Trajectory of Anoxic Encasements in Museum Use

Authors: Jennifer Herrmann,[a] Andrew Davis,[b] Rebecca Kaczkowski,[c] Antje Neumann,[d] Shannon Brogdon-Grantham,[c] Fenella France,[b] Dong Eun Kim,[a] Yun Liu,[c] Amy Lubick,[a] Mark Ormsby,[a] Sara Shpargel,[a] Charles Tilford[e]

Institutions: [a] National Archives and Records Administration, [b] Library of Congress, [c] Smithsonian's Museum Conservation Institute, [d] National Museum of African American History and Culture, [e] National Institute of Standards and Technology retiree

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Introduction

Museums face critical decisions when determining the best method to protect cultural heritage while allowing access to interested generations. Designing safe display technologies is one way to protect and provide access to cultural treasures that come in many sizes, shapes and materials. Display cases are routinely used to allow visual access but not physical access while protecting the object from environmental instabilities and potential pollution, both internal and external, through an established air exchange rate. Some materials and objects may require more stringent protection involving changing the actual chemical environment surrounding the object. The environment can be changed either actively, which can be useful to flush internal pollutants away from the object, or passively if the object is not prone to autodegradation pathways. When passive environmental controls are necessary, the display may be referred to as an encasement, which connotes a hermetically sealed case used for both storage and display. Most encasements currently used are a form of permanent display and storage that rely on an anoxic (0.5% or less oxygen) or hypoxic (below atmospheric oxygen levels of 21%) environment where an inert gas is used to fill the encasement space thus protecting the object from degradation reactions that occur in the presence of oxygen. As a note, anoxic/hypoxic encasements do not refer to anoxic pest management treatments, which are short-term practices unrelated to display. The field of conservation is continually developing new technologies and display applications. Therefore, the definition of "encasement" may evolve as new technologies protect more varied objects and materials. More nuanced approaches to conservation challenges continue to become available, including the Smithsonian's Apollo space suit case which removes volatile organic compounds (VOCs) from the display area without changing the internal concentration of oxygen.

This paper serves as a review of the history of the development of these encasements for cultural heritage display and collects information that was previously spread over many agencies and organizations. A few examples from the greater Washington area will be discussed in greater detail. The authors have also assembled a list of references for those desiring further information about the development and application of these technologies.

Timeline of Specific Encasements:

- 1940s-1950s: The National Bureau of Standards (NBS) researches anoxic preservation and after WW II uses Thermopane anoxic helium filled encasements for the Declaration of Independence, the Constitution, and the Bill of Rights to be displayed at the National Archives and Records Administration: https://cdm16009.contentdm.oclc.org/digital/collection/p16009coll4/id/10048
- 1970s: The Library of Congress first researches, designs and uses reduced oxygen encasements for display and protection
- 1985: Nathan Stolow, working with Hampton Sheet Metal, designs a reduced oxygen case for Ross Perot for the 1297 Magna Carta: https://www.dailypress.com/news/dp-xpm-19950417-1995-04-17-9504170053-story.html
- Late 1980s: The Getty creates anoxic, nitrogen filled cases for Royal Mummy collection (leak testing estimated that the cases should remain under 2% oxygen for 10 years; the addition of oxygen scavengers extended the anoxic lifetime to about 60 years); reference: *Oxygen-Free Museum Cases*. Ed: Maekawa, S. Research in Conservation Series, The Getty Conservation Institute. 1998.
- 1999-2000: Independence Hall displays six anoxic encasements of Founding Documents in their West Wing exhibit area: https://www.nps.gov/inde/learn/historyculture/conserving-the-great-essentials.htm
- Early 2000s: The National Institute of Standards and Technology (NIST, previously NBS) develops anoxic argon filled encasements for permanent display of the Declaration, the Constitution, and the Bill of Rights at NARA: https://www.archives.gov/publications/prologue/2003/fall/charters-new-era.html
- 2003: The Getty Conservation Institute creates an anoxic argon filled encasement for the Harry Ransom Center's Niépce Heliograph
- 2007: NIST creates an anoxic argon filled encasement for the Library of Congress' (LC's) Waldseemuller map: https://www.loc.gov/item/prn-07-143/1507-map-case-construction/2007-06-29/
- Circa 2006: The SI Museum Support Center and NASA's Johnson Space Center create nitrogen storage for the US Antarctic Meteorite collection.
- 2006-2009: Tate researches temporary anoxic framing with a focus on anoxia and microfading studies
- 2007: Ghiberti's Gates of Paradise bronze door panels are displayed in custom-made nitrogen-filled anoxic cases as part of a traveling exhibit: https://www.smithsonianmag.com/arts-culture/the-gates-of-paradise-174431341/
- 2008: The Smithsonian displays the Star Spangled Banner using 13% oxygen levels for fire prevention reasons: https://amhistory.si.edu/starspangledbanner/visit.aspx
- 2010: The National Park Service (NPS) installs active nitrogen cases at the Pearl Harbor USS Arizona National Memorial to preserve complex composite objects from autodegradation due to off-gassing: https://www.mydigitalpublication.com/publication/?i=130815&article_id=1215007&view=articleBrowser&ver=html5

- 2011: The Metropolitan Museum of Art exhibits five extremely light sensitive autochromes by Stieglitz and Steichen in individual anoxic encasements following completion of a three-year research project supporting the use of argon filled anoxic encasements for one week of temporary display in order to reduce the fade rate of the colorants:
    - https://www.metmuseum.org/press/exhibitions/2011/original-color-photographs-by-stieglitz-and-steichen-on-view-at-metropolitan-museum-for-one-week-only-january-2530
    - https://www.metmuseum.org/blogs/now-at-the-met/features/2011/on-view-january-2530-original-autochromes-produced-using-the-first-color-photographic-process
- 2012: NIST creates an anoxic argon filled encasement for David Rubenstein's 1297 Magna Carta (previously owned by Ross Perot) on loan to NARA: https://www.archives.gov/press/press-kits/magna-carta
- 2013: Library and Archives Canada, in collaboration with CCI, created a two-part anoxic storage and display case system for the preservation, display, and security of Canada's two copies of the Proclamation of the Constitution Act. https://cool.culturalheritage.org/coolaic/sg/bpg/annual/v35/bpga35-12.pdf
- 2013: NIST creates a hypoxic encasement for LC's Buell Map https://www.loc.gov/preservation/scientists/projects/anoxic_cases.html
- 2013-2014: NIST creates an anoxic encasement for NY Public Library's copy of the Bill of Rights
- 2017: NIST creates an anoxic encasement for President Abraham Lincoln's first handwritten draft of the Preliminary Emancipation Proclamation for the New York State Library and New York State Education Department (NYSED): https://www.nist.gov/news-events/news/2017/04/making-airtight-case-freedom:
- 2018: NIST creates an anoxic encasement for Rubenstein's copy of the Emancipation Proclamation and 13th Amendment on display at the National Museum of African American History and Culture: https://www.nist.gov/news-events/news/2018/02/nist-expertise-helps-protect-historical-documents-national-museum-african
- 2019: The Getty updates system components and reflushes the anoxic argon filled encasement for the Niépce Heliograph: https://sites.utexas.edu/ransomcentermagazine/2019/10/15/preserving-one-of-the-centers-most-celebrated-objects/

A Few Specific Examples of Encasements: Founding Documents at the National Archives and Records Administration and the Library of Congress and Treasures of the Smithsonian Institute

The Declaration of Independence, Constitution, and Bill of Rights on permanent display at the National Archives and Records Administration:

In the 1950s, the Declaration of Independence and Constitution were encased by the National Bureau of Standards (now NIST) while in custody of the Library of Congress (LC). The encasements used Thermopane technology in which a strip of lead was used to fully seal the interior environment off from the exterior atmospheric conditions. Such a seal allowed the encasements to be flushed with humidified helium to remove the air. The documents were later transferred to the National Archives, where the Bill of Rights was also encased. For 50 years the Declaration, first and fourth pages of the Constitution, and the Bill of Rights were daily lifted from a vault to the exhibit area and then lowered back to the vault at night. The second and third pages of the Constitution as well as the Transmittal page remained in dark anoxic storage through most of this 50 year period.

In the 1980s conservators observed crystals and other signs of deterioration of the encasement glass sheets. Between the two outer layers was a third pane which was in contact with the parchment surface. Because of concern about potential abrasions or reactions between the glass crystals and the documents, the Archives decided to re-encase these founding documents. The National Institute of Standards and Technology (NIST) designed the new encasements for all seven documents. NIST also analyzed the interior of the 1950s-era housings and showed that five of the seven encasements had maintained anoxic conditions, while the other 2 encasements were slightly higher than the 0.5% oxygen considered anoxic. While determining the oxygen and helium levels were the priority, gas measurements also documented the levels of carbon dioxide and nitrogen. The carbon dioxide levels were elevated over that expected from atmospheric gas ratios. In theory, the elevated levels of carbon dioxide could indicate biological activity. However, extensive examination of the documents by conservators showed no signs of active biological deterioration or damage from the glass crystals.

The new anoxic encasements were installed in 2002 for permanent display of these iconic documents. The anoxic seal maintains the humidified argon environment with a metallic C-ring between the glass and the aluminum and titanium frame. The documents only come in contact with the high quality handmade alkaline backing paper and small inert polyester tabs. The interior temperature, humidity, and pressure are monitored with sensors connected to computer ports. Later, in cooperation with LC, NIST developed an oxygen sensor which relies on diffusion to gather periodic readings of the oxygen level inside the case environment; these measurements require extracting a small gas sample.

Subsequent NIST encasements are derived from the design created for the Declaration, Constitution, and Bill of Rights, including the Magna Carta, displayed at NARA on long-term loan

from David Rubenstein, as well as two encasements at the Library of Congress, two at the Smithsonian Institution, and a few others mentioned included in the timeline.

Buell Map at the Library of Congress: Considerations of Anoxia versus Hypoxia

The Buell Map encasement at the Library of Congress (LC) followed the success of the collaboration between LC's' Preservation Directorate and the National Institute for Standards and Technology (NIST) to design, fabricate, and install the large argon encasement for the Library's Waldseemüller 1507 World Map, the only surviving copy of the earliest known map that names the continent of America.

During scientific analysis of the Buell Map, Preservation Research and Testing Division scientists identified the presence of Prussian Blue, which is known to react differently than most pigments when exposed to light and oxygen. Unlike many light-sensitive pigments which show better color stability in oxygen-free environments, Prussian Blue has been shown to undergo long-term discoloration when exposed to light in a fully oxygen-free environment. For Prussian Blue, small amounts of oxygen can actually be beneficial to preserving its coloration. Based on this knowledge, it was decided that the encasement display environment for the Buell Map would not be fully anoxic, but rather would be set at a hypoxic condition of 5% oxygen in argon. This non-zero but still reduced level of oxygen would be sufficient to benefit the Prussian Blue while low enough to reduce photo-oxidative deterioration of other components of the map.

An additional challenge with the Buell Map encasement was that oxygen sensors used in previous display encasement projects were no longer commercially available at the time of designing the Buell Map encasement. To ensure long-term monitoring capabilities, a prototype of a new oxygen sensor needed to be built, calibrated, and tested. This sensor uses a coulometric oxygen sensor, requiring only simple drift diffusion to achieve an oxygen reading with no additional gas sampling, flow, or pumping from the encasement. The design and incorporation of this sensor required additional machining and rewiring electrical connections to properly integrate into the sealed fixtures. This sensor is currently in use for monitoring of the interior oxygen concentration of the case. Due to the custom nature of the case, replacement sensors do require some specialized knowledge for their attachment (primarily for soldering and connecting to the physical case structure, followed by their calibration) and cannot be treated as simply plug-and-play. Even though vendors are limited, these sensors do remain commercially available, which is a benefit as the planned encasement life is longer than the expected lifetime of the sensors.

The Buell Map encasement has active sensors to monitor oxygen concentration, temperature, humidity, differential pressure (between the sealed case volume and the ambient atmosphere), and barometric pressure. These sensors all actively communicate with LC's internal network, allowing for active monitoring of all sensor readings in real-time from remote browsers and machines.

A motion-activated lighting system was also used for the Buell Map, where light levels on the map were reduced when no motion was detected immediately nearby. While only tangential to the anoxic component, this dynamic lighting provided further preservation benefit by reducing light intensity when visitors were not actively looking at the exhibit.

Treasures at the Smithsonian: Meteorites and the Star Spangled Banner

The Smithsonian Institution has several cases where oxygen concentrations are reduced from atmospheric conditions. Following the success of the encasements at NARA and LC, NIST built custom anoxic encasements to display the Emancipation Proclamation and 13th Amendment at the National Museum of African American History and Culture. However, the Smithsonian had previously used nitrogen filled storage cases, built by NASA's Johnson Space Center to protect and preserve the unique chemical signature of meteorites that had never experienced an oxygen atmosphere. The Smithsonian also has a reduced oxygen room to display the iconic Star Spangled Banner for fire prevention reasons.

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