AFG2
SUPERPAVE™ Gyratory Compactor
Operation Manual

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LMAFG2
Version 015
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Table of Contents

Table of Figures

I. General Information

1.1 Scope

This manual describes the proper use of the Pine AFG2 SUPERPAVE™ Gyratory Compactor (SGC), including operating instructions, periodic maintenance, standardization procedures, and safety issues. It is assumed that the reader of this manual is already familiar with hot mix asphalt design and general issues pertaining to gyratory compaction.

Figure 1.1: The Pine AFG2 SUPERPAVE™ Gyratory Compactor

1.2 Copyright

1.3 Patent

Each Pine AFG2 SUPERPAVE™ Gyratory Compactor is marked with a nameplate like that shown in Figure 2.3. The nameplate indicates the model number, serial number, power requirements, and patent information.

1.4 Trademarks

- *Superpave*™ is a trademark of the Strategic Highway Research Program now owned by the Transportation Research Board (Washington, DC)
- *Microsoft® Windows*™ and *Excel*™ are trademarks of Microsoft Corporation (Redmond, WA).
- *PinePave*™ is a trademark of Pine Instrument Company (Grove City, PA)

1.5 CE Compliance

The following "Declaration of Conformity" applies to all AFG2 Gyratory Compactors manufactured after Sept 1, 2010.

DECLARATION OF CONFORMITY

IN ACCORDANCE TO ISO/IEC GUIDE 22
FOR A

GYRATORY COMPACTOR

MANUFACTURER: Pine Electronics, LLC
101 Industrial Drive
Grove City, PA 16127
Ph: (724) 458-6391
Fax: (724) 458-4648

MODELS #: AFG2A, AFG2AS, AFG2B, AFG2BS, AFG2C, and AFG2CS

REPORT #: 100147E (Electromagnetic Compatibility)
KEY-026 (Safety Requirements)

DIRECTIVES: Low Voltage Directive (2006/95/EC) and EMC Directive (2004/108/EC), in accordance with emissions product specific standard EN 55011 and immunity product specific standard EN 61326-1.

STANDARDS: EN 55011:20070-Conducted and Radiated Emissions Limits and Test Methods for industrial, scientific, and medical (ISM) equipment.

EN 61000-3-2:2005- Electromagnetic Compatibility, Part 3-2: Limitation of current harmonics in low voltage supply system.

EN 61000-3-3:2006- Electromagnetic Compatibility, Part 3-3: Limitation of voltage fluctuations and flicker in low-voltage supply systems.

EN61000-4-2:2001- Electromagnetic Compatibility, Part 4-2: Electrostatic discharge immunity test.

EN 61000-4-3:2006- Electromagnetic Compatibility, Part 4-3: Radiated, radio frequency, electromagnetic field immunity test

EN 61000-4-4:2004- Electromagnetic Compatibility, Part 4-4: Electrical Fast Transient/burst immunity test.

EN 61000-4-5:2005- Electromagnetic Compatibility, Part 4-5: Surge Immunity test.

EN 61000-4-6:2006- Electromagnetic Compatibility, Part 4-6: Conducted Immunity test.

DECLARATION OF CONFORMITY

STANDARDS:

EN 61000-4-8:2001- Electromagnetic Compatibility, Part 4-8: Power Frequency Magnetic Field Immunity Test.

EN 61000-4-11:2004- Electromagnetic Compatibility, Part 4-11: Voltage Dips and Interruptions immunity test.

EN 61010-1:2001- Safety requirements for electrical equipment for measurement, control and laboratory use, Part 1: General requirements.

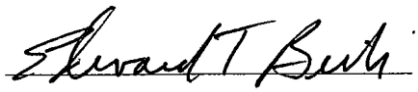
TEST FACILITIES:

EMC TESTING: Keystone Compliance, LLC.
2861 W. State Street
New Castle, PA 16101
Ph: (724) 657-9940
Fax: (724) 657-9920

SAFETY TESTING: G&M Compliance Inc.
154 South Cypress Street
Orange, CA 92866
Ph: (714) 628-1020
Fax: (714) 628-1021

All testing was performed at Keystone Compliance, LLC.

The AFG2 Gyratory Compactor models listed above conform to the Directives and Standards referenced above.



Edward T. Berti
Vice President of Engineering
Pine Electronics, LLC

Date of Issue: 09/01/10

II. Product Overview

2.1 Description

The Pine Instrument AFG2 SUPERPAVE™ Gyratory Compactor (SGC) is designed to compact prepared Hot Mix Asphalt (HMA) specimens at a constant consolidation pressure, at a constant angle of gyration, and at a fixed speed of gyration. Its features include: an integrated computer control system, a control panel with display, two USB data ports, a completely enclosed compacting chamber, an integrated mold angle measurement system, and an extruder function for removing compacted HMA specimens from the molds. The AFG2 SGC can be configured with gyratory shear instrumentation. Models with this optional instrumentation are designated with an S suffix on the part number. The AFG2 can also be configured to compact 150mm diameter specimens, 100mm diameter specimens, or 101.6mm (4 Inch) diameter specimens.

An integrated industrial computer controls all functions. The operator simply enters the appropriate compaction parameters, places the prepared mold into the compacting chamber, and presses the **START** button. Once the **START** button is pressed, the computer system takes control and applies the consolidation pressure, induces the gyration angle, then gyrates the specimen for the specified number of gyrations or to the specified height. At the end of the test, the specimen is squared and ram pressure is removed. Once the ram pressure has been released, the operator removes the mold top then presses the **RAM UP** button to extrude the specimen from the mold. This integrated extruding function permits easy removal of the specimen from the mold assembly. The compacting chamber is a completely enclosed area with a safety interlocked access door which prevents machine operation when the door is open. Pressing the **EMERGENCY STOP** button stops all motion and releases ram pressure.

The control panel permits compaction parameters to be set. Once the test is started, the parameters may not be changed. While compacting, the control panel display indicates the consolidation pressure, gyration number, specimen height, and angle of gyration.

The AFG2 stores the specimen height, the consolidation pressure, and the angle of gyration during compaction. This test data may be saved directly to a memory chip through one of the USB data ports for transfer to a computer for analysis. The USB data port also permits a printer to be connected to the compactor. A Network connection is also provided. The data from the previous twenty (20) specimens are stored in the compactor's memory.

The angle of gyration is user selectable from 0.0° to 1.5°. The AFG2 uses a closed feedback control loop to maintain the set angle of gyration. Either the external mold angle or the internal angle of gyration can be displayed during compaction.

The test sequence can be programmed to stop at a specified specimen height for achieving specific density targets, programmed to stop at a specified number of gyrations for volumetric design and quality control specimens, or programmed to stop at a specified rate of change (Locking Point).

2.2 Specifications

Power Supply	AFG2A(S): 115 VAC ±10%, 12 Amp, 50/60 Hz, 1 ph AFG2C(S): 230 VAC ±10%, 6 Amp, 50/60 Hz . 1 ph
Dimensions	875 mm W x 900 mm D x 1375 mm H (~34.5" W x ~35.5" D x ~54" H)
Weights	386 kg (850 lb)
Applied Pressure	Minimum: 200 kPa Maximum: 1000 kPa ±60 kPa gyration 0-5; ±10 kPa gyrations >6
Angle of Gyration	0.0 - 26.18 mrad (0.0° - 1.50°)
Speed of Gyration	30 ±0.5 gyrations per minute (gpm)
Number of Gyrations	0-999
Mold Dimensions	150.0mm +0.0/-0.1 mm ID x 250 mm tall 100.0mm +0.0/-0.1mm ID x 200 mm tall 4.000 inch +0.000/-0.004" (101.6mm +0.0/-0.1mm) ID x 200mm tall 0.0mm minimum specimen height
Mode of Operation	Compact to Number of Gyrations Compact to Specified Height Compact to Locking Point (Δmm/gyration)
Data Acquisition	Gyration Number Specimen height (mm) Angle of gyration (degrees) Consolidation pressure (kPa) Gyratory Shear (N-m) (optional)
Data Output Options	(2) USB Ports Network Connector (RJ45 Ethernet)
Internal Data Storage	Results from twenty (20) tests are retained in memory
Additional Features	Built-in extruder function
Software	PINEPAVE™ software PINESHEAR workbook (requires *Microsoft Excel*)
Environmental conditions for which the compactor is designed	Indoor use only Altitude: Up to 2000 meters Temperature: 5°C to 40°C Maximum relative humidity: 90% for temperatures up to 31°C Pollution degree: 2 Mains supply voltage: Not to exceed ± 10% of the nominal voltage Transient over-voltages: Overvoltage category II

*** These specifications are subject to change without notice. ***

2.3 Accessories

2.3.1 Calibration

Part Number	Description
AFGCLR05C	Proving Ring
AFG123C	Gage Block Set
RATS90	Stop Watch
AFLS1	Internal Angle Measurement Instrument
AFG2X01	External Angle Measurement Instrument

2.3.2 Specimen Related

Part Number	Description
AFG1A08	Mold Funnel
AFG1A14	150mm Specimen Lift Handle
AFG1A14T	150mm Tall Specimen Lift Handle (performance test)
AFG1A15	100mm Specimen Lift Handle
AFG1M10	100 mm Mold Assembly
AFG1M15	150 mm Mold Assembly
AFG2M4	4 Inch Mold Assembly
AFG2X04	100mm Conversion Kit
AFG2X05	4 Inch Conversion Kit
RAND10	100 mm Paper Disk (1000/pack)
RAND15	150 mm Paper Disk (500/pack)

2.3.3 Lubricants

Part Number	Description
CLGSMOS2T	Ram Foot Lubricant
CLGMOS2	Bearing Grease

2.3.4 Data Handling

Part Number	Description
AFG2X03	Printer Kit (special cable and printer required)
RCUSB512MB	USB Flash Memory
RCC25CAT5	CAT5 Ethernet cable, 25’ (blue)
RCC25CAT5X	CAT5 Ethernet cable, 25’, crossover (red)

2.4 Setting up the SUPERPAVE Gyratory Compactor

2.4.1 Machine Location

Compactor location must allow unobstructed access to the ON / OFF switch and the AC power cord coupler.

Select a level sturdy floor for the compactor location. It is not critical that the machine be exactly level, but it must be stable. Be sure to allow room to access the USB data port located on the right side of the control panel.

Figure 2.1: Lower Frame Holes

If the unit is installed in a mobile trailer or truck, it must be secured into position using the holes provided in the lower frame brackets (Figure 2.1). Be sure to allow room for servicing the machine or provide for a means to move the machine for servicing purposes.

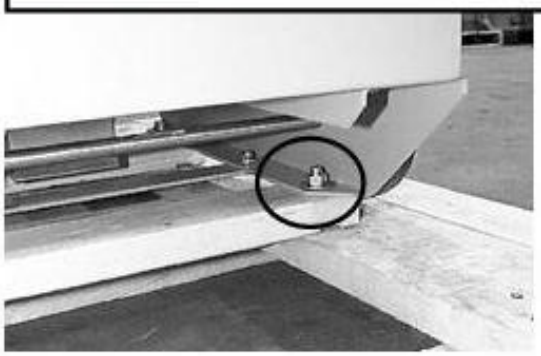
2.4.2 Unpacking the Gyratory Compactor

The compactor is shipped bolted directly to a wooden pallet. After unbolting the machine from the shipping pallet, slide the frame handles out and insert the lock pin in the handle through the handle to prevent the handle from sliding out of the frame. Carefully remove the compactor from the pallet using the 2x4 spacers under the compactor as ramps (Figure 2.2).

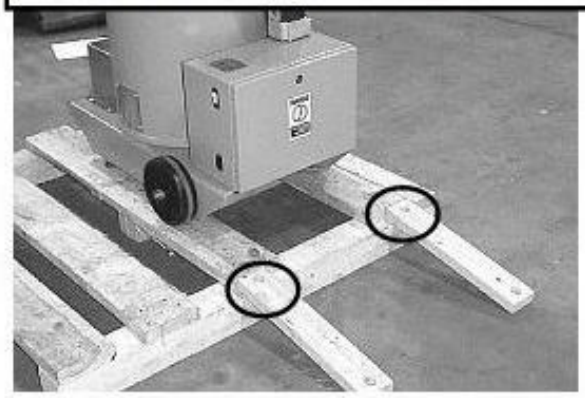
A leveling foot is installed on each side at the front of the machine. Adjust these support feet so that the compactor is stable.

Prior to using the gyratory compactor after it has been transported, the machine should be standardized. This can be accomplished with the calibration devices utilizing the standardization control routines.

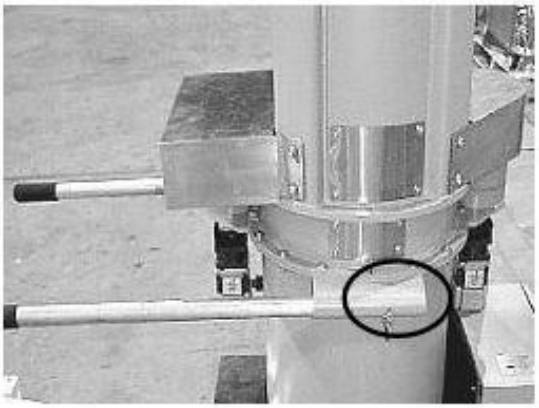
Step 1: Remove carton and accessory box from pallet. Unbolt the compactor from the shipping pallet. (4 places)



Step 2: Set the 2x4 spacers on the pallet with the notch in the 2x4 set on the pallet edge.



Step 3: lock the handles to the frame of the compactor with the safety pins in the handle.



Step 4: Slowly roll the compactor to the edge of the pallet. Use spotters to help balance the load.

Step 5: Roll the compactor down the ramps very slowly using spotters to control the compactor.

Step 6: Remove the safety pins and side the handles into the frame mounts.

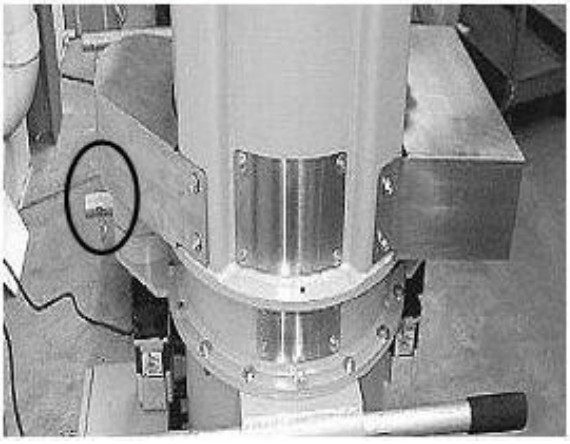


Figure 2.2: Unpacking Instructions

2.4.3 Moving the Compactor

The AFG2 SGC has a high center of gravity. Care must be exercised when moving the machine to prevent a tip over. Be sure the surface is even and free of objects. Secure the frame handles into the frame and use proper lifting technique to roll the compactor to the desired location.

The AFG2 is top heavy. When moving the AFG2 over obstructions (i.e. door jams, concrete cracks, etc.), it is suggested that the compactor be pulled (rather than pushed) to avoid tipping.

Three lifting eyes are provided for lifting the machine. In addition, the lower frame brackets are configured to receive fork truck forks.

Use proper lifting techniques when moving the AFG2 compactor.

2.4.4 Power Requirements

Connect the Pine AFG2 to the proper electrical power source using the appropriate power cable. The nameplate, main power switch, and power cord entry are located on the right side of the control box. Verify machine power requirements listed on the nameplate prior to connecting to an electrical source (Figure 2.3). The use of extension cords is not recommended due to the voltage drop over the length of the cord.

For installation at locations within the United States (115 VAC: AFG2A(S)), a standard three-prong power cable is included suitable for use with 15 Amp electrical outlets.

For installations outside the United States (230 VAC: AFG2C(S)), use the appropriate, properly grounded, electrical connection.

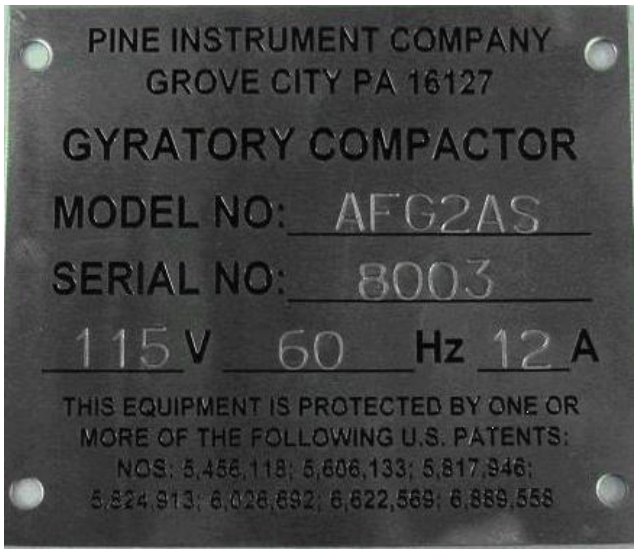


Figure 2.3: Identification Tag

2.4.5 Initial Application of Power

Read and understand this entire manual before applying power to the gyratory compactor.

Read and understand all personal safety warnings before applying power to the compactor.

When the Pine AFG2 is turned on for the very first time, it may not respond to the control panel because the **EMERGENCY STOP** button was pressed at the factory. Simply rotate the button clockwise to release it.

Before using the Pine AFG2 SUPERPAVE Gyratory Compactor to compact hot mix asphalt specimens, be sure to read and understand all of the personal safety warnings found in Section 2.5 of this manual.

2.5 Personal Safety

When working with the Pine AFG2 SUPERPAVE Gyratory Compactor, care should be taken to avoid injury. Adhere to the following personal safety warnings as a minimum:

	**Operator should wear eye protection and steel toe shoes.** **Do not wear loose-fitting clothing items (*i.e.*, jewelry, ties, etc.) which may be caught in the moving parts of the compactor. Long hair should be tied back.**
	**Use proper lifting techniques when inserting and removing specimen molds to prevent back injury.**
	**Keep hands and arms away from moving parts and pinch points.** **Keep hands and arms away from the top of the compactor when extruding the specimen.**
	**Always wear heat resistant clothing and gloves when handling hot molds and hot HMA specimens,**
	**Do not operate the compactor with any of the access panels or guards removed.**
	**Use proper lifting techniques when moving the compactor to prevent injury.**
	**If the compactor is used in a manner not specified by Pine Instrument, the protection provided by the compactor may be impaired.**

Material Disclosure Table

The AFG2 may contain materials that require special handling for disposal or recycling. These materials should be handled according to the local governing agency requirements. Table 2.1 provides a listing of the components which contain materials that may require special handling at the end of service life disposition.

Hazardous Material Disclosure Table						
Component Name	Hazardous Substances or Elements					
	Lead (Pb)	Mercury (hg)	Cadmium (Cd)	Chromium VI Compounds (Cr^{6+})	Polybrominated Biphenyls (PBB)	Polybrominated Diphenyl Ethers (PBDE)
AFG2 (-A,-AS,-C,-CS) - GYRATORY COMPACTOR	X	O	O	X	O	O
ACG2 - COMPACTOR MECHANICAL	X	O	O	X	O	O
ACG2S10 - POWER ELECTRONICS	X	O	O	X	O	O
ACG2S11 - OPERATOR INTERFACE	X	O	O	X	O	O
O: this component does not contain this hazardous substance above the maxiumum concentration values in homogeneous materials specified in the SJ/Txxxx-xxxx Industry Standard.						
X: this component does contain this hazardous substance above the maxiumum concentration values in homogeneous materials specified in the SJ/Txxxx-xxxx Industry Standard						

有毒有害物质披露表						
零部件名称	有毒有害物质或元素					
	铅 (Pb)	汞 (hg)	镉 (Cd)	六价铬 (Cr^{6+})	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
回转式压实机， 带剪切机	X	O	O	X	O	O
压实机机械部分装配	X	O	O	X	O	O
电源设备安装	X	O	O	X	O	O
操作界面组装	X	O	O	X	O	O
O：表示该有毒有害物质在该部件所有均质材料中的含量均在SJ/Txxxx-xxxx 标准规定的限量要求以下。						
X：表示该有毒有害物质至少在该部件的某一均质材料中的含量超出SJ/Txxxx-xxxx 标准规定的限量要求。						

Table 2.1: Material Disclosure List

III. Operation

3.1 General

The Pine Instrument Company Gyratory Compactor model AFG2 is designed for the compaction of Hot Mix Asphalt design specimens. Special care must be taken when compacting emulsion based cold mix or soil samples. A collection means for any fluids excreted as the material sample is compacted may be required. Using the machine to compact other materials such as dry aggregate may cause damage.

The proper operation of the gyratory compactor requires that the mold and compaction chamber be free of dirt and debris. Small stones and dirt in the compaction chamber and on the mold could result in erroneous data or damage the machine and should be removed prior to starting a test. It is especially important that the bottom flange on the mold be kept clean so that the mold is securely clamped during compaction. Keep the base of the compaction chamber clean also.

The front panel controls on the SGC provide fully automatic control of the compactor (Figure 3.1). The compaction settings are accessed using the menu navigation buttons.

Figure 3.1: The Front Panel Controls

3.2 Emergency Stop

The **EMERGENCY STOP** button is a large red button on the front panel. Pressing this button halts all moving parts on the compactor. To release the **EMERGENCY STOP** button, simply rotate it clockwise. To restart an interrupted test, press the green **START** button.

Figure 3.2: Emergency Stop

3.3 Mold Top Seated Indicator

When the mold top is properly seated, the green **MOLD TOP SEATED** light on the control panel will be illuminated. A test can not be started if the mold top is not properly seated.

3.4 Machine Ready Indicator

When the compactor is functioning normally and is ready to begin a test, the green **MACHINE READY** and the **MOLD TOP SEATED** lights on the control panel are activated. Attempting to start a test (by pressing the green **START** button) will not succeed unless both lights are on.

3.5 Fault Indicator

If a machine fault occurs during a test, the test is halted and an error code with a message appears on the main display. Contact the factory for information regarding such error codes.

3.6 Using the Menu System

The main display and the four buttons located immediately below it are used to navigate through various "menus" which control the gyratory compactor. Information in this display appears as black text on a light green background, and for purposes of this instruction manual, a similar graphical depiction of the main display is used (Figure 3.3).

```
GYRATION (n):   125
SPEC HT (mm): 116.0
ANGLE I(deg):  1.16
PRESSURE (kPa): 600
```

Figure 3.3: Liquid Crystal Display Representation

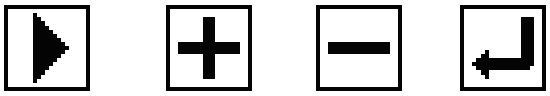


Figure 3.4: Menu Navigation Buttons

The four buttons located below the main display are used to select and change the value of testing parameters. The ▶ button navigates through the system menus by moving from one parameter to the next. When a given parameter is "selected" a flashing triangle appears beside it (on the left side of the display). While selected, the value of the parameter can be changed (incremented or decremented) using the + and − buttons. The new value is accepted by pressing the ↵ button.

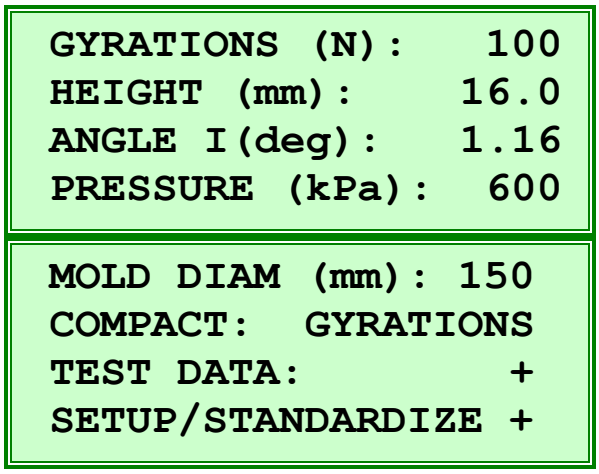


Figure 3.5: The Main Menus

The number of gyrations, mold diameter (150mm, 100mm, 4 Inch), compaction mode (Gyration, Height, Locking Point), the specified height (in Compact to Height mode only), and the change in height per number of gyrations (Locking Point mode) are adjustable on the main menus (Figure 3.5). To adjust the pressure, angle, and other settings navigate to machine setup menus using the ▶ and ↵ buttons.

Menus containing additional options (submenus) are marked with a "+" sign on the far right side of the display. To access the submenu, use the ▶ button to select the menu marked with the "+" sign and then press the ↵ button. This causes the submenu to be displayed.

3.7 Battery Powered Memory

The internal clock is battery powered so that accurate time is kept when the machine is not powered. The various machine calibration parameters, test settings, and the results from the previous twenty (20) tests are stored in non-volatile memory and do not require battery power. See Section 7.2.1 for battery information.

3.8 Setting the Date and Time

- Use the ▶ button to navigate through the main menu and select the **SETUP/STANDARDIZE** submenu. (Remember to press the ↵ button one time to enter a submenu.)
- Next, select the **Machine Setup** submenu.
- Select the **Time/Date** option from the submenu, and the display below appears:

```
Set Time and Date
▶=select ↵=accept
Time: 13:34:06
Date:  9/27/2001
```

- Use the ▶ button to move to the time or date value to be changed, then use the + and − buttons to change it. Press the ↵ button to store the selected value.

```
GYRATIONS (N):   100
HEIGHT (mm):    16.0
ANGLE I(deg):   1.16
PRESSURE (kPa):  600
```

```
MOLD DIAM (mm): 150
COMPACT:  GYRATIONS
TEST DATA:        +
▶SETUP/STANDARDIZE +
```

```
 Machine Information
▶Machine Setup     +
 Standardize       +
 Exit
```

```
 Pressure (600kPa)
 Angle (1.16 Int)
 Specimen Squaring
▶Time/Date
```

3.9 Mold Size Conversion 100mm/150mm/4 Inch

The AFG2 SGC is capable of compacting 100mm, 150mm, or 101.6mm (4 inch) diameter specimens. A conversion kit is available to change from the standard 150mm diameter setup to a 100mm diameter or to a 101.6mm (4 inch) diameter specimen. Note that the 101.6mm (4 inch) should not be confused with the 100mm specimen. (Figure 3.6)

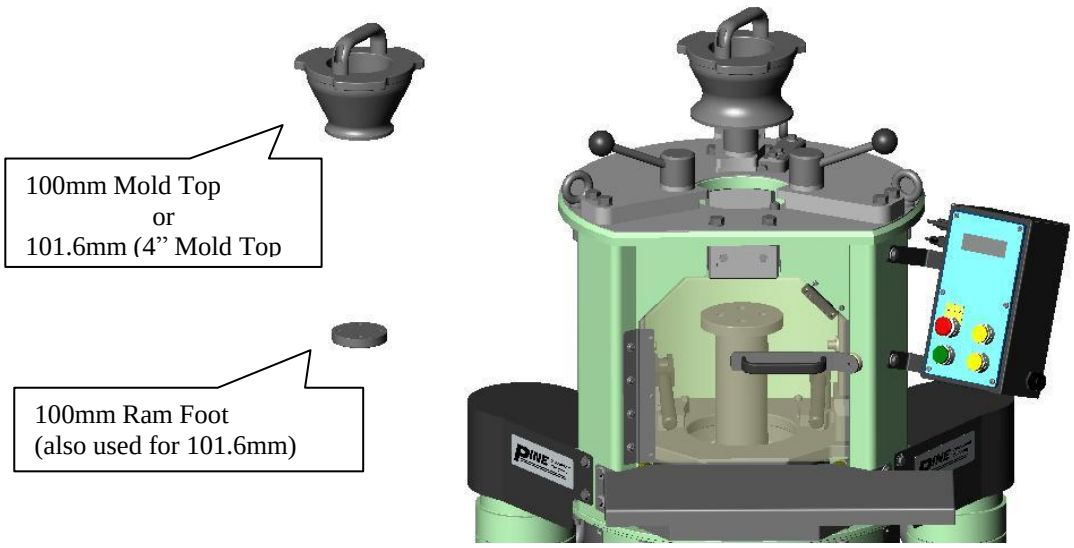


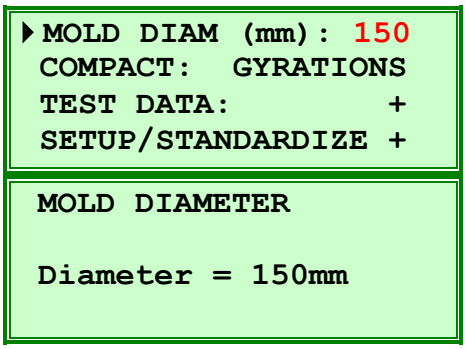
Figure 3.6: 100mm/101.6mm/150mm Conversion

To convert the AFG2 from 150mm to 100mm specimen diameter: The same procedure applies for converting from 100mm to 150mm specimen diameter or to the 4 inch diameter.

- Replace the 150mm ram foot with the 100mm ram foot. The foot is secured to the ram with four (4) hex-socket-cap-screws which require a 5/16" hex wrench.
- Replace the 150mm mold top with the 100mm (or 4") mold top.
- Calibrate the height for each size to be used. (See Section 6.4).

In applications that require switching from 150mm to 100mm (or 4 inch) specimens often, such as making 4" Hveem Stabilometer specimens, the smaller 100mm RAM foot has been used successfully with the 150mm mold, eliminating the need for changing the foot between specimens.

Program the compactor for the desired mold diameter to ensure that the proper compaction pressure is applied. Use the ▶ button to highlight the **Mold Diameter**, press ↵ Use the + and − buttons to change the setting (150mm, 100mm, or 101.6mm). Press ↵ to store the desired setting.



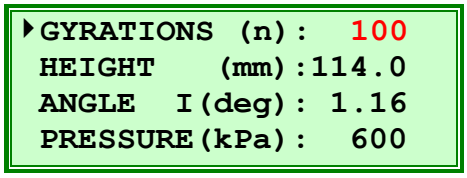
Note: **When the compactor is converted from 150mm to 100mm diameter specimens, it is recommended that the height be standardized. Control software versions 08.09a and later accommodate height calibration for each mold size separately so standardization may not be required.**

Some applications may not require precise height measurement therefore height standardization for these applications may not be required.

IV. Performing a Test

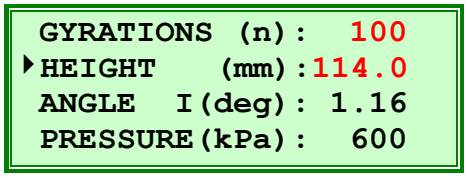
4.1 Settings

4.1.1 Number of Gyrations



The number of Gyrations for a test is adjusted by using the ▶ button to highlight the **Gyrations** parameter, and then choosing a value between 0 and 999 with the + and − buttons. Press ↵ to store the selected value. If the machine is set to **Compact to Specified Height**, be sure to set the gyrations number to a value larger than that needed to reach the specified height.

4.1.2 Specimen Height



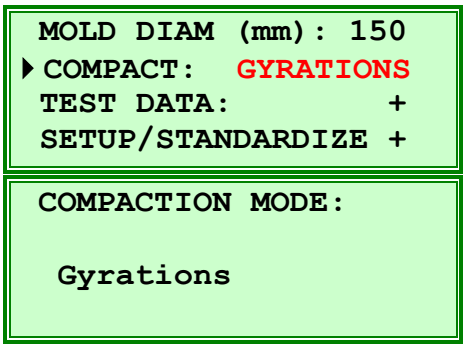
When the compactor is in compact to specified height mode, set the height at which compaction is to be stopped. Use the ▶ button to highlight the **Height** parameter, and choose a value that meets the desired final specimen height. This parameter is only adjustable when the compactor is in **Compact to Specified Height** mode (see Section 4.1.3). Press ↵ to store the selected value. Also set the number of gyrations to the maximum the test should run in the case where the specified height is not achieved.

4.1.3 Compaction Mode

The AFG2 can be configured to stop at three defined conditions: number of gyrations, specified specimen height, locking point. If it is desired to stop compaction at a predetermined number of gyrations, set the compaction mode to **Compact to Gyration**. If it is desired to stop compaction at a specified target density, set the compaction mode to **Compact to Height**. Compact to **Locking Point** is an experimental compaction mode. If the locking point is not reached prior to performing 200 gyrations, the compactor will stop.

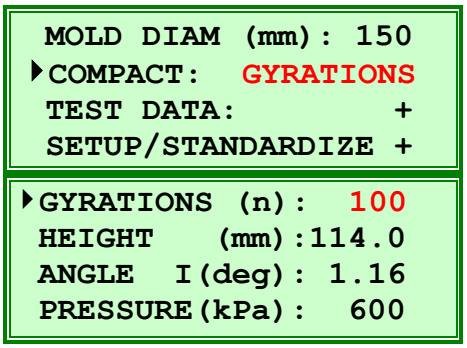
Regardless of the parameter selected to stop the compaction process the compactor will automatically apply the consolidation pressure (typically 600 kPa) then gyrate the specimen (30 rpm) at the programmed angle of gyration (internal; or external) to the preset stopping condition. The compactor will then remove the angle of gyration, release pressure, and signal the operator to remove the mold top to extrude the specimen. For tender specimens, it may be desirable to allow the specimen to cool slightly prior to extruding it from the mold.

Program the compactor for the desired compaction mode (Gyration, Height, or Locking point). Use the ▶ button to highlight the **COMPACT,** press ↵ Use the + and − buttons to change the setting (Gyration, Height, Locking Point). Press ↵ to store the desired setting.



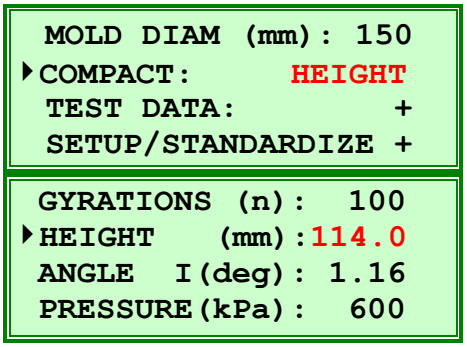
4.1.3.1 Number of Gyrations

When the compactor is in compact to gyrations, mode, set the number of gyrations at which compaction is to be stopped. Use the ▶ button to highlight gyrations, select the number of gyrations (1-999). Press ↵ to store the selected value. The number of gyrations is stored for each compaction mode.



4.1.3.2 Specified Height

When the compactor is in compact to specified height mode, set the height at which compaction is to be stopped. Use the ▶ button to highlight the **Height** parameter, and choose a value that meets the desired final specimen height. This parameter is only adjustable when the compactor is in **Compact to Specified Height** mode (see Section 4.1.3). Press ↵ to store the selected value. Also set the number of gyrations to the maximum the test should run in the case where the specified height is not achieved.

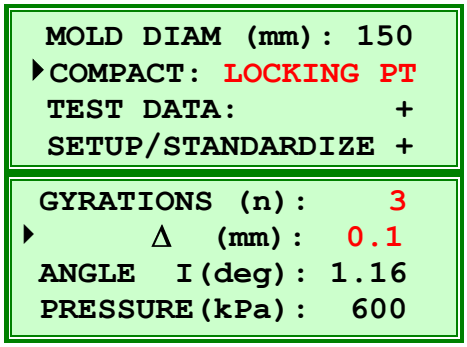


Note: **Due to rounding of the specimen height on the display and data file to the nearest 0.1 mm, the preset height may appear to have been reached prior to the compactor stopping. The compactor will stop on the first complete gyration after the specified specimen height is reached. Also, when the specimen is squared and allowed to cool, the height may change slightly. As noted previously, the compactor will also stop at the maximum number of gyrations programmed if the specimen height is not reached.**

4.1.3.3 LOCKING POINT

Locking Point is defined as the change in height per number of gyrations. The value of the desired change in height can be programmed from 0.1mm to 1.0mm. The number of gyrations can be 2 to 50.

When the compactor is in compact to Locking Point mode, set the change in height per number of gyrations at which compaction is to be stopped. Use the ▶ button to highlight the Δ parameter, and choose a value (0.1 to 1.0mm). Select the number of gyrations (2-50) over which this change in height is to be evaluated. Press ↵ to store the selected value. These parameters are only available when the compactor is set to **Locking Point** mode.



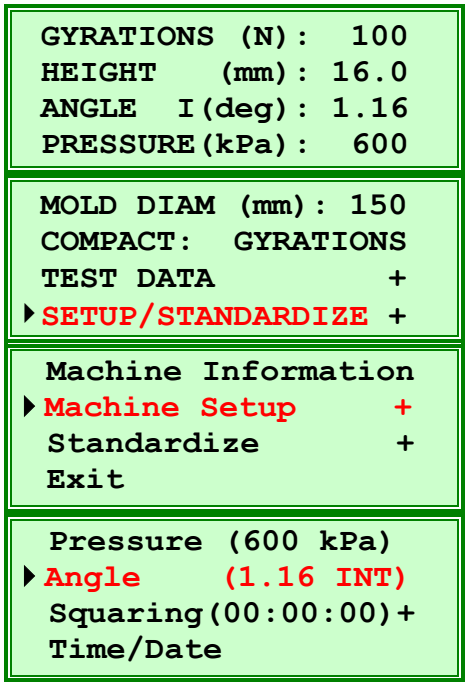
4.1.4 Angle of Gyration

The AFG2 has an integrated angle measurement system that measures and controls the angle of gyration. It is possible to set the target angle of gyration as an internal angle or an external angle. Both the internal angle of gyration and external mold angle are stored in the data file. The measured angle is displayed during compaction.

Program the compactor to apply an external angle or an internal angle of gyration. The internal angle is based on the measurement of the external angle and the internal angle calibration data.

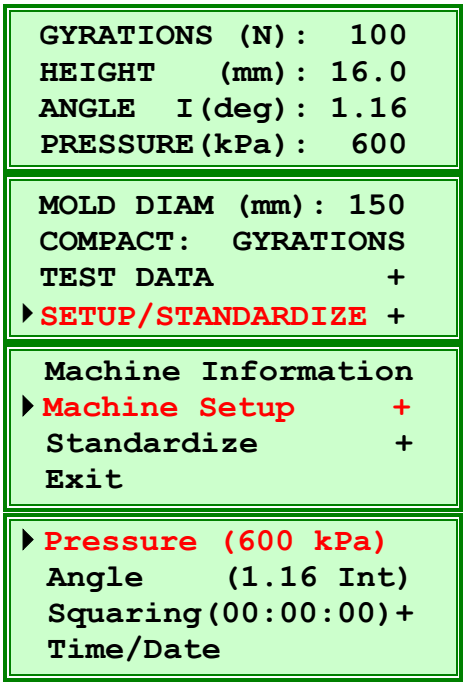
Navigate to the **MACHINE SETUP** screen. Use the ▶ button to highlight **Angle**, Press ↵. Use the + and − buttons to change the setting to External (E) or Internal (I). Also select the angle magnitude on this screen. Press ↵ to store the desired settings. Be sure to verify the angle setting on the main screen.

When the angle is set to 0.0° (Internal or External), the number of gyrations will default to "0". The consolidation pressure will be applied for the time specified by Specimen Squaring **(Section 4.1.6)**



4.1.5 Consolidation Pressure

The consolidation pressure applied to the specimen is programmed by using the ▶ button to navigate to the **MACHINE SETUP** screen, press ↵. Use the ▶ button to highlight **Pressure**, press ↵. Choose a value between 200 and 1000 kPa using the + and − buttons, press ↵ to store the desired value. Typically 600 kPa is used. Use the ▶ button to navigate to **EXIT**, press ↵.



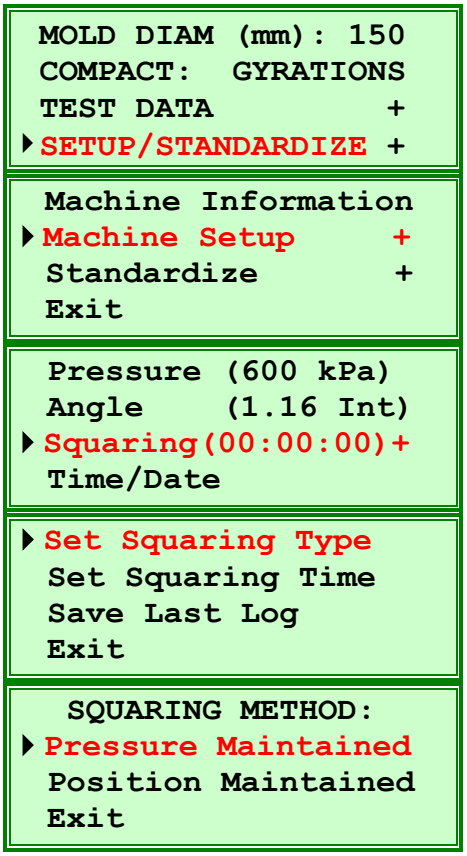
4.1.6 Specimen Squaring

Two types of square delays are programmable: **Pressure Maintained** or **Position Maintained**.

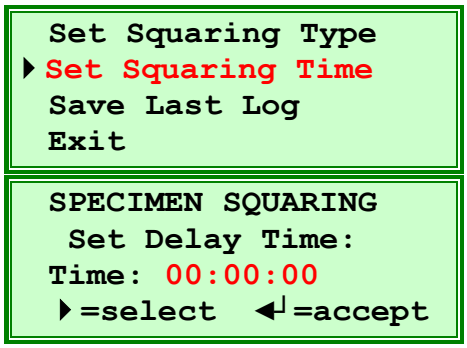
The **Pressure Maintained** squaring type holds the consolidation pressure applied to the specimen during a test for the programmed duration after gyration is complete and angle is removed.

The **Positioned Maintained** squaring type holds the compaction ram fixed (no motion) for the programmed duration after gyration is complete and angle is removed.

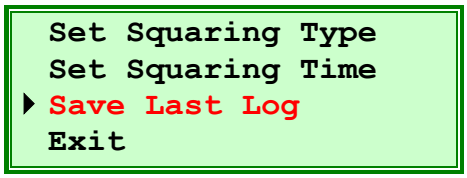
To set the squaring type, use the ▶ button to navigate to the **MACHINE SETUP** screen, press ↵. Use the ▶ button to highlight **Squaring**, press ↵. Use the ▶ button to highlight **Set Squaring Type**, press ↵. Use the ▶ button to select the desired type then press ↵.



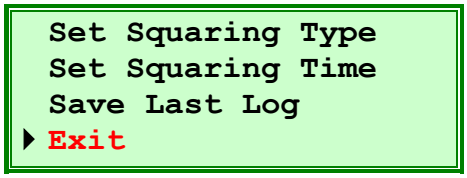
Squaring time is set similar to Time/Date, by using ▶ to select **HR:MN:SC** fields; then using the + and − buttons to change values, press ↵ to accept. Up to 24 hours of squaring time may be applied.



After the squaring time is expired, a log file is saved. The last squaring log file may be saved to USB memory by selecting **Save Last Log** on the squaring menu. Only one test is stored in memory and the data must be saved to a USB device prior to running the next test. If a USB memory device is present at the end of the test, the square log file is automatically saved to the device. Data is saved at one minute intervals on square times of one minute or longer.



Use the ▶ button to navigate to **EXIT**, press ↵.



Extended square delays may require the mold be reheated before the specimen can be extruded from the mold.

4.2 Testing Procedure

Figure 4.3 represents a basic illustration of the steps for performing a test. The machine ready green LED on the control panel must be lit before a test can begin. If the machine ready green LED is not lit, the machine may not be properly parked. Press the **RAM DOWN** button to park the machine.

Prepare the mold assembly for compaction as outlined in Section 4.2.1. Insert the mold into the compaction chamber. It is convenient to orient the knobs toward the front and the rear of the compactor. Be certain that the mold is fully seated against the rear alignment pins. Clamp the mold firmly to the swivel base with the two clamps, one on each side of the mold. Be sure to press downward on the clamp handles firmly. Close the compaction chamber door.

Install the mold top into the top of the compactor. Rotate the mold top into position clockwise until it is fully engaged with the hold downs and against the stop on the top of the machine. Lock the mold top in place by rotating each clamp handle clockwise until tight. The machine ready light and mold top seated green LED should be illuminated.

Be sure all parameters are correct before starting a test. Press the **START** button to initiate the compaction. The **EMERGENCY STOP** button will pause the test. Opening the compaction chamber door will also suspend the test. If the test is stopped for any reason, the **START** button must be pressed to restart the machine. After the programmed number of gyrations or specimen height has been reached, the machine will automatically stop and release ram pressure. Remove the mold top and extrude the specimen.

	**Caution! Be sure to keep your hands clear of the top of compactor when extruding the specimen.**
	**Caution! Be sure ram pressure has been released and ram is stopped before attempting to remove the mold top.**

4.2.1 Mold Preparation

Clean the mold, mold base and mold top. A clean mold assembly is essential for repeatable results. Preheat the mold and mold base plate. The mold base plate is usually preheated in the mold. Note the correct orientation of the mold base flange is up (Figure 4.1). The mold top does not require preheating, although it is possible to preheat the mold top in the oven or with a hot plate if desired. The preheat temperature is usually 150° Celsius (300° Fahrenheit). Consult the specific test procedure being followed for exact instructions on proper preparation and aging of the specimen. Place the preheated mold with its base plate on the compactor work surface. Next, place a paper disk into the mold on top of the base plate. Load the loose, properly prepared HMA specimen into the mold. Place a paper disk on top of the specimen (Figure 4.2).

Note: **Studies have indicated paper type used for disks impacts specimen density.**

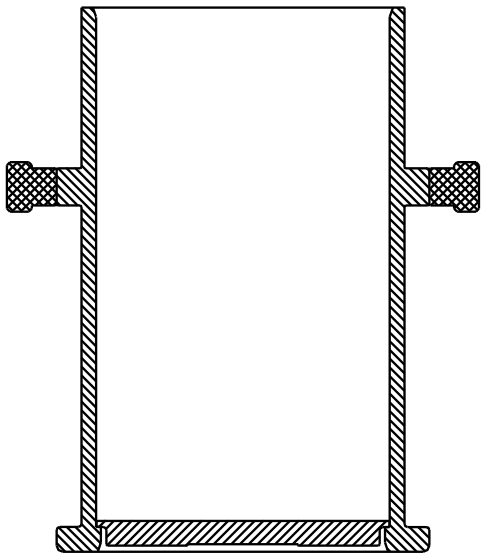


Figure 4.1: Mold Assembly

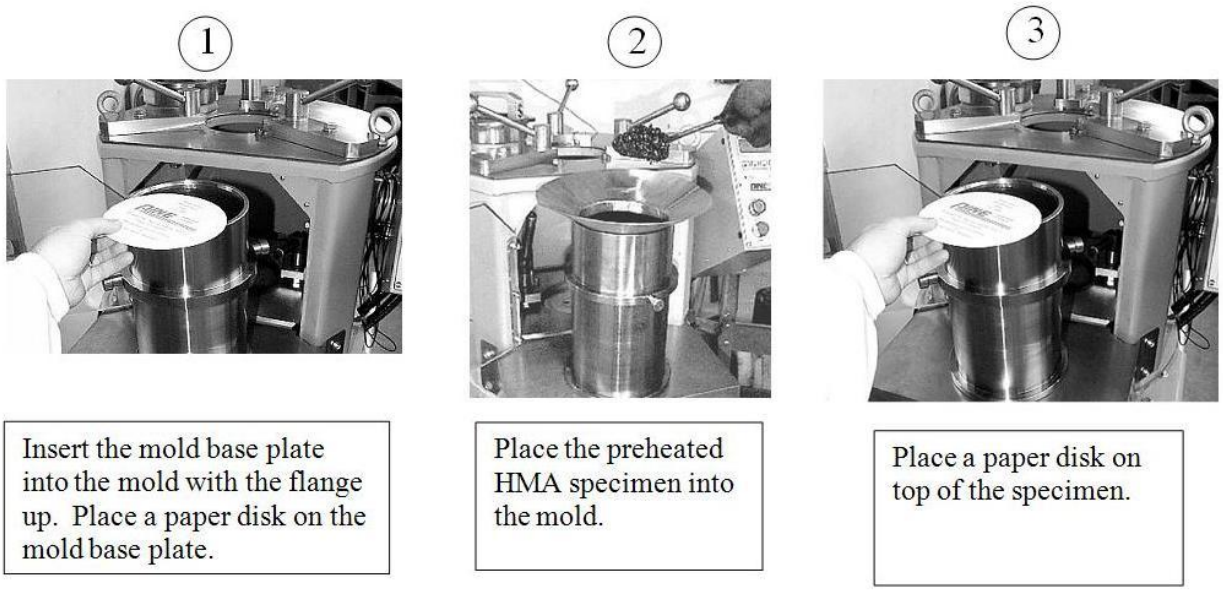


Figure 4.2: Mold Preparation

Note: **When inserting the mold into the compaction chamber, be sure the bottom flange is against the rear alignment pins on the swivel base. This can be achieved by pushing near the bottom of the mold when inserting the mold. Next, lock the mold firmly in place with the clamps located on the left and right side of the swivel frame. Press downward on the clamp handles firmly. It is also important that the mold top is firmly clamped to the frame. Failure to clamp the mold and mold top properly may cause erroneous results.**

4.2.2 Starting the Test

Figure 4.3 – depicts the normal procedure for compacting specimen. Once the compactor has been properly configured with the desired settings the compaction process can begin by pressing the green **START** button. The test continues until the desired number of gyrations is complete or until the desired specimen height is achieved. The display shows the progress of the test. Once the test is complete the final specimen height is displayed and the data is automatically saved.

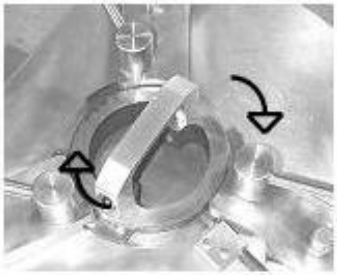
1. Prepare the mold (see Figure 4.2).

2. Insert the mold into the compaction chamber.

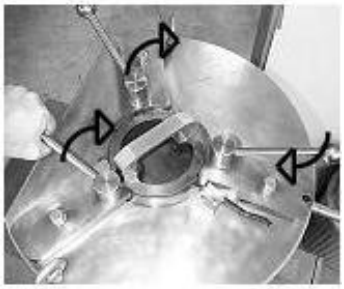
3. Clamp the mold to the swivel frame firmly.

4. Insert the mold Top into the compactor.

5. Rotate the mold top into the hold downs.

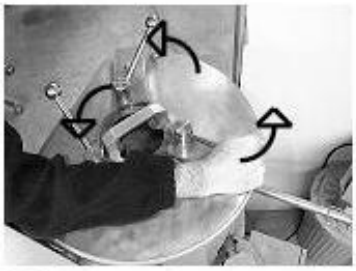


6. Clamp the mold top to the frame.



7. Press **START**.

8. After compaction is complete, release the mold top.



9. Rotate mold top fingers out of the hold downs.

10. Remove the mold top.

11. Extrude the specimen. Keep hands clear!

12. Allow specimen to cool slightly. Remove the specimen.

Figure 4.3: Performing a Test

4.2.3 Interrupting the Test

Pressing the **EMERGENCY STOP** button or opening the compaction chamber door during the test causes the machine to halt. To restart the test, release the **EMERGENCY STOP** (or close the door), then press the **START** button.

4.2.4 Removing the Specimen

The gyratory compactor is equipped with an integrated specimen extruder. When the test is completed, unlock the mold top clamps by rotating the clamps counter-clockwise, remove the mold top, then press and hold the **RAM UP** button to extrude the specimen. It may be necessary to allow the specimen to cool slightly before extruding with high air-void HMA specimens. The ram will stop when the specimen when the button is released. To resume extruding the specimen, press and hold the **RAM UP** button. When complete, remove the specimen and press the **RAM DOWN** button to automatically retract the ram.

Caution: Be sure to keep your hands clear of the top of compactor when extruding the specimen.

Alternatively, the ram may be retracted by pressing the **RAM DOWN** button prior to extruding the specimen permitting the mold to be removed from the machine to allow the specimen time to cool in the mold while additional specimens are compacted. Place the mold back into the machine and press the **RAM UP** button to extrude the specimen.

Remove the paper disks from each end of the specimen and then place the specimen on a bench to cool. A fan can be used to reduce the cooling time. Once the specimen is cooled to ambient temperature, the bulk specific gravity can be measured and any further testing can be performed.

4.3 Retrieving Test Results

The AFG2 SGC automatically records the gyration number, specimen height, angle of gyration, consolidation pressure, and internal moment for each gyration. A sample of the data file format is provided (Figure 4.4).

If a USB storage device is installed in the compactor at the end of a test, the test data file will be automatically transferred to the storage media. Approximately 140 tests may be stored per 1 Mb of memory. Pine-Pave software provides a “Load Data from Disk” function which will read the height data from a portable memory device into the Pine-Pave project workbook automatically. The PinePave Shear module loads the moment data and calculates gyratory shear. The data can be viewed graphically.

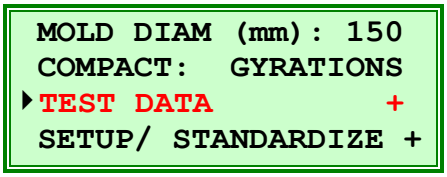
If no storage device is installed in the USB port, the test data is stored in the internal memory of the AFG2 and may be retrieved later. Up to 20 test files can be stored before the oldest files are overwritten as new files are generated. These data files can be retrieved and saved to a storage device with the following procedure. Tests are stored by the date and time compaction begins.

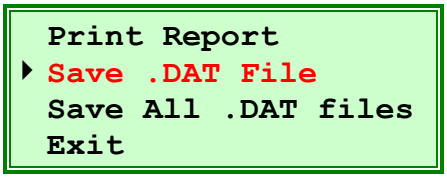
See Section V for retrieving data from a G2 connected to a network or computer.

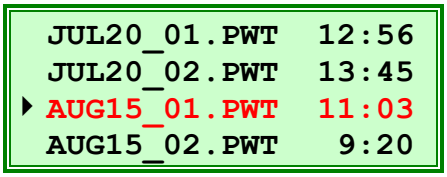
Note: Although the AFG2 has 2 USB ports, only one USB memory can be utilized at a time. The second USB port is for other device types (see Section 4.3.3).

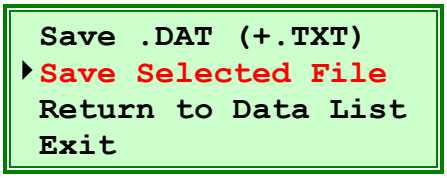
4.3.1 Saving Test Data to Portable Storage Media

- Use the ▶ button to highlight the **TEST DATA** choice on the main menu, and then press the ↵ button.
- A submenu appears which permits printing test results to a printer or saving results to a USB storage device.
- Use the ▶ button to highlight the **Save .DAT File** choice, and then press the ↵ button.
- Use the ▶ button to highlight appropriate set of test results, and then press the ↵ button. (By pressing the ▶ button multiple times, the entire list of all stored tests can be scrolled.)
- After selecting the desired data file, select the **Save Selected File** then press the ↵ button. This saves the data to the USB storage device. The printer style report can also be saved to a USB memory device as a *.txt file by selecting the Save .DAT +.TXT option.. This setting will save both the *.DAT file and the *.TXT report to the USB memory device. The *.TXT file will be in the format selected in the print options (see Section 4.3.3).
- When finished, select the **Exit** choice and press the ↵ button.









The data is stored on the USB storage media in a simple "plain text" data file that can be opened by widely available spreadsheet and word processing applications. PinePave software included with the compactor can be used (together with Microsoft® Excel) to analyze the data files and produce graphs of the results. The *.DAT files contain the data in a format compatible with PinePave (see Figure 4.4). The *.txt file formats (Brief and Full) are shown in Figure 4.5 and Figure 4.6 respectively.

Example: Pine AFG2A Data File Format

```
================================================
File Name: SEP14_04.DAT
     Time: 14:36
     Date: 04/14/07
 Diameter: 150 mm
      S/N: 8001
================================================
Gyration   Height     Angle      Pressure  Moment
   (#)      (mm)     (deg Int)    (kPa)    (N-m)
     0     144.2      ----       576        653.6
     1     140.7      1.16       576        516.8
     2     137.0      1.16       587        665.4
     3     134.6      1.16       589        710.9
     4     132.8      1.16       590        742.7
     5     131.4      1.16       590        766.5
     6     130.2      1.16       593        777.1
     7     129.3      1.16       593        786.9
     8     128.4      1.16       592        792.1
     9     127.7      1.16       593        799.4
    10     127.0      1.16       591        804.0
    11     126.4      1.16       593        809.0
    12     125.9      1.16       594        812.4
    13     125.4      1.16       595        812.8
    14     124.9      1.16       596        817.7
    15     124.5      1.16       595        818.6
    16     124.1      1.16       595        821.9
    17     123.7      1.16       596        826.3
    18     123.3      1.16       592        813.5
    19     123.0      1.16       599        843.0
    20     122.8      1.16       597        831.1
    21     122.5      1.16       595        821.6
    22     122.2      1.16       598        834.9
    23     121.9      1.16       597        831.3
    24     121.7      1.16       598        836.3
    25     121.5      1.16       598        837.4
    26     121.2      1.16       599        840.8
    27     121.0      1.16       599        845.3
    28     120.8      1.16       599        847.9
    29     120.6      1.16       600        840.7
    30     120.4      1.16       600        846.5
    31     120.3      1.16       600        845.1
    32     120.1      1.16       600        846.9
```

Figure 4.4: Data File Format (*.DAT)

4.3.2 Transferring Data to a Personal Computer

Data can be saved to a USB portable memory device then transferred to the computer or the AFG2 can be connected to a computer through its network port. See Section V for setting up a network connection.

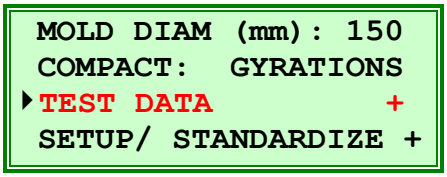
4.3.3 Printing Data

The AFG2 can print data to a dot matrix printer connected directly to the compactor with a special USB interface cable. The AFG2 can also be configured to print to network printer or

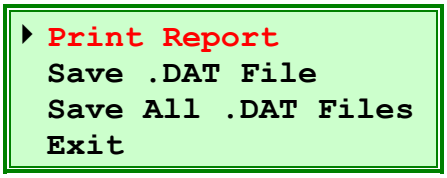
printer connected to a standalone computer. See Section V for configuring a connection to a computer or network and Section 5.3 for automatically printing data to a network printer.

Printing to printers connected directly to the AFG2 requires a special USB interface cable and dot matrix printer

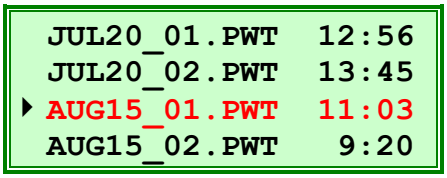
- Use the ▶ button to highlight the **TEST DATA** choice on the main menu, and then press the ↵ button.



- A submenu appears which permits printing test results to a printer or saving results in report format to a USB storage device. Use the ▶ button to highlight **Print Report** then press the ↵ button.



- Use the ▶ button to highlight the desired test, then press the ↵ button. (By pressing the ▶ button multiple times, the entire list of all 20 stored tests can be scrolled.)



- After selecting the desired data, be sure the desired format is selected (**Brief** or **Full**). Using ▶ button, select **Print Report** then press ↵ to send the report to the printer.

  Examples of the **Full** and **Brief Report** styles are shown in Figure 4.5 and Figure 4.6.

- When finished, select **Exit** then press the ↵ button.

```
================================================================================
                          Pine Instrument Company
                          Gyratory Compaction Report

                    Specimen Height (mm) vs. Gyration Number
================================================================================
       Date:  11/29/07                              Machine S/N:  8004
       Time:  09:34                                       Mode:  Set Gyrations
   Filename:  SEP07_26.DAT                      Mold Diameter:  150 mm
Specimen ID:  _______________                    Avg Pressure:  600 kPa
 Technician:  _______________            Avg Angle of Gyration:  1.16 deg
================================================================================

    |  0     1     2     3     4     5     6     7     8     9
----+-------------------------------------------------------------
  0 |149.6 144.8 141.5 139.2 137.4 136.0 134.8 133.7 132.8 132.0
    |
 10 |131.3 130.6 130.1 129.5 129.0 128.5 128.1 127.6 127.2 126.9
    |
 20 |126.5 126.2 125.9 125.6 125.4 125.1 124.9 124.6 124.4 124.2
    |
 30 |124.0 123.8 123.6 123.4 123.2 123.0 122.9 122.7 122.6 122.4
    |
 40 |122.3 122.1 122.0 121.9 121.7 121.6 121.5 121.4 121.3 121.1
    |
 50 |121.0 120.9 120.8 120.7 120.6 120.5 120.4 120.3 120.2 120.1
    |
 60 |120.0 119.9 119.9 119.8 119.7 119.6 119.5 119.5 119.4 119.3
    |
 70 |119.2 119.2 119.1 119.0 118.9 118.9 118.8 118.7 118.7 118.6
    |
 80 |118.5 118.5 118.4 118.3 118.3 118.2 118.2 118.1 118.0 118.0
    |
 90 |117.9 117.9 117.8 117.8 117.7 117.7 117.6 117.6 117.5 117.5
    |
100 |117.4 117.4 117.3 117.3 117.2 117.2 117.1 117.1 117.1 117.0
    |
110 |117.0 116.9 116.9 116.8 116.8 116.8 116.7 116.7 116.6 116.6
    |
120 |116.6 116.5 116.5 116.5 116.4 116.4
    |
================================================================================
```

Figure 4.5: Report Style: Brief

```
================================================================================
                          Pine Instrument Company
                          Gyratory Compaction Report

          Specimen Height, Angle, Pressure, Moment vs. Gyration Number
================================================================================
       Date:  11/29/07                              Machine S/N:  8004
       Time:  09:34                                       Mode:  Set Gyrations
   Filename:  SEP07_26.DAT                      Mold Diameter:  150 mm
Specimen ID:  _______________                    Avg Pressure:  600 kPa
 Technician:  _______________            Avg Angle of Gyration:  1.16 deg
================================================================================

    |  0      1      2      3      4      5      6      7      8      9
----+-------------------------------------------------------------------------
  0 |149.6  144.8  141.5  139.2  137.4  136.0  134.8  133.7  132.8  132.0  mm
    | ----   1.20   1.19   1.18   1.16   1.16   1.16   1.16   1.16   1.15  deg
    |  599    584    572    577    594    599    601    600    600    600  kPa
    |  0.0  411.6  520.5  584.3  618.4  638.1  651.1  661.7  672.8  680.5  N-m
----+-------------------------------------------------------------------------
 10 |131.3  130.6  130.1  129.5  129.0  128.5  128.1  127.6  127.2  126.9  mm
    | 1.16   1.16   1.16   1.16   1.16   1.16   1.16   1.16   1.16   1.16  deg
    |  600    600    600    600    600    600    600    600    600    600  kPa
    |686.8  690.2  693.1  698.9  704.2  708.9  712.7  717.7  722.3  725.1  N-m
----+-------------------------------------------------------------------------
 20 |126.5  126.2  125.9  125.6  125.4  125.1  124.9  124.6  124.4  124.2  mm
    | 1.16   1.16   1.16   1.16   1.16   1.16   1.16   1.16   1.16   1.16  deg
    |  600    600    600    600    600    599    599    599    599    599  kPa
    |728.0  729.6  730.6  733.6  734.8  735.5  737.6  739.2  740.3  741.6  N-m
----+-------------------------------------------------------------------------
 30 |124.0  123.8  123.6  123.4  123.2  123.0  122.9  122.7  122.6  122.4  mm
    | 1.16   1.16   1.16   1.16   1.16   1.16   1.16   1.16   1.16   1.16  deg
    |  599    599    598    598    599    599    599    599    599    599  kPa
    |741.0  740.2  740.8  741.6  741.8  741.2  741.0  741.2  742.2  742.5  N-m
----+-------------------------------------------------------------------------
================================================================================
```

Figure 4.6: Report Style: Full

V. Network or Computer Connections

5.1 Introduction

The AFG2 is capable of being connected to a single computer or to a computer network by direct cable connection. The G2 can be set up to either receive a network address (known as IP Address) from another computer, a network router; or it may be assigned an IP Address by the user.

Three connection scenarios exist:

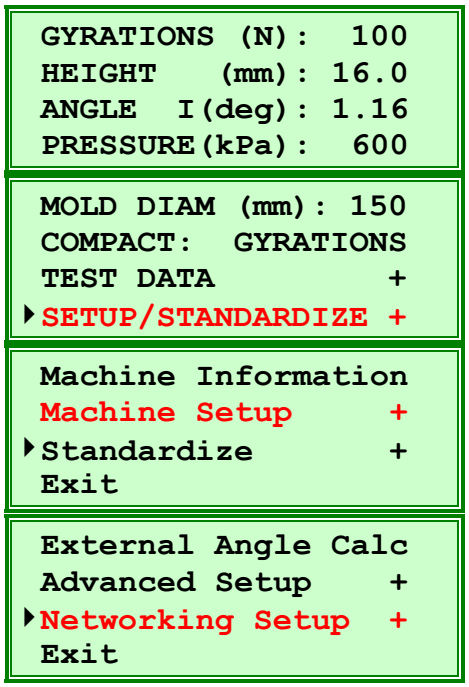
1. Receive an IP Address from a DHCP server (Dynamic Host Configuration Protocol). This is the default mode and requires a standard Category 5 cable (CAT5). The DHCP server may be a router or another computer that already exists on the network. See Section 5.2.1.
2. Manually assign IP address to the AFG2 on the network. This also requires connecting the AFG2 with a standard CAT5 cable. See Section 5.2.2.
3. Connect the AFG2 directly to a standalone (non-network) computer. This requires the user to manually assign IP Addresses to both the AFG2 and the connecting computer. A "crossover" style CAT5 cable is required for this type of setup. See Section 5.2.3.

5.2 Setup

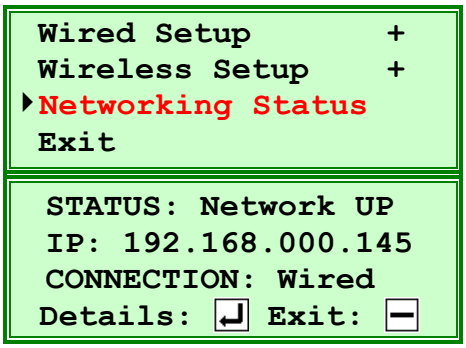
With the AFG2 turned off, connect the unit with the CAT5 cable (RJ45 connector) to the computer or router. Make sure the computer network is online, then turn the AFG2 on. Allow the AFG2 to go through its normal startup sequence. Connections to a computer network require a standard CAT5 cable. Connections to a standalone (non-network) computer require a crossover CAT5 cable.

5.2.1 DHCP Server Configuration

- Navigate to the networking main menu. Use the ▶ and ↵ buttons to select **NETWORKING SETUP**.

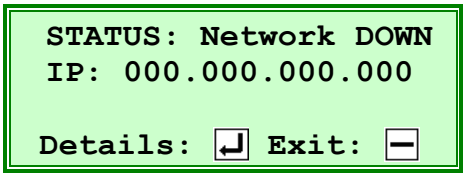


- With a DHCP server connection, the G2 should have already obtained an IP Address. Navigate to Networking Status and press the ↵ button.

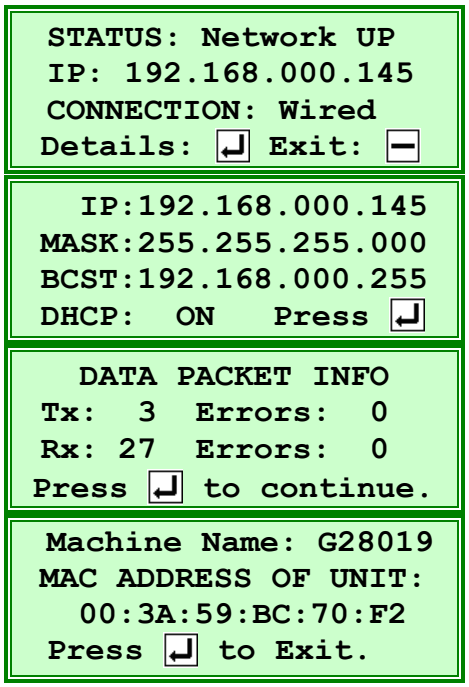


- If the unit has successfully received an address, line 1 of the Status screen should read **STATUS: Network UP**. Line 2 will have a valid IP Address. Record this address, it will be needed to access the AFG2 data from the computer.

- If the unit has not received an address, the display will indicate **STATUS: Network DOWN**.

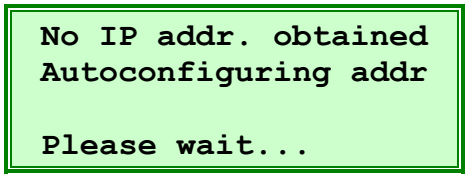


- Press the ↵ button to navigate through each status screen which displays additional information. The screen shots at the right are examples; actual numbers may vary. Pressing the – button on any status screen will exit directly to the main networking menu.
- If the unit is connected to the network correctly, there should be non-zero values for **Tx** and **Rx** with typically no errors for wired connections.
- The Machine Name is the name of the G2 on the network. It is derived from the compactor's four digit serial number, prefixed with "G2". The MAC Address is the actual hardware address of the CPU built into the G2.

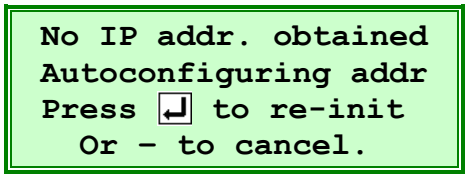


5.2.1.1 AUTO-CONFIGURATION

If the AFG2 fails to obtain an address from the DHCP server at startup, the following screen will appear while the G2 attempts auto-configuration.



If an address was not automatically obtained from the DHCP server after changes were made to the network setup, this screen will appear.



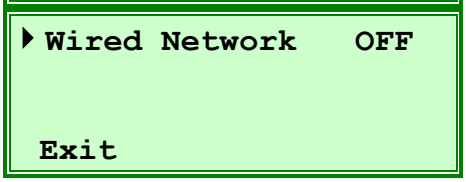
In each case, the G2 will attempt to establish communication with the computer or network by setting the IP address to 169.254.101.86. This address is within the auto-configuration range of Microsoft Windows™ and is used for computers that have networking enabled, but have not obtained an address from a DHCP server. Navigate to the G2 network status menu to confirm that a connection has been established.

5.2.2 User Defined Address Configuration

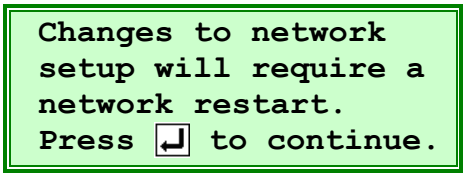
Network addresses have 4 groups of numbers called octets, separated by periods. A typical network address is: 192.168.124.231. In general, the valid range for each octet is from 0 – 255. When first connecting the AFG2 to a network, the DHCP configuration is applied by default. If changes are required or errors have occurred, the following instructions apply for manual configuration of the IP addresses.

- Navigate to the **Network Setup** menu then select "**Wired Network +**" and press the ↵ button.

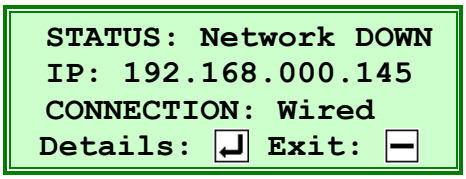
- Pressing the ↵ button with the cursor at "**Wired Network ON**" toggles the network off. Pressing the ↵ button with the cursor at "**Wired Network OFF**" will toggle networking back on. The setting is applied only when the screen is exited.



- Exiting the Wired Setup screen with the connection toggled OFF causes the networking connection to be disabled.

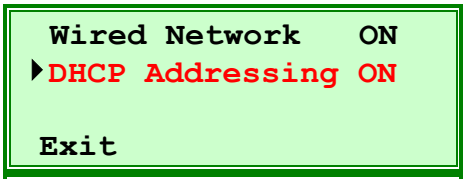


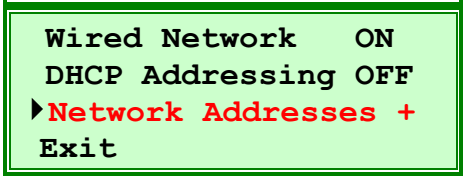
- The unit will save the current networking setup, then turn networking OFF. Viewing Network Status now yields:



The IP Address will be the last stored value. It may be **000.000.000.000** if no network connection was established. Viewing status details may show non-zero data packet numbers if the system had been UP and data packet counts are still in the status report. However, the Data Packet Tx and Rx numbers should not increment while the network is DOWN.

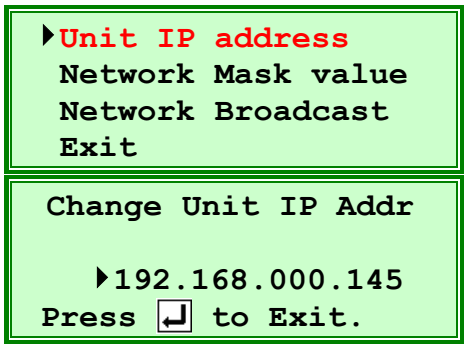
- To apply a user assigned network address, make sure that networking is turned ***ON*** and DHCP addressing is turned ***OFF*** by selecting the line **DHCP Addressing,** then press ↵ to toggle DHCP addressing on or off.
- Select "**Network Addresses +**" then press ↵.





Note: When DHCP addressing is off, the AFG2 IP Address, Mask, and Broadcast Addresses must be manually set. Most networks will have 192.168.xxx.xxx or 10.xxx.xxx.xxx network values. The IP Address and Broadcast setting for the 1st octet toggles between 10 and 192. To override this toggle, press and hold − then press +. This will allow the 1st octet to be incremented or decremented sequentially using the − and + keys.

- Select "**Unit IP Address**", then press ↵.



Use the ▶ key to move the blinking cursor to the left side of the desired octet, then use the + or − keys to change the value. Press ↵ to exit and save the IP address.

Repeat for the "**Network Mask Value"** and the "**Network Broadcast"** addresses.

After manually setting the IP Address, Mask Value, and Broadcast Address, press the ↵ key to "**Exit**" and return to the Wired Network Menu. The AFG2 will not alert the user if incorrect values are entered into the address fields, the network connection will simply not function properly. Exit the Wired Network menu to save the network setup values. These settings will now be in effect. If no changes were made to the settings, the message "***No changes to network setup were made***" will appear briefly before the unit returns to the main network menu.

5.2.3 Non-Network Computer Configuration

Connections to a standalone, non-network computer requires a CAT5 crossover cable between the AFG2 and a computer with an Ethernet port. For this type of configuration, the auto-configuration may be used to establish communication. Connect the AFG2 to the computer using the crossover CAT5 cable, turn the computer on, then turn the AFG2 on (last). The AFG2 will make three attempts to get an address from a DHCP server (default setting) during the initial power up sequence.

When the G2 fails to get an address from the DHCP, it will attempt to establish communication to the computer by setting the IP address to 169.254.101.86 with the auto-configuration utility. This address is within the auto-configuration range of Microsoft Windows™ and is used for computers that have networking enabled, but have not obtained an address from a DHCP server. This setting should enable communication between the AFG2 and standalone computer. Navigate to the AFG2 network status menu to confirm that a connection has been established.

5.3 Computer Interface Module

An Excel™ workbook (AFG2 Computer Interface.xlt) enables the user to access data stored on the AFG2 connected to the network or standalone computer. This workbook uses embedded macros to save and print data but does not perform any data calculations. Additional Excel™ workbooks are available for performing volumetric analysis for design or quality control purposes.

This workbook is stored on the USB memory supplied with the AFG2 and is compatible with Excel™ 2000 and later. No installation is required. However, the AFG2 IP Address (see Section 5.2.1) must be entered into the appropriate cell (light green).

Printing from this module utilizes printer drivers installed on the network or computer. A stored data file can be printed or copied. Twenty tests are saved in memory. The module can also be configured to automatically print the compaction results at the end of the test. The AFG2 configuration data may be viewed. See Figure 5.1.

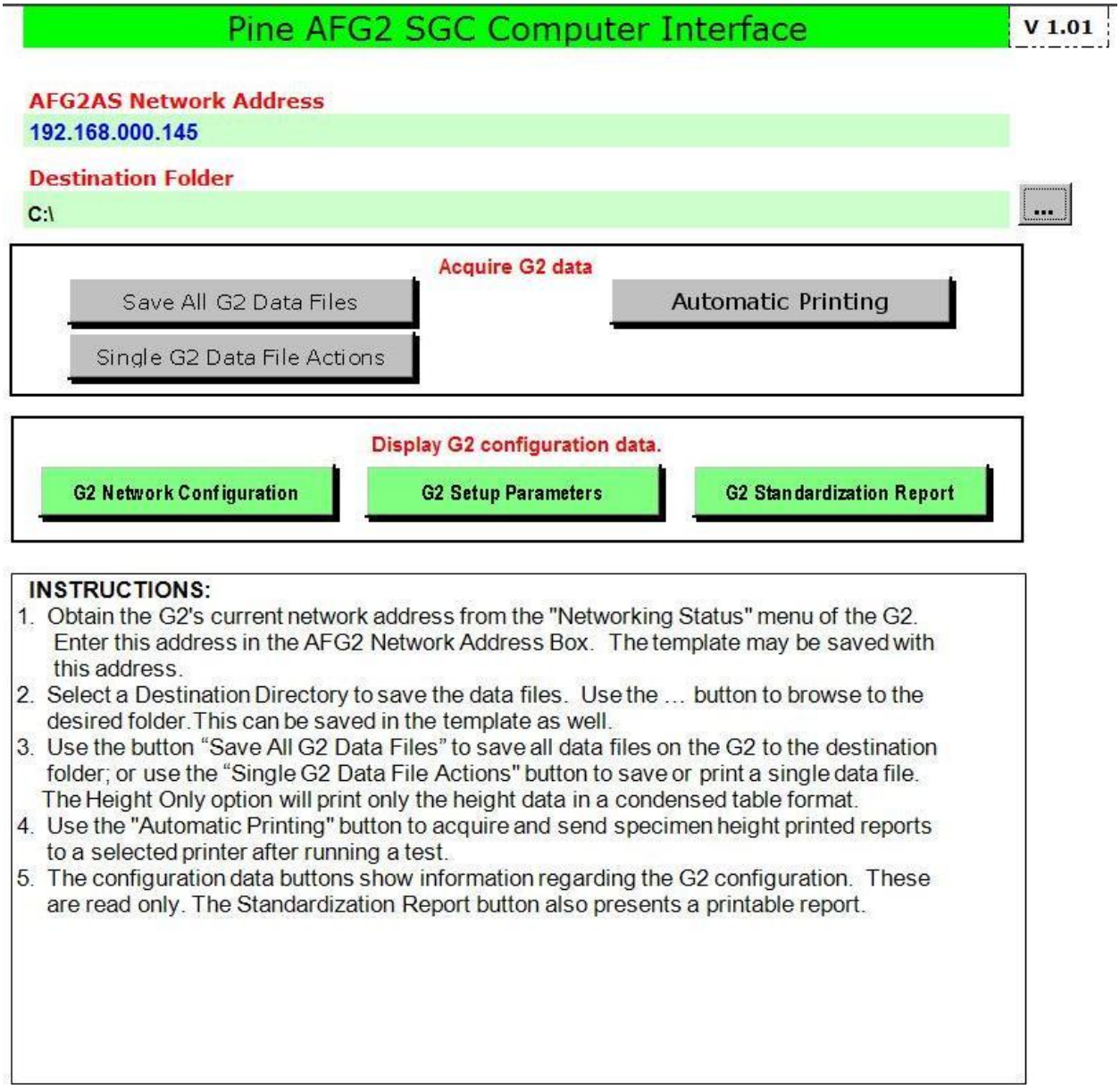


Figure 5.1: Network Interface Workbook

AFG2 Network Address: This cell (light green) requires the user enter the IP address assigned to the AFG2 to establish communication. Once the correct IP address is entered, save the interface template to retain this address for future sessions.

Destination Folder: Enter or browse (...) to the network folder where the data files are to be saved. This location will generally be project specific.

Acquire G2 Data: The buttons in this section permit actions on the AFG2 data files.

Save All G2 Data Files: This button saves all data files (up to 20) to the destination folder.

Single G2 Data File Actions: This button opens a window to save or print individual data files saved on the AFG2. Select the data file then select the action desired. A report containing only height data can be printed by selecting the Height Only check box. See Figure 5.2

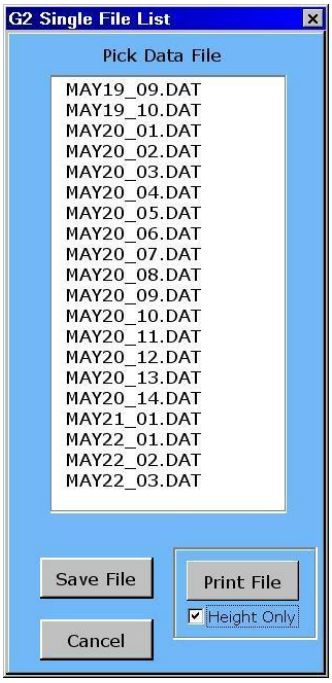


Figure 5.2: Network Single File Actions

Automatic Printing: This button opens a window which permits setup of a network printer to print the G2 data files automatically when compaction is completed. The module will continue to print each test as it is completed until the red STOP button is selected. See Figure 5.3.

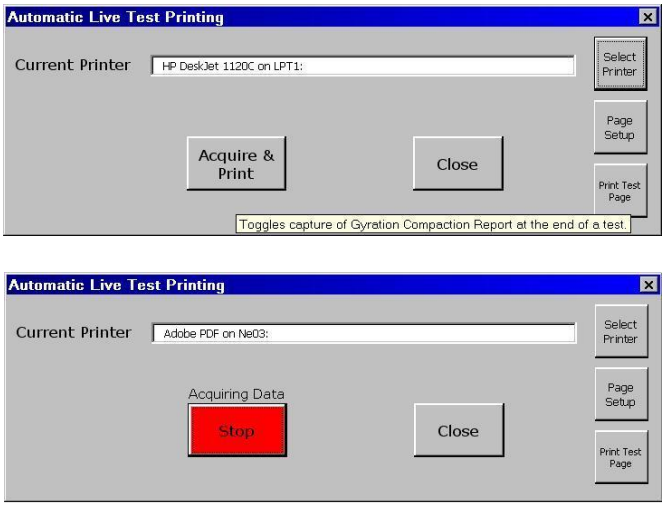


Figure 5.3: Network Printing Windows

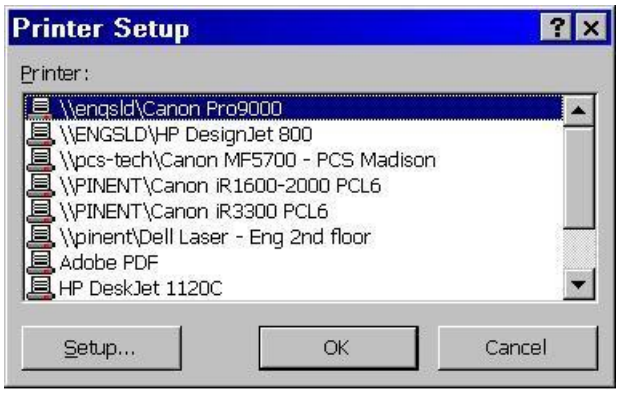


Figure 5.4: Printer Selection

Note: The printer "Setup" button (Figure 5.4) acts on the "Current Printer" (Figure 5.3). To set the desired printer to be the current printer, click the select printer button (Figure 5.3), select the desired printer, then click ok (Figure 5.4). To change the current printer settings, choose select printer (Figure 5.3) then choose Setup from the Printer Setup window (Figure 5.4).

Display G2 Configuration Data: The buttons in this section display information regarding the AFG2 configuration. This information is "read only" and cannot be changed through this interface.

G2 Network Configuration: This displays the network address and other network information for the AFG2. See Figure 5.5.

G2 Setup Parameters: This displays the current setting of the G2. See Figure 5.5.

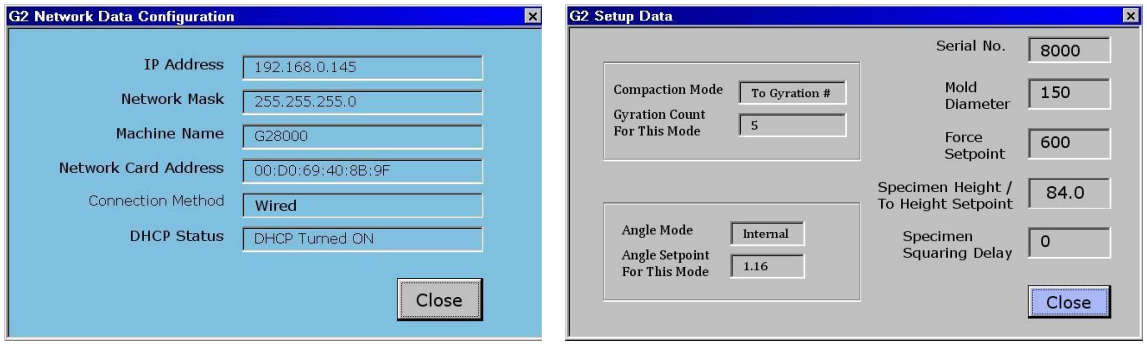


Figure 5.5: AFG2 Setup Parameter Windows

G2 Standardization Report: This window displays the current standardization dates for the G2. See Figure 5.6.

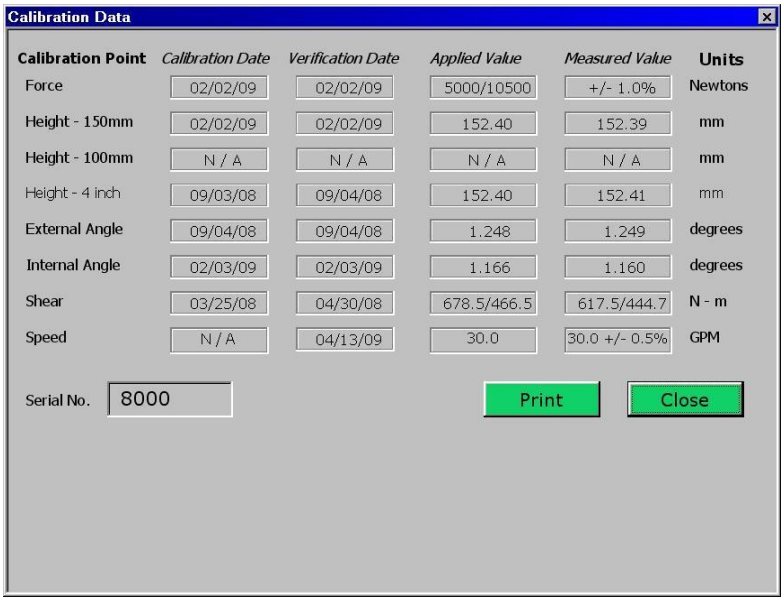


Figure 5.6: AFG2 Standardization Report Window

VI. Standardization

6.1 Definitions

Standardize: a process to bring a measuring instrument or measurement system into conformance to a known standard (i.e.: force, height, angle, etc.).

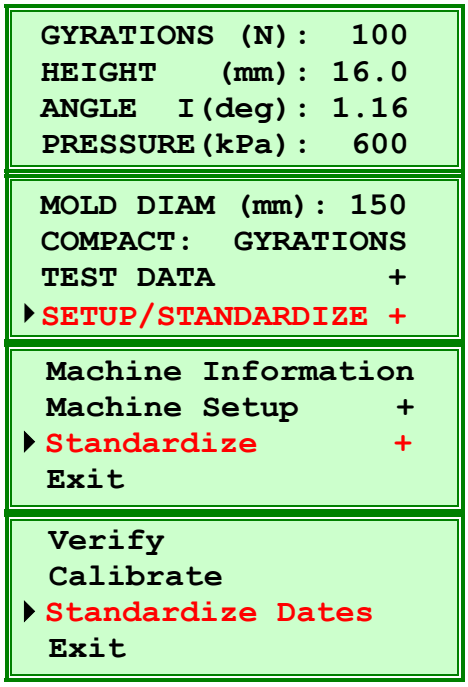
Verify: a process that establishes whether the results of a previously calibrated measurement instrument or measurement system are stable. Verification is used to maintain the traceability of a system and to determine when to recalibrate. If the machine response is in conformance, no correction is required.

Calibrate: a process that establishes the relationship (traceability) between the results of a measurement instrument or measurement system and the corresponding values of a reference standard.

6.2 General

Before attempting to standardize the gyratory compactor, be sure to read and fully understand this procedure as outlined in this section. The compactor should be standardized on a semi-annual basis, more often under severe usage and after the compactor has been transported. If the compactor is not within specifications when verified, it must be re-calibrated.

- To view the date of last standardizations, use the ▶ button to navigate to **STANDARDIZE DATES** then press the ↵ button.



Note: If the compactor passes the verification of the force, height, and angle of gyration, it is properly standardized and does not require calibration.

Be sure to follow all safety precautions, before performing any tests or procedures on the Gyratory Compactor.

The compactor should be turned on and allowed to warm up for approximately 15 minutes prior to calibrating. Room temperature should be 18°C to 25°C. Check that the date and time are correct before starting. The standardization date is stored in memory when this procedure is completed.

The gyratory compactor is programmed with menu driven standardization routines that are reached by selecting **SETUP/STANDARDIZE** from the main menu. The compactor must be parked and the **MACHINE READY** light must be on. Select **STANDARDIZE** then **VERIFY** to initiate routines that confirm the machine parameter accuracy without affecting the machine calibration data. If the compactor is not within the specified limits for a given parameter, select **CALIBRATE** from the sub-menu to initiate the calibration routines.

It is essential for accurate standardization that the compactor is clean and free of debris. It is especially important that the ram foot and the mold top be free of debris when standardizing the specimen height measurement.

SUPERPAVE™ specifications require the speed of gyration to be 30.0 ±0.5 rpm, the consolidation pressure to be 600kPa ±10 kPa, the change in specimen height measurement to be within ±0.1 mm, and the internal angle of gyration to be 1.16° ±0.02° (20.25 ±0.35mrad). Some agencies may specify alternate limits for compaction parameters such as external angle of gyration rather than internal. Check the appropriate specification for the acceptable range for a given parameter.

A precision, digital stopwatch (Pine #RATS90) is used to verify the speed of gyration. Precision gage blocks (Pine #AFG123C) are used to verify the height measurement. The Pine Instrument Company proving ring (Pine #AFGCLR05C), used to verify applied force, is supplied with a certification document which includes a table of dial readings and corresponding applied forces. It also includes ±1% and ±3% readings for the calibration points of the AFG2 compactor. This certificate is stored behind the foam in the proving ring case lid. The AFG2 has an integrated angle measurement system. An external angle measurement jig (Pine #AFG2X01) is used to standardize the external angle of gyration measurement. A simulated-load internal angle measurement instrument capable of providing a tilting moment of 466 N-m, (Pine #AFLS1) Rapid Angle Measurement (RAM), is required for standardizing the internal angle of gyration parameter. The AFLS1 is also used for calibrating the tilting moment (shear) measurement system.

6.2.1 Verification Tools Needed

- AFG2X01 - External Angle Measurement Jig
- RATS90 - Precision Digital Stopwatch
- AFG123C - Precision Gage Blocks
- AFGCLR05C -The Pine Instrument Company Proving Ring
- AFLS1- Rapid Angle Measurement (RAM) (simulated loading)

6.3 Verification

Simple routines for verifying the speed of gyration, ram force, specimen height, and angle of gyration are available within **STANDARDIZE** menus. These routines will ensure the compactor is fully calibrated. Be sure the compactor is clean and at room temperature before starting these procedures. If the compaction chamber is still warm from use, let it cool to room temperature before standardizing. The proving ring used to standardize the ram force is temperature sensitive and must be used at room temperature.

6.3.1 Verify Speed of Gyration

- Using the ▶ button, select **STANDARDIZE** from the menu. Press the ↵ button.
- Select **VERIFY** then press the ↵ button.
- Select **VERIFY SPEED** then press the ↵ button.
- Make sure that the compaction chamber is empty. Press the **START** button to begin verification.
- Check the speed of gyration by using a stop watch.

  The swivel frame will gyrate at 30 rpm while a counter on the control panel display indicates the number of gyrations. Use the stop watch to time the speed. Ten (10) revolutions should take 20 ± 0.33 seconds for 30 ±0.5 gyrations per minute. The display will indicate each complete revolution to aid in timing each gyration. Do not time the first gyration because the acceleration in the first part of rotation will affect the time slightly.
- When finished, press the ↵ button to stop the gyration and park the swivel frame.
- If the speed of gyration is within specification, press the + button. This stores the verification date. If not, press the − button. If the speed of gyration is not within specified parameters, consult the factory.
- Press the ↵ button to return to the main menu.

6.3.2 Verify Force

- Using the ▶ button, select **STANDARDIZE** from the menu.
- Press the ↵ button.
- From the **STANDARDIZE** sub-menu, select **VERIFY** then press the ↵ button.
- Select **VERIFY FORCE** then press the ↵ button. If the mold top is not in position, install the mold top. Make sure the mold top is locked in place with the clamps. (Figure 6.1)

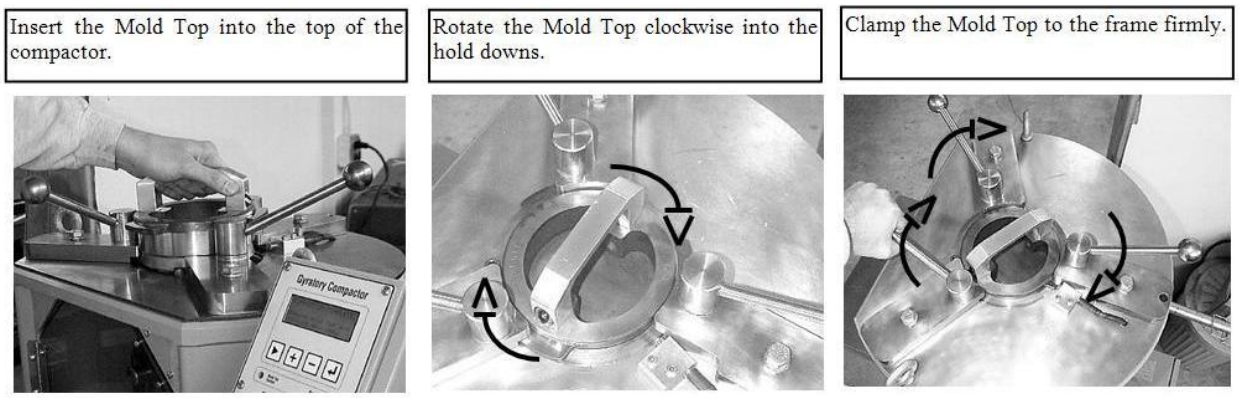


Figure 6.1: Insert the Mold Top

- Open the compaction chamber door, thoroughly clean the ram foot and mold top.
- Close the compaction chamber door and press the **START** button.
- Open the chamber door; place the proving ring on the center of the ram foot. Place the steel plate supplied with the proving ring on the top of the proving ring to protect the mold top. (Figure 6.2)
- Close the door then press the **START** button.
- The compactor will automatically flex the proving ring then retract the ram.

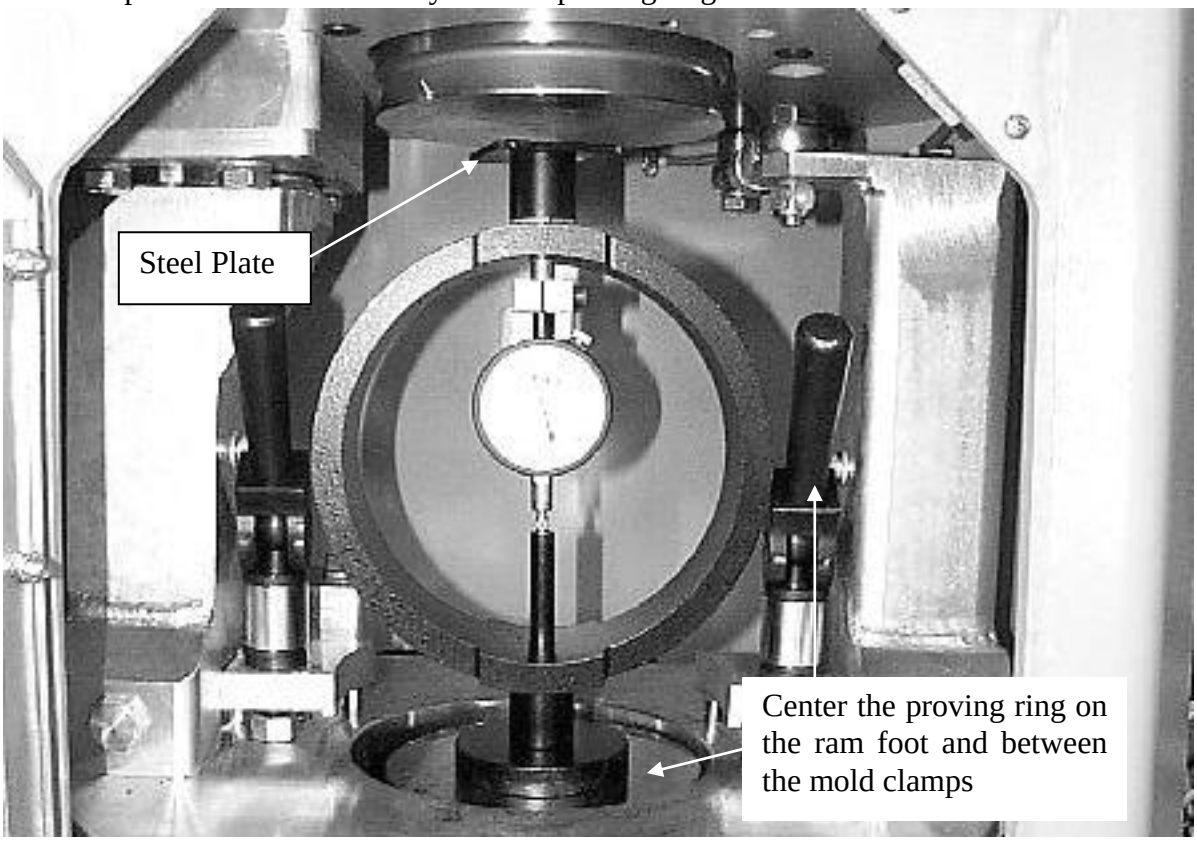


Figure 6.2: Proving Ring Placement

- After the proving ring is flexed and the force released, open the compaction chamber door, zero the dial indicator on the proving ring by rotating the bezel, close the door,

then press the **START** button. The compactor will apply a load of 5,000 Newton to the proving ring.

- Compare the force indicated by the proving ring to the force indicated by the compactor. The proving ring is supplied with a chart of the dial readings at various forces.
- Press the **START** button. The compactor will apply 10,500 Newton the proving ring. Compare this force in the same manner.
- Press the **START** button once more and the ram will park.
- If the measurements are within specifications, press the [+] button key to store the verification date.
- If the force readings exceed ±3%, calibration is required. If the readings exceed ±1%, calibration is recommended. If calibration is required, press the [−] button. When the [−] button is pressed, the control panel will display the option to repeat the verification or to abort the verification routine. Press the [+] button to repeat the verification or press the [−] button to exit the verification routine.
- Remove the proving ring from the compaction chamber then press the [↵] button to exit force verification.
- If the force is not within specification, proceed to section 6.4.2

Note:	**If full verification is select in verification settings, 12 forces spanning the operating range checked. This is not typically needed and is provided as an optional verification feature.**

6.3.3 Verify Height

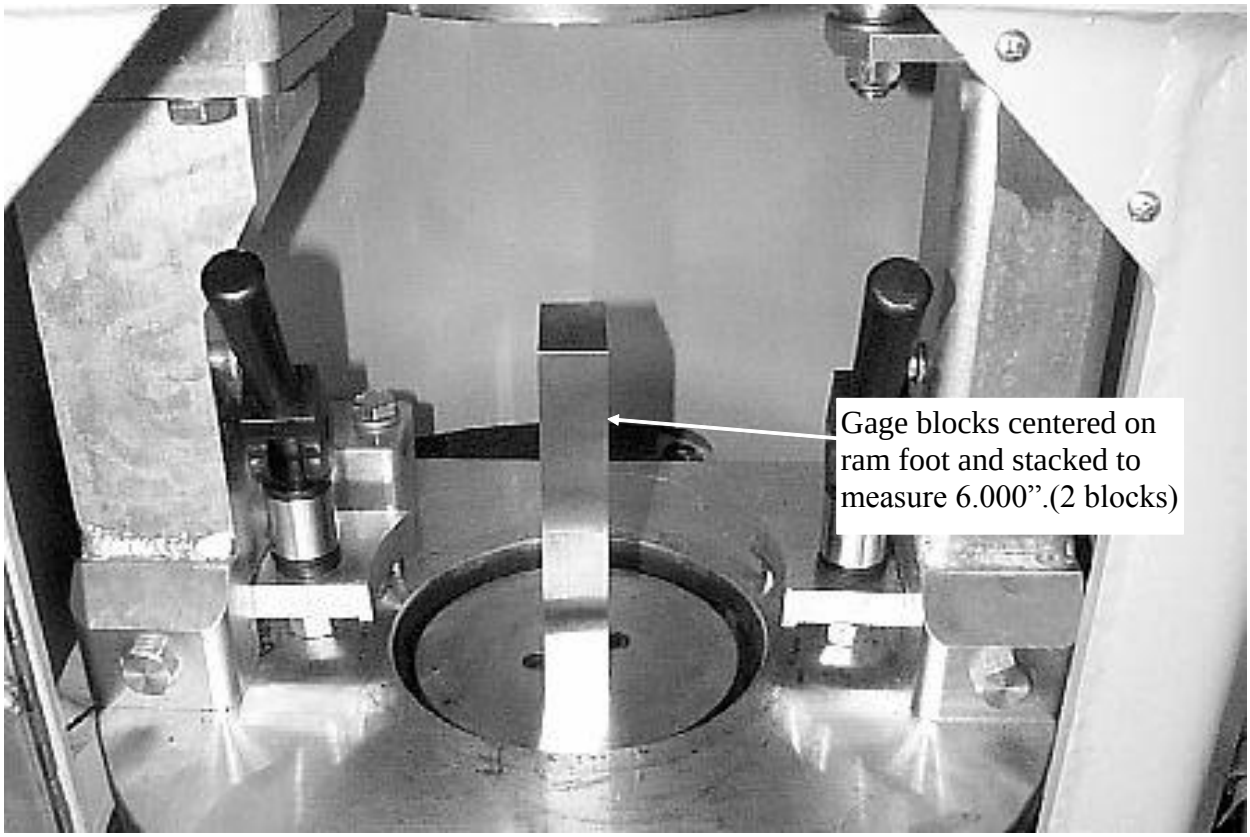


Figure 6.3: Gage Block Placement

- Using the ▶ button, select **STANDARDIZE** from the menu.
- Press the ↵ button.
- From the **STANDARDIZE** sub-menu, select **VERIFY** then press the ↵ button.
- Select **VERIFY HEIGHTS** then press the ↵ button.
- Select the specimen diameter setting which you wish to verify the height measurement (150mm, 100mm, or 4 inch) then press the ↵ button.
- Be sure the proper mold top is in position and locked in place with the clamps (Figure 6.1). Be certain the proper ram foot is installed as well (Figure 6.1).
- Place the gage blocks into the compaction chamber configured for 152.4 mm (6.000 inch). (Figure 6.3)
- Press the **START** button. The compactor will move the ram up to contact the blocks with the mold top. Once contact is made, the control panel display will show the target value 152.4 mm (6.000") and the measured value.
- Compare the target height with the measured height. If the measured height differs from the target by more than ±0.1 mm (±0.004 inch) calibration is required. If the measured height differs from the target height by more than ±0.05 mm (±0.002 inch) calibration is recommended. Be sure that no dirt or debris is affecting the measurement.
- Press the **START** button to continue.

- If the measurement is within specification, press the [+] button to store the verification date. If not, press the [−] button. If the [−] button is pressed, the control panel will display the option to repeat the verification or to abort the verification routine.

Note:	**If the height verification is not within specification, tighten the mold top clamps, clean the mold top and ram foot. Repeat the verification procedure prior to recalibrating.**

- Remove the gage blocks from the compaction chamber.
- If the height is not within specification, proceed to Section 6.4.3.
- Lubricate the ram foot with MoS_2 anti-seize lubricant prior to resuming normal operation. Refer to Section 7.3 for proper lubrication instructions.

Note:	**If only 150mm diameter specimens are compacted, it is unnecessary to standardize the 100mm and 4 inch height measurements.**

Once these routines have been completed, the standardization date will be stored if the compactor is within the specifications. The date of last standardization may be viewed by selecting **SETUP/STANDARDIZE,** then **STANDARDIZE**, then **STANDARDIZE DATES**.

Note:	**If full height verification is select in verification settings, all heights will be checked (10" through 0"). This is not typically needed and is provided as an optional verification feature.**

6.3.4 Verify External Angle of Gyration

An external angle measurement jig (Pine #AFG2X01) is used to verify that angle measurement system is properly calibrated. The jig uses trigonometry to calculate the external angle of gyration from the digital indicator measurements made while the compactor is gyrating. With the indicators configured to TIR mode, the indicator electronics captures the maximum stroke (Total Indicator Run-out) of the indicator. By subtracting the top indicator TIR reading from the bottom indicator reading you get the displacement from the gyration total cone angle. Divide the difference of TIR readings by 2 to obtain half the cone angle (this is the angle of gyration). Divide this half cone displacement by the distance between the indicators (6.000") and take the inverse tangent to get the External Angle of Gyration (Equation 1).

$$\text{External Angle of Gyration} = ArcTan\left[\frac{\frac{(\Delta B'' - \Delta T'')}{2}}{6.000''}\right] \text{ degrees} \qquad \text{Equation 1}$$

$\Delta B''$ = Bottom indicator TIR reading (inches)

ΔT" = Top indicator TIR reading (inches)
6.000" = spacing between indicators (inches)

- Using the ▶ button, select **STANDARDIZE** from the menu. Press the ↵ button.
- Select **VERIFY** then press the ↵ button.
- Mount the external angle measurement instrument to the compactor frame (Figure 6.4).
- Turn the digital indicators on, then clear the reading. Be sure the indicators are set to TIR mode.
- Select **VERIFY ANGLE** then press the ↵ button.
- Select **VERIFY EXTERNAL** then press the ↵ button.
- Enter the number of gyrations and target angle, typically 10 and 1.25°. Make sure that the compaction chamber is empty. Press the **START** button to begin verification.
- After the compactor has completed 5 gyrations clear the reading on both of the digital indicators
- After the compactor has completed several gyrations, the compactor will stop, park the swivel base and display the measured angle of gyration. Enter the TIR readings of the digital indicators into the appropriate display location. Press the ↵ button.
- Compare the angle measurement of the compactor to that of the external angle instrument.
- If the two values compare within ±0.02°, the compactor angle of gyration is within specification. Press the + button to store the verification date. If not, press the − button.
- Press the ↵ button to return to the main menu.

If it is desired to confirm the loaded external angle of gyration, compact a hot mix asphalt specimen whose final height is within specifications while the external angle jig is mounted to the frame. Compare the angle displayed on the compactor with the angle determined by Equation 1.

Figure 6.4: External Angle Verification

6.3.5 Verify Internal Angle of Gyration

The internal angle of gyration output parameter is verified by using a simulated load internal angle measurement instrument such as the Pine Instrument Company AFLS1 Rapid Angle Measurement (RAM) Instrument. The RAM should be operated at 600kPa with the standard 22mm eccentric creating a total tilting moment of 466 N-m. Be sure the external angle of gyration is properly standardized before performing this procedure. The mold, mold base, ram foot and mold top must be clean and in good repair to perform an internal angle measurement.

Verify the internal angle offset value is correct by performing a standard internal angle measurement with the simulated loading device. Follow the instructions for operating the AFLS1 instrument while performing this procedure. Be sure the compactor is programmed to operate at a specified internal angle and set the magnitude to the desired internal angle such as 1.16°. See Section 4.1.4 for instructions to configure the SGC to operate at an internal angle of gyration.

Perform the internal angle measurement which is typically three (3) top and three (3) bottom angle measurements with the RAM. The effective angle of gyration is the average of the six (6) RAM measurements. The SGC reported internal angle should match the RAM effective internal angle within ±0.02°. If the internal angle of gyration as reported by the compactor does

not match the indicated internal angle of gyration as reported by the RAM instrument within ±0.02°, the offset parameter may need calibrated.

6.3.6 Verify Gyratory Shear (if equipped)

For compactors with shear instrumentation (AFG2AS/AFG2CS), the gyratory shear measurement system is verified by using a simulated loading device such as the Pine Instrument Company AFLS1 Rapid Angle Measurement (RAM) Instrument. The AFLS1 loading device is operated at 600kPa with the standard 22mm eccentric ring creating a total tilting moment of 466 N-m and a 32mm eccentric ring creating a tilting moment of 678 N-m. The 22mm eccentric loading ring is built into the AFLS1 device and is the tilting moment typically used to measure the internal angle of gyration. The 678 N-m tilting moment is achieved with the AFLS1 device by installing the two 32mm eccentric loading rings onto the AFLS1. Be sure to orient the rings with the taper away from the RAM body (toward the wear plates). See the AFLS1 Operator Manual for details on how to install the eccentric rings. The 32mm eccentric ring has a diameter of 64mm at the loading point.

Be sure the force, height, and angle of gyration are properly standardized before verifying shear. The mold, mold base, ram foot and mold top must be clean, properly lubricated, and in good repair. When verifying shear, the 678 N-m tilting moment (32mm eccentric rings installed) is applied first, then the 466 N-m tilting moment (22mm eccentric, no rings) is applied.

- Prepare the AFLS1 by installing the 32mm eccentric load rings.
- Insert a clean mold into the compaction chamber and clamp it into position.
- Using the ▶ button, select **SETUP/STANDARDIZE** from the menu. Press the ↵ button.
- Select **STANDARDIZE** then select **VERIFY** from the submenu. Press the ↵ button.
- Select **VERIFY SHEAR** then press the ↵ button.
- Check that the eccentric size set on the AFG2 matches the loading device (i.e.: 32mm).
- Raise the compactor ram up (RAM UP) then insert the simulated loading device into the mold. Lower the compactor ram by pressing RAM DOWN, then install the mold top.
- Press the **START.** The machine will operate for 25 gyrations.
- When the compactor stops, confirm the machine measurement displayed on the compactor is within the required limits for the simulated load applied to the machine by the device.
- Repeat for the second simulated load (i.e.: 466 N-m with a 22mm eccentric).

Note:	Ram foot lubrication is extremely critical when calibrating and verifying the shear measurement system. Excess or lack of lubrication may cause changes in the frictional forces resulting in an inaccurate readings.

6.4 Calibration

Routines for calibrating the ram force, specimen height, and angle of gyration are available in the standardize menu. Be sure the compactor is clean and at room temperature before starting this procedure. If the compaction chamber is still warm from use, let it cool to

room temperature before calibrating the compactor. The proving ring used to standardize the ram force is temperature sensitive and must be used at room temperature.

SUPERPAVE™ specifications require the speed of gyration to be 30.0 ±0.5 rpm, the consolidation pressure to be within 600 kPa ±10 kPa, the change in specimen height measurement to be within ±0.1 mm, and the angle of gyration to be 1.250 ±0.020 (21.82 ±0.35mrad) loaded.

6.4.1 Calibrate Angle Sensors

Three (3) LVDT angle sensors are used to measure the external angle of gyration and typically do not require periodic standardization for displacement. If the external angle measurement is correct, the angle sensors are functioning properly and do not require service. This procedure is required when an LVDT or the LVDT signal conditioner electronics is replaced. A special micrometer-head fixture (Pine #ACG2T03) is required for this procedure.

Each LVDT is held in position by two (2) set screws. The LVDT must be removed from its mount to standardize the displacement. The three (3) LVDT sensors should be removed one at a time to avoid mounting in an incorrect position.

Note:	**This procedure should only be completed by a properly trained service technician and is not part of the routine service and calibration of the compactor. The swivel frame must be properly aligned and in the park position prior to performing angle sensor calibration.**

6.4.1.1 CALIBRATE ANGLE SENSOR STROKE

Enter sensor calibration: SETUP/STANDARDIZE/MACHINE SETUP/ADVANCED SETUP/SWIVEL FRAME SETUP/ANGLE SENSOR SETUP/CALIBRATE SENSOR

The screens will step through the following:

- Clamp micrometer head fixture ACG2T03 to frame near LVDT access cutout. Be sure the micrometer head is set to metric (mm).
- Select **FRONT LVDT** (**RIGHT, LEFT**). Follow the steps as outlined on the screens.
- Remove the appropriate LVDT from frame and place into micrometer head jig. The LVDT is still wired to the electronics.
- Set the digital micrometer head at mid-stroke plus approximately 5 mm, (approximately 0.7" on the mechanical scale), and the LVDT (extended) should be just touching the micrometer anvil. Clamp the LVDT to the fixture.
- Connect the digital volt meter (DVM) to ground and tp9 (front) on the AB01G2SC Signal Conditioner Board. (tp11: right, tp13: left)
- Use micrometer head to set the LVDT output as measured by the DVM to 0.0±0.002 vdc. This is the LVDT null position (mid-stroke).
- Zero the digital micrometer head readout (press zero).
- Use the [+] and [−] keys adjust the zero DAC count until the G2 display voltage reading is 0.00 ±0.02 vdc (zero offset). Press the [↵] button to set the zero offset. Record the DAC setting.
- Move the micrometer head anvil to +4.000mm (LVDT extended, micrometer anvil retracted). Use the [+] and [−] keys to adjust gain DAC counts until volts to 7.800

±0.02 vdc is reached on the G2 display (not DVM). Press the ↵ button to set the gain. Record the DAC setting.

- Verify null (zero) reading by returning the micrometer to 0.000 (go beyond position then approach from the same direction). Press the ↵ button to store the reading.
- Repeat offset and gain adjustment until the DAC does not change by more than 2 counts. The LVDT channel is now set (4mm/7.8volt = 0.513mm/v).
- Move the micrometer head anvil until the LVDT is extended (+4.000 mm). Press the ↵ button to store the reading. This stores the LVDT output voltage at +4.000 mm.
- Move the micrometer head anvil until the LVDT is at mid-stroke (0.000 mm). Press the ↵ button to store the reading. This stores the LVDT output voltage at 0.000 mm.
- Move the micrometer head anvil until the LVDT is retracted (-4.000 mm). Press the ↵ button to store the reading. This stores the LVDT output voltage at -4.000 mm.
- Move micrometer head to +5.000mm. Compare the LVDT angle sensor reading throughout the travel range (+5.0 mm, 0.0, -5.0 mm) (extended(+), null, retracted(-)). The LVDT reading (G2 display) should correspond to the micrometer-head reading within 0.025mm throughout the range. The LVDT stroke is now standardized.
- **Lubricate the LVDT tip** with NLGI Grade 2 grease then install the sensor at the proper frame location (i.e.: front, right, left).
- Position each LVDT so that it reads +0.80 ±0.1 mm (extended from mid-stroke) with the swivel frame in the zero position established in step. The operator display will indicate when the LVDT is in range. Be sure each sensor is installed in the correct location (left, front, right). Do not over-tighten the two set screws that hold the LVDT in position.

6.4.1.2 REPEAT FOR EACH SENSOR (FRONT, RIGHT, LEFT).

The swivel frame park position is defined by the left and right angle sensor. The LVDT readings for the park position is saved after each LVDT is positioned.

6.4.2 Calibrate Force

- Using the ▶ button, select **SETUP/STANDARDIZE**. Press the ↵ button.
- Select **STANDARDIZE,** press the ↵ button.
- Select **CALIBRATE,** press the ↵ button.
- Select **CALIBRATE FORCE/HT,** press the ↵ button.
- Select **CAL FORCE & HEIGHT,** press the ↵ button.
- If the mold top is not in position, install the mold top. Make sure the mold top is locked in place with the top clamps. (Figure 6.1)
- Press the **START** button.
- Open the compaction chamber door, be sure of the ram foot and mold top surfaces are clean.
- Place the proving ring on the center of the ram foot. Place the steel plate supplied with the proving ring on the top of the proving ring to protect the mold top. (Figure 5.2)
- Close the door, and press the **START** button.

- Use the **RAM UP** button to apply 18,000 Newton to the proving ring. The [+] and [−] buttons on the compactor control panel are used to select the ram speed and may be used while the ram is stopped or in motion The proving ring is supplied with a chart of the showing the dial reading at various forces.
- With 18,000 Newton applied to the proving ring, press the **START** button. The compactor will automatically retract the ram.
- Zero the dial on the proving ring by rotating the bezel, the dial on the proving ring should be lightly tapped to achieve an accurate zero reading. Close the door and press the **START** button. The control panel will display a target value.
- Using the **RAM UP** button, load the proving ring to the target value displayed on the control panel.

  Note: Always approach the target value from a lower value. Use the [+] and [−] buttons on the compactor control panel to select the ram speed. These buttons may be used while the ram is stopped or in motion. The control panel display will show the selected ram speed. 400 is recommended for getting the force applied to the proving ring close to the target value. Once the force applied to the proving ring is near the target value, the ram speed must be lowered to 32 using the [−] button. If the proving ring is loaded beyond the target value, use the **RAM DOWN** button to decrease the force applied to proving ring below the target value. After the force applied to the proving ring is significantly lower than the target value (i.e. at least ½ rotation of the large dial on the proving ring), use the **RAM UP** button to apply the target force.
- Press the [↵] button to store the data when the proving ring is at the target force. The control panel will display the next target value.
- Repeat the same loading procedure until 18,000 Newton applied force is reached. Once the force data is entered for 18,000 Newton, the control panel display will indicate "calibration table is complete."
- The control panel will display the options to verify the force or to re-calibrate the force. Press the [+] button to verify the force. If a mistake was made during the calibration, press the [−] button and repeat the force calibration procedure.
- Open the compaction chamber door then zero the dial on the proving ring.
- Leave the proving ring in the compaction chamber and close the door. Press the **START** button. The compactor will apply the first target force to the proving ring.
- Compare the force indicated by the proving ring to the force indicated by the compactor control display. If a force error exceeds ±3%, calibration is required. If an error exceeds ±1%, calibration is recommended.
- Press the **START** button. The compactor will apply the next target force to the proving ring.
- Compare this force also.
- Repeat for all of the target forces.
- If the measurements are within acceptable limits, press the [+] button. If the measurements were not within acceptable limits, press the [−] button and repeat the force calibration.

- Remove the proving ring from the compaction chamber and press the ↵ button to begin height calibration. When the force is calibrated, the height must be calibrated also (Section 6.4.3).

6.4.3 Calibrate 150mm Specimen Height

To calibrate the height measurement, select calibrate height from the calibrate sub-menu, then press the ↵ button. If continuing from the calibrate force routine, simply continue with this section.

- Be sure the 150mm ram foot and 150mm mold top are installed and the surfaces are clean. Place the gage blocks into the compaction chamber oriented for 10.000 inches (Figure 6.5).
- Press the **START** button. The ram will move up to contact the blocks with the mold top. Once contact is made, the compactor will automatically apply forces to the gage blocks, store the calibration data, then remove pressure from the gage blocks.
- Reduce the height of gage blocks in the compaction chamber by 1 inch to 9 inches then press the **START** button.
- Repeat this procedure for 8, 7, 6, 5, 4, 3, 2, 1, and 0 inches (no blocks). The compactor will repeat the same routine to calibrate each position.
- Once the height calibration is complete, press the + button to begin height verification. If a mistake was made during height calibration, press the − button to repeat the height calibration procedure.
- To verify the height measurement, place 10 inch gage blocks in the compaction chamber then press the **START** button. The compactor will move the ram up to contact the blocks with the mold top. Once contact is made, the control panel display will show the target value of 254.00mm (10.000") and the measured value.
- Compare target value to the measured value. If the measured height differs from the target by more than ±0.1 mm (±0.004 inches), calibration is required. If the measured height differs from the target height by more than ±0.05 mm (±0.002 inch) calibration is recommended. Be sure that no dirt or debris is affecting the measurement.
- Press the **START** button to continue. The compactor will retract the ram and pause allowing the operator to configure the blocks for the next target height. The control panel will display the next height to be verified.
- Repeat the verification procedure for 9 through 0 inch (no blocks) heights. Reference Figure 6.5 for proper gage block orientation.
- If the verification for the force and height were within specifications, press the + button to store the calibration data. If the verification for the force and height were not within specifications, press the − button to reject the calibration data.

> **Note:** Pressing the − button at this point in the procedure will cause the calibration data recorded in this routine to be discarded (i.e.: the compactor will revert to the original calibration data).

- Press the ↵ button to return to the main menu.

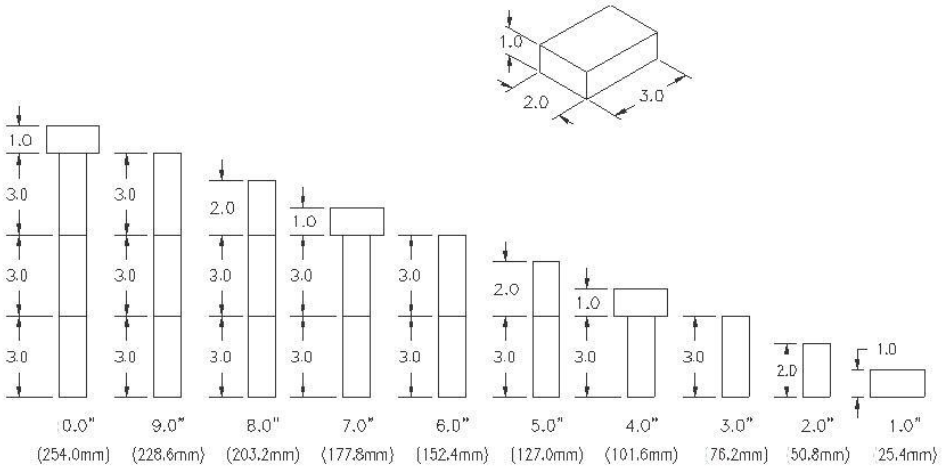


Figure 6.5: Gage Block Orientation

6.4.4 Calibrate 100mm and 4 Inch Specimen Heights

If the 100mm or 4 Inch capability is not utilized, it is not necessary to standardize the height measurement for the unused size(s). Follow these steps only if the 100mm, 4 inch, or both alternate specimen sizes are to be utilized.

- Using the ▶ button, select **SETUP/STANDARDIZE,** press the ↵ button.
- Select **STANDARDIZE,** press the ↵ button.
- Select **CALIBRATE,** press the ↵ button.
- Select **CALIBRATE FORCE/HT,** press the ↵ button.
- Select **CAL HEIGHTS,** press the ↵ button.
- Select **CAL HEIGHT 100MM (OR CAL HEIGHT 4 INCH),** press the ↵ button.
- Be sure the correct mold top (100mm or 4 Inch) is in position and locked in place with the top clamps (Figure 6.1). Make sure the 100mm ram foot is installed (Figure 6.1). The 100mm ram foot is used for both the 100mm and 4 inch specimen sizes.
- Open the compaction chamber door, be sure of the ram foot and mold top surfaces are clean. Place the gage blocks on the ram foot oriented for 6.000 inch. (Figure 6.5)
- Press the **START** button. The ram will apply pressure to the gage blocks, then return to the park position.
- Press the + to begin height verification (or − to abort).
- Confirm the 6.000" blocks are correctly installed.
- Press the **START** button. The ram will apply pressure to the gage blocks.
- Compare target value to the measured value. The measured height should be 152.4 ±0.1 mm (6.000 ±0.004 inches).
- Press **START** to continue.
- If the measured height was within tolerance, press + to accept the calibration.
- If the height is not within specification, press − then repeat the calibration. Be certain no dirt or debris is affecting the measurement.

- Press the **RAM DOWN** button to retract the ram.
- Press the ↵ to complete the height calibration.

6.4.5 Calibrate Angle of Gyration

SUPERPAVE™ specifications require the internal angle of gyration be 1.16° ±0.02° (20.25 ±0.35mrad) during compaction. Some agencies may require the angle of gyration to be set as an external angle of gyration of 1.25°±0.02°. The AFG2 compactor can be operated in either mode and is easily switched from internal to external angle of gyration.

The AFG2 gyratory compactor utilizes two gyration actuators, one on the left and one on the right, to induce the angle of gyration. The angle of gyration is measured by three integrated position sensors mounted to the lower frame. The angle of gyration is displayed and recorded during normal operation of the compactor. The angle of gyration is user selectable from 0.50°-1.50° on the AFG2 Gyratory Compactor.

6.4.5.1 External Angle of Gyration Standardization

- Using the ▶ button, select **SETUP/STANDARDIZE**. Press the ↵ button.
- Select **STANDARDIZE,** press the ↵ button. Select **CALIBRATE,** press the ↵ button.
- Select **CALIBRATE ANGLE,** press the ↵ button. Select **CAL EXTERNAL ANGLE,** press the ↵ button.
- Select the desired external angle calibration settings, typically 10 gyrations and 1.25°.
- Mount the digital angle measurement instrument to the left side of the compactor.
- Turn the digital indicators on, then clear the reading. Be sure the indicators are set to TIR mode.
- Press the **START** button
- Clear both of the digital indicators readings, after the compactor has completed 5 gyrations.
- When the compactor stops, enter the top digital indicator reading and the bottom indicator reading into the compactor display using the + and − buttons. Use the ▶ button to select which indicator reading to be entered.
- The controls will step through repeating the measurement three times (#1, #2, #3).
- When three runs are complete, select Verify/Save, press the ↵ button.
- Confirm the settings, 10 gyrations and 1.25°.
- Press the **START** button to begin the verification run.
- Clear both of the digital indicators, after the compactor has completed 5 gyrations.
- The compactor will gyrate for 10 gyrations then stop.
- When the compactor stops, enter the indicator TIR readings into the compactor display. Press the ↵ button to calculate the jig angle.
- Compare the compactor external angle to the external jig angle value. If the two values are within ±0.02°, select Exit/Save then press the ↵ button to save the data. Select Cancel then press the ↵ button to reject the calibration data.
- Remove the digital indicator jig from the compactor frame.

6.4.5.2 INTERNAL ANGLE OF GYRATION STANDARDIZATION

The internal angle of gyration offset parameter is determined by using a simulated load internal angle measurement instrument such as the Pine Instrument Company AFLS1 Rapid Angle Measurement (RAM) Instrument. If the internal angle of gyration as reported by the compactor does not match the indicated internal angle of gyration as reported by the AFLS1 instrument within ±0.02°, the internal angle should be calibrated.

Follow the instructions for operating AFLS1 instrument while performing internal angle standardization.

- Using the ▶ button, select **SETUP/STANDARDIZE**. Press the ↵ button.
- Select **STANDARDIZE,** press the ↵ button. Select **CALIBRATE,** press the ↵ button.
- Select **CALIBRATE ANGLE,** press the ↵ button. Select **CAL INTERNAL ANGLE,** press the ↵ button.
- Using a clean mold and base plate, prepare to make a top internal angle measurement with the AFLS1.
- Press the **START** button. When the compactor stops, remove the AFLS1 from the mold and enter the top internal angle as measured by the AFLS1 into the SGC display.
- Repeat the top measurement and enter the subsequent internal angle measurements into the SGC display.
- Prepare the AFLS1 for a bottom internal angle measurement.
- Measure the bottom angle three (3) times and enter the result as in the top angle measurement.
- Press the ↵ button to store the internal angle offset value.
- Verify that the internal angle offset value is correct by performing a standard internal angle measurement with the simulated loading device. Set the compactor operate at an internal angle and set the magnitude to the desired internal angle (i.e.: 1.16°).
- Perform the angle measurement, typically three (3) top and three (3) bottom angle measurements. The effective angle of gyration is the average of the six (6) measurements. The SGC internal angle should match the AFLS1 effective internal angle within ±0.02°.
- It is also useful to compare the average top angle to the average bottom angle. These angles should be within 0.08°. If it is not, check for ram foot wear.

$$Top_{average} = \frac{Top1 + Top2 + Top3}{3} \qquad \text{Equation 2}$$

$$Bottom_{average} = \frac{Bottom1 + Bottom2 + Bottom3}{3} \qquad \text{Equation 3}$$

$$Effective_{internal} = \frac{Top_{average} + Bottom_{average}}{2} \qquad \text{Equation 4}$$

6.4.6 Calibrate Gyratory Shear (if equipped)

For compactors with shear instrumentation (AFG2AS/AFG2CS), the gyratory shear measurement system is standardized using a simulated loading device (AFLS1 Rapid Angle Measurement (RAM) unit) utilizing the 22mm eccentric (44mm diameter: 466N-m) and 32mm eccentric (64mm diameter: 678N-m) simulated loading rings. Alternate calibration moments are possible.

Note:	Proper ram foot lubrication is extremely critical when calibrating the shear measurement system. Excess or lack of lubrication may cause changes in the frictional forces resulting in an inaccurate calibration.

- Select **SHEAR CALIBRATION** from the **STANDARDIZATION** menu tree. Use a clean 150 mm diameter mold and a properly lubricated AFLS1. Be sure the ram foot is properly lubricated as well.
- Run the AFLS1 (RAM) with the 22 mm eccentric rings (44mm diameter, built-in) as prompted (25 gyrations). The R.A.M. may be positioned to measure either the top or bottom angle.
- Install the 32 mm eccentric rings (64mm diameter).
- Run the RAM with the 32 mm eccentric rings 25 gyrations per menu instructions.
- Run the verification routine to confirm the machine is providing the proper output.
- Confirm the readings are within the desired limits.
- Press the [+] key if the readings are correct or use the [−] key to redo. Press the [↵] button to save the calibration data.

The shear measurement system can also be evaluated by running a normal test using a simulated loading device with angle measurement capability, such as when measuring the internal angle of gyration. Typical test would be run utilizing a 22mm eccentric(44mm diameter ring), 600kPa, 150mm specimen, 25 gyration. The tilting moment in such configuration is 466N-m. (2 * 10602N * 0.022m)

6.5 Standardization Worksheet

The standardization worksheet, located in Appendix A, is designed to ensure that all measurements are within the listed specifications. The format of the worksheet follows the verification procedure outlined in Section 6.3. The date and responsible technician signature should be recorded as well. Following the standardization worksheet and verifying that the force, height, and angle of gyration will ensure that the AFG2 Gyratory Compactor is properly standardized.

6.5.1 Initialize the Worksheet

To use the standardization worksheet, the technician should first record the serial number of the compactor, the date, technician's name, the proving ring serial number, the date that the proving ring was calibrated, and the ±1% proving ring readings for 5000N and 10500N. The proving ring calibration date and ±1% proving ring readings may be obtained from the proving ring calibration certification sheet located behind the foam padding of the case lid.

6.5.2 Speed of gyration

The speed of gyration can be verified using the procedure outlined in Section Verify Speed of Gyration. Measure and record the speed of gyration. Confirm this measurement is within the specifications listed in Section 6.3.1.

6.5.3 Force and Height

Follow the procedure outlined in Sections 6.3.2 and 6.3.3 for verifying ram force and specimen height measurement. Record both force and height measurements for each specimen diameter on the standardization worksheet.

If only 150mm diameter specimens are compacted, it is unnecessary to standardize the 100mm and 4 inch height measurements.

6.5.4 External Angle of Gyration

Verify the external angle of gyration using the procedure outlined in Section 6.3.4. Measure and record the dial indicator TIR readings for the top and bottom measurements.

$$\text{External Angle of Gyration} = ArcTan\left[\frac{\frac{(\Delta B'' - \Delta T'')}{2}}{6.000''}\right] \text{ degrees} \qquad \text{Equation 1}$$

Use Equation 1 to calculate the external angle of gyration. The digital indicator measurements can be entered on the display to calculate the angle. Record the indicator readings, the calculated angle, and the angle of gyration displayed on the control panel.

6.5.5 Internal Angle of Gyration

Verify the internal loaded angle of gyration measurement using the procedure outlined in section 6.4.5.24. If the specifying agency does not require the internal angle of gyration be measured, this step is still suggested as a way to monitor the performance of key components.

6.5.6 Worksheet

Complete the standardization worksheet (Appendix A). If any of the parameters; speed of gyration, ram force, specimen height, or angles of gyration, do not meet the specifications listed in this manual or any applicable agency specifications, calibration is required.

VII. Maintenance

7.1 Cleaning

It is important to keep the gyratory compactor clean. Dirt and debris that result from the compaction process may affect results or damage the SGC if not removed prior to starting additional tests.

Use a rag moistened with a cleaning solvent to clean the surfaces in the compaction chamber (mineral spirits or lacquer thinner work well). All surfaces should be kept free of debris including the ram foot. It is especially important to keep the swivel-frame surface, mold top plate, mold bottom flange, and all mold and mold top clamp surfaces free of debris and lubricants. Use mineral spirits or lacquer thinner to remove any excess asphalt that may be present.

Note: **It is extremely important to keep the mold bottom flange, ram foot, mold top, mold top clamps, mold clamps, and the swivel frame surfaces clean and free of debris. Failing to keep these items clean may result in erroneous compaction results. WD-40 has proven to be effective for cleaning the gyratory compactor and molds.**

However, the swivel frame surface should be dry and free of any lubricants during operation. If WD-40 is used to clean the swivel frame, all residue should be removed prior to operation.

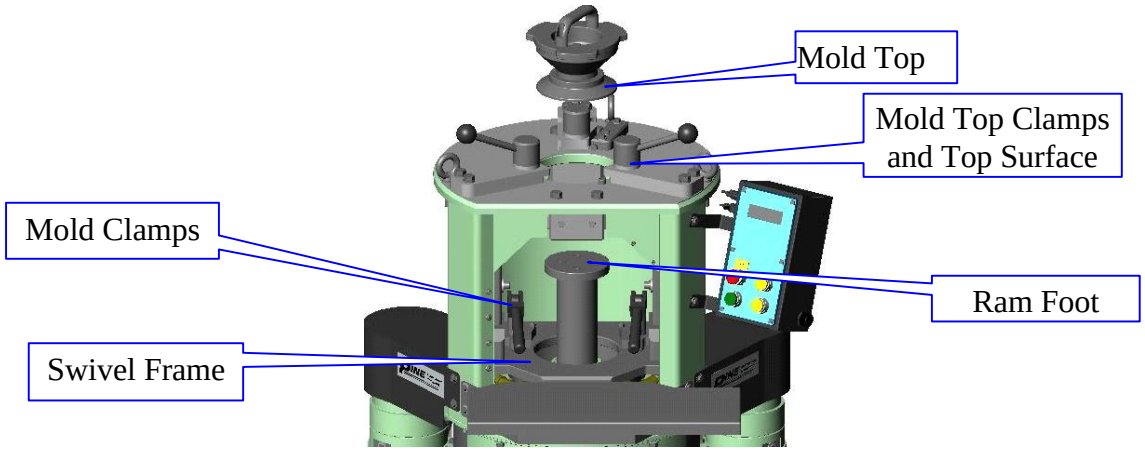


Figure 7.1: Cleaning Diagram

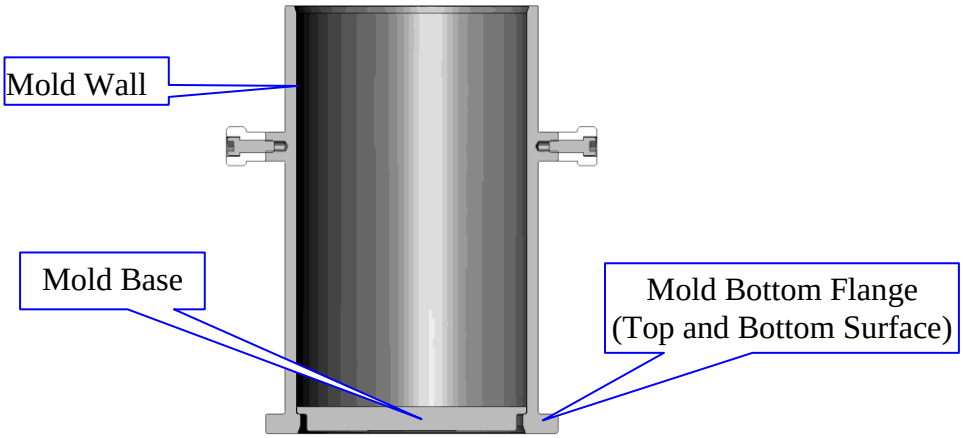


Figure 7.2: Cleaning Diagram-Mold

Note:	Do not use the NCAT Ignition Oven or similar asphalt content apparatus to clean an SGC mold. The high heat of these devices will cause the mold to distort and become unusable.

7.2 Maintenance Schedule

Table 7.1 is a guideline for periodic maintenance. Most items should be inspected after the initial 5 hours of operation and adjusted accordingly.

Table 7.1: Periodic Maintenance

Component	**Daily**	**25 hr.**	annually
		Intervals	or **every** 100 **hr.**
Clean Compaction Chamber	X		
Clean Mold Top	X		
Inspect Ram Key			X
Check Mold Base Clamps		X	X
Timing Belt Tension		X	X
Inspect Mold Clamps		X	X
Inspect Ram Foot for wear			X

7.2.1 Battery

The gyratory compactor contains a battery with a 10 year life so no periodic replacement is required. If battery power is lost, date and time will be reset but no data or calibration parameters will be lost. Should replacement become necessary, a replacement module is available directly from Pine Instrument part number EAN7200RTC.

7.3 Lubrication

Table 7.2 is a schedule of the recommended lubrication intervals in machine run hours. Machine hours are accumulate when the compactor is running and can be viewed in the machine information menu.

Table 7.2: Lubrication Schedule

Component	**Daily**	**annually.**	**5 years**
		or every 100 hr.	**every 500 hr.**
Ram Foot	A		
Ball Screw Bearings		B	
Ball Screw			B
Actuator Bearings		B	
Mold Clamp Pivot			A
Mold Top Clamps			A

Type of Lubricant: A...Anti-Seize Lubricant (Pine P/N: CLGSMOS2T)
B...Grease (NLGI Grade 2 Lithium Soap Grease) (Pine P/N: CLGMOS2)

7.3.1 Ram Foot

The ram foot surface should be lubricated on a daily basis and after standardization of the force and height. Clean the surfaces of the ram foot with WD-40 then apply a VERY THIN coating of anti-seize lubricant (CLGSMOS2T) to the surface in a ring from the mounting screws to the outside edge (Figure 7.3) Failing to properly lubricate this surface will result in premature wear of the ram foot.

Grinding noises emanating from the ram foot area during compaction is indicative of improper lubrication. Cleaning the foot and reapplying a thin coat of lubricant typically corrects this problem. Applying excess lubricant can cause debris to be picked up on the mold base. Be sure to clean the bottom of the mold and base plate regularly to prevent damage from aggregate particles.

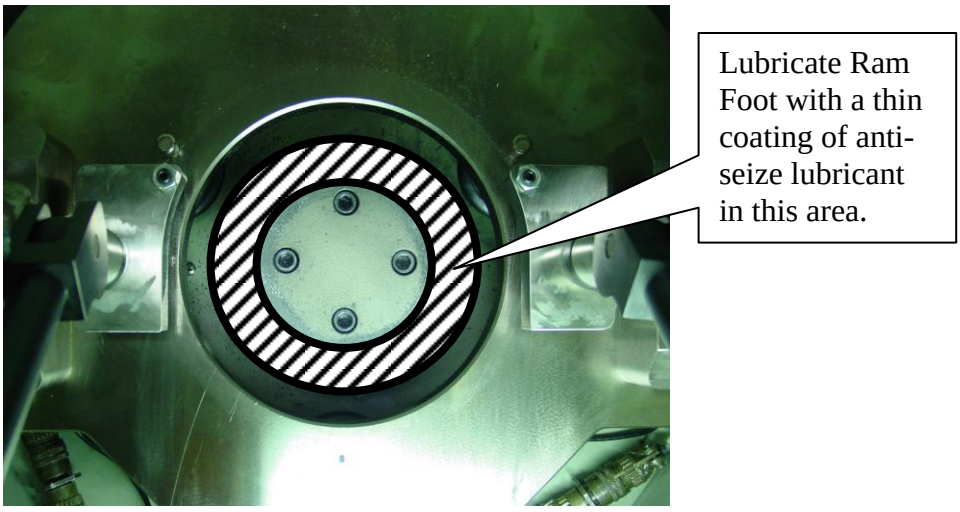


Figure 7.3: Ram Foot Lubrication

7.3.2 Ball Screw Bearings:

Remove the lower frame lower-left access panel. Apply 2-3 pumps from the grease gun to the single grease fitting.

7.3.3 Ball Screw:

Fully extend the ram. Remove the lower frame upper-left access panel and the lower frame front access panel. Loosen the bellows clamp on the upper end of the protective bellows to provide access to the ball screw. Apply the grease directly to the ball screw. A single grease bead approximately 6" long is adequate. Replace bellows clamp.

7.3.4 Actuator Bearings:

Remove the left and right covers. There are two grease fittings on each actuator. Two to three pumps of the grease gun is adequate.

7.3.5 Mold Clamp Pivot (compaction chamber clamps)

Remove the pivot screw from the swivel frame and clean thoroughly. Apply anti-seize lubricant to the pivot screw and reinstall.

7.3.6 Mold Top Clamps (upper clamps)

The mold top clamps should be lubricated periodically (every 500 run hours) and the hold down fingers cleaned daily. To lubricate the clamps, simply unscrew the clamp handles from the frame then clean and lubricate the clamp threads and thrust washer faces.

Note:	**Each top clamp has two (2) brass thrust washers and one (1) stainless thrust washer. The stainless steel washers are different sizes and are used to adjust the stop position of the clamp. Make sure to reinstall the clamp handles and thrust washers in the same position from which they were removed. Over time, the brass bushings may wear and need to be replaced.**

7.4 Replacement Parts

Part Number	Description
ACG1R11	Ram Key
ACGCR011PP	150mm Ram Foot
ACGCR011SPP	100mm Ram Foot
ACG2R25	150mm Mold Top
ACG2R28	100mm Mold Top
ACG2R29	4 Inch Mold Top
AFG1M15	150mm Mold Assembly
AFG1M10	100mm Mold Assembly
AFG2M4	4 Inch (101.6mm) Mold Assembly
EAN7200RTC	Battery Module w/ Clock (10 year expected life)

7.5 Ram Drive

7.5.1 Ram key

The ram key should be inspected periodically for wear. The key is an oil-impregnated bronze on which some light scoring is to be expected. If the key is worn, rotate the key to use

the unworn end. The key has two wear surfaces available. Calibration of the machine is not required when the ram key is removed and re-installed.

To inspect the key, disconnect power and remove the right side access panel directly beside the right actuator. With a 7/16" wrench, loosen the screws holding the key in position. Remove the key. The ram may tend to rotate without the key installed. Inspect the key for wear and replace if required. Be sure the key is fully seated into the ram keyway before tightening the screws. Re-install the access panel and reconnect power.

7.5.2 Ram Drive Belt

The ram drive belt tension should be checked every 500 run hours. To check the timing belt tension, remove power from the machine and remove the belt guard on the bottom of the machine. The belt should have between ¼" and ½" of movement for proper tension. To tighten the belt, loosen the screws that mount the ram drive assembly and slide the ram drive assembly to tighten the belt. Be sure to keep the pulleys aligned. Do not over tighten the belt. Re-tighten the screws and re-check the ram drive belt for proper tension.

7.6 Mold Clamp Adjustment

The mold clamps should be inspected periodically. These clamps must function properly to achieve correct compaction results. When the clamps are firmly clamped to the mold flange, the mold clamp handles should be at the position shown in Figure 7.4a and Figure 7.4c. If the clamp handles are not at this position when firmly clamped, the mold may not stay in the locked position during compaction. This adjustment requires two ¾" combination wrenches, a 7/16" combination wrench, and a 1/8" hex wrench. The following instructions apply to both left and right mold clamps.

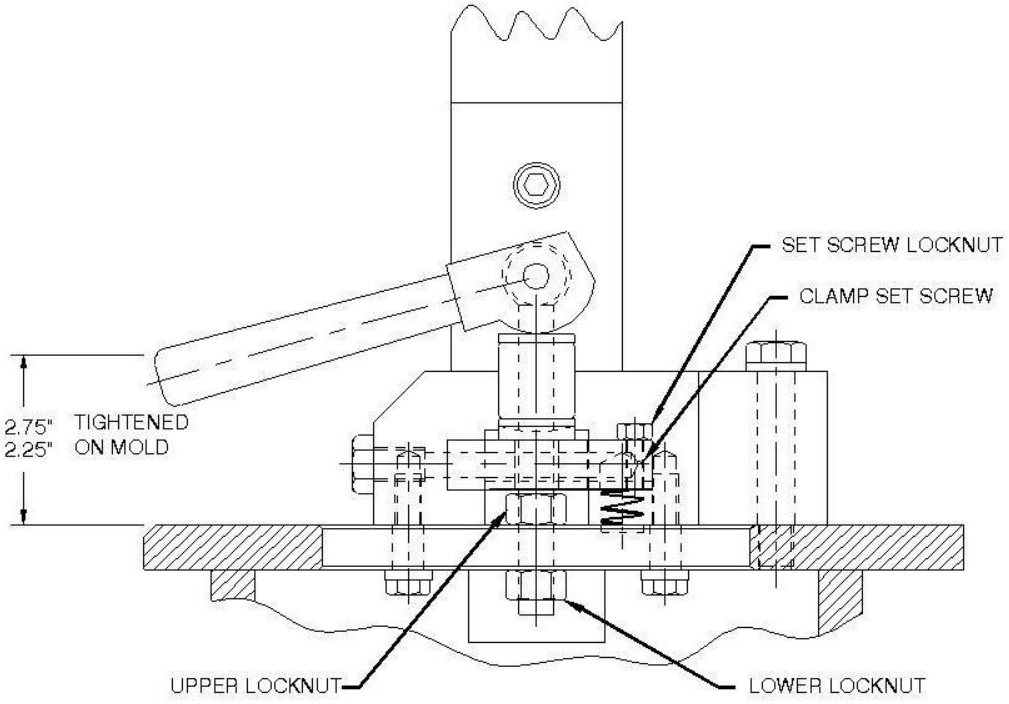


Figure 7.4a: Mold Clamp Components

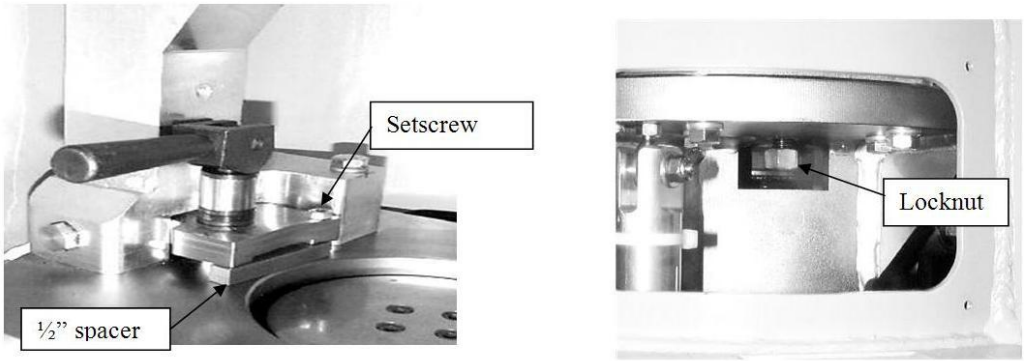
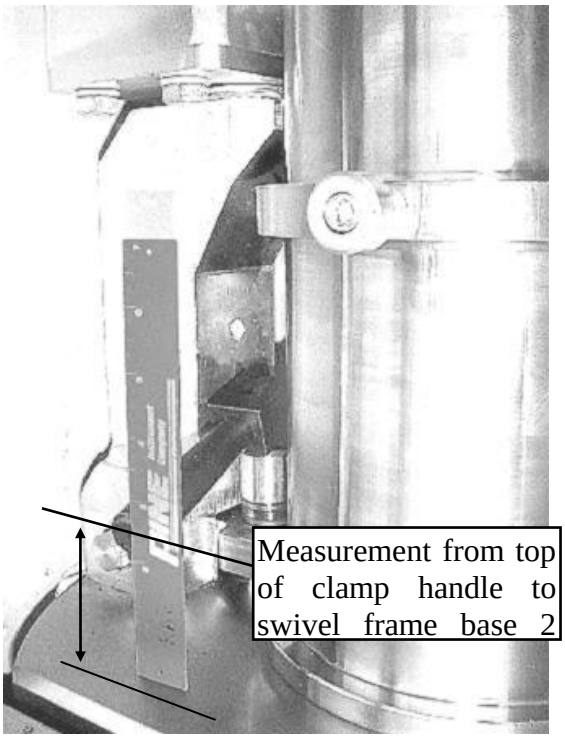


Figure 7.4b: Mold Clamp Adjustment

- Place the 0.500" square spacer under the clamp.
- Bring the clamp down lightly until the front of the clamp contacts the 0.500" spacer.
- With the clamps lightly contacting the 0.500" spacer, turn the set screw to until it lightly contacts the spacer with the 1/8" wrench.
- Lock the set screw in position with the set screw locknut using the 7/16" wrench.
- Remove the 0.500" spacer.

Note: Use a mold for the following measurement. Clamping the 0.500" inch spacer firmly may cause damage to the spacer.



- Firmly clamp a mold to the swivel frame.
- Measure the distance from the base to the top of the clamp handle.

This measurement should be between 2¼" - 2¾" with the mold <u>firmly</u> clamped into position. If the handle needs to be raised, loosen the upper locknut then tighten the lower locknut. If the handle needs to be lowered, loosen the lower locknut then tighten the upper locknut. The clamp handles should point toward the center slightly but still allow easy insertion of the mold.

- Make sure that the clamp handles clear the mold. The mold handles, pointed slightly toward the center, should still allow the mold to be easily inserted into the compaction chamber.
- Once both clamps are adjusted to the proper position, check that the clamps are operating freely and clamp the mold firmly in place.

<u>Figure 7.4c: Mold Clamp Handle Position</u>

7.7 Storage

The gyratory compactor should be stored in a heated, dry area when not in use. To store the gyratory compactor for extended periods, first thoroughly clean and lubricate the unit. Wipe the swivel-frame, mold top plate/clamps, and work surfaces with light oil or rust preventative. Molds should also be thoroughly cleaned and coated with a rust preventative. Disconnect power and cover the machine with a dust cloth.

When returning the compactor to service, thoroughly clean and lubricate the unit. Turn power on and allow the machine to warm up at least 15 minutes. Verify that all machine motions are working correctly. Degrease the swivel base and bottom flange of mold.

The compactor should be standardized prior to use.

7.8 SGC Best Practices for Maintenance and Calibration

1. **Know and follow the applicable governing agency specifications.** Each governing agency may have requirements that differ from these guidelines, such as more frequent equipment inspection intervals or different specific setting or tolerance requirements. This document does not represent the varied requirements of specific agencies. Where conflicts arise, the governing agency specifications take precedence.

2. **Read the Operator's Manual**. There is no substitute for a good understanding of the particular maintenance and calibration issues discussed in the manual for a particular SGC model.

3. **Lubricate all wear surfaces** periodically as directed by the operator's manual. Failure to lubricate wear surfaces often causes premature wear and increased repair costs.

4. **Keep the SGC clean**. Immediately clean any debris or buildup of asphalt binder. Debris and binder buildup often interfere with proper SGC operation and can cause premature wear and increased repair costs.

5. **Clean molds and end plates** after every specimen. Debris and binder buildup on mold end plate surfaces and on critical mold contact points can alter the angle of gyration applied to the specimen.

   DO NOT use an ignition oven to remove binder residue from the mold bore. The extreme heat will damage the mold beyond repair by causing it to go out of round. To clean heavy residue, warm the mold to 60°C (140°F) and use a solvent to remove the residue. WD-40 works well and provides a residual coating that inhibits corrosion.

6. **Calibration Terminology:** The following terms are used to describe calibration of machine parameters.

   Standardize: a process to bring a measuring instrument or measurement system into conformance to a known standard (i.e.: force, height, angle, etc.).

   Verify: a process that establishes whether the results of a previously calibrated measurement instrument or measurement system are stable. Verification is used to maintain the traceability of a system and to determine when to recalibrate. If the machine response is in conformance, no correction is required.

   Calibrate: a process that establishes the relationship (traceability) between the results of a measurement instrument or measurement system and the corresponding values of a reference standard.

7. **Standardize the ram pressure** measurement system a minimum of once per year or every eighty (80) hours* of operation, whichever comes first. Use the certified proving ring or load cell appropriate for the SGC model to verify the ram pressure. Electronic load cells should be calibrated annually and mechanical proving rings calibrated every two years.

8. **Standardize the height** measurement system a minimum of once per year or every eighty (80) hours* of operation, whichever comes first. Use the certified gage block(s) appropriate for the SGC model. Gage blocks require certification every two years. If blocks are visibly damaged, they should be repaired and recertified.

9. **Standardize the internal angle** of gyration. Standardize the internal angle of gyration** a minimum of once per year or every eighty (80) hours* of operation, whichever comes first. Follow the AASHTO TP71 procedure using molds at room temperature. Top and bottom angles should be within 0.10° of each other.

   Note: The AFGB1 model SGC exhibits a predictable shift between room temperature mold and compaction temperature mold angle of gyration. For this model SGC, a room temperature internal angle of 1.19° represents a 1.16° internal angle at typical compaction temperatures. The Pine SGC models AFG1, AFG2, and AFGC125X do not exhibit the shift. Standardize these SGC models at the target angle (1.16°) with room temperature molds.

10. **Monitor the external angle** of gyration. A shift in the external angle can indicate a shift has occurred in the internal angle as well. Monitor the external angle of gyration a minimum of every three months or every twenty (20) hours* of operation, whichever comes first. On models which display the angle of gyration, the display readout provides the desired information. On models which don't display the angle, refer to the Operators Manual for instructions on checking the external mold angle.

11. **Standardize the speed of gyration.** Standardize the speed of gyration a minimum of once per year or every eighty (80) hours* of operation, whichever comes first.

12. **Verify mold dimensions** a minimum of once per year or every eighty (80) hours* of operation, whichever comes first. Measurement of the inner diameter of the mold should be at three locations along the length of the

mold using a bore gage. Two of these locations should be within any observed wear areas (*i.e.* where the HMA material is compacted). The outer diameters of end plates should be verified using calipers or outside micrometers. Mold bores and end plates should also be checked for damage (deep gouges).

13. **Verify internal angle of gyration for each mold** a minimum of once per year or every eighty (80) hours* of operation, whichever comes first. Each SGC model has specific requirements for the molds to apply a correct and consistent angle of gyration. Measuring the internal angle with each mold confirms the angle is being applied consistently on each mold used with a given SGC. One top and one bottom angle is sufficient for this check. Each mold internal angle should be within +/-0.02° of the average of all molds used with a given SGC.
14. **Maintain a log book**. Create and maintain a log book to record the results of routine SGC standardization and major service events. Monitoring trends in standardization results often permits early detection of machine performance issues.
15. **When a compactor is moved to a new location**, standardize pressure, height, and internal angle after relocation. While SGC units have been moved and used successfully without being standardized, there is a risk of incorrect compaction results if any critical parameters changed from handling during transport.
16. **Turn your SGC off** when not in use for extended periods (i.e.: overnight, weekends, etc.). Saving energy saves you money.

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* The term *hour of operation* applies only to the amount of time the SGC is actually compacting specimens. It is the amount of time required to prepare about ~18 specimens (1800 gyrations).

** The *internal angle of gyration* is the angle between the mold wall and the end plates, as measured from the inside of the SGC mold. Beginning in 2003, AASHTO T 312 permitted the option of specifying an internal angle of gyration of 1.16° in lieu of an 1.25°external angle. Beginning in 2009, AASHTO T312 requires a 1.16° internal angle measured using the AASHTO TP 71 procedure.

7.9 Troubleshooting

The AFG2 compactor has error diagnostics programmed into the control software which is used for trouble shooting if a problem occurs during operation of the compactor. If a fault condition occurs, an error code will be displayed on the control panel as well as some brief instructions as to the course of action that should be taken. These fault codes help determine the root cause of the problem, which in some cases may be a failed component.

If an error code appears on the control panel display of the AFG2 gyratory compactor, the suggested course of action is as follows:

- Record the error code number and under what condition the error code occurred.
- Follow the instructions displayed on the control panel display.
- If the control panel does not display instructions or if the compactor does not respond, turn the compactor off. Leave the power off for 10-15 seconds, then turn the compactor back on.
- If the error code does not re-occur, resume normal operation of the compactor and monitor for additional occurrences.
- If the errors reoccur, or for additional information, contact Pine Instrument Company Test Equipment Customer Service at Ph: (724)-458-6391.

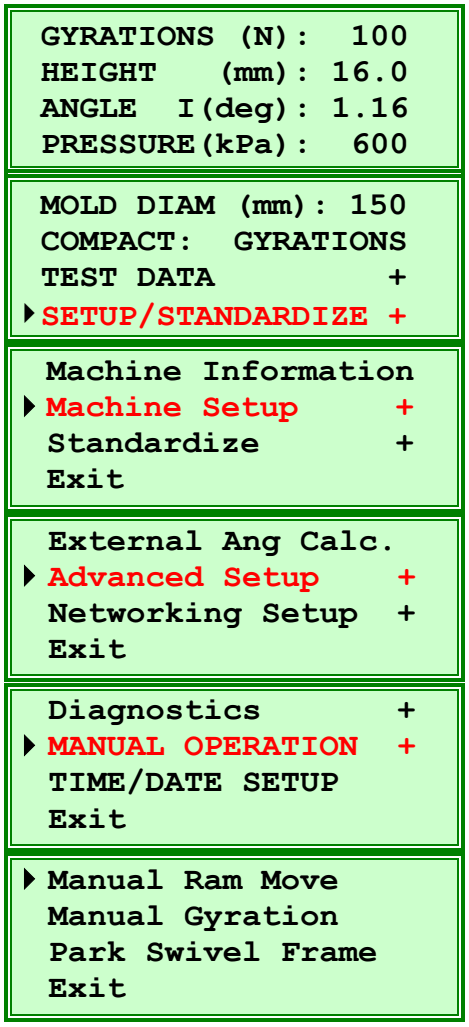
Table 7.3: Error Diagnostics

Error	Possible Cause(s)	Solution(s)
Grinding Noise	Improper ram foot lubrication	Clean ram foot with WD-40 and re-lubricate lightly
Mold Top	Debris between wear plate and frame.	Contact customer support
101	Motion controller initialization error	Controller Failure, contact customer support
301	Ram stall	Drive failure, contact customer support
333	Ram failed to park	Check for debris under ram foot Drive failure, contact customer support
443	Front angle transducer fault	Clean or repair front angle transducer
444	Left or Right angle transducer fault	Clean or repair front angle transducer
715	Network configuration missing	Turn compactor off, then on.

7.9.1 Manual Operation

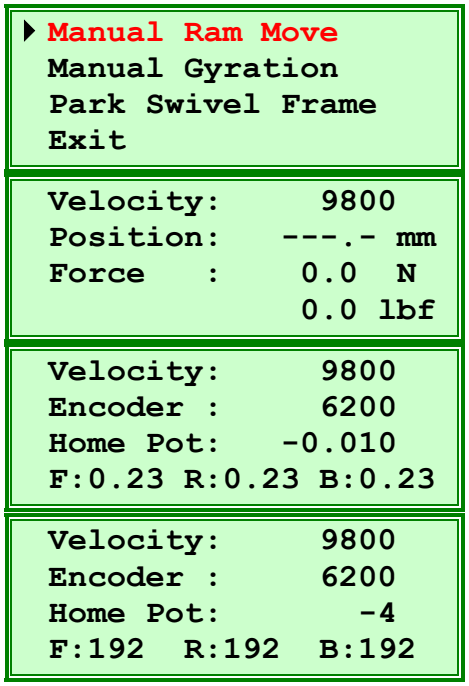
It is possible to operate each of the AFG2 motors manually which can aid in the diagnosis of error conditions, should they occur. In general, the use of these manual move menus should be reserved to troubleshooting error conditions as directed by a Pine Customer Service Representative.

- To verify the operation of each motor drive, navigate to the manual operation screen using the ▶ and ↵ buttons.
- Most sub-menus have two screens. Use the ▶ to continue within each group until the desired selection is available.



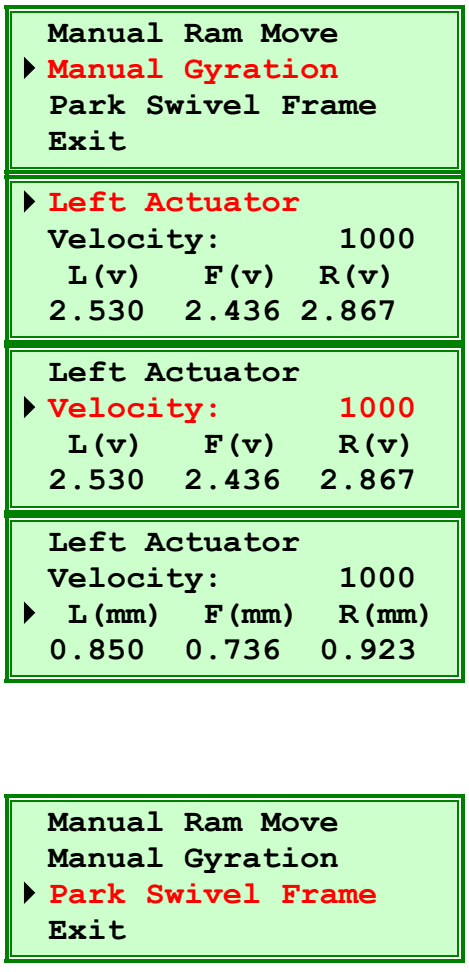
7.9.1.1 COMPACTION RAM DRIVE

- To verify the operation of the ram drive, navigate to the Manual Ram Move screen using the ▶ and ↵ buttons.
- Use the ▶ button to toggle between three screen displays shown at right.
- Use the + and − buttons to set the velocity.
- Use the yellow RAM UP and RAM DOWN operators to operate the motor.
- Press ↵ to exit this menu.



7.9.1.2 GYRATION ACTUATOR DRIVES:

- To verify the operation of each gyration actuator, navigate to the manual gyration screen using the ▶ and ↵ buttons.
- Position the cursor on line one using the ▶ button, then use the + or − button to toggle between the Left or Right Actuator. Only one actuator can be operated at a time.
- Position the cursor on velocity using the ▶ button, then use the + and − buttons to select a speed.
- Position the cursor on line three using the ▶ button, then use the + or − button to select units for the angle sensors (vdc or mm).
- Use the yellow RAM UP and RAM DOWN operators to operate the motors.
- Press ↵ to exit this menu.
- Use the Park Swivel Frame function to return the swivel frame to the home position after exiting the manual gyration screen.



7.9.2 SGC Compaction Sensitivity

The following are general statements about the sensitivity of bulk specific gravity to various compaction parameters:

- **Angle of Gyration**. A low angle of gyration leads to less compaction and higher air voids. A tenth of a degree drop in the angle of gyration lowers the bulk specific gravity by 0.010 to 0.015 (10 to 15 kg/m^3).
- **Ram Pressure**. Low ram pressure leads to less compaction and higher air voids. A 10 kPa decrease in the ram pressure lowers the bulk specific gravity by 0.002 to 0.004 (2 to 4 kg/m^3).
- **Mold Wear**. As a mold wears, the clearance between the mold and its end plates increases. For each millimeter of additional clearance, the bulk specific gravity decreases by about 0.020 (20 kg/m^3).
- **Lubrication and Paper Disks.** Excessive lubricant on end plates (especially the interface between the specimen papers and the metal end plates) leads to less compaction and higher air voids. Use non-glossy release disks.

Appendix A: SGC Standardization Log Form

SUPERPAVE Gyratory Compactor Standardization Worksheet — **Pine Instrument Company**

Compactor Model Number:________________ Serial Number:________________

Date	Technician	Gyration Speed 30 ±0.5 gpm (10 gyr @ 19.67-20.33 sec)	Force Proving Ring s/n: ________ Cal Date: ________ 5000N ±1% Dial Range: ____-____	Force 10500N ±1% Dial Range: ____-____	Height 6.000 +/-.004 inch (152.4 +/-0.1 mm)	Angle of Gyration External $\alpha = \text{ArcTan}[(\Delta B - \Delta T)/12]$ α_{ext}: External Angle of Gyration ΔT: Top Indicator TIR ΔB: Bottom Indicator TIR	Effective Internal (see worksheet)
					Mold Size: Height:	ΔT ______ ΔB ______ α_{ext}=______	α_{int}=______
					Mold Size: Height:	ΔT ______ ΔB ______ α_{ext}=______	α_{int}=______
					Mold Size: Height:	ΔT ______ ΔB ______ α_{ext}=______	α_{int}=______
					Mold Size: Height:	ΔT ______ ΔB ______ α_{ext}=______	α_{int}=______
					Mold Size: Height:	ΔT ______ ΔB ______ α_{ext}=______	α_{int}=______
					Mold Size: Height:	ΔT ______ ΔB ______ α_{ext}=______	α_{int}=______
					Mold Size: Height:	ΔT ______ ΔB ______ α_{ext}=______	α_{int}=______
					Mold Size: Height:	ΔT ______ ΔB ______ α_{ext}=______	α_{int}=______
					Mold Size: Height:	ΔT ______ ΔB ______ α_{ext}=______	α_{int}=______
					Mold Size: Height:	ΔT ______ ΔB ______ α_{ext}=______	α_{int}=______
					Mold Size: Height:	ΔT ______ ΔB ______ α_{ext}=______	α_{int}=______

Appendix B: SGC Internal Angle Standardization Form

Superpave Gyratory Compactor

Serial Number:_____ Owner:_____

Model:_____ Location:_____

Manufacturer:_____ Total Gyrations:_____

Pressure (kPa):_____ Mold Temperature_____

Angle Measurement Instrument

Serial Number:_____ Calibration Date:_____

Model:_____ Next Calibration Due:_____

Eccentricity (mm): _____ Tilting Moment:_____

Internal Angle Measurements

Angle Measured (*Top* or *Bottom*)	**Measured Angle** (report to nearest 0.01 degrees)	**Internal Angle Result**
Top	1:_____ 2:_____	Top $_{average}$=_____ $\left[\frac{Top1+Top2}{2}\right]$
Bottom	1:_____ 2:_____	Bottom $_{average}$=_____ $\left[\frac{Bottom1+Bottom2}{2}\right]$

Angle $_{effective}$=_____ $\left[\frac{Top_{average}+Bottom_{average}}{2}\right]$

Technician: _____ Date: _____

VIII. Warranty

PINE INSTRUMENT COMPANY

LIMITED WARRANTY

The Pine AFG2 Gyratory Compactor manufactured by Pine Instrument Company is warranted to be free from defects in material and workmanship for a one (1) year period from the date of shipment to the original purchaser and used under normal conditions. The obligation under this warranty is limited to replacing or repairing parts which shall upon examination disclose to Pine Instrument Company's satisfaction to have been defective. The customer may be obligated to assist Pine Instrument Company personnel in servicing our equipment. Pine will provide telephone support to guide a customer's technician to affect any needed repairs. In the event that telephone support is unsuccessful in resolving the defect, Pine Instrument Company will dispatch a factory-trained technician to the customer's location within 3 working days to perform on site service. The following restrictions apply:

- On site service does not include interfacing the AFG2 to a personal computer.
- On site service does not include standard wear items.
- On site service does not include routine maintenance or standardization.

This warranty being expressly in lieu of all other warranties, expressed or implied, and all other liabilities. All specifications are subject to change without notice.

The customer is responsible for charges associated with non-warranted repairs. This obligation includes but is not limited to travel expenses, labor, parts and freight charges.