AFGC125X
Gyratory Compactor
Operation Manual

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LMGC125X

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I. General Information

1. Security Code

Your Pine Instrument Company SUPERPAVE™ Gyratory Compactor is equipped with a built-in calibration routine. To prevent inadvertent access to this routine, a security code must be entered before the machine may be calibrated.

Your machine security code is : 125.

If it is desired that this information not be readily available, please remove and store this page in a safe location.

2. Safety Precautions

The Pine Instrument Company AFG1A Gyratory Compactor has several safety features built into the machine to prevent injury to the user. However, all improper or unauthorized use of the machine can not be accounted for. Therefore, before performing any procedures that *are not specifically mentioned in this manual*, contact Pine Instrument Company for authorization.

To ensure minimum risk of injury to the user, Pine Instrument Company suggests the following safety precautions:

- **Always wear safety goggles when preparing or compacting asphalt specimens**
- **Wear heat resistant clothing and gloves when handling any hot substances**
- **When handling the mold, hold it firmly by the handles**
- **Always inspect the compaction chamber to be sure that it is free of any debris before starting a compaction**
- **Never operate the compactor with the access panels removed**
- **When compacting or extruding a specimen, always keep hands clear of the compactor**
- **When performing any maintenance procedure on the machine, be cautious about the dangers of pinch points**
- **Keep hands clear of the compactor when manually actuating the ram or swivel frame**

3. Description

The Pine Instrument SUPERPAVE™ Gyratory Compactor 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 user-friendly control panel with display, a completely enclosed compacting chamber, a built-in extruder for removing compacted HMA specimens from the molds, a bench type working surface, and a storage cabinet. Overall size is approximately 1220 mm (48") wide x 730 mm (29") deep x 1800 mm (71") high.

An integrated industrial computer controls all functions. The operator simply enters the appropriate compacting parameters, places the prepared mold into the compacting chamber, and presses the START key. The compacting chamber is a completely enclosed area with a safety interlocked access door which prevents machine operation when the door is open. Once the START key is pressed, the computer system takes control and applies the consolidation pressure, induces the gyration angle, and gyrates the specimen for the specified number of gyrations. At the end of the test, the specimen is squared and the ram is parked. A STOP key allows the test to be terminated in a controlled manner prior to completing the specified number of gyrations. Pressing the STOP key causes the machine to pause and display a message asking if the operator wishes to abort or to continue the compacting process. The operator then responds by pressing either the START or STOP button to continue or abort the test. Actuating the EMERGENCY STOP button stops all motion immediately and releases ram pressure.

The built-in extruder permits easy removal of the specimen from the mold assembly. A manual two-stage hydraulic pump is used to extend a hydraulic cylinder which pushes the specimen from the mold after the specimen has cooled sufficiently.

The control panel permits compacting parameters to be easily changed. These parameters include (but are not limited to): consolidation pressure, specimen size, and number of gyrations. Since the compacting parameters are stored, operator input is required only when the parameters are changed. The control system software automatically calculates the force required to produce the desired consolidation pressure on the specimen being compacted. Additional controls allow for the manual operation and calibration of the machine. The control panel displays information on the compacting progress. Once the test is started, parameters may be viewed but not changed. While compacting, the display indicates the specimen diameter, consolidation pressure, current gyration number, and specimen height.

Communication ports allow specimen height per gyration to be printed directly on a printer by the compactor. The serial communications port allows data to be sent directly to a computer. The data from the previous five (5) specimens are also stored. The stored data may be printed or transmitted to a computer for analysis.

4. Specifications

Power:	208-240 vac, 50 or 60 Hz, 1 Ph, 15 A
Size:	1220 mm wide x 730 mm deep x 1800 mm high (48" X 29" X 71")
Weight:	500 kg (1100 lb.) Shipping wt. 636 kg (1400 lb.)
Consolidation Pressure:	200 kPa - 1000 kPa
From 200 kPa to 600 kPa:	± 60 kPa for gyrations zero (0) to five (5), and ± 18 kPa for gyrations six (6) and greater.
From 601 kPa to 1000 kPa:	± 10% for gyrations zero (0) to five (5), and ± 3% for gyrations six (6) and greater.
Angle of Gyration:	0.50-2.00 +/-0.02 degrees (manually adjustable)
Speed of Gyration:	30 +/-1/2 rpm
Number of Gyrations:	0-999
Data Acquisition:	Specimen height recorded once per gyration
Data Recording:	A hard copy printout of specimen height per gyration
Communication:	RS-232 (com# 2400,N,8,1) user selectable (Null modem cable required)
Molds:	150.0 mm +0.0/-0.1 mm I.D. x 250 mm 100.0 mm +0.0/-0.1 mm I.D. x 200 mm (50.0 mm minimum compaction height)
Mode of Operation:	Compact to Number of Gyrations Compact to Specified Height
Other Features:	Fully automatic and manual controls Built-in universal extruder SI units

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

5. Accessories

Description	Part Number
Calibration Kit	AFGCCAL
Angle Calibration Jig	AFGCA001A
150 mm Mold Assembly	AFGCM150
100 mm Mold Assembly	AFGCM100
100 mm Ram Foot	ACGCR011SP
150 mm Paper Disk	RAND15
100 mm Paper Disk	RAND10
Powdered Lubricant	RALMOS2
Swivel Caster Kit	ACGCA008
Printer Kit w/cable	ACGCA011

6. Unpacking

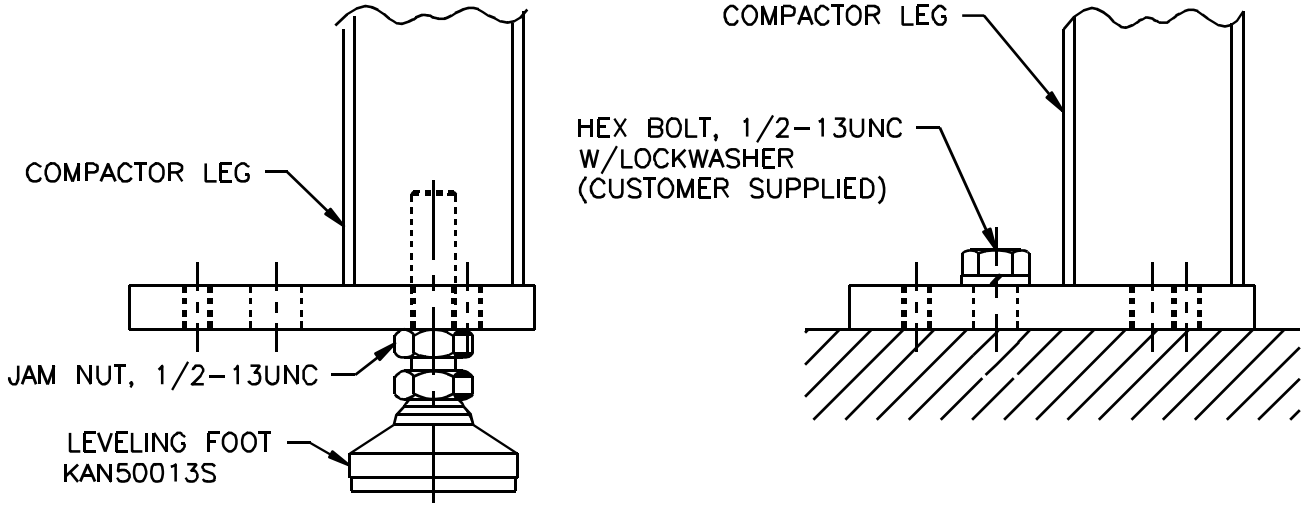
The unit is shipped bolted directly to a wooden pallet. After unbolting the machine from the shipping pallet, install the four (4) leveling feet, one each into the threaded hole in each leg. Note that there are also through holes at each foot to facilitate shipping and fixed mountings. The machine must be bolted directly to the floor when mounted in a transportable unit (see Figure 1.1, Chapter I -page 5).

Select a level surface for the compactor location. Use the leveling feet to level the compactor's work surface. It is not critical that the machine be exactly level, but it must be stable. There should be clearance on the left side of the machine for calibration and maintenance. Swivel casters are highly recommended to allow easy movement of the machine (see Figure 1.1).

Prior to using the gyratory compactor after it has been transported, the machine’s calibration should be verified. This can be accomplished with the optional calibration kit utilizing the built-in calibration verification routine (see Chapter III).

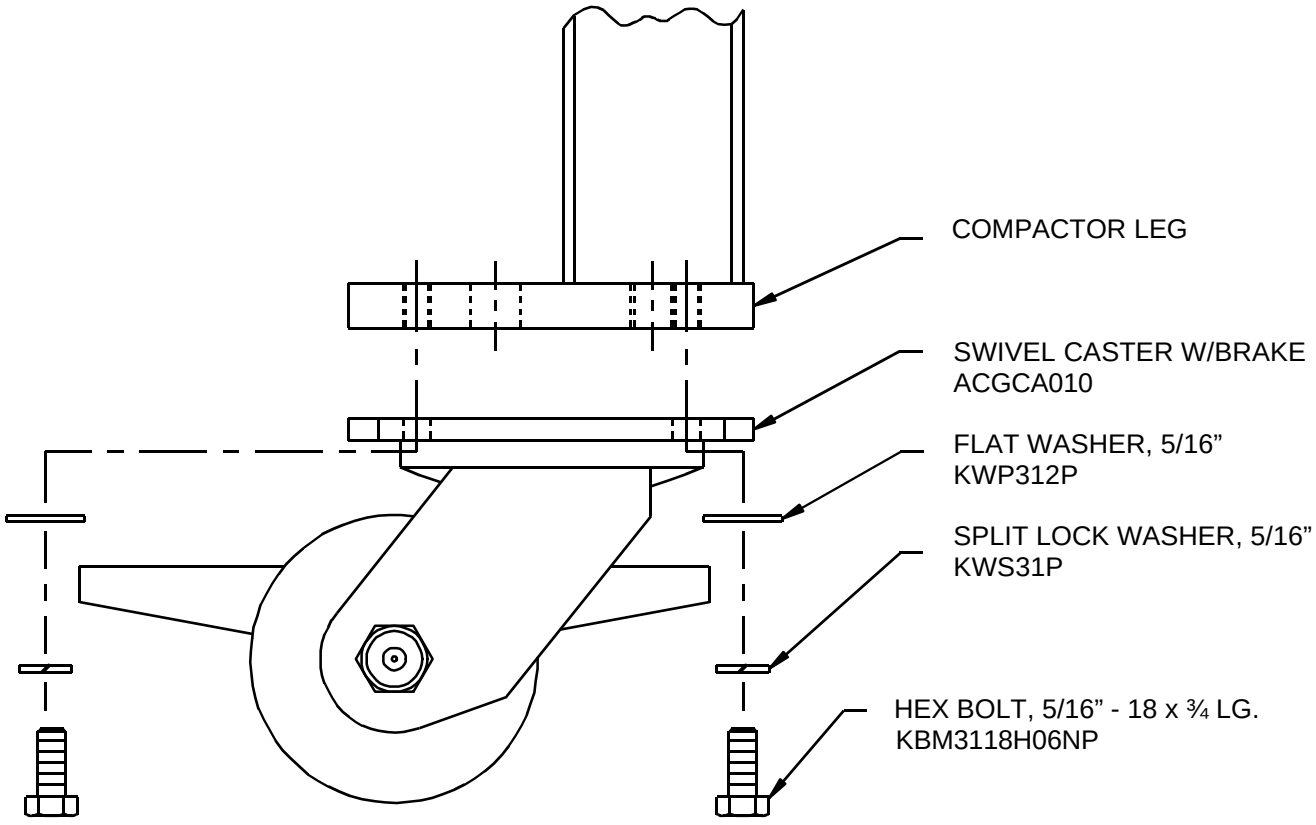
7. Warranty

The Gyratory Compactor manufactured by Pine Instrument Company is warranted to be free from defects in material and workmanship for a 1 year period from date of shipment to original purchaser and used under normal conditions. The obligation under this warranty being limited to replacing or repairing any part or parts which shall upon examination disclose to Pine Instrument’s satisfaction to have been defective and shall have been returned freight prepaid and clear of encumbrances to Pine Instrument Company in Grove City, PA within the warranty period. This warranty being expressly in lieu of all other warranties, expressed or implied, and all other obligations or liabilities. All specifications are subject to change without notice.



LEVELING FOOT (STANDARD)

FIXED MOUNTING



SWIVEL-CASTERS (OPTIONAL)

FIGURE 1.1 : MOUNTING CONFIGURATIONS

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II. Operation

1. General

The Pine Instrument Company Gyratory Compactor model AFGC125X was designed for the compaction of Hot Mix Asphalt design specimens. Only HMA above 140 degrees Fahrenheit should be compacted with the machine. Compacting other materials may cause damage to the machine.

***** CAUTION *****

Do not attempt to gyrate a mold without HMA in the mold or without a consolidation pressure applied to the HMA specimen. The gyratory mechanism relies on the consolidation pressure applied to a specimen to keep the mold in the proper position for gyration. Attempting to gyrate without consolidation pressure may cause the mold to eject from the carriage assembly and damage the machine.

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 and should be removed prior to starting a test. It is especially important that the flange on the mold be kept clean. Keep the base of the compaction chamber clean and lubricated. A dry lubricant such as powdered molybdenum di-sulfide or graphite should be used. Only a small amount of this lubricant is required and it should be applied each time the machine is operated. Do not use grease.

2. Controls

Figure 2.1, Chapter II - page 2, shows the control panel and a brief description of the function of the keys.

A test can not be started if the machine is not properly parked; that is, the ram, the angle, and the mold carriage are in the home position. Hold the ENTER key then press the START key to cause the machine to self-park.

2.1 Manual Controls

The gyratory compactor allows manual control over the ram and mold carriage. However, constant consolidation pressure is only possible under automatic operation.

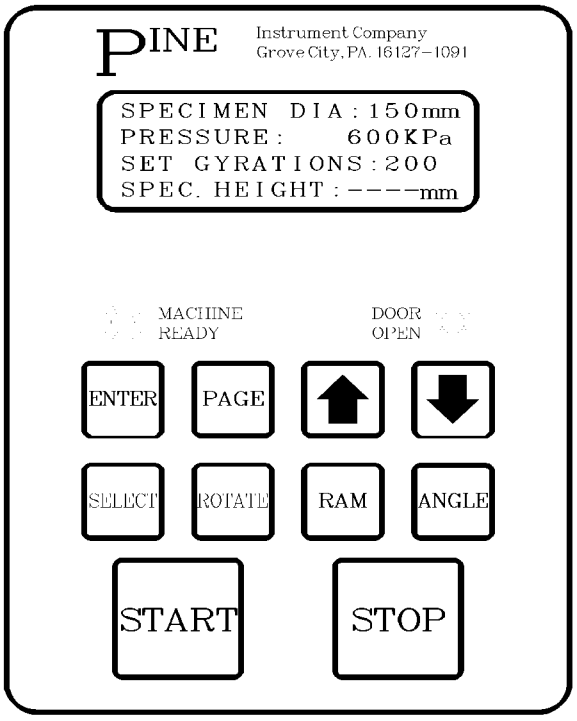
To operate the ram, press the RAM key and an ARROW key (depending on the direction of movement desired) at the same time. The ram will begin accelerating. Once motion is started, only the ram key need be pressed. The ARROW keys are used initially to select the direction of movement, then to increase or decrease the ram velocity. Maximum ram speed in manual mode is 5.0 mm/sec. unloaded and 0.4 mm/sec. with a load applied to the ram. The display will indicate the force on the ram, the ram velocity, and the ram position while the RAM key is depressed.

To manually operate the tilt mechanism, press the ANGLE and the UP ARROW keys at the same time. The hydraulic pump will induce the angle to the mold carriage. Pressing the ANGLE key will display the position of the tilt linkage. Press the ANGLE and DOWN ARROW keys to return the tilt mechanism to zero degrees. The carriage base must be parked to return the tilt mechanism to zero degrees.

To rotate the mold carriage, the mold carriage must first be tilted to align the rollers with the fixed ring. Once the mold carriage is tilted, press the ROTATE and UP ARROW keys at the same time. Releasing the keys immediately will cause one rotation. Holding the ROTATE key depressed until the mold carriage rotates through one full revolution will initiate continuous rotation. Pressing the ROTATE key while the carriage is rotating will cause the carriage to park on its next rotation. The STOP key will stop the carriage immediately. With the carriage stopped, pressing the ROTATE and DOWN ARROW keys at the same time will cause a slow speed rotation for as long as the ROTATE key is pressed or until the home position is reached. Pressing the ROTATE key will show if the carriage is parked.

***** CAUTION *****

Do not manually rotate the carriage with a mold unless a consolidation pressure is applied to a specimen in the mold.



PAGE..... Activates control screen 2
PAGE + ↑..... Activates "OTHER OPTIONS" menu
PAGE + ↓..... "Exits OTHER OPTIONS" menu
SELECT..... Slects Parameter to be changed (value flashes)
↑ or ↓ ..... Changes value of flashing parameter
ENTER..... Stores changed parameter

ROTATE..... Displays mold carriage status
ROTATE +↑ **or** ↓ **..... Rotates mold carriage**

RAM ..... Displays ram status
RAM +↑ or ↓..... Moves ram up or down

ANGLE..... Displays mold carriage position status
ANGLE +↑ or ↓..... Induces or removes angle of gyration

START..... Starts automatic compaction sequence
STOP ..... Pauses compaction
ENTER + START..... Automatic machine parking

Figure 2.1: Controls

2.2 Settings

The gyratory compactor control system allows for changing the compaction parameters. Press the SELECT key to choose the parameter to be changed (the selected value will flash). Press the ARROW keys to change the value to the desired setting. Only valid values will be accepted. Press the ENTER key to store the new value. The SELECT key will also store the new value and move to the next parameter to be changed. The OTHER OPTIONS on screen 2 will activate additional parameters that may be changed. The settings are saved in non-volatile memory so they require resetting only when a change is desired.

MODE: Compact to Number of Gyrations

In this mode of operation the compactor will apply the set consolidation pressure, gyrate the specimen to the preset number of gyrations, apply a squaring pressure, and then park automatically.

SCREEN #1

`"SPECIMEN DIA:  150mm"`	Specimen size: 100 mm or 150 mm
`"PRESSURE:    600 kPa"`	Compaction pressure. Valid range: 200-1000 kPa
`"SET GYRATIONS: 150  "`	Total number of gyrations. Valid range : 0-999
`"SPEC. HT.: ------mm "`	Data output.

SCREEN #2

`"SQ.PRESSURE: 600 kPa"`	Pressure used to square specimen after gyration. Valid range: 200-1000 kPa
`"SQ. DELAY:    10 Sec"`	Time at square pressure. Valid range: 0-99 seconds.
`"OTHER OPTIONS       "`	Access additional machine parameters.
`"MACHINE HOURS: xxx.x"`	Total machine hours. Only actual run time is accumulated.

MODE: Compact to Specified Height

In this mode of operation the compactor will apply the set consolidation pressure, gyrate the specimen until the preset specimen height is reached, apply a squaring pressure, and park automatically.

Note: Due to rounding of the specimen height on the display and printout 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 gyration after the specimen height is actually reached. When the specimen is squared, the height may change slightly. The compactor will stop if the height is not reached by the maximum number of gyrations programmed.

SCREEN #1

`"SPECIMEN DIA:  150mm"`	Specimen size: 100 mm or 150 mm
`"PRESSURE:    600 kPa"`	Compaction pressure. Valid range: 200-1000 kPa
`"SPEC. HT.:   99.0 mm"`	Desired finish height of specimen. Valid range : 50.0-200.0 mm
`"GYRATIONS:nnn (250) "`	Maximum number of gyrations allowed to achieve desired height. Valid range : 0-999 nnn: Indicates the current gyration.

SCREEN #2

`"SQ.PRESSURE: 600 kPa"`	Pressure used to square specimen after gyration. Valid range: 200-1000 kPa
`"SQ. DELAY:    10 Sec"`	Time at square pressure. Valid range: 0-99 seconds.
`"OTHER OPTIONS       "`	Access additional machine parameters.
`"MACHINE HOURS: xxx.x"`	Total machine hours. Only actual run time is accumulated.

"OTHER OPTIONS":

In this section of the menu system, pressing the SELECT key will pick which option is flashing. Pressing the ENTER key while an option is flashing will cause that option to be chosen. Press the ARROW keys to change the value or setting of the chosen option. Pressing ENTER then stores that selection.

> COMPACTION MODE

```
"-TO SPECIFIED HEIGHT"
"-TO NO. OF GYRATIONS"
```

Press ARROW keys to choose the desired mode of operation.

> SEND TEST DATA

```
"  Send Test Data    "
"                    "
" #n dd/dd/dd tt:tt  "
"Press START to send "
```

Data from the last 5 compactions is stored according to the date and time of compaction. Press the ARROW keys to select the desired data set. (Time and Date of stored Test Data)

> PRINT REPORT

```
" Print Test Report  "
"                    "
" #n dd/dd/dd tt:tt  "
"Press START to print"
```

Data from the last 5 compactions is stored according to the date and time of compaction. Press the ARROW keys to select the desired data set (Time and Date of Stored Test Data)

> DATE/TIME

```
" Set Date and Time  "
"Use SELECT to change"
"Time: nn:nn:nn      "
"Date: nn/nn/nn      "
```

> LOCK/UNLOCK SETUP

```
"Lock/Unlock Specimen"
"Dia., Pressure, and "
"Sq. Delay settings  "
"Settings: NOT LOCKED"
```

or "Settings: LOCKED"

This option will lock specimen size and consolidation pressure settings. Only the number of gyrations (specimen height in compact to height mode) may be changed when settings are locked.

"OTHER OPTIONS" (continued):

> AUTO-TILT

```
"Re-pressurize Tilt  "          "Re-pressurize Tilt  "
"Cylinder while test"           "Cylinder while test"
"is in progress: YES"   or      "is in progress:  NO"
"Activate tilt pump "           "                    "
"every nnn gyrations"           "                    "
```

This option is available for compensation of wear over the life of the compactor. It causes the hydraulic power pack to re-pressurize the hydraulic circuit during a test. This is not normally required, but as the hydraulic cylinder wears, some internal pressure bypass can be expected. This option allows for compensation of small pressure losses during gyration. Activation of the pump every 30 gyrations should be adequate.

> SERIAL PORT

```
"Set COM1 Parameters:"
"                    "
"    2400, N, 8, 1   "
"                    "
```

Press the SELECT key to choose the parameter, then the ARROW keys to change the value.

> VERIFY CALIBRATION

This routine is used to verify the machine calibration using the optional calibration kit. (See section 7, Chapter III - page 24)

> LAST CALIB. DATE

This option is used to view the date of the last machine calibration.

> Angle Calculator

This option is used to calculate the loaded angle of gyration.

```
"A1:0.2500  B1:0.2500"
"A2:0.1000  B2:0.2100"
"A3:0.0850  B3:0.1930"
"Angle = 1.242 degrees"
```

Press the SELECT key to choose the variable, then the ARROW keys to change the value. Press ENTER to calculate. Press ENTER again to exit.

> EXIT

Returns to the main screen.

3. Mold Preparation

A clean mold assembly is essential for gyratory compaction.

Clean and preheat the mold, mold base, and mold top. This is usually at about 150 degrees Celsius (300 degrees Fahrenheit). Consult the specific test procedure being followed for specific preheat temperature. Place the preheated mold in the compactor extruder bracket. Next, place the mold base into the mold. Note the correct orientation of the mold base flange is up (see Figure 2.2). The mold base may be placed into the mold prior to preheating. Place a paper disk into the mold on top of the mold base. Now place the loose, preheated specimen into the mold. Use the extruder to lift the loose specimen so that its top is near flush with the top of the mold. Place a paper disk, then the mold top plate, on top of the specimen. Note the correct orientation of the mold top is taper up (see Figure 2.2). Lubricate the surface of the mold top plate and the compaction chamber base with a dry lubricant. Place the dry lubricant in the small plastic jar supplied in the tool kit and use the brush, also supplied in the tool kit, to apply the lubricant uniformly and lightly to the base and top plate. The surfaces should have a very light coating of dry lubricant over the entire area. Release the extruder pump valve. Be certain there is no foreign debris on the mold flange. Just prior to inserting the mold into the compaction chamber, lubricate the flange with a rag moistened with WD-40 or other light oil. Do not use the dry lubricant. The mold is now ready to be placed into the compaction chamber.

Some preparation procedures may require further aging of the specimen, typically 1-4 hours. Consult the specific test procedure being followed for exact instructions.

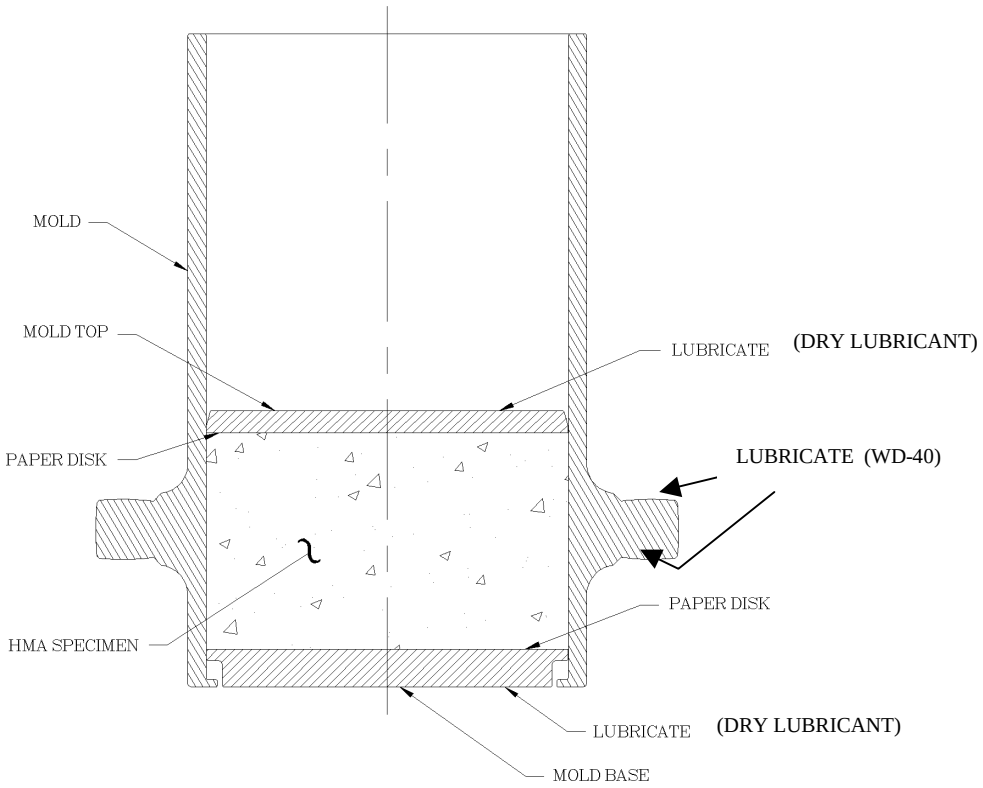


Figure 2.2: Mold Assembly

IMPORTANT: When inserting the mold into the compaction chamber, place the mold into the chamber with the anti-rotation cog at the 6 o'clock position (front of the machine). Check that the mold is properly seated in the carriage by rotating it counter-clockwise approximately 90 to 180 degrees.. The mold will spin easily when properly seated in the carriage rollers.

The anti-rotation cog prevents the mold from rotating excessively during compaction. A small amount of lubricant on this cog is recommended. A large percentage of mixes do not require this anti-rotation cog to be engaged to compact properly (see section 6, Chapter II - page 9). SUPERPAVE™ specifications allow 2 mold rotations per 200 gyrations.

4. Performing a Test

Prepare the mold as per section 3, Chapter II - page 7. Place the prepared mold assembly into the mold carriage. Be certain that the mold is fully seated and that all three sets of carriage rollers fully engage the mold flange. The anti-rotation cog on the mold should be oriented between 3 o'clock and 12 o'clock. Be sure that the mold base, top plate, and mold flange are properly lubricated (see Figure 2.2, Chapter II - page 7). Enter the desired compaction parameters on the control panel. Figure 2.1, Chapter II - page 2, describes the function of each key on the control panel. Press the SELECT key to choose the desired parameter (value flashes). The ARROW keys are used to change the value of the selected parameter. ENTER stores the value. SELECT may also be used to store the value and move to the next parameter to be changed. Once the input parameters have been set and the mold is properly seated in the compaction chamber, close the chamber door. The machine ready light should now be illuminated. If the machine ready light is not lit at this point, the machine is not properly parked and will not initiate a test sequence. Press the ENTER and START keys at the same time to have the machine self-park. Be sure all parameters are correct before starting a test. Press START to initiate the compaction. The STOP key may be used to temporarily pause the compaction process. The test may then be restarted or aborted. The EMERGENCY STOP button will stop the test and remove ram pressure. Opening the compaction chamber door will also pause the test. If the test is stopped for any reason, the START key must be pressed to restart the machine. The test printout will indicate that the compaction process was paused prior to completion. The machine will automatically stop and park when the test has been completed. Remove the mold from the compaction chamber and allow to cool sufficiently prior to extruding the specimen from the mold.

Note: Occasionally a HMA specimen will bind the mold in the mold carriage after the test is complete. If this occurs, close the compaction chamber door, manually tilt the mold carriage by depressing the ANGLE and UP ARROW keys at the same time. Do not lower the ram. The mold may now be removed easily. Return the mold carriage to zero degrees by depressing the ANGLE and DOWN ARROW keys at the same time. Note the compaction chamber door must be closed to do this.

5. Extruder

The gyratory compactor is equipped with a manual specimen extruder. Simply slide the mold into the extruder bracket, close the pump valve located on the side of the pump by rotating the lever approx. ½ turn clockwise, DO NOT apply too much force. Manually pump the actuator to extrude the specimen. Once the specimen has been removed, release the valve by rotating the lever approx. ½ turn counter-clockwise to allow the cylinder piston to return home. This extruder also facilitates the insertion of the mold top plate into the mold (see section 3, Chapter II - page 7).

CAUTION: Do not attempt to extrude a cold specimen from a mold. Doing so may damage the extruder. If a sample has seized in the mold, preheat the mold to 60°C (140°F) prior to extruding the specimen.

6. Anti-Rotation Cog

A mold anti-rotation cog is supplied with the compactor and it is strongly recommended that this cog always be used. The stop cog must be utilized when compacting 100 mm specimens at any setting and 150 mm specimens at consolidation pressures less than 500 kPa. This cog is installed on the carriage base and interfaces with the cogs installed on the molds (see Figure 2.3, Chapter II - page 10).

7. Communications

The Gyratory Compactor is equipped with a serial communications port to allow transfer of compaction data directly to an external computer. An RS-232, 9 pin, null modem cable is required. The gyration number and specimen height (in ASCII format) are transferred during compaction. This data is also stored in the compactor and may be re-transmitted after compaction is complete.

To change the communications parameters, select the “Serial Port” within the “Other Options” menu. Press the SELECT key to choose the parameter, the ARROW keys to change the setting, and the ENTER key to exit.

ITEM	DESCRIPTION
1	ADJUSTABLE LINK
2	FIXED LINK
3	INTERMEDIATE LINK
4	ANTI–ROTATION COG (ACGCC020H)
5	DOWEL PIN, 3/16" DIA. x 1/2" LG. (KAP187D08)
6	SCREW, 10–32 x 1 1/4" LG. (KSM1032S20HB)

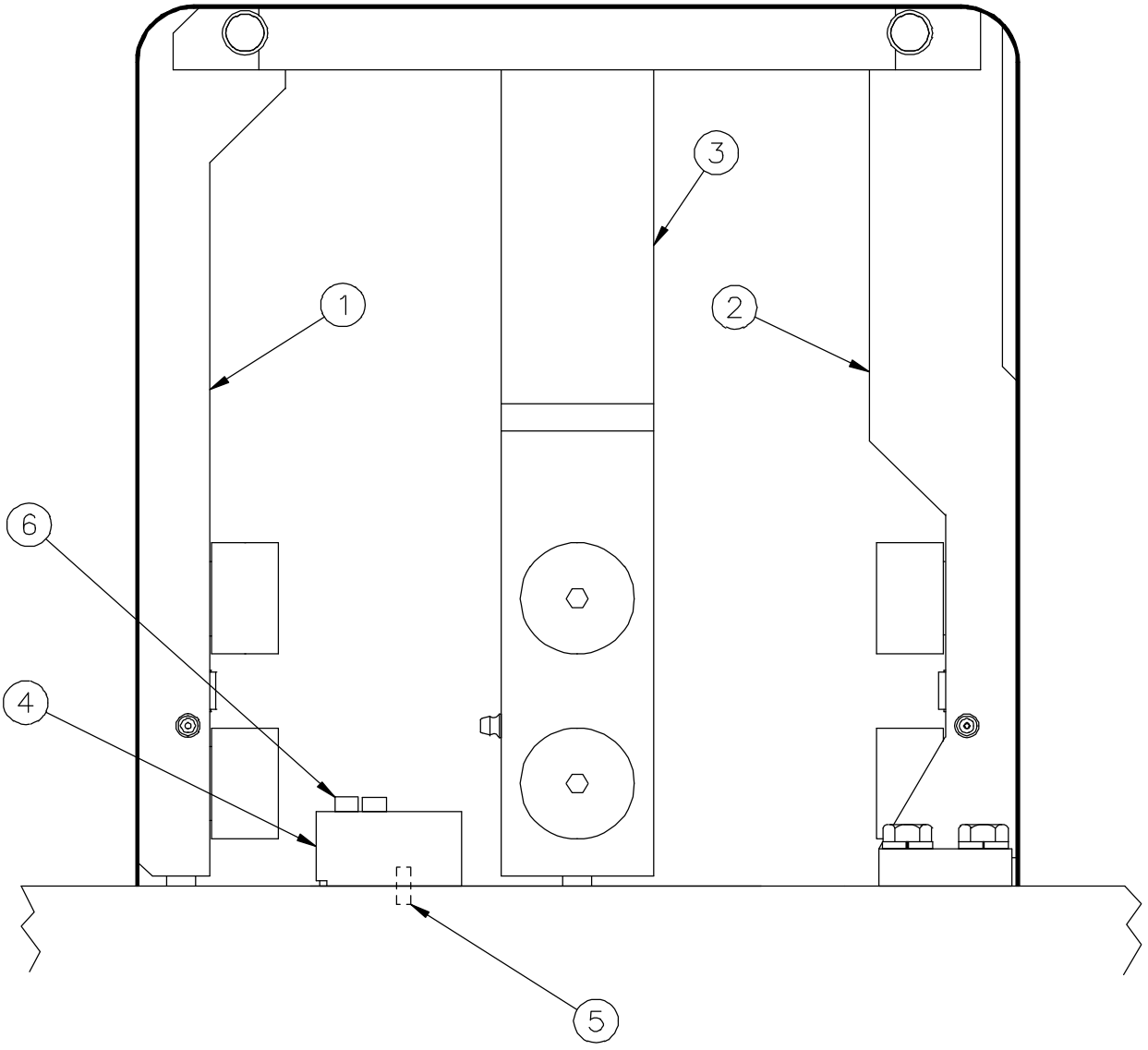


FIGURE 2.3: COMPACTION CHAMBER SHOWING ANTI-ROTATION COG

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III. Calibration

1. General

Before attempting to calibrate the gyratory compactor, be sure to fully understand this procedure. The machine should be calibrated on an annual basis, more often under severe usage. Calibration should be verified a minimum of every six months using the procedure outlined in sections 2 through 6.4 of this chapter. To view the date of last calibration, select LAST CALIB. DATE from the OTHER OPTIONS menu.

The machine 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 machine date and time are correct before starting.

The gyratory compactor is equipped with a menu driven calibration routine that is accessed by depressing the ENTER and SELECT keys at the same time. The machine must be parked and the "machine ready" light must be on. The display then prompts the operator for a special code (this code is located on a separate page in the front of this manual). Use the ARROW keys to select the proper number and press ENTER. The operator may then choose to have help screens throughout the calibration routine. The help screens should be used until the operator is fully familiar with the process.

Each menu has an option to quit the calibration procedure without saving the data. Pressing the STOP key at any time during the calibration routine will stop the routine and allow the operator the option to abort the process. For the calibration data and date to be stored, the entire procedure must be completed. If the chamber door is accidentally opened during the calibration routine, close the door. The control panel will indicate that the calibration procedure has been paused. To resume calibration press the START key. To exit (quit) the calibration routine, press the STOP key. **Note:** Exiting the calibration routine before it is completed in full will lose the calibration data.

It is critical for accurate calibration that the compactor be thoroughly cleaned. It is especially critical that the compaction chamber base, the ram foot, and the mold rollers be free of dirt and debris.

2. Date and Time settings

To view the date and time, select DATE / TIME from the OTHER OPTIONS menu. If the date and time are not properly set, use the SELECT key highlight the incorrect settings. Once the incorrect setting is blinking, use the UP and DOWN ARROW keys to change the setting. Once all of the settings are correct, press the ENTER key to store the date and time.

3. Speed of Gyration

SUPERPAVE™ specifications require the speed of gyration to be 30.0 ± 0.5 rpm.

A precision, digital stopwatch is used to verify the speed of gyration. Select VERIFY from the menu and press the ENTER key. Press the START key. Use the stopwatch to verify that the rotation speed is correct. Ten (10) revolutions should take 20 ± 0.33 seconds for 30.0 ± 0.5 rpm. To terminate the verification of the speed of gyration, press the ROTATE key. The speed of gyration is constantly compared to the central processing unit's internal clock which provides a very accurate time base. If the speed of gyration is not within specified parameters, consult the factory. Select CONTINUE and Press the ENTER key to proceed to the ram force calibration menu.

4. Consolidation Pressure (Ram Force)

SUPERPAVE™ specifications require the consolidation pressure to be within ± 3%. The ram force calibration should follow ASTM E4 “Standard Practice for Load Verification of Testing Machines”.

The consolidation pressure is calibrated by measuring the force applied by the ram with a proving ring. Prior to verifying or calibrating the ram force, the proving ring must be flexed to at least the maximum load that will be used during calibration. Use the RAM and DOWN ARROW keys to flex the ring. A steel block 1/8 inch thick between the proving ring and the ram foot must be used to prevent damage to the wear surface on the ram foot. The proving ring must be centered under the ram and the compactor and ring should be at room temperature.

The Pine Instrument proving ring is supplied with a certification document which includes a table of the dial reading and corresponding applied force. It also includes ±1% and ±3% readings. This certificate is stored behind the foam in the proving ring case lid.

Select CALIBRATE from the ram force calibration menu and press the ENTER key. The controls prompt the operator to load to a specific force (1500 through 18000 Newtons). The operator applies the predetermined force by manually jogging the ram using the RAM and DOWN ARROW keys at the same time, then presses the ENTER key when the correct force is reached on the proving ring. Note: The dial on the proving ring should be tapped lightly to achieve an accurate reading. The computer control system stores the required information and prompts for the next predetermined force, repeating until the full range of the machine has been calibrated. When applying the force to the ring, it is critical that the force always be approached from a lesser value to avoid any hysteresis in the system from affecting calibration. If the target is overshot, the force must be reduced to less than the target value. To reduce the force, use the RAM and UP ARROW keys at the same time. Once the force is less than the target value, re-apply force by using the RAM and DOWN ARROW keys to achieve the target value.

The operator must verify the ram force calibration data prior to continuing the calibration procedure by selecting the VERIFY option on the ram force calibration menu. (The CONTINUE option is not valid until VERIFY has been run.) The controls automatically load the ram to the predetermined forces and the operator must verify that the force indicated on the proving ring

corresponds to the force displayed on the control panel. Use the certification sheet supplied with the proving ring to verify the applied force. If the load readings exceed ±3%, calibration is required. If the readings exceed ±1%, calibration is recommended. If the readings are within ±1%, select CONTINUE and press the ENTER key to proceed to the ram position calibration.

Note that it is probable that ram force will not require calibration. Selecting the VERIFY option from the menu first will allow the operator to simply verify the force calibration. If it is accurate, calibration of the force is not required and CONTINUE may be selected.

5. Ram Position

SUPERPAVE™ specifications require the height measurement to be accurate within ±0.1mm.

After the consolidation pressure (ram force) has been calibrated, the operator follows a similar procedure to calibrate ram position. Note: Before ram position can be calibrated, ram force verification must have been completed.

Select the CALIBRATE option from the menu and press the ENTER key. The control system prompts the operator to insert a series of precision gage blocks under the ram (see Figure 3.1, Chapter III - page 4). Metric or English unit blocks may be used by simply selecting the appropriate units from the menu. These blocks are then loaded throughout the full range of the ram force. Several gage blocks are used to calibrate specimen height for the full range of ram travel. By applying the ram force through the entire operating range of the compactor while a gage block of known height is in the machine, accurate information on the internal frame deflection is recorded. A matrix of data for machine frame deflection at various loads and ram extension positions is stored and utilized during normal operation to eliminate errors in measurement due to machine frame deflection.

The operator must verify the ram position calibration prior to continuing the calibration procedure. This is accomplished by selecting the VERIFY option on the ram position calibration menu and pressing the ENTER key. The CONTINUE option is not valid until VERIFY has been run. The controls automatically load the ram to a predetermined force and the operator must verify that the position indicated on the display corresponds to gage block height under the ram. 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. This verification routine may also be run prior to calibrating, to check that the calibration data is correct. If it is accurate, calibration is not required and CONTINUE may be selected.

Note: The specimen height reading differs from the ram position reading to account for the mold base and top plate. The ram position is the distance between the ram foot and the mold carriage base. The specimen height is the height of the specimen in a correctly assembled mold. If the mold base plate and top plate show excessive wear, they should be replaced. Their combined height should be 25.4+/-0.1 mm (1.000+/-0.004 inch).

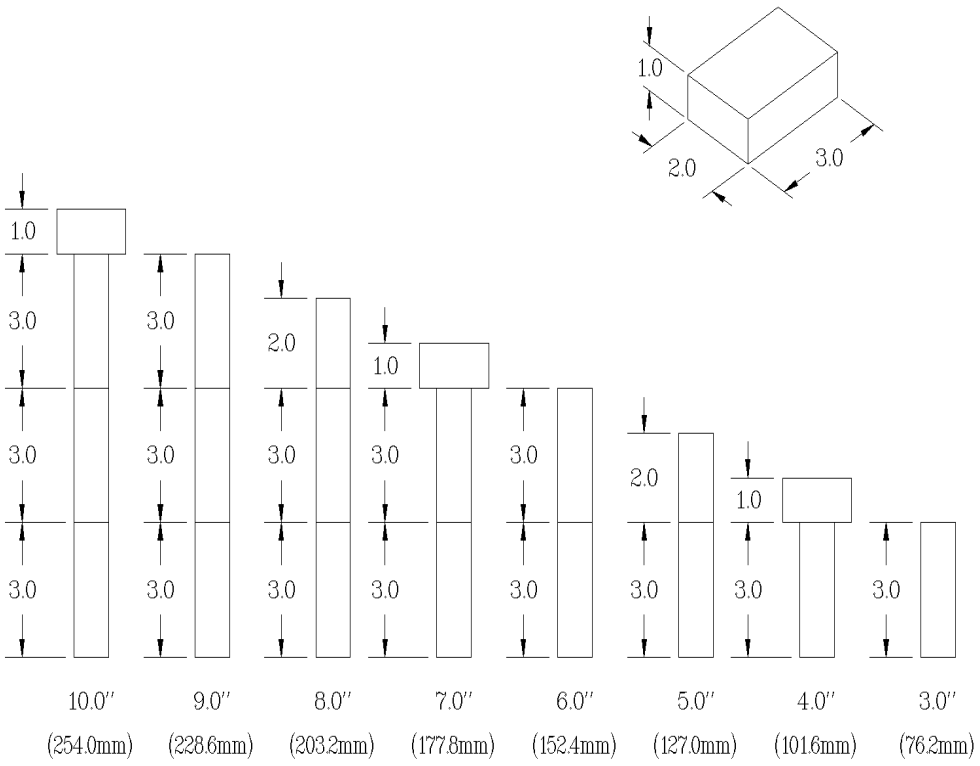


Figure 3.1: Gage Block Orientation

6. Angle of Gyration

SUPERPAVE™ specifications require the angle of gyration be $1.25^0 \pm 0.02^0$ (21.82 ±0.35mrad).

The angle of gyration is adjusted with a special, angle indicating apparatus. This is a manual adjustment. It is extremely important to thoroughly clean the mold carriage base, the mold rollers, the fixed ring, and the fixed ring rollers before starting this procedure. Any debris that is present will cause incorrect settings and will result in faulty results. This procedure should be done with the machine at room temperature. If HMA specimens have recently been compacted, let the unit cool before calibrating angle.

The angle of gyration is adjusted by changing the effective length of the mold carriage adjustable link (Fig.3.2, item 1, Chapter III - page 17). An eccentric worm driven cam (Fig.3.2, item 7), which is incorporated into the adjustable link, is used to accurately adjust the position of the fixed ring rollers. The worm screw (Fig.3.2, item 8) meshes with teeth on the eccentric cam so that rotating the worm screw causes the eccentric cam to rotate. Due to the eccentricity between the cam inside and outside diameters, rotating the cam changes the distance between the fixed ring rollers (Fig.3.2, item 9) and the mold rollers (Fig.3.2, items 3 & 4) mounted on the adjustable link. This adjustment changes the angle of gyration induced onto the specimen by the frame mounted fixed ring (Fig.3.4, item 6, Chapter III - page 19). The zero degree stop bolt (Fig.3.2, item 11) must be reset when the gyration angle is changed. The zero degree position adjustment procedure is found in section 6.2, Chapter III - page 10.

The following flow chart shows the procedure for both verification and calibration of the angle of gyration. Follow sections 6.1, 6.2, and 6.3 for detailed instructions on verifying and calibrating the mold roller clearance, zero degree position, and angle verification / adjustment.

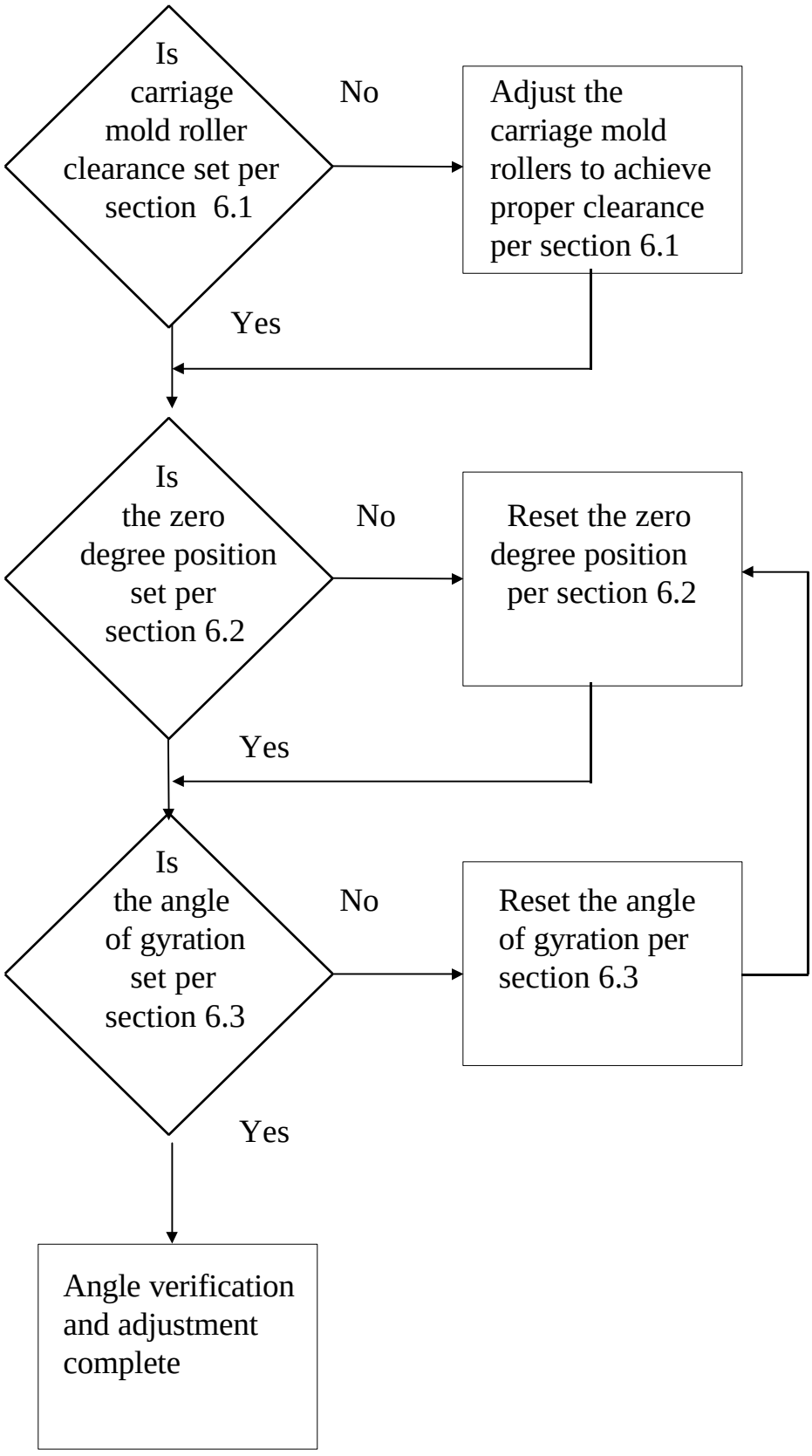
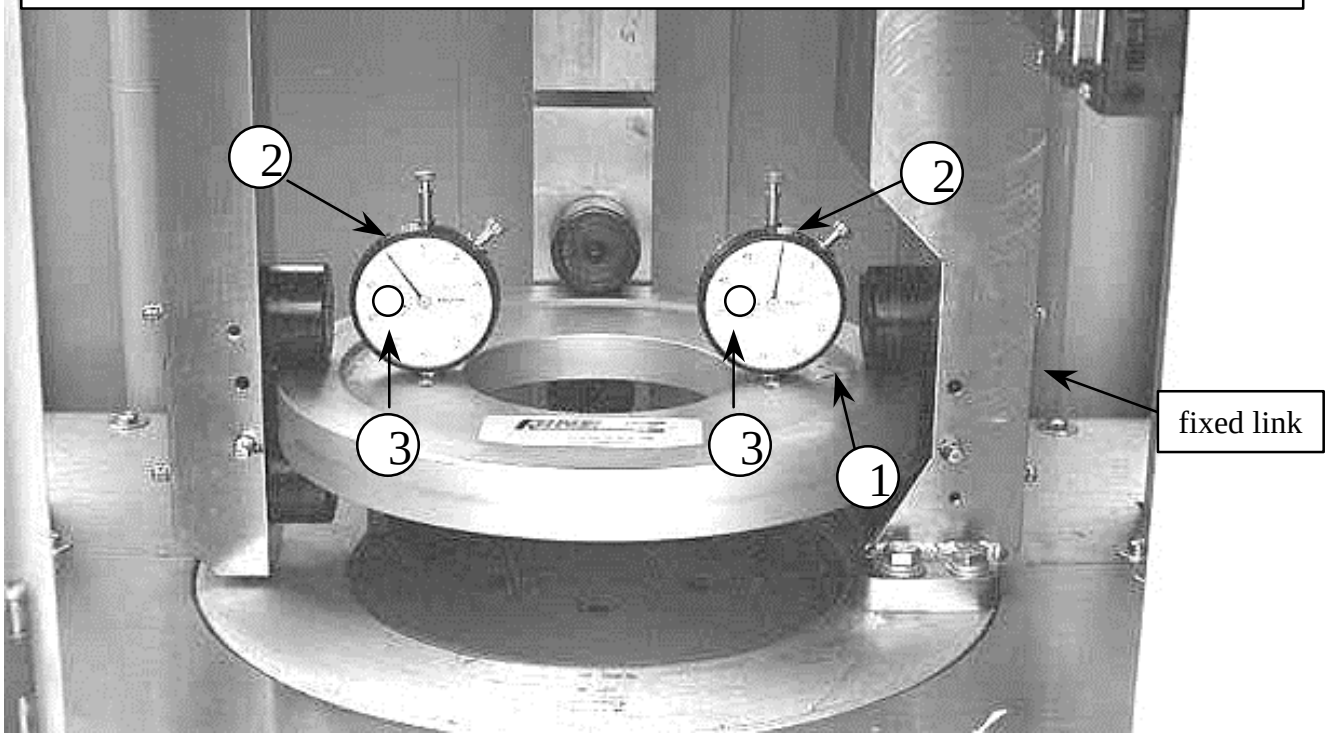


Photo A: Angle indicating apparatus in mold carriage roller sets (3 o'clock position)



6.1 Carriage mold roller clearance

The angle is set in an unloaded condition using the angle indicating apparatus which is in the shape of the mold flange (see Figure 3.3, Chapter III - page18). Remove the left upper side panel and rear access panels. Reference photo H, Chapter III- page 13, for location of left upper side panel and rear access panels.

*****Caution*****

Extreme caution must be used while operating the lift mechanism with the guards removed!

Keep hands clear of pinch points!

Note: When making adjustments to the angle of gyration, always disconnect power to prevent accidental machine movement while the mechanism is being adjusted.

1. The indicators must be properly set into the angle indicating apparatus. Check that the extensions on the dial indicators are tight. Proper placement of the indicators is required to use the angle indicating apparatus for measuring the angle of gyration. Place the angle indicating apparatus into the mold carriage roller sets (photo A). Place the angle indicating apparatus so that the engraved arrow (Photo A, item 1) is at the 3 o'clock position as viewed from the top of the machine. Set the bezel (large dial, Photo A, item 2) on each indicator to zero. The small dial (Photo A, item 3) on each indicator should be at 3.5 (see fig. 3.4, Chapter III - page 19). Reference section 7, Chapter III - page 25, figures 3.8 and 3.9 for instructions on reading the dial indicators.

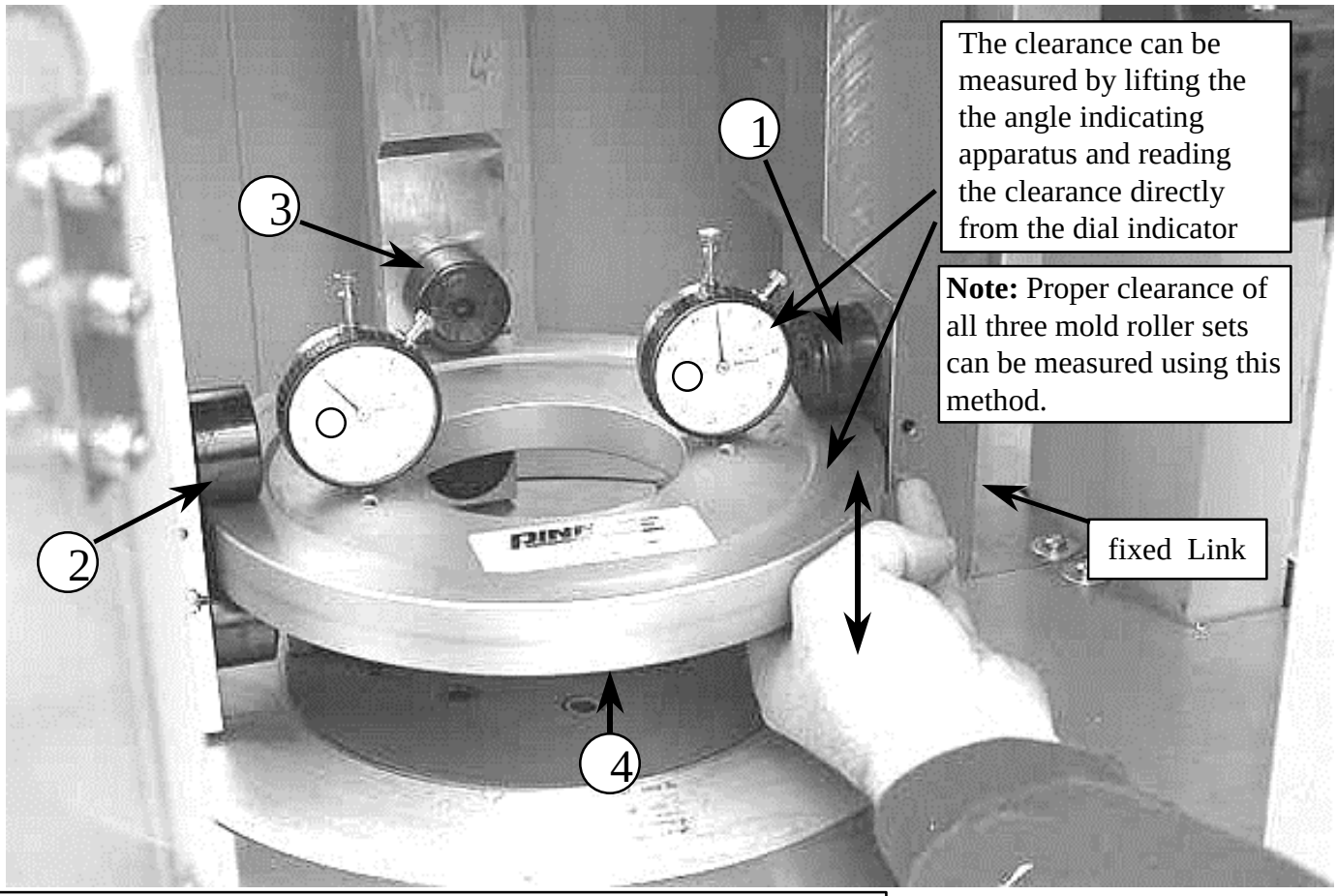


Photo B: Proper clearance measurement using angle indicating apparatus

2. Check that there is proper clearance between the mold carriage roller sets (Photo B, items 1, 2 and 3) and the angle indicating apparatus (Photo B, item 4). With the machine at the parked postion, lift the angle indicating apparatus and read the clearance directly with the dial indicators as shown above in Photo B. For an accurate measurement, the dial indicators must be aligned to the roller set being measured. Photo B shows the angle indicating apparatus aligned for measuring the roller clearances between the fixed and adjustable links. Therefore, the angle indicating apparatus must be rotated 90 degrees to the 6 o'clock position to measure the clearance of the intermediate link roller set. If the clearance between the fixed link roller set (item 1) is greater than 0.002" or less than 0.0015" it must be corrected (proceed to step 3, Chapter III - page 8). If the clearance between the roller sets on the intermediate and adjustable links (items 2 and 3) are greater than 0.004" or less than 0.002", they must be corrected. If all clearances are correct, proceed to section 6.2, Chapter III - page10.

Note: It is normal for only one roller of each set of rollers to be in contact with the mold flange during operation. It is important to maintain proper clearance between the mold flange and rollers to avoid overloading the rollers.

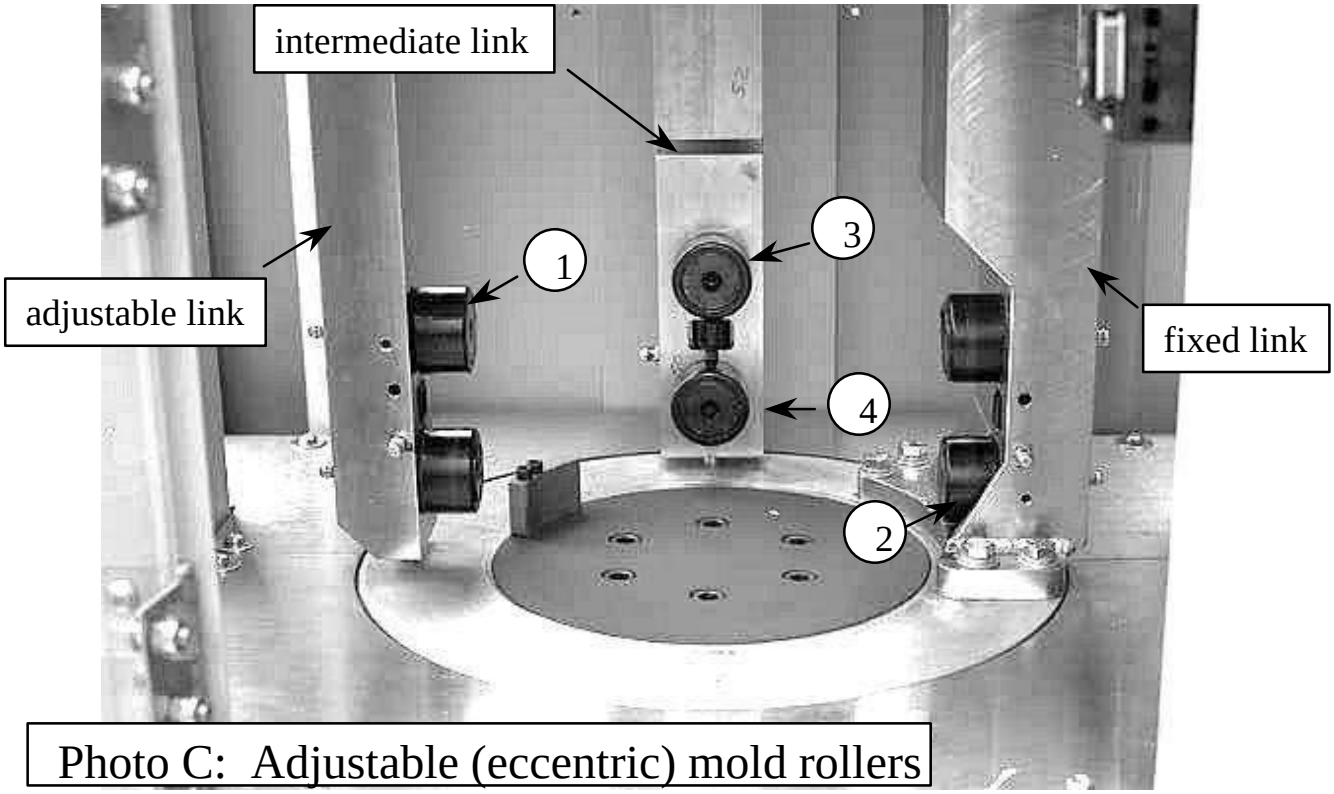


Photo C: Adjustable (eccentric) mold rollers

3. The top roller on the adjustable link (Photo C, item 1), the bottom roller on the fixed link (Photo C, item 2), and both the top and bottom rollers on the intermediate link (Photo C, items 3 and 4 respectively) have eccentric mounts. Turning these rollers will change the distance between the mold roller sets. When adjusting the clearance between the intermediate link roller set, use the top roller (Photo C, item 3). **Note:** It is very important to have the proper clearance between the fixed link rollers (Photo C, item 2). If proper clearance is not achieved, the zero degree position reading in section 6.2 will be incorrect. Figure 3.10 below shows the proper clearances for all three roller sets.

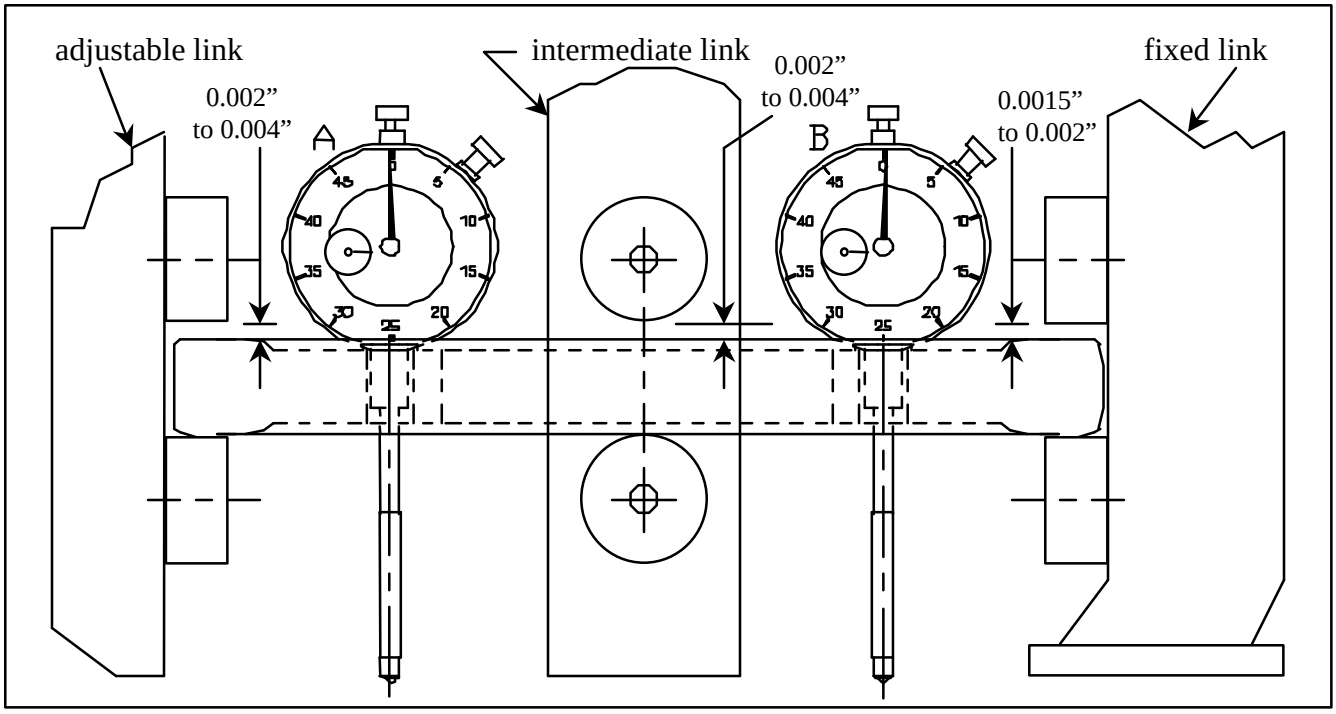


Figure 3.10 : Mold roller clearances

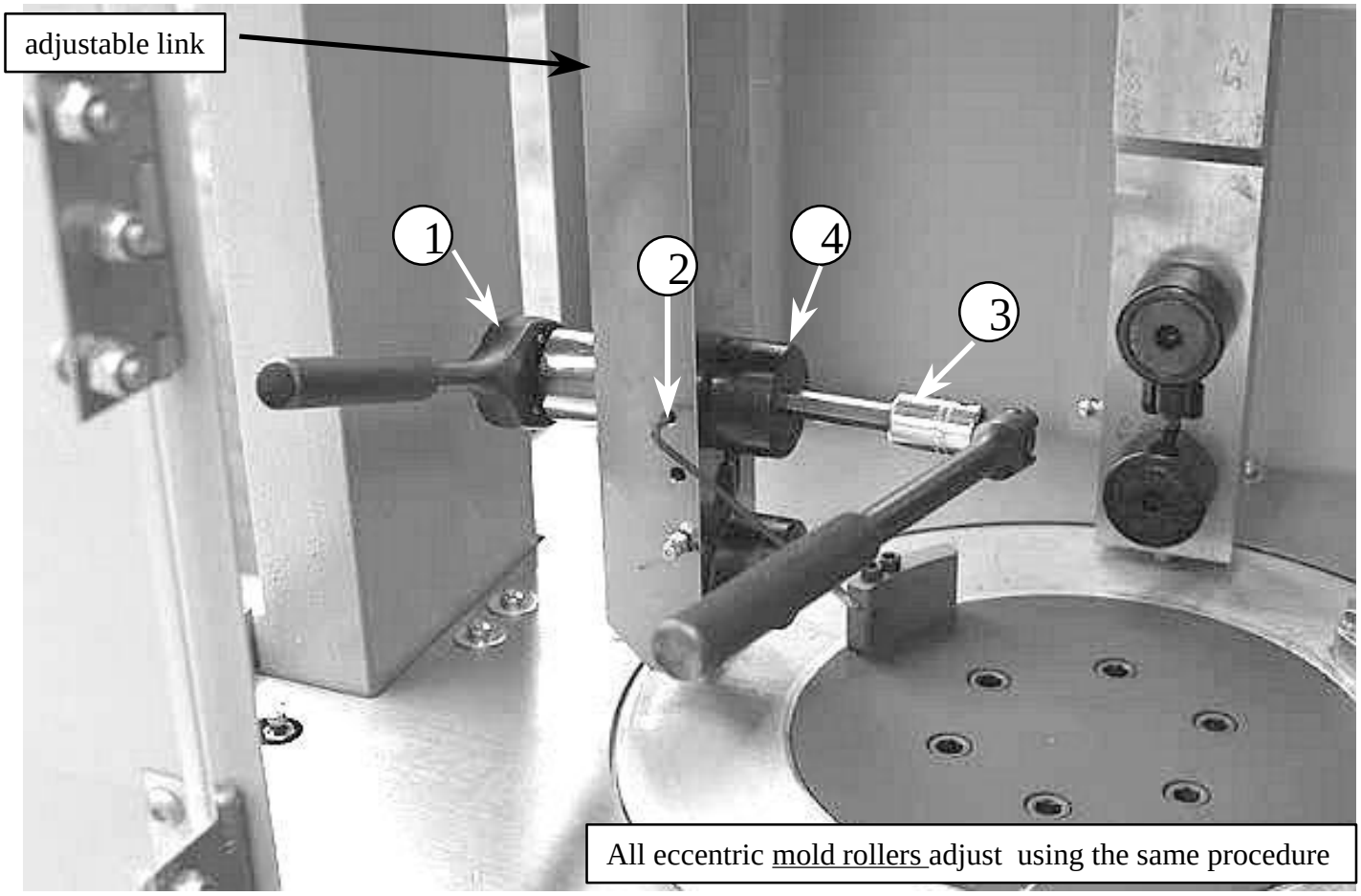


Photo D: Mold roller adjustment

4. To correct for improper mold roller clearance, loosen the set screw (Photo D, item 2). Loosen the mold roller nut with the socket wrench (Photo D, item 1) just slightly so that the nut is snug but allows the roller (Photo D, item 4) to turn. With the angle indicating apparatus in the carriage, rotate the eccentric mold roller with the hex wrench (Photo D, item 3) clockwise or counter-clockwise until there is proper clearance between the roller set and the angle indicating apparatus. Read the clearance directly with the dial indicator (see photo B, Chapter III - page 7). **Note:** When making an adjustment to the eccentric rollers, **DO NOT** pinch the mold rollers on the angle indicating apparatus (i.e. force the clearance to be 0.0000"). This may damage the angle indicating apparatus and cause false readings.

5. Recheck all roller sets for proper clearance (reference section 6.1, step 2, Chapter III - page7 for clearances). If proper clearance is obtained, tighten the roller nut with the socket wrench (Photo D, item 1) while holding the mold roller in place with the hex wrench (Photo D, item 3). Tighten the set screw (Photo D, item 2). Recheck roller sets for proper clearance. If clearance is incorrect, repeat steps 4 and 5. If correct, proceed to section 6.2, Chapter III - page 10.

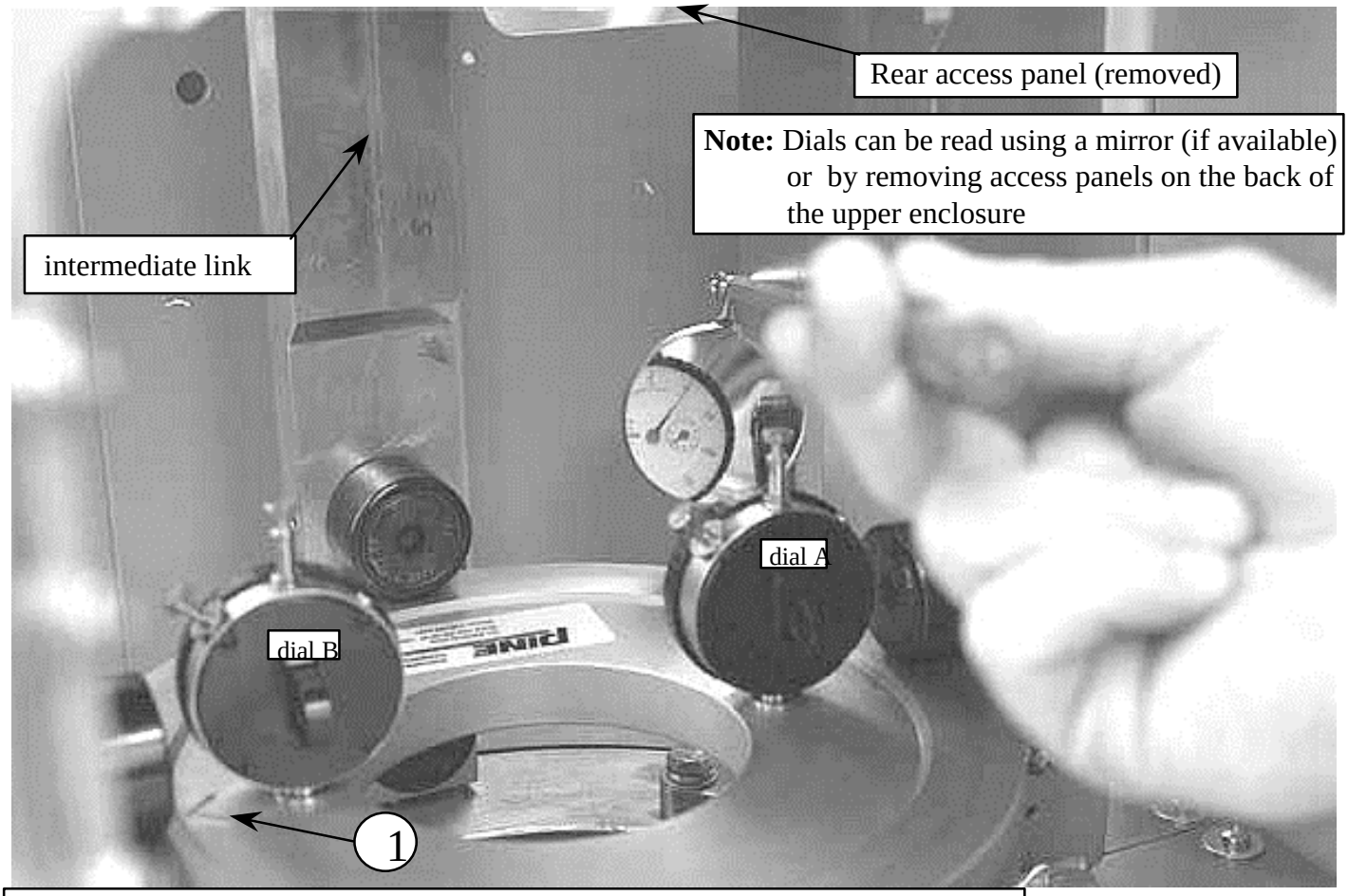


Photo E: Angle indicating apparatus in mold roller sets
(**9 o'clock position**)

6.2 Zero Degree Position

1. With the engraved arrow on the angle indicating apparatus at the 3 o'clock position (reference Photo A, Chapter III - page 6), set both dial indicators to 0.3500" (see Figure 3.8, Chapter III-page 25). Rotate the angle indicating apparatus 180 degrees in the mold carriage so that the engraved arrow is at the **9 o'clock position** (Photo E, item 1). If the zero degree position is correctly set, the dial indicator readings will remain within 0.3500" +/- 0.001" at the 9 o'clock position. If so, proceed to section 6.3, Chapter III - page 12. If the dial readings do not remain within 0.3500" +/- 0.001" at the 9 o'clock position, the zero degree position is incorrect and must be reset, proceed to step 2.

2. With the angle indicating apparatus at the **9 o'clock position,** set both dial indicators to 0.3500" (see Figure 3.8, Chapter III-page 25). Rotate the angle indicating apparatus (180 degrees) to the **3 o'clock position** (reference Photo A, Chapter III - page 6). Note the direction and the amount of change required to return dial A to 0.3500" (dial A is the left dial with the angle indicating apparatus at the 3 o'clock position). For example, if dial A reads 0.3515" the zero degree position must be raised 0.0015" to return the dial to 0.3500". Proceed to step 3 for instruction on adjusting the zero degree position.

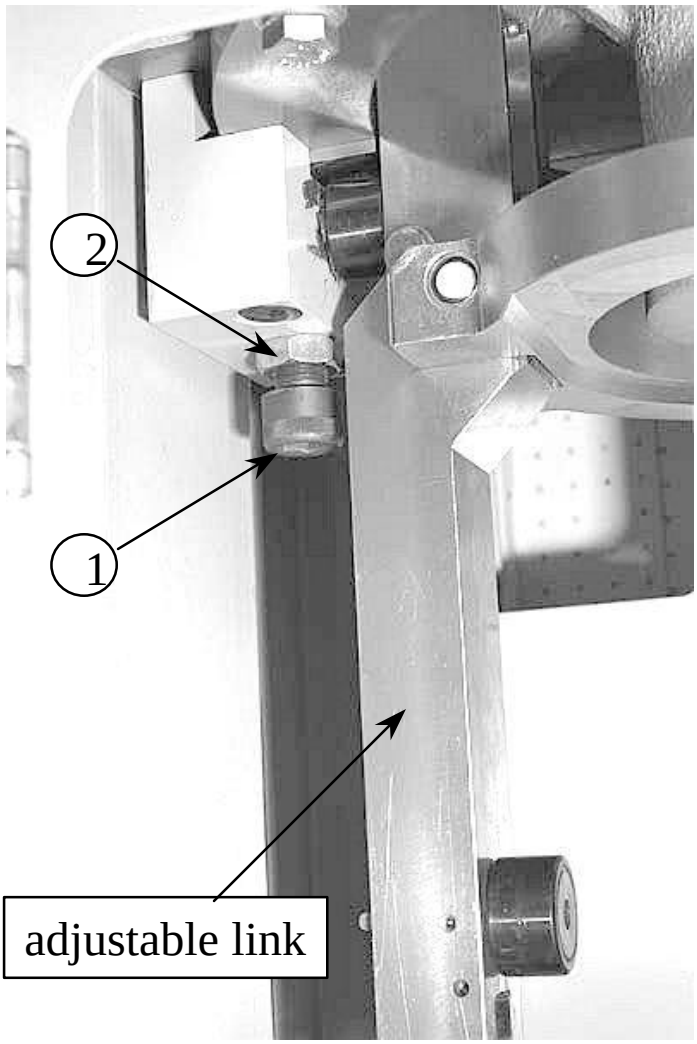


Photo F: Stop bolt and lock nut (Carriage in park position)

3. Use the stop bolt (Photo F, item 1) to adjust the zero degree position of the tilt mechanism. Press the ANGLE and UP ARROW keys at the same time to release pressure from the stop bolt. Loosen the stop bolt lock nut (Photo F, item 2) and rotate the stop bolt in the required direction. Clockwise rotation of the stop bolt will raise the zero degree position, counter-clockwise rotation will lower the zero degree position. Press the ANGLE and DOWN ARROW keys to return the lift link to the zero degree position. Recheck the dial indicator readings at the 3 o'clock and 9 o'clock positions (Reference Photo E, Chapter III- page10).

4. Repeat steps 2 and 3 until the dial indicators remain within 0.3500" +/- 0.001" at the 9 o'clock position. Lock the stop bolt (Photo F, item 1) in position with the lock nut (Photo F, item 2) without turning the stop bolt. Check that both dial indicators read 0.3500".

5. The intermediate link rollers (Photo C, items 3 and 4 , Chapter III - page 8) are both eccentric and their position must be checked. With the tilt mechanism at the zero degree position, rotate the angle indicating apparatus (90 degrees) from the 3 o'clock position to the **6 o'clock position**. If the zero degree position is correct, the dial indicator readings should remain within 0.3500" +/- 0.001". If so, proceed to section 6.3, Chapter III - page 12. If incorrect, proceed to step 6.

6. Loosen both roller nuts and set screws on the intermediate link (procedure found Photo D, steps 4 and 5, Chapter III - page 9). Use the bottom eccentric roller (Photo C, item 4, Chapter III - page 8) to adjust the zero degree position as necessary. Use the top eccentric roller (Photo C, item 3, Chapter III - page 8) to set proper clearance (as directed in section 6.1, Chapter III - page 6). **Do not** pinch the rollers sets on the angle indicating apparatus. The dial indicator readings should remain within 0.3500" +/- 0.001" as the angle indicating apparatus is rotated 360 degrees.

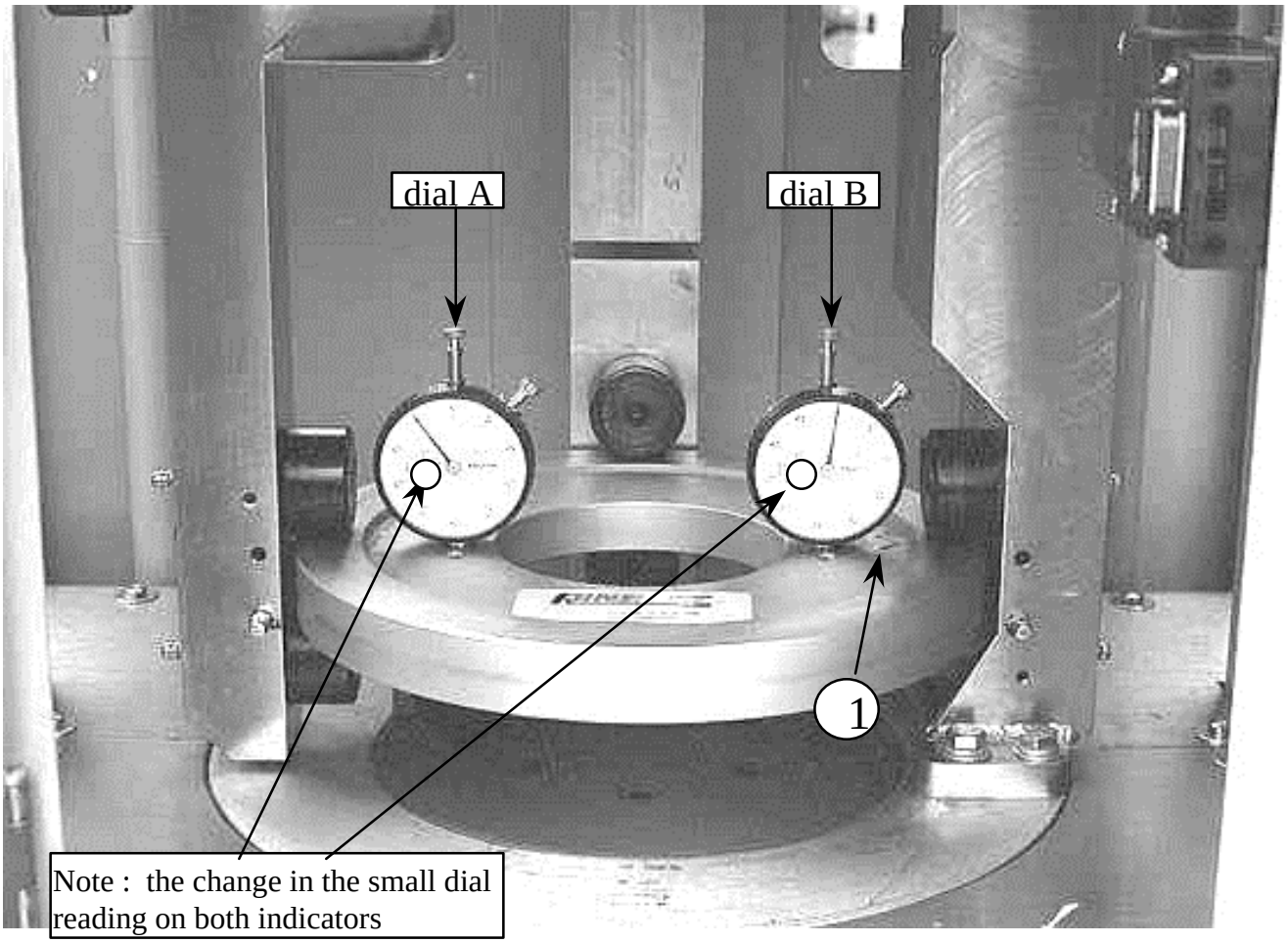


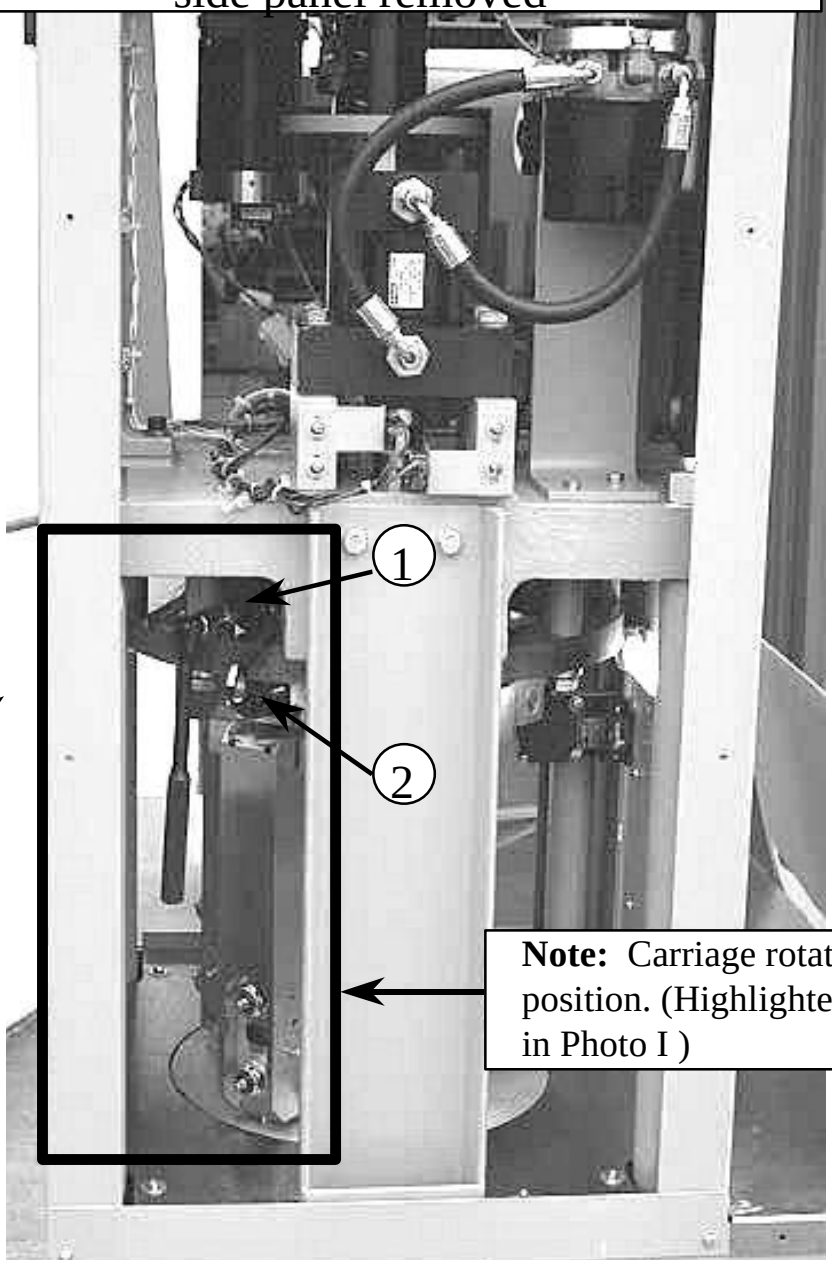
Photo G: Angle indicating apparatus in carriage mold roller sets (3 o'clock position / angle induced)

6.3 Angle Verification / Adjustment Procedure

1. Place the angle indicating apparatus so that the engraved arrow (Photo G, item 1) is at the 3 o'clock position. Press the ANGLE key and the UP ARROW key to tilt the mechanism to the inclined position so that the mold carriage may rotate. Reference section 7, Chapter III - page 25, figures 3.8 and 3.9 for instructions on reading the dial indicators.

2. Use Table 3.1, Chapter III - page 18, to determine X(IN), the difference in inches, between the dial indicator readings at the desired angle. For angles not in the table, use equation 3.2 to determine the correct difference between the dial readings. Because of a slight change in angle from an unloaded to loaded condition, it is acceptable to have the unloaded angle set slightly high (up to 1.28 degrees: X(IN) = 0.1126") to achieve an operating angle of 1.23 -1.27 degrees.

Photo H: View of upper left enclosure with side panel removed



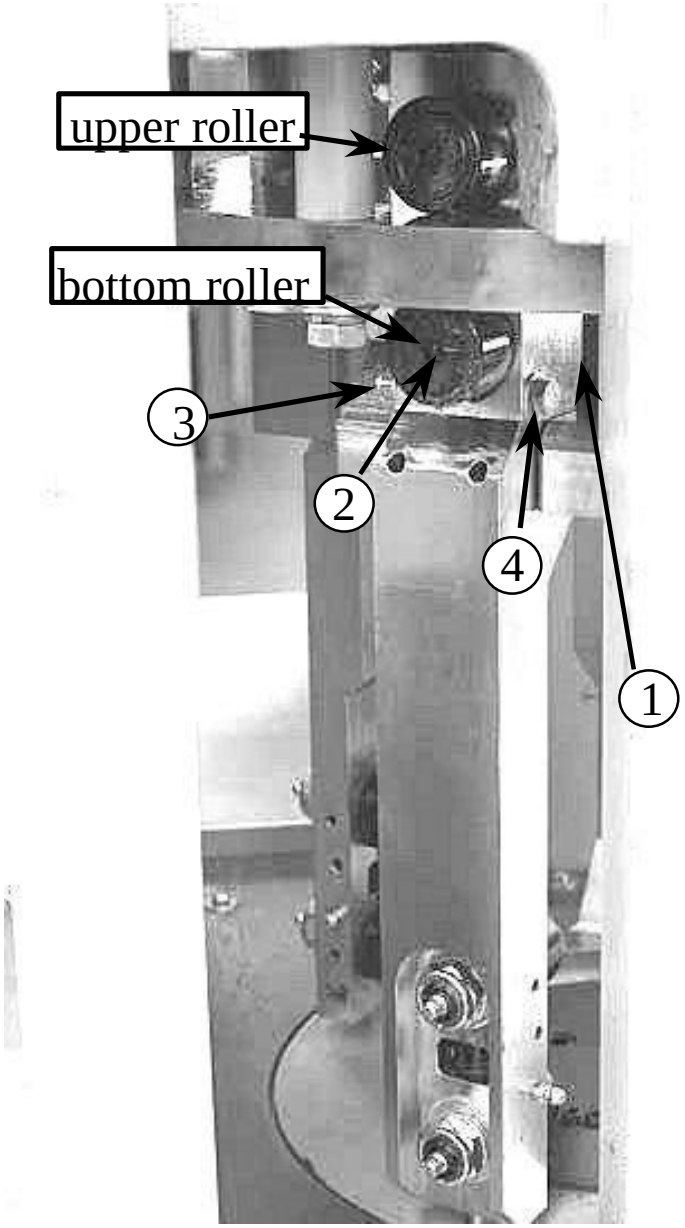
Rear access panels (not visible in this photo)

Note: Carriage rotated to access position. (Highlighted section shown in Photo I)

3. Take an angle measurement (as directed in step 2, Chapter III - page 12) and make a note of the **amount of change** in the dial indicator readings needed to achieve the desired angle. Press the ROTATE and DOWN ARROW keys to rotate the mold carriage approximately 30 degrees so that the fixed ring rollers (Photo H, items 1 and 2) are accessible. Place the angle indicating apparatus so that the engraved arrow is aligned with the fixed link.

4. To change the angle of gyration, loosen each fixed ring roller nut (Photo I, item 1, Chapter III-page 14) just slightly. The roller nuts must be snug but still allow the worm screws (Photo I, item 4, Chapter III - page 14) to turn the eccentric cam without excessive force. **To loosen the fixed ring rollers (Photo I, item 2, Chapter III - page 14) for adjustment, use the hex wrench to turn the roller while holding the roller nut (Photo I, item 1, Chapter III - page 14) with the ratchet and socket.** These tools are supplied in the tool kit.

Photo I: Adjustable link at access position



Note: Items 1 thru 4 pertain to each fixed ring roller. Item 1 shows where the fixed ring roller nuts (hidden in this view) are located. (Reference Items 9 (roller) and 13 (roller nut) , Figure 3.2)

5. Take another angle measurement. Note that the dial indicator readings are different after the rollers are loosened. Add or subtract the **amount of change** (calculated in step 3, Chapter III - page 13) to this measurement. This is the desired reading that will be set to achieve the desired angle change.

6. Loosen each worm screw nut (Photo I, item 3) approximately 1/2 turn to allow the worm screw (Photo I, item 4) to turn. **Note:** The worm screw will turn easily if the roller nut and worm screw nut are properly loosened. **Do not** force the worm screw.

7. Back the bottom fixed ring roller away from the fixed ring by rotating its worm screw (Photo I, item 4) approximately 3 turns counter-clockwise. Use the upper roller worm screw to adjust the angle. Clockwise rotation of the worm screw for the upper roller will increase the angle of gyration. **Note:** Always increase the angle to the desired measurement. If the desired measurement is below the current measurement, decrease the angle below the desired measurement then increase the angle.

8. Once the desired measurement is obtained, tighten the upper worm screw nut (Photo I, item 3) but do not turn the worm screw (Photo I, item 4). Tighten the upper roller nut (Photo I, item 1). Remove the angle indicating apparatus from the mold carriage. Use the ROTATE and ARROW keys to return the mold carriage to the parked position. Replace the angle indicating apparatus into the mold carriage. If the angle was changed, the zero degree position must be reset. Repeat steps 1 through 6, section 6.2, Chapter III - pages 10-11 . Take another angle measurement as directed in step 2, Chapter III - page 12. If the desired angle has been obtained, proceed to step 9. If not, repeat steps 1 through 8 of this section, Chapter III - pages 12-14.

9. Remove the angle indicating apparatus from the mold carriage. Press the ROTATE and the DOWN ARROW keys to rotate the mold carriage approximately 30 degrees so that the fixed ring rollers (Photo H, items 1 and 2, Chapter III - page 13) are accessible. Turn the bottom worm screw clockwise (Photo I, item 4) to achieve proper clearance (0.002") between the fixed ring and the rollers. Use a 0.002 inch feeler gage to set proper clearance. Tighten the bottom worm screw nut and bottom roller nut. Recheck the rollers for proper clearance and any indications of binding.

6.4 Angle verification During Compaction

The angle of gyration should be verified in a loaded condition to ensure all parameters are within specifications during compaction. This procedure is recommended for accurate machine calibration. The angle is verified using the angle verification jig which clamps onto the mold after the mold is inserted into the compactor (see Figure 3.7, Chapter III - page 22).

Procedure:

1. Prior to starting compaction, place the dial indicators from the angle indicating apparatus into the bushings on the angle verification jig and tighten the set screws. Make sure the dial indicators are not binding. The dial indicators should read 0.250 when clamped to a mold that is sitting on a flat surface such as the compactor worksurface.

   When using the angle verification jig, be sure that it is properly seated, firmly clamped, and that no debris is affecting the reading.

2. Prepare a HMA specimen and charge the mold. Place the mold into the compaction chamber. Be sure the mold is properly seated in the mold carriage and lubricated as normal. **Do not** lubricate the mold flange with the powder lubricant. Place the angle verification jig onto the mold flange and clamp it in position. The bar on the right side of the verification jig should be against the fixed link to center the jig between the carriage linkages. Rotate each dial indicator bezel to read .2500". Record the left indicator reading as VA_1 and the right as VB_1. (see Figure 3.7, Chapter III - page 22).

3. **Remove the angle verification jig** and press the START key. Press the ANGLE key while the ram is moving into position and **before** it applies pressure to the specimen. An asterisk will appear in the lower right corner of the panel display. **Note:** this will activate the **loaded angle measurement** run cycle.

4. Once the angle of gyration has been induced but **prior** to the carriage rotating, the machine will automatically pause. The control panel display will give instructions to take a measurement. Place the angle verification jig back on the mold and record the readings as VA_2 and VB_2.

5. **Remove the angle verification jig** and press START. Gyratory compaction will begin.

6. Press the Angle key after 40-50 gyrations have been completed to measure the angle. The carriage will rotate to the park position and pause. Place the angle verification jig onto the mold and record the readings as VA_3 and VB_3.

   Use the following equation, the Excel workbook gyroang.xls (located in the Pine directory when installed with Pine-Pave) or the angle calculator in OTHER OPTIONS (see section 2.2, Chapter II - pages 3 through 6) to calculate the angle of gyration.

$$Anglea\,^{\circ} = Tan^{-1}\left(\frac{\sqrt{\left[0.524*\left(\left(VA_2 - VA_3\right)+\left(VB_2 - VB_3\right)\right)\right]^2 + \left[\left(VB_3 - VB_1\right)-\left(VA_3 - VA_1\right)\right]^2}}{5.042}\right) \quad \text{Eq. 3.3}$$

VA_1: Initial left dial reading prior to starting the test.
VA_2: Left dial reading after tilt and pressure is applied but **prior** to gyration.
VA_3: Left dial reading during gyration (after at least one gyration).
VB_1: Initial right dial reading prior to starting the test.
VB_2: Right dial reading after tilt and pressure is applied but **prior** to gyration.
VB_3: Right dial reading during gyration (after at least one gyration).

7. **Remove the angle verification jig** and press START. Gyratory compaction will resume. Repeat step 6 and record additional VA_3 and VB_3 readings as desired for additional measurements.

8. If the angle must be adjusted, use the following equation to determine the amount to increase or decrease the setting of the angle in the unloaded condition. Add (or subtract if negative) the calculated value of *Adjustment* to the value *X(IN)* obtained in equation 3.1 when setting the angle to compensate for the change in angle from an unloaded condition to a loaded condition. Increasing (or decreasing) the dial reading A_2 by the *Adjustment* value calculated in equation 3.4 will give approximately the desired results. If the adjustment value is less than 0.002", no adjustment is recommended.

$$Adjustment = 5.042 * Tan\left(1.25^{\circ} - Anglea\,^{\circ}\right) \quad \text{Equation (3.4)}$$

$$\left(A_1 - A_2\right) - \left(B_1 - B_2\right) = X(IN) \quad \text{Equation (3.1)}$$

Do not make angle adjustments based on one set of readings due to the potential for errors in making these measurements. Take readings on several specimens and base the required changes on the average of these readings.

Note: To loosen the fixed ring rollers (Figure 3.2, item 9, Chapter III - page 18) for adjustment, use a hex wrench to turn the roller while holding the roller nut with the ratchet and socket. These tools are supplied in the tool kit.

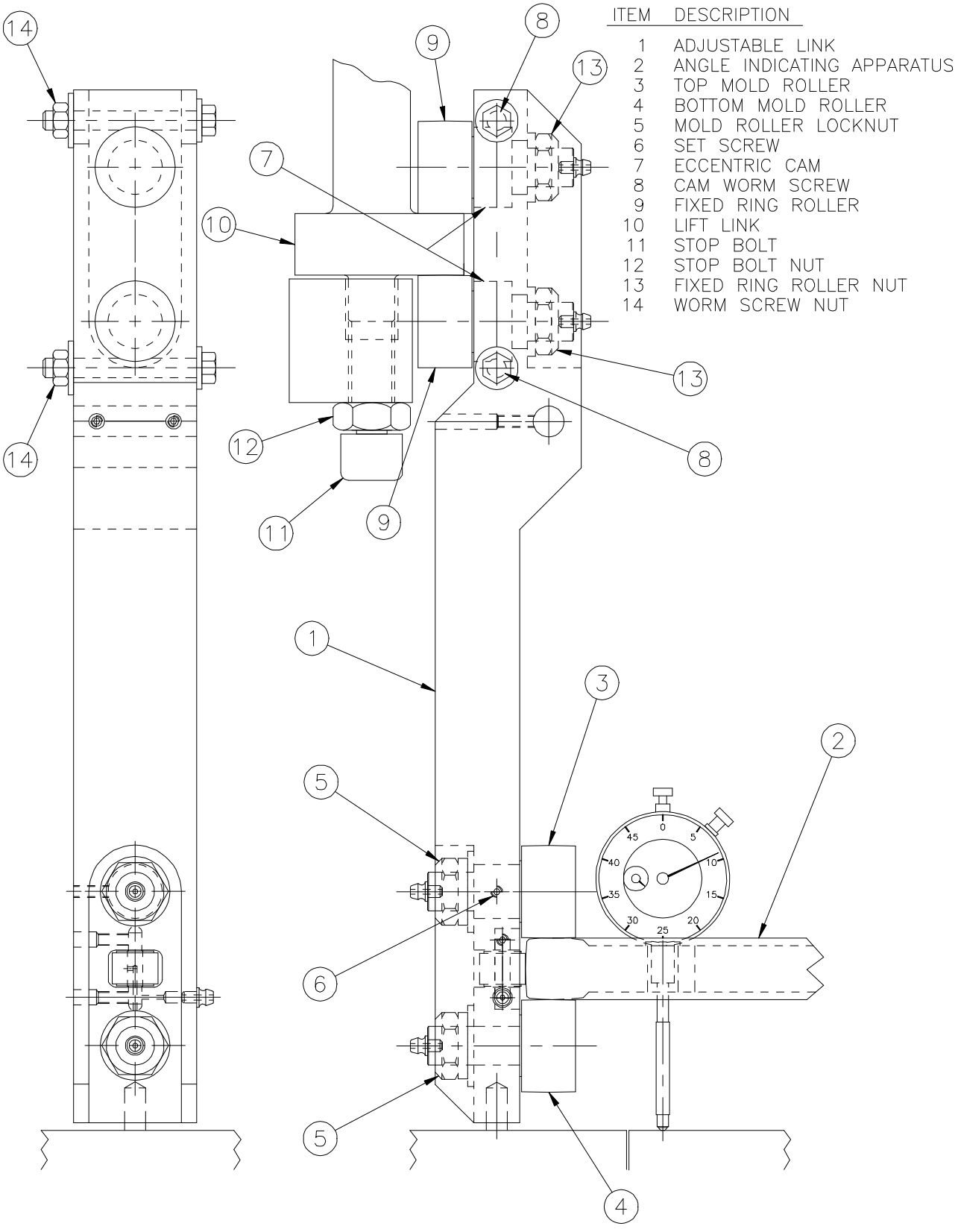


FIGURE 3.2: ADJUSTABLE LINK

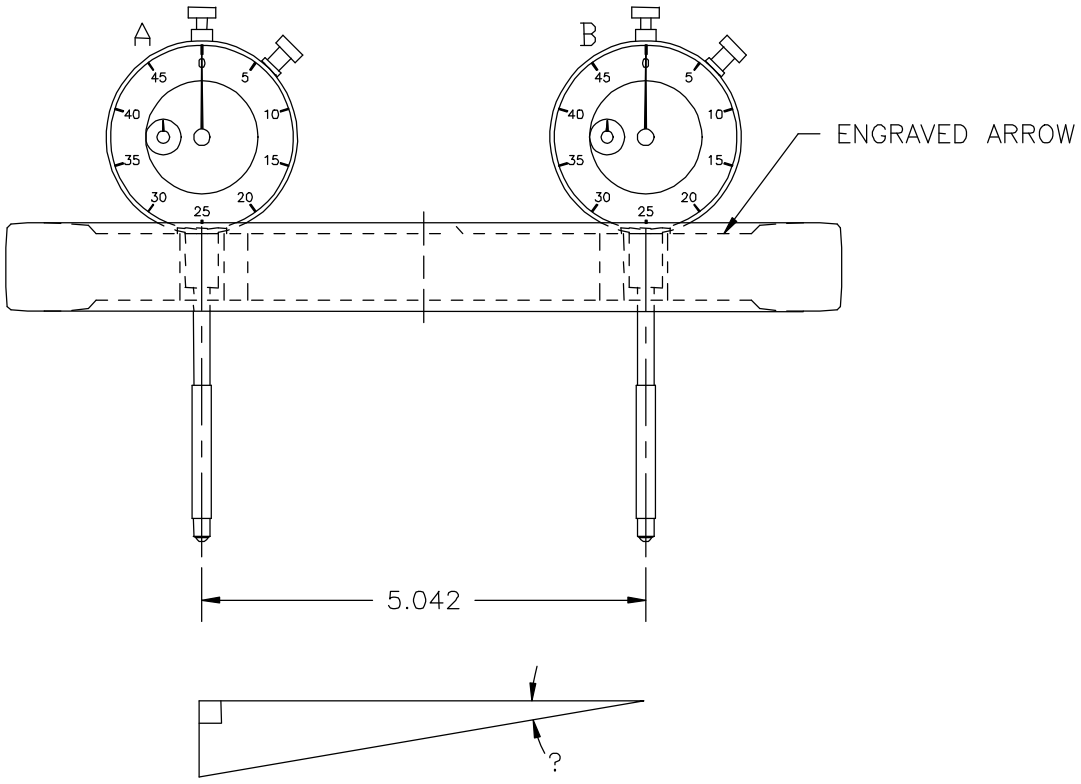


FIGURE 3.3: ANGLE INDICATING APPARATUS

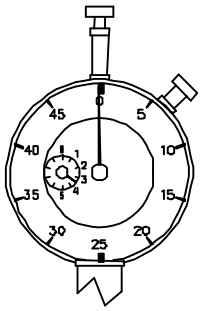
$(A_1 - A_2) - (B_1 - B_2) = X(IN)$ EQUATION (3.1)

$(5.042)\tan ? = X(IN)$ EQUATION (3.2)

A_1: READING OF DIAL A, 0.0°
A_2: READING OF DIAL A, INCLINED
B_1: READING OF DIAL B, 0.0°
B_2: READING OF DIAL B, INCLINED

TABLE 3.1: DIAL READING VS. ANGLE OF GYRATION

ANGLE OF GYRATION (?)	X(IN)	RANGE ±0.02° (±0.35mrad)
0.50° (8.73mrad)	0.0440	.0422 – .0458
0.75° (13.09mrad)	0.0660	.0642 – .0678
1.00° (17.45mrad)	0.0880	.0862 – .0898
1.25° (21.82mrad)	0.1100	.1083 – .1118
1.50° (26.18mrad)	0.1320	.1303 – .1338
1.75° (30.54mrad)	0.1540	.1523 – .1558
2.00° (34.91mrad)	0.1761	.1743 – .1778



LARGE DIAL ON ZERO AND SMALL DIAL ON 3.5 AT ZERO DEGREE POSITION.

DIAL INDICATOR DETAIL

ITEM	DESCRIPTION
1	ANGLE INDICATING APPARATUS
2	ADJUSTABLE LINK
3	LIFT LINK
4	STOP BOLT
5	FIXED RING ROLLERS
6	FIXED RING
7	ECCENTRIC CAM WORM SCREW
8	LOCKNUT
9	FIXED LINK
10	INTERMEDIATE LINK
11	CARRIAGE MOLD ROLLERS
12	MOLD ROLLERS LOCKNUTS

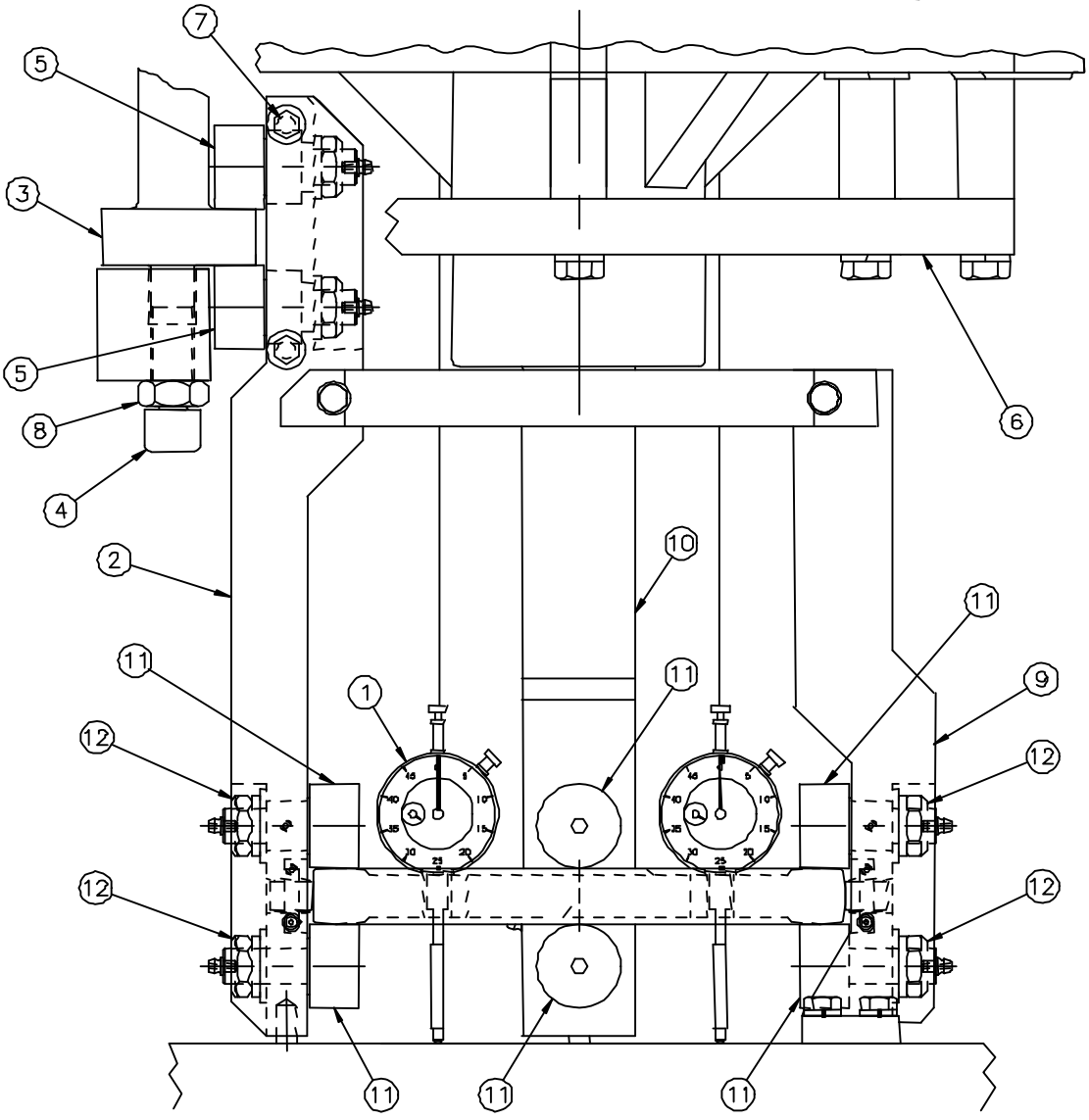


FIGURE 3.4: CUTAWAY VIEW OF ANGLE INDICATING APPARATUS IN MOLD CARRIAGE

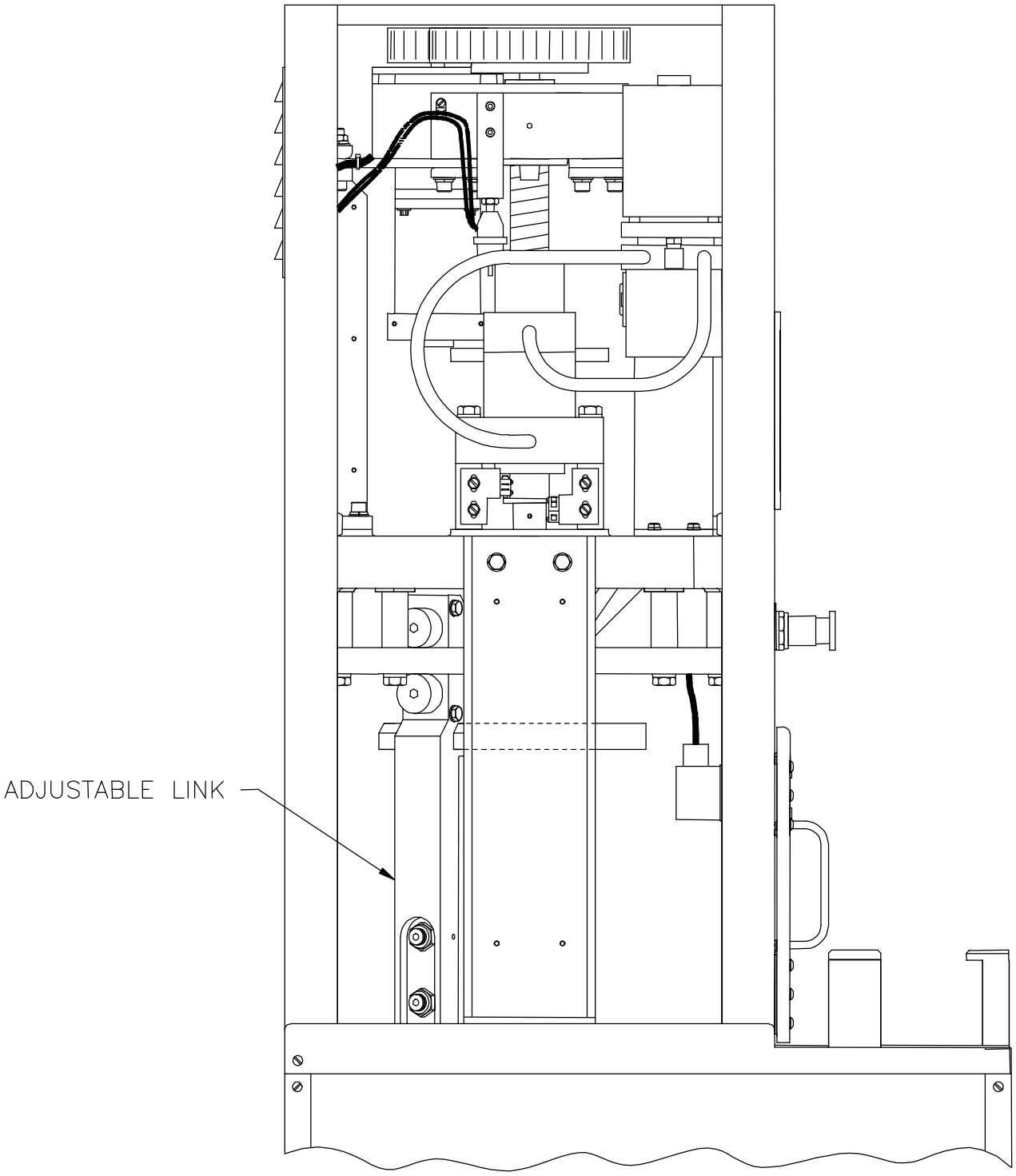


FIGURE 3.5: CARRIAGE POSITION FOR ANGLE ADJUSTMENT

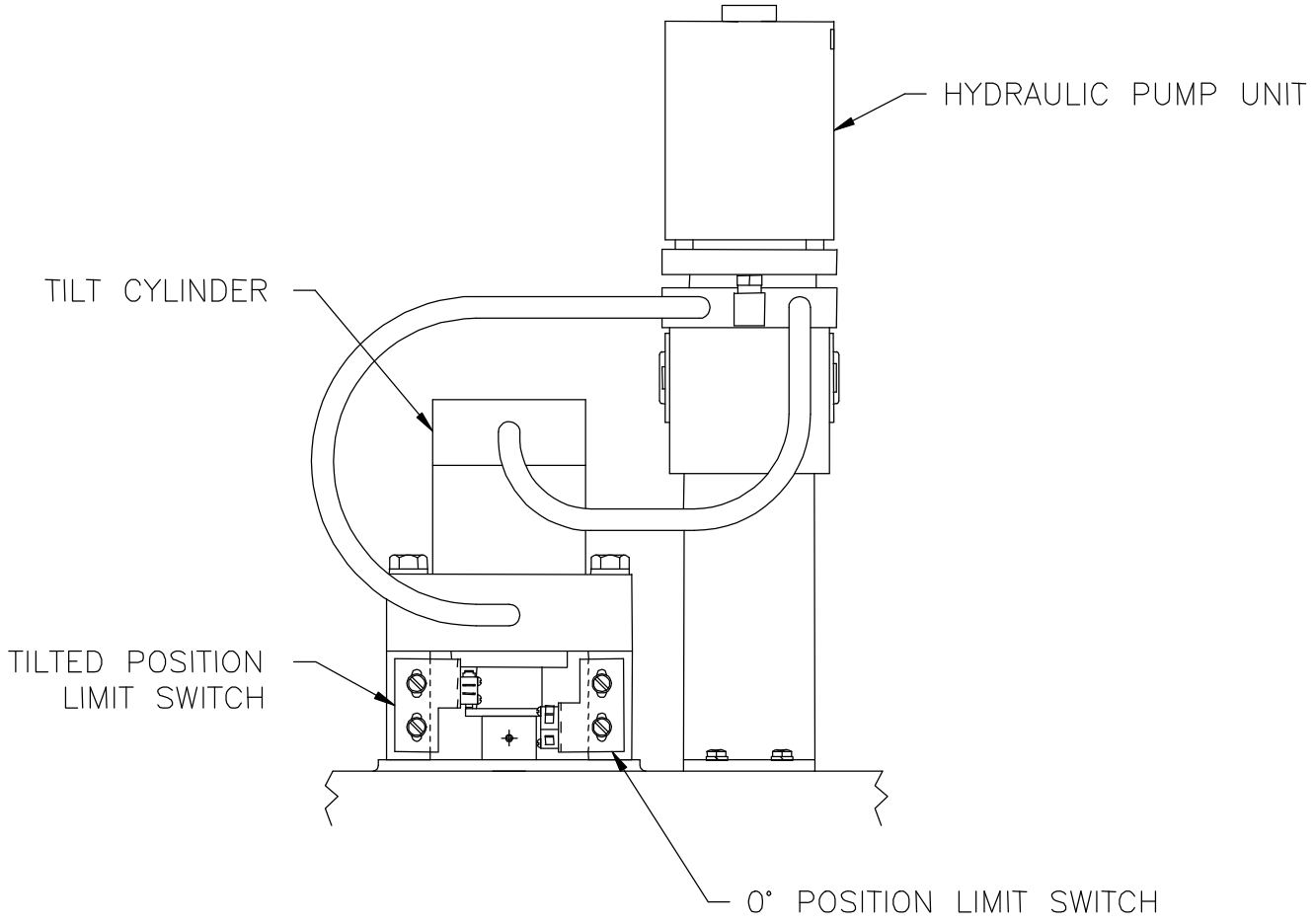


FIGURE 3.6: TILT POSITION LIMIT SWITCHES

ITEM	DESCRIPTION
1	ANGLE VERIFICATION JIG
2	ADJUSTABLE LINK
3	FIXED LINK
4	MOLD

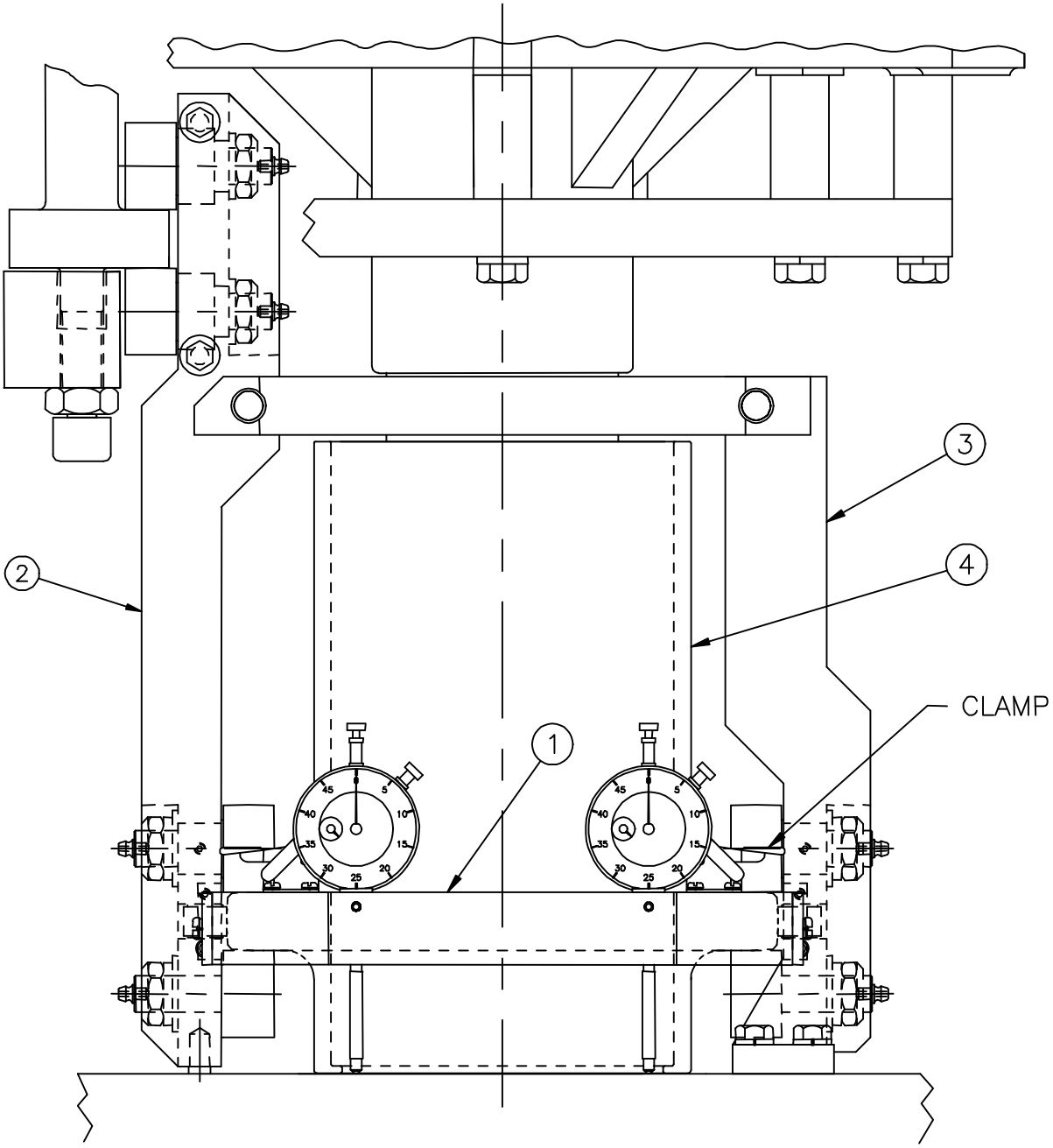


FIGURE 3.7: CUTAWAY VIEW OF ANGLE VERIFICATION JIG ATTACHED TO MOLD

7. Calibration Verification

A simplified routine for verifying the machine speed of gyration, ram force, and specimen height measurement is available in the OTHER OPTIONS menus. This calibration verification procedure will ensure the machine is fully calibrated. Be sure the machine is clean and at room temperature before starting this procedure. If machine is still warm from compacting specimens, let it cool to room temperaure before verifying calibration. The proving ring used to verify calibration 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 ±3%, the change in specimen height measurement to be within ±0.1 mm, and the angle of gyration to be 1.25^0 ±0.02^0 (21.82 ±0.35mrad).

Select VERIFY CALIBRATION from the OTHER OPTIONS menu and press the ENTER key.

First, the speed of gyration is checked using a stop watch. Press the START key and the base will rotate at 30 rpm while a counter 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 RPM. Do not time the first gyration because the acceleration in the first part of rotation will affect the time slightly. Press the ROTATE key to stop rotation and park the carriage.

Next, the ram force is checked. Center the proving ring under the ram in the compaction chamber and place the steel plate between the ring and the ram foot. Press the START key and the machine will automatically flex the proving ring to 18000 N (4046 lbf.). Once the ring has been flexed, re-zero the dial. Press the START key again and the machine will apply a load of 3500 Newton (787 lbf.) (This is 20% of full load). Verify that the machine is calibrated by comparing the load indicated by the ring to the load indicated by the machine. (The proving ring is supplied with a certification chart of the dial reading at various loads.) Press the ENTER key and the machine will load to 14500 Newton (3260 lbf.) (80% of full load). Verify the reading again. Press the ENTER key once more. If the load readings exceed ±3%, calibration is required. If the readings exceed ±1%, calibration is recommended.

Remove the proving ring and place the gage blocks into the chamber oriented for 152.4 mm (6.000 inch). Press ENTER and the machine will move the ram onto the blocks. Verify that the readings are correct. If an error occurs in the height verification, the machine will indicate an error has been detected. 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 effecting the measurement.

Once this routine has been completed, the display will prompt the user to verify that the machine is calibrated by pressing either the UP ARROW or DOWN ARROW keys. The calibration verification date will be stored if this routine is completed to the user's satisfaction. The date of last calibration and last verification may be viewed by selecting the LAST CALIB. DATE from the OTHER OPTIONS menus.

Verify the angle of gyration utilizing the angle indicating apparatus. With the machine in the machine ready condition, place the angle indicating apparatus into the compaction chamber. With the engraved arrow on the angle indicating apparatus at the 3 o'clock position, set the bezel (large dial) on each indicator to zero. The small dial on each indicator should be at 0.35 (see Figure 3.8, Chapter III - page 25). Rotate the angle indicating apparatus 180° in the mold carriage so that the engraved arrow is at 9 o'clock. If the zero degree position is correctly set, the reading on each dial indicator will stay within 0.3500" +/- 0.001". If zero degree position is incorrect, refer to section 6.2, Chapter III - page 10 (zero degree position) steps 1 thru 4. Induce the angle of gyration by pressing the ANGLE and the UP ARROW keys at the same time. The difference between the dial indicator readings should be within 0.1083-0.1118 inch for 1.25±0.02 degrees. (See Table 3.1, Chapter III - page 18). Note: The difference between the dial readings can be as high as 0.1126 (1.28 degrees) to achieve a loaded angle measurement of 1.25±0.02 degrees.

7.1 How To Read Dial Indicators

When you install the angle indicating apparatus into your gyratory compactor without an angle applied, both dial indicators should read 0.3500 as shown in Figure 3.8 below. If each little dial is not on 0.35, loosen the set screw holding the indicator in the angle indicating apparatus and move the indicator up or down until the small dial reads exactly 0.35. Once the small dial reads 0.35, rotate the bezel (large black ring which rotates large dial numbers) so the large dial reads 0.0000. The indicator now reads 0.3500. For the angle verification jig which clamps to the mold, each indicator should read 0.2500.

When the angle is applied to the machine, the readings on the dials are used to measure the angle. Both the large and small dials are read in a clockwise direction. Each number on the large dial is 0.001 inch and each division is 0.0005 inch. Each number on the small dial is 0.10 inch and each division is 0.05 inch. One revolution of the large dial is also 0.05 inch, so two revolutions of the large dial will rotate the small dial one number (e.g.: 0.1 to 0.2). Obtain a better fourth digit estimate by judging the position of the large needle between divisions on the large dial.

Figure 3.9 shows an indicator reading of 0.1707. Read the small dial first. It reads 0.1500. Next read the large dial. It reads 0.0207. Now add the larger dial reading to the small dial reading, 0.1500+0.0207=1707.

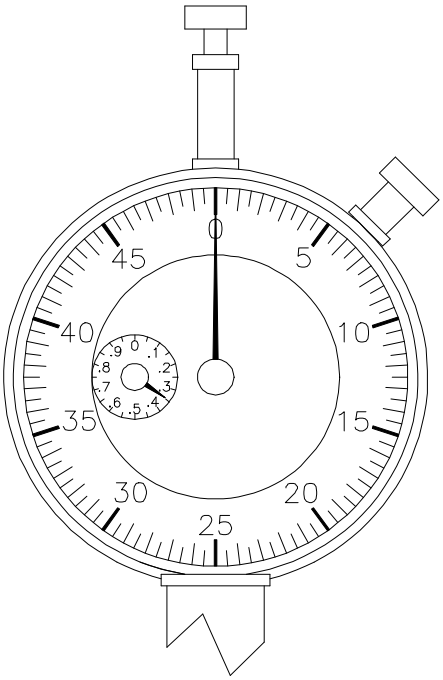


Figure 3.8: Dial Indicator at 0.3500

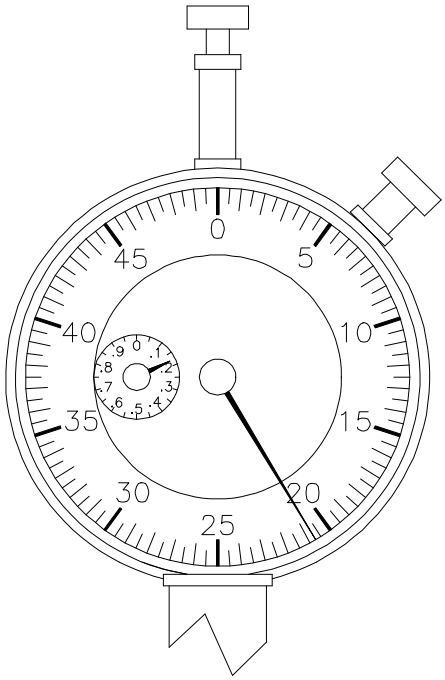


Figure 3.9: Dial Indicator at 0.1707

7.2 Calibration Verification Worksheet

The calibration verification worksheet, located on the following page, is designed to ensure that the force, height, and angle of gyration are verified and recorded for later reference. The format of the worksheet follows the verification procedure outlined in Chapter III – pages 23-24. Following the verification worksheet and verifying that measurements are within the listed specifications will ensure that the AFGC125X Gyratory Compactor is properly calibrated.

To use the verification worksheet properly, 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 3500N and 14500N. 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.

Follow the procedure outlined in Chapter III – pages 23 for verifying speed of gyration, ram force, and specimen height measurements. Record all measurements on the Calibration Verification Worksheet.

Next, the unloaded angle of gyration must be verified. Follow the procedures outlined in Chapter III – Pages 6-11. Measure and record the left/right and front/back zero planes. Measure and record the left, rear, and right mold roller gaps (clearances). Verify that the zero plane and roller gaps are within the requirements listed Chapter III – pages 6-11. Follow the procedure outlined in Chapter III – page 12 for verifying the angle of gyration. The left – right dial reading should be within the requirement listed on the Calibration Verification Worksheet to obtain a loaded angle of gyration of 1.25°. For angles other than 1.25°, reference Table 3.1, Chapter III – page 18.

Finally, verify the loaded angle of gyration by following the procedure outlined in Chapter III pages 15-16. Record the dial readings on the worksheet. Use the angle calculator located in the Other Options menu under Angle Calculation, to calculate the loaded angle of gyration. Refer to section 2.2, Chapter II - pages 3 through 6 for instructions on using the angle calculator. Note: It is recommended that the loaded angle be measured several times (minimum of 3 times) to ensure an accurate reading before making a change to the angle of gyration. Record the angle of gyration on the verification worksheet.

If any of the measurements for speed of gyration, ram force, specimen height, or angle of gyration are not within the requirements listed or any applicable state agency specifications, calibration is required.

Compactor Serial number:_____

Date / Technician	Speed of Gyration (10 gyrations in 19.67-20.33 sec.)	Force: Proving Ring S/N: Cal. Date: 3500N +/- 1% Dial Range: _____-_____	Force: 14500N +/-1% Dial Range: _____-_____	Height: 6.000 +/-0.004 inch/ 152.40 +/-0.1 mm	Comments

Date / Technician	Angle Setting Verification: Mold Roller Settings: Zero Plane: Left/Right	Zero Plane: Front/Back	Roller Gaps: Left	Roller Gaps: Rear	Roller Gaps: Right	Unloaded Angle Setting: Dial Readings: Left	Dial Readings: Right	Right-Left = 0.1110 to 0.1126	Loaded Angle of Gyration Measurement (optional): Dial Indicator Readings: Initial: Left	Initial: Right	After Tilt: Left	After Tilt: Right	After Rotation: Left	After Rotation: Right	Angle (Asphalt) 1.25 +/-0.02

Compactor Serial number:_____

Date / Technician	Speed of Gyration (10 gyrations in 19.67-20.33 sec.)	Force: Proving Ring S/N: Cal. Date: 3500N +/- 1% Dial Range: _____-_____	Force: 14500N +/-1% Dial Range: _____-_____	Height: 6.000 +/-0.004 inch/ 152.40 +/-0.1 mm	Comments

Date / Technician	Angle Setting Verification: Mold Roller Settings: Zero Plane: Left/Right	Zero Plane: Front/Back	Roller Gaps: Left	Roller Gaps: Rear	Roller Gaps: Right	Unloaded Angle Setting: Dial Readings: Left	Dial Readings: Right	Right-Left = 0.1110 to 0.1126	Loaded Angle of Gyration Measurement (optional): Dial Indicator Readings: Initial: Left	Initial: Right	After Tilt: Left	After Tilt: Right	After Rotation: Left	After Rotation: Right	Angle (Asphalt) 1.25 +/-0.02

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IV. Maintenance

1. Lubrication

Table 4.1 is a schedule of the recommended lubrication intervals in machine run hours. Press the PAGE key to display the accumulated hours The number displayed is the actual accumulated running time, and does not include idle time. (See Figure 4.2: Lubrication Points, Chapter IV - page 5).

Table 4.1: Lubrication Schedule

Component	Daily	5hr.	25 hr.	100 hr.	250 hr.	1000 hr.
Mold Top	A					
Carriage Base Plate	A					
Mold rollers (center)		B				
Fixed Ring Surface			C			
Drive Chain				C		
Ram Key				A		
Ball Screw Bearings			B			
Ball Screw			B			
Carriage Base Bearing			B			
Carriage Base Drive Reducer					check	change: D
Hydraulic Power Pack						E

Type of Lubricant:
A..... Molybdenum di-sulfide powder (RALMOS2)
B..... Grease (molybdenum di-sulfide) (Mobilgrease Special) (CLGMOS2)
C..... Oil (SAE 30)
D..... Gear oil ISO Grade 460 (Mobil SHC 634) (CLMSHC634)
E ..... Automatic Transmission Fluid (Dexron II) (CLMATF)

2. Batteries

The gyratory compactor contains parameters in its battery backed up memory. To ensure that this data is not lost, the batteries should be replaced on an annual basis.

***** CAUTION *****
Do not remove the batteries unless the machine is turned ON. Removing the batteries while the machine is off will cause a loss of calibration data.

To replace the batteries, turn the machine on, remove the batteries from the holder on the right side of the machine, near the power switch. Replace the batteries. Use only alkaline batteries. After the new batteries are installed, turn the compactor power off, then back on to restart the internal clock. After the batteries are replaced and the power cycled, the time and date must be

reset in the machine. Select the OTHER OPTIONS from screen two, then select DATE/TIME and set the correct date and time. The clock is set in military time.

3. Maintenance Schedule

The following table is a guideline for the periodic maintenance required. All items should be inspected after 25 hours of operation and adjusted accordingly.

Table 4.2: Periodic Maintenance

Component	Daily	Initial 5 hr.	25 hr.	100 hr.
Clean compaction chamber	X			
Check Angle of Gyration		X	X	
Check roller adjustments		X	X	
Inspect Ram Key			X	
Check Base Cog Screws			X	
Inspect Base, Ram Foot, for wear				X
Base rotation chain tension				X
Timing belt tension				X
Inspect Fixed Ring and Rollers				X

4. Ram Key

The ram key should be inspected periodically to check for wear. The key is a oil-impregnated bronze with 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 reinstalled. Lubricating the key with molybdenum di-sulfide powder will extend its service life. (See Fig. 4.2, Chapter IV - page 5, and Drawing ACGC125X sheet 2, Item 24)

To inspect or replace the ram key, first extend the ram manually at least two inches from the parked position. Next, disconnect power and remove the right side upper panel. Now using the supplied hex wrench, loosen the set screws holding the key in position. Remove the key. The ram may tend to unwind without the key installed. Use a wood block if necessary to keep the ram from extending. Inspect the key for wear and replace if required. Be sure the key is fully seated into the ram keyway before tightening the set screws. Reinstall the side panel and reconnect power.

5. Cleaning

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

Use a rag moistened with a cleaning solvent to clean the compaction chamber (WD-40 works well). All surfaces should be kept free of debris including the ram foot. It is especially important to keep the mold carriage rollers free of buildup. The mold must also be kept free of debris, especially the flange which the carriage rollers travel around.

Do not spray solvents directly into the chamber or onto the rollers. Direct spraying of solvents onto the rollers will thin the lubricant and may damage the seals. Use mineral spirits or WD-40 to remove the excess binder that may be present.

NOTE: It is extremely important to keep the fixed ring (Item 6, Figure 3.4) clean and lightly coated with oil. Do <u>not</u> use the molybdenum di-sulfide powder to lubricate the fixed ring. Failing to keep this ring clean and lubricated will result in premature failure of the rollers and/or the fixed ring.

6. 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 all carriage linkages, carriage base, fixed ring, lift link, extruder bracket, and work surfaces with a 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. The printer should be covered also.

To return the compactor to service, thoroughly clean all surfaces 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. The machine calibration should be checked prior to returning it to service.

7. Circuit Breakers

The Gyratory Compactor is equipped with 3 circuit breakers for protection. These circuit breakers are located inside the lower cabinet on the upper right side (see Figure 4.1, Chapter IV - page 4).

8. Troubleshooting

The gyratory compactor control system has built in error codes to aid in troubleshooting. If a error condition occurs, an error code number will be displayed along with a brief description of the problem. Table 4.3 (Chapter IV - page 6) is a listing of some errors, the probable cause and solution.

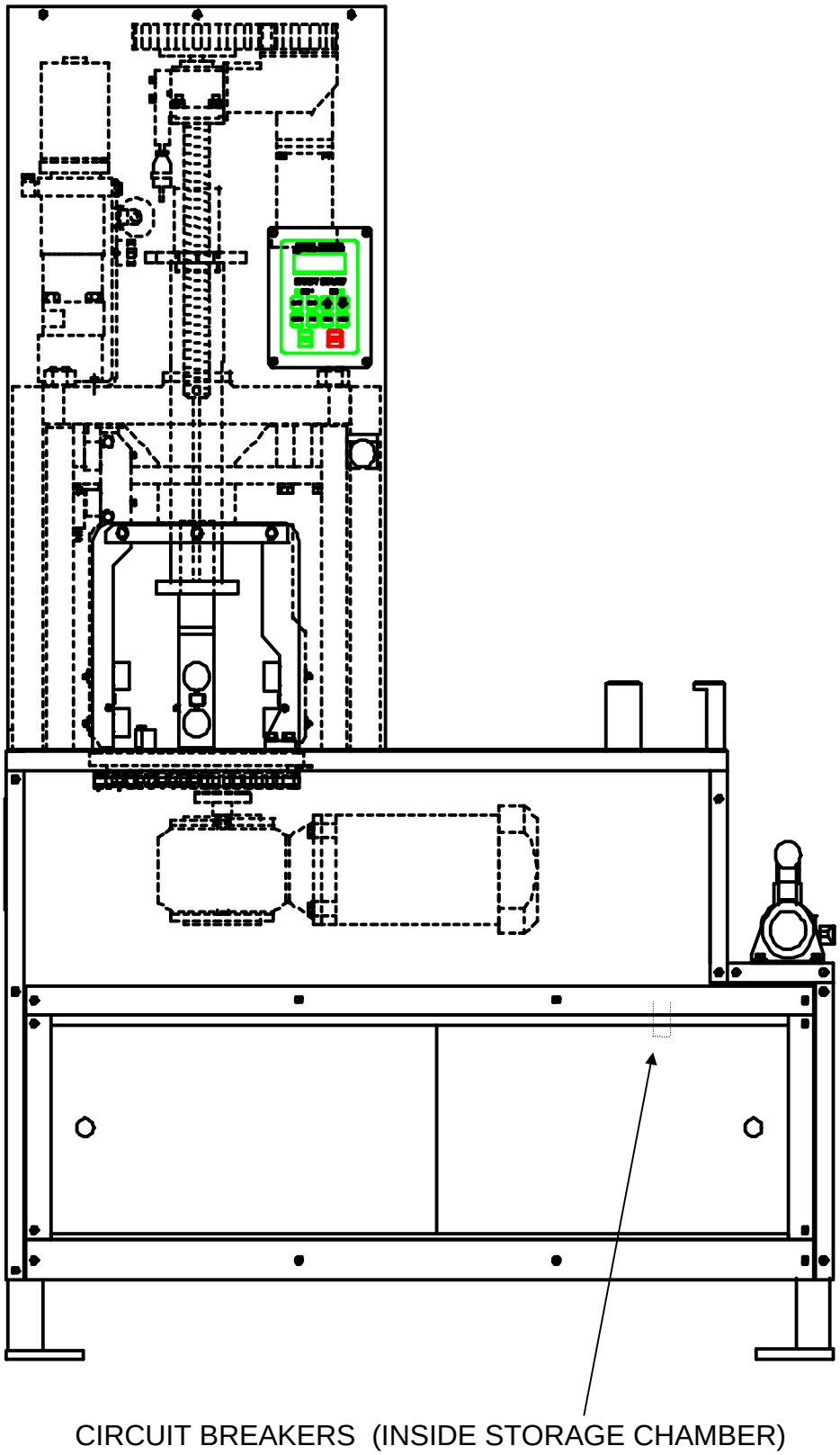

FIGURE 4.1: CIRCUIT BREAKER LOCATION

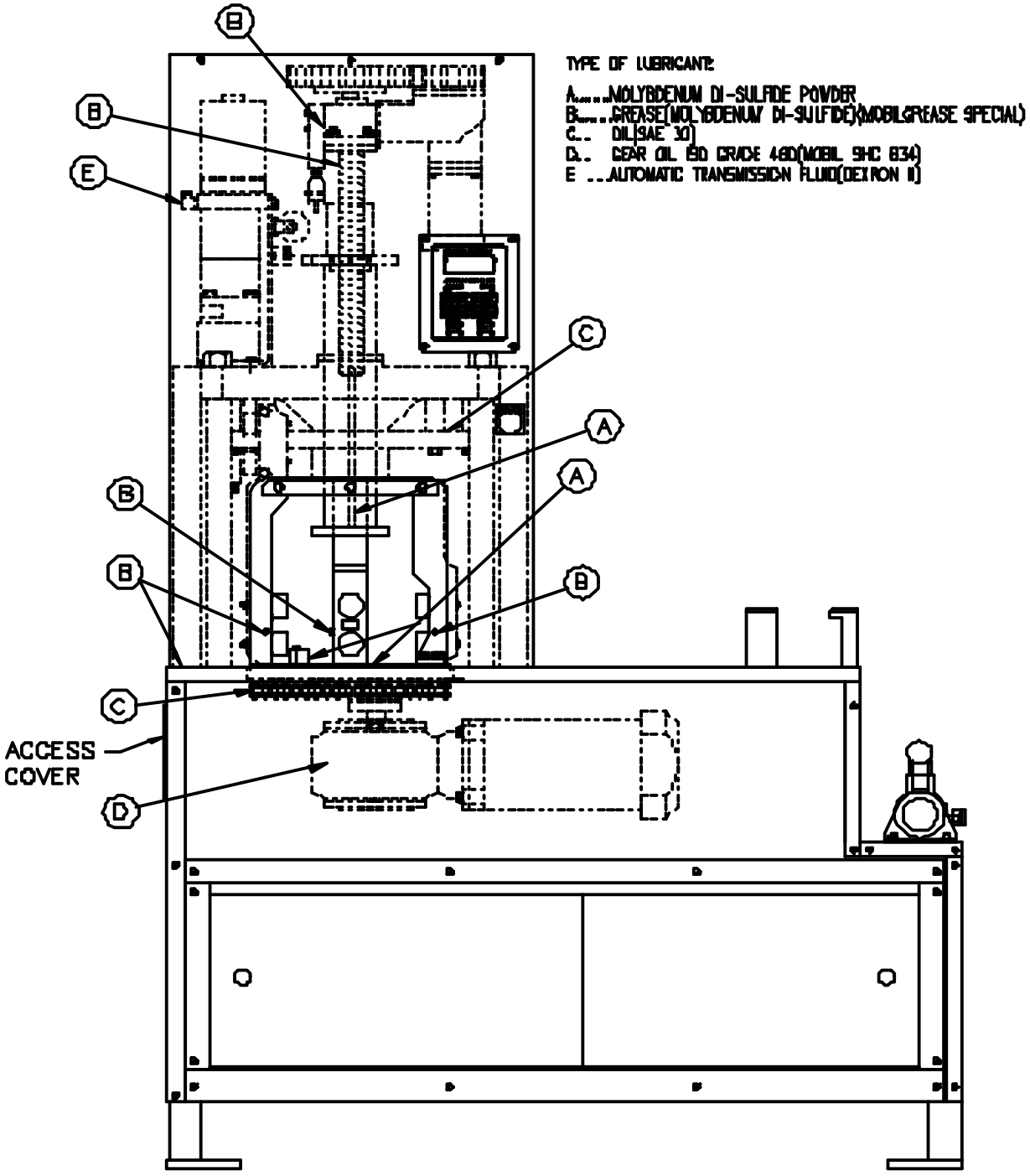

FIGURE 4.2: LUBRICATION POINTS

TABLE 4.3: TROUBLE SHOOTING

DESCRIPTION	PROBABLE CAUSE	SOLUTION
Machine won't start test	- Machine not parked	- Press ENTER and START keys at the same time to have machine self park
	- Door open	- Close door
	- Controls in "SELECT" mode	- Check settings, press ENTER
Machine won't print	- Disconnected cable	- Check cable connections
	- Printer not on	- Turn printer on, check power
Machine serial communications not working	- Disconnected cable	- Check cable connections
	- Incorrect communications settings	- Check communication parameters are correct o both the compactor and external computer
Grinding sound during gyration	- Inadequate lubrication on mold top and on base	- Lubricate as required (see section 3, Chapter II - page 7)
Thumping sound during gyration	- Debris on mold flange or rollers	- Clean
	- Debris or lack of lubrication on fixed rin	- Clean and lubricate
	- Hydraulics low on oil or air in circuit	- Add fluid and / or bleed air
	- Tilt cylinder loosing pressure	- Use auto tilt function to repressurize cylinder during compaction (see section 2.2, Chapter II - page 3) or replace cylinder
	- Hydraulic pump check valve not seating properly	- Repair or replace pump
Mold won't enter carriage easily	- Carriage rollers out of adjustment	- Adjust carriage rollers (see section 6.1, Chapter III - page 6)
Mold binding in carriage after compaction	- Incorrect (cold) compaction temperature	- Use angle and up arrow keys to manually tilt mold to release built-up pressure. Return linkage to 0.0 degrees after re-moving mold.
Carriage fails to park correctly or won't stay parked	- Loose rotation drive chain	- Correct chain tension
	- Carriage drive motor out of adjustment	- Consult factory
	- Carriage home position sensor out of adjustment	- Consult factory
	- Carriage home position sensor out of adjustment	- Consult factory
Door Open light on when door is closed	- Door switch out of adjustment	- Adjust switch
	- Faulty door switch or circuit	- Replace switch
	- Electrical fault	- Consult factory
Height verification error during calibration	-Ram key wear	- Rotate or replace ram key
Machine appears to not hold pressure at the start of a test and 150 mm specimens not compacting as expected	- Machine set for 100 mm specimen size	- Change specimen size to 150 mm

ERROR	DESCRIPTION	PROBABLE CAUSE	SOLUTION
101	Upper tilt limit switch failed to activate		
	- Hydraulic pump will run	- Limit switch out of adjustment	- Check switch for proper adjustment
		- Limit switch disconnected or defective	- Check switch electrical connections and operation
		- Low hydraulic fluid or air in hydraulic circuit	- Check for correct fluid level, bleed air from system
	- Hydraulic pump will not run	- Circuit breaker tripped	- Reset breaker
		- Pump disconnected or faulty electrical circuit	- Check pump electrical circuit for proper operation
		- Faulty pump motor	- Replace pump assembly
102	Lower tilt limit switch failed to activate		
	- Hydraulic pump will run	- Limit switch out of adjustment	- Check switch for proper adjustment
		- Limit switch disconnected or defective	- Check switch electrical connections and operation
		- Low hydraulic fluid or air in hydraulic circuit	- Check for correct fluid level, bleed, air from system
	- Hydraulic pump will not run	- Circuit breaker tripped	- Reset breaker
		- Pump disconnected or faulty electrical circuit	- Check pump electrical circuit for proper operation
		- Faulty pump motor	- Replace pump assembly
	- Error occurs at end of test	- Carriage base park speed too fast	- Consult factory for instructions
201	Carriage failed to reach home position sensor		
	- Base rotates	- Faulty sensor or actuator	- Check sensor and actuator for proper operation
		- Faulty sensor circuit	- Check sensor circuit for proper operation
	- Base does not rotate	- Object interfering with carriage rotation	- Clear debris from compaction chamber, check base cog
		- Circuit breaker tripped	- Reset breaker
		- Defected drive mechanism	- Check drive system for proper operation
		- Faulty motor or motor control circuit	- Check motor and circuit for proper operation
301	Ram stall detected while moving up	- Debris blocking ram	- Clear debris
		- Circuit breaker tripped	- Reset breaker
		- Defective or disconnected encoder	- Consult factory
		- Defective or disconnected home position sensor	- Consult factory
		- Fault in electrical circuit	- Consult factory
		- Defective ram drive	- Consult factory

ERROR	DESCRIPTION	PROBABLE CAUSE	SOLUTION
302	Ram stall detected while moving down	- Improper internal ram drive control settings	- Consult factory
		- Defective or disconnected encoder	- Consult factory
303	Ram encoder count <3000 detected	- Ram not parked on power up	- Turn power off then back on. Allow ram to park.
		- Defective or disconnected home position sensor	- Consult factory
		- Fault in encoder circuit	- Consult factory
		- Ram drive belt failure	- Replace drive belt
304	Ram over extension	- Ram contacted over travel limit switch	- Turn power off, manually rotate drive pulley clockwise so ram does not contact switch. Turn power back on. Allow ram to park.
		- Defective, or disconnected limit switch	- Check switch for proper operation
		- Fault in electrical circuit	- Check switch circuit for proper operation
305	Ram failed to park in 30 seconds	- Disconnected or broken drive belt	- Replace drive belt
306	Ram past home	- Faulty encoder or circuit	- Consult factory
		- Faulty home position sensor or circuit	- Consult factory
307,308	Ram motor control board	- Ram motor controller	- Consult factory
309	Encoder counts out of range	- Ram motor controller	- Consult factory
501	Front load cell error	- Debris obstructing ram from parking properly	- Clear debris from top of ram
		- Defective or damaged load cell	- Replace load cell. Consult factory.
		- Electrical circuit fault	- Consult factory
502	Rear load cell error	- Defective or damaged load cell	- Replace load cell. Consult factory.
		- Electrical circuit fault	- Consult factory
503	Load cell error	- Electrical circuit fault	- Consult factory
		- Damaged or disconnected load cell	- Consult factory
504	Over pressure detected	- Electrical circuit failure	- Consult factory
		- Damaged load cell	- Consult factory

9. Parts List

9.1 Recommended Spare Parts

Part Number	Description	Quantity
KABCCFE1500S	1.5" Dia. Eccentric Cam Follower	2
KABCCF1500S	1.5" Dia. Cam Follower	2
KABCCYR750S	0.75" Dia. Cam Roller	2
ACGCC020H	Anti-Rotation Cog, Base	1
ACGCM150CH	Anti-Rotation Cog, 150 mm Mold	1
ACGCM100CH	Anti-Rotation Cog, 100 mm Mold	1
ACGCR010P	Ram Key	1
KAA9450M	Air Filter Media	1
KSM1032S08HB	Screw, Machine 10-32 x 1/2” Long	4
KSM1032S20HB	Screw, Machine 10-32 x 1-1/4” Long	4
KAP187D08	Pin, Dowel 3/16 Dia x 1/2” Long	4
ELF7BX	Fluorescent Light	1

9.2 Drawings/Schematics

Drawing Number	Description
A - ACGCA001A	Angle Jig Assembly
B - ACGCC003DA	Carriage Base Assembly
B - ACGCC004DA	Fixed Link Assembly
B - ACGCC005A	Intermediate Link Assembly
B - ACGCC006A	Adjustable Link Assembly