abatek
CREATING INPUT SOLUTIONS

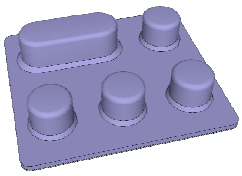
Designing High Quality Keypads

A TOUCH BETTER

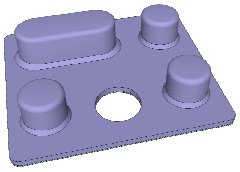
Six tips for higher quality & cost efficient keypads

1) No Opening

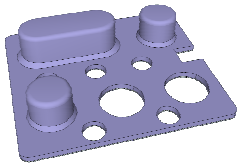
Limit the number of openings. Holes take time to process and have a higher risk of being missed during inspection.



Best Zero openings



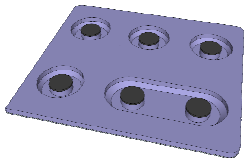
Good Only big and/or few openings



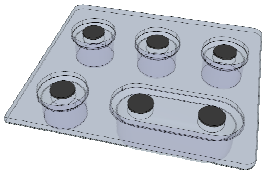
Worst Small LED or positioning holes

2) Keypad Color different from Contact Pill

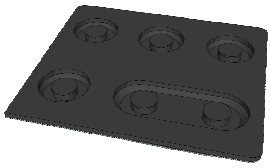
Missing pills are easier to visually detect if the color of the silicone is contrasting to the color of the (blue, gray or black) pills



Best High contrast color



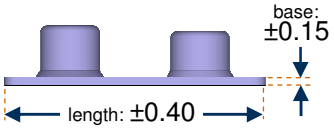
Good Clear silicone



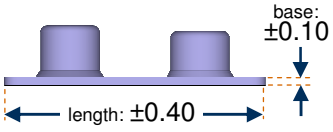
Worst Keypad color same as pill color

3) Tolerance ISO 3302-1 Class M2

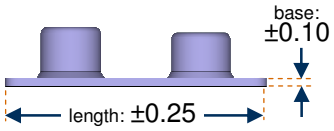
The tighter the dimensional tolerance, the easier it is for manufacturing variances to cause an out of spec part



Best M2 dimensional tolerance



Good All M2 tolerances except 1-2 critical dimensions at M1



Worst All M1 dimensional tolerance

tips 4-6

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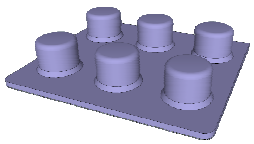
Six tips for higher quality & cost efficient keypads

4) All keys with same Force spec

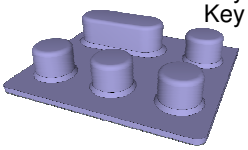
Having only one force spec on a keypad makes it easier to tune the variables to meet specifications. Multiple force specs makes it much harder.

Key A= 250g



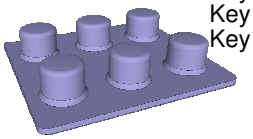
Best — One force spec

Key A = 235g
Key B = 377g



Good — Two force spec (adjusted to average measured values)

Key A = 250g,
Key B = 350g,
Key C=150g

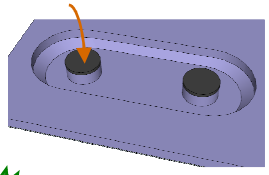


Worst — Multiple force spec (not adjusted to average measured values)

5) Contact Pill Size is Ø3mm

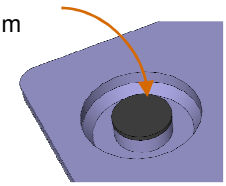
Tiny pills are difficult to place in the loading jig. 3.0mm pills ensure that the pills easily load in the jig, and easily seen if missing. Big size pills cost more than 3.0mm pills

Ø 3.0mm



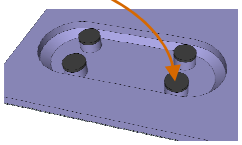
Best — Pill size = Ø3 mm

Ø 3.5mm



Good — Pill size > Ø3 mm

Ø 2.5mm

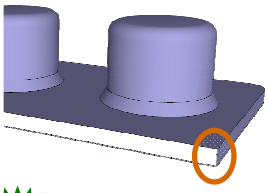


Worst — Pills size = Ø2.5 mm (smallest)

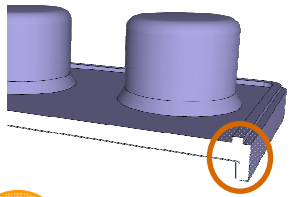
Not valid for SC-M and Gold pill due to high material price for pill

6) No Undercuts or Thin Ribs

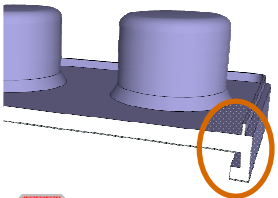
Undercuts and thin ribs are difficult to tool and make it more likely that the part will tear when removed from the mold.



Best — No undercut or rib



Good — Thick Rib / No Undercut



Worst — Undercut / Thin Rib

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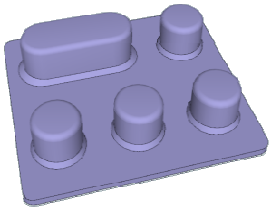
Designing High Quality Keypads
1) Openings – the problem

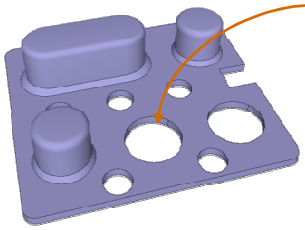
High Quality Design:



Best

no openings

Design with Increased Scrap Rate:



the flash from every opening is removed by hand

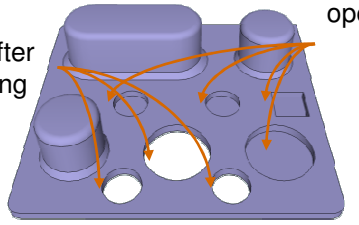
Worst

multiple openings

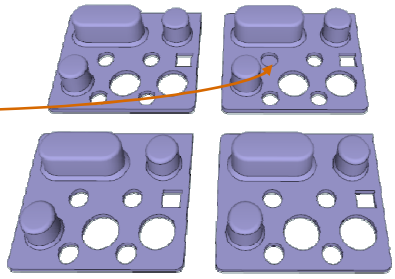
Why does having openings increase keypad cost?

All openings in silicone compression molded keypad will have flash. This flash is removed by hand.

Since keypads with multiple (small) openings have a higher risk of an opening being missed, costly inspections must be performed.

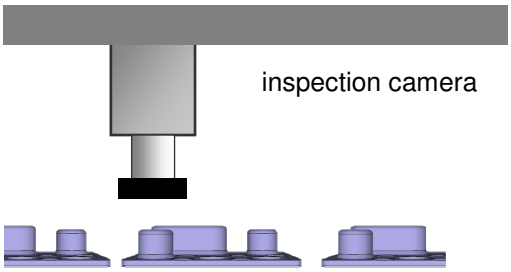


Costly Inspection Methods



Visually

After the hand tearing process, keypads are visually inspected for missed openings. This is a time intensive process and detection is not 100% certain.



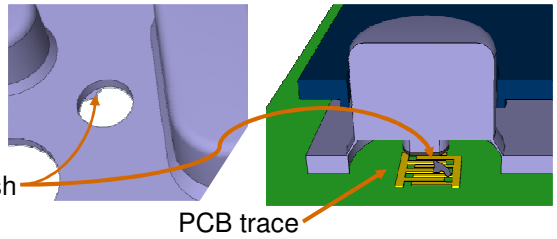
Camera

For some keypads, Abatek can use a computer controlled inspection camera for 100% detection of missed opening. The cost is greater due to the complex set-up.

Performance Issues

Because the flash removal is a manual process, larger pieces of flash can remain.

In rare cases, the remaining flash can later fall off onto the PCB and cause a contact insulation.



In addition, having openings in a keypad will affect performance:

1| Keypads without openings also help protect the PCB from the environment. Openings can allow foreign particles onto the PCB causing a short circuit.

2| Openings also weaken the keypad base, potentially changing actuation feel and/or reducing the lifetime of the keypad.

Several solutions are available to eliminate the need for openings…

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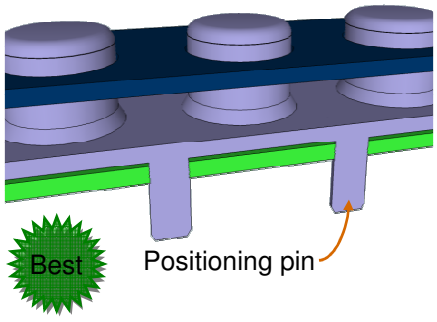
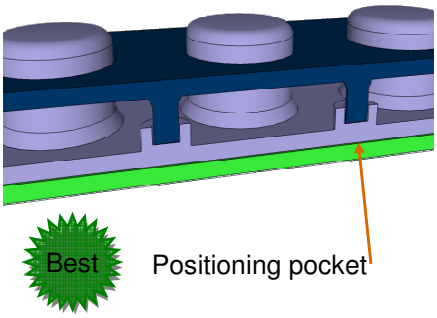
Designing High Quality Keypads
1) Openings – the solution

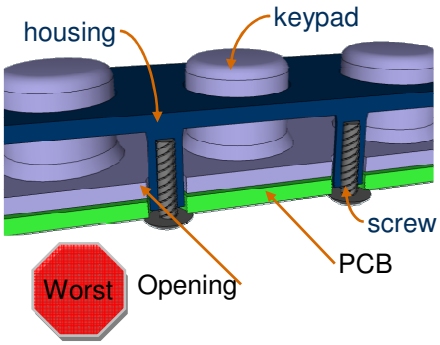
Position the keypad without using openings:



Instead of using screws, use positioning pins to position and secure keypad to the PCB without using openings.

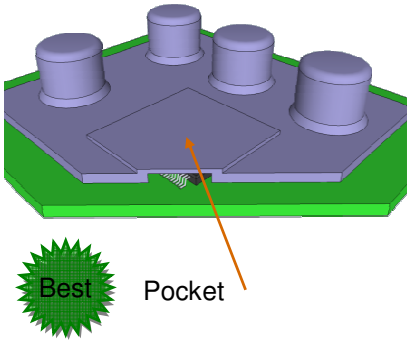


Or use a pocket to position the keypad relative to the front housing. Similarly, a perimeter lip can also be used to create an effective seal.

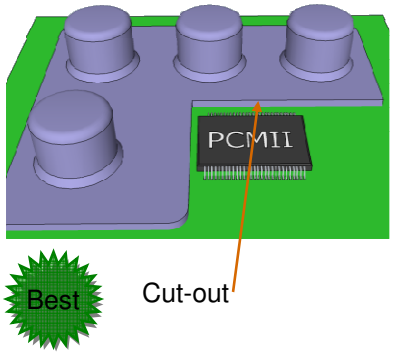


Some assemblies use screws to secure the PCB and keypad to the housing. Openings are needed to allow the screw through the keypad.

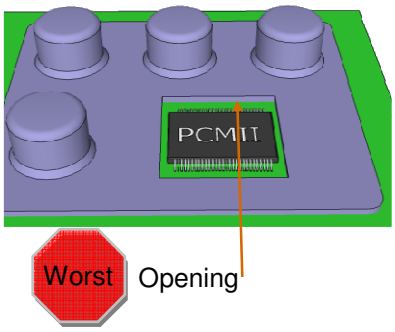
Make space for components without using openings:



For lower profile components (most are), create a pocket instead of an opening. This also helps to seal the PCB.

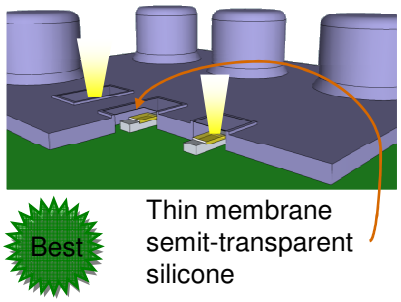


Place components around the outside of the keypad. The keypad can easily be shaped to avoid components without using openings.

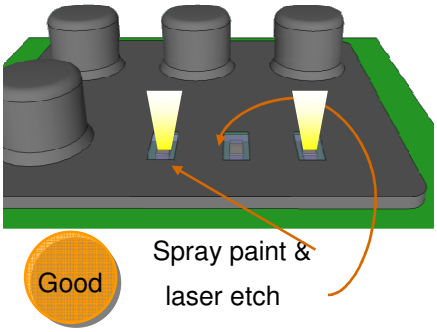


Some PCBs have components (resistors, etc.) on the same side as the keypad. Openings are used to give space to the components.

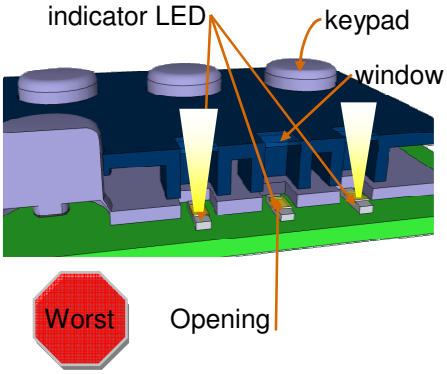
Design LED indicators without using openings:



When it is thin (0.3mm), silicone becomes almost transparent allowing LEDs to shine through solid keypads without using openings. Thick areas block the light. 0.06% - 0.08% black pigments work best.



If optimal light & dust shield is required use clear silicone, spray paint the keypad with black paint and laser etch off the area over the indicator LED.



Some assembly use LEDs on the PCB to serve as indicator lights. The light needs to pass through openings in the keypad to be seen.

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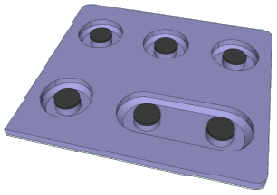
Designing High Quality Keypads
2) Keypad Color – the problem

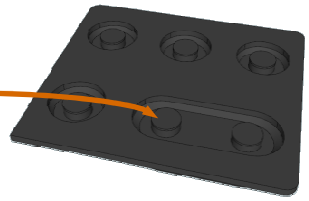
High Quality Design:



Best — High contrast color

Design with Increased Scrap Rate:

missing pills are difficult to visually inspect



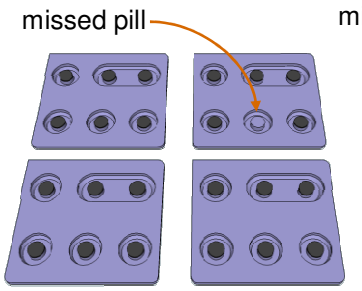
Worst — Keypad color same as pill color

Why does having contact pills the same color as the keypad increase keypad cost?

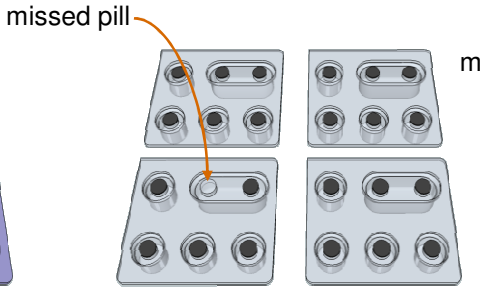
Pills are loaded into the main silicone tool using a pill jig. Two main failures can occur: 1| pill is missed, 2| the pill is not loaded flat into the main tool causing silicone to flow over the conductive pill surface.

After molding, parts are visually checked. Since defects are more difficult to detect when the silicone color is the same as the pill color: 1| risk of defective parts is higher, 2| a costly electric tester may be needed.

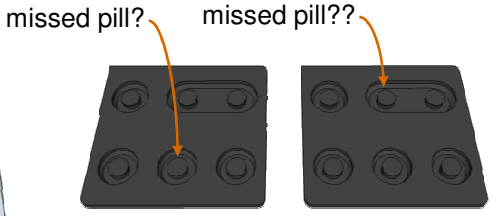
Missed Pill Issue



Visual inspecting for missed pills is easy when the color of the keypad's silicone contrasts with the color of the pill.

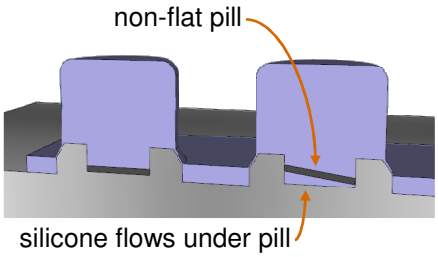


Visual inspecting for missed pills with clear silicone is also easy since it contrasts well with the darker contact pills.

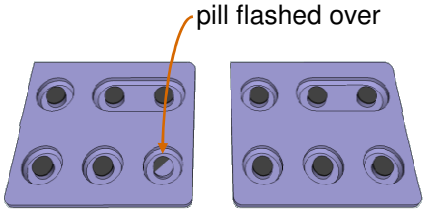


In this case, the keypad's black silicone is the same color as the standard carbon pill. Visual inspecting for missed pills is very difficult.

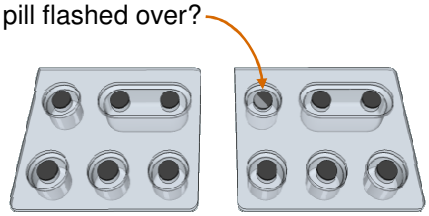
Pill flash Issue



The pill insert jig is design to press the pill flat into each pocket. If not placed flat, the silicone may flow, during molding, under the pill.



Visual inspection for flashed over pills is much easier when the color of the keypad's silicone contrast with the color of the pill.



In this case, the keypad's clear silicone makes visual detection of the thin flash over the contact pill very difficult.

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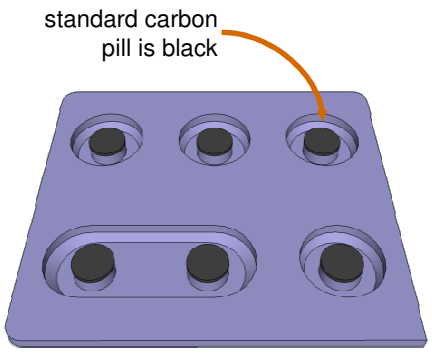
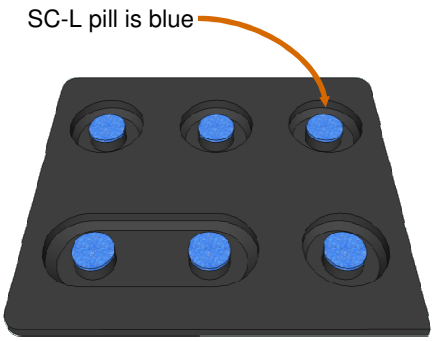
Designing High Quality Keypads
2) Keypad Color – the solution

Contrasting Silicone Color to Pill



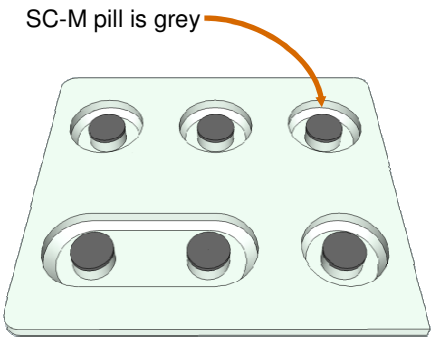
Best

For standard carbon pills, use light colored silicone, e.g. grey instead of black.



Best

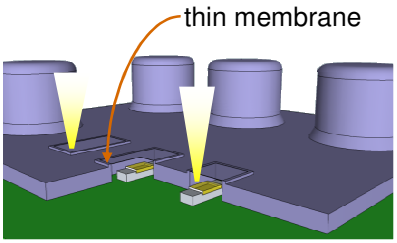
For SC-L pills, use light or dark colors, avoid using blue colors.



Best

For SC-M pills, use light or dark colors, avoid grey colors.

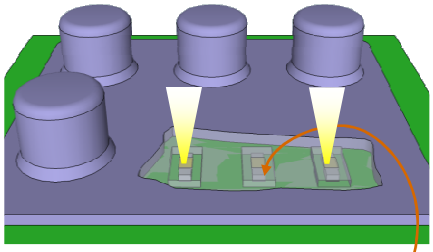
Avoid clear silicone keys



Best Colored silicone keypad

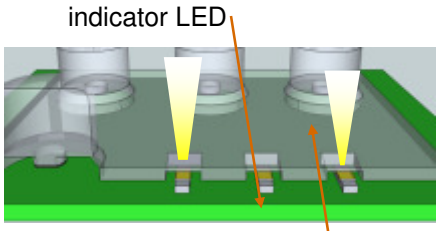
In case of LED pockets: When it is thin (0.3mm), colored silicone becomes almost transparent allowing for colored keys and discreet areas for indicator illumination.

0.06-0.08% black pigments work best.



Good Flow molded clear silicone areas

Flow molded silicones can be used to achieve multiple areas with different colors. Here, the indicator lights have clear silicone, the keys are colored silicone.



Worst Clear silicone keypad

Often, the silicone material is spec'd as clear so LED on the PCB can be used as indicator lights. However, this means the key also has to be clear.

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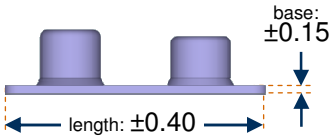
Designing High Quality Keypads
3) Tolerance – the problem

High Quality Design:

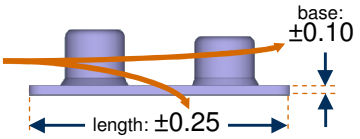


Best

DIN ISO 3302 M2 dimensional tolerance

Design with Increased Scrap Rate:

unnecessarily tight tolerance makes meeting spec more difficult



Worst

DIN ISO 3302 M1 dimensional tolerances

Why do tighter tolerances increase keypad cost?

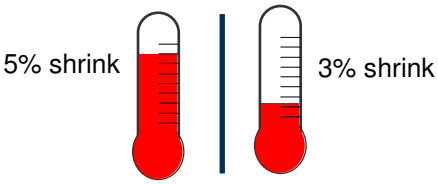
Ideally, all keypad part dimensions would measure at nominal. In reality, silicone has a shrinkage of 3%-5%, so a dimensional tolerance range is needed. Abatek controls shrinkage to meet the ISO-3302 class M2 tolerance standard. Tighter tolerance specs are more difficult to meet – often the many process variations cannot be further reduced – so parts not meeting spec must be scrapped.

Examples of keypad process variations affecting shrinkage:

Raw material

Silicone material comes with a hardness tolerance of ±1 Shore A durometer. The shrink rate is mostly related to the hardness.

Environment



During molding, environmental temperature and humidity will affect the shrinkage of the part.

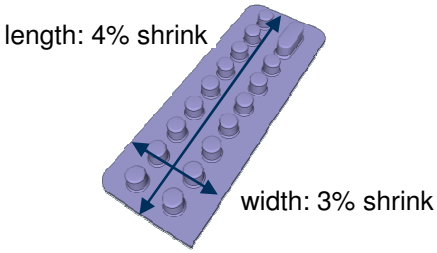
Molding parameters

The tool requires temperature, pressure and time to correctly mold the parts. Small variances in these parameters, or allowing the tool to cool too much, can cause shrink variances.

Post curing

The post curing process can shrink parts by as much as 2%. If not properly controlled, shrinkage variance can occur.

Design of part

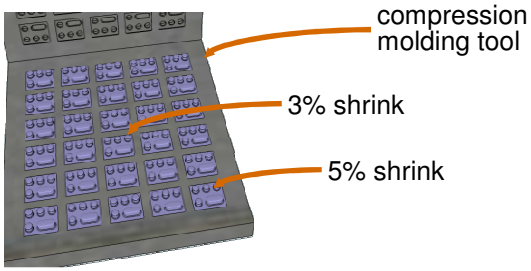


Part shape must be accounted for during tool design. Good tool design can limit, but not prevent the shrinkage variance.

Mixing

Several weight with the silicone. Small variances can affect shrinking of the final material.

Position in mold



Part variances among lots can be accounted by different parts of the tool having different shrink rates based on tool heating.

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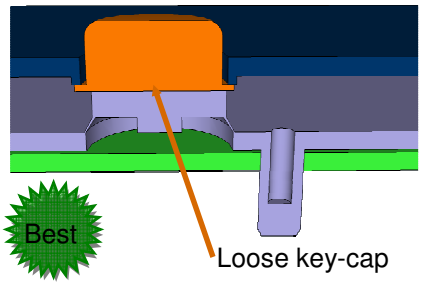
Designing High Quality Keypads
3) Tolerance – the solution

Most designs require tight tolerances because of assembly stack-up tolerances and/or need for precise keypad position. However silicone material is elastic offering two distinct advantages:

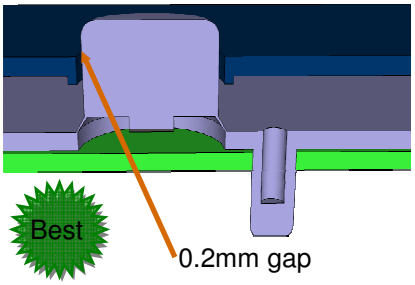
1) the silicone material will stretch and deflect in tight assemblies

2) with good design, very precise positioning of the keypad is not required.

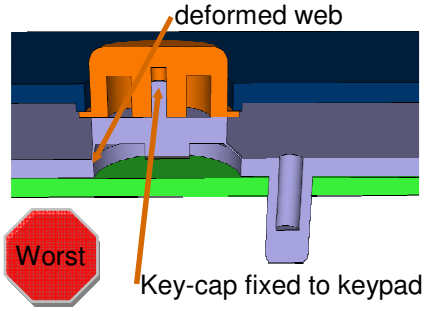
Positioning and Assembly



Use a loose key-cap design. Even with slight misalignment, actuation is not affected and the preload will avoid the cap to rattling.

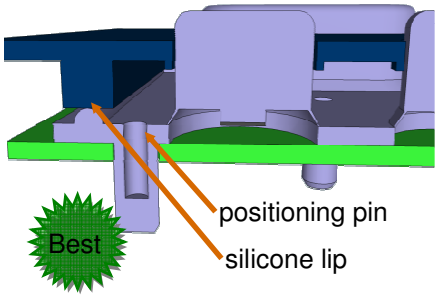


Assemblies that do not require key-caps should provide enough gap between the key and the housing to allow for slight misalignment.

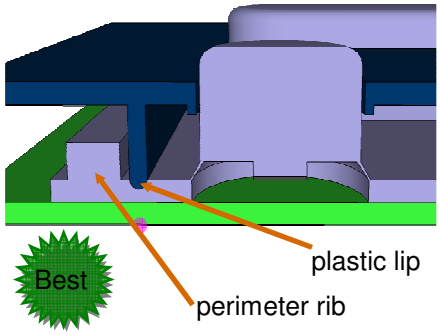


Some assembly designs force the keypad into position. Due to its wider tolerance, this may misalign the keypad and cause poor actuation.

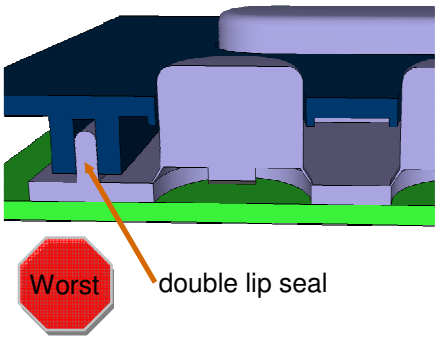
Sealing



Position pins and a silicone lip provide the best positioning and sealing solution. Here the keypad can easily be forced into position.

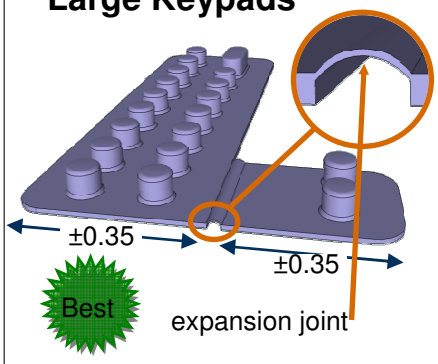


Instead use a perimeter silicone rib. The compression between the plastic lip and the silicone will still provide sealing.

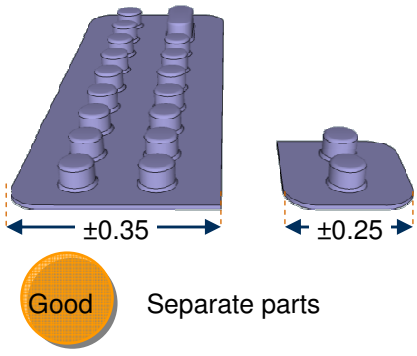


Some assemblies use double lip seals, constraining the keypad in the assembly and potentially causing poor actuation.

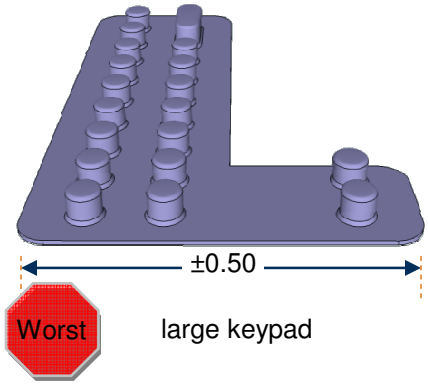
Large Keypads



Avoid large lengths by separating the keypad into sections using expansion joints. Installation is the same but the joint will improve alignment.



For high volume applications, separate the sections into individual keypads. This provides much more flexibility with the design and layout.



As dimensions on keypads get larger, the tolerance becomes wider and may affect the alignment of the keypad in the assembly.

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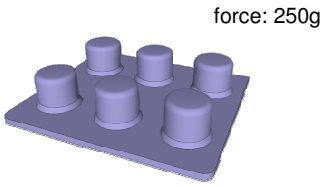
Designing High Quality Keypads
4) Force Specs – the problem

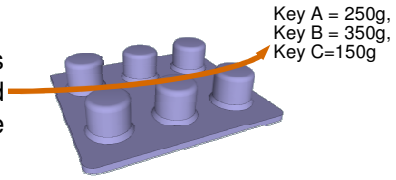
High Quality Design:



Best — One force spec

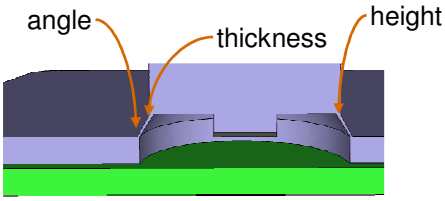
Design with Increased Scrap Rate:

multiple force specs is typically not needed and harder to manufacture



Worst — Multiple force specs (not adjusted to average measured values)

Why does having multiple forces on a keypad increase cost?



A keypad's web is carefully designed to meet the force spec. Design equations select the web thickness angle, and height with consideration for key size, shape and material.

When first-off parts are molded, the force is measured. If the force does not meet spec, the Durometer can be increased or decreased to bring the force into spec.

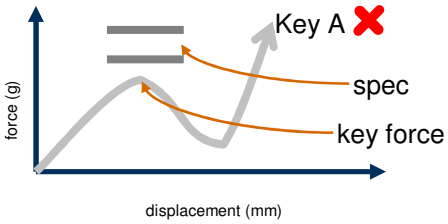
Material Hardness

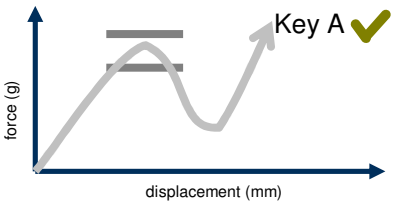
50 Shore A Durometer

Durometer is easily increased from 50 Shore A to 55 Shore A without affecting other variables

55 Shore A Durometer

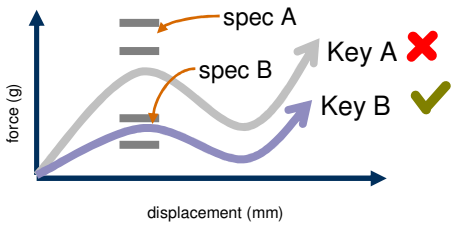
One Force Keypad

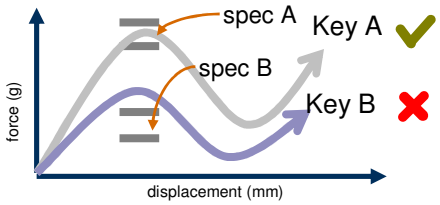




With a single force specification, a slight change in Durometer of material can bring the keys into spec. It is important to get as close to nominal as possible to account for process variations during production.

Multi- Force Keypad





When multiple forces are specified, changing the Durometer might not necessarily bring all key forces into spec. The alternative is to modify the tool, which is costly and not always 100% effective.

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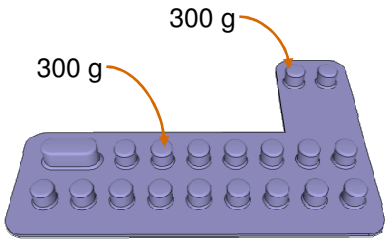
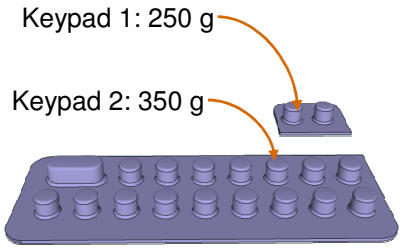
Designing High Quality Keypads
4) Force Specs – the solution

Avoid multiple force specifications in one keypad (split in two)



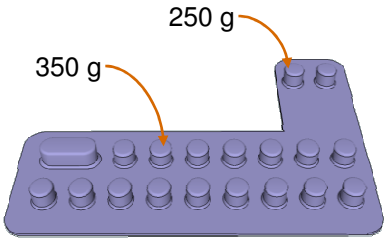
Best One force spec'd

Humans are only able to feel force differences of 50 grams or higher. Keypads with multiple forces are often not necessary.



Good Part split in multiple sections

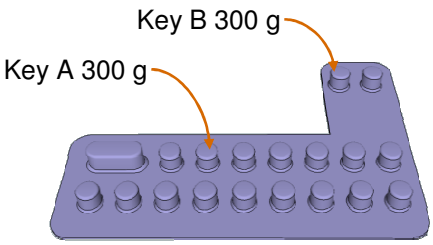
Separate the keypad into multiple sections. This makes it much easier to achieve the force specs and the design is more flexible.

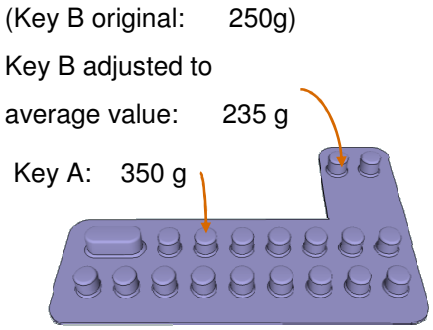


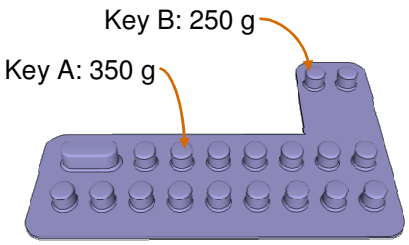
Worst Multiple force spec'd

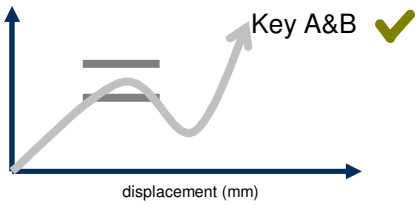
Some assemblies use multiple forces to help differentiate between many keys. This may help with tactile feel, but it is more difficult to mold.

Avoid multiple force specifications in one keypad (set average values as spec)



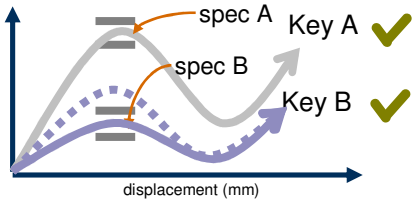






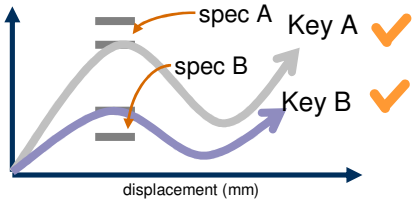
Best One force spec'd

Humans are only able to feel force differences of 50 grams or higher. Keypads with multiple forces are often not necessary.



Good Multiple force spec'd adjusted to average measured values

If the force specs are adjusted to the measured and accepted average values then the durometer still can be used to keep all keys within specs during production.



Worst Multiple force spec'd not adjusted to average measured values

Multiple specs will rarely be in center of tolerance.

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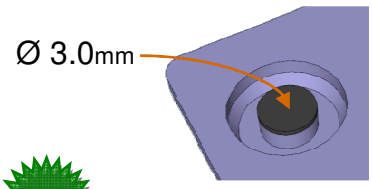
CREATING INPUT SOLUTIONS

Designing High Quality Keypads
5) Pill size – the problem

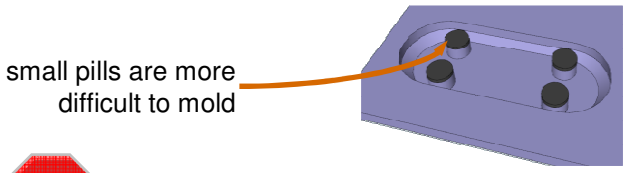
High Quality Design:



Best

Pill size = Ø3 mm

Design with Increased Scrap Rate:



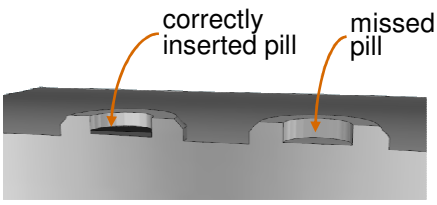
Worst

Pill size = Ø2.5 mm (smallest)

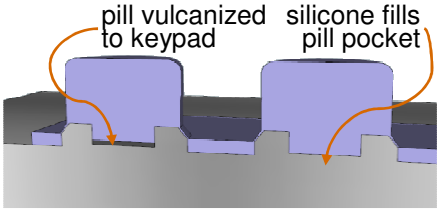
Why do small pills increase keypad cost?

Small pills are difficult to handle. Pills are loaded into the main silicone tool using a pill jig. The process has several potential failures including: missed pill, double pill, and pill flash over. The smaller pills are more likely to have pill loading failures, resulting in higher scrap and more inspections.

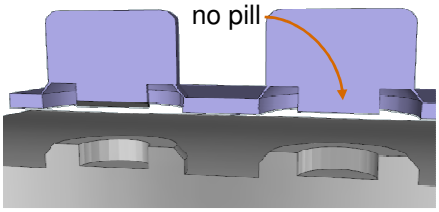
Missed Pill Issue



Pills are inserted into the pill pockets of the main keypad tool using a jig. Smaller pills have a higher risk of being missed during pill jig loading and inspection.

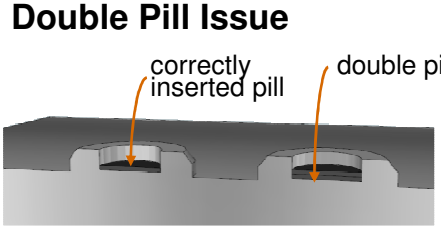


During molding, the keypad's silicone vulcanizes with the correctly positioned pills. If no pill is present, the pill pocket is filled with non-conductive silicone.

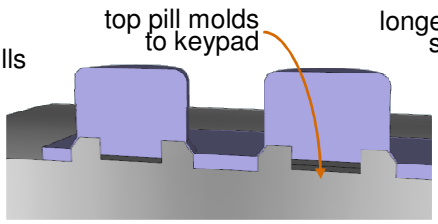


After molding, the keypad will not function electrically. Parts are visually inspected for this defect, but smaller pills have a higher risk of being missed in inspection.

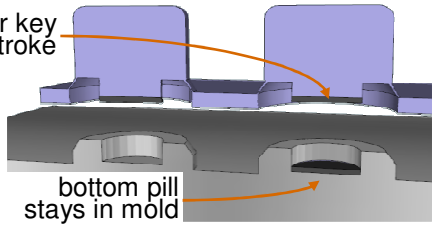
Double Pill Issue



The pill loading jig is designed to hold only one pill per pocket. There is a higher risk with smaller pills of accidentally loading double pills.

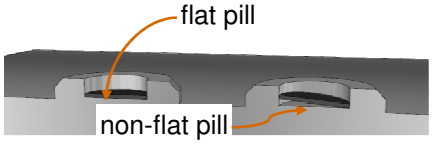


During molding the keypad cures only to the top pill. If the bottom pill is not blown-out after molding, the same defect can occur in the next cycle.

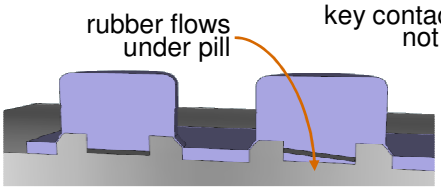


After molding, the keypad will still function electrically, but the stroke is longer, the tactile feel is different and lifecycle is possibly reduced.

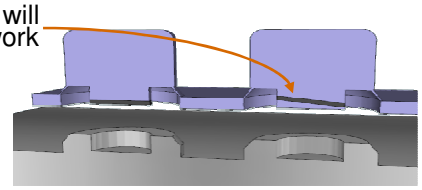
Pill Flash Over Issue



The pill insert jig is design to press the pill flat into each pock. Smaller pills have a higher risk of being inserted at an angle instead of flat.



During molding the silicone will flow over and under the non-flat pill. The bottom of the key now has silicone rubber instead a contact pill.



After molding, the key will not correctly function electrically. Visual inspection is also used for this defect, but Abatek can also test electrically when PCB is provided.

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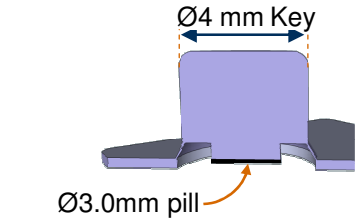
Designing High Quality Keypads
5) Pill size – the solution

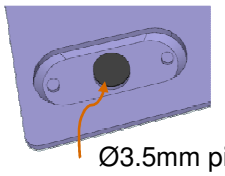
Spec pills at Ø3.0mm or larger:

Best Key and Pill Size



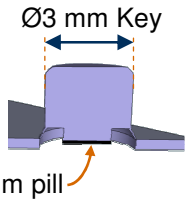
Best Pill size is Ø3.0 mm

The best key designs have a minimum key top size of diameter 4.0mm and pill size of 3.0mm.



Good Pill size is larger than Ø3.0 mm

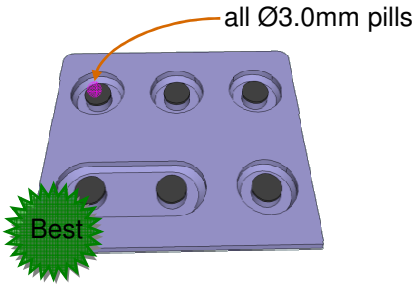
For big keys or for high power application it might be useful to select bigger pills than 3.0mm. Only disadvantage of bigger pills is that they are more expensive than 3.0mm pills (material cost). For handling in molding they are even better than 3.0mm pills.



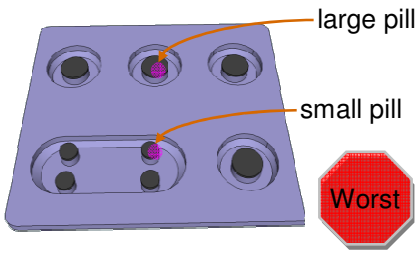
Worst Pills size is Ø2.5 mm (smallest)

A Ø3mm key can only accommodate a Ø2.5mm pill. This is causing high rejects in molding and small contact surface. Savings in material cost due to smaller pill size are more than compensated by higher rejects for all carbon and SC-L pills.

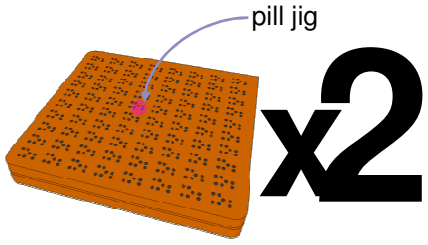
Use Only One Pill Size per Keypad



Best is is to use the same pill size and design anti-rocking features or multiple pills per key. Of course, it's better to spec pills Ø3.0mm or larger.



Insert jigs are loaded with pills before each cycle. With 1 pill size, the tool is quickly filled. With 2 pill sizes, the jig is carefully filled - twice.



With 2 pill sizes, the pill insertion process must be repeated twice with two pill jigs. There is twice the chance of having a reject.

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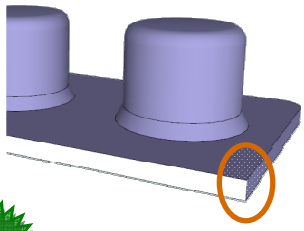
Designing High Quality Keypads
6) Undercuts/ribs– the problem

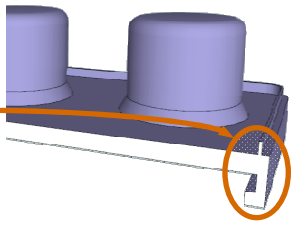
High Quality Design:



Best no undercut or rib

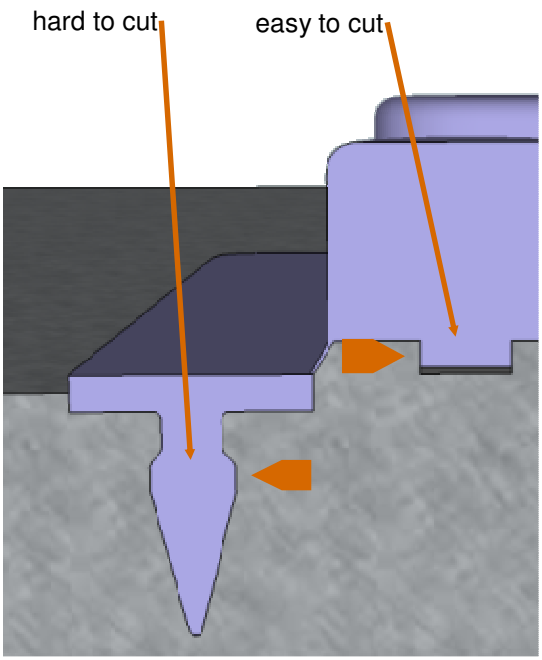
Design with Increased Scrap Rate:

these features are more likely to tear during keypad removal after molding

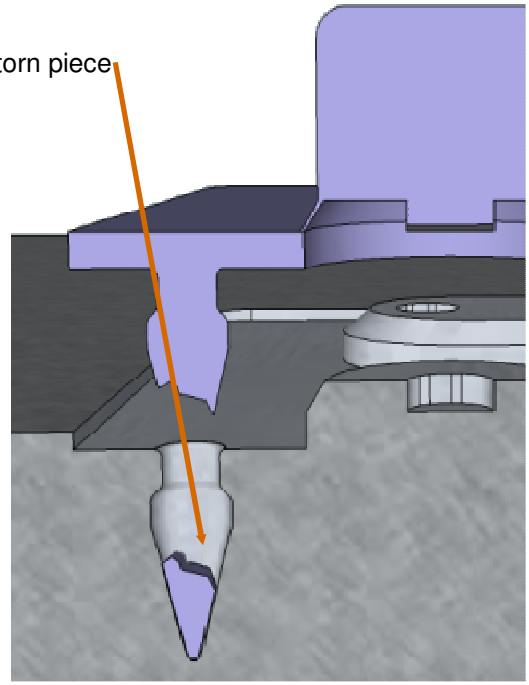


Worst full undercut / thin rib

Why do undercuts and thin ribs increase keypad cost?



Steel tools are cut to make silicone keypad molds. The cutting machines work best by cutting in a vertical direction. Horizontal cuts (undercuts) in the steel are much more difficult, increasing tooling complexity and cost.



When keypads are removed from the tool after molding, the delicate undercuts and thin ribs "stick" in the tool and can tear. If the broken pieces remain in the mold, additional parts will also be defective. The higher scrap rate increases part cost.

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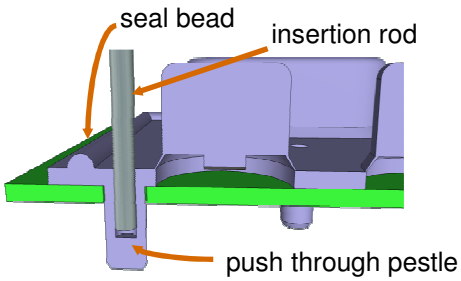
Designing High Quality Keypads
6) Undercuts/ribs– the solution

Avoid undercuts

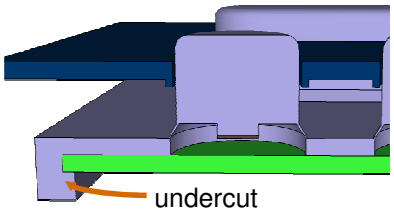


Best Pestle with hole

An **insertion rod** can be used to push the pestle through the PCB hole, making assembly easier.

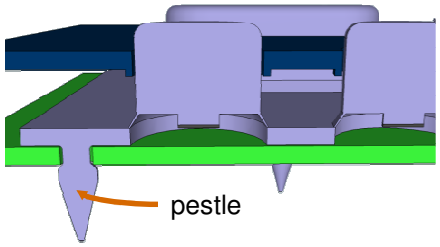
The **position pestle** is hollow which compresses then locks, like an undercut, during assembly.

The **seal bead** is far easer to mold than a rib and provides a better seal.



Worst Undercut around base

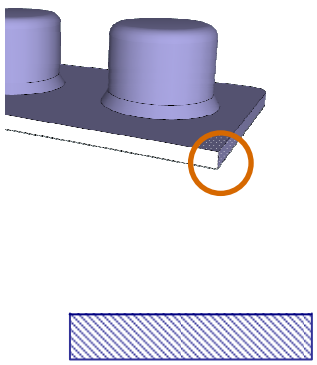
Most keypad undercuts are used to position, surround and protect the PCB. If this design is unavoidable, the undercut's edges need to be rounded (R 2 mm) and be less than 1mm deep.



Worst Pestle with undercut

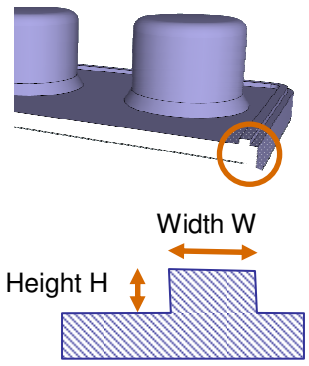
Some positioning pestle designs use undercuts to lock the keypad to the PCB. The long pestle tip helps to pull it through the PCB hole. Often these delicate tips are torn off during assembly.

Avoid thin ribs



Best No ribs

Try to keep the keypad as simple as possible, it is the most cost efficient solution.

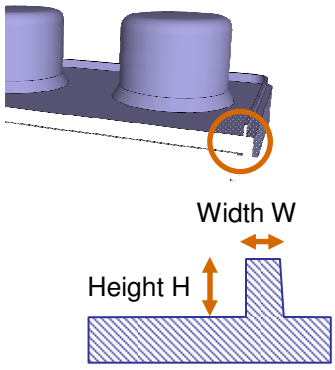


Good Thick ribs

H < W

If the width of a rib is larger than the height it can be easily manufactured. Thick ribs usually do not tear off during mould release.

The cutter for the mould making will not easily break.



Worst Tin ribs

H > W

If the width of a rib is smaller than the height it can create big problems during manufacturing. Thin ribs easily tear off during mould release.

Expensive and time consuming EDM process is needed to cut thin ribs into the mould.

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