



## **Field test of Preservatech Mini One unit with different display case configuration and fluctuating environment**

### **Tests performed by GESAAF – University of Florence**

#### **INTRODUCTION**

Preservatech Mini One is a device conceived to control the relative humidity of display cases for conservation of cultural heritage. The device can work in two modes: positive pressure mode and recirculating mode. In positive pressure mode the air get sucked from outside the display case and pumped inside the display case after conditioning. The result is a positive pressure inside the display case and a continuous air flow through the display case leakages. In this configurations the device is connected to the display case with only one pipe. In recirculating mode the air get sucked from inside the display case and reinjected after conditioning. In recirculating mode two pipes are needed (one input and one output) and no positive pressure is achieved inside the display case. The device needs to be powered h24. In case of power supply gap the unit restarts operating automatically to the same target set before the gap. Several tests were conducted in order to analyze the ability of the device to control the relative humidity of a big display case under simulated extreme environmental conditions.

#### **MATERIAL AND METHOD**

The test was conducted as a simulation of a museum environment with extreme fluctuations of temperature (T) and relative humidity (RH). The room temperature was varied between the extremes of 12 and 24°C and the RH between the extremes of 30 and 90%. A display case 2.3 m long, 1.5 m deep and 1 m tall was built for a total volume of 3.45 m<sup>3</sup>. The display case was made with gas barrier plastic film suspended to a wooden frame perfectly sealed in the junctions. The pipes length was: 0.9 m from pump to Mini One and 2 m from Mini One to display case for positive pressure configuration (see Figure 1). In recirculating mode a pipe of 2,6 m was added to connect the display case output to the pump input (the output was placed on the opposite side of the input in order to allow an optimal air flow). The Mini One regulation sensor was placed 10 cm from the display case conditioned air input.

Three different tightness configurations were tested in order to simulate different display cases: very good tightness, conventional tightness and very bad tightness. The different tightness were achieved by producing holes of different dimensions to the perfectly sealed box. The tightness was measured with the CO<sub>2</sub> method proposed by Calver et al. 2005. The tightness is expressed in AER (Air Exchange Rate) per day, that means the number of times the air gets completely changed inside the display case during a day. The tightness was determined with the Mini One switched off because is to be considered as a property of the display case that would be altered by the air pump pressure. The three conditions tested were:

- Very good tightness – AER/day 0.1 – produced with two holes of 14 mm of diameter;

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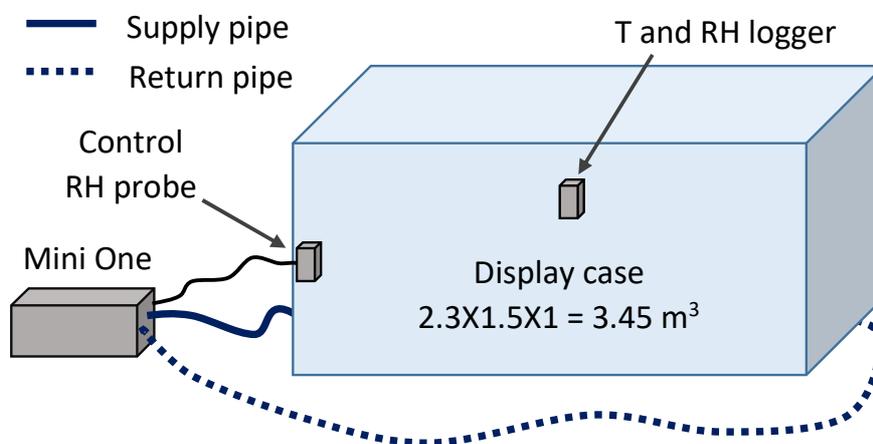
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- Conventional tightness – AER/day 0.5 – same holes as for AER 0.1 plus a rectangular hole of 106 mm by 80 mm;
- Very bad tightness – AER/day 6.1 – same holes as for AER 0.5 plus a rectangular hole of 100 mm by 200 mm.

The Mini One operation was tested at low (45%) and high (65%) relative humidity targets for very good tightness and conventional tightness conditions. The very bad tightness condition was tested at intermediate (55%) relative humidity target both in positive pressure and recirculating configurations. Independent data loggers produced by CEAM Control Equipment model C310 recorded the display case and environmental RH and T during the experiments. The accuracy of the sensors was  $\pm 3\%$  for RH and  $\pm 0.3$  °C for T. The sensor logging the display case interior was placed in the center of the display case, the sensor for the room logging was suspended in the proximity of the display case.



*Figure 1: Mini One and display case connections*

### **Case characterization**

A reference test was conducted with Mini One off in order to check the effect of the room environmental fluctuations on the display case internal microclimate with an AER of 0.5. T was a wintertime daily heating simulation with a large variation between day and night. The internal T has shown to follow perfectly the external one highlighting a negligible influence of the case (see Figure 2a). For the RH external fluctuations going from + 40 to -15 % from the median were produced (see Figure 2b). The display case interior gradually followed the room variations according to the time necessary to the diffusion to take place. These external fluctuations produced large display case internal variations going from +20 to -10 % from the median. This test is supposed to be a reference for comparison with the tests performed with Mini One switched on.

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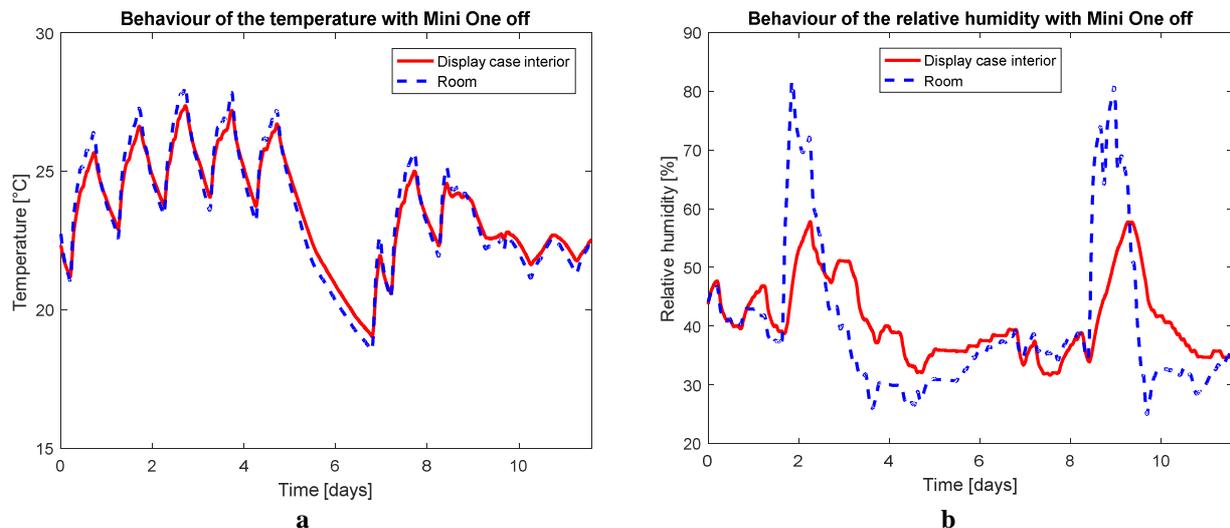
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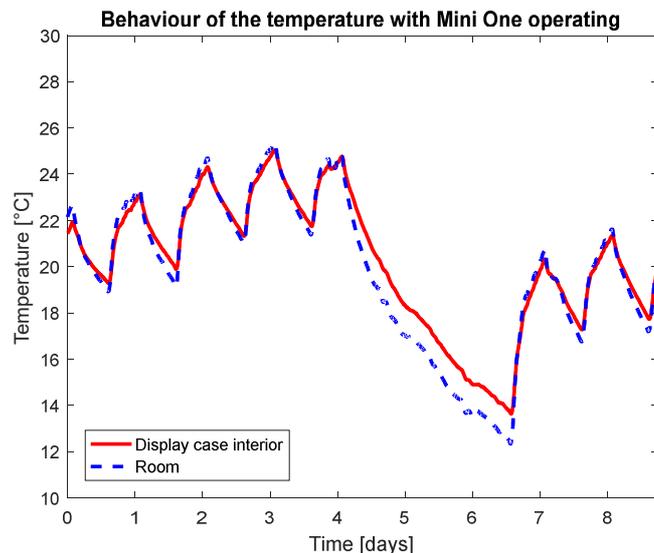
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**Figure 2: Behaviour of the temperature (a) and of the relative humidity (b) inside and outside the display case with Mini One switched off.**

### **Effect of Mini One on the display case internal temperature**

In Figure 3 are shown the display case and the room temperature with Mini One operating. The test was done with AER 0.5 and with an RH target of 45%. As can be observed the effect of Mini One on the temperature is negligible at conventional temperatures and becomes visible only at low temperature such as 12°C. This temperature cycle is typical of the other tests performed on the device and will not be shown for the following tests.



**Figure 3: Room and display case temperature with Mini One operating at AER 0.5 and 45% RH target. The influence of Mini One on the internal temperature is negligible.**

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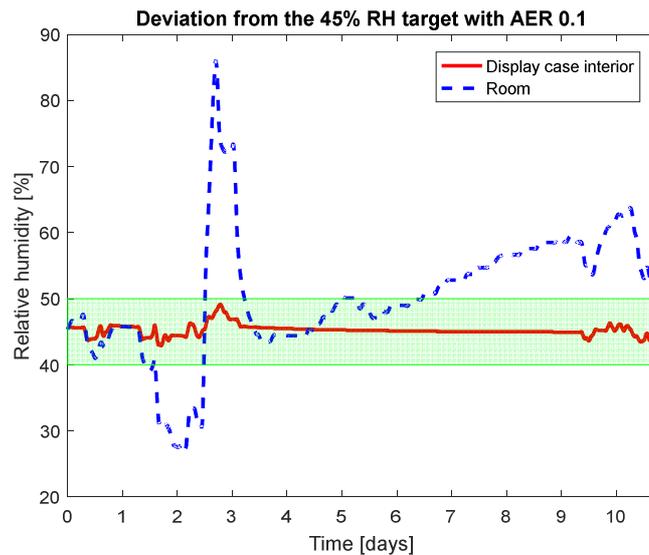


## RESULTS

### Mini One operating in positive pressure mode with AER 0.1

#### Target 45% RH

The display case relative humidity was largely kept inside the  $\pm 5\%$  RH from the target with external fluctuations going from +40% to  $-20\%$  RH (see Figure 4). Similar conditions with Mini One off resulted in internal fluctuations going from +20 to  $-10\%$ .



*Figure 4: Deviation of the display case relative humidity from the 45% RH target in a fluctuating external environment. Mini One operating in positive pressure mode with an AER of 0.1. The variation inside the green box are within  $\pm 5\%$  RH from the target.*

#### Target 65% RH

The display case relative humidity was largely kept inside the  $\pm 5\%$  RH from the target with external fluctuations going from +30% to  $-25\%$  RH (see Figure 5). Similar conditions with Mini One off resulted in internal fluctuations going from +20 to  $-10\%$ .

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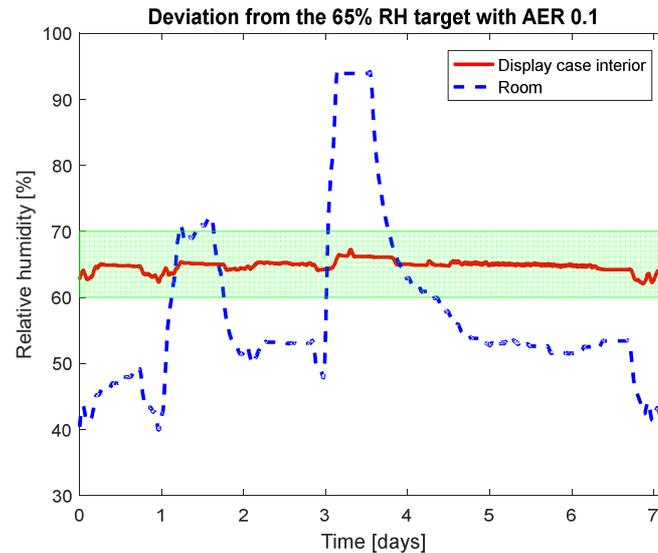
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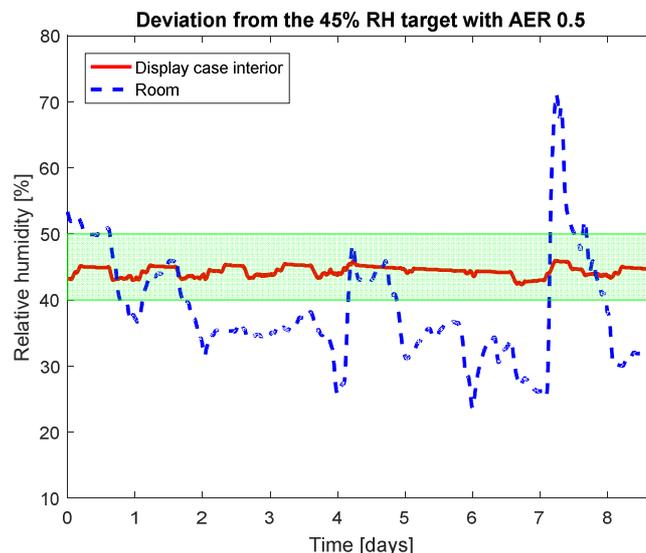


*Figure 5: Deviation of the display case relative humidity from the 65% RH target in a fluctuating external environment. Mini One operating in positive pressure mode with an AER of 0.1. The variation inside the green box are within  $\pm 5\%$  RH from the target.*

### **Mini One operating in positive pressure mode with AER 0.5**

#### **Target 45% RH**

The display case relative humidity was largely kept inside the  $\pm 5\%$  RH from the target with external fluctuations going from +25% to -20% RH (see Figure 6). Similar conditions with Mini One off resulted in internal fluctuations going from +20 to -10 %.



*Figure 6: Deviation of the display case relative humidity from the 45% RH target in a fluctuating external environment. Mini One operating in positive pressure mode with an AER of 0.5. The variation inside the green box are within  $\pm 5\%$  RH from the target.*

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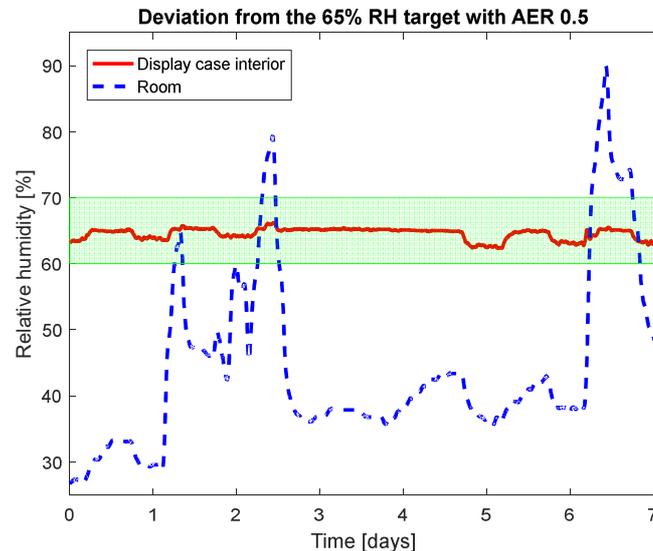
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### Target 65% RH

The display case relative humidity was largely kept inside the  $\pm 5\%$  RH from the target with external fluctuations going from +25% to -35% RH (see Figure 7). Similar conditions with Mini One off resulted in internal fluctuations going from +20 to -10 %.



*Figure 7: Deviation of the display case relative humidity from the 65% RH target in a fluctuating external environment. Mini One operating in positive pressure mode with an AER of 0.5. The variation inside the green box are within  $\pm 5\%$  RH from the target.*

### Test with MiniOne operating in positive pressure and recirculating mode with AER 6 and an RH target of 55%

Mini One has shown to produce large attenuation of the RH variations at AER 6 both in positive pressure than recirculating mode (see Figure 8). The display case RH with AER 6 and Mini One operating is more stable than with Mini One switched off and AER 0.5 as reported in Figure 2. In particular is to be noted a very good attitude to hold RH very close to target value even with much lower external humidity. It should be also noted that an RH spike of +50 % in a few hours is a very extreme case adopted in order to verify the difference between positive pressure mode and recirculating modes. As can be observed not relevant differences can be reported between the two working principles.

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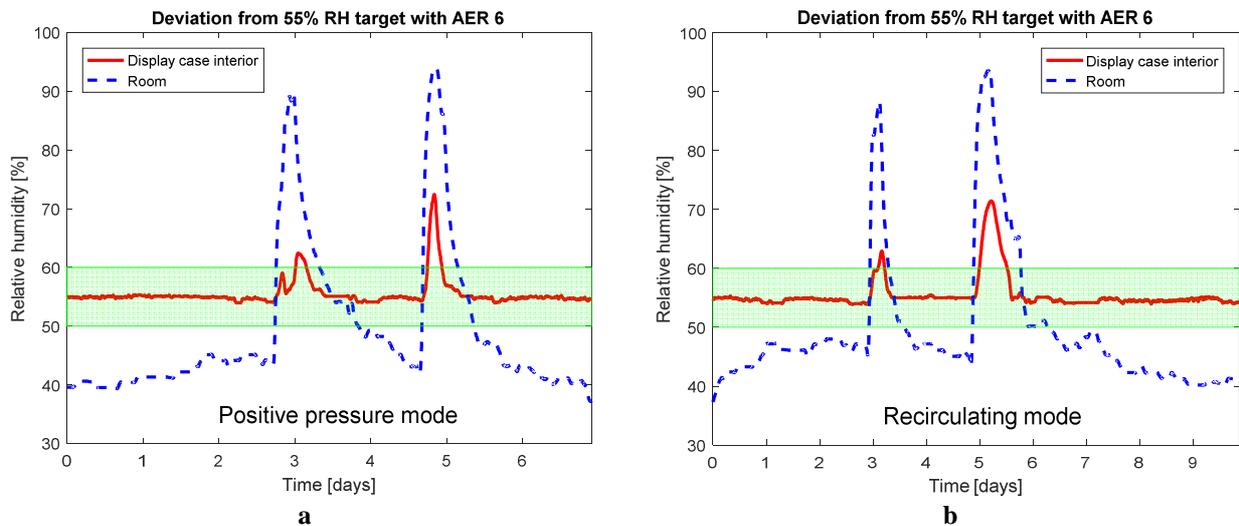
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**Figure 8:** Deviation of the display case relative humidity from the 55% RH target in a fluctuating external environment. Mini One operating in positive pressure mode (a) and in recirculating mode (b) with an AER of 6. The variation inside the green box are within + or - 5 % RH from the Target.

In order to have a better highlight of the efficiency of positive pressure and recirculating modes the time necessary to perform a humidity step was recorded with a very critical condition as with AER 6. The principle is that the more effective method would result in a more rapid step completion. A +20 RH step (going from 45 to 65%) and a -20 RH step (going from 65% to 45%) were executed with positive pressure and recirculating configurations and the results are reported in Table 1. As can be observed the difference between the two configuration is very small and they can be considered equivalent. The machine clearly shows a better ability to humidify than to dehumidify.

**Table 1:** Time necessary to Mini One to complete a humidifying step going from 45 to 65% RH and a dehumidifying step going from 65 to 45% RH in positive pressure mode and recirculating mode.

Operation	Step	Mode	Time [h:mm]
45 to 65 % RH	↑	Positive pressure	2:24
65 to 45 % RH	↓	Positive pressure	3:20
45 to 65 % RH	↑	Recirculating	2:53
65 to 45 % RH	↓	Recirculating	3:20

## Conclusions

Mini One unit has shown to behave very effectively for the relative humidity control of a large display case of 3.45 m<sup>3</sup>. The device has shown to not affect the temperature that with Mini One operating is approximately the same inside and outside the display case. With AER 0.1, corresponding to a state of the art display case tightness, the machine has performed very well both at low humidity (45%) than high humidity (65 %) targets. The display case interior was largely kept within 5% from the targets with very severe room conditions. The same is to be said for an AER of 0.5 corresponding to

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a conventional tightness. The unit has shown to give a strong support to reduce relative humidity spikes even with very bad tightness conditions such as AER 6 that corresponds to big holes on the display case. Positive pressure mode and recirculating mode have not shown relevant differences as conditioning capacity and accuracy. Working with relative humidity steps has shown a very similar behaviour for both positive pressure and recirculating modes. A better ability of the unit to humidify than to dehumidify was also recorded and in line with the specifications sheet. The positive pressure mode is more interesting than the recirculating one because the positive pressure avoid the entering of dust and promote the expulsion of undesired Volatile Organic Compounds emitted by the objects that could result in conservation problems.

### References

Calver A, Holbrook A, Thickett D, Weintraub S (2005) Simple methods to measure air exchange rates and detect leaks in display and storage enclosures. ICOM Comm. Conserv. 2005 - 14th Trienn. Meet. ICOM, pp 597–609

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