TECHNICAL REPORT

ISO/TR 9241-309

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Ergonomics of human-system interaction —

Part 309: Organic light-emitting diode (OLED) displays

Ergonomie de l'interaction homme-système —

Partie 309: Écrans à diodes électroluminescentes organiques (OLED)

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TR 9241-309 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 4, *Ergonomics of human-system interaction*.

ISO 9241 consists of the following parts, under the general title *Ergonomic requirements for office work with visual display terminals* (*VDTs*):

— *Part 1: General introduction*

— *Part 2: Guidance on task requirements*

— *Part 4: Keyboard requirements*

— *Part 5: Workstation layout and postural requirements*

— *Part 6: Guidance on the work environment*

— *Part 9: Requirements for non-keyboard input devices*

— *Part 11: Guidance on usability*

— *Part 12: Presentation of information*

— *Part 13: User guidance*

— *Part 14: Menu dialogues*

— *Part 15: Command dialogues*

— *Part 16: Direct manipulation dialogues*

— *Part 17: Form filling dialogues*

ISO 9241 also consists of the following parts, under the general title *Ergonomics of human-system interaction*:

— *Part 20: Accessibility guidelines for information/communication technology (ICT) equipment and services*

— *Part 110: Dialogue principles*

— *Part 151: Guidance on World Wide Web user interfaces*

— *Part 171: Guidance on software accessibility*

— *Part 300: Introduction to electronic visual display requirements*

— *Part 302: Terminology for electronic visual displays*

— *Part 303: Requirements for electronic visual displays*

— *Part 304: User performance test methods for electronic visual displays*

— *Part 305: Optical laboratory test methods for electronic visual displays*

— *Part 306: Field assessment methods for electronic visual displays*

— *Part 307: Analysis and compliance test methods for electronic visual displays*

— *Part 308: Surface-conduction electron-emitter displays (SED)* [Technical Report]

— *Part 309: Organic light-emitting diode (OLED) displays* [Technical Report]

— *Part 400: Principles and requirements for physical input devices*

— *Part 410: Design criteria for products for physical input devices*

— *Part 920: Guidance on tactile and haptic interactions*

For the other parts under preparation, see Annex A.

Introduction

This part of ISO 9241 introduces the OLED (organic light-emitting diode) display technology, and provides guidance for the assessment of OLED-based products. OLED technology is not addressed by ISO 9241-307 (which establishes test methods for the analysis of a variety of visual display technologies, tasks and environments) or other parts of the “300” subseries.

ISO 9241 was originally developed as a seventeen-part International Standard on the ergonomics requirements for office work with visual display terminals. As part of the standards review process, a major restructuring of ISO 9241 was agreed to broaden its scope, to incorporate other relevant standards and to make it more usable. The general title of the revised ISO 9241, “Ergonomics of human-system interaction”, reflects these changes and aligns the standard with the overall title and scope of Technical Committee ISO/TC 159, Subcommittee SC 4. The revised multipart standard is structured as series of standards numbered in the “hundreds”: the 100 series deals with software interfaces, the 200 series with human centred design, the 300 series with visual displays, the 400 series with physical input devices, and so on.

See Annex A for an overview of the entire ISO 9241 series.

Ergonomics of human-system interaction —

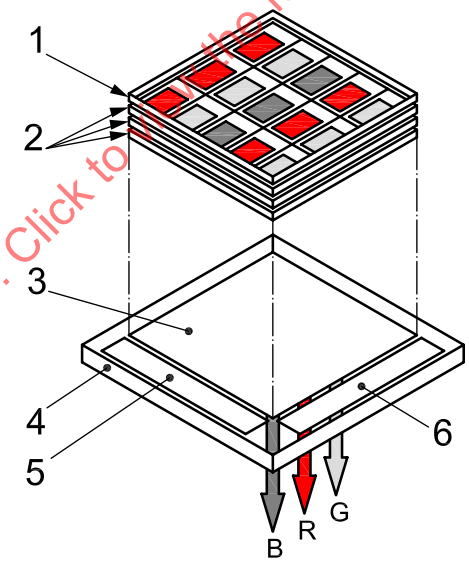
Part 309:
Organic light-emitting diode (OLED) displays

1 Scope

This part of ISO 9241 gives guidelines for organic light-emitting diode (OLED) displays.

2 OLED technology

OLED is an emissive device used in visual displays for direct view [3]. A typical active matrix OLED (AM-OLED) display panel is shown in Figure 1. It consists of three parts: substrate, organic layers and reflective electrode. A pixel contains three or more primary-colour sub-pixels in full-colour OLED displays.



Key

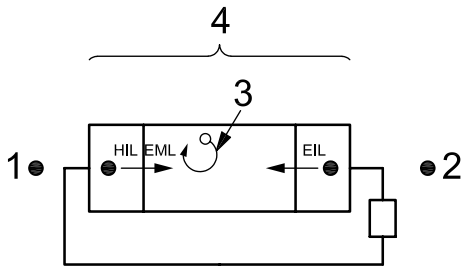
1 cathode
2 organic layer (electron transport layer, emitting layer, hole transport layer)
3 anode
4 low temperature poly-Si TFT substrate
5 driver, horizontal
6 driver, vertical

Figure 1 — Typical OLED display panel structure (bottom emission type)

The substrate of an AM-OLED display panel is usually a low temperature poly-Si TFT (thin film transistor) substrate.

The organic layers consist of more than two layers. These layers are chosen from the electron injection layer (EIL), electron transport layer, emitting layer, hole transport layer, hole injection layer (HIL) and so on. The cathode is usually made of aluminium. It reflects light from the emitting layer (EML) in the viewing direction.

The OLED operation is summarized in Figure 2.



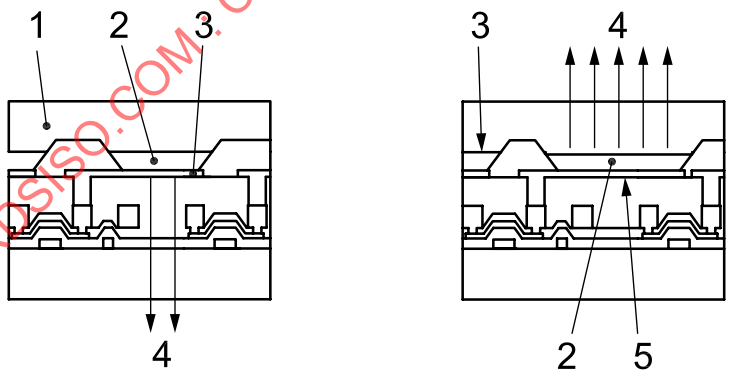
Key

1 hole, h^+
2 electron, e^-
3 exiton
4 emission

Figure 2 — OLED operation

Electrons and holes are injected through the cathode and the anode, respectively. Then electrons and holes are recombined in the emission layer and the light is emitted.

There are two types of OLED, depending on the direction of the emissive light: the bottom emission type and the top emission type. These are shown in Figure 3.



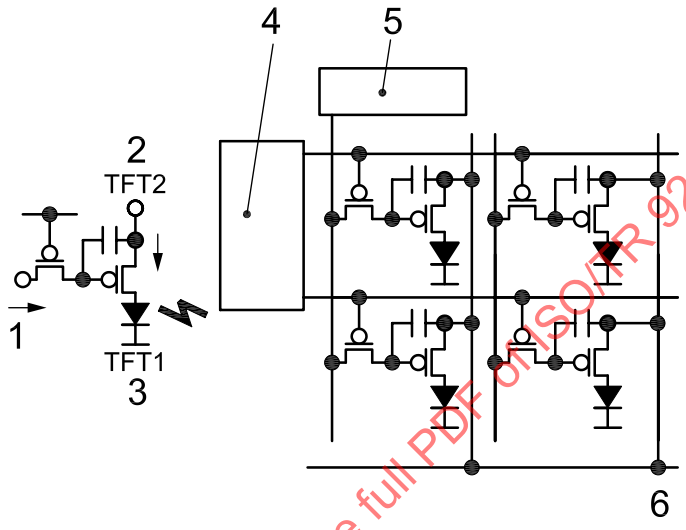
Bottom emission **Top emission**

Key

1 cathode, metal electrode
2 organic layer
3 cathode, semi-transparent
4 light
5 anode, metal electrode

Figure 3 — Ways of emission

OLED displays are driven by line scanning or TFT switching elements, as shown in Figure 4 [3]. A sub-pixel consists of at least an OLED, two TFTs and a memory capacitor which memorizes signal voltage in a full-colour OLED display. Each signal line is driven by a data drive circuit and simultaneously selecting TFT (TFT2) for writing is driven by a scan drive circuit. Signal voltage is applied to the gate of the driving TFT (TFT1) when the pixel is selected for writing. The voltage is held by the memory capacitor during off-selected term (TFT2 off). Current flow through the OLED continues, controlled by TFT1 corresponding to the signal voltage. The memorized signal is applied to the LED through the scanning period by the driving TFT. The pixel emits light according to the signal level. The response time of the OLED is so fast that moving picture quality is excellent.

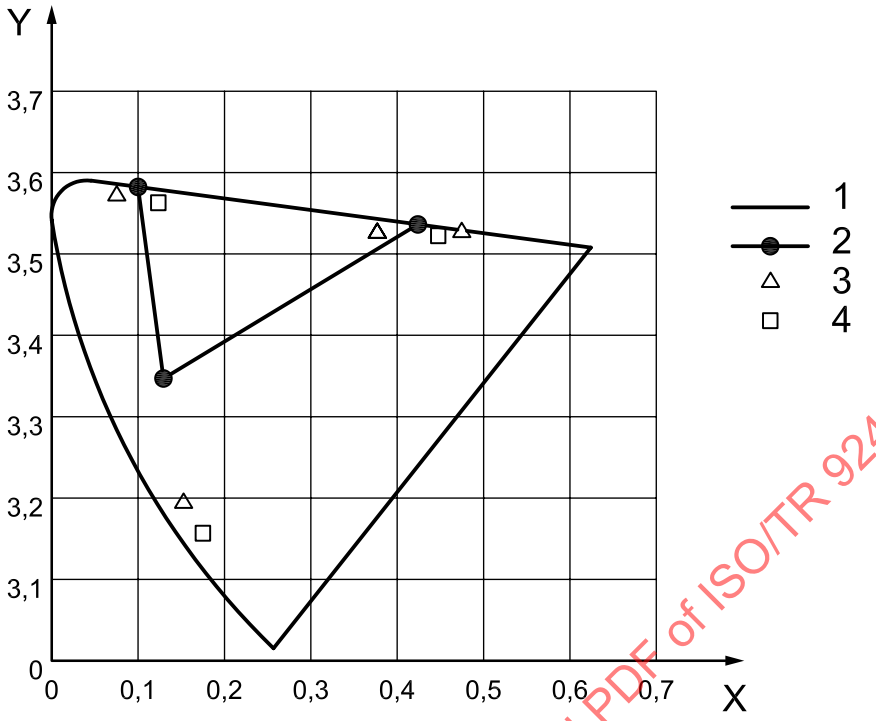


Key

1 signal
2 current
3 light emission
4 scan drive
5 data drive
6 power source

Figure 4 — Primitive circuit for driving AM-OLED

A typical colour reproduction range of OLED displays is shown in Figure 5.



Key

u', v'	chromaticity coordinates
1	spectrum focus
2	OLED (typical)
3	ITU-R BT 470
4	ITU-BT 709

Figure 5 — Chromaticity diagram of an OLED display

The picture of a 3,5 in QVGA 116 ppi OLED panel is shown in Figure 6.

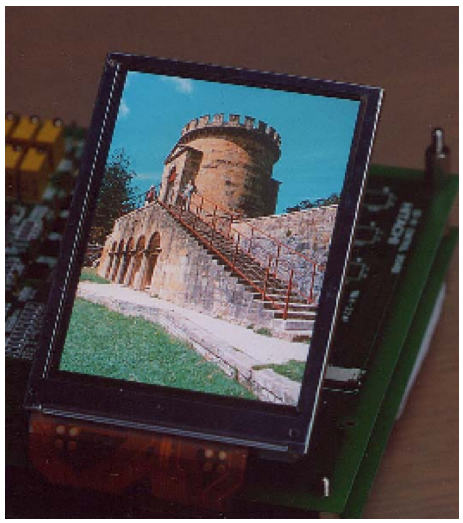


Figure 6 — OLED display of 3,5 in QVGA panel

The pixel image of an OLED panel is shown in Figure 7. The electroluminescence material of each colour is deposited by using an appropriate mask for that colour.

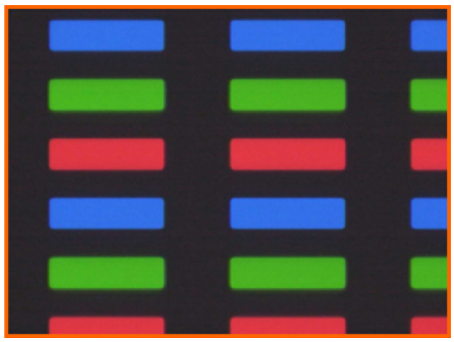


Figure 7 — Electroluminescence image of pixels in a display panel

3 Information about OLED displays

Examples of dimensional specifications are given in Table 1.

Table 1 — Example dimensional specifications

Pixel pitch horizontal/vertical	(H) 0,056 mm × (V) 0,168 mm
Number of pixels horizontal/vertical	(H) 480 × 3 × (V) 320
Horizontal display size, W_{view}	77 mm
Vertical display size, H_{view}	58 mm
Active diagonal millimetre/inch	97 mm/3,8 in
Front	glass panel with antireflective treatment

Table 2 compares OLED and other VDT devices in terms of their basic features.

Table 2 — Comparison of OLED typical basic features with those of other VDT devices

Feature	VDT device			
	OLED	CRT (cathode ray tube)	LCD (liquid crystal display)	PDP (plasma display panel)
Emitting principle	Electroluminescence	Hot-cathode luminescence	Back light	Photo-luminescence
Optical performance	Isotropy	Isotropy	Anisotropic	Isotropy
Thickness of face plate	Very thin	Thick glass	Thin	Thin
Pixel type	Fixed type	Not fixed type	Fixed type	Fixed type
Displaying method	Hold and duty	Scanning	Hold	Subframe

4 Intended contexts of use

The typical intended contexts of use of an OLED display are given in Table 3.

Table 3 — Typical intended contexts of use for an OLED display

Design screen illuminance	Up to 600 lx at indoor location
Illuminant	CIE illuminant A and D65
Content and perception	Full-colour graphics of artificial and of really existing objects and scenes
Design viewing distance	Same as for handheld device and stationary one
Design viewing direction	Perpendicular
Design viewing direction range	The maximum angle of inclination, Θ, is 80°. The azimuth angle, Φ, is 0° to 360°.

5 Guidelines for assessment

These guidelines are based on initial optical measurements of an OLED product in an accredited optical lab.

NOTE These measurements have been the subject of discussion within the Japan Electronics and Information Technology and Industries Association (JEITA).

a) Isotropy

The isotropy of the OLED was determined. The luminance at any inclination angle $\Theta \leqslant 40°$ did not deviate by more than 12 % from luminance measured perpendicular. The OLED therefore has optically isotropic behaviour.

As a result of this measurement, the assessment methods given in the compliance route for “PDP display for indoor use” [2] may serve as a good basis for the assessment of the OLED product.

b) Distortion of the entire screen

A flat CRT has geometrical distortion, which is caused by the thickness difference between the face plate centre and the face plate corner. As the OLED uses a substrate of thin, uniform thickness and a fixed pixel type display, it has no geometrical distortion.

c) Focusing on the display corner

A flat CRT has defocus on the display corner. It is caused by defection defocus. As the OLED is a fixed pixel type display, it has uniform and sharp focus on the entire screen.

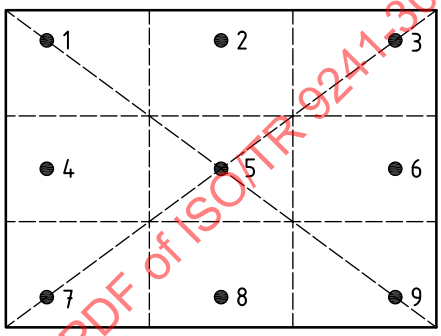
d) Motion picture

AM-OLED displays have less moving-image blur compared with TFT-LCD because OLED displays have a quick reponse time (less than 1 ms) and are operated by a hold-type drive method with a small duty ratio.

e) Specific attributes for assessment

Relative to the normative assessment specified in ISO 9241-307, additional attributes to be considered for OLED products are given in Table 4.

Table 4 — Specific attributes for assessment

Attribute	Assessment
Design viewing distance	For reality information, consider ITU-R BT.710: $D_{\text{design,view}} = 3 \times H_{\text{view}}$ For artificial information consider user age: under 18 years old: 200 mm; adults: 300 mm; over 45 years old: 400 mm.
Measurement locations	Standard measurement locations 1, 3, 7, 9 are at the locations on the diagonals that are 10 % of the diagonal length in from the corners of the addressable area of the display [1].
	
Geometric distortion	No need to consider because alignment of picture elements (pixels) are fixed in a matrix pattern.
Pixel fault	Need to consider.
Colour misconvergence	No need to consider because each colour signal is precisely addressed through solid signal lines.

f) Other attributes

For all other attributes, such as luminance, contrast and luminance non-uniformity, the measurement example below (in Table 5) shows that the metrology in the compliance route “PDP for indoor use” can be used for OLED products [2].

Table 5 — Measurement examples

Item	Value	
Luminance	200 cd/m^2	(typically)
Luminance non-uniformity	< 1,2 : 1	(typically)
Colour non-uniformity	< 0,05	(typically)
Darkroom contrast	> 1 000 : 1	(typically)
Contrast under 600 lx	> 50 : 1	(typically)
Reflectometer value, R_D	0,01	(approximately)
Colour reproduction area under darkroom conditions	18,7 %	(typically)
NOTE The total area inside of the spectrum locus in CIE 1976 uniform-chromaticity-scale diagram is set to 100 %.		

6 Conclusion

Because there are no assessment methods available for an OLED display, the assessment methods given in ISO 9241-307 for PDP for indoor use may be used, considering the above-mentioned specific attributes and assessment guidelines.

Annex A
(informative)

Overview of the ISO 9241 series

This annex presents an overview of ISO 9241: its structure, subject areas and the current status of both published and projected parts, at the time of publication of this part of ISO 9241. For the latest information on the series, see: http://isotc.iso.org/livelink/livelink?func=ll&objId=651393&objAction=browse&sort=name.

Part no.	Subject/title	Current status
1	General introduction	International Standard (intended to be replaced by ISO/TR 9241-1 and ISO 9241-130)
2	Guidance on task requirements	International Standard
3	Visual display requirements	Replaced by the ISO 9241 “300” subseries
4	Keyboard requirements	International Standard (intended to be replaced by the ISO 9241 “400” subseries)
5	Workstation layout and postural requirements	International Standard (intended to be replaced by ISO 9241-500)
6	Guidance on the work environment	International Standard (intended to be replaced by ISO 9241-600)
7	Requirements for display with reflections	Replaced by the ISO 9241 “300” subseries
8	Requirements for displayed colours	Replaced by the ISO 9241 “300” subseries
9	Requirements for non-keyboard input devices	International Standard (intended to be replaced by the ISO 9241 “400” subseries)
11	Guidance on usability	International Standard
12	Presentation of information	International Standard (intended to be replaced by ISO 9241-111 and ISO 9241-141)
13	User guidance	International Standard (intended to be replaced by ISO 9241-124)
14	Menu dialogues	International Standard (intended to be replaced by ISO 9241-131)
15	Command dialogues	International Standard (intended to be replaced by ISO 9241-132)

Part no.	Subject/title	Current status
16	Direct-manipulation dialogues	International Standard (intended to be replaced by ISO 9241-133)
17	Form filling dialogues	International Standard (intended to be replaced by ISO 9241-134)
20	Accessibility guidelines for information/communication technology (ICT) equipment and services	International Standard
Introduction		
100	Introduction to software ergonomics	Planned
General principles and framework		
110	Dialogue principles	International Standard
111	Presentation principles	Planned to partially revise and replace ISO 9241-12
112	Multimedia principles	Planned to revise and replace ISO 14915-1
113	GUI and control principles	Planned
Presentation and support to users		
121	Presentation of information	Planned
122	Media selection and combination	Planned to revise and replace ISO 14915-3
123	Navigation	Planned to partially revise and replace ISO 14915-2
124	User guidance	Planned to revise and replace ISO 9241-13
129	Individualization	Planned
Dialogue techniques		
130	Selection and combination of dialogue techniques	Planned to incorporate and replace ISO 9241-1:1997/Amd 1:2001
131	Menu dialogues	Planned to replace ISO 9241-14
132	Command dialogues	Planned to replace ISO 9241-15
133	Direct-manipulation dialogues	Planned to replace ISO 9241-16
134	Form-based dialogues	Planned to replace ISO 9241-17
135	Natural language dialogues	Planned
Interface control components		
141	Controlling groups of information (including windows)	Planned to partially replace 9241-12
142	Lists	Planned
143	Media controls	Planned to partially revise and replace ISO 14915-2