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Design Considerations for Egress Signs Based upon Visibility through Smoke

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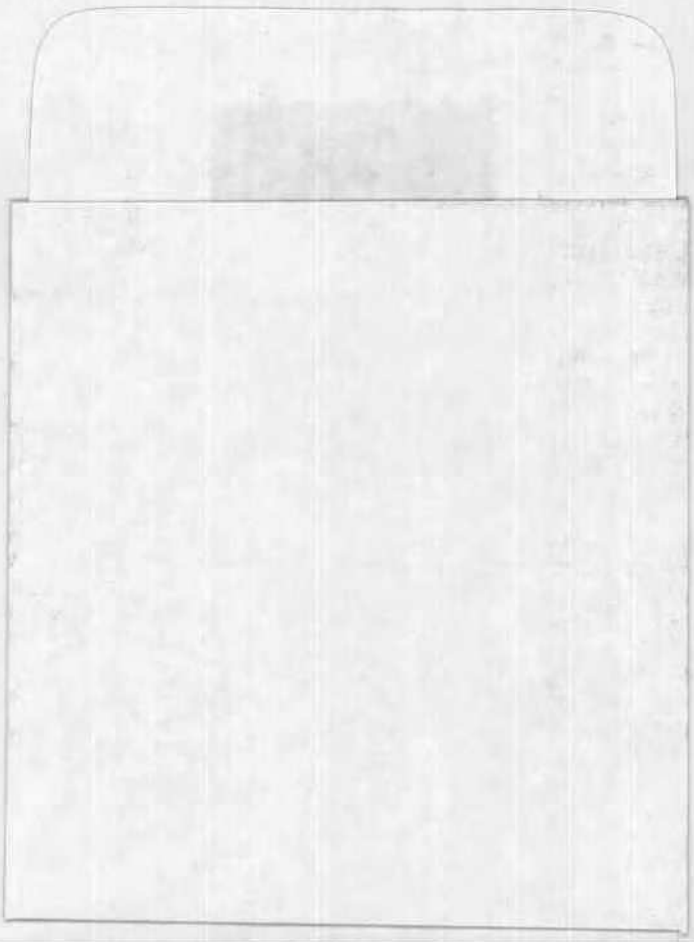
RÉSUMÉ

La visibilité à travers la fumée des panneaux "sortie" d'un bâtiment est un important facteur à considérer dans le choix du type de panneau à installer. Une étude menée récemment sur ce sujet a porté sur plusieurs panneaux recommandés actuellement au Canada. Certains paramètres influant sur la visibilité des panneaux ont été étudiés. Certains panneaux actuellement acceptés ne sont pas visibles à travers la fumée, même légère. Les facteurs qui influent sur la visibilité des panneaux "sortie" dans la fumée sont décrits dans ce document, qui fournit des lignes directrices concernant leur conception et leur installation.



DESIGN CONSIDERATIONS FOR EGRESS SIGNS BASED UPON VISIBILITY THROUGH SMOKE

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Abstract

The visibility of egress signs in smoke should be an important factor when specifying the type of sign to be installed in a building. We have recently completed a study of the visibility in smoke of several exit signs currently recommended for use in Canada. Some parameters influencing sign visibility in smoke have been examined. Some currently sanctioned signs are invisible in relatively small amounts of smoke. Factors affecting sign visibility in smoke are described, with some guidelines for the design and installation of egress signage.

Introduction

Egress signs are part of the emergency and fire protection system in buildings. These signs are expected to direct building occupants to points of egress during emergencies. Egress signs are especially important to occupant safety in smoke. The specifications for egress signs by the various sanctioning bodies in Canada and elsewhere differ considerably, but all are vague with respect to sign visibility. Some contain recommendations for minimum or maximum luminances, letter size and spacing, colour, and sign mounting heights,[1-5] but it is rarely clear on what basis these recommendations have been made.

Several studies have dealt with egress sign visibility.[6-12] However, most of these studies have not adequately defined the optical properties of the signs or the smoke, nor have they adequately characterized the visual capabilites of the observers. Usually, sign colour and brightness are only qualitatively described. The experiments often fail to adequately simulate visibility through smoke. Some studies employ other optical methods for reducing visibility, or simply ask subjects to make value judgements about the visibility of signs without actually attenuating visibility. An exception to this approach has been the work of Jin.[9] In his study people actually made observations of egress signs through smoke, and from their responses Jin developed an empirical, quantitative model. The empirical model is limited in its utility, however, because it is more concerned with the optical properties of smoke than with the visual properties of the signs.

The purpose of the study by Rea, Clark and Ouellette[13] was to develop better recommendations for the visibility of egress signs through smoke. To simulate conditions that building occupants might experience in a fire, actual signs and smoke were employed in the experiment. The data were consistent with well established principles of vision and optics. This paper summarizes the recommendations made from the study.

Experimentation

Procedures

Photometric and psychophysical observations were made of thirteen egress signs, some of which are currently approved for use in Canada. The brightness ('general luminance') of each sign was obtained in a smokeless, dark environment. A cosmetic oil smoke was added to a chamber housing the exit signs to reduce their visibility. In a parametric psychophysical experiment, sixteen volunteers made threshold observations of each sign through the smoke by two criteria; detectability and readability. Observations were made both with and without ambient illumination of the smoke chamber housing the egress signs. Full experimental details are in the original reference.[13]

Results

In general, the brighter the sign, the more visible it was through smoke. Thus, the greater the measured luminance of the sign, the greater the smoke density required to render it unreadable or undetectable (Figure 1). It took less smoke to make a sign unreadable than to make it undetectable.

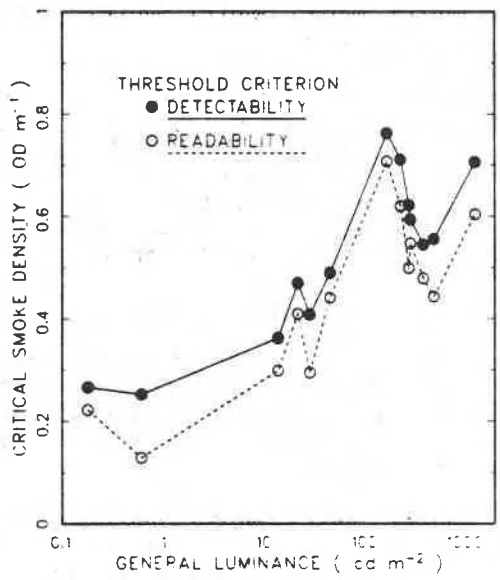

Figure 1. The smoke necessary to bring the exit signs to the readability and detectability threshold criteria are plotted as functions of the general luminance of each exit sign face. Critical smoke density is defined in units of optical density (OD), or the logarithm of reciprocal of light transmitted at 632.8 nm/m. A circular field aperture, just large enough to cover the exit sign face, was used to measure the general luminance (cd m^{-2}) of each sign.

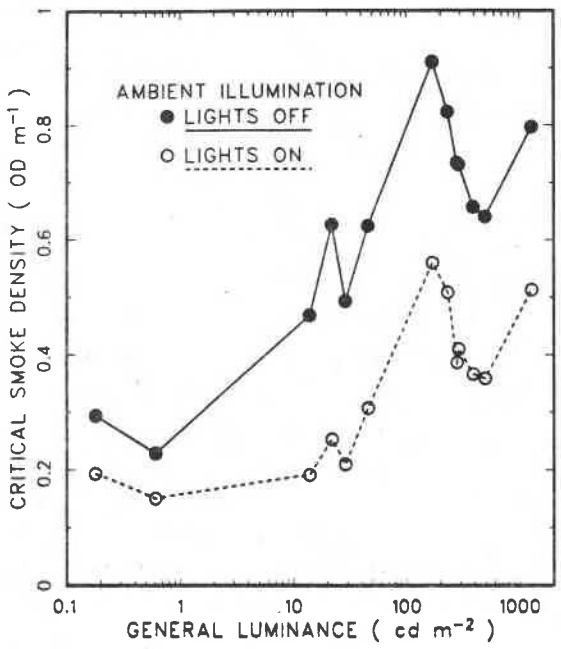

Figure 2. The amounts of smoke necessary to bring the exit signs to threshold with ambient illumination 'on' and 'off'. Critical smoke density and 'general luminance' are as defined for Figure 1.

The ambient illumination in the room also affected the visibility of the egress signs in smoke. The egress signs were more visible through smoke with rooms lights 'off' than with the room lights 'on' (Figure 2). Scatter from the room lights created a 'luminous cloud' through which the egress signs had to be detected or read.

Scattered light from the egress sign itself also affected visibility. Scatter from 'downlights' at the bottom of the sign and luminous backgrounds for the sign lettering reduced visibility. Readability was reduced more than detectability. An observer could still tell where the sign was located, even though he could not read the lettering.

Recommendations

Egress signs should be bright to be visible through smoke. Simply replacing incandescent lamps with more efficacious fluorescent sources would improve their brightness by as much as five times for the same lamp wattages.[14]

The visibility of egress signs would be improved if scattered light from other luminous sources (light fixtures) could be reduced by appropriately locating egress signs with respect to other light fixtures. Similarly, the readability of egress signs could be improved if unnecessary sources of scatter from the sign itself could be limited. Thus downlights and bright areas surrounding the lettering should be avoided. Cutout signs will be more readable for the same brightness.

The colour of the sign also influences visibility to some extent. Translucent filters (i.e. sign faces), reduce the amount of transmitted light. The actual brightness of the sign will depend upon (a) the spectral power distribution of the lamp, (b) the spectral transmission (or reflectance) of the sign, (c) the spectral transmission and scatter of the ambient medium (e.g. smoke), and (d) the spectral sensitivity of the observer. Typically, translucent green materials will be brighter to more people than translucent red materials for the same light source. Thus, green signs are likely to be more visible through smoke than red signs. Jin[9] demonstrated that smokes differ in their wavelength dependent scattering; however, this was a relatively small effect in the study by Rea et al.[13]

Because coloured signs are translucent, their brightnesses will be less than if no filter had been used. It might be argued, therefore, that colourless, or white, egress signs should be used. However, because most other luminous sources in buildings are colourless, some confusion may exist in a smoke filled room or hallway between a white ceiling fixture and a white egress sign. Although this has not been previously studied, it seems reasonable to employ coloured egress signs to aid occupants in discriminating between luminous sources. In retail areas where many coloured light sources are used, other strategies should be employed to aid discrimination.

The preceeding arguments for egress sign design are based upon the assumption that buildings employ conventional, 'static' signs that operate the same way under all building conditions. These recommendations also had the aim of improving egress sign visibility through smoke. Other criteria could be met, however, if egress signs could respond to different environmental conditions. Bright signs are probably unnecessary for good visibility under most building operating conditions; they are certainly unappealing with respect to energy and aesthetics. A 'smart' sign that brightens in response to smoke would be most desireable. It could be highly visible in smoke and still be energy efficient and aesthetically less offensive under normal operating conditions. Operated in conjunction with an automated lighting control system, ambient fixtures that produce deleterious scattered light in smoke could be extinguished or dimmed when smoke is detected. This would further improve the likelihood that the bright egress sign would be seen.

The study by Rea et al[13] has indicated some better principles for egress sign visibility in smoke. More experiments should be conducted to refine the recommendations made here and in that report.

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