# Display usability, performance specifications and standards

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**Abstract**

This contribution establishes relations between display usability, intended context of use and compliance testing via measurement, modelling and field assessment. It reports on the current status of international standards for electronic visual displays in general (across a multitude of organisations) and provides details on the work currently carried out and scheduled specifically in the working-groups of IEC TC110 (*display device specifications*) and in the WG2 of ISO TC159/SC4 (*ergonomics of displays and their applications*). The current revision and major extension of ISO 13406-2 is introduced (being submitted for voting as ISO 9241) and the work currently carried out in IEC TC110, especially that on metrology for PDPs, LCDs and OLED-displays is described. We also report on an encouraging move currently initiated in the IEC to provide the customer with reasonable data for comparison of different display technologies, the positive example of a joint working group (TC100 and TC110) established for developing a rational basis for comparing the *power consumption* of TV-sets with PDPs and LCDs.

**Keywords:** **Display usability, measurement and characterisation, Display measurement standards, specmanship, Electronic visual displays, ergonomy, metrology, ISO 13 406-2, ISO 9241, IEC TC 110, IEC TC 100**

## Contents



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## Introduction

Far from their innocent appearance and our sometimes naive perception of standards as being a basis that helps to mate e.g. an electrical plug with a socket (just travel to a foreign country to verify this presumption), standards have become a serious matter of competition in electronics business these days.


The ballyhoo of manufacturers and vendors confronts the customer with choices between a contrast ratio of 10 000 for a PDP-based TV-set and a contrast ratio of 500 for a LCD-TV (both measured but not used in a dark room), digital still cameras are rated by the millions of pixels that are integrated on their opto-electric transducer chip neglecting the fact that there is an optical system in front of the transducer that has some effect on what is finally captured from a given scene [Don Williams: "Debunking of Specsmanship: Progress on ISO/TC42 Standards for Digital Capture Imaging Performance“, IS&T-PICS2003]. Data and video projector manufacturers have introduced a new unit of measurement in photometry which is called „ANSI lumen“, and LCD-monitors recently feature "response times“ (unspecified quantity) of 2 ms (compare Edward F. Kelley: "What Do the Specifications Mean ?“, 2004 SID ADEAC).

This escalating hype of "dizzying performance specifications“, also known as "specmanship“ has created a bazaar-like atmosphere where manufacturers’ claims of contrast, response times, brightness, crispness of colours, etc. sound like those of common market barkers. This atmosphere unfortunately penalises those companies that want to stay honest and reasonable, since they are running the risk of perishing in that cacophony of marketing blatancy.

The seriously exerted user of electronic display devices wants to have a reliable (i.e. unbiased), understandable and reasonable basis of data describing the performance of the product according to its application as a solid basis for a purchasing decision without ensuing hangover and regrets. At the same time the customer has to realise, that some products just have become so sophisticated that their performance cannot be simply measured and characterised by one integral "figure of merit“ rating. Depending on which application we have in mind (office work, video and movies, graphics and design, computer games, home cinema, nomadic ICT devices, etc.) we must place emphasis on different individual aspects of performance, at least as long as the *ideal display* is not yet available at affordable prices. That simply means, also the user has to continue the process of education and learning. This continuing education process is of even more importance for all those that are involved in the making of public opinion by publishing of technical articles, websites, TV-shows and other educational measures.

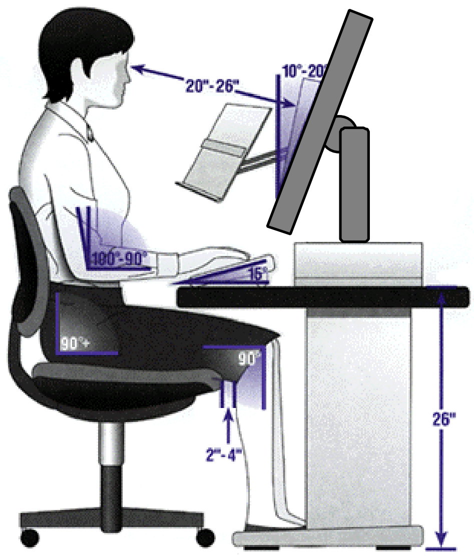
There are more responsibilities on the other side: those who publish performance specifications have to stay realistic and perform their measurements and evaluations with due care and responsibility and those who make standards according to which the performance is assessed and characterised must make sure that they provide standards and measurement procedures that are non-ambiguous, robust and yielding significant results.

These days however, it is not a lack of standards that is contributing to the current confusion of the public (from the interested layperson to the ambitious specialised journalist), but rather the variety of not or badly synchronised, sometimes even contradictory standards.

## From display application to display specification

Everyone wishing and planning the purchase of a visual display device would like to carry home a product that is fulfilling his/her requirements as good as possible and at an affordable price. The degree the display fulfils the requirements of the user is named ***usability***.

***Usability*** is the measure and multidimensional attribute of ***ease & efficiency*** with which *users* of a product can employ that particular device in order to carry out a specific task. ***Usability*** of visual displays, when considered from a systems perspective, should be comprising the hardware, the software and its interfaces, (the documentation, packaging, etc.) and any other aspect that affects the user. Also the *context of intended use* (i.e. the *task* to be carried out and the *application* situation) have to be taken into account in the process of usability rating.




| | |
|---|---|
| Workplace situation with computer monitor and keyboard; position and posture of single observer/user are quite well defined. | Television entertainment situation with a multitude of observers; any position and posture of observer is possible. |

**Figure 1:** Workplace (left) and entertainment scenario (right) with electronic display devices

**ISO 9241 defines usability as follows:**

The **effectiveness**, **efficiency** and **satisfaction** with which specified **users** achieve specified **goals** in particular **environments**.

- **effectiveness:** the accuracy and completeness with which specified users can achieve specified goals in particular environments.
- **efficiency:** the resources expended in relation to the accuracy and completeness of goals achieved
- **satisfaction:** the comfort and acceptability of the work system to its users and other people affected by its use.

***Usability*** of electronic displays can be rated from ***modelling*** (i.e. from a detailed model of the intended use together with suitable performance specifications for the display and the user, also comprising the task and the environment) and it can be rated by application of well-defined standardised in-situ ***assessment methods***.

In the process of defining a list of required or wanted performance features for the “optimum display” for a specific purpose we should start with an analysis of the ***context of intended use***.

## Context of intended use

### Task to be performed

- **Work** (office work, text processing, CAD, etc.)
- **Entertainment** (Video, TV, games, etc.)
- **mixed and other tasks**

### Application situation

- **Conditions of observer** (impairment of vision, etc.)
- **Conditions of observation** (location of observer, degrees of freedom of observer, number of observers, etc.)
- **Ambient conditions** (illumination [spatial and spectral distribution of light sources, intensities and dimensions, etc. ], temperature, humidity, noise, etc.)

**Intended context of use, definition according to ISO 9241-307**

Attributes concerning ***user***, ***environment***, ***tasks*** and the ***use of the technology*** are derived by an ***analysis of the intended context of use*** as they are essential and prerequisite for the compliance assessment. Therefore, different context elements of those described in this method could influence the pass/fail criteria.

The supplier shall specify the intended context of use as well as the value or value range of an attribute. The values specified shall match with the intended context of use. The intended context of use is part of the ***compliance report***.

While the *context of use* was well defined and delimited in the title of the standard ISO 13 406-2 as: “*Ergonomic requirements for work with visual displays based on flat panels*”, this is not so easy in the successor standard series ISO 9241-300 “*Ergonomics of human-system interaction - Ergonomic requirements and measurement techniques for electronic visual displays*” which covers *all display tasks and applications* (from office work and mobile work to entertainment) and *all available display technologies*.

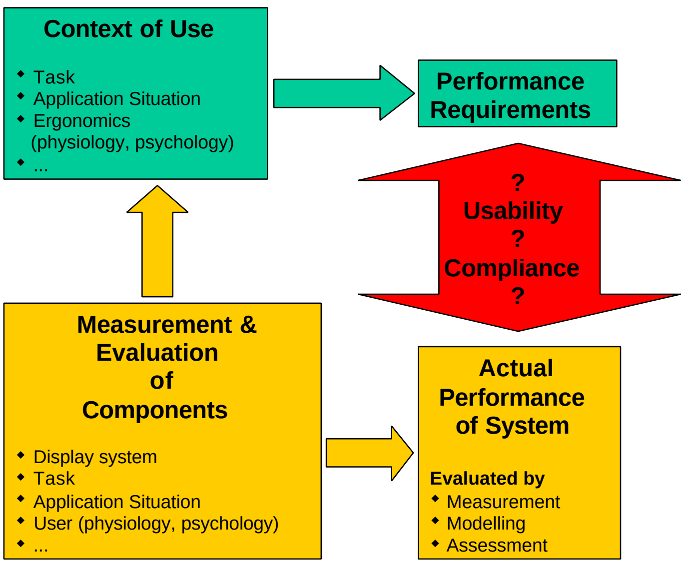



**Figure 2:** Block diagram illustrating the paths to *rating of usability* and *performance compliance*

Figure 2 illustrates the paths that are leading to the rating of usability which is equivalent to rating the compliance with respect to minimum performance requirements as done in ergonomics standards, e.g. ISO 13 406-2 and ISO 9241-300.

A basic component in this context is the analytical evaluation of performance features of the building blocks of the system (comprising display & visual content, task, observer and ambient). Information obtained from measurements take part in the definition of performance requirements (e.g. which contrast is required ?) and they are the basis for specification of the performance of the complete system in the actual application situation (which should be as close to the intended context of use as possible).

It is a common misconception that (numerical) modelling will eventually replace measurements, but all models are based on generalised experimental results (rules and laws expressed in mathematical formalism) and any model can only be as good as its components are described completely and accurately in terms of physical quantities tha have to be measured. The convenience of modelling is the accurate control of parameter values and the flexibility for modifications once the basics are defined.

This general statement can be illustrated by the evaluation of a display in various ambient illumination conditions. Alternative 1: the display is placed in the *context of use* (e.g. on the desk in an office) and the illuminations sources in the ambient are placed, fixed adjusted, and given time to warm up before one measurement is carried out - OR - alternative 2: the BRDF (i.e. *bidirectional reflectance distribution function*) and other electro-optical characteristics of the display are measured and then the context of use is put together in a simulation software and the desired result (e.g. contrast in the presence of reflections) is evaluated numerically. While the experimental approach requires new measurements every time one parameter is changed (e.g. luminance of light sources), the modelling does the same with just one modified parameter value. A further advantage of the modelling is the easy separation of otherwise coupled parameters, e.g. the variation of the spectrum of emission of incandescent bulbs (i.e. correlated colour-temperature) with varying luminance.

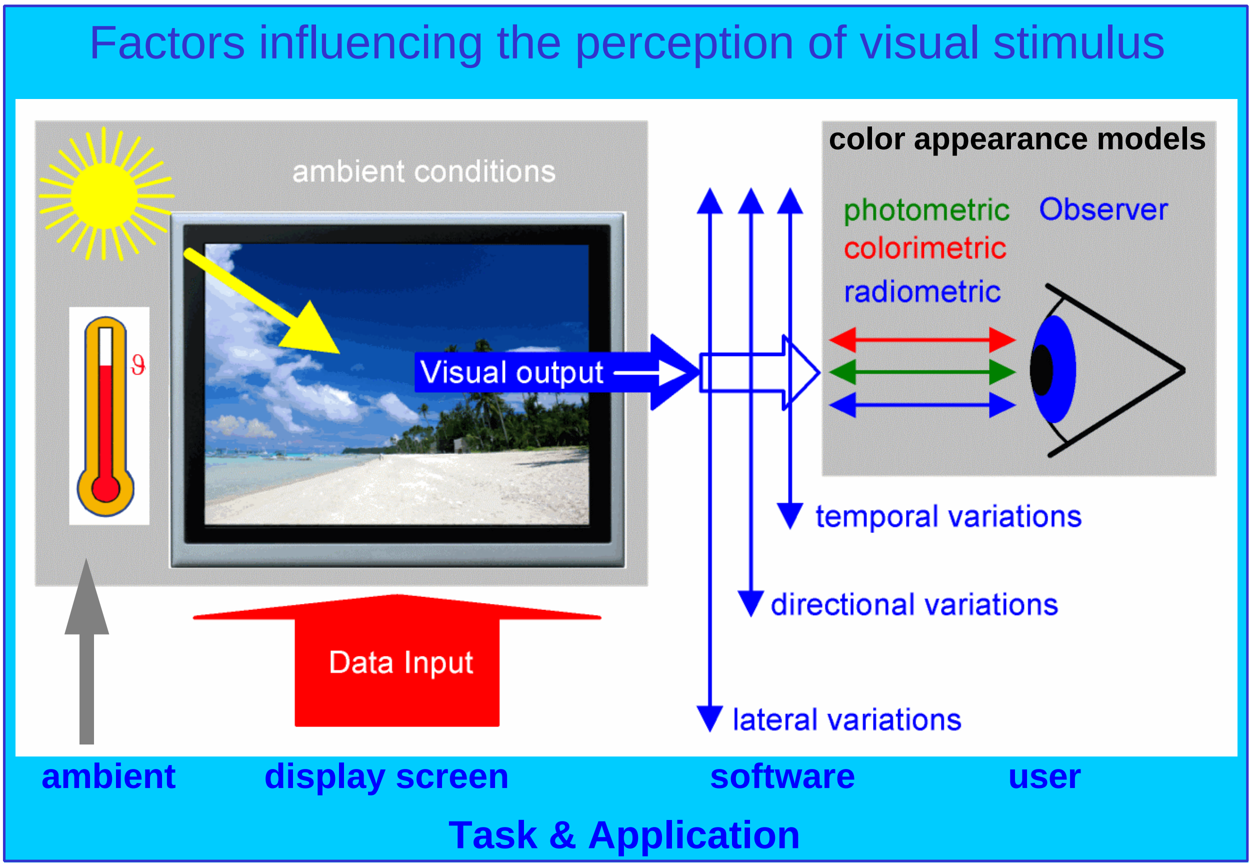



**Figure 3:** Schematic representation of factors influencing the perception of visual information.

Since especially in optical metrology the instruments used and their settings, the arrangement with respect to the object of measurement may significantly affect the results (e.g. BDRF), such measurements and related evaluations have to be described unambiguously and in detail by (international) standards and application of these standards should be mandatory throughout the world whenever performance characteristics are evaluated that are influencing purchasing decisions (e.g. performance specifications as provided in product data-sheets).

These days it is not only the lack of standards in certain areas (standards are created much slower than the respective products !), it is also the multitude of different and sometimes contradicting standards that is exploited by certain companies to confuse the customer with an avalanche of numbers (which are sometimes meaningless or jerked out of context).

This unpleasant situation could be improved by two measures:

- the most prominent international standards organisations ISO and IEC must take action to monitor and adjust the process of standards-making (sometimes overlaps and discrepancies are existing under the same roof, e.g. in the IEC: LCDs in multimedia equipment [TC100] and LCDs as devices and components [TC 110]) and to synchronise the contents of the standards, especially measurement methods, definition and evaluation of the final results and characteristics.

- those who are bamboozling and cheating with product performance specifications in order to present their product from the "sunny side" to gain commercial advantages must be exposed and doomed in public. Consumer protection organisations in cooperation with other parties should publicly denounce such misbehaviour in order improve the ethics in this field.

In addition to my naive postulation above I have one more "candid" claim for all of us: we, the customers, have to continue improving our knowledge about technical devices and technology if we want to become or stay able to make solid purchasing decisions. The increasingly complex electronic devices in our world just cannot be rated by a single *figure-of-merit* any more, but we have to learn to judge the ***usability*** for our ***context of use*** even if there is more than a single performance characteristic involved in the rating process. This applies above all to those with responsibility toward the public (e.g. specialised journalists) because of their multiplier function in the formation of public opinion.

With the current convergence of applications (e.g. mobile communication merges with data-processing, computing, web-services, games and video entertainment, etc.), performance requirements for *multipurpose displays* have the tendency to become more severe. However, as long as the ***ideal display*** is not yet available at reasonable prices, the price/performance ratio can still be optimised for limited ranges of the ***context of use***.

## Protecting the user ...

Even though display manufacturing has somehow moved out of the western part of the world this region has positioned itself in the meantime as the worlds biggest market for electronic displays. In addition to that, the Americas and Europe have established industries that are purchasing "raw displays" from Asia and refine and improve them in specific aspects for use in special applications (e.g. industrial, medical, etc.) or integrate them into highly sophisticated systems (e.g. control room display-walls, 3D-displays, etc.). It should therefore be of vital interest for the western industry that is buying displays for their products as well as for the customer (both private and corporate) to actively contribute to the making of standards.

The international standard ISO 13406-2 shows that a standard can actually help to advance technology and the quality of products to which we are exposed for many hours every day. If the European Union really wants to provide contributions to the well-being of its citizens in the *information society* of today and of the future, it should eventually take action and support European contributions to international standards making bodies by funding of travel expenses and expert resources (after identification and prioritisation of the needs).

## Performance specifications for standards

The functional requirements of standards has been specified by the ISO and IEC as follows (ISO / IEC Directives, Part 3: *Drafting and Presentation of International Standards*):

"*The objective of a data sheet is to define clear and unambiguous provisions in order to facilitate international trade and communication.*

*To achieve this objective, the data sheet shall be as complete as necessary; consistent, clear and concise; and comprehensible to qualified persons who have not participated in its preparation.*"

We can compile a list of *basic performance requirements for metrology standards* in the field of electronic display devices with the following one being based on a selection of Ed Kelley (e.g. Short Course *Display Metrology*, SID'05). Measurement methods described in standards and used industry have to be…

- **Reproducible:** Following the method everybody can obtain the same results from the same device under test using specified instrumentation (basic requirement for any metrology).
- **Robust:** The method must be insensitive to small changes in apparatus and geometry. This is most important for realising reproducibility.
- **Unambiguous:** The method must be described clearly and it must be easily understood (see above ISO/IEC directive). All details that are important for implementatioon and accomplishment of the method must be disclosed.
- **Extensible:** The method should be applicable to a wide range of different display technologies thus permitting comparisons across technologies.
- **Distinct:** The name of each measurement method must be chosen so that it is not confused with another procedure.
- **Honest:** The measurement method shold not be devised to hide deficiencies.
- **Accommodating:** The method shall allow for a broad range of metrology instruments.
- **Accessible:** The approach shall not prescribe and require the use of unusual, highly specialized, or hardly accessible instrumentation or methods (e.g., people who influence written standards should not turn standards into marketing instruments for their products).
- **Simple:** Procedures should be as uncomplicated as possible, avoiding deliberate obscuration by elitism for restricted commercial exploitation (e.g., deliberately making standards so difficult to use that only a few experts and laboratories can realise it).
- **Meaningful:** The methods must properly take into account the human physiology and psychology in the definition of quantities the be measured and characteristics to be evaluated. Measuring *what the eye sees* should never be sacrificed in display metrology for other objectives.

One advice should be added to that list: "In case of the slightest doubt, repeat the measurement until the doubts are dispersed.

## Exorcising confusion - an ecouraging first step

The market of large-area TV-sets recently has advanced to be champion with respect to continually increasing growth rates, thus duplicating the success of LCD-computer monitors in the last couple of years. Besides the CRT, which however are hardly suited for display diagonals beyond 32 inch, there are three major technologies readily available: LCDs, PDPs and rear-projection TV-sets.

The customer in his attempt to make a decision for one of the technologies may also wonder about the "power consumption" (i.e. the power *dissipated* by the device) of the three technologies. Amazingly (or not) it turns out that the "power consumption" of PDPs (and CRTs) is a function of the visual information that is displayed on the screen. The power is maximum for a full-white screen and minimum for a black screen. But what is the power required for displaying a "typical TV-program image content" averaged over e.g. a year ? The power "consumed" by LCD-TV-sets on the other hand is not depending on the displayed information. So how could these technologies ever be compared by a layperson ?

Since "power consumption" has occasionally become a topic of national and global relevance, sufficient momentum has been created to initiate a joint working group in the ICE to bring together experts from the TC100 (multimedia equipment) and TC110 (flat panel display devices) to work out a measuring method for objective evaluation of the power input of TV-sets with both LCD and PDP screens.

This horizontal synchronisation between technical committees and working groups in the IEC that are taking care of different display technologies and different applications is a very encouraging start that should be expanded to also cover other urgent topics. It has been proposed that measuring methods for key visual characteristics like contrast, colour gamut, etc. should be included in the agenda of such a horizontal working group, especially when it comes to measurement of these quantities under ambient illumination. Up to now, the contrast of a PDP panel is measured in a way that is different from the contrast measurement of LCDs and the contrast measurement method under ambient illumination for PDPs (and, derived thereof for OLED displays) is using an arrangement that does not support reproducibility.

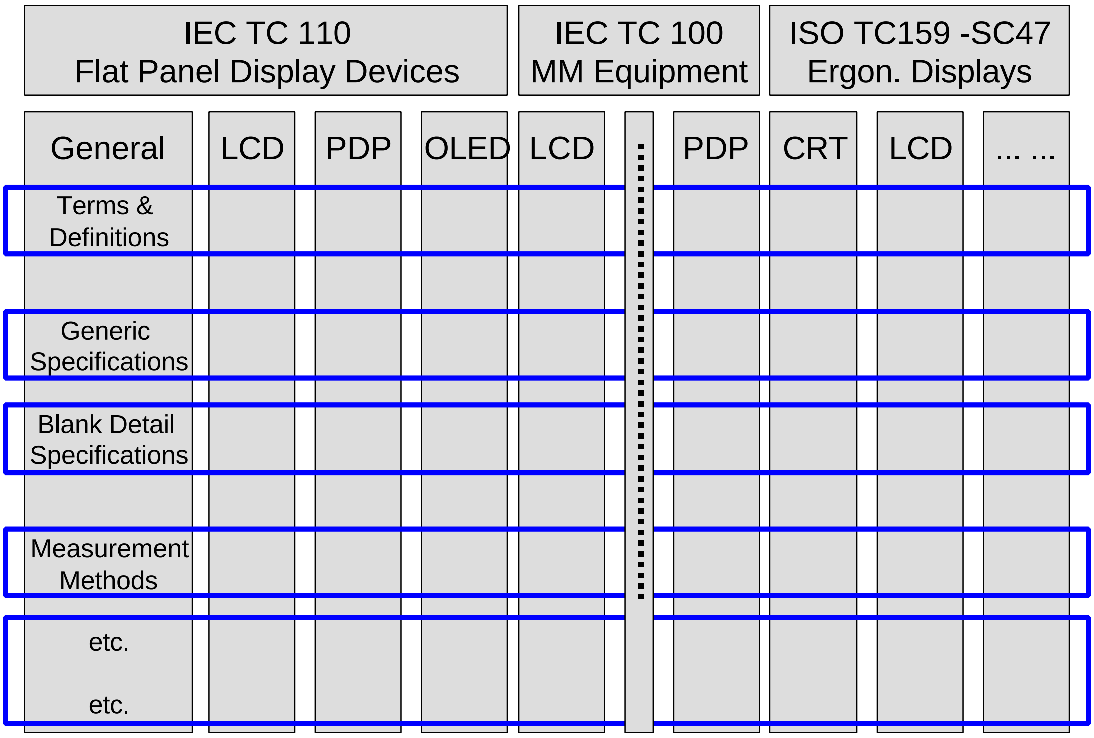



**Figure 4:** Synchronisation of standardisation activities across standardisation organisations, committees and sub-committees, technologies and applications.

Three *new work items* have been introduced, discussed and worked on during the TC110 meeting in Delft in September 2005:

- IEC 61747-5-2: Liquid crystal display devices – Visual Inspection of Active Matrix Liquid Crystal Displays 110/15/NP
- IEC 61747-6-2: Liquid crystal display devices – Measuring methods for liquid crystal display modules – Reflective type 110/41/NP
- IEC 61747-6-3: Liquid crystal display devices – Motion Artifact Measurement of Active Matrix Liquid Crystal Display Modules 110/37/NP

## Measurement Methods for Reflective LCDs

### Standard Measuring Conditions (proposal in working document)

- Introduction into measurement and evaluation of reflectance
- Introduction of the BRDF and its measurement
- Basic illumination geometries (according to CIE 38)
  - *directional illumination*
  - *conical illumination (intermediate state)*
  - *hemispherical illumination*

- Standard measuring geometries
  1. directed illumination
  2. ring-light illumination
  3. conical illumination
  4. hemispherical illumination

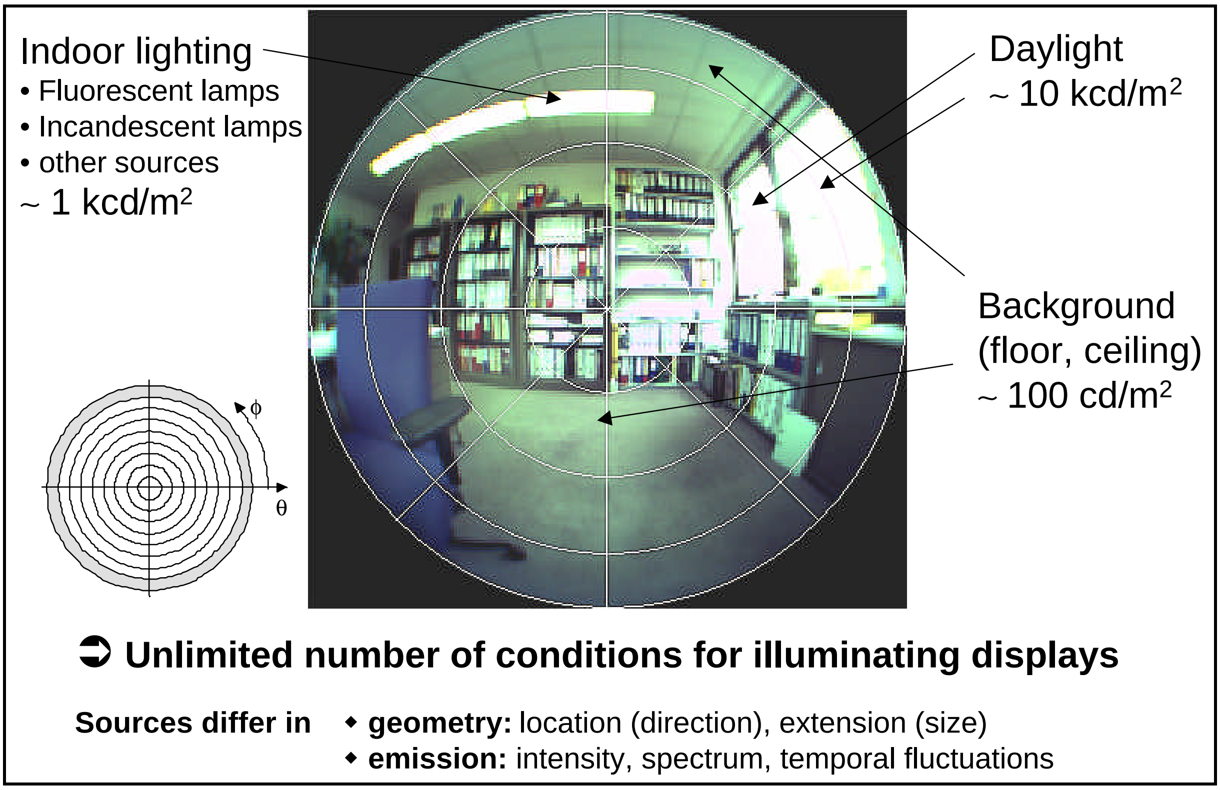



**Figure 5:** Illumination conditions in a typical office environment "seen" from the perspective of the desktop computer monitor.

The ***measurement methods for reflective LCDs*** will have to specify comprehensively and in detail several arrangements for illuminating the device under test during the measurement procedure which is quite a demanding task, especially since the variation of reflectance is to be measured as a function of the viewing-direction (see M. E. Becker: *Reflections on Measurement Methods*, Information Display 2, 2003, p. 14 - 18). Such a compendium of illumination geometries however, once established, introduced and accepted could be useful for any kind of display for evaluation of the electro-optical characteristics under well-defined ambient illumination and thus eventually fill a gaping vacancy in metrology for electronic display devices. Up to now, only some display manufacturers occasionally publish contrast values that are measured with ambient illumination, however without specification of the illumination geometry (e.g. inclusion or exclusion of specular components, etc.). This is mainly done in order to promote the advantages of LCDs under ambient illumination in comparison to PDP screens (PDP screens produce contrast values of up to several 1.000 in a completely dark room which however decreases to about 1/10 of the contrast of LCD screens at illuminance values of 100 lx and 300 lx).

## Recent insanities in the displays field

The marketing departments in their never-resting efforts to establish special *distinguishing features* for the products of their company sometime pass beyond all limits of reason ... just for the sake of the show:

- Replace the anti-glare layer of LCD-screens by a specular surface (sometimes even anti-reflection coated) and advertise this as a “X-cool" pretending that these measures increases contrast and colour saturation in bright surrounds (which is even true, but only for special conditions). Some publications in the meantime even noticed that this might be a step back in time and visual performance !

- Create a coupling between the intrinsically separated controls of backlight intensity (“brightness”) and “contrast” in LCD-monitors to step back to the contra-intuitive situation we had with CRTs where the "contrast" control sets the maximum white level (via an amplification factor) and the "brightness" control displaces the input signal by an offset along the "gamma-curve" (with positive or negative bias).

- Improve the response-times of your LCD-screen by a factor of 2 by specifying *grey-to-grey transition times* instead of *image formation times* according to ISO 13 406-2. While this could be basically OK, only one transition time is now entered into the datasheet instead of the two transitions according to ISO 13 406-2 (black->white & white->black) and the result is being yelled out proudly ....

Do not listen to specmanship and oversimplified advertising. Remain critical and sceptical, trust your eyes ! Collect substantial information (sometimes not easy to separate the wheat from the chaff, but the louder & more blatant things are offered and advertised, the lower the chance for true values ...) before you choose & buy. Return the goods if they should not perform at the final destination as advertised, expected or promised. Be or become a discerning customer (this applies for private and even more for corporate customers).

## Annex I: Standardisation organisations and activities for electronic displays and related fields of metrology (e.g. photometry, colourimetry, spectrometry, reflectometry, etc.)

- AAPM: American Association of Physicists in Medicine
- ANSI: American National Standards Institute
- ASTM: American Society for Testing and Materials
- CIE: Commission Internationale de l'Eclairage (*Colourimetry of Displays*)
- CORM: Council for Optical Radiation Measurements (USA)
- EIA: Electronic Industries Association (USA)
- JEITA: Japan Electronics & IT Industries Association (former: EIAJ)
- IEC: International Electrotechnical Committee (LCDs, PDPs, OLEDs, etc.)
- IEEE: Institute of Electrical and Electronics Engineers
- ISO: International Organisation for Standardisation (Visual Ergonomics, etc.)
- NEMA: National Electrical Manufacturers Association
- ICOM Greyscale Standard Display Function
- NIDL: National Information Display Laboratory (USA)
- SAE: Society of Automotive Engineers
- SMPTE: Society of Motion Picture and Television Engineers
- VESA: Video Electronics Standards Association (USA)
  *Flat Panel Display Measurement Standard*

An impressive number of standardisation organisations working in the same or in similar fields does not mean impressive results and well organised and classified standards, in the worst case it just means lack of synchronisation and sub-optimal use of resources (continuously re-inventing the wheel).

### Reversal of effect

The variety of different standardisation activities - if not properly synchronised - provide more confusion than help ! The result is:

- contradictory terms and definitions,
- contradictory measurement methods.

The marketing department of display and monitor manufacturers often use the approach of: c*hoosing the "standard" that provides the best numbers* for a given product, a behaviour that contributes considerably to the general confusion.

Who however could support an synchronisation of display standards on an international level ? This question was raised by Jim Greeson in 1994 ("Display Standards in Trouble", ID Magazine 12, 1994, p. 24) and he suggested that the SID may take over this responsibility. The SID then eventually established a *Definitions & Standards Committee* which calls together people from time to time, but the actual activities and the progress of that committee yet remain to become apparent.

It is the conviction of the author that the demanding task of synchronisation of international standardisation activities can only be handled successfully by the major standards organisations, i.e. IEC, ISO, CIE and others.

In this presentation we will restrict ourselves to the display standards of the IEC (*device and component specifications* and *multimedia equipment*) and of the ISO (*ergonomics of display devices* in various applications).

# Annex II: IEC (International Electrotechnical Commission)

The IEC comprises a total of about 180 technical committees and subcommittees with three of them relevant for electronic displays and their applications.

- SC 62B *DIAGNOSTIC IMAGING EQUIPMENT*
- TC 100 *AUDIO, VIDEO AND MULTIMEDIA SYSTEMS AND EQUIPMENT*
- TC 110 *FLAT PANEL DISPLAY DEVICES (*a ***Technical Committee*** since 12/2003)

## IEC Electronic Display Standards - TC 110 Flat Panel Display Devices

- **PDPs** (WG4) IEC 61988 *Plasma Display Panels*
  - Part 1 *Terminology and letter symbols*
  - Part 2.1 *Measuring methods – optical*
  - Part 2.2 *Measuring methods – opto-electrical*
  - Part 3 *Guidelines of mechanical interface*
  - Part 4 *Environmental, endurance and mechanical test methods*

- **LCDs** (WG2) IEC 61747-1/N (patchy structure)
- **OLEDs** (PT) IEC 62341-1/6 *Organic Light Emitting Diode Displays*
- MEMs ...

## Plasma Display Panels (PDPs)

- IEC 61988-1 (2003-08)
  Plasma display panels - Part 1: Terminology and letter symbols
- IEC 61988-2-1 (2002-10)
  Plasma display panels - Part 2-1: Measuring methods - Optical
- IEC 61988-2-2 (2003-02)
  Plasma display panels - Part 2-2: Measuring methods - Opto-electrical
- IEC 61988-3-1 (2005-10)
  Plasma display panels - Part 3-1: Mechanical interface

### Work in progress

- IEC 61988-2-3
  Plasma Display Panels - Part 2-3: Measuring methods - Quality
- IEC 61988-3-2
  Plasma display panels - Part 3-2: Electrical interface
- IEC 61988-4
  Plasma Display Panels - Part 4: Environmental and mechanical endurance test methods
- IEC 61988-5
  Plasma Display Panels - Part 5: Generic Specification

## Liquid Crystal Displays (LCDs)

- IEC 61747-2-1 (1998-10)
  Liquid crystal and solid-state display devices - Part 2-1: Passive matrix monochrome LCD modules - Blank detail specification

- IEC 61747-2-2 (2004-10)
  Liquid crystal display devices - Part 2-2: Matrix colour LCD modules - Blank detail specification

- IEC 61747-3 (1998-03)
  Liquid crystal and solid state display devices - Part 3: Sectional specification for liquid crystal display (LCD) cells

- IEC 61747-3-1 (1998-04)
  Liquid crystal and solid-state display devices - Part 3-1: Liquid crystal display (LCD) cells - Blank detail specification

- IEC 61747-4 (1998-09)
- Liquid crystal and solid-state display devices - Part 4: Liquid crystal display modules and cells - Essential ratings and characteristics

- IEC 61747-4-1 (2004-11)
  Liquid crystal display devices - Part 4-1: Matrix colour LCD modules - Essential ratings and characteristics

- IEC 61747-6 (2004-04)
  Liquid crystal and solid-state display devices - Part 6: Measuring methods for liquid crystal modules - Transmissive type

### Work in progress

- IEC 61747-3
  Liquid crystal display devices - Part 3: Liquid crystal display (LCD) cells - Sectional specification

- IEC 61747-3-1
  Liquid crystal display devices - Part 3-1: Liquid crystal display (LCD) cells - Blank detail specification

### Notes

The scattered patchy structure of the IEC 61747 series is resulting from the fact that LCDs are subdivided in:

- cells (without electronics)/ modules (including electronics),
- active / passive matrix addressed LCDs,
- matrix colour / matrix monochrome type,
- transmissive mode of operation (the reflective mode has to be standardised yet).

### Oddity

Almost 35 years after introduction of reflective LCDs in 1972 there is still no international standard for measuring these devices, however there is a national standard available in Japan.

### Organic Light Emitting Diode Displays (project team PT 62341)

IEC 62341-1-1 Ed. 1.0
Organic Light Emitting Diode Displays - Part 1-1: Generic specifications

IEC 62341-1-2 Ed. 1.0
Organic Light Emitting Diode Displays - Part 1-2: Terminology and letter symbols

IEC 62341-5 Ed. 1.0
Organic light emitting diode displays - Part 5: Environmental and mechanical endurance test methods

IEC 62341-6 Ed. 1.0
Organic Light Emitting Diode Displays - Part 6: Measuring Methods

IEC 62341-6-2 Ed. 1.0
Organic Light Emitting Diode (OLED) Displays - Part 6-2: Measuring Methods of Visual Quality

### Special Standards - High Fidelity Displays

- DIN 15 996 Bild und Tonbearbeitung in Film-, Video- und Rundfunkbetrieben Anforderungen an den Arbeitsplatz (August 2004)

- DIN 6868-57 Sicherung der Bildqualität in röntgendiagnostischen Betrieben Teil 57: Abnahmeprüfung an Bildwiedergabegeräten

- ISO IEC 24 705 Machines for color image reproduction

- ISO 12 646 Graphic technology - Displays for colour proofing - Characteristics & viewing conditions

## Other standardisation organisations of interest

**SMPTE - Society of Motion Picture and Television Engineers**

- RP 145-1999 SMPTE C Color Monitor Colourimetry
- RP 166-1995 Critical Viewing Conditions for Evaluation of Color Television Pictures
- RP 167-1995 Alignment of NTSC Color Picture Monitors
- RP 133-1991 Specifications for Medical Diagnostic Imaging Test Patterns for Television Monitors and Hard Copy Recording Cameras

**ITU-R – International Telecommunication Union**

**EBU - European Broadcasting Union**
Whilst the EBU is not an international standards-setting organisation in the same sense that ISO and IEC are, for example, the EB-Union does establish Standards and Recommendations for adoption within the EBU broadcasting community.

- EBU Technical Standards,
- EBU Technical Recommendations,
- EBU Technical Statements,
- EBU Technical Information documents.

# Annex III: ISO (International Standards Organisation)

## Revisions to ISO 13 406-2

Despite some weak spots this standard for the first time provided a solid basis for measurement and rating of the visual performance of LCD-monitors under realistic ambient illumination conditions. The flaws of ISO 13406-2 that are being corrected during its revision and transformation into ISO 9241 are:

**Image formation times (IFTs)**
- ♦ Full-swing transitions are best-case IFTs for LCDs
- ♦ Moving images (TV, video) feature mainly transitions between intermediate grey-levels
- ➲ Combinations of min. 20 or 72 start and end-levels (5x5 or 9x9 matrix) are required

**Viewing-direction classes (4 classes)**
- ♦ Class IV actually is a *privacy-screen* (not included in scope of standard)
- ♦ Class III represents an *absolute minimum requirement*
- ➲ remaining 2 classes not sufficient

**Pixel-fault classes**
- ♦ Class I zero defects (that's what we all want !)
- ♦ Class II specified # defects per million pixels (# too large)
- ♦ Class III/IV # defects too high

## Suggested revisions & extensions to ISO 13406-2 (among others)

**Viewing-direction classes (4 classes)**
- ♦ Class IV VC of 15° (absolute minimum)
- ♦ Class III VC of 30° (comfortable range) (ITU recommendation for CRT-TV)
- ♦ Class II VC of 45° (multi-user, e.g. TV) (29% geometric distortion @ 45°)
- ♦ Class I VC > 45° (public address)

**Contrast under ambient illumination (@ design VD)**
- ♦ with diffuse illumination of e.g. 250 lx (large aperture source, specular excluded)
- ♦ with directional illumination of e.g. 2000 $cd/m^2$ (small aperture source, specular included)

***Viewing-cone*** (VC) = range of viewing-directions that is usable for the intended application under realistic conditions (e.g. **including** ambient illumination).

A realistic specification of the viewing-cone under ambient illumination is urgently required for replacement of the "*178° viewing angel*" !

## Structure of ISO 9241

**ISO 9241:** *Ergonomics of human-system interaction — Ergonomic requirements and measurement techniques for electronic visual displays*

- ♦ Part 300 Introduction
- ♦ 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