EVT COIL PROJECT

Quality Assurance Policy

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1. INTRODUCTION

The EVT COIL was designed and built by SOFCA s.r.l. to tighten the VISA® clamps produced by company CAILLAU.

1.1. Purpose

This document describes the principles of operation of the EVT COIL and all stages of control to which it is subjected during its lifetime to ensure maximum performance. In particular the controls to which the COIL will be undergoing include the following topics:

a) Sofca Acceptance
b) Sofca Validation
c) On Site Self-learning
d) On Site Verifications
e) Maintenance

1.2. References

1. EVT COIL Manual Rev0 8Jul16
2. Brochure EVT COIL 21Sep16
3. Company site sofcaproject.it
4. EVT Bench Specifications 21Mar16
5. EVT COIL Bench – Accuracy & Resolution
6. ACCREDIA Certificate -EVT COIL Bench Load Cell
7. ACCREDIA Certificate -EVT COIL Linear Transducer

2. COIL OPERATING MODE

The EVT COIL (Electrical Visa Tool Control Objectification Integration Line) task is to objectify and control the tightening of the VISA® clamps.

2.1. Objectification

Objectification is a procedure that, once executed, makes a smart equipment capable of controlling a production process.
The objectification consists of two phases: a programming phase and an execution phase, including in the latter the series production cycle.
During programming an expert performs, with controlled operation, a sequence of assemblies accomplished properly; in this phase the equipment is set in monitoring with the purpose of learning what is being done.
In the next phase of execution the equipment will have to monitor the operations on the production line, verify them in terms of what has been learned previously and report any anomaly in the values of the measured parameters.

2.2. Machine-learning

For the COIL, the function that performs the objectification is called “Machine-learning”.
Initially the Force & Stroke windows are large.
Then clamps begin to be tightened under the supervision of an expert who declares, under his responsibility, that each subsequent clamp was correctly tightened.
After every operation, the COIL will narrow the force and stroke windows.
The more are the operations, the better is the windows definition.
The obtained windows represent limits of the variability for force & stroke due to:

a) Tolerance on the shearing strength of the fuse
b) Accuracy on the reading of the basic COIL parameters (see next paragraphs)

Because is not possible to carry out so much clamps, the COIL gives the operator the possibility to widen the windows, always under the responsibility of the expert.

The self-learning procedure is to be performed after:

1- It is changed the type of clamp
2- repairing a component
3- pre-determined period of time or number of clamps made
4- with the use of a new or different EVT COIL

2.3. Objectification advantages

After self-learning the EVT COIL is ready to operate and declare whether the windows limits have been respected, otherwise an anomaly is reported.

2.3.1. Correct clamping event

During tightening the fuse, engineered to a pre-determined shearing force that provides a calibrated clamping force, is cut and in its place there is a hole.
The shearing of the fuse indicates that the proper force has been applied to the clamp and the COIL system gives the confirmation of such force within limits, and hence validates the correct tightening of the clamp.

2.3.2. Anomaly reporting

Following is a table of the main possible occurrences during tightening with anomalies.

<table>
<tr><th>EVENT CASES</th><th>Fuse: sheared</th><th>Fuse: not sheared</th></tr>
<tr><td rowspan="4">Stroke
low limit exceeded:</td><td>Example:
A cluster of fuses has blocked the stroke.
Result:
Not Ok</td><td rowspan="2">Example:
The operator has exchanged a clamp with another
In this case can occur also an error due to the mechanical extra stroke limit
Result:
Not Ok</td></tr>
<tr><td>Example:
See Fig. 1
Result:
Not Ok</td></tr>
<tr><td>Example:
It has been used a wrong clamp
Not Ok</td><td rowspan="2">Example:
The operator positions the clamp in a wrong position.
In this case can occur also an error due to the mechanical extra stroke limit
Result:
Not Ok</td></tr>
<tr><td>Example:
It has been used a wrong sleeve
Not Ok</td></tr>
<tr><td>Stroke
high limit exceeded:</td><td>Example:
The operator exchange a clamp with another
Result:
Not Ok</td><td>Example:
The operator exchange a clamp with another
Result:
Not Ok</td></tr>
</table>

	Example: It has been used a wrong sleeve Result: **Not Ok**	Example: The operator positions the clamp in a wrong position. In this case can occur also an error due to the mechanical extra stroke limit Result: **Not Ok**

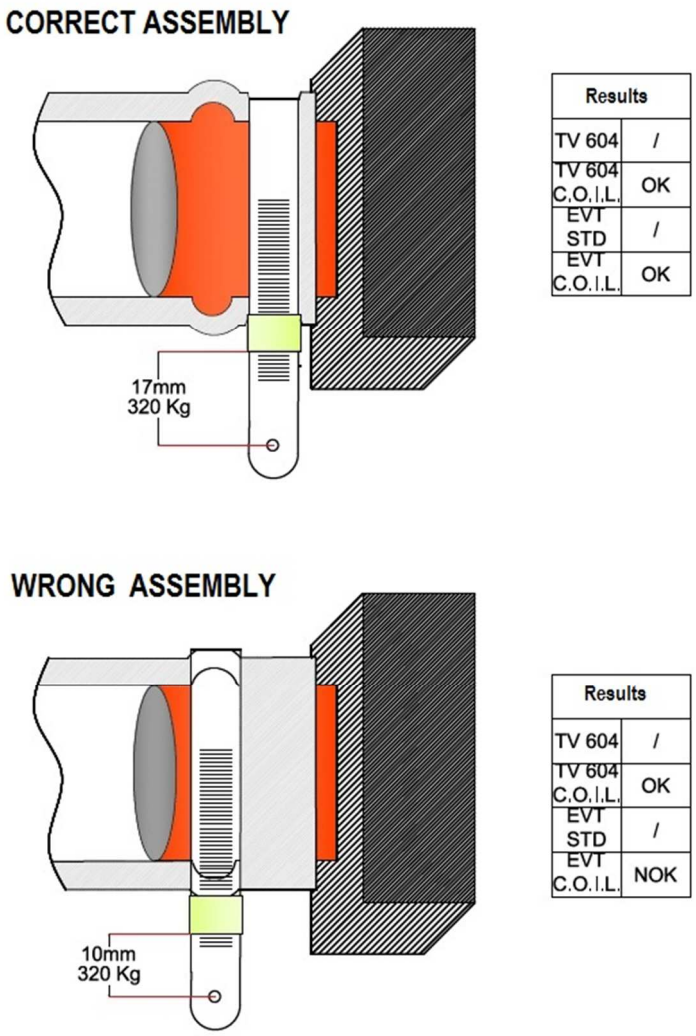

Figure 1 Possible assemblies

EVENT CASES	Fuse: sheared	Fuse: not sheared
Force low limit exceeded	It can occur as a result of an incorrect positioning of the tool on the clamp band. The fuse, usually, appears flattened Result: **Not Ok**	Exceptionally It may happen with the crash of the work piece. Result: **Not Ok**
Force high limit exceeded:	A technologist should analyze the clamping sealing. If it is ok, under his responsibility, the limit can be raised Result: **To be investigated**	The tool continues its run until the intervention of max current or max stroke limit Result: **Not Ok**

CAUTION:

The force parameter is meaningful of the tightening quality.
The stroke parameter is discriminatory for the correctness of the performed operation.
Because a possible anomaly has the highest priority in the evaluation of the success of a tightening, it follows that the stroke parameter is more significant than force.
So, while the force window can be changed suitably by the technologist, greater attention should be given to the change of the stroke window.

2.3.3. COIL windowing

As an example, a series of tightenings were made during a certain production in line.
The recorded data relative to stroke and force parameters were collected and now they are shown below as:

- Graph of detected tightening forces versus number of operations
- Graph of detected tightening strokes versus number of operations
- Graph of a single tightening represented by force versus stroke
  (the peak is relative to the fuse shearing)

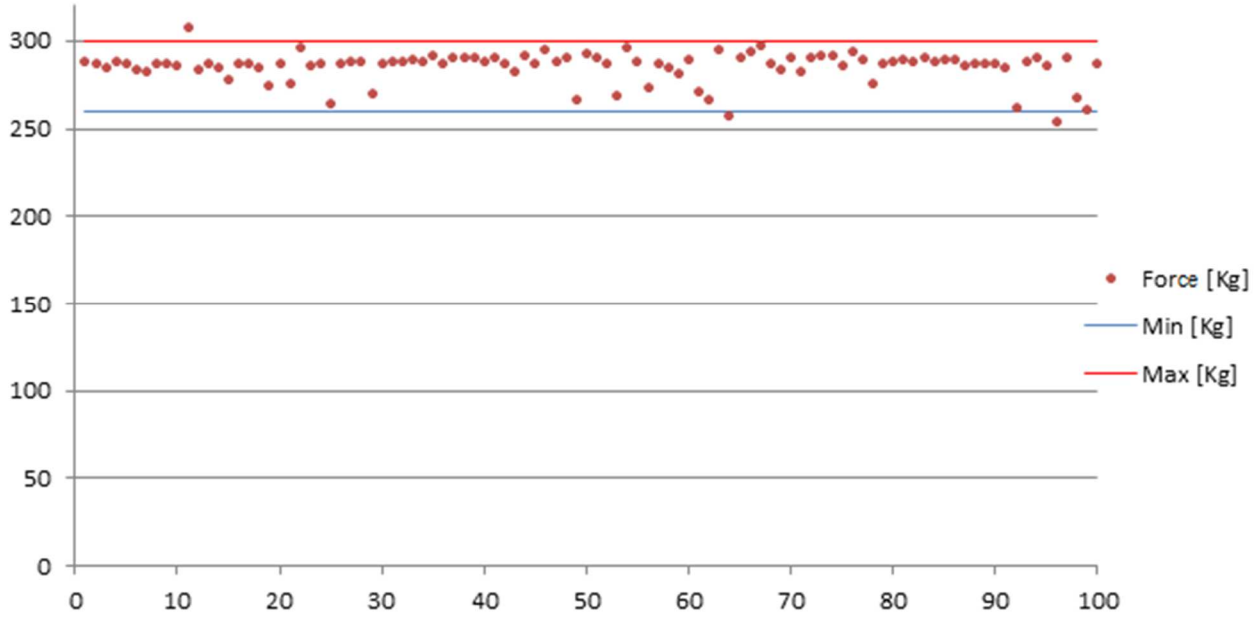

Figure 2 Force versus tightenings

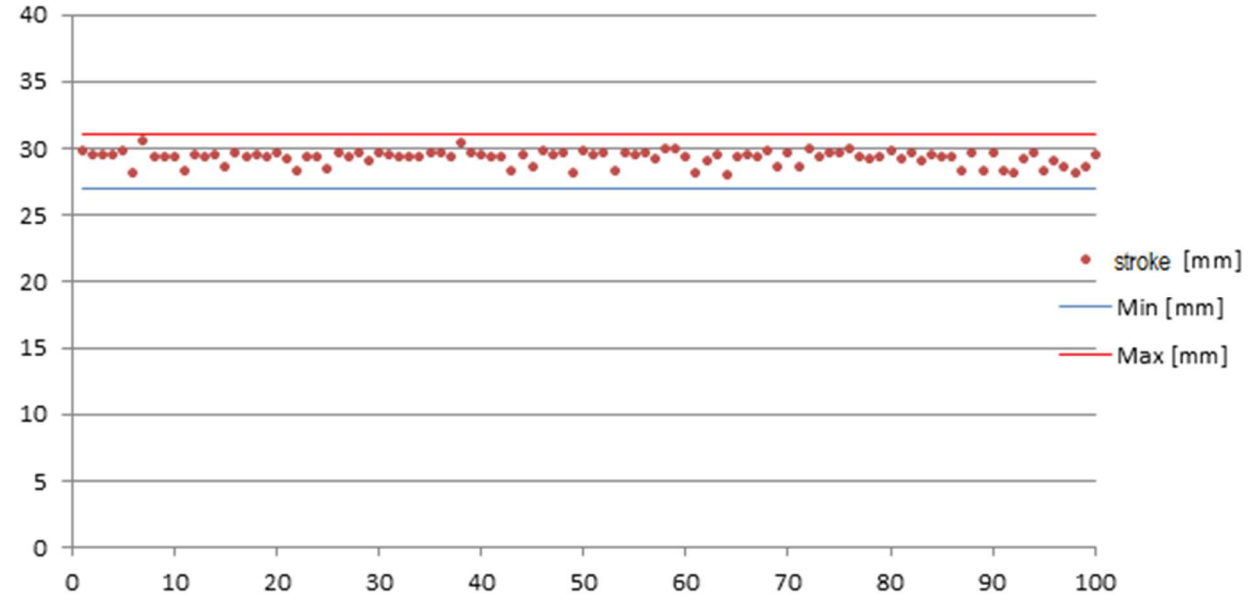

Figure 3 Stroke versus tightenings

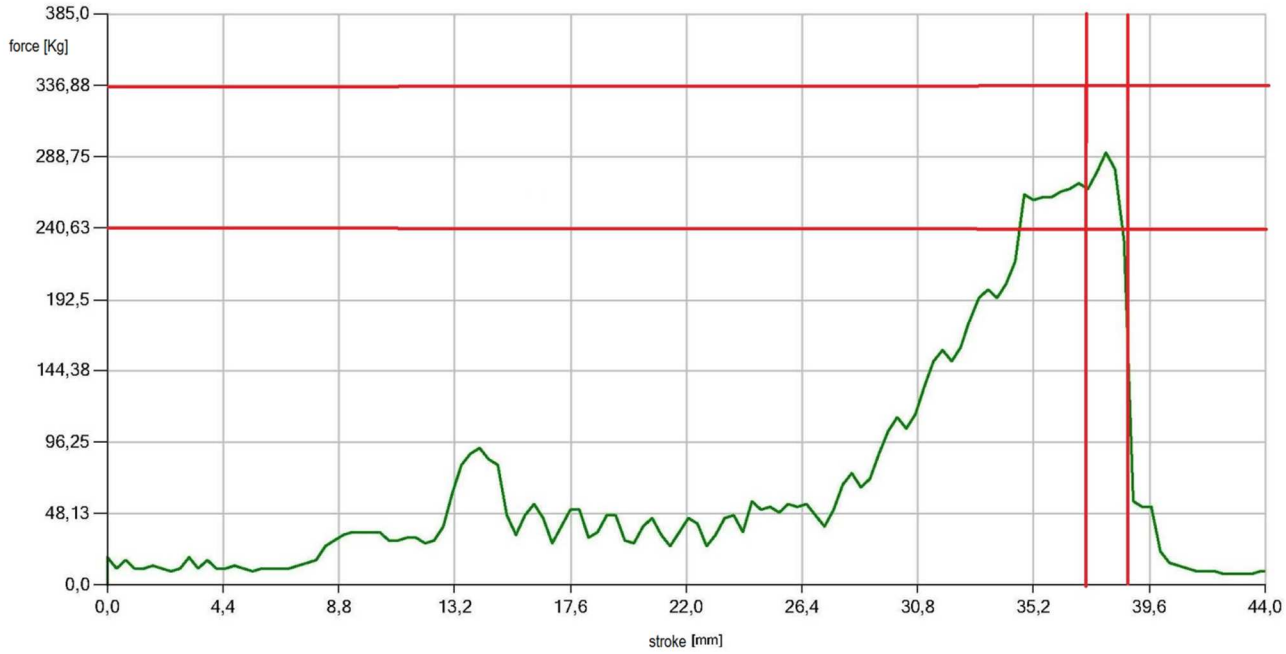

Figure 4 Force versus stroke

3. COIL QUALITY ASSURANCE

When the COIL system comes out of factory production, it is first functionally tested, then characterized and validated in our laboratory before being delivered to the customer.
In addition to ordinary maintenance (replacement of cutter & socket when the Control Unit will request it), the system, being composed of parts subject to wear, must be periodically checked (extraordinary maintenance) according to the number of cycles carried out.
Such verification can be carried out by Sofca, returning the tool to its laboratory, or on site by the customer if the customer is equipped with a proper test bench as described in the following paragraphs.

3.1. Sofca prototype acceptance tests

- Qualification tests
- Endurance tests

3.2. COIL acceptance tests

Once assembled, the following tests are performed on each COIL:

a. Functional tests on Control Unit and EVT tool
b. Wi-Fi tests with range and RF power measurements
c. Some tens of clamps tightenings
d. Trial tests on EVT mechanics; in this case a device slaved to the control unit (see figure 5) provides the mechanical reaction to the tractor, and the test is automatically running for some hundred cycles

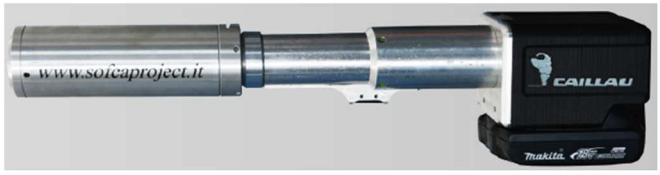

Figure 5 Endurance test device

3.3. COIL characterization and validation tests

The characterization tests are performed, manually and for each COIL, with an instrumented bench, called EVT COIL Bench, where the system performances of the COIL are evaluated by detecting the relevant physical magnitudes operating in the tool.

The EVT COIL Bench allows to:

1- Check if the major components (motor, gearhead, nut and screw) are within their specifications (Extended Acceptance Testing)
2- Verify if the available output force of the EVT is higher than a proper safety margin and therefore suitable for its installation by the customer (Validation Testing)
3- Characterize the overall EVT and its major components in order to trace their performances during the lifetime (Maintenance Testing)

Detected magnitudes are:

1- Motor input current
2- Torque at the output of the gearhead
3- Force at the output of the nut screw (i.e. available force at the EVT nose)
4- EVT stroke

Working out the readings of the previous magnitudes, the EVT COIL Bench reports the following performances:

1- Rolling test as output graphic (see figure 6)
(Note: the rolling test is a void cycle - no clamp involved- and it is used to evaluate the basic internal friction of the tool)
2- Characterization of Current/Torque/Force/Stroke as output graphics (see figure 7)
3- Nut/Screw efficiency as Force to Torque ratio
4- Motor/Gearhead performances as Torque to Current ratio
5- Stroke linearity and repeatability as comparison of the linear transducer output to motor resolver output

The previous tests or characterizations represent:

A. A condition for acceptance of the tool or its repairing/reconditioning
B. A photograph of the EVT current tool capabilities to be compared with future characterizations in order to ascertain the possible tool degradation with its age for maintenance reason.

3.3.1. Bench operations

The tool is arranged and instrumented on the EVT COIL Bench. The operator simply selects remotely the test and triggers it. The EVT COIL test bench facility will run the test automatically and all data regarding the current, torque, force, stroke are acquired and recorded versus time.

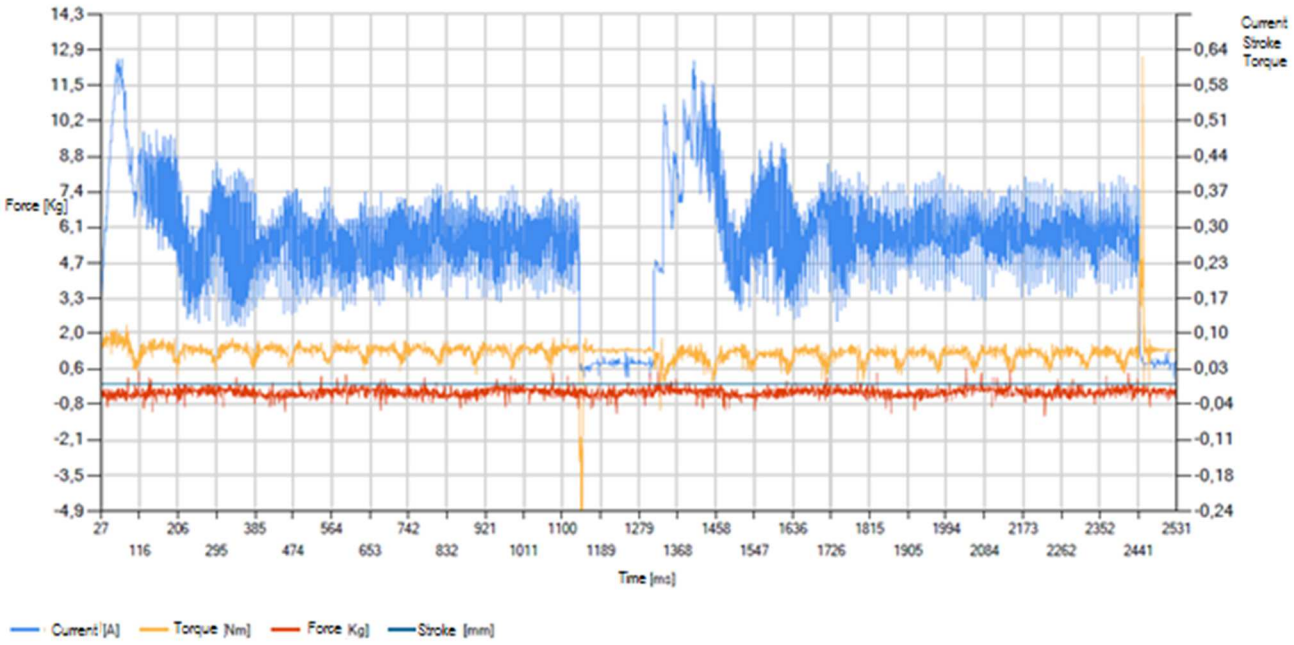

Figure 6 Rolling test output

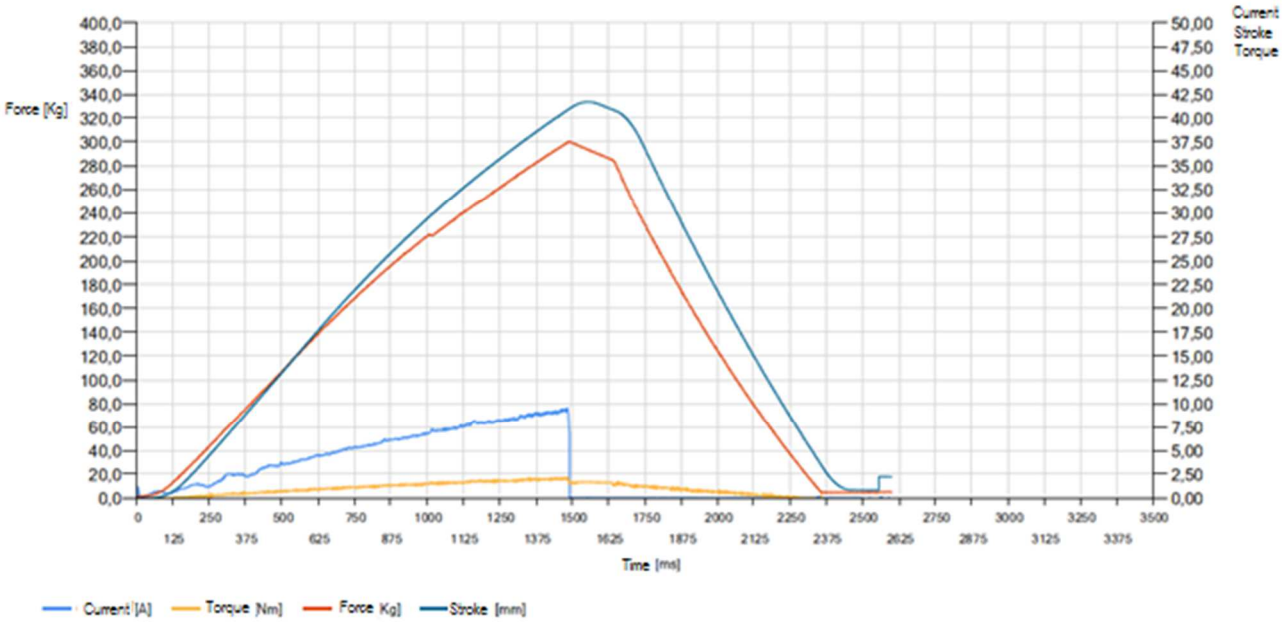

Figure 7 Magnitudes characterization

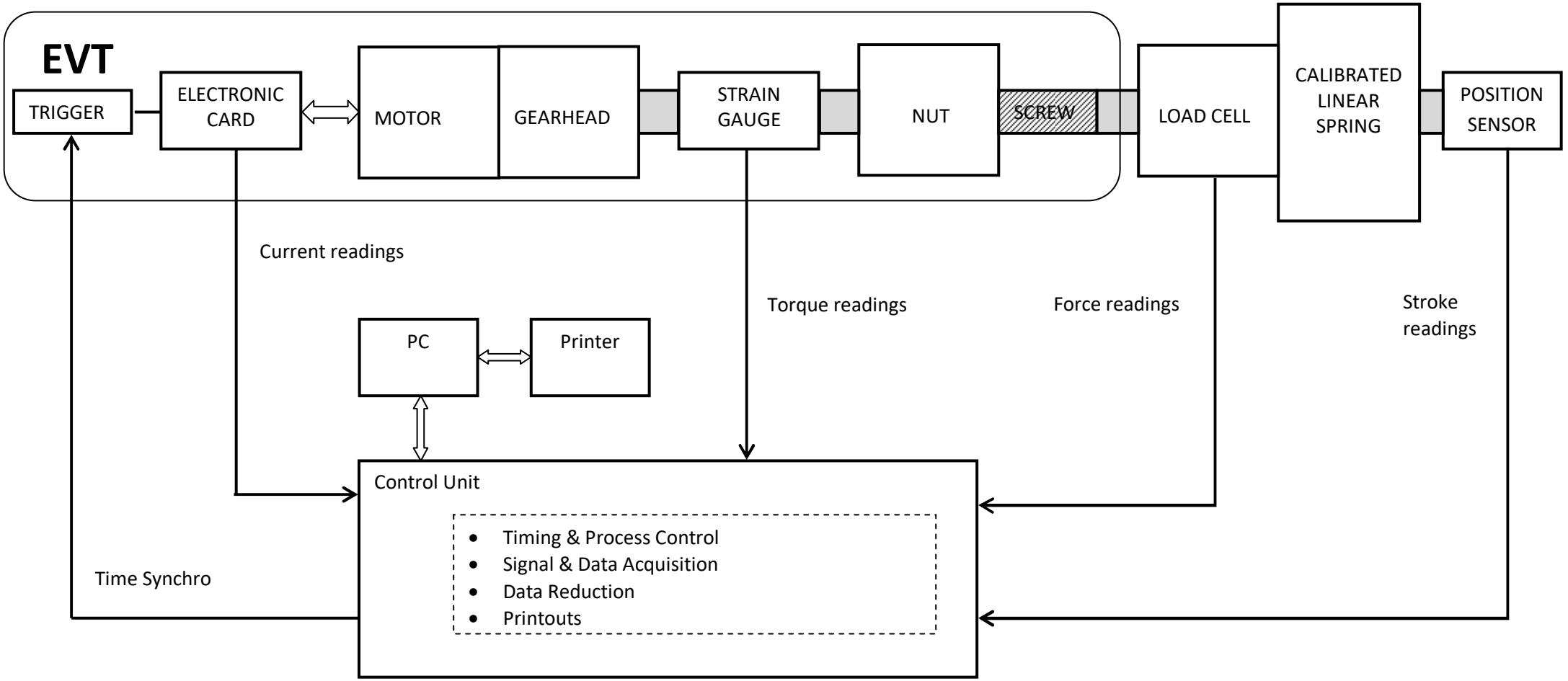

Figure 8 Functional Block Diagram of EVT COIL Bench

3.4. On site verifications

After the installation, start up and self-learning procedure, the EVT COIL is ready to operate in the production line.
Since then, the aging of the mechanical components becomes important because the EVT internal friction will lower the available output force with time.
Thus a regular periodic monitoring of the tool performance is needed to maintain the quality level of the production line at an acceptable level.

3.4.1. On site test bench

This bench, called EVT COIL On-site Bench (see figure 9), is a simplified version of the instrumented EVT COIL Bench and measures only the two basic magnitudes: Stroke and Force.
The On-site Bench is used to monitor the status of the COIL and it can declare whether the tool is still working at an acceptable level of performance or the tool need to be submitted to an extraordinary maintenance. Obviously a single bench can maintain a series of EVT COIL tools.

3.4.2. On site test program

A user friendly program allows not only the execution of the tests but also the maintenance info like:

- ✓ Tool management
- ✓ User management
- ✓ Deadline management
- ✓ Statistics on line
- ✓ Recordings of the tests
- ✓ Graphs of the tests
- ✓ Printouts of the tests
- ✓ Retrieve and reading of the tests performed

3.5. Extraordinary maintenance

To know what mechanical component limits the performance (e.g. motor, gearhead or Nut/screw), the instrumented bench 'EVT COIL Bench' is necessary.
Three way are possible:

1) The customer returns the tool to Sofca for repairing; usually it consists in replacing the degraded component.
2) The Sofca, under a separate maintenance contract, performs the extraordinary maintenance at the customer plant
3) The customer is equipped by an instrumented bench and himself performs the extraordinary maintenance, at his risk, after a maintenance course.

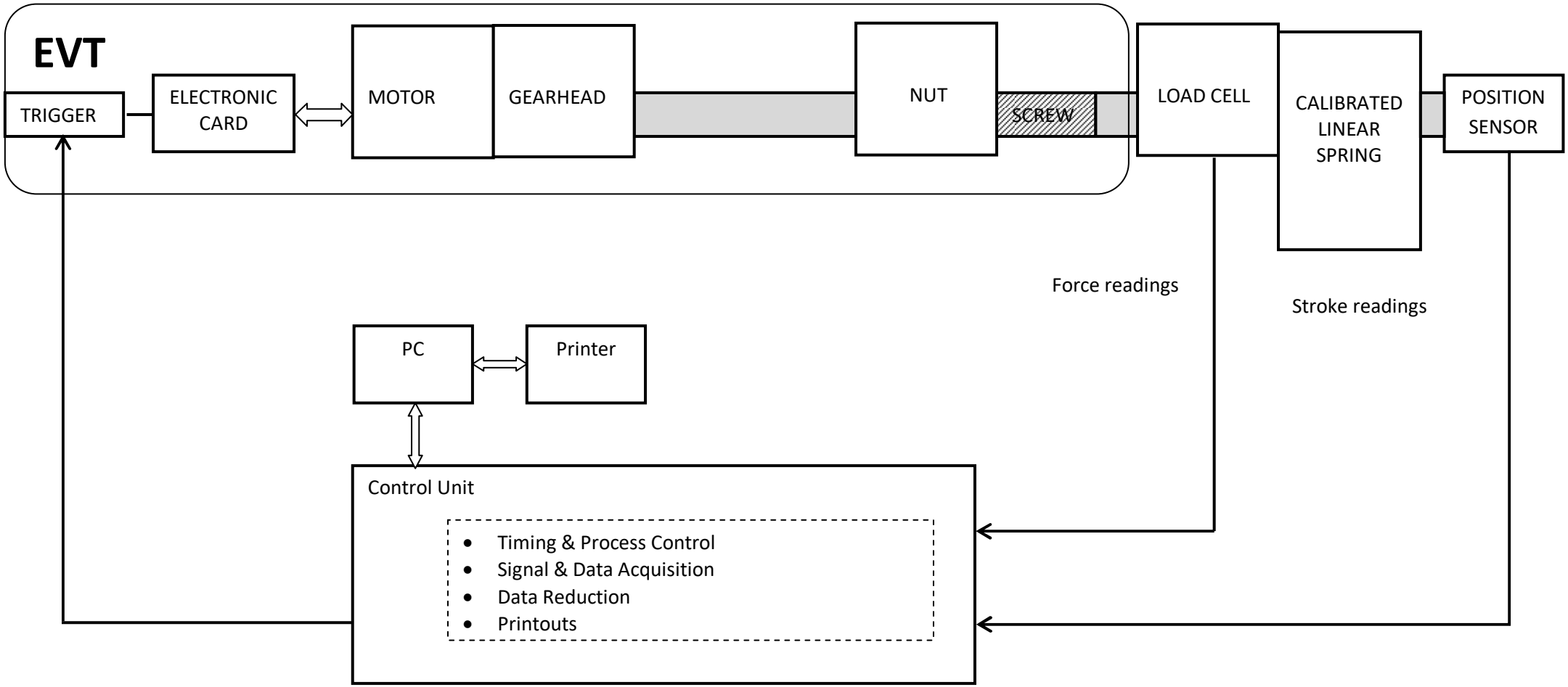

Figure 9 Functional Block Diagram of On-site Bench