Università degli Studi di Firenze

Dipartimento di Economia, Ingegneria, Scienze e Tecnologie Agrarie e Forestali

Sezione Scienze e Tecnologie Ambientali Forestali

DEISTAF

Preservatech PMCG-2-M-HD unit testing in different conditions

Tests performed by DEISTAF – University of Florence

Contacts:

- **Prof. Marco Fioravanti – marco.fioravanti@unifi.it**
- **Dr. Giacomo Goli – giacomo.goli@unifi.it - office +390553288675 – mobile: +393290656674**
- **Dr. Paola Mazzanti – paola.mazzanti@unifi.it**

Abbreviations:

RH: Relative humidity [%]

T: Temperature [°C]

max RH: maximum value of *RH* for the considered period [%]

min RH: minimum value of *RH* for the considered period [%]

max Δ_{RH}: difference between the maximum and the minimum of RH for a given period [%]

INTRODUCTION:

The Preservatech *PMCG* units are a series of devices using solid state technology in order to condition the relative humidity of a given space. The devices use a patented technology in order to input humidity from the external environment into a sealed case or vice versa. In this process no liquid water is involved and the device does not require liquid water to work, no reservoirs or refills are needed. The device is composed of a body, of a programming display and of a relative humidity sensor to be placed inside the case to be controlled and connected to the body via a cable. The device needs to be connected to the case via two pipes (air send and air return) that should be as short as possible. The device in order to work properly needs to be powered h24. In case of power supply brake the unit once the power is restored starts again working automatically to the same target set before the brake. Several tests were performed in different conditions according to the following material and method.

MATERIAL AND METHODS

Unit used in the tests

The device tested was a Preservatech PMCG-2-M-HD (hereafter only *PMCG*) unit conceived to control in humidification and dehumidification a volume up to 0.5 m^3.

RH and T measurement

The *RH* and *T* measurement was performed by third party freshly calibrated sensors produced by CEAM Control Equipment with ± 3 % *RH* and 0.4 °C *T* accuracy. The sensors (the sensor used for the measurements and the *PMCG* unit sensor) were placed in the middle of the case very close each other.

Tests scheme

The testing of the unit was performed with three methods:

- *Test A*: Performed in a 0.11 m^3 well-sealed case. Uninterrupted work for 10 days with a low external relative humidity (40 %) and constant temperature (30 °C). During the period the device was set to three different targets (55, 60 and 65 % *RH*). Send pipe length: 1.25 m, return pipe length: 1.6 m. This test was performed in order to evaluate the ability of the unit to input humidity when the environmental *RH* is low.
- *Test B*: Performed in a 0.11 m^3 well-sealed case. Uninterrupted work for 3 daily cycles with varying temperature conditions from 15 to 30°C in low external relative humidity (40 %). At the end of the test the device was switched off for one cycle in order to observe the differences. Send pipe length: 1.25 m, return pipe length: 1.6 m. This test allowed to verify the ability of the unit to humidify and dehumidify
- *Test C*: Performed in a 0.22 m^3 (0.93 x 0.575 on the horizontal axis and 0.4 m in the vertical one) well sealed case. The test was performed imposing cyclic temperature variations simulating day and night successions. The temperature variation, in order to simulate a very complex environment to be controlled, was 10°C going from 25 to 15°C and back to 25°C in two cycles with a flat controlled zone at the beginning and at the end. The test was conceived with 8 hours ramps in order to be as close as possible to a daily cycle and allow performing a complete test in 48 hours. The temperature scheme of the test is reported in *Figure 1*. *RH* target was set to 55 %. Send pipe length: 1.25 m, return pipe length: 1.6 m. This test was conceived to verify the behavior of the unit working alone and simultaneously to *Art Sorb®* and to compare its behavior with an uncontrolled environment and *Art Sorb®* controlled environment. In the details the following tests were executed by performing the above describer *T* cycle on a well-sealed case:
    - empty case without any sort of conditioning in order to give a reference;
    - case with two boxes of 800 g each of *Art Sorb®* conditioned to 55%;
    - case controlled by the *PMCG* unit set to a target of 55% and two boxes of 800 g of *Art Sorb®* conditioned to 55%;
    - case controlled by the *PMCG* unit set to a target of 55%.

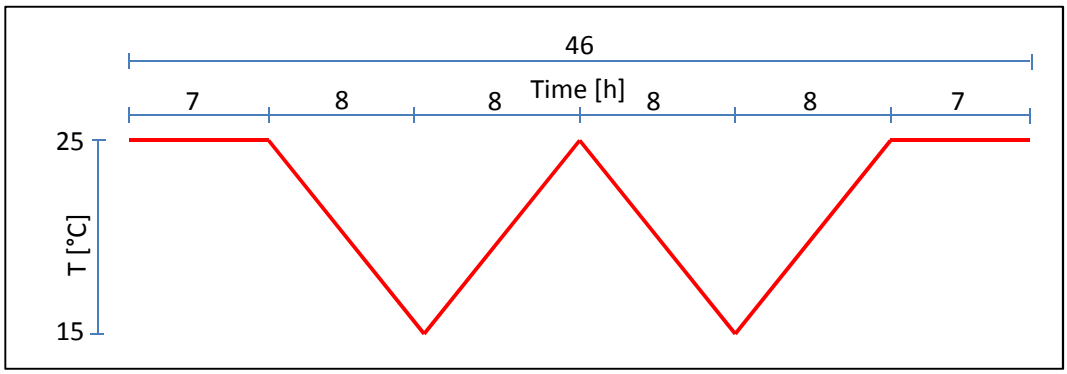

Figure 1: The temperature cycle and the scheduling of the tests

RESULTS

TEST A - Test performed at constant temperature with low external relative humidity and mild internal relative humidity

The results of this test are presented in *Figure 2*. As can be observed the environment outside the controlled box was kept at constant *T* (~ 29 °C) and *RH* (~ 35 %). In these conditions the *PMCG* unit has shown the ability to keep *RH* within ± 1 % from the targets (55, 60 and 65 %) set up.

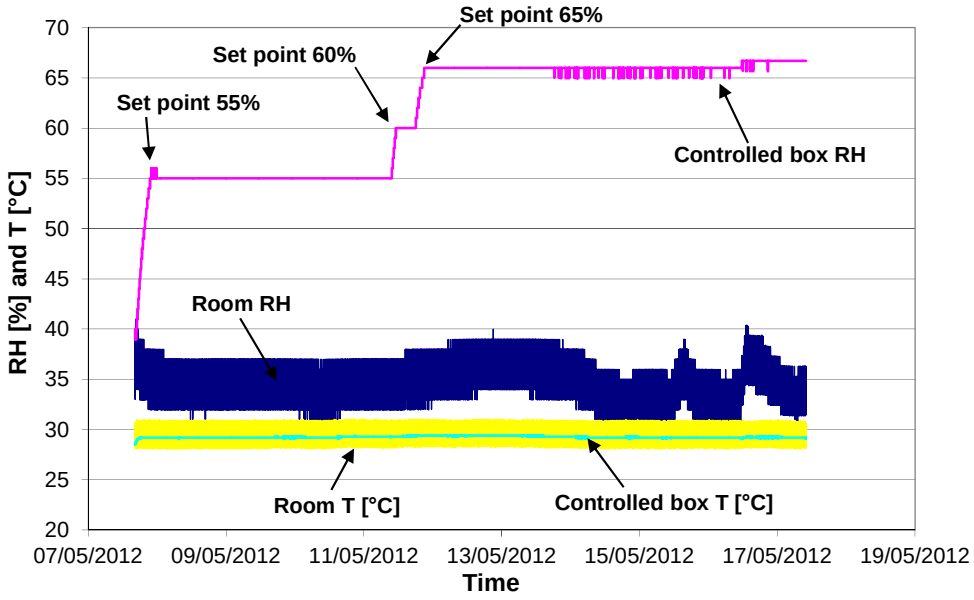

Figure 2: Test performed at constant environmental conditions with a high temperature setting a mild target inside the case and a low relative humidity in the external environment.

TEST B - Test performed with large temperature fluctuations with low external relative humidity and mild internal relative humidity

The device was tested for large *T* fluctuating conditions (from 14 to 29°C and back) in order to verify its ability to humidify and dehumidify. The fluctuation was performed in 24 hours in order to simulate an extreme daily cycle. The test results are shown in *Figure 3*. The *PMCG* unit target was set to 60 % *RH* and performed with an average *RH* of ~ 60 % staying within a *min RH* of ~ 59 and a *max RH* of ~ 62 % with a *max* Δ_{RH} of ~ 3 % for the period the *PMCG* was on. After a few days of testing the device was switched off in order to evaluate the effect of the same temperature variations in the same environment without control. With the unit switched off an average *RH* of ~ 42 % was measured and *RH* varied between a *min RH* of ~ 28 % to a *max RH* of ~ 56 % with a *max* Δ_{RH} of ~28 %.

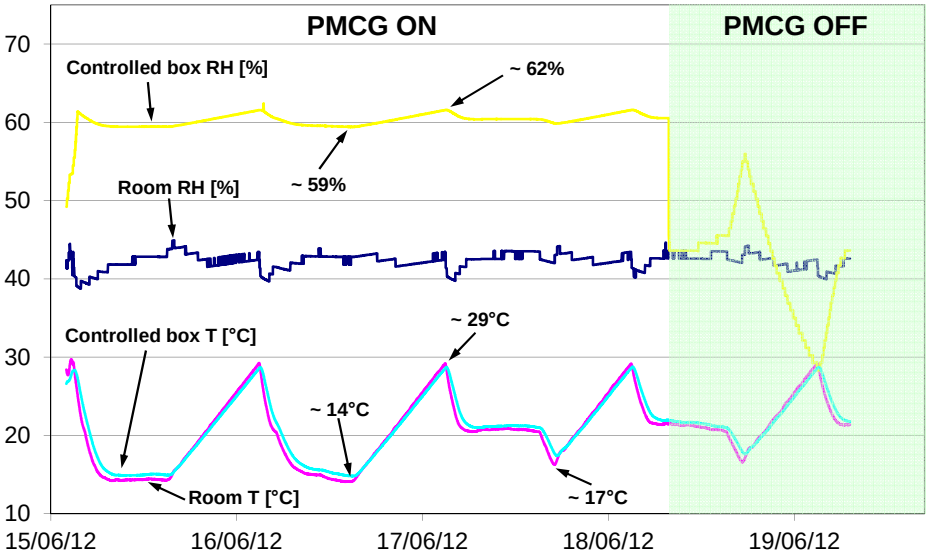

Figure 3: Test performed in fluctuating temperature conditions setting a mild target inside the case and a low relative humidity in the external environment.

TEST C: Tests performed in fluctuating temperature conditions in order to evaluate the performance of the PMCG unit compared to unconditioned and Art Sorb® conditioned case

Test performed without conditioning

A reference test performing temperature cycles without conditioning was executed and resulted in very large RH variation as shown in *Figure 4*.

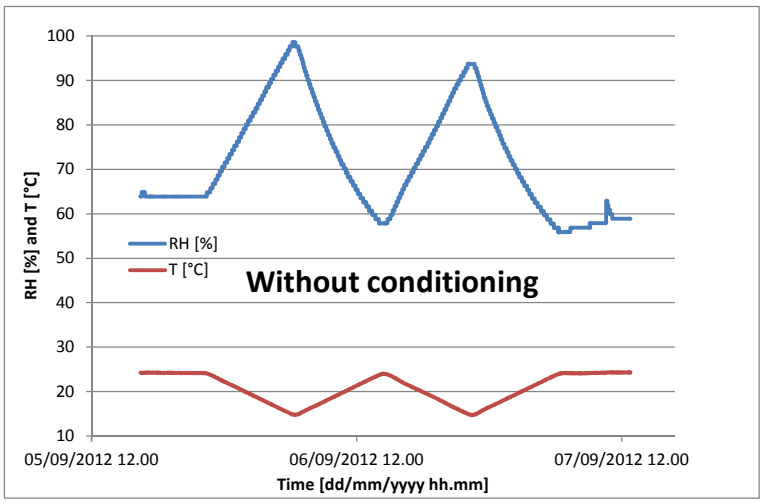

Figure 4: T and RH measured inside the case without conditioning

The following values were measured:

max RH	98.6 [%]
min RH	55.9 [%]
max Δ_{RH}	42.7 [%]

Test performed conditioning with Art Sorb®

The temperature cycles performed conditioning the case with *Art Sorb®* show that the *Art Sorb®* is able to reduce *RH* fluctuation (see *Figure 5)* if compared to uncontrolled environment.

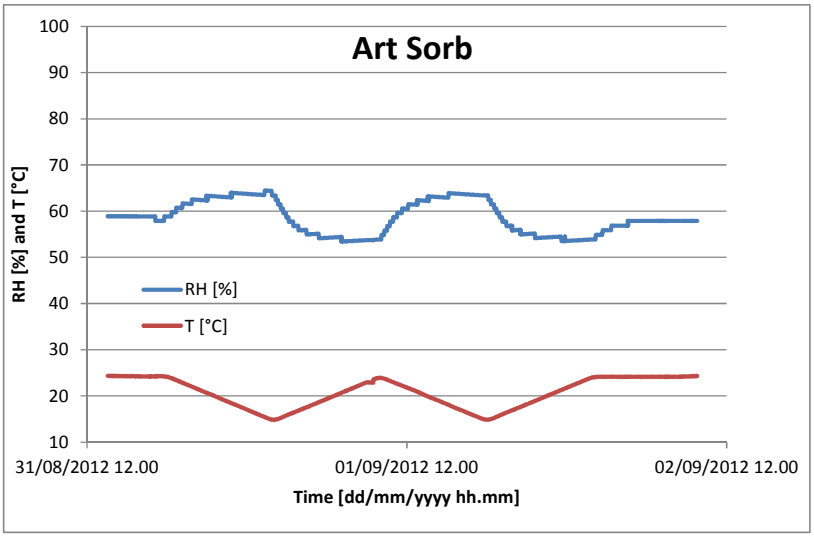

Figure 5: T and RH measured inside the case conditioned with *Art Sorb®*

The following values were measured:

max RH	64.5 [%]
min RH	53.4 [%]
max Δ_{RH}	11.1 [%]

Test performed conditioning with PMCG unit + Art Sorb®

The temperature cycles performed conditioning the case with *PMCG* unit and *Art Sorb®* result in lower *RH* fluctuations if compared with *Art Sorb®* alone as shown in *Figure 6*.

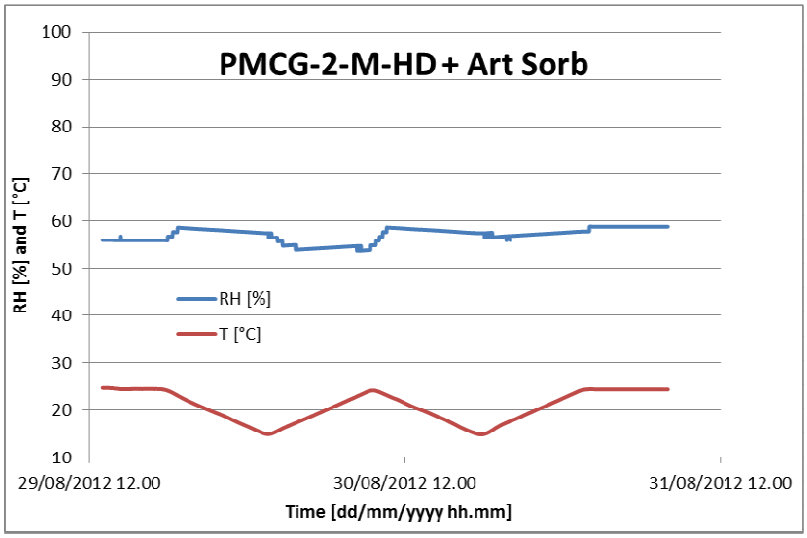

Figure 6: T and RH measured inside the case conditioned with PMCG unit and *Art Sorb®*

The following values were measured:

max RH	58.9 [%]
min RH	53.7 [%]
max Δ_{RH}	5.2 [%]

These extreme temperature cycles resulted in *max* Δ_{RH} not far from the extremes imposed by the Italian standard UNI 10829 (maximal allowed daily variation of 4%).

Test performed conditioning with PMCG unit

The cycling temperature in the environment controlled with a *PMCG unit* alone affects the RH variations as shown in *Figure 7* and the behavior is similar to the test performed conditioning with PMCG and *Art Sorb®*.

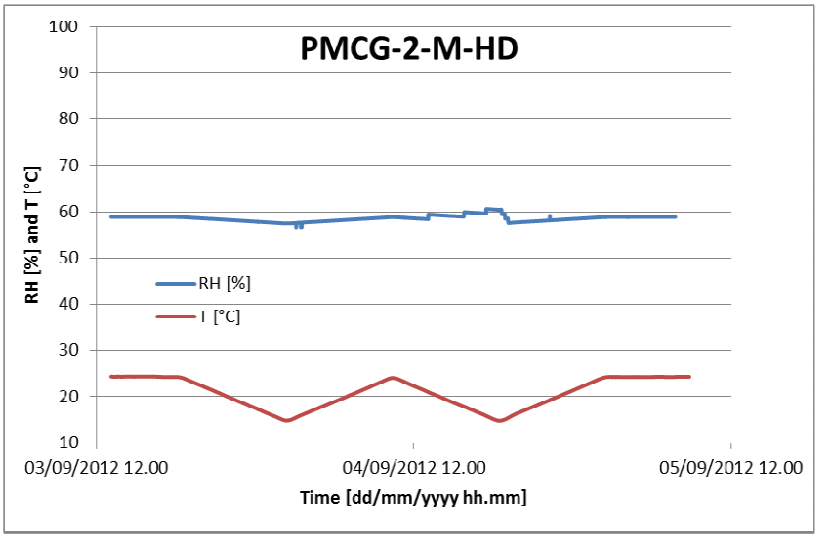

Figure 7: T and RH measured inside the box conditioned with PMCG unit

The following values were measured:

max RH	60.6 [%]
min RH	56.6 [%]
max Δ_{RH}	4.0 [%]

These extreme temperature cycles resulted in *max* Δ_{RH} compliant with the extremes imposed by the Italian standard UNI 10829 (maximal allowed daily variation of 4%).

CONCLUSIONS

In conclusion the *PMCG* unit was tested in different conditions keeping *RH* always close to the target. The *PMCG* unit was tested at constant *T* and large *RH* differential between the case to be controlled and the external environment. During the test the unit maintained *RH* within a neighborhood of ± 1 % from the targets of 55, 60 and 65 % *RH*. The *PMCG* unit was tested for variable *T* conditions with large variations (15 °C) showing a good ability both in humidifying and dehumidifying by keeping the *RH* within a neighborhood of ± 2 % from the target of 60 % *RH*. Finally *PMCG* unit was compared to *Art Sorb®* and for the same test conditions resulted in a maximal *RH* variation of 4 % compared to the 11 % of *Art Sorb®* for the same target of 60% *RH*. The *PMCG* unit was tested working simultaneously with *Art Sorb®* showing a variation not significantly different if compared to when working alone. The simultaneous use of PMCG unit with *Art Sorb®* is recommended in order to rely on a passive conditioning system in case of lacks of the power supply or PMCG unit maintenance.

The responsible of the testing
Prof Marco Fioravanti

The executor of the tests
Dr. Giacomo Goli