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Pest Treatment Case Study: Carbon Dioxide Treatments at Historic New England-Society for the Preservation of New England Antiquities

Overview

Originally developed for the food and grain industry, Carbon Dioxide (CO_2) treatments (sometimes also referred to as either modified or controlled atmosphere treatments) have been safely adapted into the museum environment. Historic New England-Society for the Preservation of New England Antiquities (HNE-SPNEA) continues to use other forms of treatments like low temperature/freezing, and low-tech heat treatments; but the use of CO_2 remains the preferred choice for the following reasons:

- Existing in-house system.
- Unit is able to accommodate large objects, up to 9' w x 11' h.
- Gas is inert with no residue or carryover effects on collections.
- Lower cost, per large-volume operations and lesser need for auxiliary humidification compared to nitrogen.
- objects can be safely and immediately returned to storage following treatment
- Cost effective. Equipment and initial set up is expensive, but price of gas is quite reasonable and equipment needs little maintenance. In-house staff time is minimal during treatment cycle.
- With proper training, treatments can be done by staff without need for special permit or license depending on local and federal regulations.

Background

HNE-SPNEA follows guidelines for using CO_2 to treat pest infested collections based on material found in the Getty Conservation Institute's 1998 publication *Inert Cases in the Control of Museum Pests*, which includes detailed technical data and information on mortality rates, personal research and studies, and 15 years experience using the system. . Generally speaking, the length of treatment time inside of the unit is largely dependent upon temperature (25-30ºC), species vs. time (days), and a consistent oxygen level of 4.9- 8.4%, corresponding to a CO_2 range of 75-60%. During the process, the CO_2 levels drop to 60% over a 7 week period and then maintained at this level for an additional 21 days. This is to ensure mortality for more resistant species and heavy infestations.

Treating collections with carbon dioxide

HNE- SPNEA has over 37 primary historic house sites, and a collection of more than 80,000 oversized objects, for example, furniture, architectural fragments, and large rugs. After a bad infestation of webbing clothes moths and furniture beetles at one of its sites and a moth infestation in a storage area at the facility, the museum chose to purchase a standard Rentokil bubble unit in 1992. A new membrane was installed in 2000 by the Maheu & Maheu Company. Purchasing an in-house CO_2 bubble unit made it possible to treat oversized collections on a regular, monthly cycle. It also proved to be cost-efficient in terms of seeking alternative treatment methods and outside service vendors. The museum currently offers treatment services to outside clients including neighboring museums, galleries, and private clients. Once objects have been treated, they can be safely and immediately returned to storage areas.

The museum has treated many different types of collection items including: organic, inorganic, and composites. Thus far, there has been no damage to collections, as each treatment run is monitored daily for temperature, relative humidity (RH), oxygen and CO_2 levels.

There has been some discussion about the risk of the formation of carbonic acid when carbon dioxide encounters water during treatment, particularly at higher relative humidity levels (Reichmuth 1987). However, the formation of carbonic acid is unlikely: it is a two step process and requires liquid water, not moist air. Furthermore, the reaction is endothermic, meaning that an input of energy is required to break some stable CO_2 bonds, so it does not spontaneously. Therefore there is little possibility of damage to objects with sensitive surfaces; however users should avoid treating anything that is wet or saturated.

Another reason for favoring CO_2 for large-volume operations is its lesser need for auxiliary humidification. At a 60% CO_2 level, 40% of the original water vapor remains, in addition to additional moisture buffering by wooden and paper collections in the treatment chamber (Selwitz, Maekawa 1998, chapter 8).

Procedures

The unit consists of a large plastic membrane that is closed and sealed by a zip strip. An inner framework of wood supports the unit and acts as a 'skeleton' for the membrane. Auxiliary heating and humidification should be done prior to loading the unit, making sure to give collections ample time to slowly adjust to changing conditions. The room that the unit is in has an overhead heating system with a thermostat and a fan-driven humidification system. Overall conditions within the room and inside of the unit are monitored with LCD data loggers.

Collections are loaded into the unit and arranged for an even balance, allowing the CO_2 gas to easily permeate through the objects within the unit. The unit is then zipped closed and a motorized vacuum system draws residual air out of the bubble creating a vacuum. The gas is now pumped into the unit at a rate of 5psi. Once the gas inside of the bubble reaches the maximum capacity volume, the unit is drawn creating another vacuum. The gas is once again pumped into the unit until the ideal oxygen/ CO_2 levels are reached, within a 7-day period (25-30ºC; 60% CO_2). From this point on, the unit is maintained at the ideal levels and temperature and RH are regulated throughout the cycle, or about 21 days.

Once the cycle is complete the unit is vacuum drawn, the ventilation system is turned on, and the unit is opened. Once the CO_2 levels within the room have returned to normal levels (.040%) the collections can be returned to their respective locations.

Technical Information

- The original unit was purchased through Rentokil in 1992 and a new membrane was purchased through Maheu & Maheu in 2000. The motorized vacuum unit was part of the original unit.
- There is a CEI Instruments CO_2 analyzer, which is hard wired to a powerful ventilation system which automatically runs when CO_2 levels exceed .10%. The monitor has a digital display reading and it monitors the level by taking a gas sample every two minutes.
- An overhead heating unit, with digital thermostat allows the museum to run the unit through the colder winter months month's while maintaining the ideal temperature.

- An OXOR II oxygen monitor is used during the treatment cycle to monitor the O_2 levels inside of the unit.
- The humidification system, which is used primarily during the winter months, is a portable, commercial fan-driven model.
- The museum uses size 200 T-cylinders of bone-dry grade CO_2 gas. There is a gas regulator unit that has a built-in heater to prevent freezing. En-route to the unit, the gas passes through a three-jar humidification system which allows the gas to be humidified as it enters the unit.
- A digital hygrothermograph monitors the temperature and RH of the gas entering the bubble.

Equipment

The unit is located in a secure room location, separate and away from permanent storage areas. The room is across from the freight elevator for easy access and loading. While all of the Collections staff has access to the room, only the Collections Technician is allowed to operate the unit, and has sole responsibility of its use and safety.
Systems and specs:

- The original unit was a Rentokil system, which included membrane- 2 parts, motorized vacuum system, and spring-valve accessories. The new membrane was purchased through Maheu & Maheu.
  http://www.maheu-maheu.com/Fiche.aspx?Page=BulleFumigation
- OXOR II O_2- Single gas analyzer. Connects to unit through spring-valve and draws gas sample, and gives LCD readout of oxygen percentage
  http://www.bacharach-inc.com/single_gas_analyzers.htm
- CEI- Instruments CO_2 analyzer, model 266. Wall mounted unit which has an infra-red sensor that draws a gas sample every two seconds, displays through LCD readout. Normal atmospheric CO_2 levels are .040% and set to trip alarm at .10%, which sends an automatic signal to the operation of the exhaust fan.
  www.ceainstr.com/pdf_datasheets/266_Info.pdf

Issues concerning treatments, health, and safety of staff and collections

Precautions for unit set up and CO_2 usage should always be followed. The usage and classification of CO_2 vary from state to state in the U.S., and within other regions, countries, and continents, so classification and use should be researched. HNE-SPNEA operates within the Commonwealth of Massachusetts which does not list CO_2 as a fumigant. Therefore it is not required to have a special permit or license to buy, own, or use. However, the potential dangers and risks of its usage should not be ignored. It is an inert gas but does pose human health risks. See MSDS: www.airgas.com/documents/pdf/1013.pdf

The museum operates the unit in an area that is not occupied or crossed through by staff, and utilizes the CO_2 analyzer to monitor the levels along with an exhaust fan.

References

Selwitz, Charles and Maekawa, Shin. 1988. Inert *Gases in the Control of Museum Insect Pests*, Getty Conservation Institute.
http://www.getty.edu/conservation/publications/pdf_publications/inertgases.pdf

Reichmuth, C**.** 1987. Low oxygen content to control stored product insects. In: *Donahaye, E., and Navarro, S., ed., Proceedings of the 4th International Working Conference on Stored-Product Protection*. Tel Aviv, Israel, September 1986. 194-207.