

Foam Deformation in CO₂ Pest Eradication Treatments



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Summary

Low oxygen pest eradication using a CO₂ modified atmosphere has been considered a safe method for objects of historic and artistic value. For the large majority of objects this appears to continue to be true. However, some foams have been found to distort just after being removed from a CO₂ treatment. Presented here are results from initial experiments designed to identify the types of foam that distort and the extent of those distortions.

Introduction

Winterthur Museum has employed a CO₂ modified atmosphere pest eradication method since 1990. A flexible chamber mounted on a rigid frame provides the structure in which these treatments take place. When loading the chamber with objects it is often necessary to support them on temporary mounts. In 2011, cradles made of Ethafoam® 220 were used to support two carpets being treated for carpet beetle infestation. When the chamber was opened post-treatment the carpets were left resting on these cradles. Twenty-four hours later it was observed that the cradles were shriveled and distorted.



Cradles – shriveled and distorted 24 hours after being removed from a CO₂ treatment
 Photo by: Jim Schneck

This result raised concerns regarding foam items that are more than temporary support mounts which might pass through the chamber. Possible classes of objects are:

- Foam lined packing crates
- Textiles mounted on foam mannequins
- 20th and 21st century art and upholstered objects
- Objects stored in foam cavity packed boxes
- Upholstered objects conserved using Ethafoam® and minimally invasive conservation treatments

Foams likely to be found in such objects were identified as:

- Backer Rod, a closed cell polyethylene foam
- Ethafoam® 220, a closed cell medium density polyethylene
- Foamcor®, a closed cell polystyrene core between two skins of paper
- Natural or synthetic latex foam
- Etherfoam, an open cell polyether polyurethane foam
- Esterfoam, an open cell polyester polyurethane foam
- SenFlex®, a laminated polyethylene foam
- Styrofoam, a closed cell extruded polystyrene
- Volara® Foam, a cross-linked polyethylene

Experimental design

In order to begin to identify the real risks to objects several samples of each foam listed above were put through a 14 day CO₂ treatment. The run maintained a CO₂ concentration of 70% +/- 8% at 71.1° F and 26.5%RH.

Six samples of each foam type were cut in 10 cm squares with the exception of the Backer Rod which was cut in a 10 cm long tube. The depth of each sample was determined by the sheet of foam from which it was cut.

The 9 foam types were prepared in six different ways:

1. No pressure or restraint
2. Restraint only - One side of the foam sample restrained by adhering the sample to a sheet of plywood with hot melt adhesive
3. Weight and restraint - As method #2 with a weight or clamp added to the surface parallel to the adhered surface
4. Restraint only - Two parallel surfaces of the foam sample adhered to sheets of plywood with hot melt adhesive
5. Weight or clamp only
6. Control sample – as method 1 and left outside the chamber during the run

These different methods of preparation were devised to identify the impact of weight on the distortion as well as whether to force causing the distortion was strong enough to cause tearing within a restrained foam or shearing away from a surface to which the foam was adhered.

Three length, width and depth measurements were taken on each surface of the foam before treatment, immediately upon removal from the chamber and then 1 day, 1, 2, 4, 6, 10, 14 and 29 weeks after removal. Documentary images were taken at each of these intervals.

Results

Four of the tested foams were measurably distorted when subjected to the described conditions. All four are closed celled polyethylene foams. All but Volara® Foam emerged from the chamber appearing unchanged. Distortion slowly developed and reached a maximum within 24 hours.

Backer Rod



Pre-Treatment



24 hours after removal from chamber

Ethafoam® 220



Pre-Treatment – restrained on one side

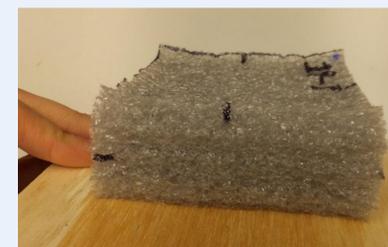


24 hours after removal from chamber

SenFlex®



Pre-Treatment – restrained on one side



7 days after removal from chamber

Volara® Foam



Pre-Treatment



Immediately after removal from chamber

In almost all cases, the foams eventually return to their original dimensions. The exception is foam with a significant pressure applied. In some cases marks from weights and clamps remain visible 2 years later.

- **Backer Rod** - returned to original dimensions in 10 weeks
- **Ethafoam® 220** – returned to original dimensions in 10 weeks
- **SenFlex®** - returned to original dimensions in 29 weeks
- **Volara® Foam** – returned to original dimensions in 1 week

Additionally, upon removal from the chamber the foams are much more easily compressed than untreated foams and the treated foams do not immediately spring back from an applied compression.

Further Research

A baseline has been established. The results are not acceptable. Why the physical distortion takes place, whether the process weakens the foams and whether or not objects can be protected from the distortion are some of the questions that need to be answered.

A variety of theories are being explored with regard to why the distortion takes place. The most promising to date hypothesizes that upon removal from the chamber the CO₂ still inside the closed cell polyethylene foams diffuses out of the cells at a rate faster than N₂ in ambient air can replace it.¹

Simultaneously factors which may or may not protect items from distortion are being explored. One theory offered that a foam mannequin upholstered in layers of wadding and fabric might not shrink. A recent test of this theory proved otherwise:



Photo by: Jim Schneck



Photo by: Jim Schneck

A 20 cm x 10 cm Ethafoam® block upholstered with polyester batting and muslin. Left image before treatment. Right image 24 hours after removal from the chamber. The foam inside the upholstered sample on the right has clearly distorted.