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DESIGN GUIDE

# Silicone Rubber Keypad



## SYSTEM SUPPLIER FOR INPUT DEVICES

CONSTRUCTION | PRODUCTION | LOGISTICS

MODULES & SYSTEM SOLUTIONS

KEYPADS & SWITCHES

CABLE ASSEMBLY & CONNECTORS

ELECTRONIC COMPONENTS

MOULDED PARTS & TOOLING



Management System  
ISO 9001:2015

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## ABOUT N&H TECHNOLOGY

N&H Technology GmbH was founded in 2001 and supplies components, and complete solutions for customer-specific user interfaces (HMI), according to our guideline: Single Source Supply.

### STRENGTHEN

We see ourselves as a link between production plants in Asia and our customers in Europe. On the one hand, our strengths lie in the technical advice and support of our customers projects and on the other hand in professional procurement, quality assurance and logistics. Through highly qualified German and Chinese engineers in our company, we communicate excellently with our customers and suppliers, even about complex technical issues. On customer demand, we also can take over entire development and design tasks.

### PRODUCTION

Our production processes economically take place in selected factories, mainly in China. All production plants are certified according to DIN ISO 9001, DIN ISO 14001, DIN TS 16949 and DIN ISO 13845. The European quality standards of our products are ensured by a comprehensive quality management system in the production plants and in-house.



*Firmensitz im Stahlwerk Becker in Willich*

### QUALITY

We are certified according to DIN ISO 9001. In January 2013 we set up a second N&H location in China (Shanghai) to continuously improve our ongoing commitment to quality and service. In addition, we can carry out technical tests and analyzes for our customers in our own laboratory in Willich.



#### Modern meets History

Since the turn of the millennium, the area of the former Stahlwerk Becker has been transformed into a diverse business park, where carefully restored monuments alternate with modern architecture.

## MATERIALS & PROCESS

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## N&H PRODUCT RANGE

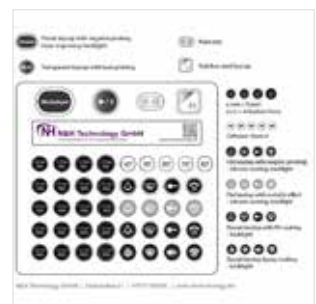
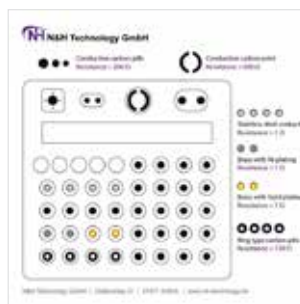
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## SAMPLE KIT

Please ask for our sample keypad.

The N & H sample set includes a special silicone rubber keypad with a variety of sample buttons and constructions, as well as a sample of a membrane keypad with various options.

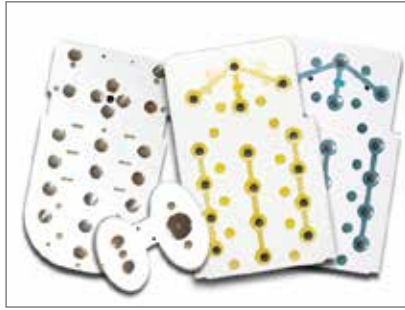
We charge a nominal fee of 29,- € (excl. transport costs) for it.



# TECHNICAL TYPES OF SILICONE RUBBER KEYPADS



Keycaps with Carbon Pills and Metal Pills



Keycaps with Polydome and Metal Dome



Multi Moulding Colours



Translucent material for Night Design with positive & negative printing



Laser Engraving on rubber keys for Night Design



Laser Engraving on plastic caps for Night Design



Keytop with PU or Epoxy Coating



Silver painted or Chrome plated surface



IMD film technique



Rubber and plastic keys with integrated Light Guide



Rubber with plastic keys



P+R technique



Integrated EL and LED Backlight



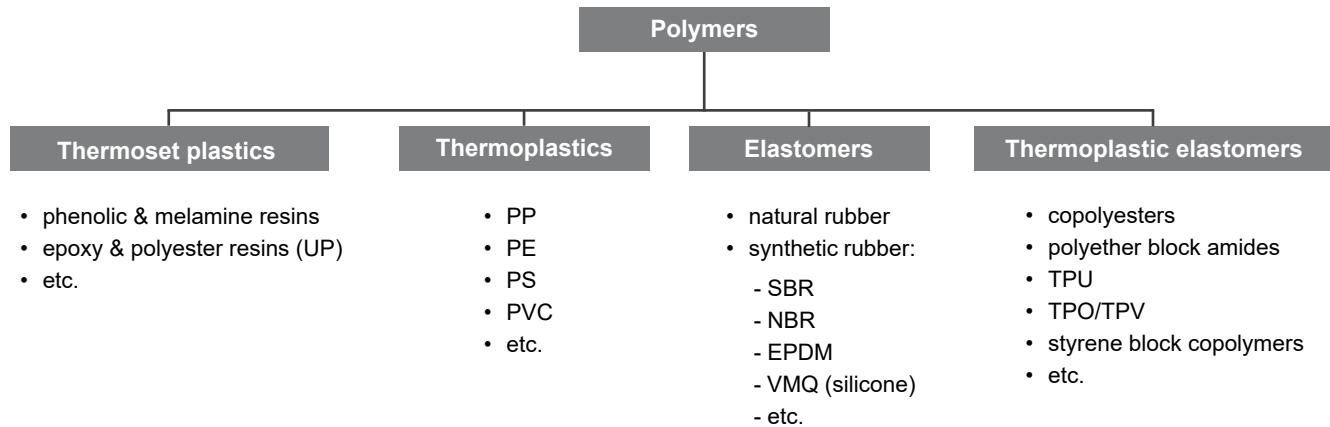
Metal keys with backlit legends and Metal Tops



Other rubber parts

## POLYMERS

Silicone, the basic material of Rubber Keypads, belongs to the elastomers, a subgroup of polymers. Elastomers can be natural rubber and synthetic rubber as well. For a long time natural caoutchouc was the rubber industry's sole basic raw material. It is produced mainly from the juice of the rubber tree. Synthetic caoutchouc is a product of organic chemistry. Starting material is crude oil.



### CAOUTCHOUC / ELASTIC RUBBER

Caoutchouc is a tacky, tough and plastic material composed of long, ductile and flexible molecular chains. If subjected to force, the molecular chains flow past each other causing the caoutchouc to change shape. After reduction of force, the material remains more or less in its distorted form.

However, vulcanization and the application of specified components cause the molecular chains to interlink and become permanent. Thus the original plastic caoutchouc is transformed into a rubber with elastic properties. Application of force now only causes the molecular chains to alter in shape and they do not slide past each other. They return almost to their original state after force is reduced.

### ELASTOMERS

When heat is applied to the plastic raw materials, crosslinking occurs. This crosslinking (vulcanization) gives the material its permanent high elasticity through a chemical process in which the molecular chains interlink. It is not possible to reshape or recycle the vulcanized rubber material by reapplication of heat. The main advantages of this group include their elasticity and durability even under long-term thermal and mechanical stress. This viscoelastic property is also retained despite exposure to a wide range of temperatures.



## VULCANIZATION PROCESS

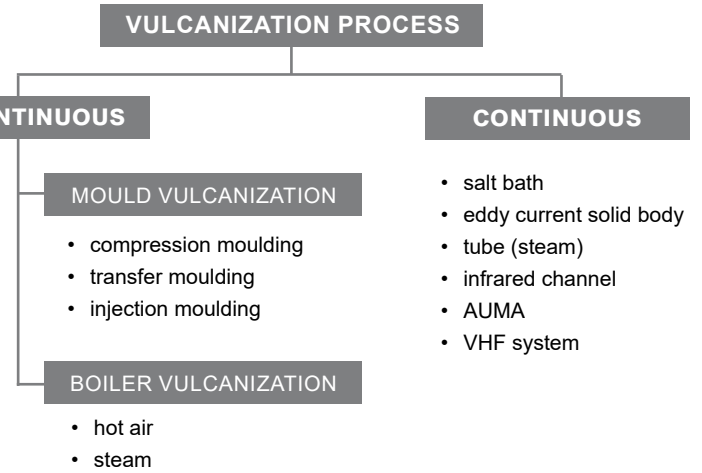
When heat is applied to the caoutchouc compound, it is transformed from the plastic to the elastic state. The caoutchouc turns into rubber. This crosslinking process is called vulcanization.

## MOULDING TYPES

Silicone Rubber Keypads are manufactured by using closed moulds and applying a discontinuous vulcanization process. Compression moulding is the most common method. Injection moulding is suitable for large and thin keypads, precision parts or for the manufacture of high quantities.

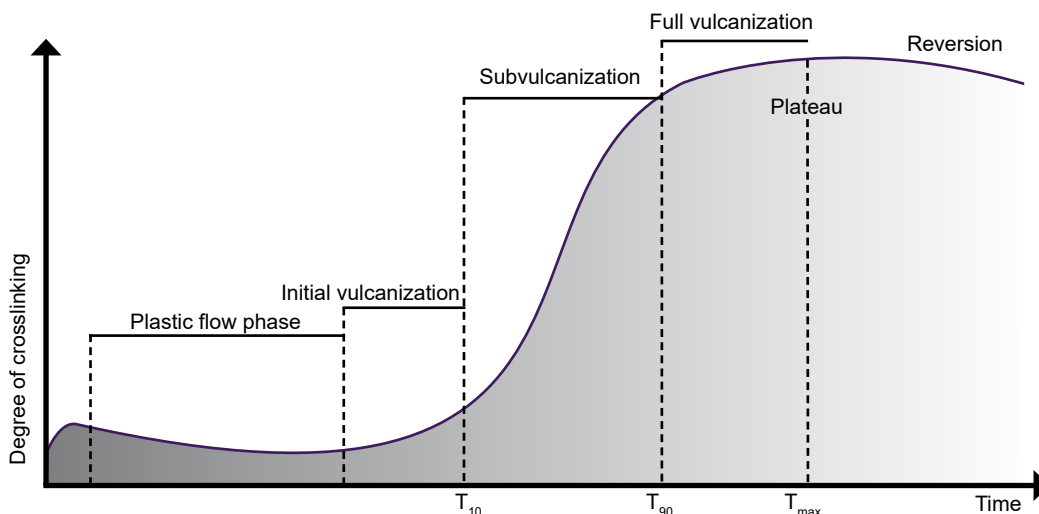
## VULCANIZATION CHARACTERISTICS

The most important parameters of vulcanization are temperature and time. One must be coordinated with the other to enable optimal vulcanization of the given parts. The higher the vulcanization temperature, the shorter the curing time needed. This inevitably reduces the manufacturing costs. On the other hand, a reversion of the process may occur when the time can not be accurately controlled as in the case of too high temperatures. De-moulding is more difficult at high temperatures. Type and size of keypad are also crucial factors.



Thick parts have to be cured for a longer time at a relatively low temperature in order to achieve complete uniform vulcanization.

To attain economical production of the keypads and at the same time realize an optimal vulcanization of the rubber, a Post Curing Process is applied as part of the standard process for Silicone Rubber Keypads. Another purpose of Post Curing is the diffusing out of uncombined constituents and the elimination of rubber colours.



## PHYSICAL PROPERTIES

	Conductor	Insulator
Density (g/cm <sup>3</sup> ) <i>DIN 53479</i>	1.2	1.1 - 1.4
Hardness (Shore A) <i>DIN 53505</i>	65 ± 5	30 - 85 ± 5 (55 ± 5 typical)
Tensile strength (N/mm <sup>2</sup> ) <i>DIN 53504</i>	6.0	5.0 - 9.0
Elongation at break (%) <i>DIN 53504</i>	170	115 - 600
Compression set (%) <i>DIN 53517</i>	20	11 - 22

## MECHANICAL CHARACTERISTICS

Actuation force (cN)	20 - 500	180 ± 50 typical
Snap Ratio (%)	< 80	50 ± 10 typical
Stroke (mm)	0.3 - 5.0	1.1 ± 0.1 typical
Operating life (cycles)	1 x 10 <sup>5</sup> - 3 x 10 <sup>7</sup>	2 x 10 <sup>5</sup> typical

## CHEMICAL RESISTANCE

Due to its inert state, silicone rubber is not affected or damaged when exposed to various chemicals and food products for a limited time. However, continuous immersion for a longer period of time and at high temperatures may have an effect on the silicone rubber. There is no corrosion of silicone rubber as it does not contain any aggressive agents such as sulphur or plasticizers. Silicone rubber may be exposed for a short time to these media without any harmful effects:

Solvents:	Acids:	Bases:	Food Products:
Aceton	Acetic Acid 5%	Ammonium Hydroxide	Beer, Wine, Liquor
Butyl Alcohol	Hydrochloric Acid 10%	Potassium Hydroxide	Cola Syrup
Ethyl Alcohol	Nitric Acid 10%	Sodium Hydroxide	Coffee
Isopropyl Alcohol	Phosphoric Acid 10%		Vinegar
Mineral Spirits	Sulfuric Acid 20%		Water & Steam

## OIL AND FUEL RESISTANCE

Most oils and fuels do not normally affect the physical properties of silicone rubber after a short time of exposure. Should it be necessary to expose the silicone rubber to oils and fuels constantly, the formula of the silicone may be adjusted to meet this requirement.

## ELECTRICAL PROPERTIES

Contact resistance (Ω)	See table Contact Type
Insulation resistance at 250V (MΩ) <i>DIN 53482</i>	> 100
Dielectric strength (kV/mm) <i>DIN 53481</i>	23 - 27
Contact bounce (ms)	≤ 12
Contact rating	See table Contact Type
Conductor volume resistivity (Ω•cm)	2.5 - 5.0
Insulator volume resistivity (Ω•cm)	> 2 x 10 <sup>14</sup>

## TEMPERATURE CHARACTERISTICS

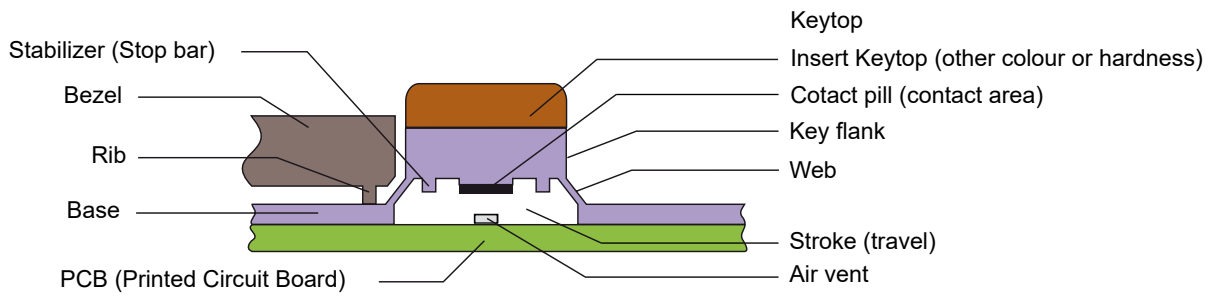
Operating temperature (°C)	- 40 ~ + 85	typical
Storage temperature (°C)	- 60 ~ + 120	typical
UL flammability	HB and 94V-0	HB typical

Burns to neutral and non-conductive SiO<sub>2</sub> powder. Flame retardant. No melting or dripping occurring. No toxic fumes

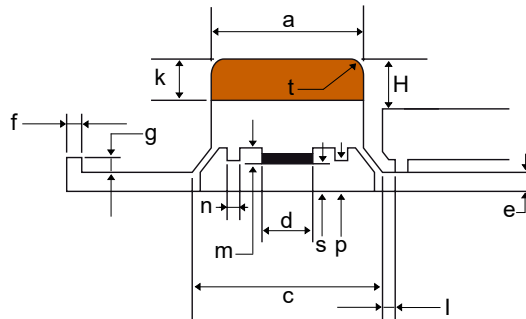
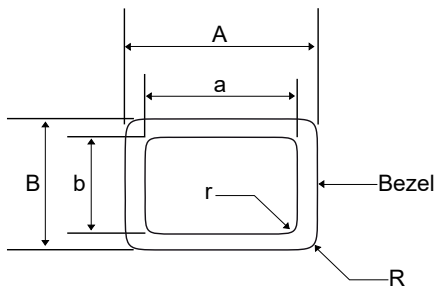
## ENVIRONMENTAL RESISTANCE

Sunlight and climate conditions neither affect the colour of silicone rubber nor cause it to disintegrate. Physical properties remain unchanged.

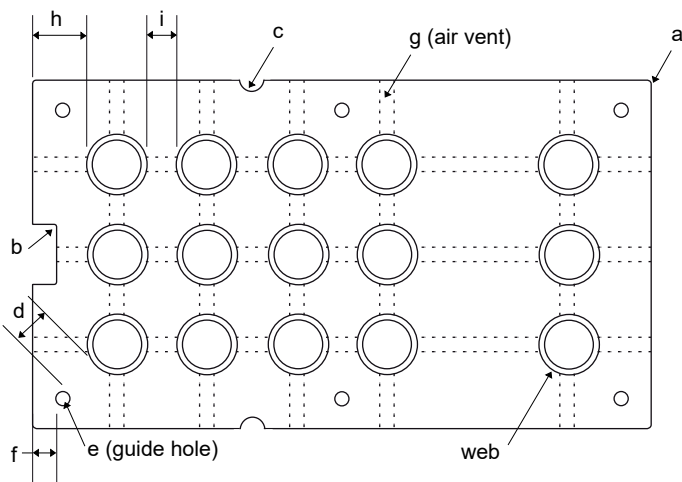
## TERMINOLOGY



## DIMENSIONS



- A - a ≥ 0.4 mm
- B - b ≥ 0.4 mm
- a - d ≥ 1.5 mm
- c - a ≈ 2.0 mm
- H ≥ s + 0.4 mm
- p - s ≥ 0.15 mm
- R > r
- e ≈ 0.8 - 1.2 mm
- f ≥ g / 2
- l ≥ 1.2 mm
- k ≥ 1.5 mm
- m ≥ 0.6 mm
- n ≥ 1.0 mm
- r ≥ 0.4 mm (R)
- t ≥ 0.3 mm (R)



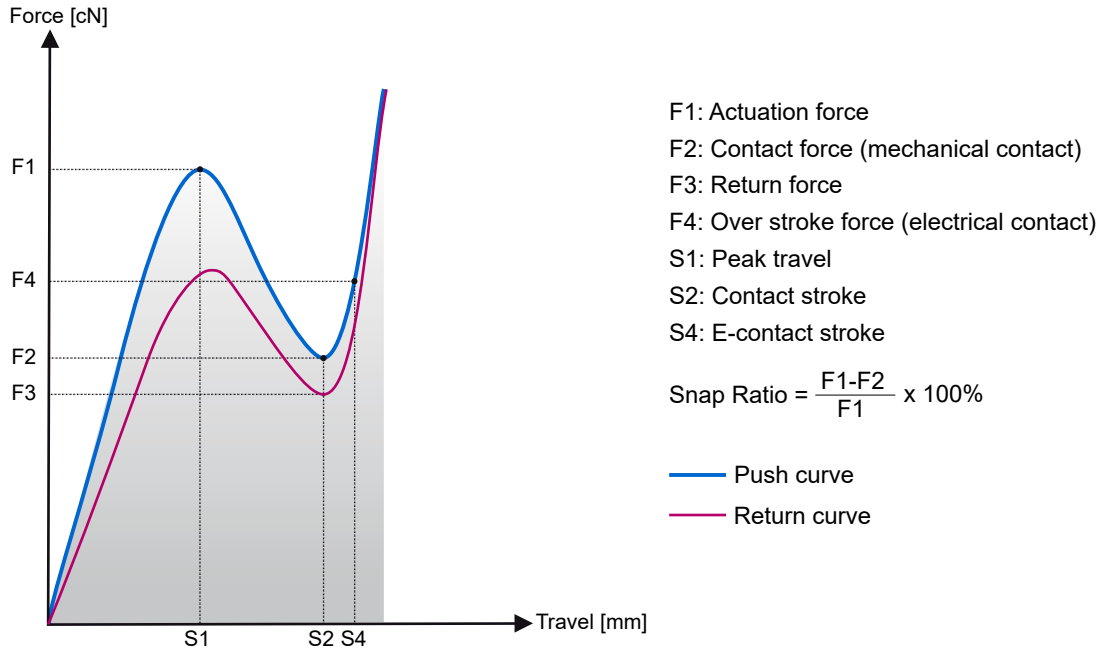
- a ≥ 1.0 mm (R)
- b ≥ 0.5 mm (R)
- c ≥ 2.0 mm
- d ≥ 1.2 mm
- e ≥ 1.5 mm (Ø)
- f ≥ 2.0 mm
- g ≈ 1.0 mm wide; 0.3 mm deep
- h ≥ 2.0 mm
- i ≥ 1.5 mm

In applications where the keypad is completely sealed, Guide Holes are not allowed and air venting can be achieved through venting paths between keys, i.e. the air vents should not lead to outer edge of keypad.





## FORCE-TRAVEL DIAGRAM



The force drop from F1 to F2 yields Tactile Feeling. The higher the Snap Ratio, the stronger the Tactile Feeling. On the other hand, a higher Snap Ratio means a lower Return Force F3 which could cause Key Jamming. In the case of Polydomes or Metaldomes, the Tactile Feeling is concise and strong although the Snap Ratio is nominal low, because the force drop is rapid and the curve of the force drop is steep.

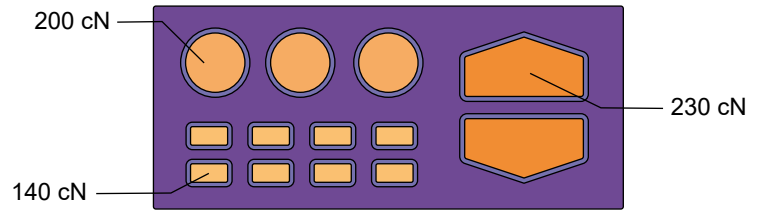
## KEY SHAPES AND CHARACTERISTICS

Type	Flat Cone	Single Cone	Single Bell	Double Cone	Double Bell	Flat Bell
Curve						
Force Range	30 - 350 g	30 - 250 g	30 - 200 g	30 - 90 g	30 - 250 g	20 - 80 g
Stroke Range	0.5 - 3.0 mm	0.7 - 2.0 mm	0.5 - 3.0 mm	2.0 - 4.0 mm	1.0 - 2.5 mm	0.3 - 1.0 mm
Life Cycles (x10 <sup>3</sup> )	200 - 2,000	200 - 2,000	1,000 - 5,000	5,000 - 20,000	1,000 - 20,000	1,000 - 30,000
Typical Uses	Telephone, Remote Control, Automotive, Radio, Calculator, etc.	Telephone, Remote Control, Automotive, Calculator, etc.	Telephone, Office Machinery, Remote Control, Measuring Instruments, etc.	Computer, Typewriter, etc.	Telephone, Test Instruments, Typewriter, etc.	Computer, Calculator, Remote Control, Typewriter, etc.

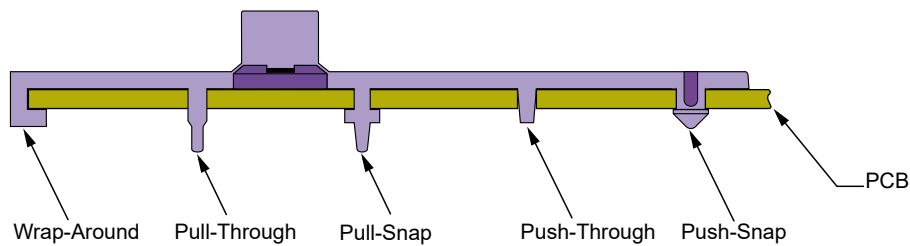
## DESIGN RECOMMENDATIONS

### FORCE DEFINITION

The Actuation Force should be defined in proportion to the size of keys, especially when the keys have considerably different sizes.

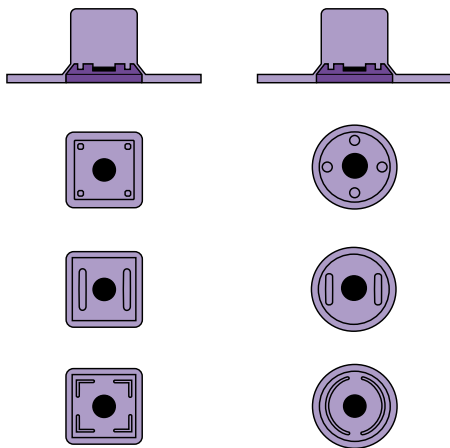


### MOUNT BOSS



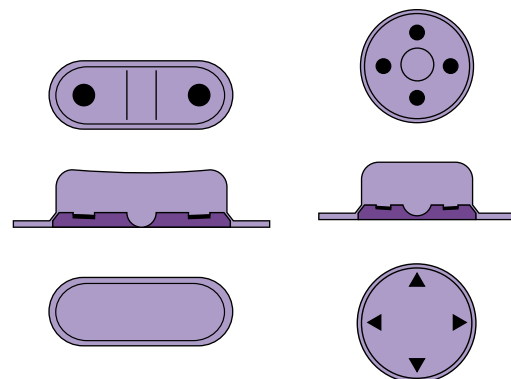
For manufacturing purposes it is an advantage when the diameter of the mount boss is as large as possible.

### STABILIZER (STOP BAR)



If the contact size is significantly smaller than key size, Stabilizers are necessary. This reduces keytop wobble.

### ROCKER KEY



For Rocker and Cursor Keys please send PCB Contact Circuit to N&H for approval.

### STRETCHING JOINT



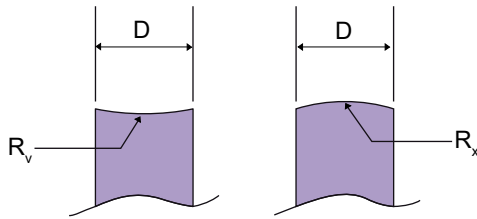
The Stretching Joint compensates the tolerances at assembly and is therefore necessary for rubber keypads with large dimensions.

### SEPARATING GROOVE



The Separating Groove enables the rubber keypad to be torn into sections.

## KEYTOP RADIUS FOR SILKSCREEN PRINTING



$$R_v = D + 1 \text{ mm, R30 min.}$$

$$R_x = D + 1 \text{ mm, R20 min.}$$

Printing can be done on concave or convex keytop surfaces.

## KEYTOP COATINGS

- Matt silicone spray (MSS)
- PU
- Epoxy { Standard
- Others { UV-resistant

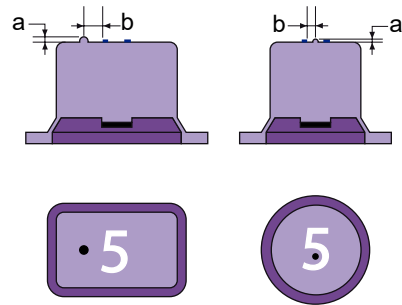
The abrasion resistance of printed legends can be enhanced by surface coating. The touch feeling of PU Coating is matt and the surface allows optimal finger grip. The appearance of Epoxy Coating is similar to plastic and can be matt or glossy.

## CHOICE OF COLOURS

An additional rubber colour can be easily realized, whereas an extra printing colour requires a completely new printing process. Therefore, a supplementary rubber colour is less expensive than a further legend colour.



## KEYTOP „5“ WITH ORIENTATION DIMPLE



The Orientation Dimple can impair the quality of Silkscreen Printing. To define the dimensions a and b and the shape of Dimple, please contact N&H.

## LONG KEYS



With longer keys there is more danger of wobbling and jamming than with circular and rectangular keys. Solutions to prevent this are available from N&H.

## GAP BETWEEN KEYTOP & BEZEL

If the gap between the keytop and bezel can not be defined at the beginning of the project and needs to be clarified, N&H will provide details on procedure.

## DOUBLE SNAP KEYS

For solutions on designing double snap keys please contact N&H.

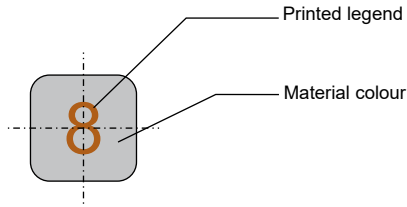
## SPECIFICATION DETAILS IN THE DRAWING

In addition to dimension definitions of keypad the drawing should include the following specifications:

1. Actuation force F1 in cN with tolerance
2. Snap Ratio in % with tolerance of  $\pm 10\%$
3. Return force F3 in cN as minimum
4. Stroke S2 in mm with tolerance of  $\pm 0.1 \text{ mm}$
5. Life in cycles as minimum
6. Contact type
7. Material colour(s) in RAL, Pantone or NCS
8. Legend colour(s) in RAL, Pantone or NCS

Shape and dimensions of web will be determined by tool designer.

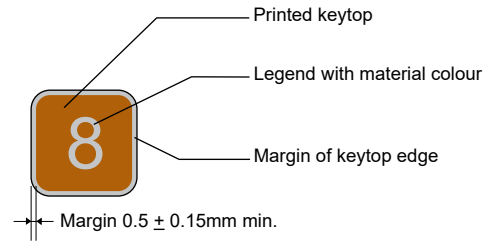
POSITIVE PRINTING



Legend off-centre:  $\pm 0.3$  mm  
Line width:  $\geq 0.2$  mm

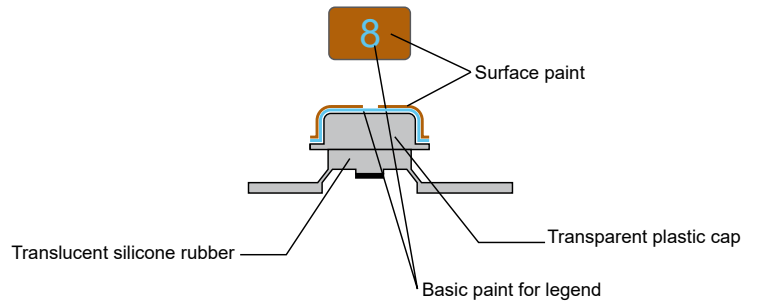
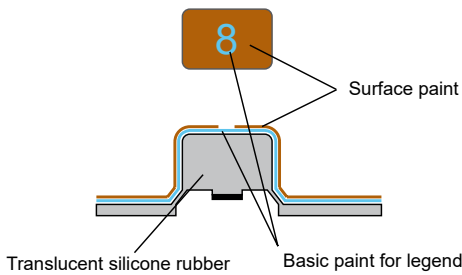
Through application of transmissive material the keytop and the key flank can be backlit.

NEGATIVE PRINTING



The legend, the margin of the keytop edge and the key flank are illuminated by use of transmissive material.

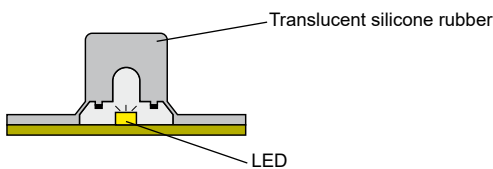
LASER ENGRAVING LEGENDS



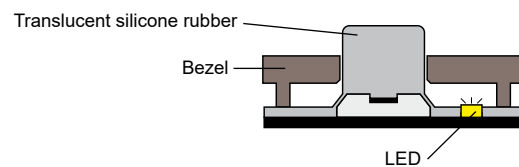
The surface paint of legend area is evaporated by applying a laser beam. The basic paint, which makes up the legend colour, is a light transmissive layer, whereas the surface paint is impermeable to light. If the basic paint is omitted, the key material colour forms the legend colour.

ILLUMINATION OPTIONS

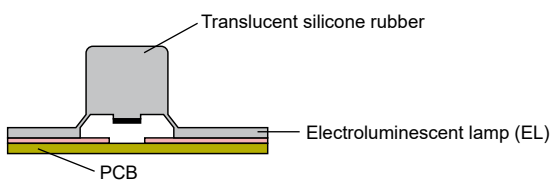
CENTER LED ILLUMINATION



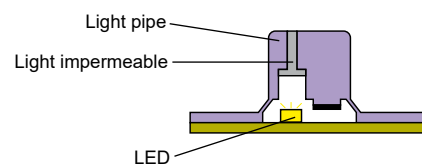
SIDE LED MOUNTING



EL BACKLIGHTING



LIGHT GUIDE INTEGRATION



In order to eliminate the dark colour of the Carbon Contact, which is visible through translucent silicone rubber, the contact area can be pre-printed white before Carbon Dip Printing, or optionally Carbon Pills printed white on one side can be used.

# ELECTRICAL CONTACT

## CONTACT SHAPE



Circular



Circular Ring



Semi-Circular Ring



Oval



Square



Square Ring



Semi-Square Ring

## CONTACT TYPE

Contact Surface of PCB:		Gold	Carbon	Gold	
Type	Contact Shape	Contact Resistance		Max. Rating	Life Cycles
Carbon Dip Printing	no limit	150 - 300 Ω	< 600 Ω	30 V <sub>DC</sub> / 3 mA	1-3 Mio
Carbon Pill	circular	< 100 Ω	< 200 Ω	30 V <sub>DC</sub> / 5 mA	> 5 Mio
Low Resistance Carbon Pill	circular	< 10 Ω	< 30 Ω	30 V <sub>DC</sub> / 5 mA	> 5 Mio
Polydome	circular	1 - 10 Ω	< 30 Ω	42 V <sub>DC</sub> / 20 mA	> 1 Mio
Metal Powder Pill	circular	10 - 50 Ω	< 100 Ω	30 V <sub>DC</sub> / 30 mA	1 - 5 Mio
Metal Pill	circular	1 - 5 Ω	< 20 Ω	100 V <sub>DC</sub> / 100 mA	> 5 Mio
Metaldome	circular, square, oval	1 - 5 Ω	< 30 Ω	42 V <sub>DC</sub> / 30 mA	> 1 Mio

The value of contact resistance is depending on the size of contact pill, the PCB circuit dimensions and the force applied by contact closing



Keypad with Gold Contacts



Keypad with Carbon Contact Pill

## STANDARD SIZE OF CARBON PILL

Carbon pills are usually circular from Ø 2.5 mm to Ø 8.0 mm with step 0.5 mm. Other diameters and shapes are possible with more costs involved.

## PCB CONTACT SURFACE OPTIONS

PCB Contact Surface	Material	Contact Surface
Rigid	FR4, CEM1, etc.	Gold, Nickel, Carbon
Flexible	Polyimide	Gold, Nickel
Flexible	Polyester	Carbon, Silver, Carbon-Silver-Mixture

For high reliability applications Gold plated PCB is preferred. Silkscreen printed carbon is the most commonly used plating because of low cost and high chemical resistance.

## PCB CIRCUIT TYPE

### Gold Traces



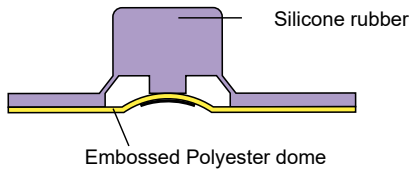
### Carbon Traces



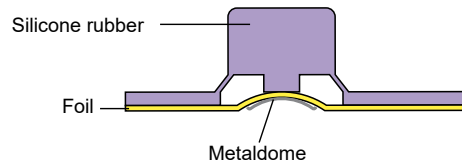
The PCB Contact Area in each direction should be 0.5 mm min. larger than the Contact Area of keypad. For Rocker Key and Keys with Metaldomes, please send PCB Contact Circuit to N&H for approval.

# TECHNICAL OPTIONS OF KEYPADS

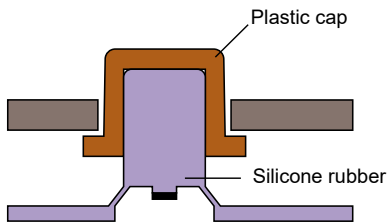
## SILICONE RUBBER WITH POLYDOME



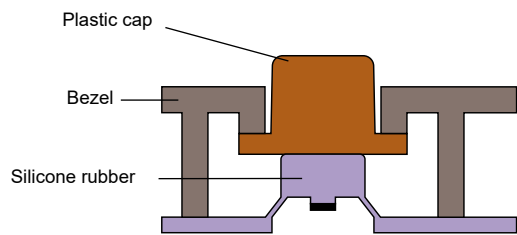
## SILICONE RUBBER WITH METALDOME



## SILICONE RUBBER WITH SNAP-ON PLASTIC CAPS

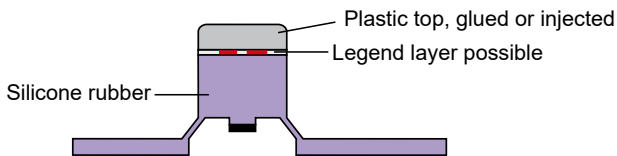


## SILICONE RUBBER WITH FREE FLOATING PLASTIC CAPS

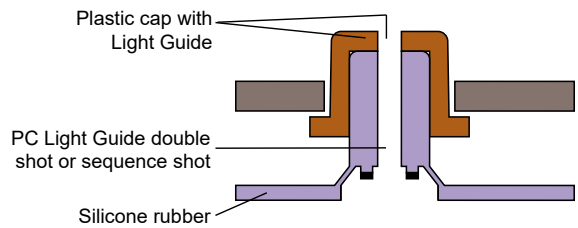


Necessary preloading of the keytop through plastic cap: 0.1-0.2 mm

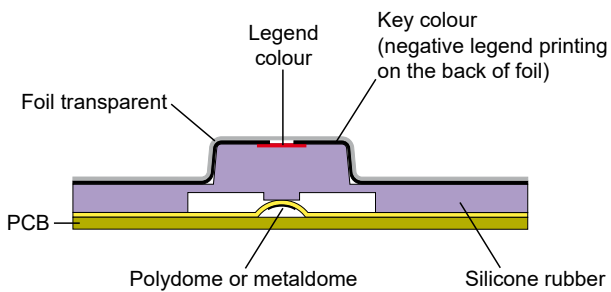
## P+R TECHNIQUE



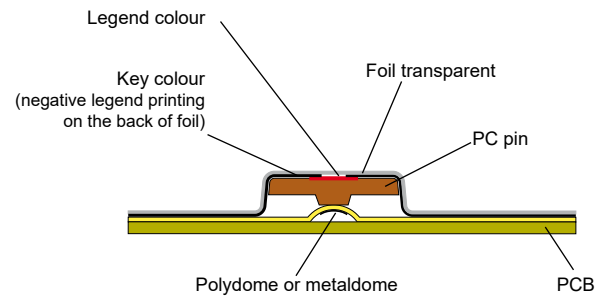
## PLASTIC CAP WITH LIGHT GUIDE



## IMD-FILM ON SILICONE RUBBER KEYPAD



## IMD-FILM WITH POLYCARBONATE (PC) PIN

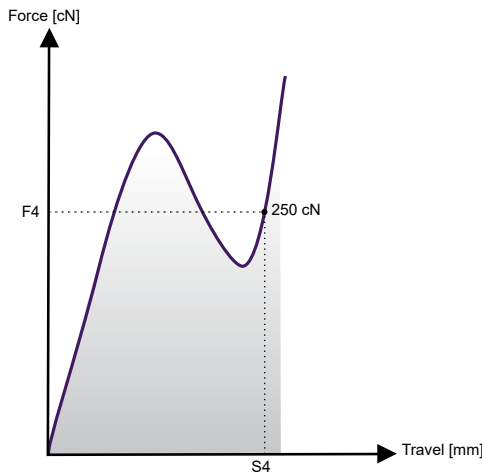


# STANDARDS

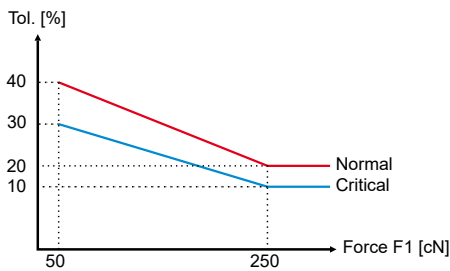
## LIFE MEASURING

Firstly the key is loaded with Over Stroke Force F4 of 250 cN. The Over Stroke S4 is now determined. The push head of the Life Tester presses the key with a constant travel of S4 and a frequency of 3.3 Hz.

Mechanical life is evaluated when cracks arise in the web or the Actuation Force F1 is reduced by more than half. The life is dependent on the Material Hardness, Actuation Force, Press Travel and Snap Ratio. The higher these are, the shorter the life.



## ACTUATION FORCE TOLERANCE (CN)



The Normal criterion is the standard tolerance. The Critical criterion is only available after drawing evaluation by N&H.

$$\text{Tol.}[\%] = 45 - \frac{F1}{10}$$

Note: Force measurement after 10 actuations.

	≤ 50	≤ 80	≤ 100	≤ 120	≤ 150	≤ 180	≤ 210	≤ 250	> 250
Normal	± 20	± 30	± 35	± 40	± 45	± 50	± 50	± 50	± 20
Critical	± 15	± 20	± 25	± 30	± 35	± 35	± 40	± 40	± 15

## DIMENSION TOLERANCE DIN ISO 3302-1 M2

	≤ 4	≤ 6,3	≤ 10	≤ 16	≤ 25	≤ 40	≤ 63	≤ 100	≤ 160	> 160	
F	± 0.10	± 0.15	± 0.20	± 0.20	± 0.25	± 0.35	± 0.40	± 0.50	± 0.70	± 0.50	Dimension: mm F = tool bound dimension C = dimensions depending on tool closure Note: Dimension Tolerance Standard for plastic parts according to DIN ISO 16901
C	± 0.15	± 0.20	± 0.20	± 0.25	± 0.35	± 0.40	± 0.50	± 0.70	± 0.80	± 0.70	

## ABRASION RESISTANCE

The abrasion resistance of legends is tested by use of various methods. The standard tests at N&H are:

- Norman Tester
- STO Tester
- Wazau Tester APG
- 

A paper strip is continuously pulled over a printed or painted specimen. A defined weight presses the paper strip on the specimen. The result of the test is the length of paper (STO and Wazau Tester) or wheel cycles (Norman Tester) until max. 0.25 mm<sup>2</sup> of legend area has been rubbed off.

## ELECTRICAL CONTACT RESISTANCE MEASURING

The Contact Resistance depends on the contact material, size and circuit of keypad and PCB, the Force-Travel-Behaviour and the applied force. In order to compare the results the following standard measuring method is applied.

The rubber keypad is placed on a Gold plated PCB which shows comb layout of 0.3 mm line width and 0.3 mm line distance. The contact resistance is measured when the key is loaded with an Over Stroke Force F4 of 250 cN.

## POST CURING

To determine that the rubber keypad is sufficiently post cured, the test of Weight Loss according to ETR-2 Part 2 from October 1992 is applied:

- Storage at room conditions for 24 hours
- Weight measurement
- Storage at 200 °C for 24 hours
- Weight measurement immediately

The weight loss must be ≤ 2% .

### MODULES & SYSTEM SOLUTIONS

- Complete solutions for operating units
- Development and construction of assemblies
- Manufacturing and delivery
- Procurement of third-party components
- Final test

### KEYPADS & TOUCH PANEL

- Silicone Rubber Keypads
- Membrane Switches
- Capacitive Keypads
- Vandal-resistant Keyboards
- Touch Panel

### SWITCHES

- Micro Switches for SMD
- Vandal-resistant Push Buttons

### MOULDINGS

- **Plastic Parts**
  - Tool design
  - Single and multiple injection molding
  - Largest parts (tool weight up to 20t)
  - Micro precision parts
  - various surface finishes
  - Combined plastic-metal parts
- **Metal Parts**
  - Die-Cast Metal Parts
  - Punched, Turned, Milled Parts
  - Deep Drawn Parts
  - Precision Parts
  - Combined plastic-metal parts
  - Combined rubber-metal parts
- **Rubber Parts**
  - Silicone Safety Covers
  - O-Rings, Grommet, Seals
  - Damper
  - PU molded parts
  - Combined rubber-metal parts
- **Glass Parts**
  - Front glass for input devices, chemically hardened
  - Formed glass panes, thermally hardened
  - Glass panels with optical coating
  - Glass panels for household appliances

### CONNECTORS

- Spring contact pins (pogo pins)
- Single pens
- Spring contact connectors
- Male and female headers
- High current connector
- magnetic connectors (customized)

### CABLES

- Cable harness
- Data, communication cable
- Wire sets
- Connection cables for LCD and flat screen
- coax cable
- Telephone cable
- Singel cables, etc.

### LCD- AND OPTOELECTRONICS

- TFT, OLED, DFSTN, FSTN, EBTN, STN, HTN, TN, VA
- with Touch Panels
- alphanumeric and graphic
- Controller (COB, COF, COG, TAB/TCP)
- EL-, LED- or CCFL-Backlight
- LED-Modules

### ACOUSTIC COMPONENTS

- Buzzer
  - Piezoelectric
  - Magnetic
  - for SMD / THT
- Transducer
  - Piezoelectric
  - Magnetic
  - internal / external Drive
  - for SMD / THT
- Speaker
- Microphones and Receiver

### PCB

- Flexible, rigid and rigid-flex circuits
- Multilayer

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## YOUR PROJECT

We are looking forward to your inquiries and we are always keen on submitting you an offer as quickly as possible.

### CHECKLIST

For an individual offer we need:

- technical drawing, sketch or sample
- technical specifications
- required quantity

Please send us the data to our email: [info@nh-technology.de](mailto:info@nh-technology.de)

One of our engineers will contact you immediately.

For technical advice and all questions about our products and services, please contact us by phone: **+49 (0) 2154 – 81250**

A first project meeting in our company is possible at any time. Especially complex projects can be discussed and determined with our engineers in such a straightforward way.

### N&H SERVICE

Each project is individually managed by one of our engineers. We offer technical support in the following areas:

- Research and Analysis on product feasibility
- Recommendation and advice on technical improvements
- Evaluation and technical options for cost-cutting solutions
- Construction, development and design (CAD-Software/ ProEngineer)
- Prototype construction with 3D printer

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