Technical Report

ISO/TR 9241-313

First edition
2025-07

Ergonomics of human-system interaction —

Part 313: Optical measurement methods for reflective displays

Ergonomie de l'interaction homme-système —

Partie 313: Méthodes de mesure optique pour écrans réfléchissants

Reference number
ISO/TR 9241-313:2025(en)

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Published in Switzerland

Contents

Page

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 04, *Ergonomics of human-system interaction*.

A list of all parts in the ISO 9241 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document provides an overview of recent research on applying the optical reflection measurement methodology for flat direct view electronic displays to electrophoretic displays (EPDs). This document contributes background to ISO 9241-307, ISO 9241-305 and ISO 9241-303, providing information regarding reflective displays in ambient indoor and outdoor illumination environments defined by CIE 015:2018, CIE S017:2020, and ISO/CIE 11664-2:2022.

Reflective displays convey information by modulating the reflected light, using independently controlled segments or pixels. Any reflective display performs the following two basic optical functions, either equally for all wavelengths achromatically or for selective wavelengths chromatically:

— reflecting ambient illumination towards the human observer;

—modulating the amount and spectral distribution of the reflected light.

For example, EPDs use electrically charged pigments to reflect and modulate light. Opaque white pigments with near-Lambertian reflection characteristics form the paper-like, diffuse reflecting background. Light-absorbing black pigments attenuate the reflected light as traditional ink does on paper. These properties differentiate EPDs from other display technologies by its paper-like appearance that offers a wide range of viewing directions and sunlight readability. Other properties are low power consumption and the absence of flicker. Other known reflective display technologies use reflectors with metallic, mirror or retroreflective characteristics, combined with diffusers, achromatic reflection modulators (for example liquid crystal shutters) and a colour filter array (CFA). EPDs are used in static and mobile applications including e-readers, wearables and signage for both indoor and outdoor applications.

A reflective display must have ambient illumination for the displayed information to be visible. Ambient illumination has directional and diffuse components. In outdoor environments, direct sunlight is the directional component, and skylight the diffuse component. In indoor environments, the diffuse component is dominant, e.g. diffuse daylight through windows and light is scattered by walls and ceiling. In addition, specular reflection of light sources of various sizes (from small luminaires to large windows) has the potential to obliterate the information on display screens. This document explains how to separately measure the display's reflection characteristics under specific measurement illumination conditions, e.g. off-specular directional, hemispherical-diffuse, and specular variable aperture source (VAS) illumination. The three fundamental reflection components (specular, haze, and Lambertian) are measured separately and as a function of illumination source size. Once the reflection coefficients for each illumination geometry are measured, the reflected luminance from each illumination component is determined, and the infinite variety of ambient multi-source illumination is expressed as a summation of reflected illumination components from these sources. The total spectral radiance entering the observer's eye when viewing a display is then predicted as a summation of all the ambient light components reflected into the direction of viewing. The contributions from each source are scaled according to their irradiance spectra for specific in- and outdoor illumination environments.

This document includes examples of standardized indoor and outdoor illumination conditions, and uses EPDs to illustrate the measurement methods.

Ergonomics of human-system interaction —

Part 313:
Optical measurement methods for reflective displays

1 Scope

This document provides background information and a validated methodology for optical reflection measurements for flat direct view electronic displays. This document includes calculation methods for using measured reflection coefficients to predict display performance in specific indoor and outdoor ambient illumination conditions.

This document demonstrates optical measurements of electrophoretic displays (EPDs), as a reflective electronic visual display technology; many methods are also applicable to other appropriate reflective and emissive displays. This document does not include a methodology for ergonomics evaluation.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9241-302, *Ergonomics of human-system interaction — Part 302: Terminology for electronic visual displays*

ISO 9241-303, *Ergonomics of human-system interaction — Part 303: Requirements for electronic visual displays*

ISO 9241-305:2008, *Ergonomics of human-system interaction — Part 305: Optical laboratory test methods for electronic visual displays*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9241-302, ISO 9241-303, ISO 9241-305 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1.1
reflective display
electronic display device that modulates light from an external source by reflection, using independently electronically controlled segments or pixels

Note 1 to entry: Any reflective display consists of at least two basic optical elements: reflector and reflection modulator. The reflector reflects ambient light back towards the human observer; the reflection modulator changes the reflectance either equally for all wavelengths for an achromatic display or in a spectrally selective manner for a colour one.

Note 2 to entry: Information on reflective displays is only visible in ambient illumination.