the vacuum desiccator.

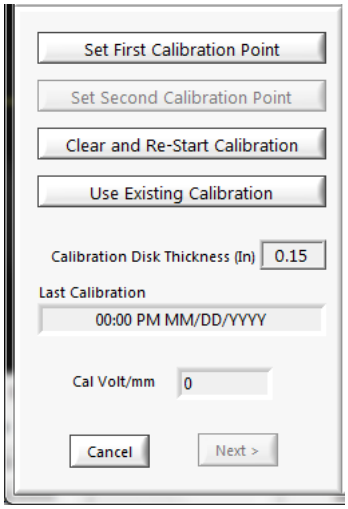
15. Apply a vacuum to the desiccator for 5 minutes.

16. Let the core plug sit in the desiccator for at least 24 hours before starting the swelling test.

5.2 Calibration

Each measurement channel must be calibrated before starting a test. This requires a certified thickness calibration disk and a suitable calibration spacer block.

Although not a recommended practice, it is possible to begin a test using a previous calibration. To do so, select the **Use Existing Calibration** button (see figure below).



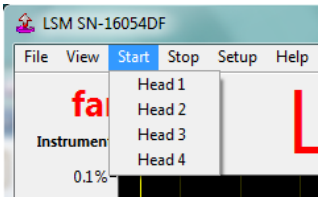
Calibration Menu

To begin a new calibration, proceed as follows:

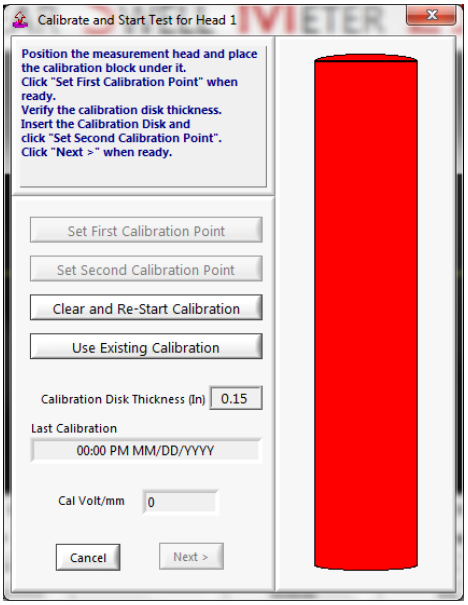
1. Start the LSM software by clicking the desktop icon. Wait for the software to fully load (~ 2 minutes or less).

LSM Desktop Icon

2. To make the channel measurement head active, on the **Start** menu, click the head number. The **Calibrate and Start Test for Head** screen will appear. (The example shows Head 1).



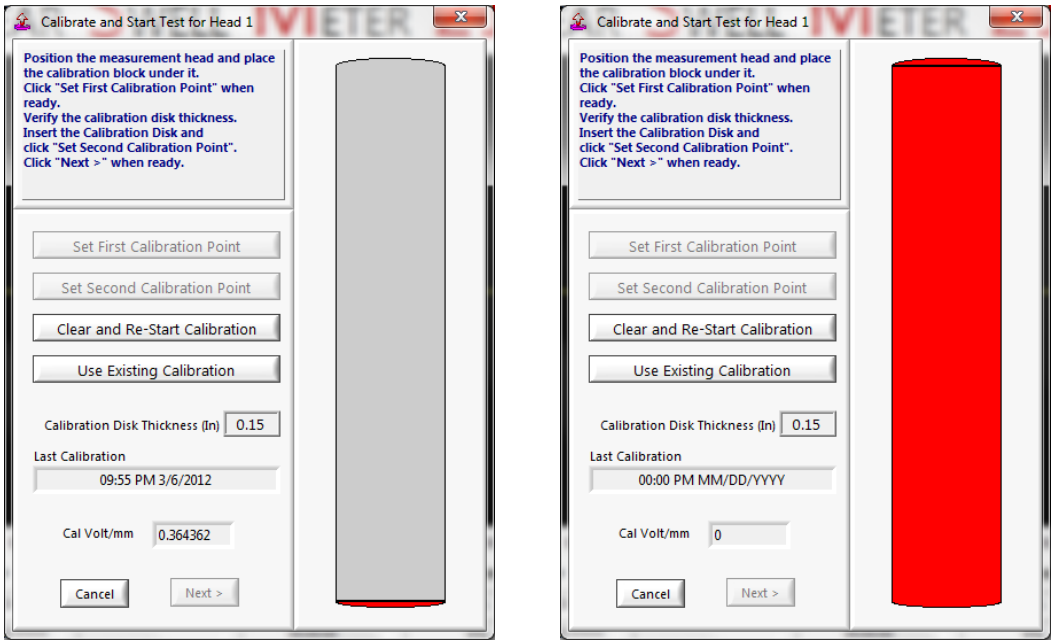
LSM Start Menu



Example - Head 1 Calibration

Initially, the height of the head may be out of range (identified by partially or fully red-filled cylinder) or in range (blue-filled).

When a head indicator shows red, it is out of the measurement range for the transducer. The **Next >** button is inactive. The user cannot start the test. Correct the out of range condition by adjusting the measurement head with the UP/DOWN switch on the front panel on the instrument.



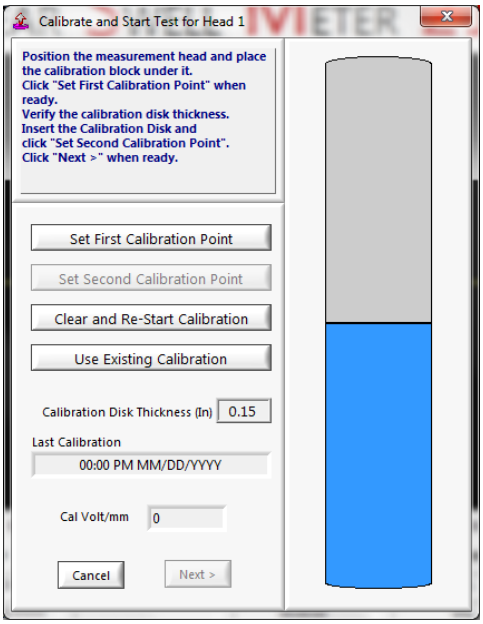
Head Indicator out of Range

3. A non-compressible spacer (e.g., aluminum or stainless) with parallel top and bottom surfaces approximately 1.25 inches (3.17 cm) thick should be placed below the measurement head. This thickness is approximately the same as a compacted sample. See Figure 5-6.

4. Press and hold the **Down** switch on the LSM base to lower the channel measuring head so that it will touch the spacer. Lower the measuring head until the position indicator turns blue, which should be in the lower half of the scale.

Figure 5-6 Spacer Block

5. When the position indicator turns blue (ready), click **Set First Calibration Point**.



Example – Head 1, First Calibration Point

6. Manually lift the measurement shaft upwards, and place the certified calibration disk (Figure 5-7) between the spacer block and the head.

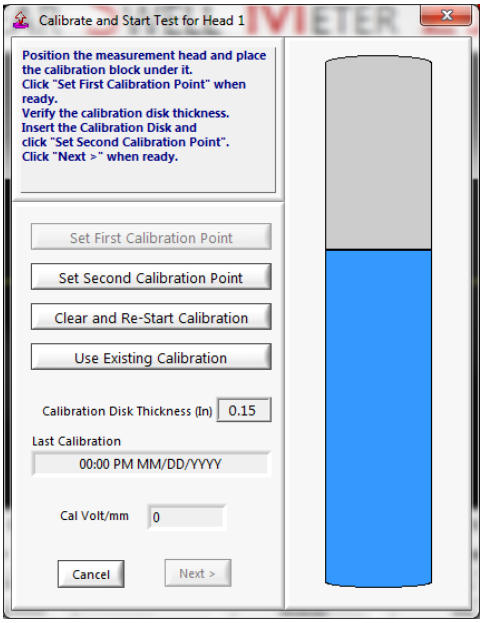
The calibration disk must be certified to have 0.150 in. thickness

Figure 5-7 Certified Calibration Disk

7. Lower the head onto the calibration disk.

Figure 5-8 Calibration Disk on Spacer Block

8. Observe the position indicator. It should be blue and stable. If so, click **Set Second Calibration Point**. If the measurement does not stabilize or the position indicator becomes red, restart the entire calibration process. If after two attempts to calibrate, the measurements are not the same, then the LVDT may be defective. Call Fann Instrument Company for service.



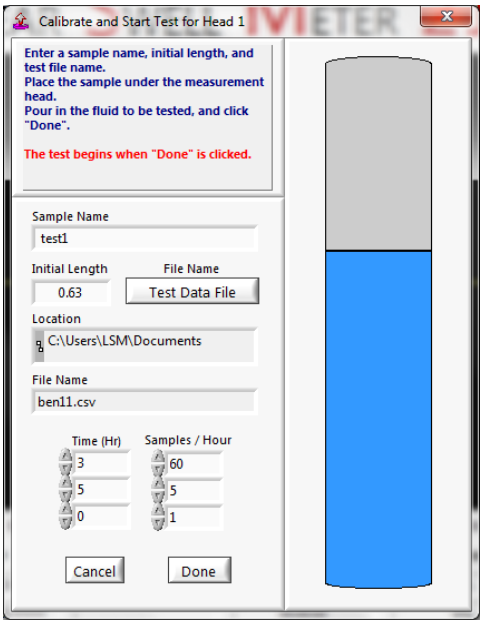
Example – Head 1, Second Calibration Point

The new calibration is retained even if you do not start a test.

9. The calibration of the head is complete. Manually raise the shaft and remove the spacer block and calibration disk.

10. The next button will become active (gray to active). Click **Next** to continue onto the next screen to allow test sample information to be entered.

Only after a channel has been successfully calibrated will the screen change to allow test sample information to be entered. **Done** (lower right) is grayed out until this basic information is entered.



Start Test – Test Data Entry

11. Enter a name for the sample in the **Sample Name** box. The same sample name may be used for multiple tests.

12. Accurately measure the core length (inches) with digital calipers and enter the initial length of the sample in the **Initial Length (In)** box.

13. Select **Test Data File**, and enter the desired location and file name. The file name must be unique.

14. After entering data in **Sample Name**, **Initial Length**, **Location** and **File Name** fields, **Done** will change from gray to active.

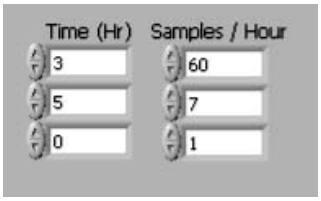
Do NOT click the **Done** button yet!

15. Different sampling rates may be set for three time periods (maximum). Set the values in the **Time (Hr)** and **Samples / Hour** windows for the desired time periods and sample rates.

Entering a time of zero (0) means to run continuously at the specified sample rate. The **Samples/Hour** field must have values of 1-60 (i.e., 1 sample per hour to 1 sample every minute).

For an example, see the following screen capture (a section on the Calibrate and Start Test screen previously shown). Sampling takes place as follows:

- From start to 3 hours, data is recorded 60 times per hour (once every minute).
- From 3 to 8 hours, data is recorded 5 times per hour (every 12 minutes), and after 8 hours, data is recorded once per hour.



Sampling Rate Screen Capture

The values that you enter in these fields cannot be changed after the test starts.

Do NOT click the **Done** button yet!

16. After entering your sample data, you will set up your sample in the measurement head.

5.3 Shale Core Plug Installation

This section explains how to install a core plug onto a measuring head and plot one channel. Installations can be made simultaneously or sequentially as desired. The LSM measuring heads are completely independent of each other.

1. Take one core sample from the desiccator.

2. Weigh the core and accurately measure the core length in inches with a caliper. Should the core have any flashing on it, this should be removed by rubbing on a piece of sandpaper or with a sharp knife before weighing and measuring. Record the weight and length on the data sheet.

3. Measure the hardness of the core with a type D durometer (Model 307L, P/N 205253). Record the hardness on the data sheet.

4. Stack an acrylic disk spacer (1.125 inch diameter and 0.19 inch thickness), the core sample plug, and the Teflon® plunger cap. Wrap the core holder around the stack and secure with the core holder lock. See Figure 5-9 and Figure 5-10.

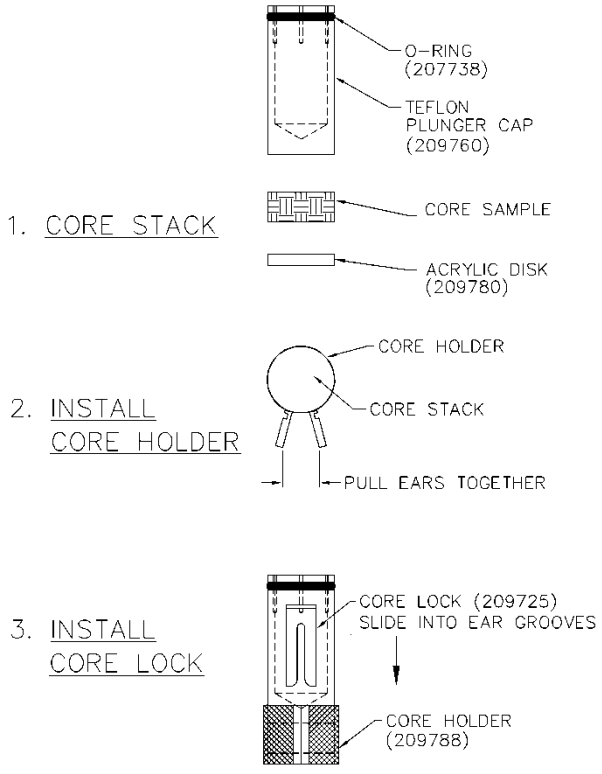


Figure 5-9 Step-by-step Assembly for Shale Core Plug

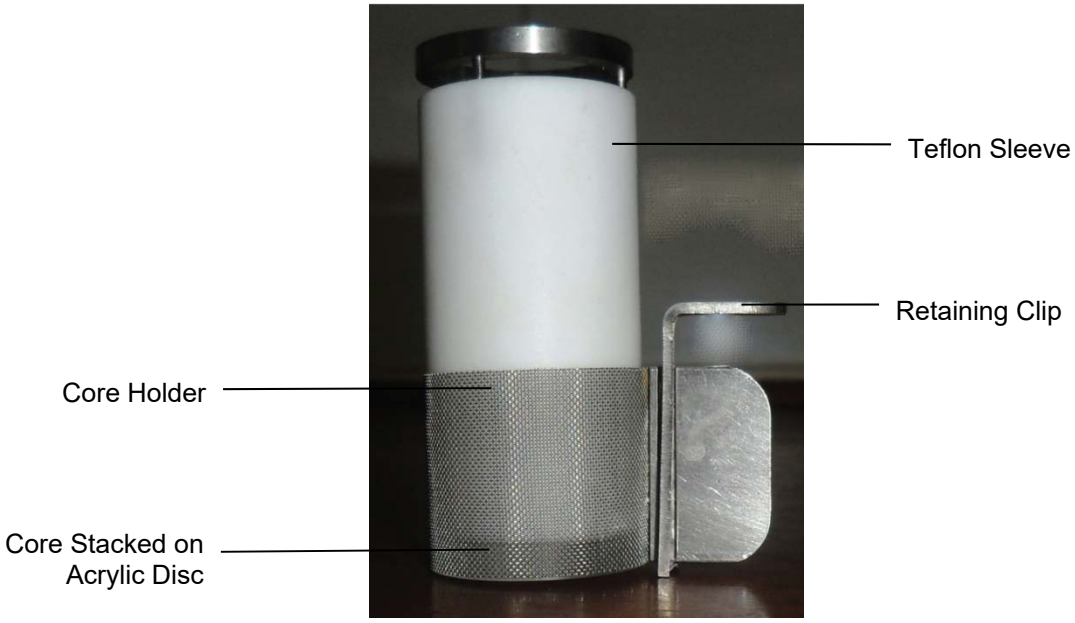


Figure 5-10 Spacer and Core Plug Stacked in Core Holder

5. Place a Pyrex® evaporation dish (or sample cup) under the measuring head. See Figure 5-11.

Figure 5-11 Evaporation Dish under the Measuring Head

6. Lower this measuring head by pressing and holding its rocker switch in the down position and at the same time pressing the release switch (Position Release) on the right end of the LSM (Figure 4-1).

7. Continue lowering until the core assembly touches the bottom of the evaporation dish as indicated by the red pilot light in the head lighting.

8. Continue lowering the measuring head until the bar graph turns blue (usually in the lower 1/3 of the range).

The loading weight of the plunger and plunger cap is 550 grams (1.21 pounds). If desired, place the auxiliary loading weight on top of the displacement plunger to obtain a total loading of 2000 grams (4.4 pounds). Record the Loading to be used 550 grams or 2000 grams on the data sheet.

5.4 Test Start-Up

1. Place your test sample up in an appropriate vessel and center it beneath the measurement head.

2. Manually lower the measurement head (use the switch on the front of the measuring unit) until it contacts the sample and the bar graph turns blue (usually in the lower 1/3 of the range).

3. Carefully pour the drilling fluid into the vessel surrounding the sample.

4. When you are ready to begin the test, click the **Done** button.

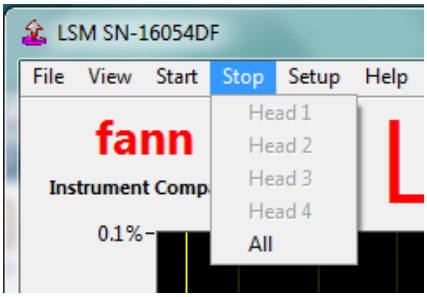
5. Repeat the steps for calibrating, installing the shale core plug, and starting the test until all channels and samples are done. Enter a unique file name for each test that you start.

Figure 5-12 Test in progress

5.5 Test Shutdown

On the **Stop** menu, click the **Head** number on which you want to stop the test, or select **All**.

Repeat for additional channels (if all was not selected).



Stop Menu for ending test

6 Test Analysis

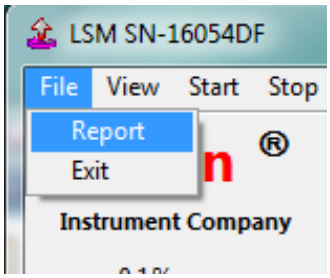
The LSM 2100 software records and graphs the test data. The test results are graphed to show the percent of swelling versus swelling time.

This section explains how to use the software to view and print the test results.

6.1 View Test Data

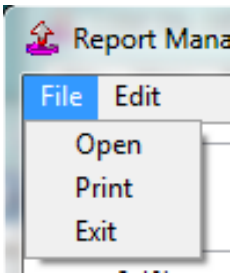
It is important to know where your files are stored. It is recommended that you use the same folder for storing all tests. Some users create unique folders for each customer or sample type.

1. To open a test file, open the **Report Manager** section. From the **File** menu, click **Report**.



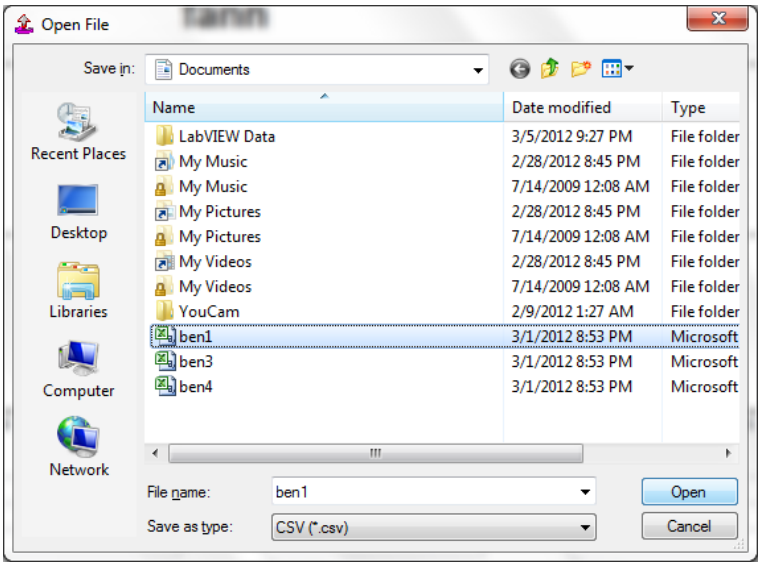
LSM File Menu

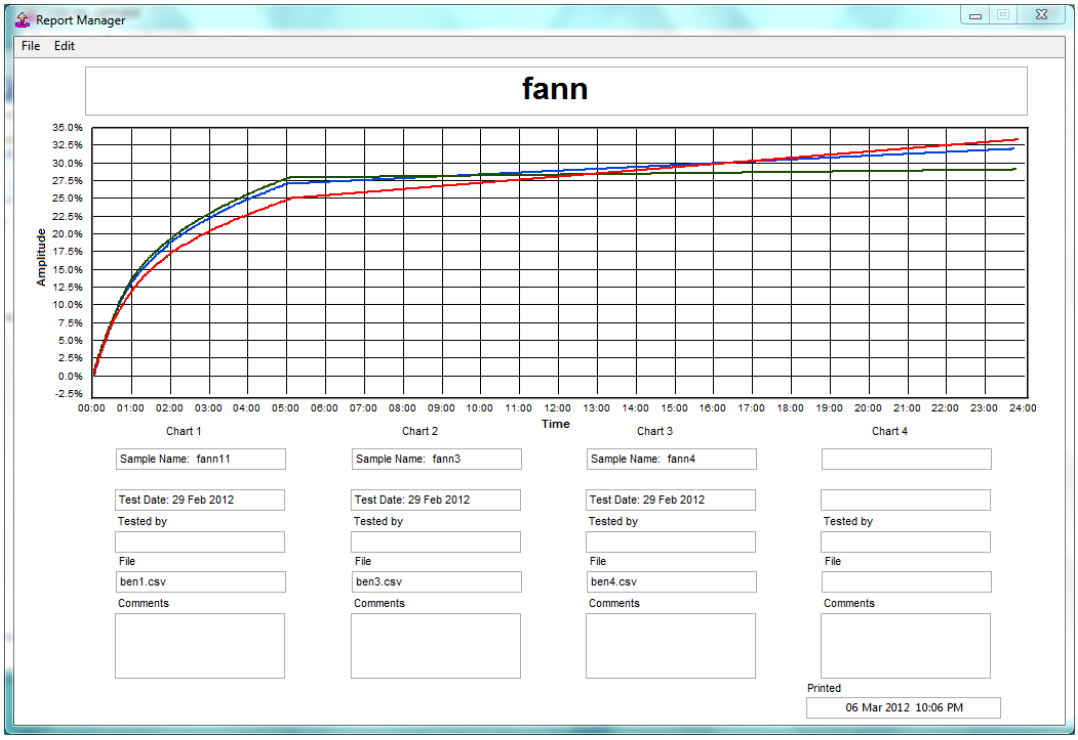
2. In **Report Manager**, click **Open** from the **File** menu, and browse to the desired file location.



Report Manager File Menu

3. Select the desired file, and then click **Open**. The next screen capture will display the test report.





Test Report on Report Manager

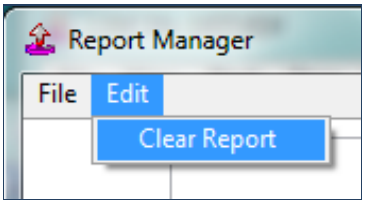
4. The information in the boxes below the graph can be edited. To change the contents, click inside the box and enter the new information.

You can enter information in the fields, **Tested by** and **Comments** for the test report only. This information is not stored with the test data.

5. The displayed test reports can be printed, or printed to a PDF report, if PDF printer software (not included) has been previously installed.

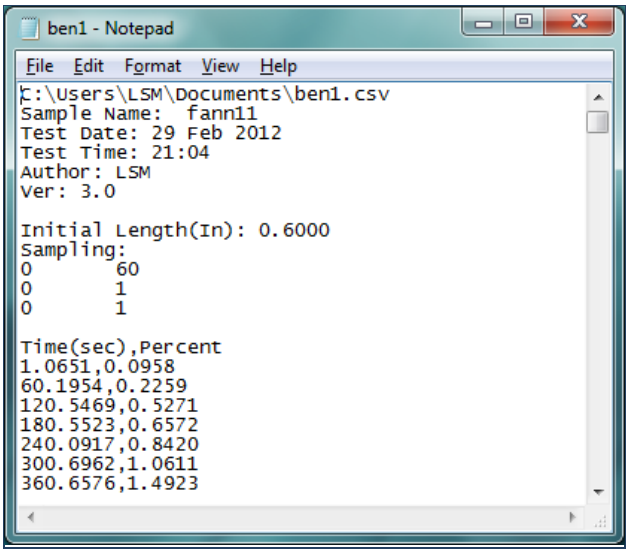
6. Up to four test charts can be displayed in **Report Manager** at the same time. To open additional test charts, repeat the previous steps.

7. To clear all the displayed test reports, select **Clear Report** from the **Edit** menu bar.



Report Manager Edit Menu

8. The actual test data is stored in either a comma separated value (CSV) or tab separated value (TSV) format.

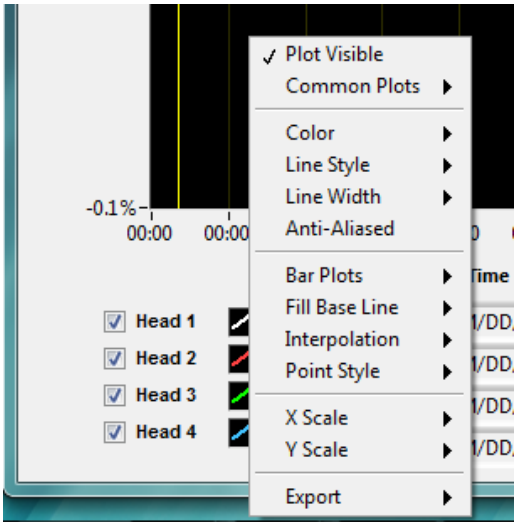


Test Data in CSV

6.2 Adjust Graph Settings

The line style, line color, line weight, and point style for each measurement head can be individually adjusted.

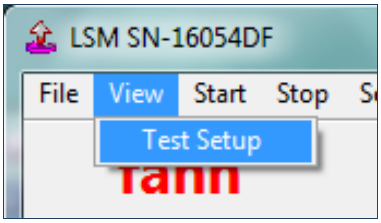
Right click on the plot legend to display the settings and make the desired changes.



Graph Settings Menu

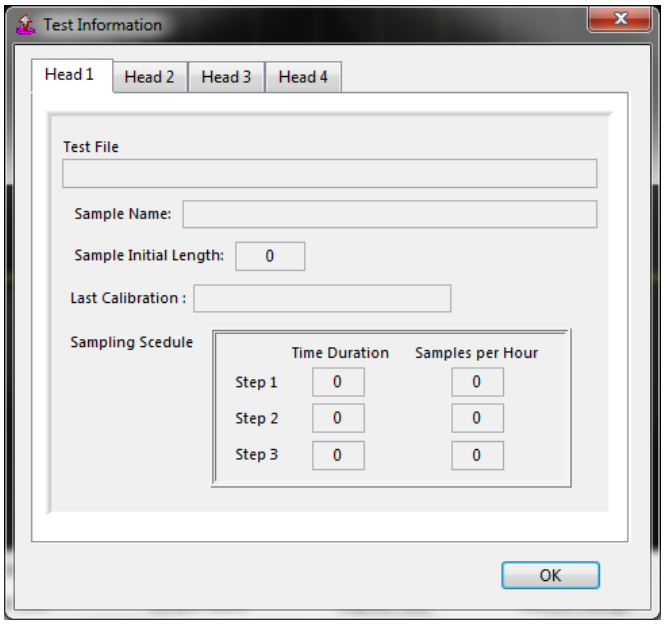
6.3 View Test Setup

To view test setup information, click **Test Setup** from the **View** menu.



LSM View Menu

On the **Test Information** window, you can see the setup for each measuring head.



Test Information Window

7 Troubleshooting and Maintenance

The Fann Model 2100 Linear Swell Meter is a precision measurement instrument.

This section helps the user solve problems that can be fixed easily and recognize problems that require outside assistance.

This section discusses these topics:

- Troubleshooting
- Safety
- Hardware testing and repair
- Processor unit testing

7.1 Troubleshooting Tips

The following tables list symptoms, causes, and solutions for common problems associated with the compactor and the Linear Swell Meter.

Only qualified personnel who are specially trained in the construction and repair of the LSM should attempt electronic or hydraulic repairs.

Table 7-1 Compactor Troubleshooting Guide

Problem or Symptom	Possible Cause	Corrective Action
Hand pump will not build pressure.	Pump release valve is open.	Close the valve.
	Panel valve to unused cylinder is open.	Close the valve.
	Hand pump oil reservoir is low or out of oil.	Check and refill the oil reservoir.
Compactor pressure cannot be maintained.	Leakage back into pump.	Close the panel valve.
	Air is in the hydraulic system.	Bleed the system.
	Core is extruding from core chamber around bottom of cylinder.	Core sample is too wet.

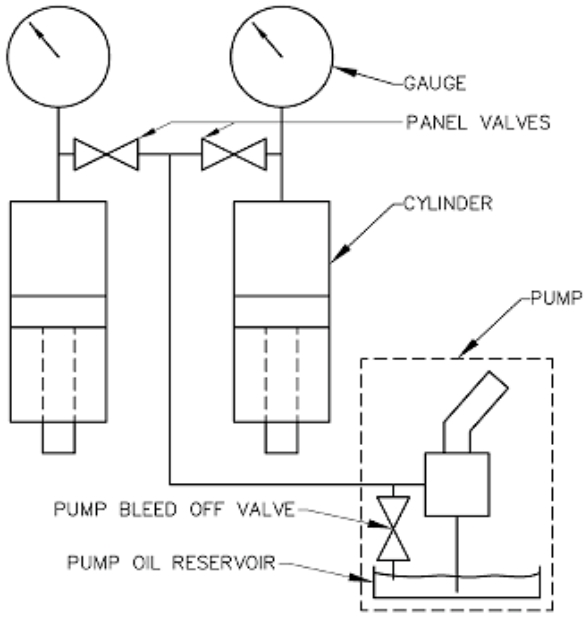


Figure 7-1 Hydraulic Flow Diagram for Compactor

Table 7-2 Linear Swell Meter Troubleshooting Guide

Problem or Symptom	Possible Cause	Corrective Action
Measuring Head will not move in either direction and motor makes no sound	No power to Linear Swell Meter.	Check power cable and power source.
	Power switch turned "OFF."	Turn power switch "ON." Light in the switch should glow.
	Fuse is blown.	Replace the fuse (1 Ampere).
	UP/DOWN and POSITION RELEASE switches are not held at the same time.	Press and hold the switches at the same time.
	Defective motor and/or capacitor.	Replace motor and/or capacitor.
Motor runs, but head does not move up or down.	Set screw that connects motor to elevating screw is loose.	Tighten set screw
The pilot light will not light.	Sensor position stop misadjusted.	Adjust position stop screw.
	Defective resistor and/or diode.	Check resistor and diode on terminal strip positions 1, 2, and 3. See the LSM wiring diagram, Figure 9-1. Replace defective parts.
	Sensor position switch defective.	Replace switch.
	Pilot light defective.	Replace pilot light.
Pilot light on continuously.	Sensor position switch defective.	Replace switch.
Sensor Bar on computer screen is not near zero. Computer is in Calibrate Mode.	No power to Linear Swell Meter	Check power cable and power source.
	Transducer not at zero position.	Raise or lower sensor head by operating the motor.
	Cable between Linear Swell Meter and computer is unplugged or not making connection.	Check cable and cable connections. See Figure 9-1.
	No signal from Linear Swell Meter.	Check USB cable connection.

Problem or Symptom	Possible Cause	Corrective Action
	Broken wire or defective connection to 14 VDC power supply, or defective power supply.	Replace wire, repair connection, or replace power supply. See Figure 9-1.
Computer does not respond to movement of sensor bar.	Defective transducer.	Disconnect transducers, one at a time, and determine if the 10V returns at TP-10 to GND. Check connector on end of the transducer cable. If defective, repair or replace the transducer.
	Defective Plus and Minus 12V DC power supply.	Check for voltage TP-12V+ to GND on power supply. Replace if bad.
	Improper transducer output.	Inspect the transducer cable connector for broken or damaged wires or pins. Repair wiring. Remove the sensor body cover and verify the core rod is mechanically passing through the transducer. Repair as required. Test the LVDT for defective channel. Channels 1-4 measure voltage R_2, R_4, R_6, R_8, respectively to ground. Voltage should change from 1.5 to 5 V DC when core rod is moved through the transducer. Move core rod by raising and lowering the measuring plunger. If defective, replace the transducer.

7.2 Maintenance

This section contains information and instructions for performing maintenance and repairs on the Model 2100 Linear Swell Meter.

7.2.1 Safety Precautions

Perform the following safety procedures before performing in-depth maintenance on the Model 2100 Linear Swell Meter.

You can be injured or the equipment can be damages if you fail to follow these safety precautions.

1. Turn off the power switch and disconnect the power cable to LSM.
2. Relieve the compactor pressure.
3. Let the unit cool to room temperature.

7.2.2 Compactor and Pump Maintenance

The LSM compactor is basically a hydraulic hand pump joined to a hydraulic cylinder. The cylinder plunger applies pressure to the core holder and compresses the pulverized shale into a plug.

Keeping this hydraulic system clean and free of oil leaks is important. This section provides steps to add oil to the hand pump when it is low and to replace O-rings when oil leaks from the compactor.

See Figure 9-3 for the hydraulic schematic diagram. See Figure 9-6 and Table 9-4 for assembly and parts location of the hydraulic pump.

Oil Level

At startup of compacting a series of cores, check the hydraulic oil level in the hand pump.

1. Tip the compactor on its back with the handle end on the hand pump up.
2. Remove the fill cap and observe the oil level on the dip stick attached to the plug.
3. Add hydraulic oil (P/N 207805) to the level indicated on the dip stick.

4. Replace and tighten the plug, and then set the compactor right side up.

Oil Leaks

Inspect the outside of the pump and around the compactor cylinders for hydraulic oil. Total inspection of the entire hydraulic system requires removal of the stainless steel cover behind the panel.

Leaks usually result from a loose or damaged tubing fitting or a worn or damaged O-ring. A leaking fitting may require tightening or disassembly and replacement of the ferules. Leaking O-rings require replacement. Refer to the following repair procedures.

1. Make sure all hydraulic pressure has been released and that the compactor ram is in the full UP position.

2. Remove the core chamber and core chamber cap if not already removed.

3. Remove 5 mounting screws each end of cover behind panel and remove the cover.

4. Loosen the two 10-32 socket set screws in the panel plate above the cylinder.

5. Using a strap wrench unscrew the cylinder from its top cap leaving the top cap mounted to the underside of the flat portion of the panel. Hold the cylinder securely as it unscrews, since a spring will be released. Refer to Figure 9-4 for cylinder assembly.

6. Remove the piston, spring and spring holder from the cylinder by sliding them out through the top.

7. Remove, clean and inspect the piston O-ring and the cylinder cap O-ring. The cylinder cap is still mounted to the panel; however the O-ring is accessible from under the panel. Replace O-rings if deformed, hard or have nicks or cuts. Make sure O-rings are lubricated when installing them. Repair or replace any other damaged parts.

8. Reassemble the spring holder, spring, and piston with O-ring into the cylinder. Screw the cylinder assembly onto the cylinder cap and tighten with the strap wrench.

9. Tighten the two 10-32 set screws.

10. Install the panel cover.

7.2.3 Hydraulic Hand Pump Repair

1. Remove the pump from the compactor.

2. Disconnect the tubing fitting on the front of the pump.

3. Remove the four 10-32 nuts from the U-clamps on the bottom of the base, and remove the two U- clamps.

4. Disassemble and repair the pump following the illustration in Figure 9-6, and the parts list of Table 9-4.

5. Fill the pump with clean hydraulic oil (P/N 207805) or equivalent after re-assembly.

7.2.4 Swell Meter

Maintain a clean work surface free of spilled fluid and other debris.

Yearly lubricate the measuring head drive screw and thrust bearing with lithium-based grease. Refer to Section 7.2.7 for drive motor removal and repair.

To troubleshoot and repair the LSM, you must remove the back/bottom cover plate or the top and/or bottom measuring head covers. Refer to Figure 9-1, the wiring diagram for electrical troubleshooting.

7.2.5 Power Supply

The power supply furnishes the 14 volt DC power to power a 10 volt regulator which in turn operates the four LVDT transducers. On units having the power supply mounted with a subplate to the base assembly, 115 volts AC is connected to the two terminals toward the end of the chassis and the +14 V DC to the center terminal and the ground side of the 14 V DC to the opposite end terminal. On units having the power supply mounted to the bottom cover, 115 volts AC is connected to the two terminals away from the end of the chassis.

To test the power supply, verify the 115 volt input and the 14 V DC output.

If the power supply is defective, then replace it as follows:

1. Disconnect power cable to the LSM.

2. Turn off power to the LSM.

3. Turn the LSM on its front and remove the 10 mounting screws to remove the back/bottom cover.

4. Disconnect the four wires from the power supply.

5. Remove the four power supply mount screws. For earlier LSM models, you must access the four power supply mount screws from the bottom cover plate. For later models, remove the two nuts holding the power supply mount bracket, and then remove the four power supply mount screws.

6. Remove the power supply module.

7. Replace power supply module with a new one.

8. Install the mounting screws and the mount bracket nuts to the chassis (if used). Reconnect wires, and then remount the back/bottom cover.

7.2.6 Drive Motor

Replacing drive motor requires removal of the measuring head position drive system. While this system is disassembled, inspect, clean, and lubricate the guide tube-elevating nut assembly, elevating screw and thrust bushing. Worn parts should be replaced.

If the motor replacement is due to motor burn out or other electrical problems, the motor capacitor should also be replaced.

Remove the drive motor and motor capacitor

1. Disconnect power cable to the LSM.

2. Place the measuring head in the highest possible position to easily access the motor.

3. Pull the plunger cap from the bottom of the sensor plunger to release the O-ring detent.

4. To remove the guide tube-elevating nut assembly (P/N 209766), first, remove the measuring head top cover (four screws) shown in Figure 7-3. Second, remove the roll pins (P/N 208787; one each side) that hold this assembly into the measuring head body. The pins can be driven inward into the center of the guide tube for removal. Refer to Figure 7-2. If the elevating screw is still connected, the guide tube will be removed with the motor assembly.

5. Unscrew the elevating screw (counterclockwise) from the guide tube-elevating nut assembly. Replace the elevating screw if it is worn or bent.

6. Protect the front edge of the swell meter base with a cloth, and then place the swell meter on its front side to access the bottom. To remove the back cover/ bottom plate, take out the 18 mounting screws. Some of these screws also hold the rubber feet.

7. For earlier LSM models, you will need to remove the four small screws holding the power supply to the base, or disconnect the four wires from the power supply. The power supply is mounted to the bottom cover and also attached with wires to the base. Omit this step on later models.

8. Disconnect the black motor lead wire from terminal 9 of the measuring head's terminal strip.

9. Disconnect the orange wire from one terminal, and disconnect the red wire from the other terminal of the motor capacitor.

10. Remove the four 10-32 hex nuts and flat washers holding the motor mount bracket to the swell meter base.

11. Pull the motor assembly further out. Slide the motor shaft out of the elevating screw, and then remove the motor assembly.

12. Unplug the yellow and grey motor lead wires from the motor capacitor.

13. Remove the four screws attaching the motor to its motor bracket, and then remove motor.

14. The thrust bushing is over the motor output shaft. Remove it and replace it if it is worn.

15. Loosen the set screw(s) in the elevating screw and separate it from the motor assembly. Replace the guide tube-elevating nut as an assembly if required.

16. Install the elevating screw from the bottom and screw it into the guide tube - elevating nut assembly.

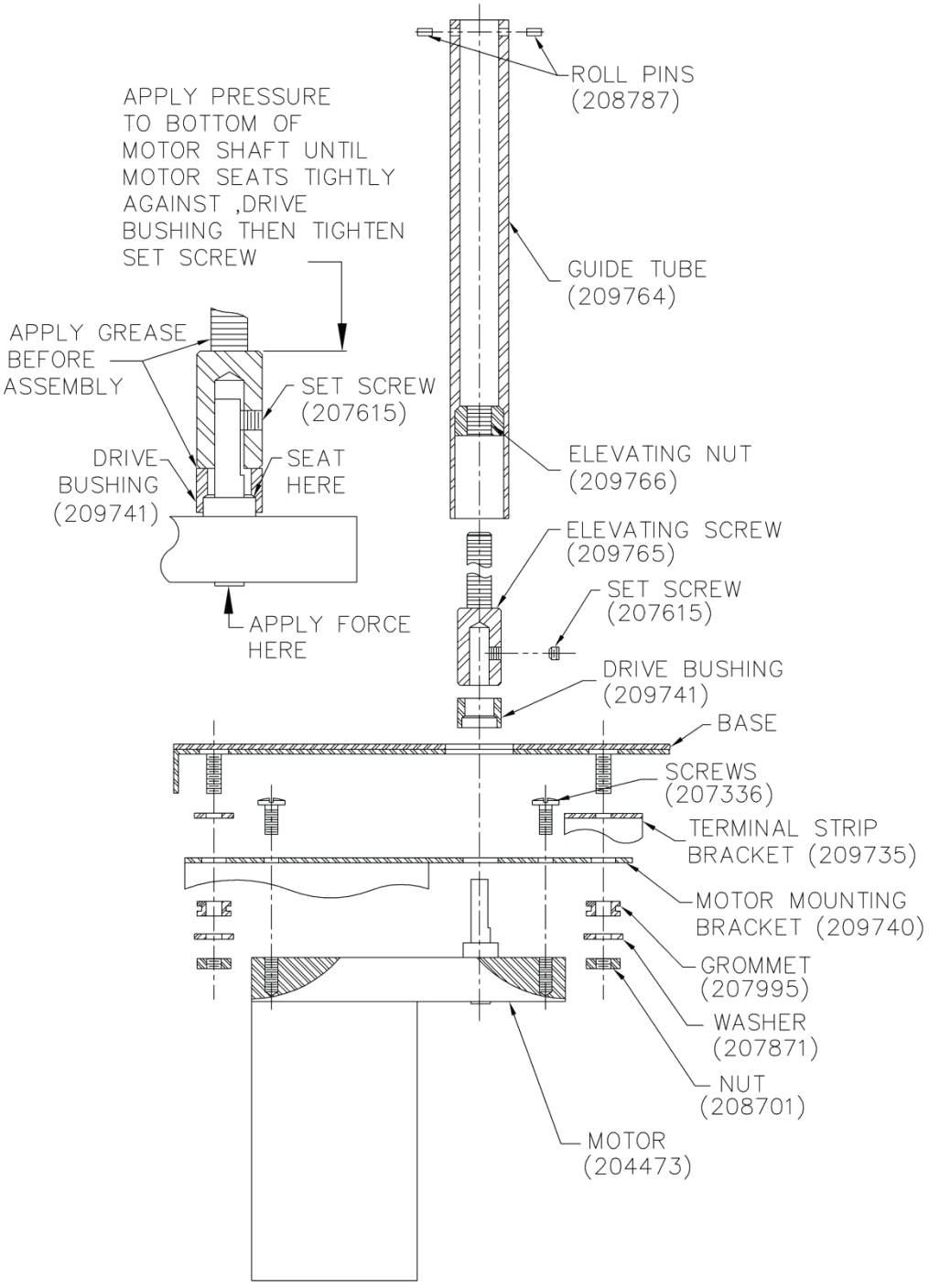


Figure 7-2 Measuring Head Drive System

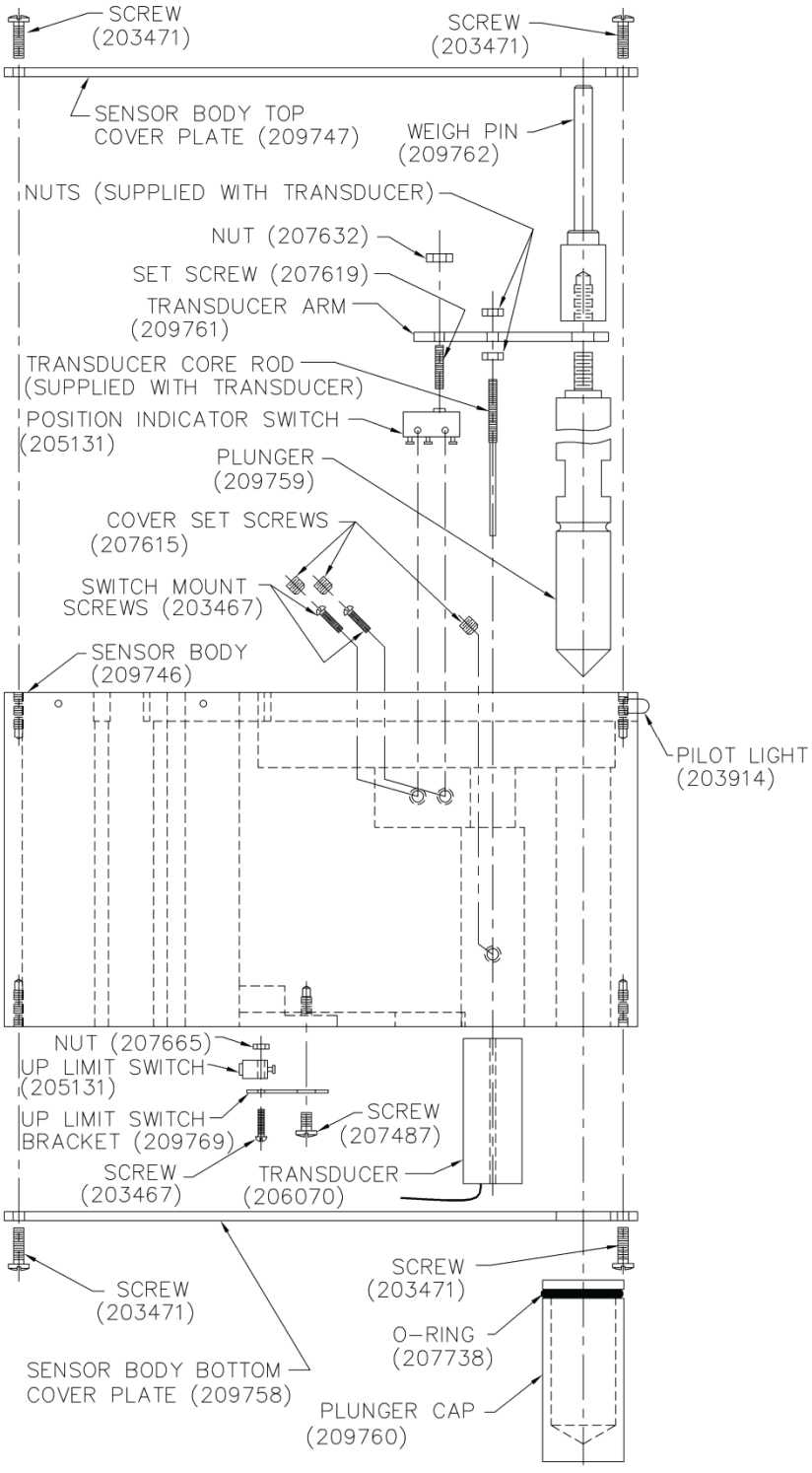


Figure 7-3 Measuring Head

Replace the drive motor and capacitor

1. Preassemble the motor and motor capacitor onto the motor mount bracket (four screws), and then connect the yellow and grey motor lead wires, one to each side the capacitor. Use new Fast On push-on connectors crimped on the new motor leads.

2. Put the drive bushing over the motor shaft (make sure that it is lubricated), and then assemble the motor shaft into the collar of the elevating screw. Make sure that the shaft slides all the way into the collar and that the collar end is against the drive bushing end.

3. Press on the motor output shaft from the bottom of the gear housing. Push the shaft as far as possible into the collar, and then tighten the set screws. The right connection assures that the drive bushing takes the thrust load, and the internal bushings in the motor's gear reduction do not take the thrust load.

4. Attach the guide tube to the measuring head. Force the drive pins through the measuring housing into the top of the guide tube. Make sure that the pins are flush on the outside and that the tube is centered in the hole in the measuring housing. Replace the sensor body top cover (four screws).

5. Connect the motor black lead to terminal 9.

6. Connect the orange wire to the terminal with the yellow motor lead.

7. Connect the red wire to the terminal with the gray motor lead.

8. Reconnect the power supply in the base cover if it was removed or disconnected.

9. Reassemble the base/back cover and rubber feet.

7.2.7 Transducer

A defective transducer must be replaced. Refer to Figure 7-3.

Remove the transducer

1. Disconnect power cable to the LSM.
2. Remove the back cover plate or the back / bottom cover.
3. Remove the sensor body top and bottom covers (four screws each). Let the bottom cover drop down on top of the base.
4. Disconnect the transducer connector. To access the transducer connector, open the back / bottom cover.
5. Remove the connector from the transducer cable. If you are replacing the transducer, cut off the connector from the cable or unlock the pins by pressing the side of the pin with a very small screwdriver while pulling on the pin by its wire. New transducers are furnished with replacement pins and connector body. However, if you are not replacing the transducer, reuse the connector body.
6. Free the connector end of the transducer cable of cable ties in the base area, and then pull the cable up and out of the back leg assembly.
7. From the bottom side of the sensor body, pull the cable through the hole between the leg assemblies. Then pull the cable out of the groove in the bottom of the sensor body until it reaches the transducer.
8. Loosen the set screw in the left side of the sensor body, and then remove the transducer from the bottom of the sensor body.

Replace the transducer core rod (optional)

1. If the transducer core rod needs replacing lift the plunger assembly out the top of the sensor body.
2. Then remove the nut attaching the rod to the transducer arm.
3. Remove and replace the transducer core rod. Leave one-eighth inch of the threads on the end of the transducer core rod protruding through the nut.

Replace the transducer

1. Install the new transducer, placing the cable end at one-half inch above the sensor body bottom. Then tighten the set screw.

2. Route the transducer lead cable up and through the measuring body, and then move it down the rear leg into the base. For a neat installation, the cable can be cut to the same length as the old cable.

3. Crimp the new contact pins on the end of the cable, and then assemble them into the connector body. New pins and a connector body are packaged with replacement transducers. See the LSM wiring diagram, Figure 9-1 for proper pin arrangement.

4. Replace the sensor body bottom cover.

5. Adjust the sensor position stop. This is the screw in the transducer arm near the transducer core rod. The end of this screw should only press down on the switch when the plunger assembly is hanging in the sensor body. Slightly raising the plunger should release the switch and allow the pilot light to burn.

6. Test for proper transducer operation. See Table 7-2 for troubleshooting tips.

7. Reassemble the sensor body top cover, back cover, or back/bottom cover.

7.2.8 Pilot Light

Before replacing the pilot light, verify it is defective by testing the resistor and diode in its circuit and on the terminal strip, positions 1, 2, and 3. Refer to the wiring diagram, Figure 9-1.

1. Disconnect power cable to the LSM.

2. Remove the sensor body top cover.

3. Remove the plunger cap from the bottom end of the plunger, and then lift the plunger assembly out through the top of the sensor body.

4. Press the pilot inward toward the recess for the plunger then rotate it upward to raise the leads out of the wire groove.

5. Cut away the heat shrink insulating tubing and unsolder the light leads.

6. Slide two new pieces of heat tubing shrink (about one-eighth inches) over the green and black wires. Solder the new light leads to these wires.

7. Slide the heat shrink tubing over the joint and against the bulb, and then shrink it in place.

8. Fit the pilot light and its leads back into the wire groove for the leads, and insert the bulb into the hole in the sensor body.

9. Replace the plunger assembly in the sensor body.

10. Replace the body top cover (four screws).

7.2.9 Position Indicator Switch

The position indicator switch turns the pilot lamp on when the plunger assembly is positioned for a test to start or for a test is in progress.

1. Disconnect the power cable.

2. Remove the sensor body top cover.

3. Remove the plunger cap from the bottom end of the plunger, and then lift the plunger assembly from the top of the sensor body.

4. From the left side of the sensor body, remove the two cover screws to access the switch mount screws, and then remove the two switch mount screws.

5. Lift the switch from its groove, and unsolder the two wires on the terminals.

6. Solder the wires onto the terminals of the new switch. Solder the black wire from the four-conductor cable to COM, and the black wire to the pilot lamp to NC.

7. Remount the switch and install switch mount screws and the cover screws on left side of sensor body.

8. Replace the plunger assembly in the sensor body.

9. Adjust the sensor position stop, the screw in the transducer arm near the transducer core rod. The end of this screw should only press down on the switch when the plunger assembly is hanging in the sensor body. Slightly raising the plunger should release the switch and allow the pilot light to burn

10. Replace the body top cover (four screws).

7.2.10 Up Limit Switch

Refer to Figure 7-3.

The UP limit switch shuts off the power to the portioning motor in the UP direction when the sensor head is raised to its highest position.

1. Disconnect power cable to the LSM.
2. Remove the bottom sensor body cover plate (four screws).
3. Remove the two screws holding the UP switch bracket to the bottom of the sensor body. Take the switch and bracket out of its cavity.
4. Un-solder the 2 wire connections.
5. Remove the 2 screws and nuts holding the switch to the switch mount and remove the switch.
6. Mount the new switch to the switch bracket.
7. Solder the lead wires to the new switch; Red to COM, and white to NO. NC is not used.
8. Mount the switch and switch bracket and install but do not tighten the 2 screws.
9. Slide the switch and bracket toward the leg until the switch actuator presses against the stationary outer leg.
10. Press the UP switch and allowing the measuring head to rise until the limit switch plunger slides down the taper at the top of the outer leg. This should cause the motor to stop. When the switch is operating properly tighten the switch bracket mount screws.
11. Replace the bottom cover plate (4 screws).

8 Optional Equipment

These items are available as separate purchases.

Table 8-1 Optional Equipment

Part Number	Description
205838	BALANCE, PORTABLE BEAM
209942	CALCIUM CHLORIDE BRINE SOLUTION, 8 OZ.
206113	CALIPER, 6 IN.
209952	DEIONIZED WATER, 8 OZ.
205251	DESICCATOR, VACUUM
205305	DISPOSABLE WIPES, 60 BOX
205252	DUROMETER, TYPE A
205253	DUROMETER, TYPE D
209948	ISOPROPYL ALCOHOL, 1 GAL.
205963	JAR, PLASTIC, 1 PINT WITH LID
205250	LABORATORY OVEN
205254	SIEVE, 5 IN. DIAMETER, 60 MESH
205255	SIEVE, 5 IN. DIAMETER, 200 MESH
206033	SPATULA, 6 IN.
209948	SYNTHETIC SEA WATER, 1 GAL
204731	XYLENE, 1 GAL

9 Parts List

Table 9-1 Linear Swell Meter, Model 2100

Item No.	Part No.	Quantity	Description
0001	102527580	1	LINEAR SWELL METER WITHOUT COMPACTOR
0002	102100513	1	MEASURING UNIT, FOUR HEAD, 115 V, 50/60 Hz
0003	209745	1	COMPACTOR, TWO HEAD
0004	102100841	1	LINEAR SWELL METER SOFTWARE
0005	102114531	1	INSTRUCTION MANUAL

Table 9-2 Measuring Unit, LSM 2100, P/N 102100513, Revision B

Item No.	Part No.	Quantity	Description
0001	207085	2	FUSE 1 AMP SLOW-BLOW 3 AG
0002	207336	18	8-32 X 3/8 BHMS STAINLESS STEEL
0003	207487	16	6-32 X 1/4 BHMS STAINLESS STEEL
0004	207619	4	6-32 X 1/2 HSSS STAINLESS STEEL
0005	207610	4	8-32 X 1/2 BHMS STAINLESS STEEL
0006	207632	12	NUT 6-32 HEX REGULAR STAINLESS STEEL
0007	207664	2	4-40 X 1/4 BHMS STAINLESS STEEL
0008	207665	8	NUT 2-56 HEX REGULAR STAINLESS STEEL
0009	207738	4	O-RING, 9/16 X 11/16, NEOPRENE N-11 0 (LSM PLUNGER CAP)
0010	207759	14	8-32 X 1/4 BHMS STAINLESS STEEL
0011	207760	12	10-32 X 3/16 HSSS BOPL
0012	207631	4	NUT 8-32 HEX REGULAR STAINLESS
0013	207871	32	WASHER FLAT 10 STAINLESS STEEL
0014	207995	16	GROMMET RUBBER 3/16in. ID X 5/16in.
0015	208421	1	SWITCH PUSH-BUTTON SPST 3AMP MOMENTARY
0016	101476559	3	TERMINAL, FEMALE QUICK-SLIDE
0017	208438	1	PLUG INTL ELECT CODE TYPE
0018	207615	8	8-32 X 1/8 HSSS BOPL
0019	208452	1	CABLE POWER 115V 18 AWG
0020	208454	4	TERMINAL FORK 6 22-16 AWG
0021	208455	5	TERMINAL RING 6 22-16 AWG RED
0022	208476	12	TUBE HEAT SHRINK 1/4 DIA BLA
0023	206241	7	WIRE 20 AWG TEFLON STRANDED ORANGE
0024	208550	120	CABLE 22 AWG SHIELDED 2 PAIR
0025	207633	32	NUT 10-32 HEX REGULAR STAINLESS
0026	204647	8	PIN ROLL 3/32 X 1.50 STAINLESS
0027	102105459	1	OVERLAY, FRONT PANEL
0028	209730	1	OVERLAY POSITION RELEASE
0029	209731	1	OVERLAY FUSE & POWER
0030	102100492	1	CIRCUIT BOARD ASSEMBLY
0031	209735	4	BRACKET TERMINAL STRIP H7011
0032	209736	1	BASE ASSEMBLY
0033	209737	1	BOTTOM & BACKBASE
0034	209738	4	PLATE SPACER MOTOR MOUNTING
0035	209739	8	NUT SUPPORT LEG
0036	209740	4	BRACKET, MOTOR MOUNTING
0037	209741	4	BUSHING DRIVE
0038	209746	4	BODY
0039	209747	4	TRIM TOP BODY
0040	209758	4	TRIM BOTTOM BODY
0041	209759	4	PLUNGER
0042	209760	4	CAP PLUNGER
0043	209761	4	ARM TRANSDUCER
0044	209762	4	PIN WEIGH
0045	209763	8	LEG SUPPORT
0046	209764	8	GUIDE TUBE
0047	209765	4	SCREW ELEVATING

Item No.	Part No.	Quantity	Description
0048	209766	4	NUT ELEVATING
0049	209769	4	BRACKET LIMIT SWITCH MOUNTING
0050	203481	16	2-56 X 3/8 LG FILHMS STAINLESS STEEL
0051	203469	7	6-32 X 3/4 SOC HD CAP STAINLESS STEEL
0052	203696	16	PIN CONNECTOR
0053	203754	4	CONNECTOR HOUSING 4 COND 0.1
0054	203769	1	CONNECTOR HOUSING 3 COND
0055	203770	2	CONNECTOR PIN
0056	203904	4	DIODE SIGNAL 1N4004
0057	203914	4	LED RED
0058	204131	2	FUSE HOLDER BODY
0059	204133	2	FUSE CARRIER 1/4 X 1-1/4 FUSE
0060	204285	4	TIE WRAP 6in. LONG WITH 8 MTG
0061	204294	30	TIE WRAP 1/16in. TO 2in. DIAMETER
0062	205296	14	TIE WRAP ADHESIVE PAD
0063	101934687	1	POWER SUPPLY, +/-12VDC DUAL OUTPUT
0064	204473	4	MOTOR GEAR 115V 1/100HP 35 RPM
0065	100026443	16	NUT, ELASTIC STOP, 10-32 NF, PL
0066	204953	4	RESISTOR 10K OHM 5W 5%
0067	205128	1	SWITCH POWER 15 AMP LIGHTED
0068	205131	8	SWITCH SPDT 5 AMP SUBMINIATURE
0069	205132	4	SWITCH ROCKER 125V 5A
0070	205164	48	SECTION TERMINAL BLOCK MODULAR
0071	205156	8	JUMPER BAR 2 STATION TERMINAL
0072	205160	4	LABEL TERMINALS 1-10 H7011 SEC
0073	205161	4	LABEL TERMINALS 11-20 10-NUMBERS PER STRIP
0074	205162	4	JUMPER BAR 4 STATION TERMINAL
0075	204344	20	DISCONNECT FEMALE .250 TAB 22
0076	205398	8	TUBE HEAT SHRINK 1/16 DIA
0077	205778	4	FEET RUBBER 1/2in.
0078	205787	4	BRACKET CAPACITOR MOUNTING
0079	205789	4	CAPACITOR, MOTOR RUN, 5 UF, 370 VAC 2.16 WIDTH X 1.31 DEPTH 0.25 IN TERMINAL BLADES
0080	101937144	4	TRANSDUCER LINEAR
0081	208526	0.5	WIRE 18 AWG PVC STRANDED GREEN
0082	206217	130	WIRE 20 AWG PVC STRANDED RED
0083	206218	60	WIRE 20 AWG PVC STRANDED WHITE
0084	206219	72	WIRE 20 AWG PVC STRANDED BLACK
0085	206226	60	WIRE 20 AWG PVC STRANDED VIO-WHT
0086	203471	32	6-32 X 1/2 HSBH BOPL
0087	207947	2	WASHER SPLIT 8 STAINLESS STEEL
0088	207259	4	4-40 X 1/4 FHMS STAINLESS STEEL
0089	209767	1	PLATE POWER SUPPLY MOUNTING 46
0090	209780	6	DISK PLEXIGLAS CORE
0091	205163	8	END TERMINAL BLOK MODULAR w/MT
0092	204381	0.01	COMPOUND THERMAL
0094	209794	1	CALIBRATION DISK
0095	209795	1	WEIGHT, CORE (AUXILIARY WEIGHT)
0097	205256	4	DISH PYREX® 100mm DIA X 50mm DEEP

Item No.	Part No.	Quantity	Description
0098	209788	6	HOLDER CORE 60 MESH
0099	208457	12	BUTT SPLICE 2RA-18
0100	206113	1	CALIPERS DIAL 6in. ECONOMY
0101	100028273	1	SCREW, HEX SOCKET, #6-32 NC X 1/2, STAINLESS STEEL
0102	101367493	1	USB CABLE, 6 FT

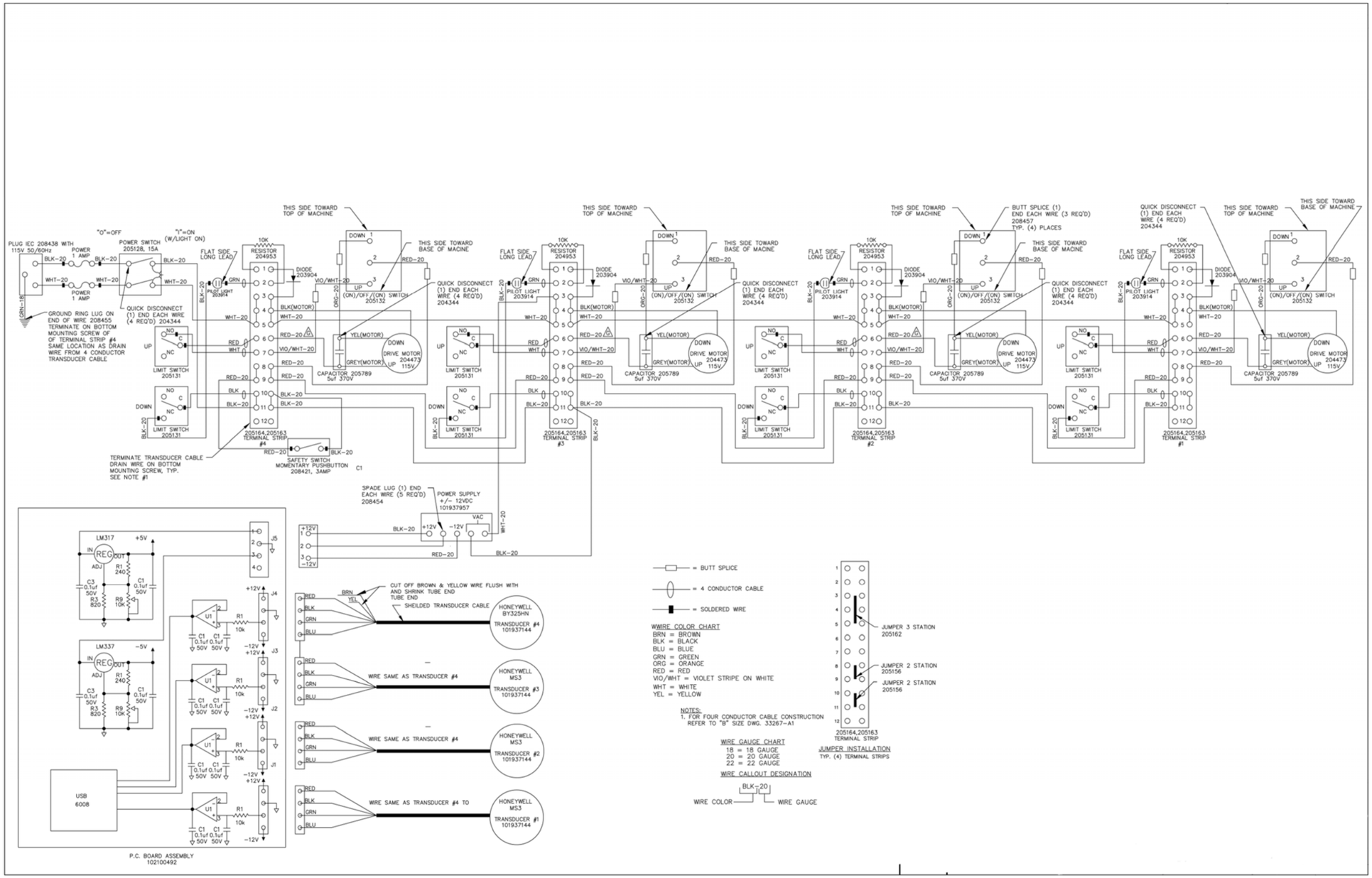


Figure 9-1 Wiring Diagram

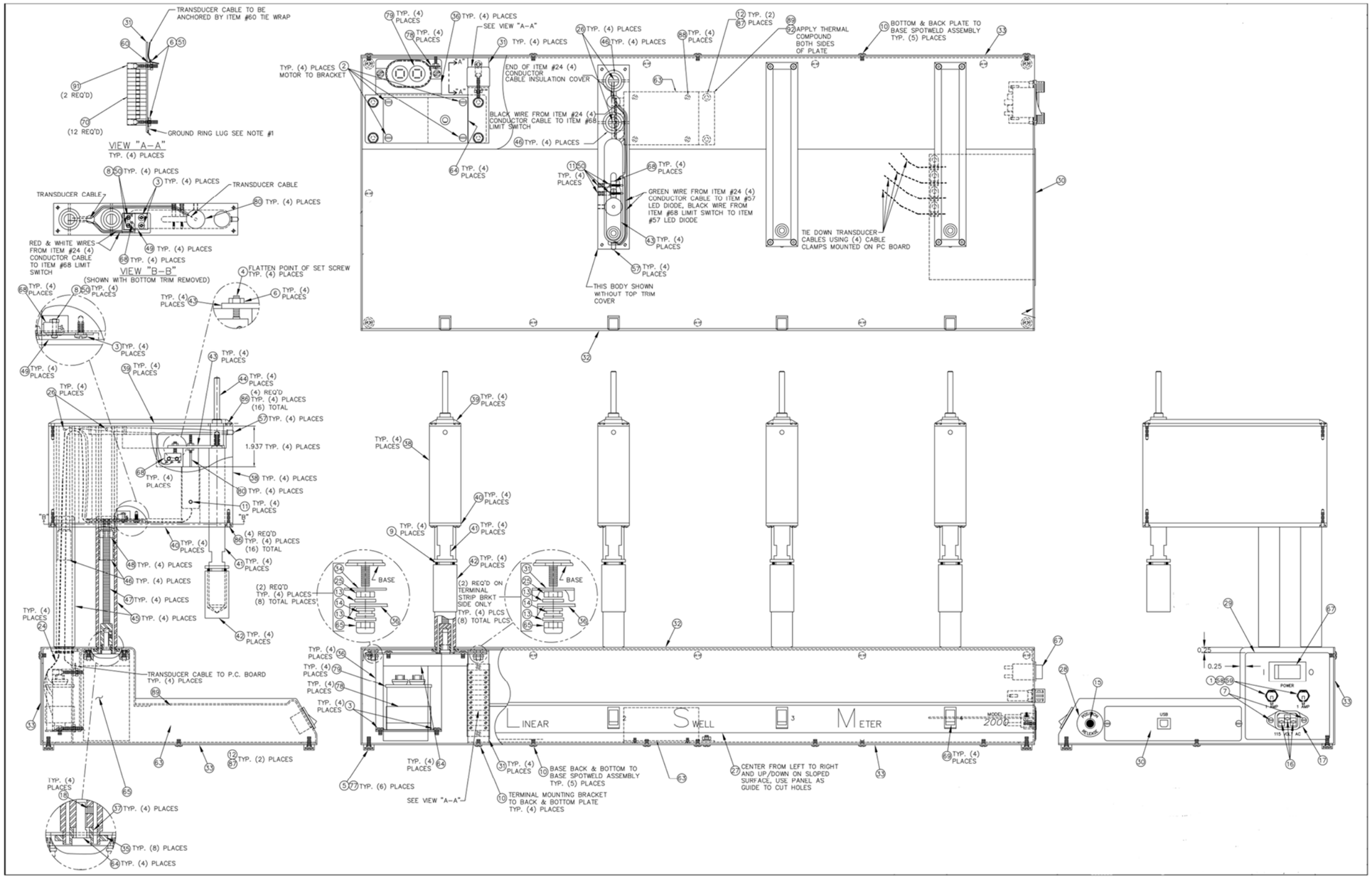
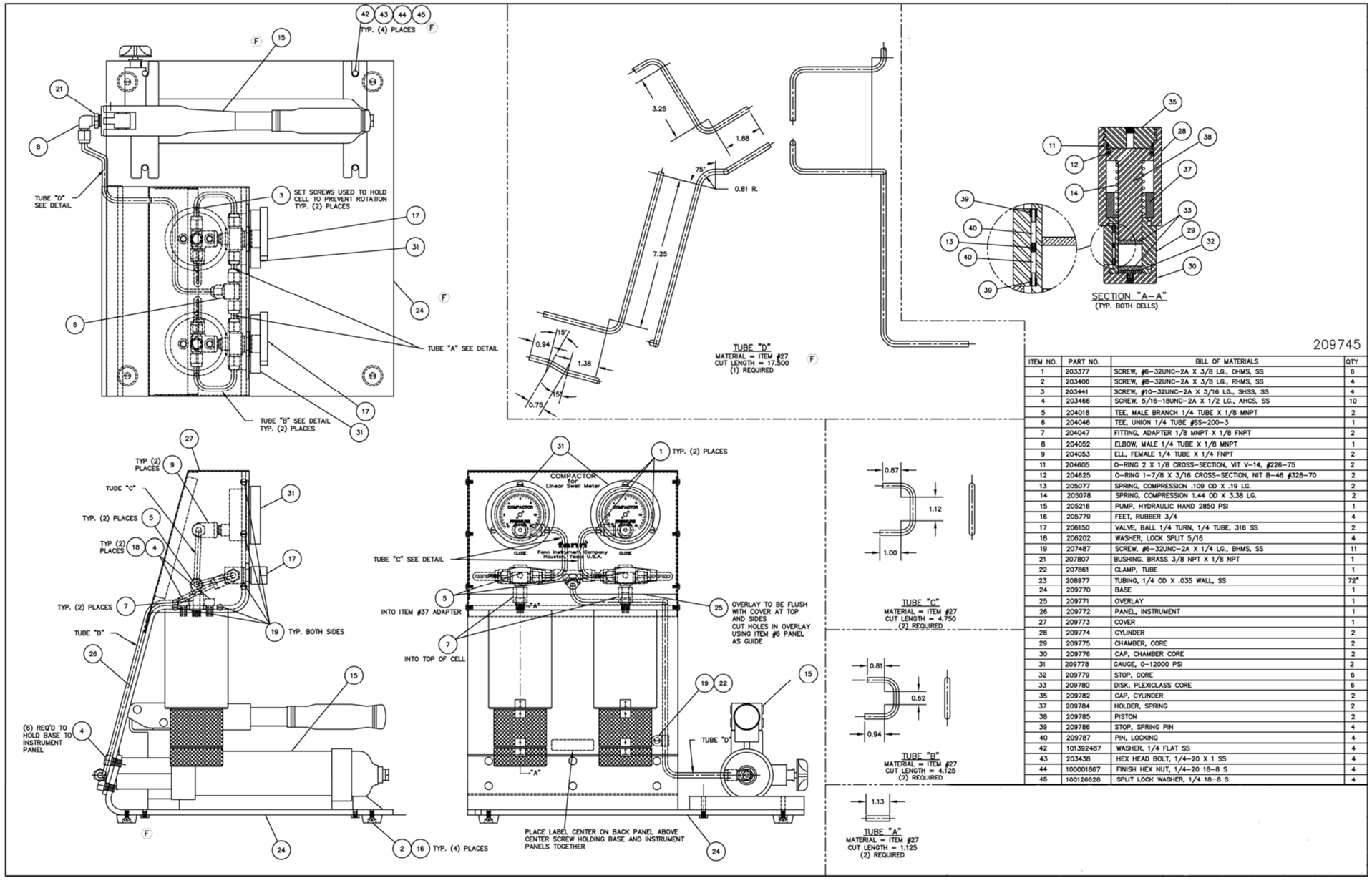


Figure 9-2 Mechanical Assembly, Measuring Head

Table 9-3 Compactor, 2 Head, LSM 2100, P/N 209745, Revision D

Item No.	Part No.	Quantity	Description
0001	203377	6	6-32 X 3/8 OHMS STAINLESS STEEL
0002	203406	4	8-32 X 3/8 RHMS STAINLESS STEEL
0003	203441	4	10-32 X 3/16 SHSS STAINLESS STEEL
0004	203466	10	5/16-18 X 1/2 AHCS STAINLESS STEEL
0005	204018	2	TEE MALE BRANCH 1/4T & 1/8 MP
0006	204046	1	TEE UNION, 1/4 TUBE, SS-400-3
0007	204047	2	ADAPTER, 1/8 MNPT X 1/8 FNPT, STAINLESS STEEL
0008	204052	1	ELBOW, MALE, 1/4 TUBE X 1/8 NPT
0009	204053	2	ELBOW, FEMALE, 1/4TUBE X 1/4 NPT
0011	204605	2	O-RING, 2 X 1/8, VITON V14 226-75 (COMPACTOR CYLINDER)
0012	204625	2	O-RING, 1-7/8 X 3/16, NITRILE B-46 3 (COMPACTOR PISTON)
0013	205077	2	COMPRESSION SPRING, 0.109 OD
0014	205078	2	COMPRESSION SPRING, 1.44 OD X 3
0015	205216	1	PUMP, HYDRAULIC HAND 2850 PSI
0016	205779	4	FEET RUBBER 3/4in.
0017	206150	2	VALVE BALL, 1/4, SWAGELOK IN & OUT
0018	206202	4	WASHER LOCK SPLIT 5/16in.
0019	207487	11	6-32 X 1/4, BHMS, STAINLESS STEEL
0020	207633	4	NUT, 10-32 HEX REGULAR, STAINLESS STEEL
0021	207807	1	BUSHING BRASS 3/8P-1/8P
0022	207861	1	CLAMP CABLE 1/4 X 1/2
0023	208977	72	TUBING 1/4 OD X .035 WALL
0024	209770	1	BASE
0025	209771	1	OVERLAY
0026	209772	1	INSTRUMENT PANEL
0027	209773	1	COVER
0028	209774	2	CYLINDER
0029	209775	2	CHAMBER CORE
0030	209776	2	CAP CHAMBER CORE
0031	209778	2	GAUGE 0-12000 PSI
0032	209779	6	STOP CORE
0033	209780	6	DISK PLEXIGLAS CORE
0034	209781	2	CLAMP COMPACTOR PUMP(J1016)
0035	209782	2	CAP CYLINDER
0036	209783	1	TOOL EXTRACTION
0037	209784	2	HOLDER SPRING
0038	209785	2	PISTON
0039	209786	4	STOP SPRING PIN
0040	209787	4	PIN LOCKING
0041	207805	1	HYDRAULIC FLUID, 1 QUART BOTTLE
0042	101392487	8	WASHER 1/4 IN, FLAT, STAINLESS STEEL
0043	203438	4	1/4-20 X 1 HHCS STAINLESS
0044	100001867	4	NUT, HEX, 1/4-20 NC, STAINLESS STEEL
0045	100126628	4	WASHER, LOCK, SPLIT, 1/4 STAINLESS STEEL, REG



ITEM NO.	PART NO.	BILL OF MATERIALS	QTY
1	203377	SCREW, #6-32UNC-2A X 3/8 LG., OHMS, SS	6
2	203406	SCREW, #8-32UNC-2A X 3/8 LG., RHMS, SS	4
3	203441	SCREW, #10-32UNC-2A X 3/16 LG., SHSS, SS	4
4	203466	SCREW, 5/16-18UNC-2A X 1/2 LG., AHCS, SS	10
5	204018	TEE, MALE BRANCH 1/4 TUBE X 1/8 MNPT	2
6	204046	TEE, UNION 1/4 TUBE #SS-200-3	1
7	204047	FITTING, ADAPTER 1/8 MNPT X 1/8 FNPT	2
8	204052	ELBOW, MALE 1/4 TUBE X 1/8 MNPT	1
9	204053	ELL, FEMALE 1/4 TUBE X 1/4 FNPT	2
11	204605	O-RING 2 X 1/8 CROSS-SECTION, VIT V-14, #226-75	2
12	204625	O-RING 1-7/8 X 3/16 CROSS-SECTION, NIT B-46 #328-70	2
13	205077	SPRING, COMPRESSION .109 OD X .19 LG.	2
14	205078	SPRING, COMPRESSION 1.44 OD X 3.38 LG.	2
15	205216	PUMP, HYDRAULIC HAND 2850 PSI	1
16	205779	FEET, RUBBER 3/4	4
17	206150	VALVE, BALL 1/4 TURN, 1/4 TUBE, 316 SS	2
18	206202	WASHER, LOCK SPLIT 5/16	4
19	207487	SCREW, #6-32UNC-2A X 1/4 LG., BHMS, SS	11
21	207807	BUSHING, BRASS 3/8 NPT X 1/8 NPT	1
22	207861	CLAMP, TUBE	1
23	208977	TUBING, 1/4 OD X .035 WALL, SS	72"
24	209770	BASE	1
25	209771	OVERLAY	1
26	209772	PANEL, INSTRUMENT	1
27	209773	COVER	1
28	209774	CYLINDER	2
29	209775	CHAMBER, CORE	2
30	209776	CAP, CHAMBER CORE	2
31	209778	GAUGE, 0-12000 PSI	2
32	209779	STOP, CORE	6
33	209780	DISK, PLEXIGLASS CORE	6
35	209782	CAP, CYLINDER	2
37	209784	HOLDER, SPRING	2
38	209785	PISTON	2
39	209786	STOP, SPRING PIN	4
40	209787	PIN, LOCKING	4
42	101392487	WASHER, 1/4 FLAT SS	4
43	203438	HEX HEAD BOLT, 1/4-20 X 1 SS	4
44	100001867	FINISH HEX NUT, 1/4-20 18-8 S	4
45	100126628	SPLIT LOCK WASHER, 1/4 18-8 S	4

Figure 9-3 Mechanical Assembly, Compactor, 2 Head

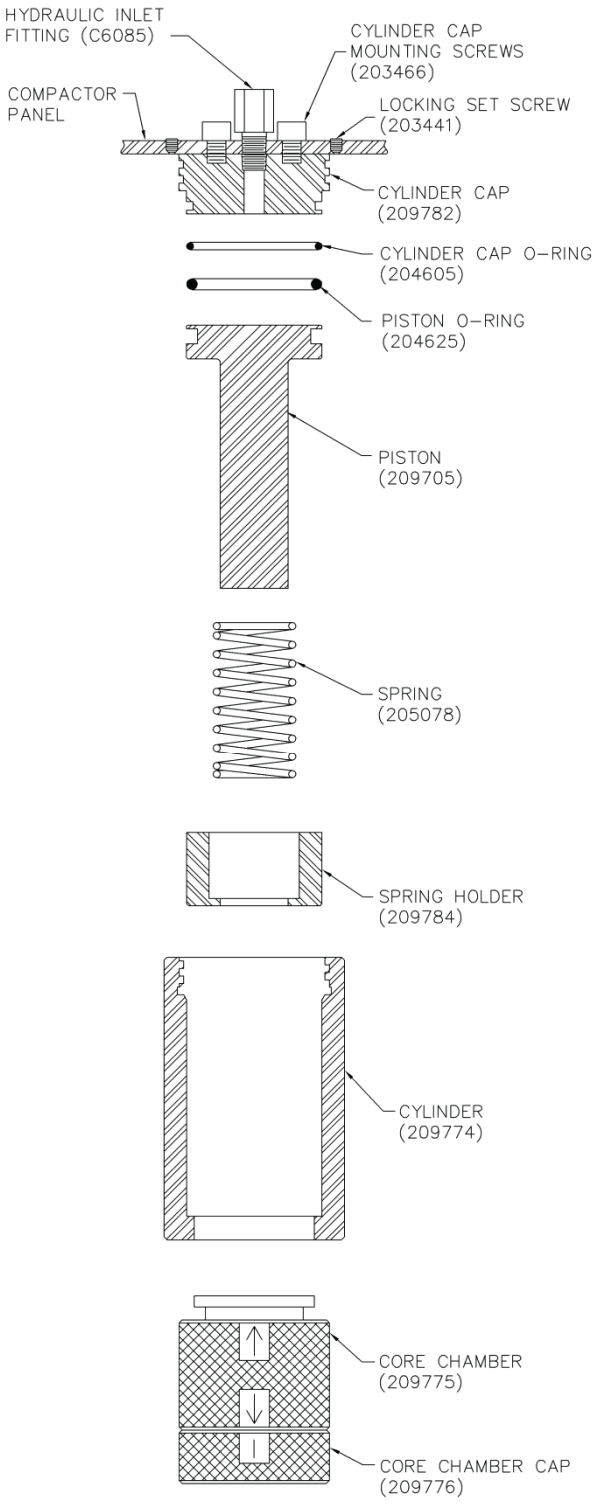


Figure 9-4 Compactor Hydraulic Cylinder

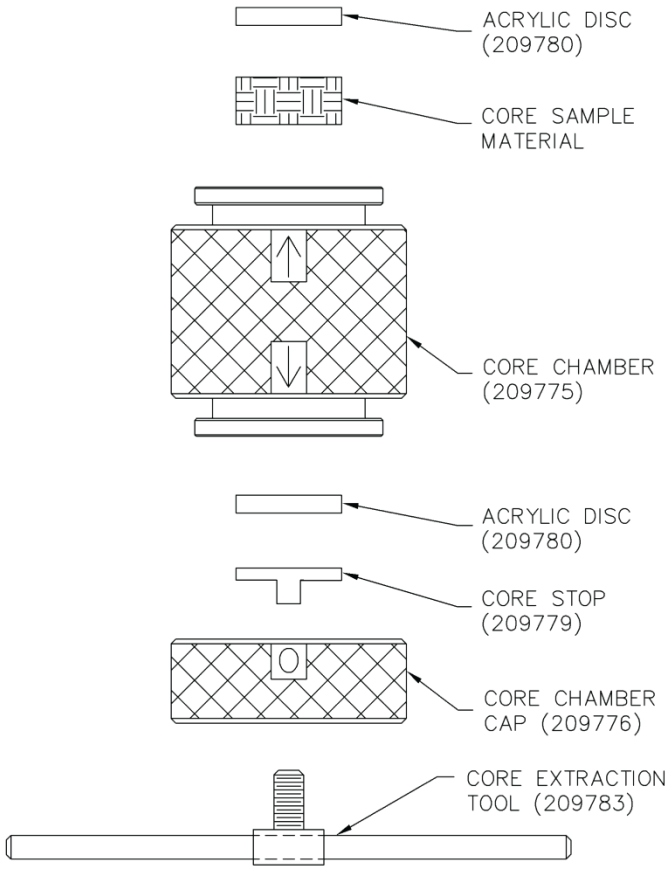


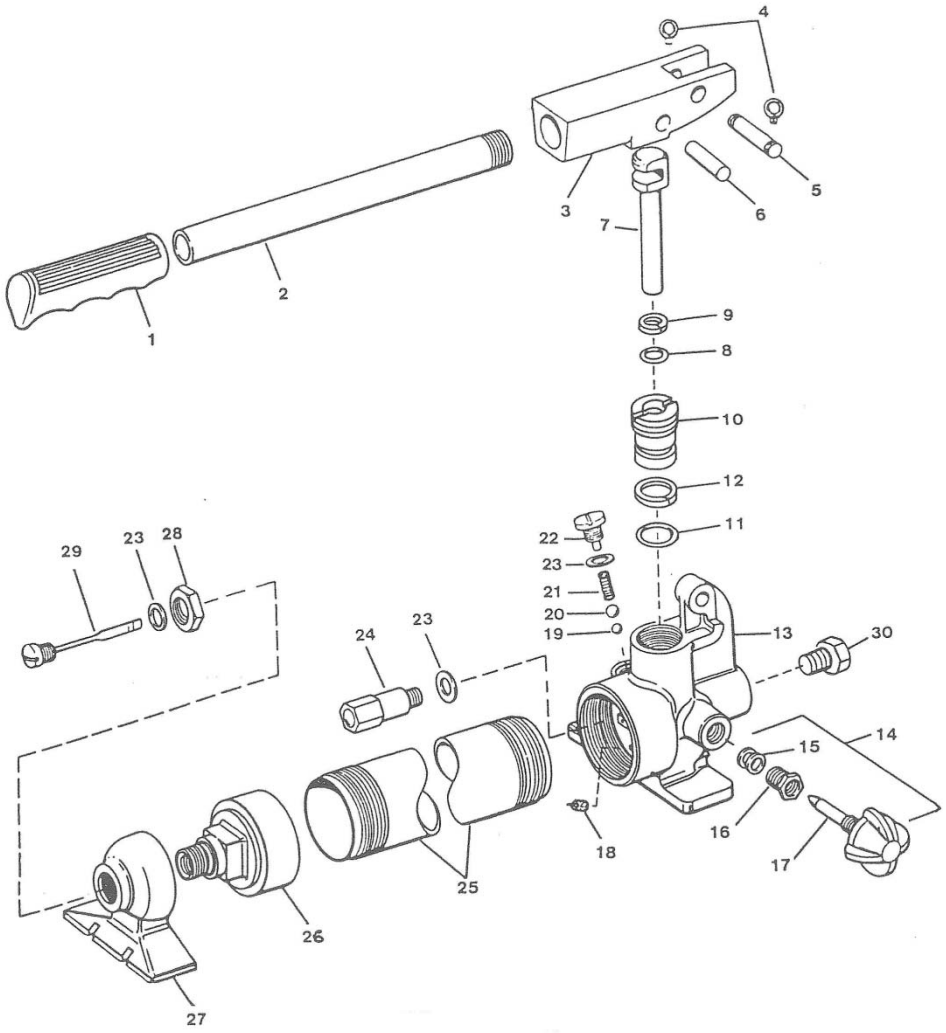
Figure 9-5 Compactor Cell

Table 9-4 Hydraulic Hand Pump, 2850 PSI, P/N 205216, Revision A

Item No.	Model P-18-5 Part Number	Quantity	Description
1	C7.550	1	GRIP
2	B382.070	1	HANDLE
3	B113.060-1	1	BEAM
4	CB415.044	2	RETAINING RING
5	CB334.060	1	BEAM PIN
6	P75.57	1	CROSS PIN
7	P16.51	1	PUMP PLUNGER
8	B1112.803	1	O-RING
9	B1112.564	1	BACK-UP RING
10	CN204.446	1	SLEEVE, PISTON
11	B1117.903	1	O-RING
12	B1117.565	1	BACK-UP RING
13	B121.005-1	1	BASE
14	CL655.950	1	VALVE ASSEMBLY, RELEASE
15	B217.074	2	PACKING
16	MJ11-1	1	PACKING NUT
17	B109.900	1	SPINDLE ASSEMBLY
18	P307.18	1	OIL SCREEN
19	B1006.016	2	BALL
20	B1009.016	1	BALL
21	S1.183	1	SPRING
22	K3.006	1	VALVE PLUG
23	B159.167	1	GASKET
24	CH46.900	1	BY-PASS VALVE
25	B381.025	1	RESERVOIR
26	P75.266-1	1	RESERVOIR CAP
27	P76.267-1	1	PUMP REST.
28	P75.181	1	NUT
29	B110.900	1	FILLER PLUG
30	R515.245	1	PLUG

Table 9-5 Hydraulic Hand Pump Specifications

CATEGORY	SPECIFICATION
OPERATING PRESSURE	0-2850 psi (19,650 kPa)
RELIEF VALVE SETTING	2850 psi (19,650 kPa)
OIL VOLUME PER STROKE	0.1595 in^3 (2.614 cm^3)
RESERVOIR CAPACITY	22 in^3 (360 cm^3)



SOURCE: Enerpac®

Figure 9-6 Hydraulic Hand Pump

10 Warranty and Returns

10.1 Warranty

Fann Instrument Company warrants its products to be free from defects in material and workmanship for a period of 12 months from the time of shipment. If repair or adjustment is necessary, and has not been the result of abuse or misuse within the twelve-month period, please return, freight prepaid, and correction of the defect will be made without charge.

Out of warranty products will be repaired for a nominal charge.

Please refer to the accompanying warranty statement enclosed with the product.

10.2 Returns

For your protection, items being returned must be carefully packed to prevent damage in shipment and insured against possible damage or loss. Fann will not be responsible for damage resulting from careless or insufficient packing.

Before returning items for any reason, authorization must be obtained from Fann Instrument Company. When applying for authorization, please include information regarding the reason the items are to be returned.

Our correspondence address is:

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Toll Free: 800-347-0450
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