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## ECO<sub>2</sub> Controlled Atmosphere Low – Oxygen Disinfestation of Post Harvest Commodities, Structures, Silos and ( export/import ) Containers

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**Abstract:** The ECO<sub>2</sub> Controlled Atmosphere (CA) treatment, based on low – oxygen is commercially used world – wide to control insects in post harvest commodities, structures, silos, and container cargo (imported and exported and treated according Quarantine and Pre – shipment regulations). CA treatments have gained industry and government acceptance as a non – toxic fumigant technology for a variety of applications.

Treatments are carried out by applying them in climate controlled rooms, silos, barges or containers with fixed or mobile installations. CA has shown to be effective in controlling eggs, larvae and pupae, present in different sorts of dried commodities.

CA treatments have many advantages over traditional fumigants, including no pest resistance, residue – free and safe. Installations equipped to carry out CA treatments are available in 14 countries serving a wide variety of industries.

**Key words:** Controlled Atmospheres, heat, disinfestations, stored product pest control, fumigation, quality preservation, insects.

### Introduction

The use of Controlled Atmospheres (CA) to control insect in post – harvest durables is growing rapidly, replacing toxic chemicals such as Methyl Bromide and Phosphine. In the past, CA had some disadvantages in price, longer treatment times and availability but currently these constraints are reduced by the technical developments of the Dutch company, ECO<sub>2</sub>.

The ECO<sub>2</sub> CA process is based on establishment of a low-oxygen environment which kills insects. The ECO<sub>2</sub> b. v. developed commercial application of CA to control all stages of insects, rats and mice in food, associated products, artifacts, silos, food (processing) facilities, airplanes and barges.

In this study, low oxygen CA are established by means of an oxygen burner system or a nitrogen generator. The low-oxygen atmospheres are applied in airtight environments which range from 1 m<sup>3</sup> to 1 000 m<sup>3</sup>. Insects in all stages, present in the products treated, are eliminated (99.9 % lt) due to oxygen suffocation and dehydration. One unique effect of CA is that insects do not die inside the product. The insects try to escape the low – oxygen condition in the product by moving towards the walls of the chambers, thus moving out of the product.

### Materials and Methods

#### Exposure time with CA

The up-to-date application of CA (= EcO<sub>2</sub> Rapid Treatment<sup>®</sup>) decreases treatment times for stored products pests to an acceptable level. This decrease in treatment time was managed because of mechanical developments in the technology and the machinery used to perform CA. Treatment times now vary between 3 to 5 days, depending on the type of product (density level) and type of insect (exposure level).

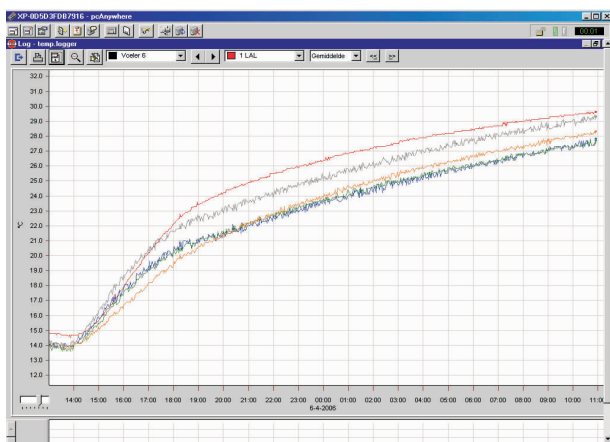
To decrease treatment time, improvements in airflow circulation in the airtight treatment chambers were developed, shortening the time to heat the products. Tests conducted in several EcO<sub>2</sub> service centers showed very positive results. The results of one test conducted with dried organic peaches from South Africa are shown in the Figures 1 and 2. Figure 1 visualises the rapid increase in temperature measured by 5 data loggers, placed in the dried peaches at different positions in the treatment chamber. The increase in temperature progresses relatively uniformly throughout the cargo treatment. Figure 2 shows the former situation when the improvements were not yet applied to the existing equipment.

Each insect species has different exposure

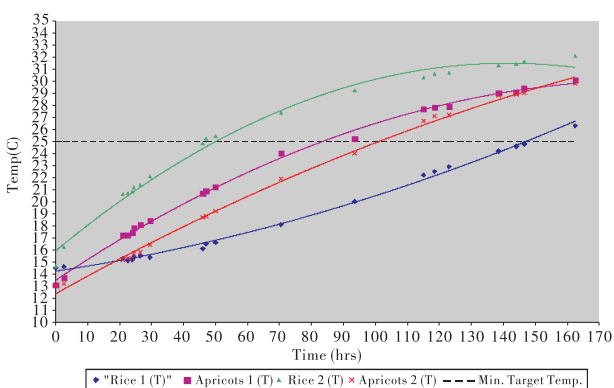
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**Fig. 1 Decreased heat – up times with the ECO<sub>2</sub> Rapid treatment<sup>®</sup>**



**Fig. 2 Standard heat – up times using CA without the ECO<sub>2</sub> Rapid treatment<sup>®</sup>  
Control of insects with CA**

times to control each stage of development. When lower product temperatures are used, exposure times will increase. When higher product temperatures are used, exposure times will decrease. This effect is very important for the industry where time is money.

Given this valuable information, the ECO<sub>2</sub> Rapid Treatment<sup>®</sup> was developed to create an optimum environment for the insects to be dehydrated and suffocated from a lack of oxygen. During the development of the treatment time improvement, several different insect species were tested. All stages of the insects (adult, pupae, larvae, eggs) were tested. Treatment was carried out using the ECO<sub>2</sub> Controlled Atmosphere including Rapid Treatment<sup>®</sup>. Insects were treated according to the parameters stated in Table 1.

**Table 1. Insect species treated with ECO<sub>2</sub> Controlled Atmosphere incl. Rapid Treatment<sup>®</sup>**

Insect Species	Life Stage	Treatment Type	Treatment Parameters
<i>Carpoglyphus lactis</i>	All stages	CA	CA, 38°C, 24hrs
<i>Acarus spp.</i>	All stages	CA	CA, 32°C, 24hrs

Insect Species	Life Stage	Treatment Type	Treatment Parameters
<i>Carpophilus dimidiatus</i>	All stages	CA	CA, 40°C, 16hrs
<i>Ephestia elutella</i>	All stages	CA	CA, 35°C, 10hrs
<i>Ephestia Cautella</i>	All stages	CA	CA, 35°C, 10hrs
<i>Plodia interpunctella</i>	All stages	CA	CA, 34°C, 16 hrs
<i>Oryzaephilus mercator</i>	All stages	CA	CA, 36°C, 16hrs
<i>Oryzaephilus surinamensis</i>	All stages	CA	CA, 30°C, 24hrs
<i>Sitophilus oryzae</i>	All stages	CA	CA, 35°C, 48hrs
<i>Sitophilus granarius</i>	All stages	CA	CA, 30°C, 4days
<i>Stegobium paniceum</i>	All stages	CA	CA, 32°C, 24hrs
<i>Tribolium castaneum</i>	All stages	CA	CA, 34°C, 24hrs
<i>Bruchus spp.</i>	All stages	CA	CA, 32°C, 2days
<i>Rhizopertha dominica</i>	All stages	CA	CA, 32°C, 3days
<i>Sitotroga cerealella</i>	All stages	CA	CA, 30°C, 3days
<i>Tribolium confusum</i>	All stages	CA	CA, 30°C, 36hrs

Each insect species was controlled according to the given parameters. Control samples of insects were prepared similarly but not subjected to treatment.

Test showed 100% effective control of all tested insect species according to the given parameters.

### Price and Availability Fumigation with CA

Toxic fumigants are still widely used but due to the phase out of Methyl Bromide consumers are pushed to use other fumigants or technologies. Phosphine is a world-wide fumigant and is affordable. However, the fumigation takes long exposure times to be effective and the product is meeting increased levels of pest resistance. Sulfuryl Fluoride is another fumigant which however cannot guarantee an effectiveness of 99.9%. It, and is not yet registered in every country to be used for insect control on food commodities. Phosphine and Sulfuryl Fluoride need investments in fumigation rooms and information technology to be applied on an acceptable level.

CA are most efficient in airtight climate rooms which are made of solid, impermeable panels. These rooms often require a large investment and a large volume. ECO<sub>2</sub> managed to implement their converter based system in a 20ft shipping container which is moveable and connectable to different areas, as long as the proposed treatment area can be made gastight.

The system can be connected to a 40ft isolated shipping container. The smallest treatment unit is 24 m<sup>3</sup>/ton per treatment. With the system designed and built as a transportable unit, prices of the treatments are at reasonable levels and affordable for use by small and medium sized companies. A company can purchase their own system, constructed turn-key at the desired location. Treatment prices range a few EUR per metric tonne (depending on yearly volume).

ECO<sub>2</sub> CA process installations and facilities are currently available in 14 countries in Latin America, Asia, Africa, Middle East and Europe. These facilities consist of more than 105 treatment sites of which some have 12 rooms on one facility (Fig. 3 and 4). Information about the efficiency of treatments can be demonstrated by reports. The system is proven in commercial practice as an effective pest control option.



**Fig. 3 CA facility in Greece (total 1029 m<sup>3</sup> treatment rooms)**



**Fig. 4 CA facility which fits 2 TEU in one treatment room**

### Usability of CA

Treatment of durable commodities with CA as developed by ECO<sub>2</sub> are carried out in gastight climate chambers, isolated containers,

silo's, warehouses, barges, etc. The machinery is moveable and can even be placed outside and connected to the treatment area inside. Small rooms are available for yearly volumes of 1 300 metric tonnes and can be upgraded to rooms with a yearly volume of more than 20 000 metric tonnes. Computer software makes it possible to monitor and control the entire process on-line and trained operators at a central treatment location monitor each individual treatment to maintain a constant level of quality control. The entire process is easy to use and owners of such systems only have to take care of loading and unloading the rooms and closing the doors. The rest of the system is entirely automatic.

Products that are exposed to CA in the facilities as described are a variety of food commodities, harvested and transported world wide. Each individual facility is equipped to handle variable sorts and quantities of products depending on the requirements of the user. A wide variety of cereals, pulses, nuts, spices, dried fruits, seeds and others are treated every day.

CA is also highly effective in the control of insects in furniture, art, antique and library or museum items. The technology will not deteriorate the products and their value will not be damaged.

### Conclusions

The use of Controlled Atmosphere is more competitive now than a few years ago. Barriers of treatment time, price, availability and usability have been lowered considerably. The growing trend in awareness and food safety is forcing commodity and wood product industries to implement better and safer fumigation technologies. The use of CA has several advantages compared to existing methods for chemical insect treatments on products:

Insects do not die inside the product. The insects try to escape the low oxygen atmosphere by moving out of the product toward the sides of the chamber.

There is no use of insecticides and thus no residues.

The method is environmental friendly.

The system can be used without waiting for a fumigator.

Each treatment is certified by an internationally recognized certificate of treatment.

No insect resistance is found with the use of Controlled Atmosphere.

There is very low danger for the working personnel.

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