tacterion

plyon®

Integration Guide

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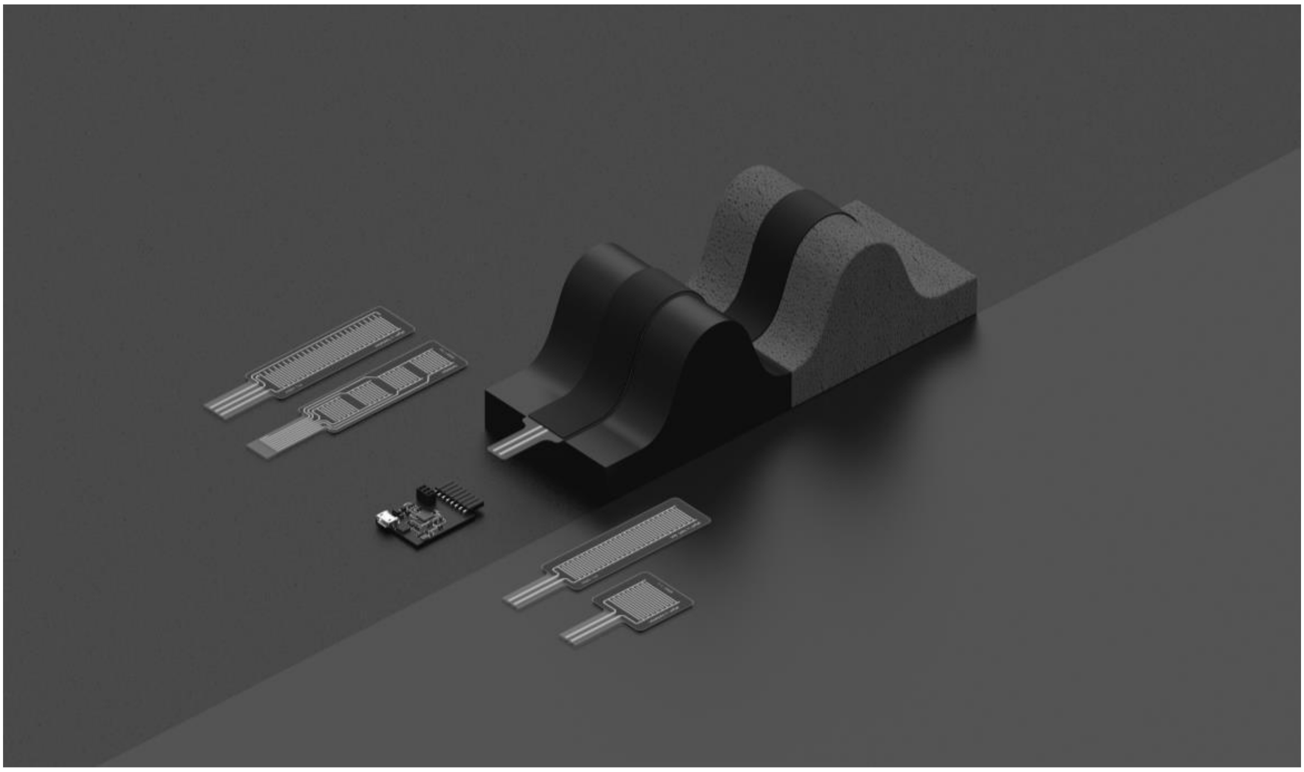
1. Introduction

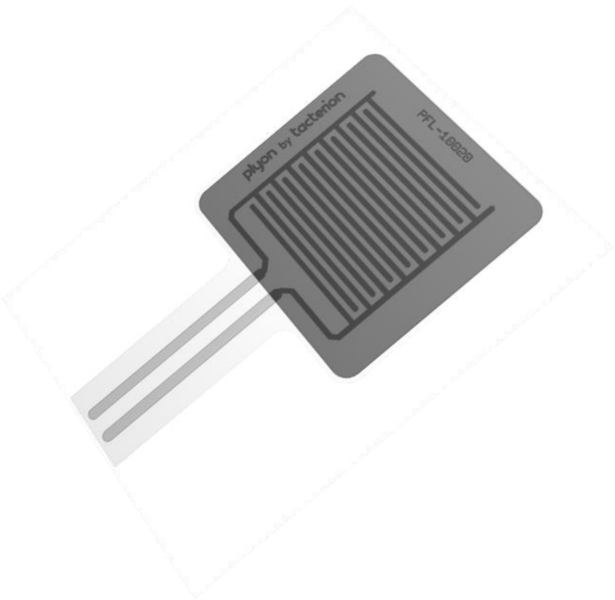


The plyon® platform is a capacitive-resistive touch and force sensor based on a versatile layered architecture. It is a new approach to how physically and functionally unique sensor modules can be designed, produced, and implemented.
Our modules offer an incredible range of problem-solving potential in the fields of robotics, body tracking and direct human-machine-interactions.

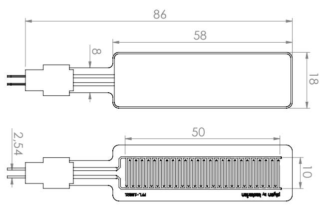
The wide range of possible shapes and sizes, as well as materials, allow an adaptive and versatile use of the sensor in many fields of application, and the TrueZero feature provides a reliable readout together with an unprecedented flexibility. Thanks to the underlying technology, plyon® sensors can be bent around curved surfaces and still be characterized by an excellent signal integrity. While the simple electrical interface is ideal for prototypes and integrated systems, the sensor fits to any kind of application which requires a reliable force-to-voltage conversion.

2. plyon® flex sensors

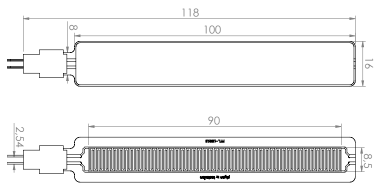
a. Overview



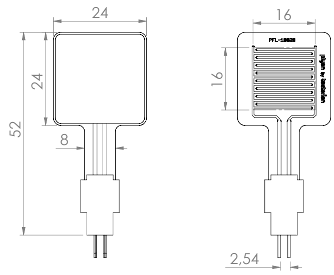
Structured as a stack of different thin flexible layers, plyon® results in a variable resistor. This phenomenon is the result of its sensing layer combination, which consists of electrically conductive nanoparticles, suspended in a matrix. Once a force is exerted on the surface of the sensor, the sensing layer comes into contact with the counter electrodes printed on the substrate underneath, changing the resistance between the electrodes. plyon® flex comes as standardized sensor modules. The sizes are chosen to be especially suitable for prototypical use cases, covering a wide range of integration and testing scenarios.



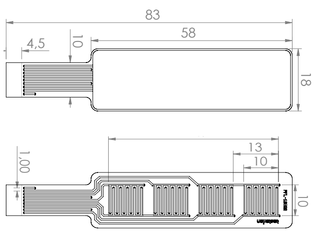
plyon® Medium
PFL-10021



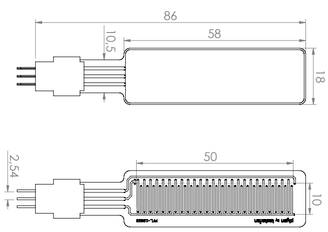
plyon® Stripe
PFL-10010S



plyon® Square
PFL-10020



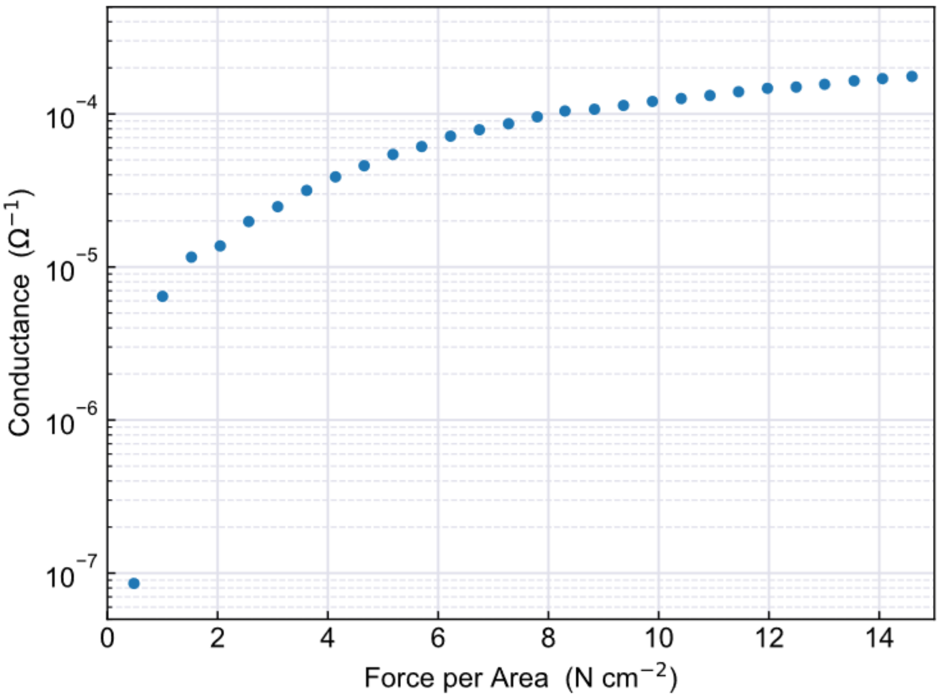
plyon® Array
PFL-10022



plyon® Slider
PFL-10023

b. Characteristics

A typical conductance vs. force curve is shown in the figure below:



The reported force-conductance curve is measured from a model PFL-100010S with a cylindrical Nylon (MC901) actuator of 8 mm diameter, resulting in a total actuation area of 0.5 cm^2. The readout signal as well as the main sensor parameters, such as the force range and the sensitivity, are influenced by many factors:

- The size and shape of the actuator
- The hardness of the actuator
- The hardness and the shape of the surface on which the sensor is placed
- The readout electronics

At relatively high forces, the sensor response eventually saturates. Beyond a certain value of the applied force, the conductance does not increase further. From our observations, the saturation depends on several factors, for instance, actuators with different areas, shapes and hardness.

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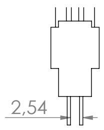
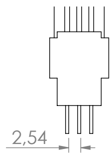
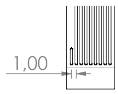
3. Interconnect types

Our standard sensors can be connected using a FFC connector (2.54 mm pitch, 2 or 3 pins) or via exposed flex tail (1 mm pitch for the PFL-10022).
For the array sensors (PFL-10022), the electronics is provided with a ZIF connector in order to read the signal through the bare flex tail. All the examples are reported in the table below.







FCC connector, 2 pins	FCC connector, 3 pins	Exposed flex tail

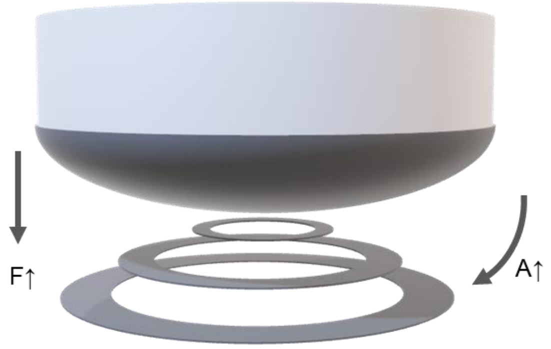
Note: for specific purposes and request, we can also provide female pins and housing.
It is also possible to solder wires directly to pins. The recommended temperature for the solder tip is around 320° C to be applied no longer than 1 to 2 s on the area of interest.

4. Actuation

Many materials and geometries (flat, dome, pyramidal shape, etc.) for the actuator are possible, as well as sizes and cross sections (square, circular, etc.). The variation of these parameters concurs to modify the applied force range.

The contact part of the actuator plays an important role in the response of the sensor. If the contact part is flat on the side in touch with the sensor, the activated sensor area will not depend on the applied force. A dome shaped contact part on the other hand will lead to a gradual enlargement of the activated area with increasing force. This effect is even more pronounced for contact parts with reduced hardness.

For clarification, a schematic representation follows.



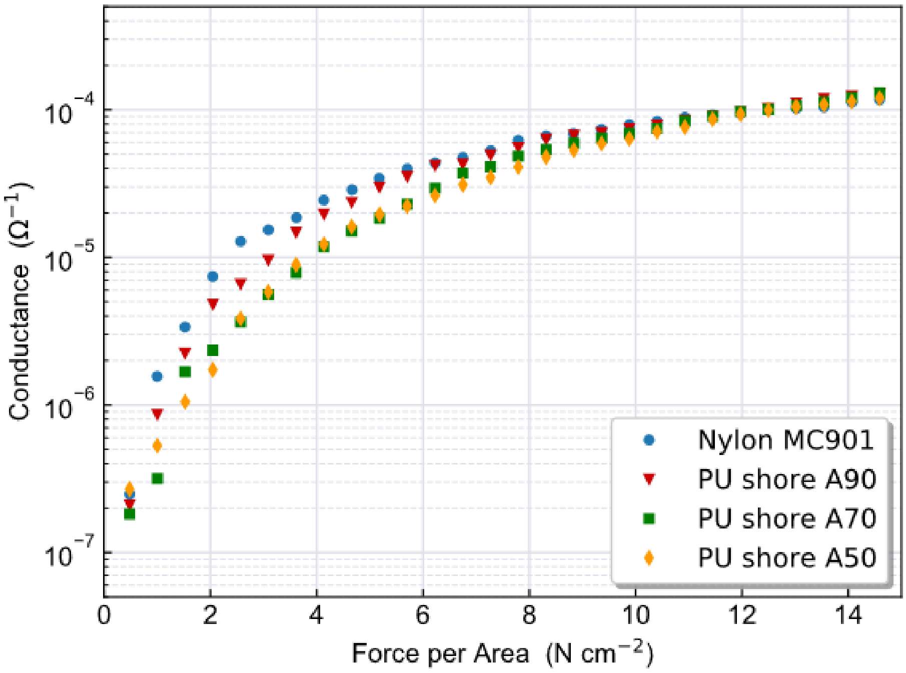
Flat actuator	Dome shape actuator
The interaction area remains constant while increasing the applied force	By increasing the applied force (F), the interaction area (A, depicted as rings with increasing radius) increases as well.

Another important consideration is related to the thickness, the material and the structure of the actuator. For instance, an actuator made of a single piece of rubber will give a different response than a harder material one, ending with a thin added rubber layer. Therefore, issues regarding a possible force dispersion in the actuator must be taken into account.

Our sensors have been tested with different kinds of actuator materials and hardness, with the aim to provide the closest scenario of all the possible interactions with the real-world applications.
For this purpose, the actuator consisted of a nylon support with a thin added PU layers of different hardness (shore A90, A70 and A50), with an area of ca. 0.5 cm^2 and a flat head with circular cross section (the graphic example is reported below).

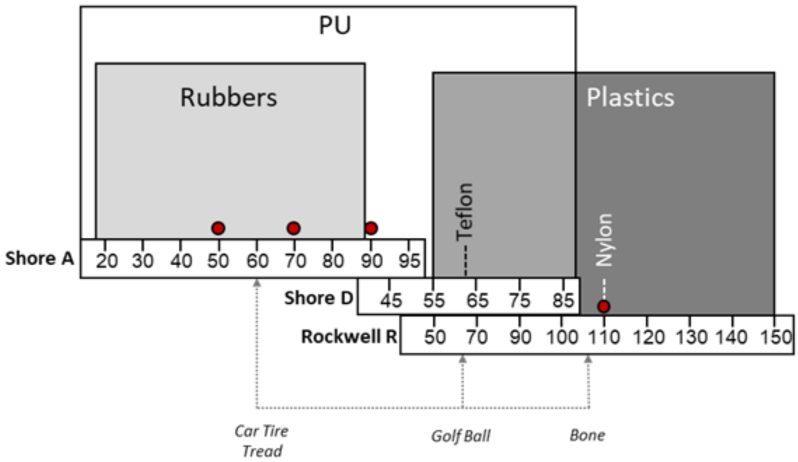
Example of possible actuator: harder support and added softer cushion.

The comparison of the conductance-force characteristics of the sensor resulting from the actuation with different tips is reported in the following plot as an example:



The response resulting from an actuation with the Nylon contact part (the hardest) is plotted as blue circles. For softer materials with a shore hardness between A90 and A50, a shift in the response is observed especially at lower actuation forces. This can be interpretated as a continuous deformation of the material under the applied force due to the different viscoelasticity of the polyurethanes.

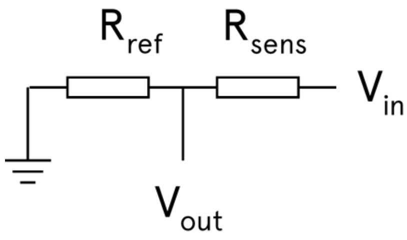
For the reader's convenience, here we illustrate the durometer scale with some examples for clarification. The red dots indicate the used material for test results reported above.



5. Connect your plyon® flex sensor

In the following, two electronic circuits are suggested to readout the signal from your plyon® sensor.

a. Voltage divider

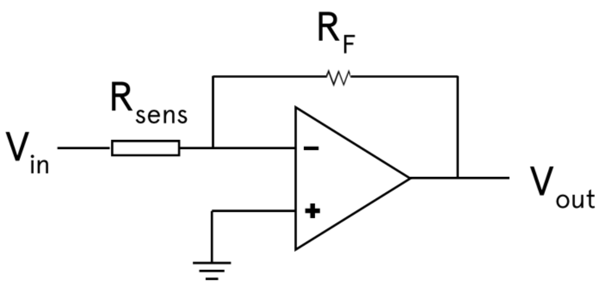


A voltage divider configuration is the simplest readout circuit to determine sensor resistance. Given that R_{ref} and V_{in} are known, the sensor resistance R_{sens} can be calculated by measuring the voltage drop V_{out} across the reference resistor R_{ref}.

The output voltage can be expressed as:

$$V_{out} = \frac{V_{in} \cdot R_{ref}}{R_{sens} + R_{ref}}$$

b. Transimpedance amplifier (I-V converter)



A transimpedance amplifier (TIA) converts the current flowing through the sensor (V_{in} /R_{sens}) to a voltage signal (V_{out}), providing a more ideal transfer function than a voltage divider.

Under the assumption of an ideal op-amp, the output voltage is calculated as:

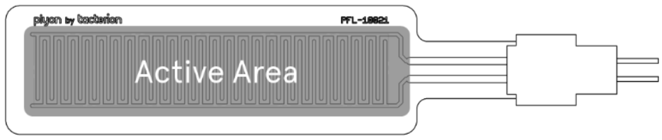
$$V_{out} = - \frac{V_{in} \cdot R_F}{R_{sens}}$$

6. Many Ways to Integrate your plyon® flex

a. Techniques

When it comes to sensor integration, many ways are possible. Despite this, due to different effects, the sensor performance and its signal integrity might be affected by the assembly process. Some of these effects are related to the sensor structure, while others are related to the technique employed to fix the sensor (e.g. usage of adhesives). For this reason, in this chapter the most common and simple solutions are addressed and recommended. For any other special request or questions about the integration, we encourage you to contact us.

Note: in the further discussion, we will refer to the "active area" of the sensor, which consist of the region where the conductive traces are confined. An explicative sketch can be seen below:



I. Liquid Adhesives

The application of glue on the sensor must be processed carefully. Due to the fact that the glue changes its mechanical characteristics during its hardening, it is recommended to avoid applying the glue on the entire silicone side of the sensor and on the substrate (PET) in correspondence of the active area. Applying the glue on the PET "frame" around the active area should be sufficient.

PET has a low surface energy, making it a fairly non-stick surface (and therefore hard to glue). Glues that can be used with PET are: 3M Scotch-Weld, 3M High Strength 90 spray adhesive and Permabond TA4610.

II. Film Adhesives

The tapes have in general a great advantage compared to the glues since they can immediately bond two items, avoiding the clamp time, typical of glues. However, the tape composition might affect the sensor performance, especially the TrueZero feature.

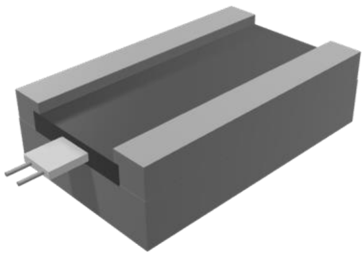
In fact, the intrinsic physical and chemical properties of the tape, especially after reaching its final bonding strength, can cause a deformation of the sensor substrate (PET), which could be translated in a parasitic perpendicular force on the sensor able to cause readout issues. There are several variables behind this phenomenon. The major ones that can be accounted are the surface energy of the material on which the sensor is applied and the physical-chemical properties of the adhesive (including shear module, Poisson ratio, etc.).

Several adhesives have been tested on metal (aluminum) and plastic (PLA) curved surfaces for the integration of the sensor, and we recommend the usage of tapes with good viscoelastic properties. Some of them are listed below:

Tape	On Aluminum	On PLA
3M VHB RP25	✓	✓
3M VHB 4952P	✓	✓
3M VHB 4936	✓	✓
3M 9088-200	✓	✗

III. Force Closure

Another way to integrate the sensor in a system is to fix it mechanically. Some supports might be built on the side without covering the active area. One of the advantages of this configuration is that the sensor can be easily installed and removed (if needed) and it is not subject to any effects related to chemical composition of the adhesives. In this case, the only effects to consider are the ones related to the sensor, described in the next section.

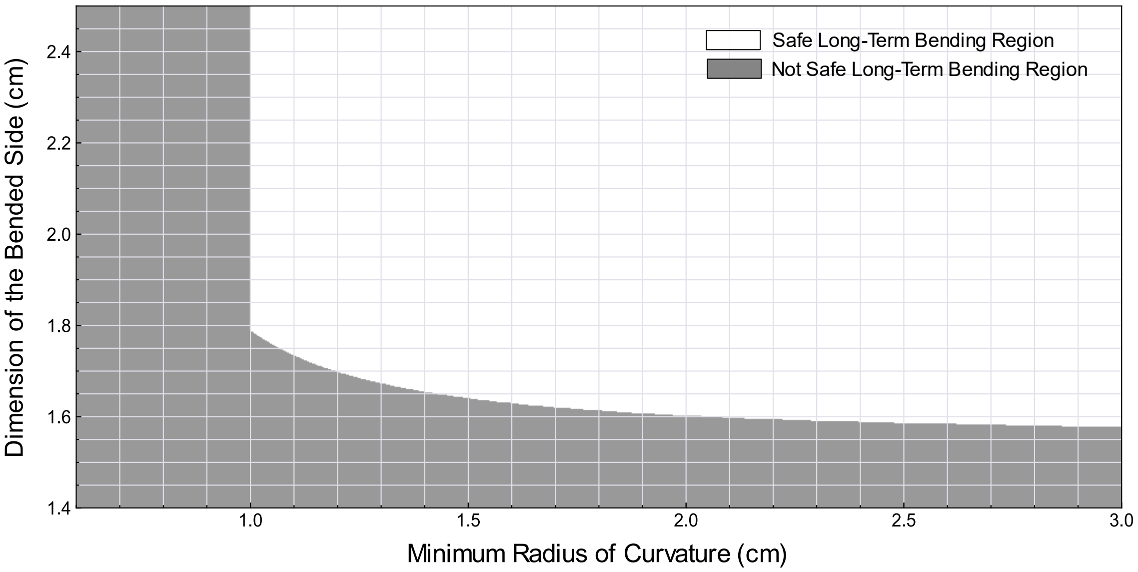


Example of force closure of your plyon® flex

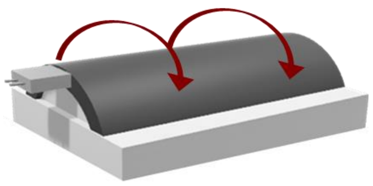
b. Curved Surface Integration

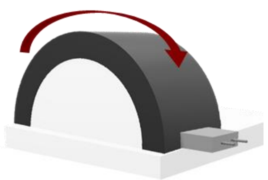
When it comes to integrating your plyon® sensor on a curved surface, it is very important to check the conditions of the support. The following recommendations are intended for long-term bending application.

Our TrueZero technology allows to reach down to 1 cm radius of curvature without false readout, but for smaller radii this ability is limited due to physical constraints. Therefore, we strongly discourage to fold completely the sensor beyond a certain bending limit. Due to the reduced elasticity of the PET substrate, kinks might be generated. This could modify the functionality and ultimately damage your plyon® sensor. For this reason, we recommend to follow the graph below as a mean to take full advantage of your plyon® sensor's performance.



The white area of the graph represents the regime in which the TrueZero remains valid, which shows a minimum bending radius of around 1 cm. Please note that these are general and indicative values that have to be checked for a given application. As illustrated in the figure below, the sensor can be bend along its long side (L) as well as along its short side (W). The graph for the minimum bending radius is valid for both bending directions.





Bending along the width (W)	Bending along the length (L)

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7. Take care of your plyon® flex

DO NOT ✗	NOT ADVISABLE ?	DO ✓
Dip it in the water	Storage at temperature above 120°C	Clean the surface on which the sensor is installed
Fold the sensor	Storage at temperature below -40°	Follow the latest datasheet specifications in terms of max current /max voltage
Actuate with sharp objects		Follow the recommendations in the integration guide
Crease sensor or flex tail		Explore all your plyon® sensor capabilities