

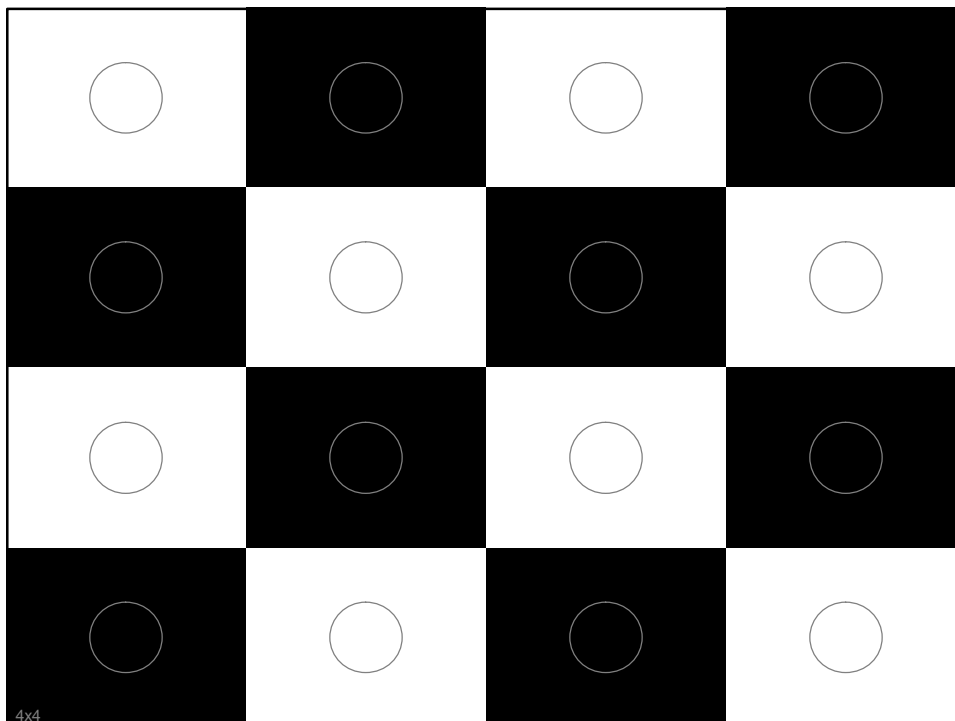
Display Metrology Concerns in International Standards

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WHY IS METROLOGY IMPORTANT FOR DISPLAY STANDARDS?

- **Establish Conformance**
 - *Is the display appropriate for the task?*
 - *Is this the display that I asked for?*
- **Establish Requirements**
 - *What specifications are needed?*

Standards, cont'd.

- **Who writes these standards?**
- **Who uses these standards?**
- **How does the process work?**
 - *ISO—NWI->CD->DIS->FDIS->standard (two years)*
 - *VESA—WG->Committee->BOD->membership->standard (two months)*
- **What are some of the problems/concerns?**

Good Display Metrology—What Is It?

Measurement methods used in standards and industry need to be...

- **Reproducible** — Everybody can get the same results on the same display using appropriate instrumentation. This is probably the most important goal of metrology.
- **Robust** — Insensitive to small changes in the measurement apparatus that will affect the ease with which reproducibility is attained.
- **Unambiguous** — The method is clearly stated and easily understood. Important details that are required for success are not left out.
- **Extensible** — Applicable to as many different technologies as possible permitting intercomparisons of technologies.
- **Distinct** — The name of a measurement method must be chosen so that it is not confused with another metric.
- **Honest** — The measurement method is not devised to hide an obvious deficiency; redefining familiar terms to cloak a problem.

...and we might be tempted to add (sometimes the following are not possible)...

- **Accommodating** — We want to enable as broad a range of apparatus as possible.
- **Accessible** — Requiring the use of unusual, highly specialized, or otherwise arcane apparatus or methods would be avoided unless it is necessary (e.g., for people who influence written standards in order to sell their apparatus when it is not necessary to do so).
- **Simple** — Procedures should be made as uncomplicated as possible, avoiding deliberate obscuration from elitism or exploitation (e.g., deliberately making the standard so difficult to use that only a few experts can use it).
- **Meaningful** — Properly captures the visual experience for task and environment. Measuring what the eye appreciates should not be sacrificed for some related esoteric measurement method of limited use.

Example: Character contrast of a black letter on a white screen must first be measured correctly accounting for veiling glare in the measurement apparatus (discussed later). (Calculating that contrast on the basis of the Gaussian beam profile of an electron beam in a CRT to avoid measuring the real contrast would not be a measurement of the contrast; besides it would be applicable to CRTs.) After a proper contrast measurement is made, if need be, an appropriate vision model can be applied to determine how the eye appreciates that contrast.

Why do we need good display metrology?

● Level Playing Field — Competition

- **Between FPDs within a technology** – Which LCD is better for my purposes?
- **Between different technologies of FPDs** – How do we compare a plasma display with a front-projection display (or HMD)?

● Specification Language Defined

- **Task-dependent specifications possible** – How do the contrast requirements differ for a display used in a dark room vs. a display used in a bright surround?
- **Enables clarity and removes ambiguity** – Why should we use darkroom contrast vs. ambient contrast vs. highlight contrast?
- **Clear and understandable measurement standards**

● Measuring What the Eye Sees

Ergonomics and vision science must be based upon good metrology – “Measure twice, cut once.” It would be sad to set a compliance standard for a minimum contrast if that contrast was measured incorrectly during the research.

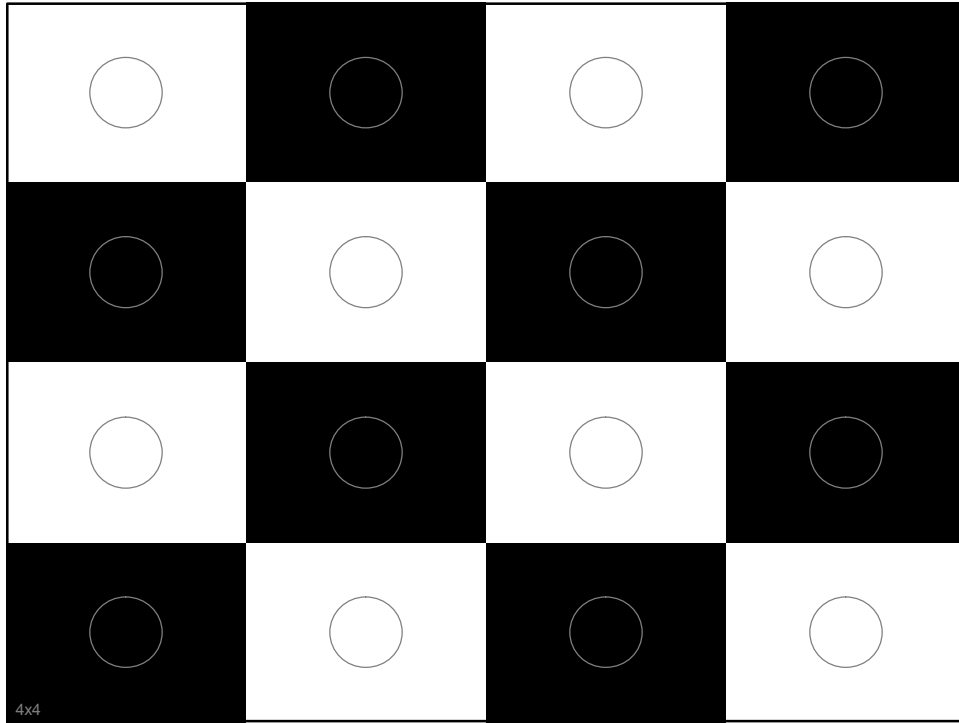
Not So Simple!!!

Complications:

- **Photometry-colorimetry uncertainties START at 1 % level.**
Anticipated luminance uncertainties in the field can be from 2 % to 4 %. Be very happy if you get 1 %!
- **Eye response quasi-logarithmic yet measurement comparisons linearly based, so we don't see some of the problems we are measuring.**
- **Display output can drift in time both in color and luminance.**
- **Measurement can be very sensitive to alignment.**
- **Instruments with a lens may be affected by stray light**

I was telling a non-technical friend that I was involved in making display measurements. He laughed and exclaimed, "What's so hard about that!" Um... it was very hard to explain. How embarrassing!

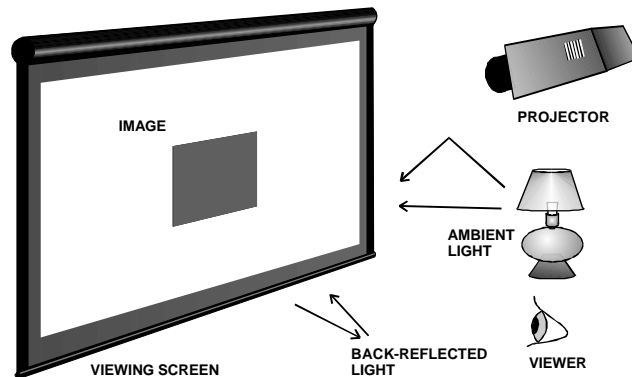




Front Projection and Stray Light

Accounting for Stray Light

Projector should not be blamed for the less than perfect viewing conditions of the screen and room. GOAL: Obtain intrinsic performance of projector

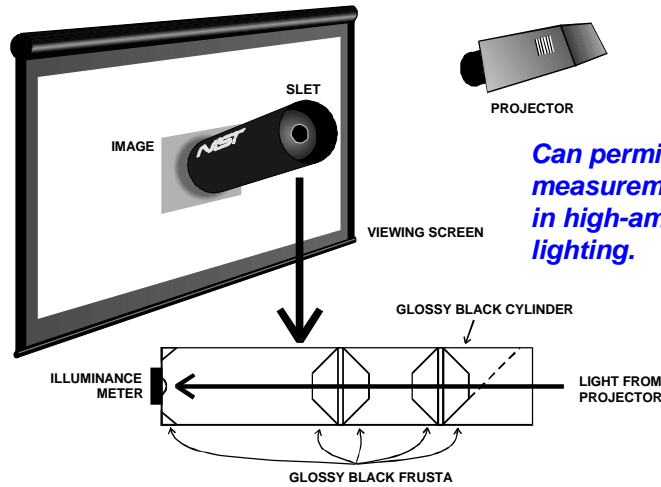


Even in a black-walled darkroom using a black screen with a checkerboard displayed, significant errors of several tens of percent can be made if we are not careful.

Front Projection & Stray Light, Cont.

Stray-Light Elimination Tube (SLET)

Can permit accurate measurements even in high-ambient lighting.

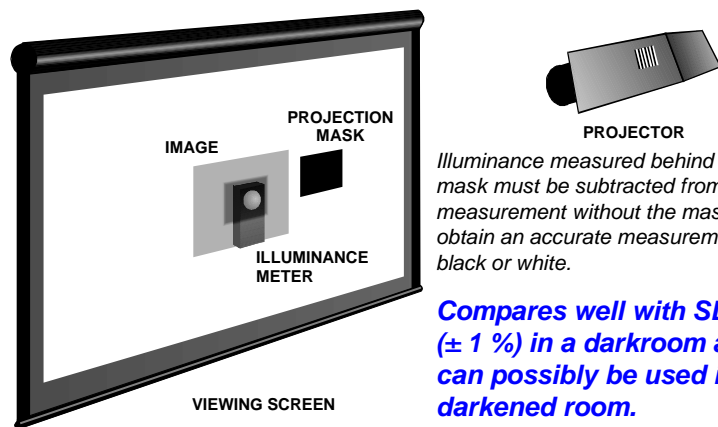


Can permit accurate measurements even in high-ambient lighting.

Front Projection & Stray Light, Cont.

Accounting for Stray Light in Room – Projection Mask

Use a projection mask (wider than the lens diameter) placed from 35 cm to 60 cm from the screen. Objects in room and room walls reflect light from the white screen back into black area. This can be a serious corruption of the black even in a darkroom and even using a black screen!

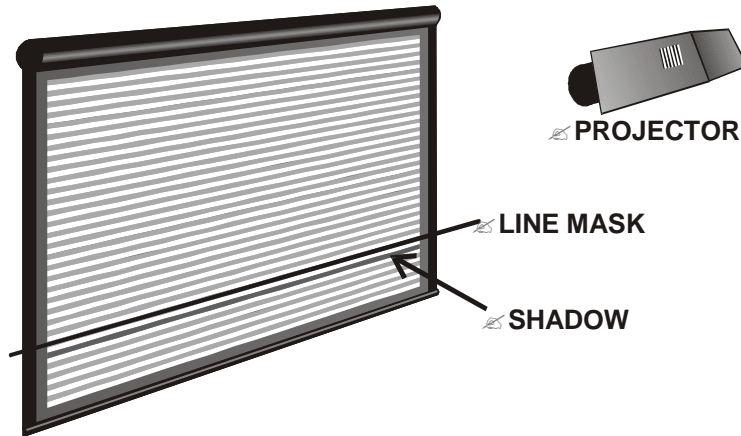


Illuminance measured behind the mask must be subtracted from the measurement without the mask to obtain an accurate measurement of black or white.

Compares well with SLET ($\pm 1\%$) in a darkroom and can possibly be used in a darkened room.

Front Projection & Stray Light, Cont.

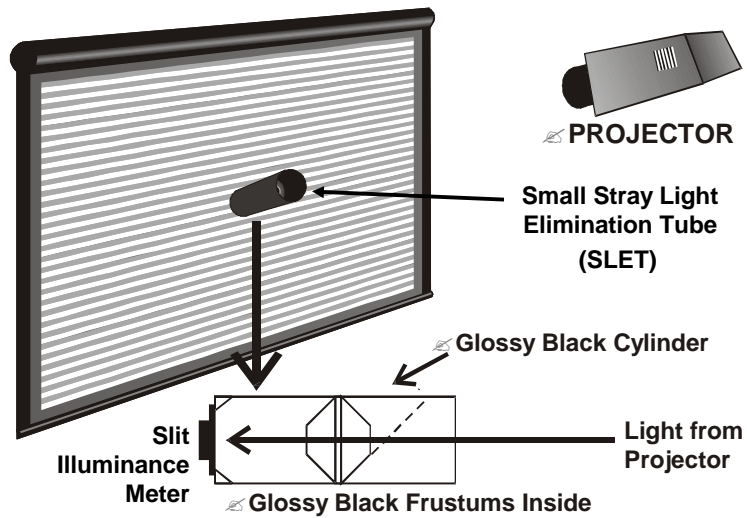
Grille Measurements to Establish Resolution



[See FPDM 303-7: Resolution from Contrast Modulation]

Front Projection & Stray Light, Cont.

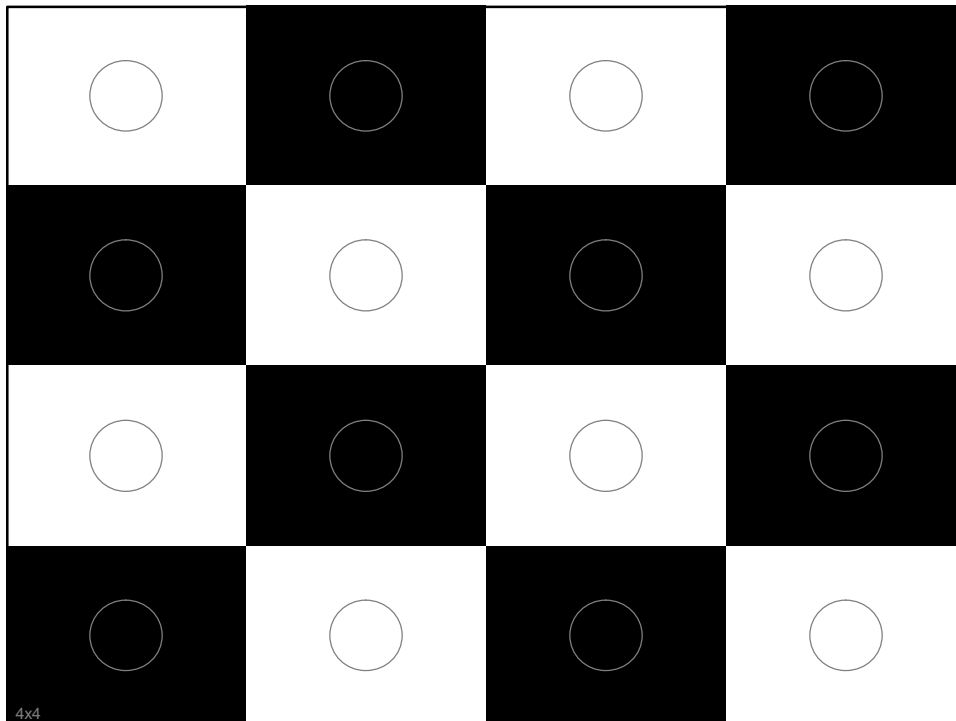
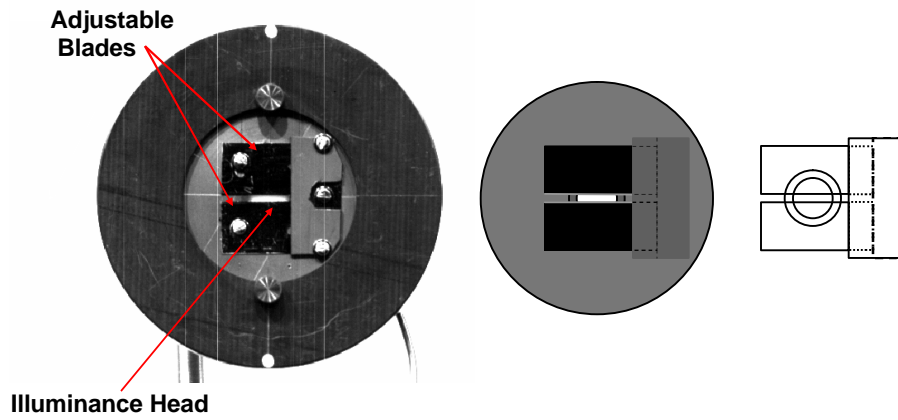
Direct Measurement Using Slit Illuminance Meter



Front Projection & Stray Light, Cont.

Slit Illuminance Meter

Small illuminance head placed behind razor-blade adjustable slit with razor blades painted gloss black. Unit mounts on back of small SLET.



Front Projection & Stray Light, Cont.

The effect of stray light tools

Stray-light tools	Using luminance meter	Using illuminance meter
None	91:1	96:1
Projection Mask	165:1	173:1
SLET	N/A	170:1

Comprehensive Document Available

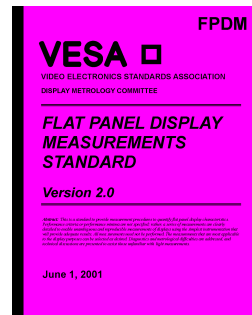
VESA FPDM — Flat Panel Display Measurements Standard

Features:

VERSION 2.0

- Specification of good metrology for displays
- Self-contained measurement procedures
- Buffet of measurements—use what you need
- Easy to use and read
- Extensible—more will be added as needed
- Adaptable—affords a variety of equipment
- Accommodating—special needs permitted
- Metrology Section, Technical Discussions Section
- Includes diagnostics, cautions and hints
- A reasonably priced document (\$40) of over 320 pages—

VESA 408-957-9270



ISO Grand Revision

ISO TC159/SC4/WG2 — Visual Display Requirements

Under Development

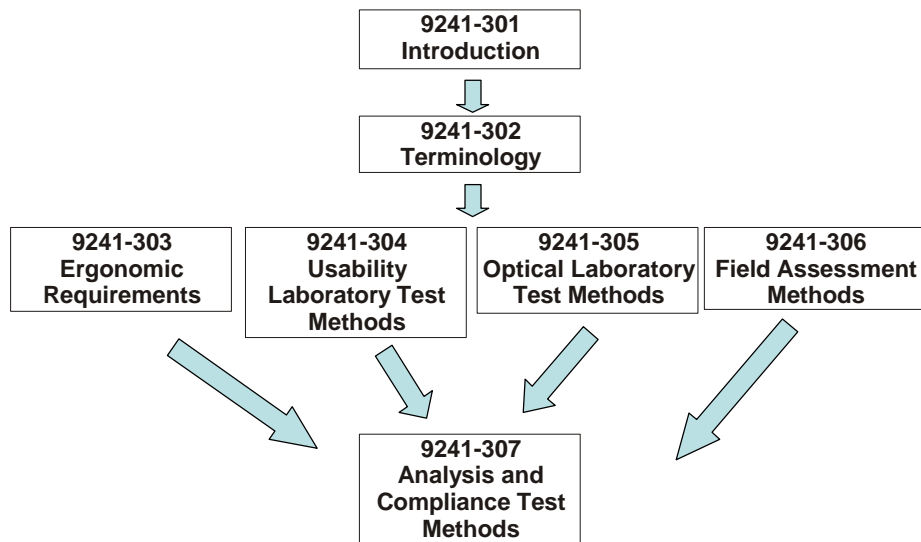
Features:

- Ergonomic standard
- Easier to use and read
- Separate sections for ergonomic requirements, test methods, and compliance routes
- Specification of good metrology for displays
- Combines ISO 13406-2 and 9241-3, 7 & 8
- Scope to be extended to include applications beyond office environment and technologies other than desktop CRTs and LCDs
- Extendable—more will be added as needed

ISO, Cont.

ISO Grand Revision

ISO TC159/SC4/WG2 — Visual Display Requirements



What Is “Good Enough”?

We should not compromise good metrology in favor of tradition when that tradition might be based upon inadequate metrology.

How was that “limitation” of the eye determined? If the instrumentation used to determine the “rule” is not as good as the eye, then what can’t see, the eye or the instrument? What measurements were made? Was the instrumentation capable of an accurate measurement, how do we know?

What diagnostics were performed to prove that the instrument was measuring things correctly? How was “adequately” defined?

Be a skeptic!

ERGONOMICS IN SOME HANDS
CAN BE A DANGEROUS THING!



RUSTIC METROLOGY

Courses & Services at NIST

- NIST Photometry Short Course

http://physics.nist.gov/Divisions/Div844/facilities/photo/Photometry_Course.html

- NIST Spectroradiometry Short Course

<http://physics.nist.gov/Divisions/Div844/events/srsc.html>

- NIST Colorimetry of Displays — A Calibration Facility

http://physics.nist.gov/Divisions/Div844/facilities/photo/Projects/colorimetry_of_displays.htm

Based Upon the Four-Color Matrix Method for
Correction of Tristimulus Colorimeters

- NIST Display Metrology Short Course

Coming soon (hands on lab work)... if this course goes well...
see <http://www.fpd.nist.gov>
or <http://www.fpd.nist.gov>

- NIST Flat Panel Display Laboratory — Publications, Links, Overview

<http://www.fpd.nist.gov> (“FPDL”) or <http://www.fpd.nist.gov>

Slides of NIST seminar on metrology: <http://www.fpd.nist.gov/seminars.html>