

Rethinking ADA signage standards for low-vision accessibility

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Americans With Disabilities Act (ADA) and International Code Council (ICC) standards for accessible buildings and facilities affect design and construction of all new and renovated buildings throughout the United States, and form the basis for compliance with the ADA. While these standards may result in acceptable accessibility for people who are fully blind, they fall far short of what they could and should accomplish for those with low vision. In this article I critique the standards, detailing their lack of evidence base and other shortcomings. I suggest that simply making existing requirements stricter (e.g., by mandating larger letter size or higher contrasts) will not ensure visual accessibility and therefore cannot act as a valid basis for compliance with the law. I propose two remedies. First, requirements for visual characteristics of signs intended to improve access for those with low vision should be expressed not in terms of physical features, such as character height and contrast, but rather in terms of the distance at which a sign can be read by someone with nominally normal (20/20) visual acuity under expected lighting conditions for the installed environment. This would give sign designers greater choice in design parameters but place on them the burden of ensuring legibility. Second, mounting of directional signs, which are critical for effective and efficient wayfinding, should be required to be in consistent and approachable locations so that those with reduced acuity may view them at close distance.

Introduction

Architectural signage can be found nearly everywhere in the built environment. Signs display explicit wayfinding information through directional information; implicit wayfinding guidance through sequential numbering and zone markings; functional information about rooms and other places through labeling; and safety information (Arthur & Passini, 1992). In some environments, a lack of signage can make it nearly impossible for travelers to find their way, but an effective sign system can make it easy. Signs can be critical to efficient travel in environments such as large and complex transportation facilities, sparsely deco-

rated medical facilities, repetitive spaces such as office buildings, and places that we visit only infrequently. This article focuses on accessible visual signage for building interiors whose goal is to provide the kind of wayfinding assistance to those with low vision that visitors with typical vision almost invariably get. I make the case that the accepted accessibility standards that currently define compliance with major disability-rights legislation do not achieve that goal for those with low vision. At the end of the article, I outline two proposals that can help to remedy this.

It is obvious that signs composed solely of visual text and symbols are useful only to those with sufficient vision to read them, and that those with visual disabilities are at a clear disadvantage. The extent to which equivalent information is made available to people with visual impairment through alternate means or universal design enhances the accessibility of the space to them. The extent to which it is *not* provided presents a barrier to effective wayfinding. Such barriers can violate accessibility laws that guarantee the right of public access in the United States and elsewhere in the developed world. Although development of new technologies to provide equivalent information to people with visual impairment is vigorously pursued in the research community (Giudice & Legge, 2008; Legge et al., 2013; Walker & Lindsay, 2006; Wilson, Walker, Lindsay, Cambias, & Dellaert, 2007), nearly all of the efforts have been focused on providing access through purely nonvisual means; relatively little research has focused on enhancing visual access for those with low vision. Since advanced technologies to address low-vision access to buildings and other spaces are unlikely to be widely available in the foreseeable future, accessibility laws will continue to treat traditional architectural signage as the appropriate way to ensure wayfinding access for those who navigate and find their way visually, including those with low vision, for many decades to come.

Disability-rights laws such as the Americans With Disabilities Act of 1990 (ADA) state society's mandates only in general terms, whereas the specifics of how to remove barriers to usability and what constitute appropriate accommodations are expressed in formal

Citation: Ardit, A. (2017). Rethinking ADA signage standards for low-vision accessibility. *Journal of Vision*, 17(5):8, 1–20, doi: 10.1167/17.5.8.

doi: 10.1167/17.5.8

Received December 13, 2016; published May 16, 2017

ISSN 1534-7362 Copyright 2017 The Authors



published standards. There are two main accessibility-standards documents: the 2010 ADA Standards for Accessible Design (SFAD; United States [U.S.] Department of Justice, 2010), based on guidelines published by the U.S. Access Board and adopted by the Department of Justice for facilities subject to the ADA; and the ICC A117.1 Accessible and Usable Buildings and Facilities standard (ICC A117.1, 2009). The SFAD and A117.1 standards developed independently but share a great deal through some shared membership and compatible goals.¹

Because the laws and standards they support have such broad reach, decisions on the content of these standards have enormous impact not only on those with disabilities but also on the architectural, manufacturing, building, and graphic-design communities, who must comply with the laws (Calori & Vandendynden, 2015). The standards are living documents. They are revised, elaborated, and refined every few years in response to changes in technology, demographics, and legal challenge. Authored by committees of stakeholders (government agencies, manufacturers, building-code authors and enforcers, trade representatives, and advocacy groups for people with disabilities), the standards have an impact on nearly every building that accommodates the public.²

The goal of accessible signage in general is to remove barriers for all of those with vision loss, including those who are blind and those with impaired but functional vision. This article focuses on provisions in the standards that attempt to ensure access for people who have enough residual vision to navigate visually through the environment and to read text but who may not have sufficient visual acuity to access signs that are designed for people with typical vision. I restrict my focus to low vision because removing barriers to readability for that population generally entails specification of the visual properties of signs, whereas doing so for people who are blind requires the very different presentation of sign content through nonvisual (e.g., tactile or auditory) sensory channels.³

Why don't those with low vision just use braille or raised-letter signs for access to buildings and spaces? First, since low vision is most often acquired late in life, few people with low vision ever learn braille. Second, those with low vision do not generally relate to their surroundings by touch. With vision sufficient for basic ambulatory navigation, even those with significantly reduced visual acuity have little trouble locating large objects and architectural features. Their most natural, efficient, and preferred mode of acquiring information is through vision. Asking someone with moderate low vision to rely solely on braille or raised-letter signs is a bit like expecting someone who can use a support cane or walker to use a wheelchair instead.

There are approximately 325,000 people with visual acuity of bare light perception or less in the United States (based on statistics from Leonard, 2002, and extrapolating to the current size of the U.S. population), but about 6.5 million people with low vision (based on 2010 data cited in National Eye Institute, n.d., and extrapolating to the current size of the U.S. population), so low-vision accessibility is clearly an important priority. This is especially so given a recent clarification in the breadth of the definition of “disability” in the ADA issued by the U.S. Department of Justice (2016). Despite the very different needs of those who have low vision from those who are blind—and for complicated reasons—there are few organizations advocating for the unique needs of the low-vision population (Arditi, 2009). Consequently, there is little informed representation of the specific interests and needs of those with low vision on the standards committees.

This article takes the position that the approach to visual accessibility embodied in the current standards is lacking due to its reliance on specifying physical features and parameters of signs rather than on aspects of design that affect how it functions for those with impaired vision. As I show later, the extent to which some signs—those identifying permanent rooms or spaces—are accessible to those with low vision, is due to their mandated mounting in consistent locations so that people who are fully blind can locate them by touch. The requirements that address low vision, however, are inconsistent and lack rationale and empirical support. Moreover, they fail to ensure accessibility, as standards should, since sign illumination, contrast, and finish are incompletely or poorly specified. For signs that are critical for wayfinding, such as directional signs, the requirements either fail to enhance low-vision accessibility at all or do so only insignificantly.

In this article, I critique the accessibility requirements provided in the SFAD and A117.1 standards (hereafter, the standards) with respect to visual signage. I then offer two proposals to rectify the shortcomings identified. Proposal 1 states that accessibility requirements relating to visual characteristics of signs should be expressed in terms of the visual-function limitations of the population with low vision—generally visual-acuity loss—rather than on traditional measurement units of sign features such as linear character size expressed in inches or centimeters. Proposal 2 suggests the addition of requirements that make mandatory the mounting of directional signage in predictable and closely approachable locations. Accompanying each proposal is an example requirement to illustrate how it might be implemented and worded within a standards document.

| Parameter | Raised visual | Visual only |
|---|---|--|
| Font style | Sans serif, all uppercase | Serif or sans serif; upper-, lower-, or mixed case |
| Character height (as determined by height of upper case <i>l</i>) | Between 5/8 in. and 2 in. | 5/8 in. to 3 in. based on height from floor and viewing distance. For characters with baselines 40–70 in. from floor and horizontal access of 72 in. or less, 5/8 in. minimum; for horizontal access greater than 72 in., 1/8 in. of height added for each 12 in. of horizontal access |
| Character stroke thickness | 10%–15% of <i>l</i> -height | 10%–30% of <i>l</i> -height |
| Width-to-height ratio (width of uppercase <i>O</i> ; height of uppercase <i>l</i>) | 55%–110% | 55%–110% |
| Character spacing | Minimum 1/8 in., maximum 4 times stroke width | 10% of stroke width to 35% of character height |
| Line spacing (baseline to baseline) | 135%–170% of <i>l</i> -height | 135%–170% of <i>l</i> -height |
| Finish | “Non-glare” | “Non-glare” |
| Contrast | “Light characters on a dark background, or dark characters on a light background” | “Light characters on a dark background, or dark characters on a light background” |
| Mounting location | On wall adjacent to door on latch side, with character baseline 48–60 in. above floor | Character baseline minimum 40 in. above floor; otherwise, no mandated location |

Table 1. Basic requirements for visual signs under the Standards for Accessible Design.

This article does not address many important accessible signage issues, including nonvisual access by people who are fully blind (which is of obvious importance to that group) and signage in important domains outside the scope of the standards, such as exterior spaces. It addresses only interior signage of three specific types within the standards: directional and informational signs that help point the way to building locations, identification signs for permanent rooms and spaces (known as designation signs), and means-of-egress signs. Variable-message signs (whose requirements appear in the A117.1 standard but not the SFAD) are not discussed, nor are pictograms in signs, though it should be easy for the reader to see how both of these can be addressed by extension.

Current state of the standards

Nearly all of the requirements and recommendations in the standards that relate to signage are expressed in simple physical terms, so that compliance can be assessed with observation or with straightforward measuring devices like rulers or tape measures. While having the virtue of ease of measurement, the requirements fail to take into account even fundamental visual-function concepts such as visual angle and visual size, much less the roles of crucial variables such as illumination and contrast in visibility and legibility. This section gives an overview of the most relevant sign

types that fall within the scope of the standards and identifies what is missing or inconsistent. It concludes that simply adding more detail to the requirements to address contrast, illumination, finish, sign typography, and other variables is unlikely to be effective in ensuring accessibility, due to the interdependence of all of those variables in creating legible signage.

Display types

The current standards imply the use of two distinct types of accessible visual-sign display. Raised-visual (RV) signs have lettering (or pictograms) that is raised so it is decipherable by touch and printed in a color distinct from its background, providing visual as well as tangible contrast. Visual-only (VO) signs are printed with visual contrast only, and the letters may be flat (i.e., without relief) against the surface of the sign. Both RV and VO signs are used in accessible signage, subject to restrictions based on the sign’s functional type (discussed in the next section).

Table 1 summarizes the requirements of each type in mounting, typography, contrast, and finish. A more comprehensive summary of all signage requirements in the SFAD is given by the Society for Environmental Graphic Design (2012). The SFAD and A117.1 documents are, of course, the most authoritative and detailed, but they are also the most difficult for readers to navigate.



Figure 1. Examples of a designation sign (left) and a directional and informational sign (right).

Functional types

Signs are also explicitly distinguished by function. Three types are addressed here: (a) Designation signs, also called *identification signs*, serve to label or convey identifying information about permanent rooms or spaces. These signs, usually located just outside the entrance to a room or space, may contain information about the function of the space being identified (e.g., “Conference Room,” “Restroom”) or sequential location information that may be useful in wayfinding (e.g., “Room 4567”). (b) Means-of-egress signs mark places or passages of egress (typically a horizontal route component that leads to a safe exit from a building), exits, or areas of refuge. (c) Directional and informational signs convey directions to locations within a building interior or other information about interior spaces. Examples of designation and directional signs are shown in Figure 1. Both types can be critically important in wayfinding, with designation signs informing a traveler of the current location and directional signs indicating direction to navigate toward a destination. Designation and means-of-egress signs have the same requirements and are therefore discussed together in the next section.

Typographic requirements for designation and means-of-egress signs

Designation and means-of-egress signs are required to present their information both with raised letters and braille *and* visually. At the designer’s option, this can be accomplished with RV signs, which combine visual and tangible contrast in the same characters, or VO signs, but the latter require separate raised letters and braille containing the same information. The texts in RV signs (see Table 1) are more restrictive in their parameter values (including font, character proportion, spacing, and stroke thickness) than those in VO signs, to meet the joint legibility requirements of characters that can be read by touch (Loomis, 1981) and by sight. The

option of using either RV or VO plus separate braille and raised letters allows designers to trade off size against style, since RV signs are more compact but VO signs allow greater typographic-design flexibility.⁴

Since designers may opt for using RV or VO signs (with separate braille and raised characters), it is reasonable to ask whether those signs are equally legible. As can be seen in Table 1, for some features—such as character width-to-height ratio, line spacing, finish, and contrast—parameter values are the same for VO and RV signs. For other features that have different requirements for the two sign types—such as the choice in font style of serif versus sans serif (VO) or sans serif only (RV)—the difference between VO and RV is unlikely to have a significant impact on sign legibility (Arditi & Cho, 2005; Moriarty & Scheiner, 1984; Russell-Minda et al., 2007).

But some differences in feature requirements between VO and RV signs do make likely differences in legibility (and thus accessibility). For example, character stroke thickness is required to be 10%–15% of character height for RV signs but may be between a minimum 10% and maximum 30% of character height for VO signs. Since thicker character strokes are generally more legible (Arditi, Cagenello, & Jacobs, 1995), the visual accessibility and maximum reading distance of these signs may depend on whether they are set in fonts allowable for the RV or VO type. Interletter spacing, another variable widely acknowledged to have an impact on text legibility (Arditi et al., 1995; Bouma, 1970; Chung, 2002; Liu & Arditi, 2001), also has different rules depending on whether signs are of the RV or VO type. RV signs require spacing ranging from a minimum of 1/8 in. to 4 times the stroke-width maximum, whereas characters on VO signs must have spacing ranging from 10% to 35% of the character height.

Perhaps the most striking example of a difference in legibility between RV and VO signs arises from requirements pertaining to letter case. Only uppercase characters are permitted on RV signs, whereas lowercase and mixed case are allowed on VO signs, with character size determined only by the height of the uppercase *I*, despite the fact that x-height is a better predictor of legibility for lower- and mixed-case text (Legge & Bigelow, 2011). If signs were always composed solely of uppercase characters, the height of the *I* might be a good proxy for character size. But for signs that use lowercase letters, expressing the letter-height requirement only in terms of the uppercase *I* inflates how legible sign text is likely to be. Uppercase characters are known to be more legible to those with low vision (Arditi & Cho, 2007, although some research indicates that mixed- and lowercase text is preferred and more comfortable to read for continuous reading). Figure 2 shows a comparison of lowercase lettering,

conference room

(a)

CONFERENCE

(b)

Figure 2. (a) Minimally compliant (when printed so that x-height is 0.4 in.) visual-only sign set in a sans serif font (Gill Sans). (b) Minimally compliant raised visual sign set in the same font, for comparison. Obviously (b) will be readable at greater distance or with significantly less magnification than (a).

allowed in VO signs, and all-uppercase lettering, mandated in RV signs, for one simple sign using Gill Sans, an allowable font for both VO and RV signage. It is easy to see that the text in Figure 2a is far less visually accessible than that in Figure 2b. The character size is so much larger with uppercase—about 48% larger—that only the first word fits in the space that fits two words in lowercase. Practically, this means that for Figure 2a a traveler will need to be closer by half the distance they would require to read the text in Figure 2b.

With designation signs, travelers with low vision can easily move quite close, making differences in typography less important since close viewing can compensate somewhat for smaller effective character sizes. This boost in visual accessibility has little to do with required character sizes, font styles, and parameters. Rather, it is an incidental benefit of mandated mounting in consistent locations (so users who are blind can find them by touch) near doors, which by definition need to be approachable. Nevertheless, the all-uppercase lettering that is mandatory on RV signs and optional on VO signs can accommodate those with substantially worse visual acuity than can mixed- or lowercase lettering. Indeed, the designer's option of VO (with separate braille and raised lettering) or RV signs itself leads to inconsistency in the degree of visual-acuity loss that is addressed by the standard.

The requirements for visual designation and means-of-egress signs, then, provide an inconsistent degree of access due to specification of character size by a single uppercase letter. In addition, effectiveness of signage for those with low vision depends in part on the designer's choice of whether to present combined or

separate visual and tactile lettering within each wayfinding message.

Typographic requirements for directional and informational signs

The category of directional and informational signs encompasses many different kinds of signs, including those displaying rules of conduct (e.g., “No smoking,” “Maximum occupancy 300,”), warnings (e.g., “Caution: Open door slowly”), and, most commonly, directions to other locations within a building or facility. Given the diversity of information expressed on such signs, it is not clear why the standards combine them into a single category. Our main concern is with directional signs, since these have special and often critical value in wayfinding, possibly even more than that provided by designation signs. Designation signs can inform a traveler only of his or her current location, but directional signs point the way to potential destinations, mostly at decision points for direction of travel (e.g., straight ahead, left turn).

The current standards do not impose additional requirements for directional and informational signs beyond those of any VO sign (shown in the rightmost column of Table 1), nor do they require an accompanying tactile display. Since the requirements for these signs are identical to those of VO designation signs for signs approachable to less than 7 feet, one might conclude that both categories of sign are equally accessible to users with low vision. But VO designation signs, due to their function of identifying spaces beyond doors and the requirement of braille and raised letters on the wall adjacent to a door, are virtually guaranteed

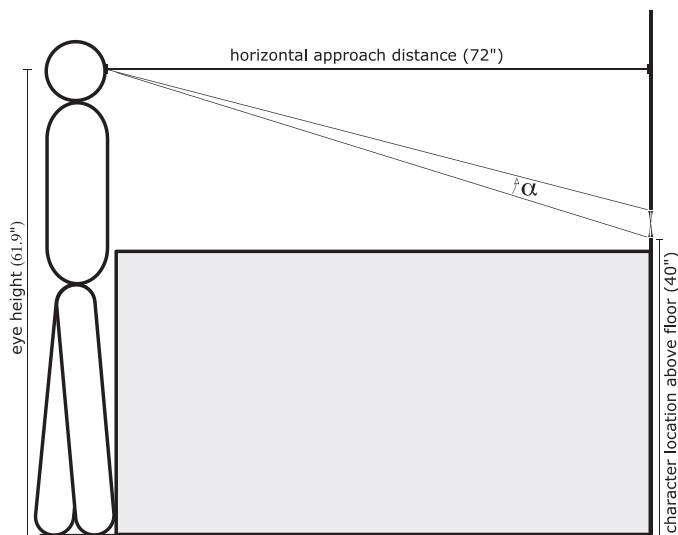


Figure 3. A traveler with average eye height viewing a sign whose characters are 40 in. from the finished floor, where an obstruction restricts horizontal approach to the sign. In this situation, character height must meet minimums in linear size as shown in Table 2, but not in visual angle (α).

to be closely approachable—a huge benefit to those who may need close-up viewing or use near-vision magnification aids—while directional signs are not.

In fact, because directional and informational signs are not required to be in fixed and consistent locations nor mounted where they can be approached closely, they are often *not* visually accessible to those with low vision. For one thing, the 5/8-in. minimum letter height is no larger than the minimum for designation signs, even though directional signs are usually designed for and typically viewed from greater distances. It is especially at these greater distances that low-vision accessibility is compromised or inconsistent.

Compounding this is the fact that the standards define “viewing distance” as “horizontal distance

between the character and an obstruction preventing further approach toward the sign,” rather than the sign-to-eye distance, which in turn affects the character’s visual size (see Figure 3).

The first two columns of Table 2 show the minimum character heights required by the standards for VO signs (which includes virtually all directional and informational signs). These minimums depend on both the vertical distance of the characters above the finished floor (shown in the first column) and the “viewing distance” (i.e., uninterrupted horizontal access—how close a traveler may approach without being restricted by an architectural element such as a counter, a fountain, or other obstructing element; shown in the second column). So, for example, on VO signs having character baselines 40–70 in. above the floor, characters may be 5/8 in. high for horizontal access restrictions less than 7 feet (at which distance character height must be increased to 6/8 in.). A sign approachable only to just under 7 feet, then—say 83.9 in.—may be compliant with uppercase letters that are 5/8 in. high and have lowercase letters that are substantially smaller in x-height.

The third and fourth columns of Table 2 illustrate by example the minimum effective letter x-heights allowed by these requirements, in units of visual angle (third column) and approximate Snellen acuity required for comfortable reading (fourth column). The example uses a font with a relatively small but clearly permissible x-height (the same one used in Figure 4). At the approach distance of 83.9 in., the lowercase letters in the example can be just 0.24° in visual angle, assuming an average eye height of 61.9 in. (Gordon et al., 1989) and a character baseline 40 in. above the floor. This is just barely larger than the size that a person with typical vision would require for fluent reading of high-contrast printed text, the kind one might find in a printed book or document. Text of this size can be comfortably read

| Height of characters above floor (in.) | Minimum character height (<i>l</i> -height) | Minimum compliant angular x-height (°) | Approximate Snellen acuity required for comfortable reading |
|--|--|---|---|
| 40–70 | 5/8 in. for horizontal access restricted to 6 ft; additional 1/8 in. for each 1 ft of horizontal restriction | 0.24 | 20/37 |
| 70–120 | 2 in. for horizontal access restricted to 15 ft; additional 1/8 in. for each 1 ft of horizontal restriction | 0.50 | 20/76 |
| Above 120 | 3 in. for horizontal access restricted to 21 ft; additional 1/8 in. for each 1 ft of horizontal restriction | 0.39 for 120-in. height, less for greater mounting heights; no maximum specified in standards | 20/59 |

Table 2. Minimum character height (*l*-height) for directional and informational visual signs mounted at different heights. The third column of the table shows minimum character x-height in angular units for the given range, assuming x-height of 57% of *l*-height and horizontal access restriction of 11.9 in. (i.e., just under 1 ft) longer than the value given in the standard. The last column shows the approximate Snellen acuity required to read the sign, assuming that the letters have the x-height of the font used in Figure 4 and the sign is viewed at maximum horizontal access restriction.



Figure 4. A compliant visual-only designation sign under the standards at actual size (when printed so that the x-height is 0.35 in.). The text is set in Cochin (Linotype AG) at 68.4 points. The x-height in this font is 57% of the *l*-height and 37% of the nominal point size.

by someone with just 20/37 Snellen acuity—such a modest departure from 20/20 that drivers with that level of acuity would in most states be able to drive without corrective lenses. In the absence of close approach to a sign, then, the character sizes required in VO signs do very little to enhance accessibility even for those with the mildest of visual-acuity impairment. The degree of visual-acuity loss that is accommodated by the most common sign-mounting height (first row of Table 2) fails even to meet the “worse than 20/70” minimum criterion for low vision defined by the World Health Organization (n.d.). The third and fourth columns of Table 2 also show that in terms of visual function, the current requirements result in inconsistent visual sizes of letters, with the characters on the middle range of sign-mounting heights (70–120 in. above the floor) providing the visually largest letters—for no apparent reason.

Another serious but rarely addressed problem with respect to accessibility is that those with moderate to severe low vision may have difficulty locating directional signs to begin with, and thus do not necessarily know which direction to walk to approach the sign to view it better (Dalke et al., 2010). Highway signage has for many years considered the issue of sign “conspicuity” (Garvey & Kuhn, 2004), which is an essential element in the effectiveness of highway signs. The standards, however, do not even address the issue of how those with low vision can detect the presence of directional signs.

Other visual-sign requirements

While character size is a major determinant of legibility and visual accessibility to those with low vision, there are obviously other important variables, most of which modify and are interdependent with character size. It is basic to modern vision science that variables including contrast and illumination can drastically alter the character sizes required to read text. In the following, I address these most important variables and the treatment of sign finish, all of which are either inadequately or not at all addressed in the standards.

Contrast

A major difficulty in developing valid accessibility requirements for visual signs centers around the issue of sign contrast. Older people and those with low vision are well known to have serious deficits in perception of low contrasts—that is, objects and patterns with little variation in lightness (Faye, 1976; Owsley, Sekuler, & Siemsen, 1983). Having effective contrast in text—a sufficient ratio of luminance of letters relative to luminance of their backgrounds *and* to the reader’s contrast sensitivity—is necessary for effective reading of any text, including that on signs. Contrast sensitivity measurement (Arditi, 2005; Regan & Neima, 1983; Scheiman, Scheiman, & Whittaker, 2007) has been a mainstay of low-vision assessment and rehabilitation. Reduced ability to see low contrasts is often the presenting complaint in clinical low vision, and in many cases providing enhanced contrast through a video magnifier or computer-displayed imagery helps to ameliorate the effects of reduced contrast sensitivity.

In the signage and accessibility-standards communities, contrast (*C*) is commonly expressed as a number ranging from 0 to 100, representing light-reflectance values (LRVs),⁵ such that

$$C = 100 \times \frac{\text{LRV}_{\max} - \text{LRV}_{\min}}{\text{LRV}_{\max}}, \quad (1)$$

where LRV_{\max} and LRV_{\min} are the maximum and minimum light-reflectance values of the sign surface and it is assumed that there are only two such values (i.e., LRV of the letters and LRV of the background). Light reflectance is the proportion of light that is reflected from the sign surfaces, and can be inferred from luminance measurements made with a photometer, if the sign is illuminated by an accepted “white” light source. Vision scientists will recognize *C* as closely related to the Weber definition of contrast used in clinical letter contrast sensitivity tests such as the Mars Letter Contrast Sensitivity Test (Arditi, 2005). In such tests, the lowest contrast at which a person can correctly identify letters is taken as a measure of sensitivity to contrast.

There are other definitions of contrast that have been used in accessibility standards. One, also familiar to most vision scientists and used in a Canadian standard (Canadian Standards Association, 2015), is closely



Figure 5. The text in this sign is compliant with the standards, since there is a measurable difference in lightness between characters and background.

related to the Michelson definition of luminance contrast:

$$C = 100 \times \frac{L_{\max} - L_{\min}}{L_{\max} + L_{\min}}, \quad (2)$$

where L_{\max} and L_{\min} are maximum and minimum luminances. Another definition, used in ISO 21542 (2011) and used in a British standard (UK Government, 2015), is simply the difference between maximum and minimum LRVs:

$$C = \text{LRV}_{\max} - \text{LRV}_{\min}. \quad (3)$$

An Australian signage standard (Standards Australia, 2009) adopts yet another definition of contrast:

$$C = 125 \times \frac{Y_{\max} - Y_{\min}}{25 + Y_{\max} + Y_{\min}}, \quad (4)$$

where Y is luminous reflectance. This formula is dimensionally incorrect, as is the procedure for measuring reflectance specified in that standard. The definition is presented here because it has been adopted as a national standard, and because it has been suggested in committee discussion for potential adoption in the United States.

A detailed discussion of the pros and cons of these definitions for accessibility standards is beyond the scope of this article. But the variety of different definitions in use shows that there is little international consensus even on how contrast should be calculated, much less how it should be measured in the context of signage. More importantly, specification of sign contrast without specification of the amount of light that is incident on the sign does virtually nothing to ensure the sign's visibility or legibility. A sign with maximum contrast, irrespective of which definition is used, will be unreadable under conditions of sufficiently dim illumination.

It is important to note that virtually all of the research on contrast sensitivity and its clinical measurement uses displays or illumination that have controlled, consistent lighting, so that either the average luminance or the background luminance is kept constant. This is to isolate the effects of contrast from the strong effects of luminance on contrast sensitivity. In short, the visibility and legibility of any

reflective display (such as an ordinary painted sign) are highly dependent on its illumination.

Because of the significant problems in defining and measuring contrast, the (U.S.) standards have adopted very weak requirements regarding contrast, simply specifying either light characters on a dark background or dark characters on a light background. Thus the sign in Figure 5 is entirely compliant. The standards obviously require nothing more than that the characters should not be completely invisible, because relative to the lighter sign background, the letters are dark. That is neither a high bar nor a standard that ensures accessibility (even for those with good vision).

The choices of character and background lightnesses made in Figure 5 are ones that one would hope few designers would make, even for people with typical vision, due to the sign's low contrast (though even lower contrasts would still comply under the current standards). But again, if the purpose of the standard is to ensure a degree of accessibility for those with low vision by prohibiting specific practices, the current standards clearly fail, for they do not rule out signs that have are clearly inaccessible to anyone with a visual-contrast deficit.

Would a mandated minimum contrast value help ensure legibility of sign text? Unfortunately it would not. Many signs have letters that are printed against nonuniform, patterned, wood-grained, or textured surfaces. In addition, some sign surfaces have LRVs that differ depending on the angle at which they are viewed. Both of these variants make contrast difficult to define and measure. Accurate LRV measurement even of uniform features such as thin text letter strokes can be challenging without specialized equipment, so under the best of circumstances, compliance with any contrast standard can be difficult or expensive to determine.

Mandatory minimum sign contrast also fails to ensure any degree of legibility because, as already noted, the effectiveness of any contrast of light against dark depends critically on the illumination of the visual pattern. A sign barely visible and likely unreadable in near darkness may have contrast identical to a very readable one that is mounted in a well-lit room, so specifying contrast without also prescribing sign illumination that will ensure sufficient visibility does

nothing to ensure any level of visual accessibility to those with low vision. For that reason, the standards simply cannot prescribe meaningful minimum contrasts for sign lettering without also specifying illumination.

Over many years, both committees that write the standards have struggled with whether or not there should be a visual-contrast requirement for sign text (as well as other visual architectural elements). The issue is difficult to decide in part because while several sources recommend a 70% minimum contrast value (Architectural and Transportation Barriers Compliance Board, 1991; Low Vision Design Committee, 2015; RTiG Inform, 2012; e.g., Zimring, Bostrom, & Wineman, 1985), none of them does so with any sound theoretical basis or well-grounded empirical research. Intuitively, it would seem that a requirement more specific than “light on dark or dark on light” would promote better sign accessibility, but sources that argue for a specific value are sorely lacking in evidence base, while at least one empirical study (Lomperski, 1997) has found that the 70% minimum value now recommended (but not required) in the standards is substantially higher than what is appropriate.

What is the origin of the recommended 70% contrast value, which is currently being considered as a new requirement for the 2018 edition of the A117.1 standard? Appendices to both the 1991 Americans With Disabilities Act Accessibility Guidelines and the 1992 A117.1 standard (American National Standards Institute & Council of American Building Officials, 1992) simply state that “research indicates that signs are more legible for persons with low vision when characters contrast with their background by a minimum of 70 percent,” but neither document provides citations to research or even theoretical support for that particular value. Earlier documents from which these were derived, including the Uniform Federal Accessibility Standards (Architectural and Transportation Barriers Compliance Board, 1984) and the Minimum Guidelines and Requirements for Accessible Design (Architectural and Transportation Barriers Compliance Board, 1982) similarly no mention of a specific minimum contrast value.

However, in the mid-1980s the U.S. Access Board clearly saw a need to have a research-evidence base to validate the Minimum Guidelines and Requirements for Accessible Design and the Uniform Federal Accessibility Standards it was charged with authoring. To that end it supported a large project including workshops and empirical research on signage conducted through a Department of Education contract with the College of Architecture at the Georgia Institute of Technology. The final report of that project (Zimring et al., 1985), citing a preliminary report by Arthur (1984), stated that a “minimum contrast of about 70% is necessary for good legibility.” Arthur’s

report is apparently unavailable, but in a later work (Arthur & Passini, 1992, p. 179) he again makes the same recommendation, citing a 1970 interim project report (Arthur, 1970) which had recommended a minimum sign contrast of 75%. Arthur, who was enormously influential in the emerging discipline of environmental graphic design (and is even credited with coining the term “signage”), was a participant in the Georgia Tech signage workshop and apparently supplied the 70% figure as a trusted authority, but he provided no evidence or rationale for that particular choice—at least none that was incorporated into the results of the workshop that were disseminated or into other available publications. While other authors have referenced the Georgia Tech study as if it provided empirical evidence in support of the 70% value, it appears that all cases have their origin in an ipse dixit on the authority of Arthur that cannot be traced to actual data or even specific rationale.

Arthur’s reports, incidentally, propose that in the computation of contrast, LRVs be taken from paint manufacturers’ specifications, which is not relevant for current interior-sign manufacturing processes that do not use paint and do not report LRVs. LRVs can be inferred from conjoint photometric measurements of luminance and illuminance, but this is only useful when background and foreground surface colors are uniform. Such measurements may also pose new problems in choosing appropriate measurement standards and protocols and measurement instruments, whose accuracy vary substantially with cost. As alluded to before, defining and accurately measuring sign contrast poses substantial theoretical and practical challenges.

Note also that the 70% contrast minimum proposed now as a requirement for the 2018 standard required the ad hoc addition of a minimum LRV (45 was proposed) for the lighter of the foreground and background. If a minimum for the lighter color were not included, then very dark colors, say with LRVs of 4% and 1%, would meet the standard [$100 \times (4 - 1)/4 = 75\%$] despite being of very low *effective* contrast. As with the contrast minimum, there is neither a specific rationale nor empirical support for the proposed minimum value of 45 for the LRV of the lighter color.

Finish

The standards state that the surfaces from signs must be “non-glare.” Most perceptual scientists resist such usage of this term, since they do not view glare as a physical attribute of a material. Rather, it refers to a broad class of perceptual phenomena. We may experience dazzling glare when we exit a darkened theater and enter bright sunlight, or discomfort glare from viewing headlights of oncoming vehicles. We may experience what is known as disability glare from the scatter of

light by the gradual opacification of our crystalline lenses as we age, which eventually becomes cataracts. Glare may even be reported, especially by those with certain types of low vision, in viewing a brightly lit surface such as a sun-illuminated sign with a white background (Faye, 1976; Rosenberg, 1984) or one with a high-gloss finish. All of these different phenomena, which may have a variety of different physiological causes, are sometimes described as glare, but there is no type of surface that is accepted as “non-glare.”

What the standards most likely intend to limit is the use of glossy sign surface finishes, from which light rays may be reflected directionally (as, in the extreme, a mirror does) rather than diffusely (as does a matte surface). High gloss can add spurious imagery from reflections to the sign and obscure its message. While matte surfaces are often recommended for materials printed for those with low vision (Arditi, 1999; Jose, 1983), there are few empirical studies to support those recommendations beyond anecdotal reports. Even prescription of absorptive lenses, the mainstay intervention for ameliorating glare in those with low vision, relies primarily on anecdotal evidence (Eperjesi, Fowler, & Evans, 2002). While recommendations regarding matte finishes for sign surfaces may be useful, they should not be expressed as requirements absent specific and quantitative criteria for what constitutes too much gloss; and those criteria, if expressed, should of course also be empirically based.

Illumination

A critical determinant of visual accessibility is illumination. Obviously, without sufficient light no objects in the environment, including signs, are visible to anyone. It is well documented that older people and most people with low vision require stronger illumination to function visually than do younger people and those without visual impairment (Commission Internationale de l’Eclairage, 1997, 2011). Yet illumination is virtually unmentioned in the standards, except with respect to the illumination within elevators and interior stairways. It is also true that ambient and direct illumination, which obviously determine luminance of sign elements (at least in the case of nonemissive signs), affect the impact on legibility of contrast (Brown, Zadnik, Bailey, & Colenbrander, 1984; Van Nes & Bouman, 1967), letter size (Sagawa, Ujike, & Sasaki, 2003; Sheedy, Bailey, & Raasch, 1984), and many other variables. In general, increasing illumination increases contrast sensitivity (within limits) and reduces the degree of sign contrast required to read a sign; it also increases visual acuity and reduces the letter size required for effective sign reading. These are large effects. Illumination has a profound impact on legibility, not only through its effects on contrast sensitivity and

visual acuity but also indirectly on other important signage variables—including stroke width, letter spacing, and font—since these also affect reading acuity (Arditi et al., 1995; Mansfield, Legge, & Bane, 1996). Given the variability in (a) illumination over the course of a day in windowed environments (along with weather-related variation and seasonal variations over the year, and usually in combination with artificial lighting), (b) design choices for illumination in windowless spaces (e.g., auditoriums, hotel hallways), and (c) incentives and economic pressures to save electrical energy, it seems clear that a one-size-fits-all approach to sign variables that simply specifies contrast, letter size, and a few other typographic values is unlikely to succeed in providing a uniform approach to visual accessibility.

Summary of the state of current signage standards

There are significant challenges in ensuring a consistent, effective standard for removing barriers for those with low vision in accessing signs. Where signs are required to be mounted so that they can be approached to arbitrarily close distances—that is, designation and means-of-egress signs—access for those with low vision is surely better than it would be were the signs not so required. For these signs, low-vision accessibility would appear to come as an incidental benefit from the fact that such signs mark doors that almost by definition must allow close approach. But even with low-vision travelers’ enjoyment of that benefit, the standards fail to ensure visual accessibility due to serious inconsistencies, ambiguities and omissions:

1. The designer’s option to employ RV or VO signs for designation and means-of-egress signage can result in legibility differences between these types for users with visual impairment that may translate to significant differences in distances at which these signs can be read. Since the goal of accessibility standards is to inform and ultimately regulate how facilities may be designed to remove usability barriers for users with disabilities, these differences result in an inconsistent degree of accessibility that depends on the designer’s choice—which may have more to do with aesthetics or cost than in designing with visual accessibility in mind.
2. The standards for directional signage (which fall under the category of directional and informational signs) do almost nothing to ensure the availability of essential wayfinding guidance to those who have low vision (nor, incidentally, to

those who are blind). This is primarily because mounting location is virtually unrestricted, making it difficult for users with visual impairment to find these signs and then approach them in order to read them.

3. Lack of consistency in the levels of visual impairment addressed by the standards suggests that many requirements are guided not by consideration of visual function at all, but by physical or architectural considerations. Minimum letter sizes for visual signs that have viewing-distance restrictions are readable by users with only minor visual-acuity loss that fails even to meet the criterion for low vision.
4. The requirement specified in the standards for contrast is so vague as to be virtually meaningless (“light on dark or dark on light”). But the currently proposed A117.1 standard’s requirement for contrast is *too* specific (70% with minimum LRV of 45 for the lighter of foreground or background), since there is no credible evidence base supporting its numerical values and since so many other sign variables interact with contrast, including letter size, letter stroke width, letter spacing, illumination, and foreground and background texture and pattern.
5. Requirements specified in the standards for sign finish (though termed “non-glare”) are similarly without empirical support.
6. Light levels (illumination and luminance) are not specified anywhere in the SFAD except for elevator interiors—and in the A117.1 standard for interior stairways as well—as if these were the only environments in which insufficient light levels could pose a barrier to visual access.

These deficiencies cannot be addressed by simple augmentations of the current standards (such as the proposal to adopt a 70% contrast requirement), by increasing required character sizes, or even by specifying an illumination requirement for signs. There are too many variables that contribute to and interact to determine the legibility of a sign, to ensure accessibility for any specified degree of visual-acuity loss. The problem calls for a different kind of solution, one that uses human observers to evaluate sign legibility. Proposal 1 in the next section offers such a solution.

Addressing inadequacies in accessible visual-signage standards

Given the shortcomings already described, this article proposes two changes to the standards, intended to remove barriers to readability for people with low

vision. Proposal 1 recommends that the standards requirements that are meant to address visual accessibility of text and pictorial symbols be articulated using a criterion based on the human functional measure of visual acuity rather than on multiple physical criteria such as letter size, typographic parameters, gloss, and contrast, as is currently done. Proposal 2 specifically addresses the deficiencies of directional and informational signs by suggesting a mandate of consistent and approachable mounting locations. The signs at these approachable mounting locations will, as visual signs, be required to comply with requirements stemming from Proposal 1 as well.

Neither proposal is written in the kind of language that standards require; my hope is that standards committees adopt their intent, but formulate appropriate language consistent with the form of their respective document.

Proposal 1

Signage requirements for visual characteristics of signs that are intended to eliminate barriers to visual readability for persons with low vision should be expressed in terms of the distance at which a person with nominally typical visual acuity (20/20) can read the sign under expected illumination conditions for the installed environment.

This proposal would replace all specifications of letter size, stroke width, contrast, sign finish, and so on with a single criterion for legibility based on human visual function—the convenient, relevant, and familiar visual function of visual acuity, usually expressed as a Snellen fraction. Snellen acuity does not characterize performance for all visual tasks, of course, but overall ability to see and decode visual patterns is highly correlated with it. It serves as a good summary measure of visual capability, and it has a long history of acceptance in other domains (e.g., occupational testing, driver’s licenses, definitions of visual disability), serving as a proxy for visual-function tasks involving spatial resolution. It predicts legible type size (Mansfield, Ahn, Legge, & Luebker, 1993), the predominant variable affecting legibility for the most common forms of low vision (i.e., those affecting the macular region of the retina that is critical for effective reading and those affecting the optical quality of the image reaching the macular region, including mild opacities, cataracts, and refractive errors).⁶ Snellen acuity also has the practical advantage that it expresses visual function in terms of distance at which visual patterns such as letters can be identified, something that has an obvious analogy to reading information on signs.

Since Snellen acuity is used to broadly characterize visual functioning in so many other domains, those in the vision-science and vision-care communities may see this suggestion as unremarkable. But given that several generations of accessibility standards have expressed requirements in terms of physical characteristics of architectural features (including signs) rather than in terms of their functional value for those with disabilities, this proposal will require a very different way of thinking about accessibility in the built environment—one that adopts a visual rather than a structural notion of what constitutes a barrier to sign usability. Note that this recommendation does not necessarily entail testing of those with low vision, nor does compliance *require* that signs be legible to those with a specific degree of visual-acuity loss. Like the current standards requirements, there is no assurance that everyone with low vision will be accommodated. But unlike the current standards, this requirement is at least indexed to a single human visual-performance metric—one that is linked in a meaningful way with the specific functional difficulties people with low vision have in reading signs.

To illustrate the new approach, consider the following hypothetical requirement for designation signs, keeping in mind that the specific values used in the example, which can be negotiated among the stakeholders, are less important than the form of the requirement:

Visual signs (whether of the VO or the RV type) shall, even in the artificial illumination provided for viewing outside daylight hours, be legible to those with visual acuity of 20/20, when viewed at a minimum distance of 400 cm (158 in.), or at 40 cm (16 in.) when the text is optically minified to 1/10 of its size.

(Note that 40 cm, or 16 in., is a typical reading distance for those with 20/20 visual acuity, and is the distance for which nearly all eye doctors prescribe reading corrections.) Optical minification can be accomplished simply by viewing through a 10× binocular or other telescopic device, held in reverse.

Setting aside for the moment how legibility and visual acuity will be determined, the immediate value of this type of specification is that instead of specifying all the physical factors that might interact in complicated ways to affect sign legibility (including letter height, stroke width, color, contrast, and illumination), it specifies a level of legibility that implicitly uses as a criterion for legibility what a person with nominally typical visual acuity (i.e., 20/20 distance acuity with correction) can discern at a particular distance (or level of minification) under the illumination expected in the installed environment. Thus, if a sign is legible to person with typical sight under the expected illumina-

tion conditions, but at 10 times the viewing distance the person would typically require (or equivalently at a magnification of 0.1), then the sign should be legible to a person with roughly 20/200 vision under similar viewing conditions. This in effect simulates reduced visual acuity in the person with typical vision by increasing that person's viewing distance by tenfold. The simulation does not, of course, capture important aspects of the disorder underlying the visual-acuity loss—such as difficulty in fixating and executing saccades or lessened tolerance to reduced light levels and contrast, all of which are common in age-related macular degeneration—but full simulation of the disorder is not the goal.

For this example and those to follow, 20/200 is a reasonable value to consider as the acuity that must be accommodated because that degree of acuity loss has been widely adopted as a threshold value that defines blindness for certain social benefits (including the federal blindness tax exemption, Social Security disability benefits, and blindness benefit entitlements from state governments). The choice does not imply that those with acuity worse than 20/200 will be unable to read signs; in many cases they will be able to, especially if they approach the sign to closer than 40 cm or use personal magnifiers. Nor should the choice of 20/200 be taken to imply that all of those with that level of visual acuity would be accommodated. The essential characteristic of the example is that a sign be legible to travelers with typical vision even at a standards-specified and significantly greater distance than they would normally require. Interestingly, using data from 2015, a recent study (Varma et al., 2016) found 3.22 million adults with visual impairment over age 40 in the United States with best-corrected visual acuity better than 20/200, compared with 1.02 million adults who are legally blind. This suggests that at least 3/4 of those with visual disability can be accommodated using a 20/200-based guideline.

Why do we propose evaluating legibility using observers with typical vision rather than those with low vision? First, it is virtually impossible to characterize a “standard” low-vision observer, as the low-vision population is highly diverse in age as well as visual-function capacity (Faye, 1976), with much of the diversity relevant to signage arising from lens opacities and pupil size—both of which restrict the amount or spectrum of light entering the eye—and from diversity in retinal function that affects acuity as well, especially in the macular and foveal regions that are so critical to reading and spatial resolution. Indeed, assessing visual acuity in most people with low vision is a challenging and time-consuming affair, and often gives very inaccurate results.

A second reason for using nominally typical observers is that they are in abundant supply and can

be easily recruited within most architectural graphic-design firms and by code officials who want to verify compliance with the standards on-site, at least informally. Relative to the low-vision population, nominally typical observers are quite uniform in functional ability. While there is some variability in visual acuity, it is far less than what is observed in the low-vision population, and there is an accepted, albeit imperfect, consensus that 20/20 represents typical acuity in those with nominally typical vision.

Expressing the visual-accessibility requirement in these terms would be of enormous benefit to designers, who would have the freedom to alter any of the variables that affect sign legibility, provided the sign remains legible at a viewing distance of 400 cm (or minified by a factor of 10). Thus if the designer wishes to use colors that result in a lower contrast than would be legible under certain conditions, she may do so, provided that letter size or other variables compensate for the reduction in legibility. The sign designer, then, can choose typographic and color variables, provided that the sign meets the functional requirement that it be legible at a distance of 10 times typical print-reading distance. With that flexibility, however, comes the responsibility to ensure that those with nominally typical visual acuity can read the sign at the specified distance *under expected lighting conditions*. For a hotel hallway, for example, a designer of room-identification (designation) signs will have to make assumptions about ambient illumination and test under those conditions. If ambient lighting may be insufficient to support the requirement, the designer may choose to alter any number of other variables to adjust the sign's legibility, including character size, stroke width, letter case, color, and contrast. Of course, arrangements may be made to increase the ambient illumination in the installed environment. This also places on the designer, architect, or building contractor the burden of proving that a sign may be read by those with 20/20 vision at the distance specified by the requirement, which may be considerably more difficult than, say, showing that the letters meet the size, stroke-width, and spacing requirements in the current standards.

Under Proposal 1, how much, if any, would character size need to change on existing signs to meet the new example requirement? Figure 4 shows a sample, set in a font with a relatively (but not unnaturally) small x-height, perhaps something close to a “worst case.” Viewed at a close distance of 40 cm (16 in.)—the typical optometric refraction distance for reading printed material—the x-height of the font used in Figure 4 at its minimum compliant size under the current standards subtends 1.28° of visual angle. For readers with low vision (as well as typical vision), threshold-x-height print size is roughly half that required for fluent reading (Cheong, Lovie-Kitchin, &

Bowers, 2002), so readers with a reading acuity of 0.64° (in x-height) should be able to read the sign comfortably at that distance, assuming good lighting and contrast. Note that 40 cm is not the typical distance that a person with typical vision would usually read a sign, but it (or even closer) is a feasible reading distance for someone with low vision who is able to approach the sign close up.

What minimum Snellen acuity will readers with the 0.64° reading acuity most likely have if they can read the sign in Figure 4? Mansfield et al. (1993), using a sample of 14 observers with typical sight and 21 with low vision, found that Snellen acuity was highly correlated with reading acuity ($r = 0.97$) and was on average 0.1 log unit (or a factor of 1.26) lower than reading acuity (where letter size was taken to be the x-height of the Courier font they used). Radner et al. (1998), who tested with German text presented in a sans serif font, also found Snellen acuity to be 0.1 log unit worse than reading acuity. While reading acuity and Snellen acuity are assessed with psychophysical criteria that are difficult to compare directly, to a first approximation readers who read 0.64° (x-height) letters at threshold should be able to identify letter optotypes of roughly $1.26 \times 0.64 = 0.81^\circ$ at their acuity thresholds, assuming they are viewing the sign at a distance of 40 cm (16 in.) and that there is sufficient and appropriate lighting, good contrast of letters against background, and a reasonably matte sign finish. This letter size corresponds to 20/194 visual acuity, which is very close to the criterion visual acuity of 20/200 suggested by the example requirement. Considering character size alone, the 5/8-in. minimum character size seems reasonable, so a large proportion of existing installed signs would likely already be compliant with this new requirement, assuming good illumination and contrast, reasonable values for stroke width and letter spacing, and the ability to approach the signs to within 40 cm.

A functional criterion for legibility benefits users with low vision because it clarifies what the standard accepts as appropriate *in terms of visual function* (in the example requirement, roughly up to the acuity criterion for “legal” blindness), which is currently lacking in the standards. The functional visual-accessibility standard also has benefits for those ensuring that compliance is maintained. For example, it implies that lighting changes must maintain a sufficient level for the sign to comply with the legibility requirement, and that color and contrast fading must be minimal enough that legibility is not significantly degraded.

A practical test for sign legibility

In the hypothetical requirement, where signs are to be legible to those with visual acuity of 20/20 when viewed at a minimum distance of 400 cm or at 40 cm

when magnified by a factor of 0.1 or less, how should “legible” be construed? At first glance, a legibility criterion might appear to be too vague and subjective to have a place in the standard, where noncompliance may have significant legal ramifications. But is it? Consider that most laypeople with normal or corrected-to-normal visual acuity can confidently assess whether or not a sign is legible to them at a given distance. Indeed, those who feel the need to renew their distance eyeglass prescriptions almost always do so on the basis of the finding that distant signs previously readable to them are no longer so. Note that when we characterize an individual’s visual acuity as $20/x$, we are in effect stating that a visual object (e.g., an optotype letter) is legible to that individual at 20 ft, while someone with 20/20 vision can read it at a distance as far as x ft. Thus, a person with visual impairment with 20/200 acuity can likely identify the text on a sign that is typically legible to a person with nominally normal vision at 200 ft, only at a viewing distance of 20 ft.

An alternative way to optically simulate a $10\times$ viewing distance is to magnify a visual stimulus by a factor equal to the Snellen fraction ($20/200 = 0.1$). (Magnification by a factor less than 1 reduces retinal size and therefore is equivalent to minification.) Magnification of a sign by 0.1 can be accomplished by viewing it through a $10\times$ telescope or a pair of $10\times$ binoculars held in reverse, so that the eye is closest to the objective-lens end and the sign is closest to the ocular lens. This may be an attractive solution when testing space is limited.

Full specification of a full practice standard for testing or proving sign legibility is beyond the scope of this article, but it is useful to consider several characteristics that such a test must have. First, it will need to be simple, because in most cases it will be performed by people with little experience in psychophysical testing. Second, it needs to contain a large number of different texts to be read by the observer in order to minimize potential learning effects. The MNRead protocol (Legge, Ross, Luebker, & Lamay, 1989) and text from other standardized reading tests (Baldasare, Watson, Whittaker, & Miller-Shaffer, 1986; Radner et al., 1998) or a sign-specific corpus are good starting points. Third, it needs to resist the biases of those doing the testing. For example, manufacturers may be biased toward smaller character sizes (for economic reasons) or lower contrast muted color combinations (for aesthetic reasons), while disability advocates may be biased toward larger characters with bolder, higher contrast strokes. Finally, it must be feasible for multiple stakeholders to be able to conduct tests, at least to a first approximation, including graphic designers, sign manufacturers, and of course code officials who will need to test compliance. Note that since the stakeholders may have different concerns,

there may be different tests for different stakeholders. For example, those who have the burden of proof of readability (and the economic risks associated with noncompliance) may opt to adopt lengthier but more accurate testing procedures than other stakeholders.

Visual-acuity measurement for graphic designers, architects, and others evaluating compliance

Proposal 1 suggests using observers with nominally typical (20/20) visual acuity, under conditions of visual-acuity loss simulated through increased viewing distance or minification to determine compliance with a legibility standard. How should nominally typical visual acuity be determined in order to certify that the observers we use have 20/20 acuity? As noted earlier, visual acuity is commonly used as a criterion functional measure in occupational testing, driver licensure, and other applications. It is commonly assessed in settings that are easy for the public to access, including pharmacies and departments of motor vehicles, using vision charts designed to screen observers with typical sight (i.e., not for those with low vision) that are cheap and readily available, and there are already useful standards for such applications (e.g., American National Standards Institute, 2015) that might be incorporated by reference into the standards. For purposes of accurately determining compliance, authors of these standard may wish to require specific acuity tests with specific characteristics and lighting, such as those used in clinical vision research. But designers and sign manufacturers would likely want to use inexpensive charts with simple test protocols that they can implement in-house. For design and in-house testing purposes, acuity charts printed on an ordinary desktop printer or purchased from an eye-care products dealer will likely be adequate. Designers wishing to be especially sure of compliance may want to employ conservative design criteria. This might entail using observers with slightly worse acuity than 20/20 (e.g., 20/25) or using slightly less illumination in the legibility-test environment. In any case, it should be easy to find observers, even in-house, who can be used to evaluate legibility at longer distances (or with minification). Since the burden of proof of compliance, when challenged, is on the builder or designer, there is an incentive to ascertain that the standard’s requirement of legibility is met, and therefore to adopt a conservative criterion for in-house testing.

What about observers with visual acuity better than 20/20? Can they still be used for legibility testing? Indeed they can, provided the criterion distance (or minification) is adjusted appropriately. For instance, if an observer has 20/10 visual acuity, a viewing distance of 20 times the intended reading distance of the sign or a magnification of 0.05 would simulate for that

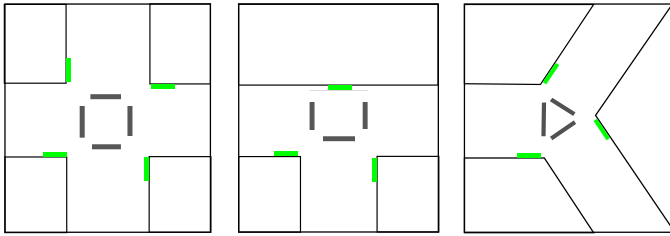


Figure 6. Optimal and approachable wall sign placement (shown in green) for visually impaired travelers entering the three main types of corridor intersections along the wall to their right. These accessible signs should supplement signs designed for able-sighted travelers, such as the overhead signs indicated.

observer the visual size of the sign to a person with 20/200 vision. Incidentally, a way to minimize the potential for such observers to unfairly present themselves as 20/20 observers in asserting compliance is to require multiple observers.

Proposal 1 is neither a perfect nor a complete solution. Among other things, it will require drastic changes in the thinking of the A117.1 and SFAD standards committees, detailed procedures for legibility testing, and a published, comprehensible practice standard for graphic designers and those enforcing code compliance. Its central virtues are in eliminating the arbitrary and unfounded choices of design parameters that exist in the current standards and in providing a framework for signage requirements that are indexed to human visual performance.

Proposal 2

The standards should require directional signs to be mounted in consistent and closely approachable locations.

Directional signs are extremely important for independent wayfinding in complex spaces like large office buildings and medical facilities. However, as noted earlier, the current standard has no requirement for the location of directional and informational signage; these signs need only meet the other requirements for VO signs. This proposal would add the requirement of specified mounting location of directional signs where they can be approached closely for near viewing.

Figure 6 shows optimal placement of directional signs in the three configurations of intersections that exist in buildings with corridors (see also Arthur & Passini, 1992). Each intersection has signs to accommodate travelers with low vision moving into the intersection, and such signs would be recommended (but not always required) for all such intersections. The figure also shows examples of overhead or “chandelier” sign mountings, which are often used in larger spaces

like hospital facilities. Arthur and Passini suggest that the duplication of information from such signs in wall-mounted signs in a consistent location is essential to accommodating those with low vision, and Proposal 2 adopts this suggestion. But as noted earlier (see footnote 2), the standards do not mandate the placement of signage; where signs are installed, they simply must comply with accessibility requirements of the standards. Proposal 2, then, should be read as requiring that where there is directional signage, it must be mounted or duplicated in consistent and closely approachable locations. Additional directional signage (e.g., overhead, or chandelier style) in different locations is permitted, but only if signs with the same content are installed in the required mounting locations as well. As with designation signs, there are some circumstances that will limit mounting in the required locations, but these can be handled by the standards as exceptions. Where spaces are large and open, such as in atriums or large halls, travelers who have severe low vision may need to follow walls in order to locate signs, but at least they will be able to find their way independently, as they will be able to locate the signs mounted in consistent places. While there are surely some challenges in how the standards authors will supply the details of such a requirement, providing this kind of signage is clearly feasible.

Here is an example of how a requirement for directional signage might be stated:

Directional signs shall be located at corridor intersection corners, with no horizontal access restrictions, so that they may be approached for close viewing. Text on such signs shall have character baselines of 40 in. minimum and 60 in. maximum above the floor. Additional directional signs may be mounted overhead or at locations other than the required mounting locations, provided that equivalent information is given on signs meeting these location and character baseline-height requirements. Such signs shall, even in the artificial illumination provided for viewing outside daylight hours, be legible to those with visual acuity of 20/20 when viewed at a minimum distance of 400 cm, or 40 cm when magnified by a factor of 0.1 or less.

Character baseline-height requirements for this example have been chosen to be consistent with those for designation signs, for consistency and to make finding signs easier for travelers with low vision. Note that compliance with this requirement also depends on the visual-function standard articulated in Proposal 1, and not on letter size, contrast, illumination, or any of the other physical characteristics that determine legibility. Many business buildings already have wall-

mounted directional signs installed in closely approachable sites consistent with the example requirement, and many will already meet the character baseline-height requirements as well. Note that if braille and raised lettering are also required at these same mounting locations, Proposal 2 can be of great benefit to travelers who are blind, so the standards committees may wish to consider adding this requirement as well.

Conclusion

As the A117.1 and SFAD committee members and their predecessors can attest, the process of developing accessibility rules that are rational, clear, enforceable, of appropriate scope, and fair to all stakeholders is extremely challenging. This is so even when the physical characteristics of users' needs are easily definable and measurable and when compliance is easy to assess (e.g., minimum door width to accommodate wheelchairs, number and location of accessible parking spaces).

But when users' needs are highly variable and cover a broad range of functional abilities, as they do in low vision, devising appropriate solutions for enhancing accessibility can be substantially more difficult. Travelers with low vision, defined for this article as those who can read sign text only with magnification or close viewing, may include those with Snellen acuity ranging from 20/60 to 20/1200 (comprising a factor of 20 in letter size) and beyond, with contrast sensitivity losses to nearly 2 log units, greatly restricted visual fields, reduced color vision, decreased performance associated with glare, spatial distortions, and light- and dark-adaptation functional losses. Adding even more variability is the fact that those with low vision may use a host of visual aids, including optical and electronic magnifiers, high-plus lenses, absorptive lenses, prism aids, and other tools for enhancing their own access to visual information. Rules that attempt to provide access for vision disability must cope with both the enormous range of low-vision function and users' wide variety of assistive devices, making low-vision accessibility a complicated issue. Allowing close approach is probably the most important accessibility feature for low-vision signage, and that is why Proposal 2 is so important.

Close approach, however, is not enough. This article has taken the position that requirements based on visual function are essential to specifying a consistent degree of legibility as well, in order to address the complex of variables that impact legibility. Since visual acuity is a simple and familiar visual-function measure that is closely linked to sign reading, a criterion visual-acuity loss that can be simulated with observers with

typical sight is a sensible and practical way to express sign legibility requirements in units that can be traced to visual function. Expressing the requirements this way also makes explicit the degree of function (visual acuity) loss that the requirement can accommodate visually, providing some clarity to what the standards will put forth as readily achievable.

The proposals described in this article can both further the removal of communication barriers for those with low vision and at the same time provide more design choices than graphic designers and sign manufacturers currently have. For these reasons, it is my hope that these proposals will gain the support of both low-vision advocates and the architectural-sign community, and that they will join together to improve access to the built environment for travelers with low vision.

Keywords: accessibility, low vision, reading

Acknowledgments

This work was supported by National Institutes of Health grant EY023483. The author gratefully acknowledges Glenn Dea, Gordon Legge, Marsha Mazz, Edward Steinfeld, and Suzan Uysal for providing helpful commentary and critique of an earlier version of this article.

Commercial relationships: none.

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Footnotes

¹ On March 15, 2011, the SFAD became the enforceable standards document under Titles II and III of the ADA for new construction, alterations, program accessibility, and barrier removal. Based on the Americans With Disabilities Act Accessibility Guidelines of 2004, it superseded the preceding Americans With Disabilities Act Standards for Accessible Design of 1991 (the U.S. Access Board published the original ADA accessibility guidelines on July 26, 1991, and the U.S. Department of Justice adopted them as its ADA Standards on the same day). The ICC A117.1 Accessible and Usable Buildings and Facilities standard also details technical standards for accessibility that generally overlap with the SFAD with respect to signage, and is referenced by many federal documents and state accessibility laws. The A117.1 standard has a history dating back to 1961, and there have been

continuous attempts to coordinate its content with other standards (e.g., Fair Housing Act Accessibility Guidelines, Architectural Barriers Act Standards, International Building Code) as well as the SFAD, to maintain consistency.

² It is commonly believed that the ADA and related standards require accessible signage to be installed in publicly accessible spaces. In most cases they do not. What they do require is that if certain types of signs are provided for people with typical vision, then accessible signs must also be provided, so as to not impose a barrier to access for people with visual disabilities.

³ In this article I use the term “blind” to refer to those who cannot read visual signs at all due to an uncorrectable vision loss. Most of these individuals have difficulty navigating without navigation aids such as a long cane or a guide dog. I use the term “low vision” to refer to those individuals with visual impairment who can read text signs (but not necessarily continuous text) visually, although they may require magnification aids or very close viewing. There are some people who are considered to be blind or have severe low vision due to severely restricted visual fields rather than visual acuity losses (this is commonly called “tunnel vision”), but this is a very small group whose functional limitations, when severe enough, are better addressed through a combination of visual and nonvisual senses (such as touch and hearing).

⁴ Interestingly, the RV type of sign was the only type allowed in the original ADA Accessibility Guidelines published in 1991, with the less restrictive option of VO signs with accompanying braille and raised letters added in the 2004 edition.

⁵ This definition of contrast and the use of “LRV” to denote light-reflectance value are nonstandard in vision science, where contrast ordinarily ranges from 0 to 1 and reflectance is denoted simply *R* rather than “LRV.” They are, however, conventional in the signage and architectural-accessibility worlds.

⁶ Other functional deficits resulting in low vision, such as those limiting the extent of the peripheral visual field, usually do not affect a person’s ability to access signs as strongly as vision losses in the macular region, although when severe they may limit the ability to locate signs in the environment.

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