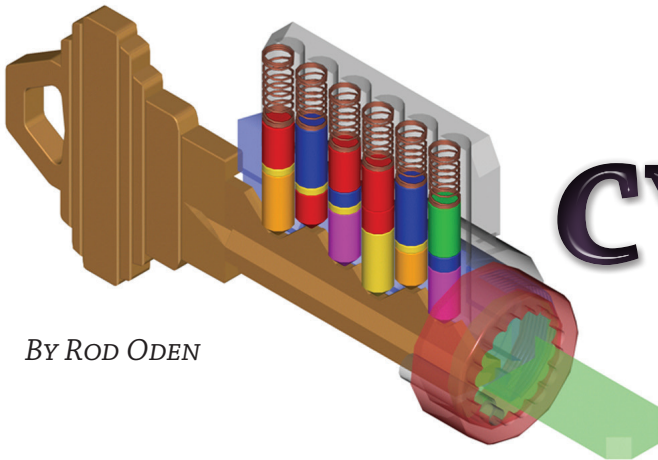




MASTERKEYING BASICS: LOCK CYLINDERS



BY ROD ODEN

There is no substitution for experience. When beginning locksmiths encounter problems, it behooves them to disassemble lock cylinders and take a close look at what is going on.

Beginning locksmiths can encounter problems when keying commercial lock cylinders. Some problems can be caused by pin stacks, crushed springs, mis-cut keys, and assembly errors. A great deal of frustration can be eliminated by taking a close look at what is going on inside the cylinder and implementing the tips within this article.

Beginning locksmiths should never be shy about asking their more experience peers for solutions. Lock representatives are always willing to help out and often can provide materials that can aid in understanding what goes on inside the lock cylinder.

PIN STACKS

The definition of the pin stack is the overall

height of all pin tumblers in a given chamber. The pin stack height is often expressed in units of increments established by the lock manufacturer. The pin stack height can be a given number or an actual size.

Interchangeable core manufacturers have given their cores a set pin stack height to ensure that the core operates properly when an operating key is inserted. One of the reasons for having a specific pin stack height is because the core is smaller than a standard lock cylinder and the operating space within the core is limited. A set pin stack height ensures that driver springs will not be crushed.

Pin stacks of most standard lock cylinders can be less critical as there is more space for springs to operate; therefore pin stacks do not have to be exact.

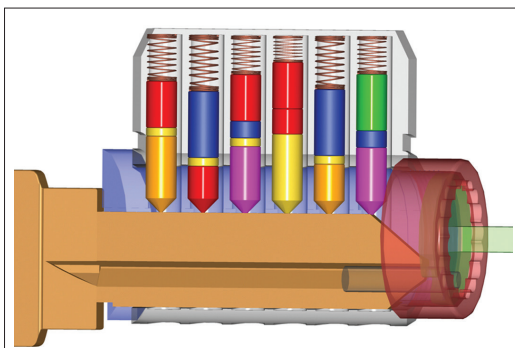


Figure 01. Driver spring over-compression (fourth chamber).

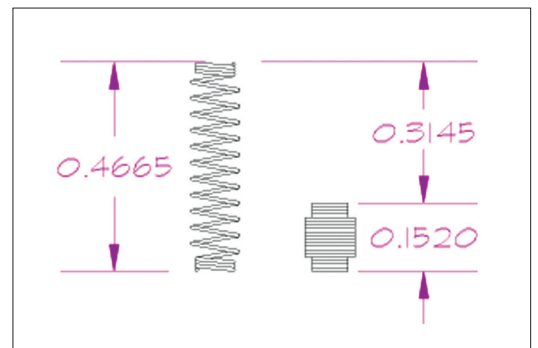


Figure 02. Maximum driver spring compression.

Locksmiths may forget to remove all pins and springs from the lock cylinder in preparation to rekey it. All the bottom pins and some master pins are removed by running a follower through the lock cylinder. Depending on the combination of the operating key, some master pins may remain in the upper chambers.

Master pins left behind will add to the overall height of the pin stack and could damage driver springs. Top pins might be too long for the pin stack, also creating a condition where the driver springs will be crushed. Driver springs left inside the lock cylinder shell could already be damaged.

Sometimes lock manufacturers create a problem when lock cylinders are delivered to locksmiths with the wrong size

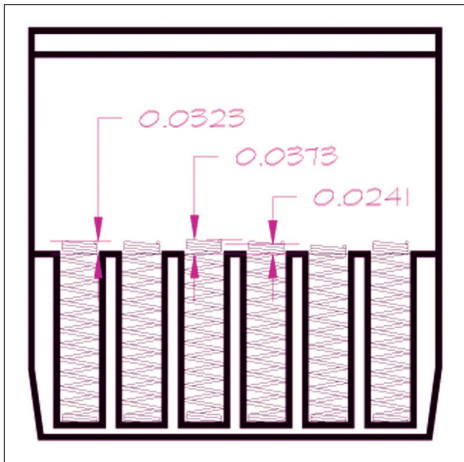


Figure 03. Driver springs at rest.

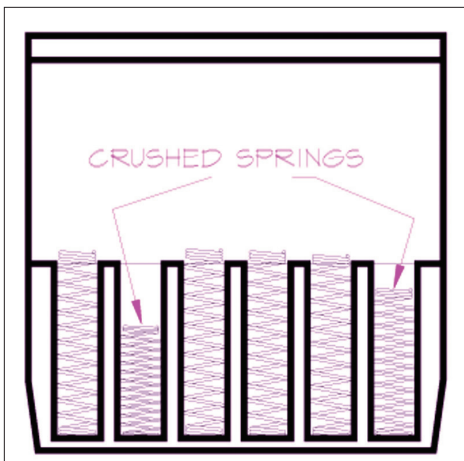


Figure 04. Visual check for damaged springs.

top pins installed. Zero-bitted or one-bitted (where a key cut with all zeroes or ones can operate the cylinder) lock cylinders, keyed from the factory, will often have short drivers installed, anticipating that the locksmith will not empty out the top pins when preparing for a rekey. This creates a problem during construction if the lock cylinder is turned without a blank construction key. Because short drivers were installed with short bottom pins, the pin stack at rest falls below the operating shear line. A turn with a screw driver may operate the lock but also may mangle the driver springs.

In Figure 01, during the keying process the top chambers were not emptied; a master pin was left in the third chamber and the top pin in the fourth chamber is too long for the new pin stack. A blank key inserted into this lock cylinder will crush the driver spring in the fourth chamber. Operating keys will be hard to insert. The extra master pin develops an unexpected operating shear line.

Driver springs have a load range. The “universal” driver springs found in popular pinning kits can safely compress about .315”. Compressions greater than .315” will crush or deform the driver spring so that it becomes ineffective.

The driver spring is placed on top

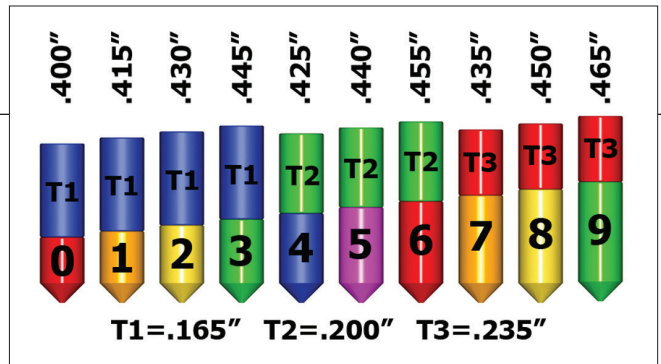


Figure 05. Manufacturer specified top drivers.

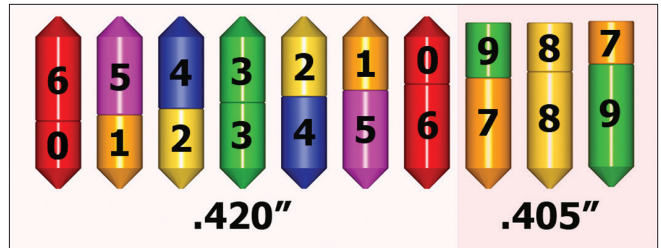


Figure 06. Graduated driver set.

of the pin stack to exert pressure on the pin tumblers.

To check that driver springs are in good shape, unload all pins, flip over the lock cylinder shell (so it is upside-down) and carefully remove the follower. Look into the bible portion of the shell; all pins should protrude from each chamber of the bible about .030”, like in Figure 03. If a visual check reveals that some driver springs do not protrude, like in Figure 04, those driver springs are crushed and must be replaced.

The definition of a bible is that portion of the cylinder shell normally houses the pin chambers.

The top pin or driver pin is the first pin in the stack that the driver spring directly contacts.

If a manufacturer does not specify an exact pin stack height, the pin stack height will be established as a range. For their standard commercial cylinders, Schlage uses three different top pins: T1 (.235”); T2 (.200”); and T3 (.165”). Figure 05 shows which top pins are designated for use with different pin

NORMALIZED PINNING KIT FOR SCHLAGE										
	0	1	2	3	4	5	6	7	8	9
Driver Pins	.255 B	.240 B	.225 B	.210 B	.195 B	.180 B	.165 B	.135 T	.120 T	.105 T
Master Pins		.015 T	.030 T	.045 T	.060 T	.075 T	.090 T	.105 T	.120 T	.135 T
Bottom Pins	.165 B	.180 B	.195 B	.210 B	.225 B	.240 B	.255 B	.270 B	.285 B	.300 B
Stack Height	.420	.420	.420	.420	.420	.420	.420	.405	.405	.405

Figure 07. Pinning kit based on customized pin stacks.

stack heights. Notice that the pin stack heights fall into a range between .400" and .465". What is inferred is that pin stack heights must be taller than .400" and shorter than .465".

The definition of a uniform pin stack is an exact pin stack height established by the lock manufacturer.

The definition of an increment is the uniform difference between successive key cuts. It can be expressed as a dimension or a number designating the dimension.

The definition of a graduated driver set is a set of top pins of different lengths. Each length corresponds to the height of the rest of the pin stack to achieve a uniform pin stack. Usually the difference between pins in the set is a single increment.

There are advantages to having shorter (.400") pin stacks. Driver springs are never fully compressed so they are never stressed or crushed; less compression translates to less overall pressure. Keys and plugs are less likely to wear out; and keys are easier to insert and remove.

NORMALIZING PIN STACKS

Figure 06 demonstrates that shorter preferred pin stacks, can be developed from .005" universal pins. This is ac-

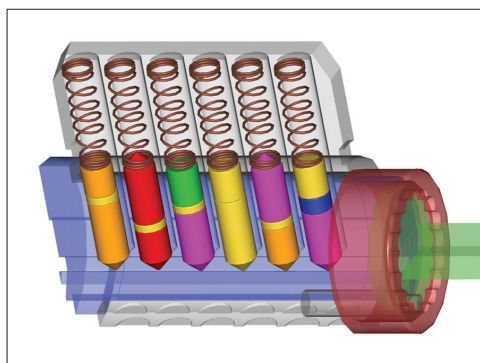


Figure 08. Normalizing pin stacks.

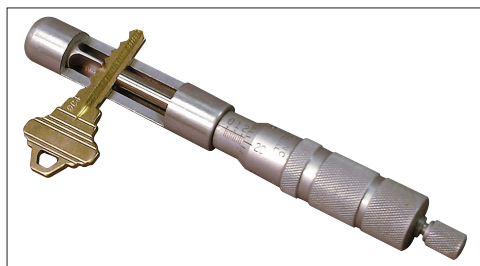


Figure 09. Using a straight yoke micrometer.

complished by flipping bottom pins over so that each driver spring is centered over the pointed end of the pin. This does not affect the relationship between pin and spring. The pin stack heights in Figure 06 safely range between .405" and .420".

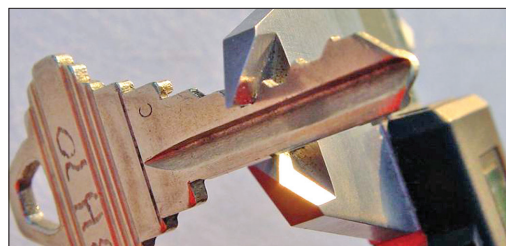


Figure 10. Using dial calipers.

SCHLAGE SPECIFICATIONS										
	0	1	2	3	4	5	6	7	8	9
Root Depth:	.335	.320	.305	.290	.275	.260	.245	.230	.215	.200
Operating Stack*:	.165	.180	.195	.210	.225	.240	.255	.270	.285	.300
EDP or Effective Diameter of the Plug: .500										

**Operating Stack is the total height of pins that relate to the root depth.*

Figure 11. Schlage root depths.

Pin sizes in the kit were deliberately selected to match the bottom pins normally used for Schlage. In this manner, the kit uses less pin sizes. This becomes important while performing mass rekey projects where pin sizes are ordered in bulk.

When pinning specifications are customized or altered to enhance performance while at the same time keeping within the guidelines established by the manufacturer, this is called "normalization."

The table in Figure 07 specifies each pin size in the normalization kit for Schlage. The normalized pinning kit contains: ten size bottom pins, and nine size master pins. This are three pins less than normally found in a standard Schlage pinning kit. Driver pins: T1, T2, and T3 are not needed.

During large master keying projects, where pinning is performed on site, normalized pinning kits are easy to use. For example, if in a chamber a #6 bottom pin is dropped in and then a #2 master pin, the sum indicates that a #8 driver pin will be top of the stack. Periodically as pins are filled, the driver sizes #0 through #6 can be refilled using bulk quantities of bottom pins.

New keys sometimes work rough until they are broke

in (when the initial cuts slightly wear). Since normalized pin stacks yield overall less pressure on the pins, new keys will work more smoothly.

In Figure 08, the cutaway reveals relaxed but effective springs, while the pins are at rest. Theoretically, this should make the lock a little harder to pick as nothing is given away by probing the plug with a feeler pick; all pin stacks are the same; and all spring tension is uniform.

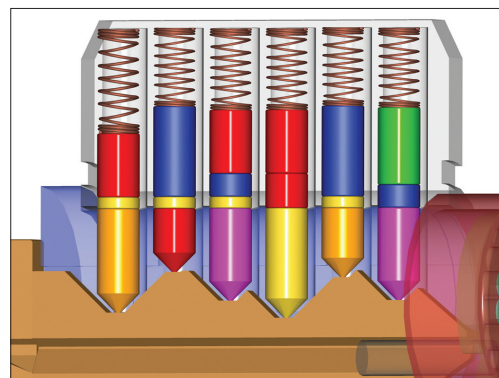


Figure 12. Operating shear line.

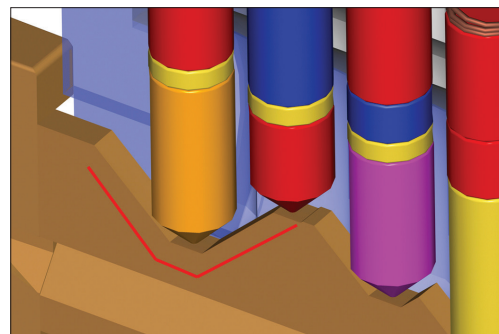


Figure 13. MACS at the limit.

MIS-CUT KEYS, OUT OF SPEC KEYS

Another problem that occurs is when the lock cylinder is built to specification, and the keys do not work properly.

If the plug rotates with a lot of resistance or only partial turns, the key may not be cut deep enough. This is an easy check. Pull out the key and see if there are impression marks left in each chamber.

If the plug rotates only after the key is slightly pulled out, the key may be cut too deep.

Both scenarios would indicate that the root depth needs to be checked. The root depth is the dimension from the bottom of the cut to the bottom of the blade.

Many different types of key gauges can read the manufacturer's unit designation of a root depth, but the preferred method to check the root depth is to use a straight yoke micrometer or dial calipers.

In Figure 09, the root depth is checked using a straight yoke micrometer. This is a great tool to use to measure root depths, but is more limited than dial calipers.

In Figure 10, a root depth is checked using dial calipers. Dial calipers can also be used to measure small pin parts like plugs and pin, and to measure the spaces of the key.

The correct root depths for Schlage are listed in Figure 11. To operate correctly the measured dimension should be no more than two-or-three thousandths plus-or-minus the manufacturer's specification.

OPERATING SHEAR LINE

The operating key is a key that by design operates the lock. Locks can be made to operate by many different operating keys. Operation keys are not control or reset keys which are designed to remove the cylinder or core.

The operating shear line is created when an operating key lifts bottom and master pins to the designated height so that the plug can rotate inside the lock cylinder.

The root depths are designed to lift the operating stacks in each chamber so that a shear line is created and the plug can rotate inside the lock cylinder. This is called the operating shear line.

In Figure 12, the operating key lifts the pins and an operating shear line is created.

The relationship between a root depth and the operating stack is called the "Effective Diameter of the Plug" (or EDP).

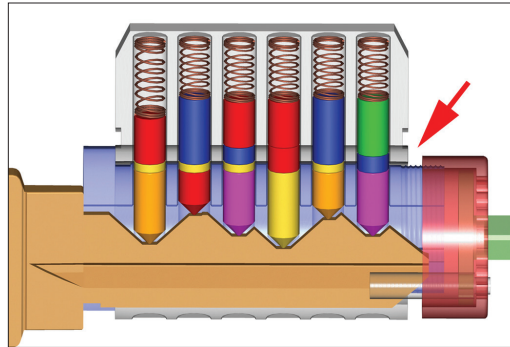


Figure 14. Loose screw-on plug retainer.

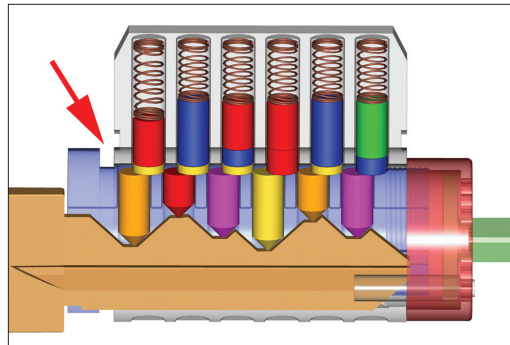


Figure 15. Unaligned chambers keep key from retracting.

The beginner locksmith might think of the "diameter" in EDP means the diameter of the plug. This is a mistake as the diameter of the plug may be inconsistent with the EDP. The root depth may lift the corresponding pin above the normal diameter of the plug or below it.

The sum of the root depth and the length of the corresponding pins that establish the operating shear line is called the effective plug diameter, or the effective diameter of the plug, or called by the abbreviation, EDP.

Every lock manufacturer will specify the EDP. The root depth taken from the EDP will determine the size of the pin

or pins (operating stack). For example (using Schlage specifications), if the EDP is .500" and the chamber is to be operated by a #7 root depth (.230"), the bottom pin length will be (.500"-.230") or .270"

MAXIMUM ADJACENT CUT SPECIFICATION

The maximum adjacent cut specification is the maximum difference between cut depths.

A problem can occur when the lock cylinder will not operate at all, even though the proper pins are installed, and the root depths are within the manufacturer's specification.

Check to make sure that the MACS is within range. Measure each cut and make sure that adjacent cuts are not greater than the lock manufacturer's specified MACS. For example, the MACS for Schlage is 7 (or 7 increments where an increment has been established as .015"). No two adjacent cuts can be more than .105" in difference from one another.

In Figure 13, the #0 and #7 root depth are next to each other; the MACS is to the limit. The red line indicates what would happen if the root cut were one increment deeper; cut to a #8 depth. The shape of the cutting blade would destroy the adjacent #0 cut; after that the pins in that chamber would not be able to reach shear.

Specialty blades are available to increase the MACS. These are primarily used when master keying large complexes, to regain key combinations that would be normally eliminated. These specialty blades feature sharper side angles so less of the adjacent cut is affected.

ASSEMBLY ERROR MIMICS PINNING PROBLEM

The right operating key is inserted into the lock cylinder, but the plug is hard to rotate or only partially rotates. When the key is removed and examined, there are no impression marks on the flats of the key that would nor-

mally indicate cuts that are not cut deep enough or wrong size pins.

The solution might be to check the tension on the screw-on retainer on the back of the plug. Depress the spring-loaded lock pin and back off the tension by one-or-two notches.

If the retainer is too loose it will create a problem where the key can be inserted, the lock can operate, but the key can't be

removed without applying pressure on the key face before removing the key.

Figure 14 shows the pins are at rest. While at rest the loose retainer on the back of the plug cannot be detected as the pins are locking both the plug and shell together.

In Figure 15, the key is inserted, the plug rotates easily, but when an attempt to remove the key is made it will not re-

tract. The plug is allowed to move forward because of the loose retainer, and this creates a situation in which the pins in the plug cannot move into the bible. The key is trapped into the plug. To remove the key: push the key all the way forward, use a pencil or your finger to apply forward pressure on the surface of the plug while pulling the key out of the plug.



Article Quiz:

Answers will be posted at www.locksmithledger.com.

1. The pin stack is:

- A. The sum of the heights of the bottom pin and all master pins in a chamber.
- B. Another name for the chamber in which pin tumblers are inserted.
- C. The over all height of all pin tumblers in a given chamber.
- D. None of the above.

2. The driver spring is:

- A. Placed on top of the pin tumblers in the chamber to exert pressure.
- B. Part of the plug retainer assembly, it keeps the retainer from being unscrewed.
- C. Forces the tailpiece into the spindle so rotating the plug opens the lock.
- D. None of the above.

3. The bible:

- A. Is another name for the shell portion of the cylinder.
- B. Is the part of the shell where the pin tumblers can be found.
- C. Refers to the book "Everything About Locks"
- D. None of the above.

4. Top pins:

- A. Are the same as driver pins.
- B. Are used to cap the top of interchangeable cores.
- C. Can sometimes be used as bottom pins when pinning Schlage Locks.
- D. None of the above.

5. A uniform pin stack:

- A. Is another name for graduated pin stack.
- B. Is only found in interchangeable cores.
- C. Is the only pin stack approved by the Uniform Building Code.
- D. None of the above.

6. The root depth:

- A. Is measured from the outside of the plug inside the chamber to the flat of the key.
- B. Is the dimension from the bottom of the cut to the bottom of the blade.
- C. Is the difference between successive key depths.
- D. None of the above.

7. The operating key:

- A. Is used only when referring to a change key that opens an interchangeable core.
- B. Is the same as a control or rest key.
- C. Is never a master key.
- D. None of the above.

8. The sum of the root depth and the length of the corresponding pins that establish a shear line:

- A. Is called the effective diameter of the plug or effective plug diameter.
- B. Is also called split pin master keying.
- C. Determine the uniform pin stack.
- D. None of the above.

9. Maximum adjacent cut specification:

- A. Is the center-to-center dimension, chamber-to-chamber.
- B. For Schlage locks is .105"
- C. Is determined by measuring the flats of keys with a dial caliper.
- D. None of the above.

10. To accurately determine the root depth:

- A. Use a key gauge.
- B. Use either a straight yoke micrometer or dial calipers.
- C. Use a key gauge, straight yoke micrometer, or dial calipers.
- D. None of the above.