ARC FORENSICS INC
"CERTIFIED"
FORENSIC LOCKSMITHS ~ PHOTOGRAPHERS
VEHICLE THEFT & FIRE ~ TRANSPONDER DIAGNOSTICS
Honesty ~ Professionalism ~ Integrity
P.O. BOX 239 WESTFIELD, IN 46074-0239
Phone (317) 669-7581 ~ Fax (317) 669-7582 ~ Cell (317) 710-7971 ~ mail@ARCForensics.com

SOME FACTS ABOUT KEYS

Keyway or profile – is cross-sectional shape of a key after milling. (Illustration 1.) The shape is determined by the overall thickness, height and length, and the shape of the milling or grooves.

A keyway is designed to be unique to a specific key system (i.e. Ford 10-Cut, GM 10-Cut, Chrysler 8-Cut, etc.), allowing only keys of the same or similar profile to be inserted into a lock of the same key system. Slight variations in the milling allow for creating Primary/Secondary or Master/Valet keys.

NOTE: In automotive lock parlance, the term "Master Key" refers to a key that is cut to work all the locks of a specific vehicle and not the locks across a number of vehicles using the same key system. Its counterpart, the Valet key, is designed and cut to work specific locks on a specific vehicle – i.e. the ignition and door locks only, and not the glove compartment and deck locks.

1 GM 10 cut

1. The key profile is unique to a manufacturer's key system. Proper use allows for creation of PRIMARY/SECONDARY or MASTER/VALET keys and eliminates similar keys from entering or operating the lock.

ARC FORENSICS 01/06

Space – is the distance to each cut along the length of a key blank. Space is measure from a specific point of registration or index, known as the STOP. The stop is typically located at a shoulder near the bow or head of the key, or the tip of the key. Spaces mark the center points of each cut made across the length of a key.

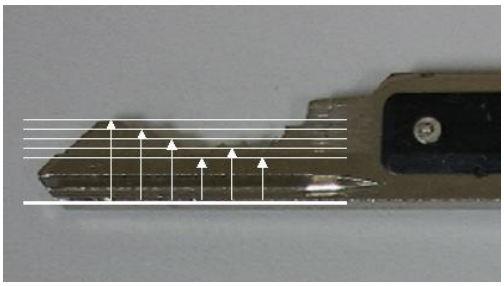
Measuring the space is compromised of the Distance-To-First-Cut and the Cut-To-Cut dimensions. Distance-To-First-Cut is the distance from the stop to the center of the first cut. The Cut-To-Cut specification is the distance as measured from the center of each subsequent cut starting from the First Cut. Although variations do exist, traditionally, the First Cut is the cut closest to the bow or head of the key. With some exceptions, manufacturers assign 1 to the First Cut in a system, while adding 1 to each subsequent increment. Common systems in North America range from 6 to 10 spaces.

Depth – is perceived and understood from two perspectives.

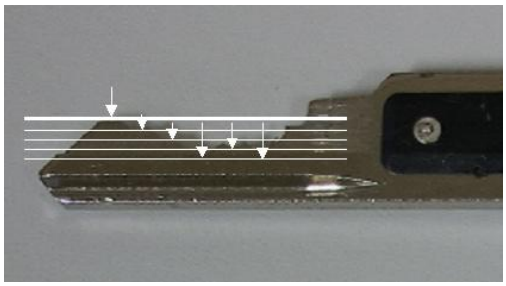
1.) Root depth references the depth of a cut as the distance from a specific line of registration or index along the length of the key blade to the bottom or root of a cut. (Photograph 2.) Often this line is the opposite edge or bottom of the key blade, or a milled groove along the length of the key. This is the preferred method for referring to depth from an engineering perspective, and is typically the method used for developing key blueprints.

2.) Read depth references the depth of a cut as the distance from the top edge of the key to the root of the cut. (Photograph 3.) This method is more commonly used in the field for describing the specific depth of a cut.

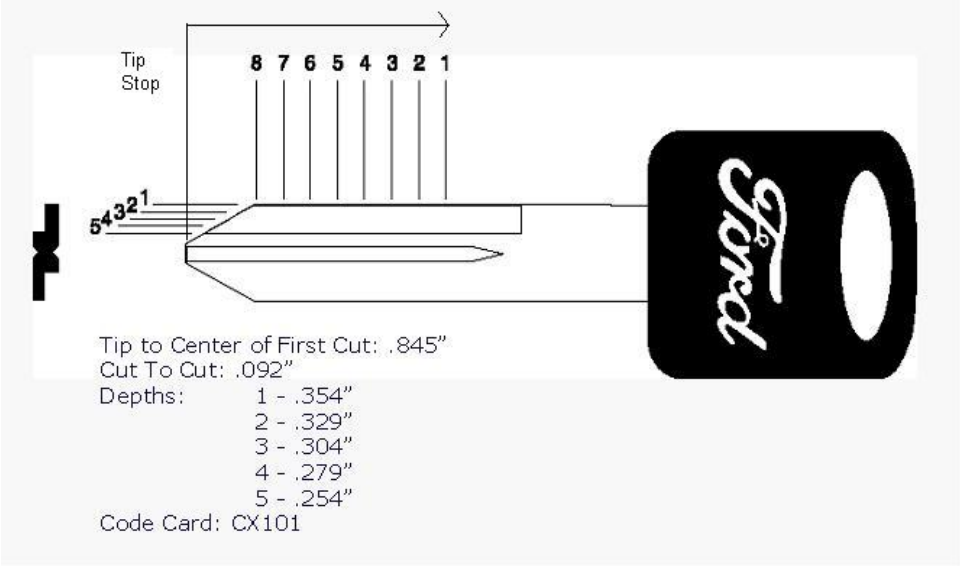
In either case, the depth of the finished cut is the same. Root Depth measures the amount of metal left from a line of registration to the root of the cut, while the Read Depth measures the amount of metal removed from the edge of the key to the root of the cut. The balance of this paper uses the Read Depth method in referring to the depth of a cut. Depths are typically equally incremented, with each increment being assigned a specific number to reference a specific depth. With some exceptions, manufacturers assign 1 to the shallowest depth in a system, while adding 1 to each subsequent increment. Common systems in North America range from 1 to 6 depths. (Illustration 4.)



2. Root Depth is measured from a line of registration to the root of the cut.



3. Read Depth is measured from the top edge of the key to the root of the cut.



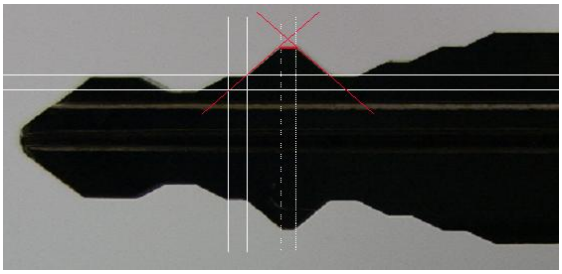
4. Typical Space & Depth key specifications

Angle-Of-Cut – the angle of the key moving from one cut to the next. In most key systems, this angle is identical on all depths. A few systems change the Angle-Of-Cut based on the depth of adjacent cuts.

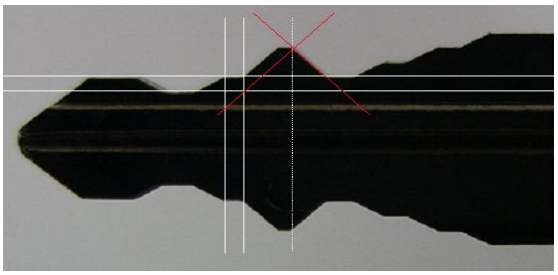
Land – the area of the cut on a key on which the lock's tumbler seats or rests when the key is fully inserted into the lock. The land is assigned a specific length along the axis of the key blade to assure proper and positive seating even after multiple duplications and varying differences of depth between adjacent cuts.

ARC FORENSICS 01/06

Maximum Adjacent Cut Specification (MACS) – is the maximum allowable difference in depth between two adjacent cuts. This specification is a physical limitation determined by the Angle-Of-Cut, Depth, Cut-To-Cut, and Land specifications. (Photographs 5 and 6.)



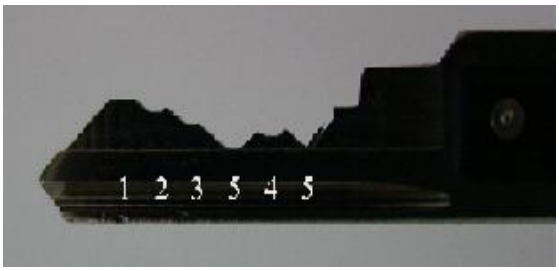
5. MACS, when followed, allows proper seating for the tumbler.



6. MACS violated does not leave proper seating for the tumbler.

Bitting – is a method for easily referencing the corresponding depths and spaces on a key. In practice the index of the digit in the sequence of the number corresponds to the space of a cut. In most systems, the first number of the bitting references the First Cut of the key. The size of the digit corresponds to the depth of the cut at that corresponding space. (Photograph 7.)

For example, the bitting 132443 references six cuts on a key. The first number – 1 – indicates that the first cut on the key is a 1 depth. The second number – 3 – indicates that the second cut on the key is a 3 depth. Etc.



7. The bitting represents both the space and depth for each cut on a key. As the key bitting is typically presented moving from the head of the key to the tip, the bitting of the key illustrated above is actually 545321.

The Cousin Key

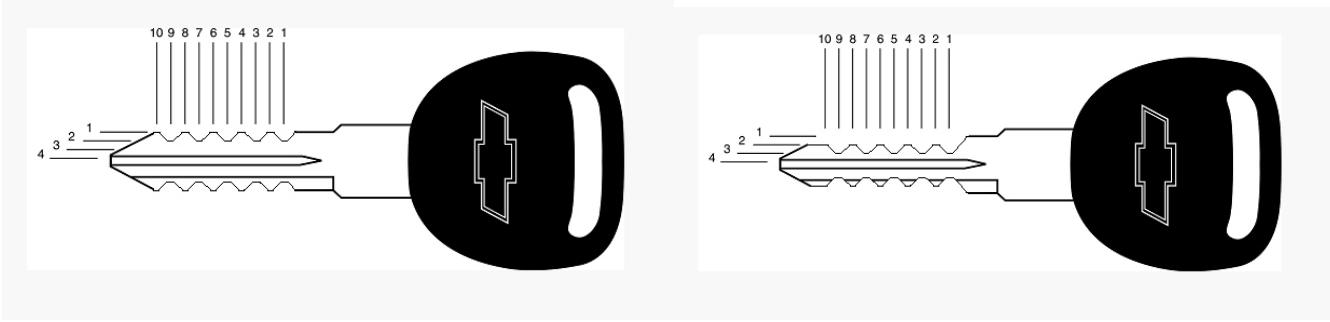
Definition – Cousin Key is a term used by at least one manufacturer to describe a specific relationship between two or more keys with similar bitting. (Illustration 8.)

However, at the writing of this paper, the term Cousin Key is not recognized by the Associated Locksmiths Of America (ALOA). Nor is the term listed in "Locks, Safes And Security, An International Police Reference," by Marc Tobias, J.D.

As used by the manufacturer, Cousin Key refers to two or more keys that have bittings that are different, but are similar enough where interchange poses a threat.

For example, a key cut to 121212 is different than a key cut to 232323. However, when each key is cut, the contours of each key are almost identical. Other bittings may also be different, but when cut on a key are similar in contour– i.e. 121213, 2212323.

The possibility for interchange between "Cousin Keys" is determined by the physical dimensioning of the key, the lock specifications listed above, and system tolerances (both designed and inherent). This trait is common to the lock and key systems of all automotive manufacturers.



8. Example of "Cousin Keys." Different but similar bittings. **ARC FORENSICS 01/06**

Lock & Key Manufacturing

Tolerances – to accommodate the varied environments, in which automotive locks must work, the acceptable amount of variation in dimension ranges from approximately ±.0050" to ±.0150". On most newly manufactured locks and keys, severe binding is noted when the depths of a key are cut at ±.0100"to ±.0150" off the specified dimension. Differences exceeding ±.0250 often result in failure to operate.

Markings to the key, tumbler and inner lock case are typically noticeable when keys exceed the manufacturer's listed tolerances. Marks are most prominent at those locations where the cut depth is too shallow. Where cut depth is deeper than specified, marks are less distinct and may not be discernable.

In general, duplicate keys fail to properly operate a lock after 8 to 10 generations.

Partitioning – A consideration in the potential for key interchange is the fact that many of today's automotive key systems rely on partitioning when creating the locks for the system.

Partitioning is where the locks employed on a vehicle use only a portion of all possible spaces on a key. The door locks on many of the late model GM trucks and vans, for example, only use spaces 1 through 7 of the key. Their ignitions use spaces 2 through 10 on the key.

On many late model Fords; the door locks use either spaces 1 through 6 or 2 through 7, while the ignition uses spaces 2 though 8.

Because the various locks used on a vehicle don't utilize all possible spaces on the key, the possibility for key interchange is increased. As partitioning is a design feature of a manufacturers' key system, they are careful to build in safeguards to prevent key interchange.

Theoretical Keys

When a key system is generated, based on the space and depth specifications, a key chart or table is created that includes the full compliment of all possible key bittings. In this first phase, all bittings are included regardless of whether they violate system specifications.

The GM 10-Cut system, for example, has 10-Cut key employing 4 depths. The total number of possible bittings is 4^{10} or 1,048,576.

Manufacturer Sorting – as manufacturers are fully cognizant of the security risks involved with key interchange. As such, all have developed intricate systems for sorting the theoretical bitting list for those bittings that pose the most likelihood for causing a functional and/or security risk. High-risk bittings are eliminated from the system and are not used.

To meet international security standards, automotive keys systems must offer a minimum of 2000 distinct bittings after passing all sorting criteria.

Common Sorting Strategies:

Following are conditions for eliminating a theoretical key from a working key system.

1. System Specification Violations – all bittings that violate MACS and other system specifications are removed.
2. Cousin Keys – all bittings posing an interchange risk are removed.
3. Partitioning – all bittings posing a security risk due to the portioning characteristic of the locks are removed.
4. Ramped or Declining Step Keys – bittings that form a step or ramped contour pose a safety and security risk and are removed from the system.

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Wafer/Sidebar Locks

Automotive lock manufacturers, recognizing the intrinsic weaknesses of various lock designs, have taken determined steps in designing locks that are resistant to force, picking and key interchange.

Toyota employs a “split-wafer” system resist picking, and hardened disks and break-away plugs to prevent lock tampering.

GM employs a sidebar and wafer tumblers with false sidebar notches to deter picking and key interchange.

Wafer Lock – a lock that employs flat tumblers often referred to as wafer, disk or plate tumblers. Various design features are utilized to help resist picking and key interchange, including serrated edges and split-wafer designs.

Sidebar Lock – a lock that employs a sidebar either as its sole method for locking, or in conjunction with the shearline formed by wafer tumblers. In operation, the sidebar does not retract unless all tumblers are correctly aligned with the sidebar. Further pick and key interchange resistant enhancements include false sidebar notches on the wafer tumblers.

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Tryout Keys/Jiggler Keys/Key Picking

The following devices exploit the tolerances inherent in automotive lock and key systems. Newer locks systems are less susceptible to these devices than older and worn systems.

Tryout Keys – a set of keys designed with the sole purpose of opening the locks of a specific key system. The keys vary in number depending on the complexity of the useable bittings. Depending on the manufacturer, blanks milled to manufacturer's specifications are used to cut samples that closely match the bittings of the original keys. To reduce the total number of key necessary to complete a set, the depths of each space are cut to ½ increments. In use, keys are inserted into a lock and rotated. Combined with vibrating the key, a key matching the approximate bitting may rotate the lock. Although little skill is required to use Tryout keys, older and worn locks are more susceptible to Tryout key than newer locks. In most cases, rotation leaves discernable marks on the key, tumblers, and/or inner lock case.

Jiggler Keys (often called Rocker Picks) – a set of flat spring steel "keys" designed with the sole purpose of opening the locks of many key systems. Unlike Tryout keys that base each key on actual bittings, the blade of the Jiggler Keys is cut to follow common contours. In operation, the Jiggler Key is inserted into a lock and "Jiggled" in an attempt to bring the tumblers to the shearline and rotate the lock. Tool markings are easily discerned with this device. Some degree of skill is needed in using this tool. Older and worn locks are more susceptible to Jiggler Keys than newer locks.

Key Picking – a single key designed with the sole purpose of opening the locks on a specific key system. The key is specially cut and does not follow the key bitting of any workable key. In operation, the key is inserted into a lock. While rotating towards the open position, the key is withdrawn from the lock in an attempt to pick it. Tool markings are easily discernable when this device is used. This device requires a high degree of skill.

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Conclusion:

Key interchange is not a new problem for automotive manufacturers, and is not a problem limited to a specific manufacturer or system. All manufacturers employ intricate sorting methods and techniques to severely limit the potential for key interchange.

While the term “Cousin Key” is not recognized by legitimate locksmith authorities or organizations, the concept and problems inherent with key interchange have long been recognized and addressed by all manufacturers. In the strictest definition of the term, manufacturers do not release any locks and/or keys that are would be considered “Cousin Keys.” And while key interchange still exists, it is typically the result of poorly duplicated keys or excessive wear to the key and/or lock components.

Since its 1994 introduction, the GM 10-Cut system has introduced three basic ignition styles – Modular, CSS, and Modular-In-Dash. These locks are currently produced by three separate Original Equipment Manufacturers, each employing their own unique lock designs. A combination of standard wafer or sidebar designs is utilized.

Ignition locks produced by the predominant supplier of GM locks utilize a sidebar and wafer tumblers with false sidebar notches. While originally designed to deter picking, the sidebar/false notch combination also limits the possibility of inadvertent “Cousin Keys” from operating a new GM ignition lock. This conclusion is supported by the fact that Locksmith Tryout Key sets for the GM 10-Cut system typically run in excess of 500 distinct keys – more than double of many other systems.

Herb Miller & Tom Seroogy Certified Forensic Locksmiths