GRIP™ SYSTEM

PREPARATION AND CALIBRATION

ELABORATION

PROCESS RESEARCH
FACTORY SUSTAINABILITY
ECO-FACTORY

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1. INTRODUCTION

1.1 Purpose

This document describes the standard operating procedure assumed by Fiat Research Center to make the *Grip*^{TM} System ready for measurements, according to its user manual.

1.2 Field of application

Evaluation of forces and pressures generated on the factory worker's hand for ergonomic assessment of tools and workstations.

2. PROCEDURE

2.1 The *Grip*^{TM} System

The *Grip*^{TM} System, manufactured by U.S. Company Tekscan, consists of a force sensor based on resistive technology able to detect the forces acting on the user's hand, the surface subjected to a load and thus the pressure distribution over the entire hand equipped with the sensor.

The system is also equipped with all electronics and hardware necessary to capture, to store and to analyse data.

Figure 1 shows the sensor in its entirety.

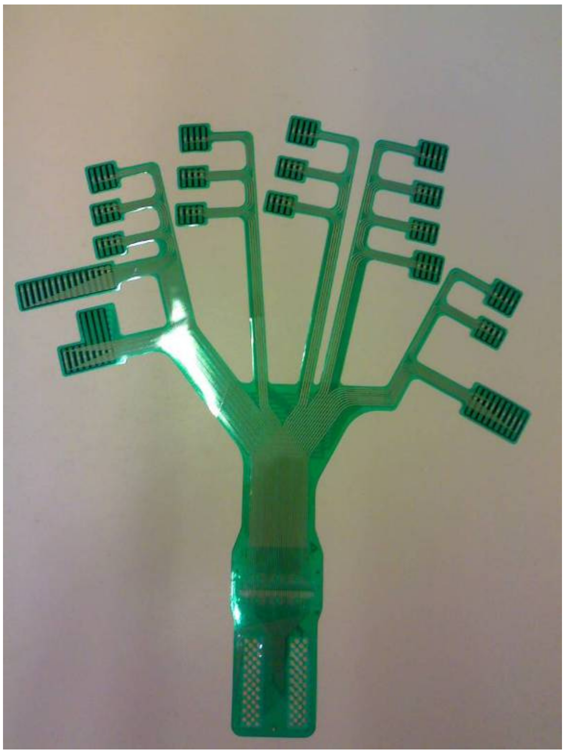
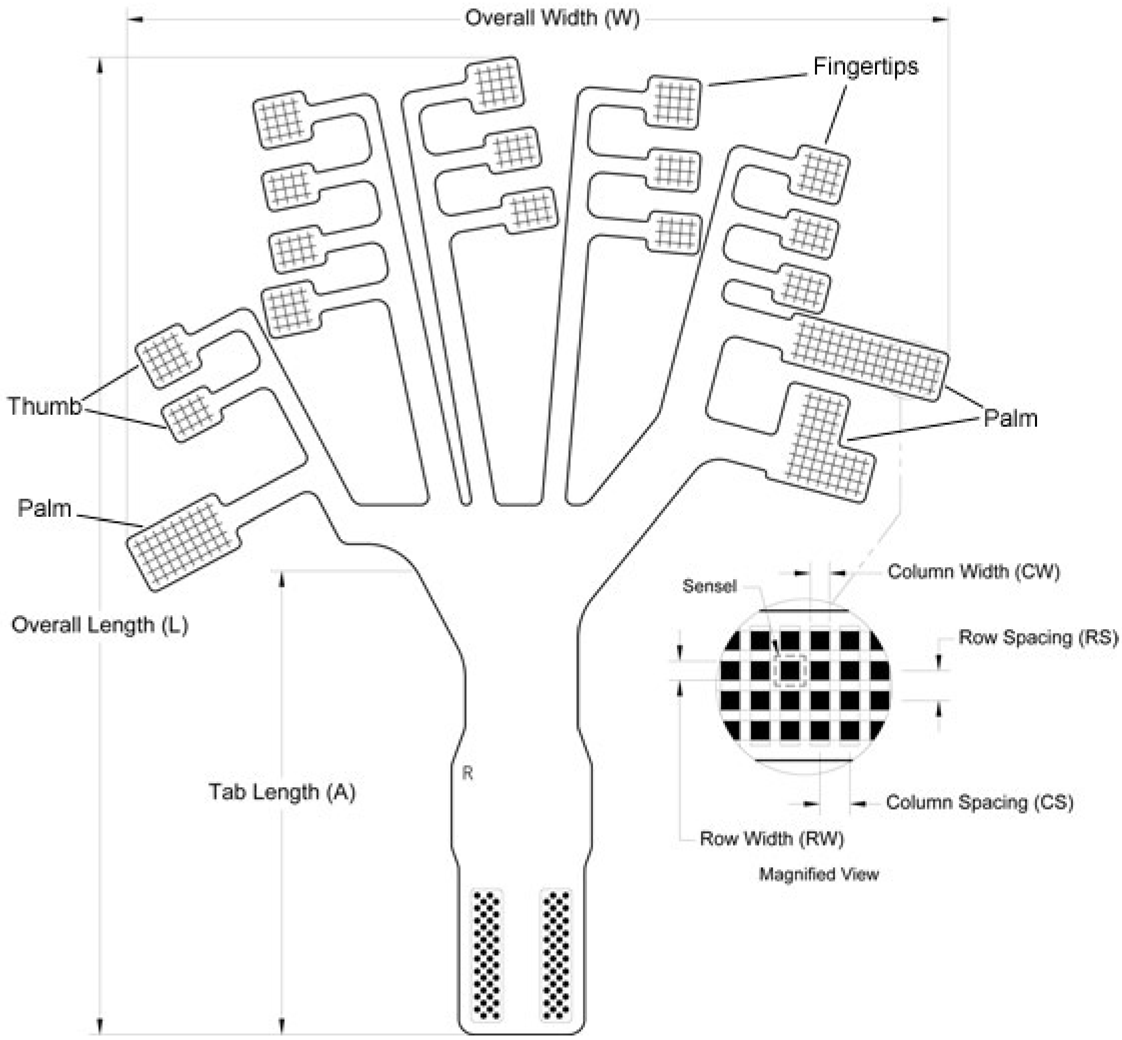


Figure 1 – Grip sensor, 4256 model

The sensor used, model 4256 (shown above), consists of 349 sensing areas, divided into 18 independent regions, positioned on palm and fingers of the user's hand.

The spatial resolution of the sensor is approximately 6.2 sensing areas each cm^2 of surface. Moreover, it's reduced thickness (0.15 mm) ensures to the user the maximum ease of movement and doesn't affect the simulated working task, whose force and pressure parameters are under analysis.

Figure 2 shows a pattern of the used sensor, with indication of size and of some technical data.



	General Dimensions			Sensing Area Dimensions								Summary	
Model	Overall Length L	Overall Width W	Tab Length A	Matrix Width MW	Matrix Height MH	Columns CW	Columns CS	Columns Qty.	Rows RW	Rows RS	Rows Qty.	Total No.of Sensels	Sensel Density
US	(in.)	(in.)	(in.)	(in.)	(in.)	(in.)	(in.)		(in.)	(in.)			(sensel per sq. in.)
4256	15.44	12.99	7.30	Various	Various	0.100	0.158	36	0.100	0.158	23	349	40.3
Metric	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)		(mm)	(mm)			(sensel per sq. cm)
4256	392.2	329.9	185.4	Various	Various	2.54	4.0	36	2.5	4.0	23	349	6.2

Figure 2 – Grip sensor, 4256 model – pattern

The following paragraphs will describe in detail the operations for the correct use of the *Grip*^{TM} System.

In particular, the procedure requires the following steps:

1. sensor equilibration and conditioning;
2. sensor preparation;
3. sensor calibration.

2.2 Sensor equilibration and conditioning

Equilibration is the phase of the procedure in which the variations in individual sensel output can be compensated by software.

It is accomplished by applying a highly uniform pressure across the individual sensing elements. Each element within the sensor should produce a uniform output. When this is not the case, the software determines a unique scale factor for that sensel to compensate for the slight variation. To do that, the PB100-C equilibration device (shown in figure 3) is used.

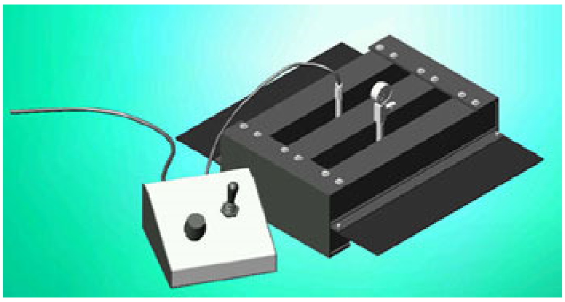


Figure 3 – PB100-C equilibration device

The same device is used to perform the sensor conditioning, after equilibration.
During sensor conditioning, a pressure of 40 PSI is applied for one minute on the sensor, then the pressure is removed for about one minute. The same procedure is repeated for a total of five times.

2.3 Sensor preparation

First of all, it is necessary to decide whether to use the sensor directly pasted on the hand of the user or pasted on a seamless glove. Because of the necessity to analyze different users and to preserve the integrity of the sensor, in our procedure the sensor is pasted on a seamless glove.

First necessary step is to remove the layer of transparent protective cover from the sensor. Then, it is necessary to sprinkle a thin layer of adhesive spray over the active regions of the sensor (one of which is highlighted by a red circle in figure 4).

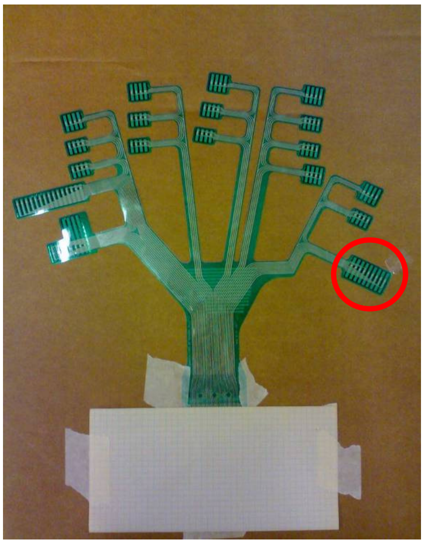


Figure 4 – Adhesive spray sprinkling over active regions of the sensor

After a few minutes waiting for adhesive drying, it is possible to start to paste the sensor on the glove previously worn by the operator. Figure 5 represents a phase of this operation, in which seven active regions were pasted on the thumb, index and palm.

Figure 5 – Active regions pasted on the glove

This operation is carried out by placing the back of the hand on the sensor, making the active regions to rotate of 180° in order to make them move from dorsal area to palm area. During this phase, particular attention is paid to the placement of active regions on the areas of interest, phalanges and palm of the hand.

Figure 6 represents the final configuration after this operation. The glove appears to be completely sensorized on the areas of interest.

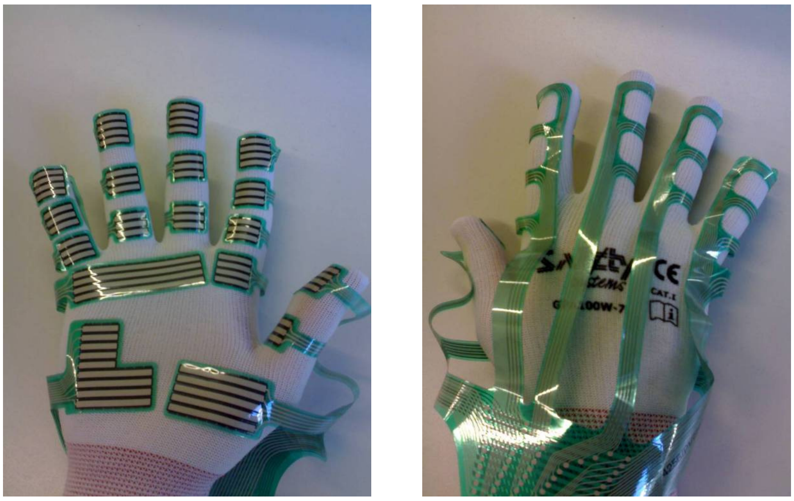


Figure 6 – Configuration after pasting phase (palm and back)

After this phase, to give more consistency to the system, a further seamless glove is positioned over the sensor. This will also give a better grip on the object to be handled.

Then the system is put for 24 hours under the action of some small weights placed on the active regions, in order to completely dry the spray adhesive.

Figure 7 shows the system in its final configuration.

Figure 7 – Grip sensor in its final configuration (palm and back)

2.4 Sensor calibration

Before a calibration is performed, the Real-time window displays raw pressure directly from the sensor. This data could be more meaningful if the pressures are given in actual measurement units, such as "PSI" or "mmHg" or “N/cm^2”.
Then, calibration is the method by which the raw digital output of the sensor is converted to actual pressure units.

The calibration is performed according to the procedure here reported:

1. conditioning exercises;
2. application of a known load and signal recording;
3. calculation of the calibration function;
4. verification of the accuracy of the performed calibration.

The following figures represent the four steps of calibration procedure described above.

Conditioning (step 1) is performed by applying a load similar to what the system must bear during the execution of task that will be analyzed and studied, increased by 10%-20%. Normally, in our procedure we perform three or four working tasks at 110%-120% of the real force range without saving the acquisitions, in order to have the system conditioned.

As shown in figure 8, for example, the conditioning in this case was carried out by the execution of some tightening with a screwdriver (the same used in subsequent tests), with a grip force increased by 10%-20% compared to the real application.

Figure 8 – System Calibration, step 1

After sensor conditioning, a known load must be applied on the sensor segments (tiles) through the pressure on a load cell, carried out by one finger at a time (step 2), as shown in figure 9. The same operation is carried out separately for the active regions located on the palm (tiles calibration).

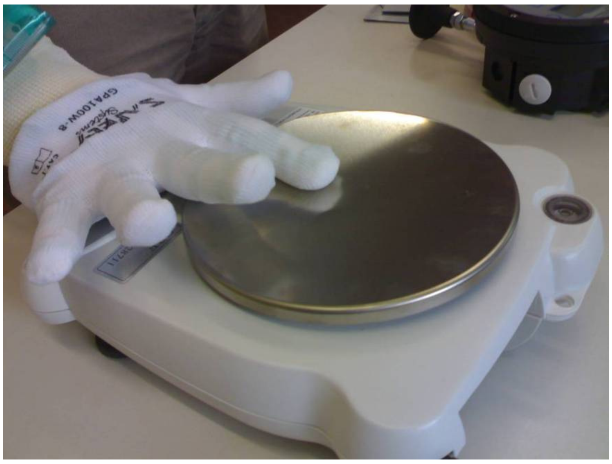


Figure 9 – System Calibration, step 2

The system is able to automatically track the calibration curve on each area of the glove (step 3), as shown in figure 10.

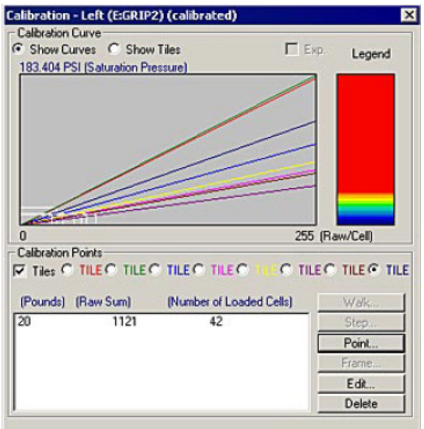


Figure 10 – System Calibration, step 3

After step 3, a verification of the accuracy of the performed calibration must be carried out (step 4). Figure 11 shows an example of step 4, in which a load of 1 kg (9.81 N) is applied to the load cell through the hand of the operator for 10 seconds.

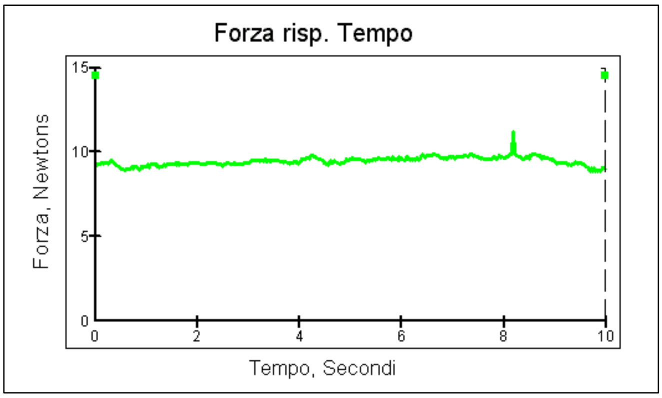


Figure 11 – System Calibration, step 4

After the calibration phase, the system is ready for use. Figure 12 shows a possible example of application.

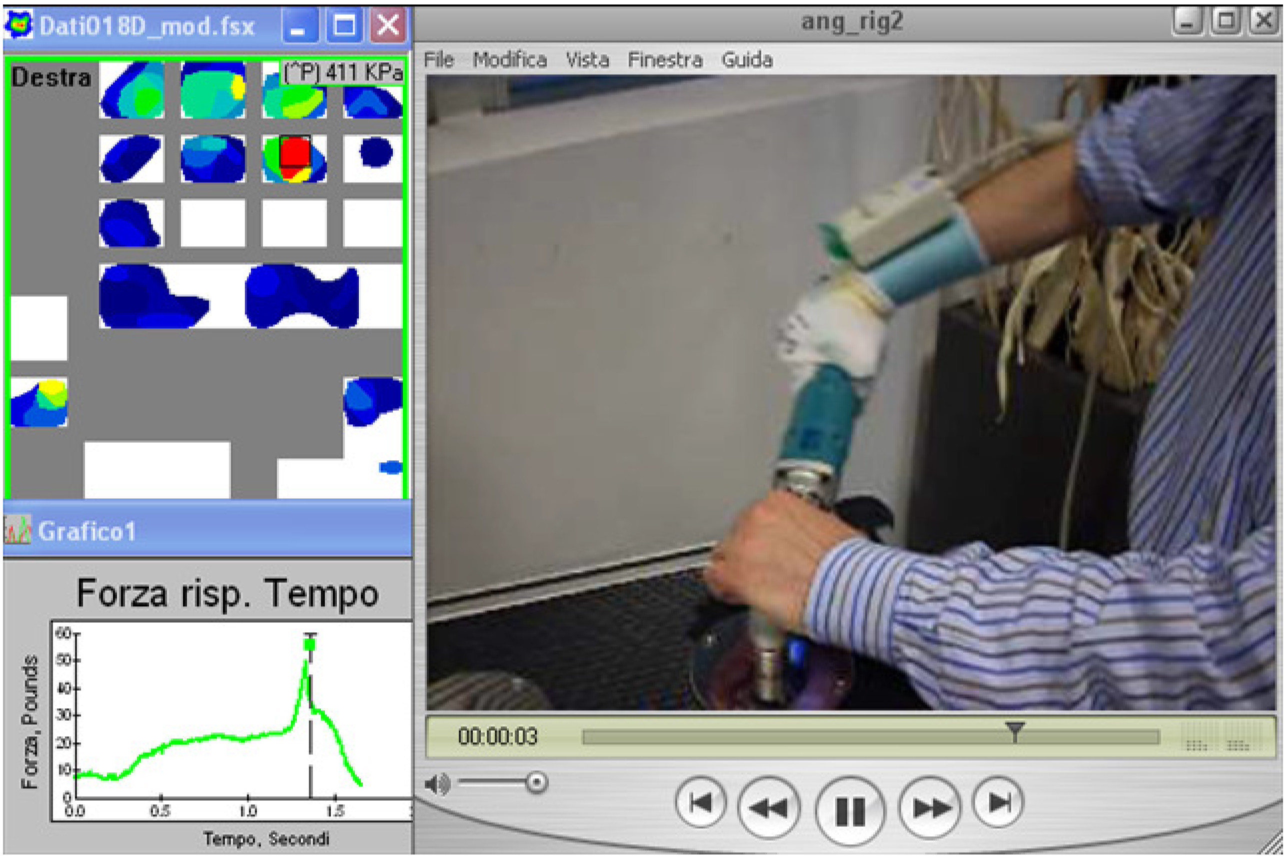


Figure 12 – Example of system use

3. BIBLIOGRAPHY

[1] Tekscan – *Grip*^{TM} User Manual

[2] http://www.tekscan.com