Evaluating the Lifecycle of Building Materials: **The Case for Green ADA-Compliant Signage**

Researched and written by
Daniel M. Tessier, PhD
Chem-Intel Consulting, LLC
Wilmington, DE 19899

for Green Dot Sign, Inc.
January, 2019

CONTENTS

EXECUTIVE SUMMARY

As part of their commitment to producing eco-friendly signage, the founders of Green Dot Sign sought an objective evaluation of their innovative approach. A third party environmental scientist, Daniel Tessier of Chem-Intel Consulting, LLC, was hired to evaluate the development and standard practices of the U.S. ADA-compliant signage industry, and assess signs' lifecycle and environmental impact. A comparison of signs made by Green Dot Sign to traditional ADA-compliant signs determined that green signage is better for the planet based on material inputs, manufacturing waste and long-term environmental impacts.

Since the Americans with Disabilities Act (ADA) was enacted, the U.S. signage industry has almost exclusively used plastic for ADA-compliant signs. Most plastic signs use acrylic, which is cost-effective and durable, but also comprised of fossil fuels and not bio-degradable. Even though clean acrylic is technically recyclable under stream 7 plastics, very few municipalities offer recycling. Additionally, acrylic signs are generally painted and have adhesive or vinyl, which makes them ineligible for recycling.

The quantity and impact of acrylic ADA-compliant signs quickly adds up. In U.S. commercial buildings alone, at least 243 million pounds of acrylic ADA-compliant signs are in use today. As existing buildings are renovated these signs will be tossed into a landfill for future generations to deal with.

Switching to eco-friendly ADA-compliant signage would keep 250 grams of plastic per sign out of the environment. While plastic is only part of our climate crisis, there is no denying that it is one of the root causes we must confront. An industry shift to responsibly sourced, bio-degradable signs could further green building objectives and contribute to a healthier planet.

ADA-COMPLIANT SIGNAGE

The Americans with Disabilities Act (ADA), signed into law in 1990 by President George H.W. Bush, guarantees equal opportunities to persons with disabilities. Under the ADA, persons with physical or cognitive impairments are protected from unfair limitations to their conduct of daily life.

A significant part of the ADA governs the physical environment in the public sphere, for example in accessibility to transportation, public spaces and commercial spaces. ADA-compliant signage is a requirement for all government, public accommodation and commercial buildings to provide basic information such as room numbers and the locations of exits, elevators and restrooms1. ADA-complaint signage features tactile lettering and pictograms as well as Braille, making it functional for blind persons or those with limited vision.

Given the increasing ubiquity of ADA-compliant signage, these elements of the built environment are ideal candidates for consideration in sustainable design, that is, architectural, interior design and construction decisions that minimize harmful effects on the environment and human health by using environmentally friendly materials and building practices.

TRADITIONAL VERSUS SUSTAINABLE SIGNAGE COMPARISON

ADA-compliant signs are manufactured as a subspecialty of sign-making enterprises, whether by large national companies or local small businesses. A variety of materials are used in ADA-compliant signage, based on considerations of durability, aesthetics and cost. The overwhelming majority of ADA-compliant signs are made of plastic, and while these are often the most cost-effective option, they entail production methods and life cycle characteristics that are not environmentally friendly. The manufacture of plastic sign components depends on toxic starting materials that are derived from fossil fuels, produced on an industrial scale, and that present occupational and environmental hazards in their production. Production of plastic signs involves significant waste and associated landfill inputs. At the end of their useful life, plastic signs become persistent waste in the environment, take up valuable landfill space and contribute to plastic and microplastic pollution that is harmful to wildlife and the environment.

Green Dot Sign introduces sustainably designed signage that dramatically reduces the environmental footprint of ADA-compliant signage. Their signs are based on renewable, sustainably sourced wood as the sign blank and a minimal input of environmentally friendly

additive manufacturing material to accomplish tactile lettering, pictograms and the Braille features of ADA-compliant signs. They are aesthetically pleasing, functional, and 99% biodegradable, thus reducing landfill and environmental impacts when their useful life has ended.

MATERIAL INPUTS

Plastic is a generic term for synthetic, polymeric material. Acrylic and modified acrylics are the types of plastic used to make most ADA-compliant signage. Acrylics feature high clarity, a smooth surface and scratch resistance. The chemical name of acrylic is polymethyl methacrylate (PMMA), formed by the polymerization of methylacrylate monomers. The monomer starting material for the chemical synthesis of PMMA is called methyl methacrylate (MMA). Global annual production of PMMA is close to 3 million metric tons, while close to 5 million metric tons of the MMA monomer is produced globally every year[2]. Acrylic is used in an incredible variety of products and applications, from display cases, windows, vehicle parts and paint additives to exterior and interior building signage.

The manufacture of MMA is based on fossil fuel inputs[3]. One of two chemical processes are commonly used to synthesize MMA. One involves the industrial scale reaction of acetone with hydrogen cyanide, followed by reaction of the resulting intermediate product with concentrated sulfuric acid. The other synthetic process is based on the reaction of ethane, carbon monoxide and methanol. A principal concern with acrylic based signage is therefore its provenance in toxic starting materials that 1) are derived from non-renewable fossil fuels and 2) depend on industrial processes that are inherently hazardous to workers and the environment.

Green Dot Sign ADA-compliant signs are made from sustainable, responsibly sourced wood. The use of recycled, site-significant wood is also an option. Once cut and milled to the appropriate size and shape, ADA-compliant lettering, pictograms and Braille components are additive manufactured with proprietary non-toxic materials[4]. Roughly 1% of the total weight of a Green Dot Sign ADA-compliant sign is the additive manufacturing material, so their signs are 99% renewable material.

PRODUCTION WASTE

Production of acrylic ADA-compliant signs generates significant waste. Acrylic-based signs are made from acrylic blanks cut from sourced panels that leave roughly 10% waste material from cutting the blanks to size. A polymeric, acrylic-based appliqué with the intended text and pictogram is adhered to the blanks and cut with a router, leaving up to 90% of the appliqué material as waste for text applications and up to 50% waste for pictograms. Therefore, the production of a typical 6” by 9” acrylic sign yields up to 100 grams of environmentally persistent waste material.

Green Dot Sign ADA-compliant signs are created by additive manufacturing of text, pictogram and Braille on wood blanks. The additive manufacturing process is highly efficient, with less than 0.02% material waste during the manufacturing process. Cutting wood blanks leaves sawdust and wood scrap as waste, both of which are biodegradable and compostable. It is also common for sawdust in production wood shops to be processed into wood pellets for heating purposes.

ENVIRONMENTAL PERSISTENCE

Like buildings themselves, ADA-compliant signs will have a useful life followed by a need for disposal, whether due to interior remodeling, building redesign, or demolition. The qualities of acrylic that make it a useful signage material also make it difficult to dispose of without environmental impacts that persist for generations.

Acrylic is essentially impervious to degradation by common environmental mechanisms – heat, water, sunlight and microbial degradation. Acrylic is also very difficult to recycle and is therefore not collected in recycling streams[5]. The available recycling process is cost-prohibitive and involves the use of lead – a highly toxic metal – to depolymerize acrylic. When deposited in landfills, acrylic signs add significant volume and due to their chemical, heat and oxidative stability they will persist for thousands of years[6]. Acrylic signs that are not properly land-filled will persist in the environment for generations. Even worse, exposure to environmental conditions can result in physical wearing that is a source of plastic particles (i.e., microplastics) that end up in waterways and eventually the ocean, negatively impacting sea life[7,8].

Green Dot Sign offers an environmentally friendly solution to disposal issues. Whereas an acrylic sign is permanent environmental waste, Green Dot Sign ADA-compliant signs can be naturally recycled in a matter of months, because wood is biodegradable and their wood-based signs can even be chipped for compost or mulch[9]. The non-toxic material used to create the lettering, pictograms and Braille represent only 1% or less of the sign weight and therefore substantially reduces the environmental impact of sign disposal.

QUANTIFIED IMPACT

In the U.S., the median commercial building size is 5,000 square feet (i.e. half of all U.S. commercial buildings are less than 5,000 and half are greater than 5,000 sq ft). The average commercial building size is 15,700 square feet as of 2012 (the last year for which data are available)[10]. Using a conservative value of 200 sq ft as an average room size[11] (office, reception area, restroom, break room, conference room, etc.), the median commercial building contains approximately 25 rooms and the average building approximately 75 rooms. Considering hall space, elevator and exit signage,

we calculate signage requirements of 50 to 100 signs on average, recognizing that larger buildings might require hundreds of ADA-compliant signs. Assuming a conservative sign weight of 250 grams and production of 75 signs, this means an average building uses close to 20 kg of acrylic-based material for ADA-compliant signage.

There are upwards of 6 million commercial buildings in the U.S., containing over 87 billion square feet of workspace. This figure does not include government buildings or schools, hospitals and other public buildings requiring ADA-compliant signage. Therefore, the national market for ADA-compliant signage is in the hundreds of millions of sign units. Using the conservative estimates of 200 sq ft per room and 250 grams per sign, this equates to nearly 110 million kg or 243 million pounds of acrylic signage in the U.S. alone. This amount does not even take into account the substantial number of non-commercial buildings that require ADA-compliant signage. Clearly, acrylic signage requires a significant use of fossil fuel inputs and toxic chemical starting materials and yields persistent plastic waste that negatively impacts our environment, forever.

CONCLUSION

Utilizing renewable materials and state-of-the-art additive manufacturing technology, signs made by Green Dot Sign offer distinct advantages to traditional, acrylic ADA-compliant signs. Environmental benefits of non-toxic material inputs, low material waste and biodegradability make Green Dot Signs an attractive, eco-friendly signage option in the ever expanding signage and green building market.

THE ENVIRONMENTAL BOTTOM LINE		
SIGNAGE ASPECT	**GREEN DOT SIGN**	**TRADITIONAL ACRYLIC SIGN**
Materials	Forest Stewardship Council (FSC) wood and a non-toxic additive material	Fossil fuels
Manufacturing Process	Individually milled wood blanks and additive manufacturing	Industrial processes and toxins can harm workers and the environment
Manufacturing Waste	Less than 0.02% non-biodegradable waste	25 to 90% non-biodegradable waste
End of Life Cycle	99% biodegradable by weight	100% non-degradable
Plastics	Each sign keeps 250 grams of plastic out of environment	Creates environmentally persistent plastics during production and disposal

REFERENCES

1. 2010 ADA Standards for Accessible Design. U.S. Department of Justice. September 15, 2010. https://www.ada.gov/2010ADAstandards_index.htm.
2. Uses of Polymethyl Methacrylate. http://www.essentialchemicalindustry.org/polymers/polymethyl.html
3. Polymethyl Methacrylate. https://www.britannica.com/science/polymethyl-methacrylate
4. What is Additive Manufacturing? http://additivemanufacturing.com/basics/
5. Azo Materials. How do you recycle acrylic resin? https://www.azom.com/article.aspx?ArticleID=7945
6. United Nations Environmental Program, 2018. Plastic planet: How tiny plastic particles are polluting our soil. https://www.unenvironment.org/news-and-stories/story/plastic-planet-how-tiny-plastic-particles-are-polluting-our-soil
7. A.L. Andrady, 2011. Microplastics in the Marine Environment. Marine Pollution Bulletin. (62)1596-1605.
8. J. Wang et al., 2016. The Behaviors of Microplastics in the Marine Environment. Marine Environmental Research. (113)7-17.
9. S. Bennett, 2014. Recycle Nation. https://recyclenation.com/2014/04/recycle-wood/
10. A Look at the U.S. Commercial Building Stock: Results from EIA's 2012 Commercial Buildings Energy Consumption Survey (CBECS). https://www.eia.gov/consumption/commercial/reports/2012/buildstock/
11. What Is the Average Square Footage of Office Space per Person? https://mehiganco.com/?p=684