Monitor Selection for Industrial Digital Radiography

SAND2012-5623C

Presented by:

Kyle Thompson - Sandia National Laboratories

ASNT Digital Imaging XV

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Who is the FWG-IDR?

- An organization consisting of federal and contractor employees* with responsibilities for the application of nondestructive testing methods. (*Users Group*)
- Dedicated to the advancement of DR within the federal industrial radiographic community.
- Self chartered
- Endorsed by the Defense Working Group on NDT

****Contractor Membership:*** *Contractor Membership is restricted to contractors supporting federal government contracts that require the application of nondestructive testing (NDT), inspection (NDI) and/or evaluation (NDE). Contractors with federal government contracts for development, design, fabrication, assembly and/or delivery of NDT, NDI or NDE inspection systems do not meet the requirements for membership. Contractors can submit membership requests with supporting justification to any Leadership Committee member. Exceptions to these Contractor Membership requirements will only be allowed upon approval of the FWG-IDR Directors.*

In a Perfect World....

- Defect standards, phantoms, and Image Quality Indicators (IQI) insure inspection capability
- Subsystem qualification would not be necessary
- Subsystem monitoring would not be necessary

But We Live in the Real World....

- •Phantoms and Standards are sometimes cost prohibitive
- •Can also be difficult to produce
- •Might change over time (cracks propagate)
- •IQIs may not be representative
- •Sometimes there are ”no defects allowed”

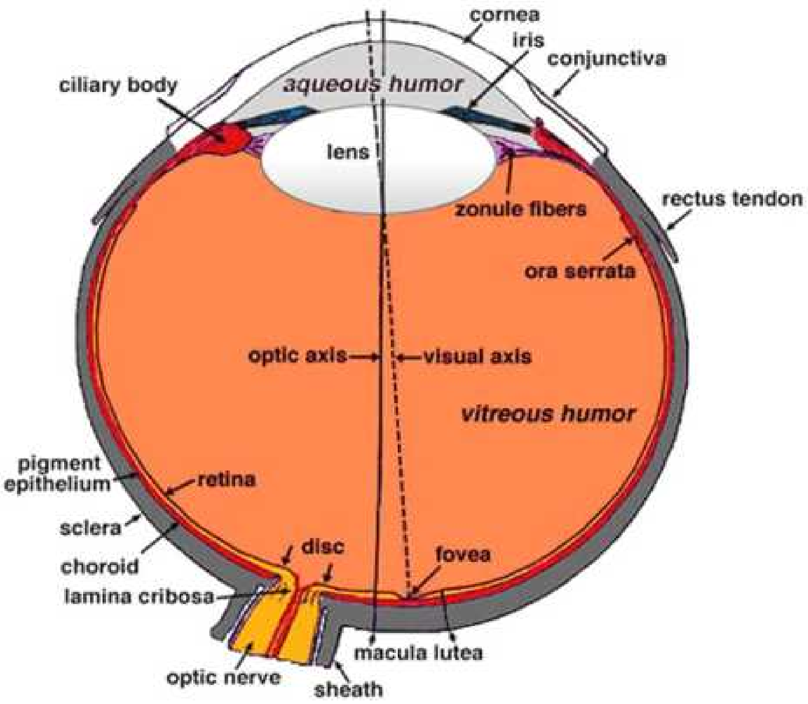
Goals

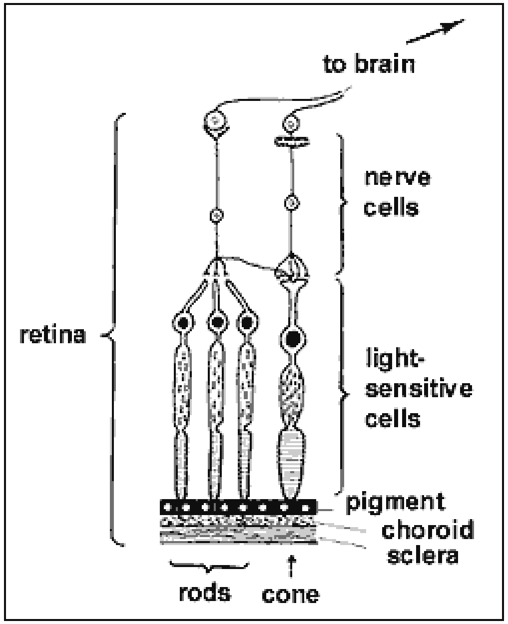
- Research visual capability of the human eye
- Research monitor technology
- Evaluate monitor technologies to determine what is required for image interpretation
- Make recommendation for monitor selection
- Produce white paper containing all of the above
- Review existing work (DICOM)
- Create quantitative method for monitor validation

Assumptions

- Acceptable SNR
- Basically - good quality source images
- Image enhancement and interpretation is a separate issue.

Basic Anatomy of the Eye





Basic Anatomy of the Eye

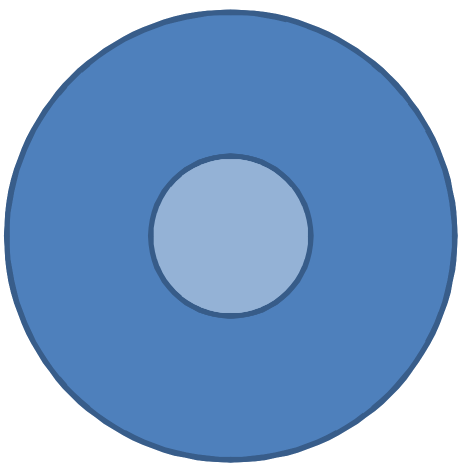
- Rods
  - Low light or night time vision
  - Monochrome vision, One type of Photopigment (rhodopsin)
  - “Scotopic” vision
  - ~ < 1 candela/m^2
  - Peak sensitivity, 507nm (blue)
  - Dark Adaptation (5 minute half-life)
  - ~120 million cells

Anatomy of the Eye (cont)

- Cones
  - Daylight vision
  - Color vision, Three types of Photopigments (cyanolabe, chlorolabe, and erythrolabe)
  - "Photopic" vision
  - ~ > 1 candela/m^2
  - Peak sensitivity 555 nm (green)
  - Light Adpatation (1.5 minute half-life)
  - ~6 million cells

Contrast Sensitivity

- Contrast = Change in Intensity/ Average Intensity
- Webers Law
  - Scotopic Vision – 14%
  - Photopic Vistion – 1.5%



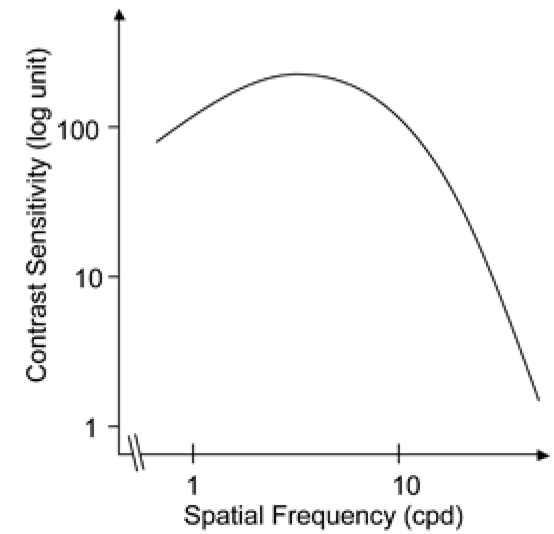


FIGURE 3
Typical shape of the spatial CSF at a photopic level for a subject with a normal visual system.

Resolution Sensitivity

60 cycles/degree or 60 line pairs/degree maximum

30 cycles/degree is common rule of thumb

60 cycles / degree			
Viewing Distance		Line pairs / mm	Pixel Size (mm)
(inches)	(mm)		
6	152	22.6	0.022
12	305	11.3	0.044
18	457	7.5	0.066
24	610	5.6	0.089
36	914	3.8	0.133
60	1524	2.3	0.222
120	3048	1.1	0.443

30 cycles / degree			
Viewing Distance		Line pairs / mm	Pixel Size (mm)
(inches)	(mm)		
6	152	11.3	0.044
12	305	5.6	0.089
18	457	3.8	0.133
24	610	2.8	0.177
36	914	1.9	0.266
60	1524	1.1	0.443
120	3048	0.6	0.887

Dark/Light Adaptation

The process by which the eye adjusts to changing light conditions is similar to radioactive decay.

As Rods and Cones are exposed to light the pigment molecules in these cells bleach (lose the ability to capture light). These molecules spontaneously revert back to the unbleached state.

For Rods the time for half the molecules to revert back is 5 minutes (i.e. 5 minute half-life)

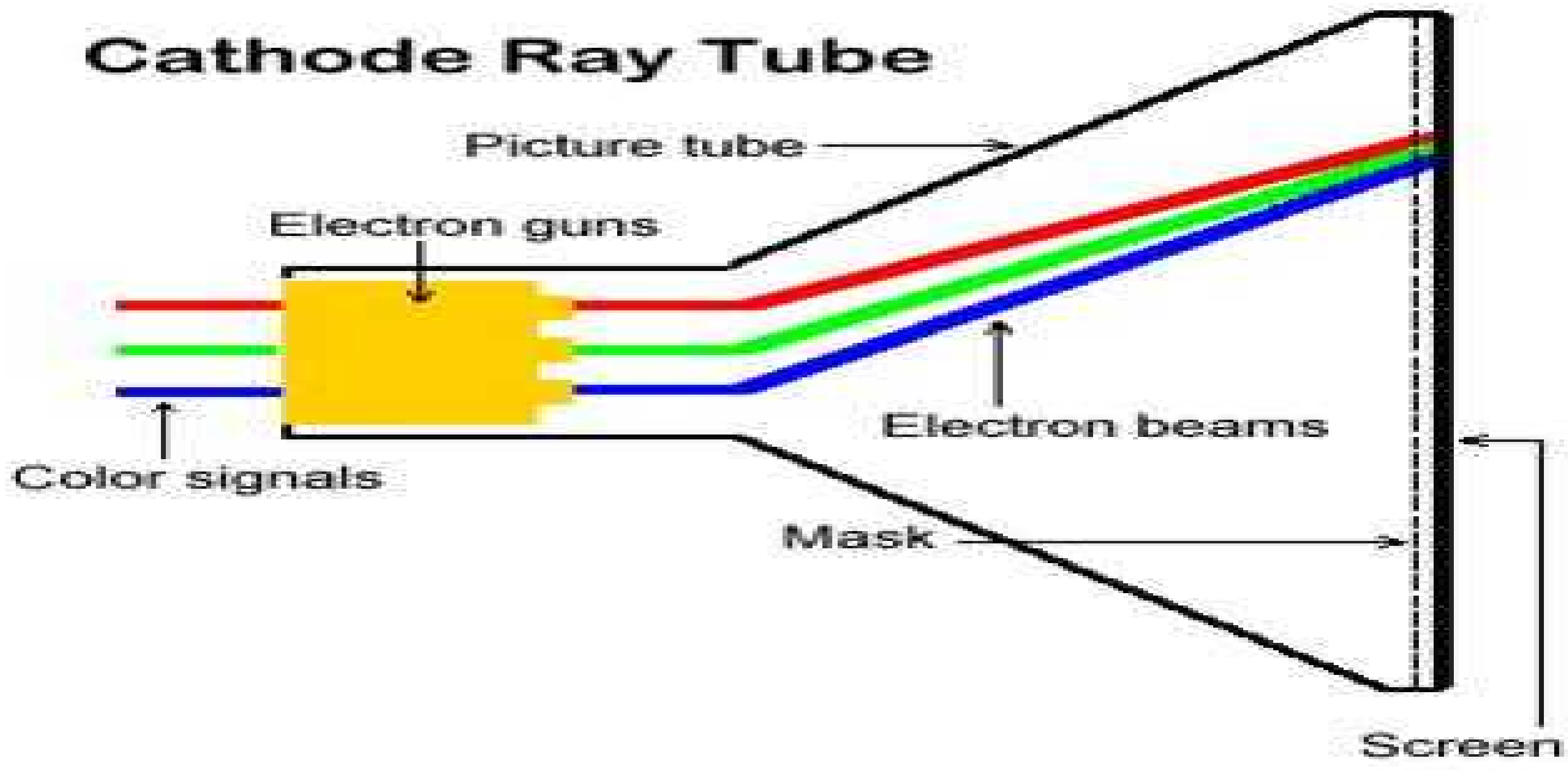
For Cones the half-life is 1.5 minutes

Depending on the ambient lighting conditions it will take *minutes* for yours eye to adjust.

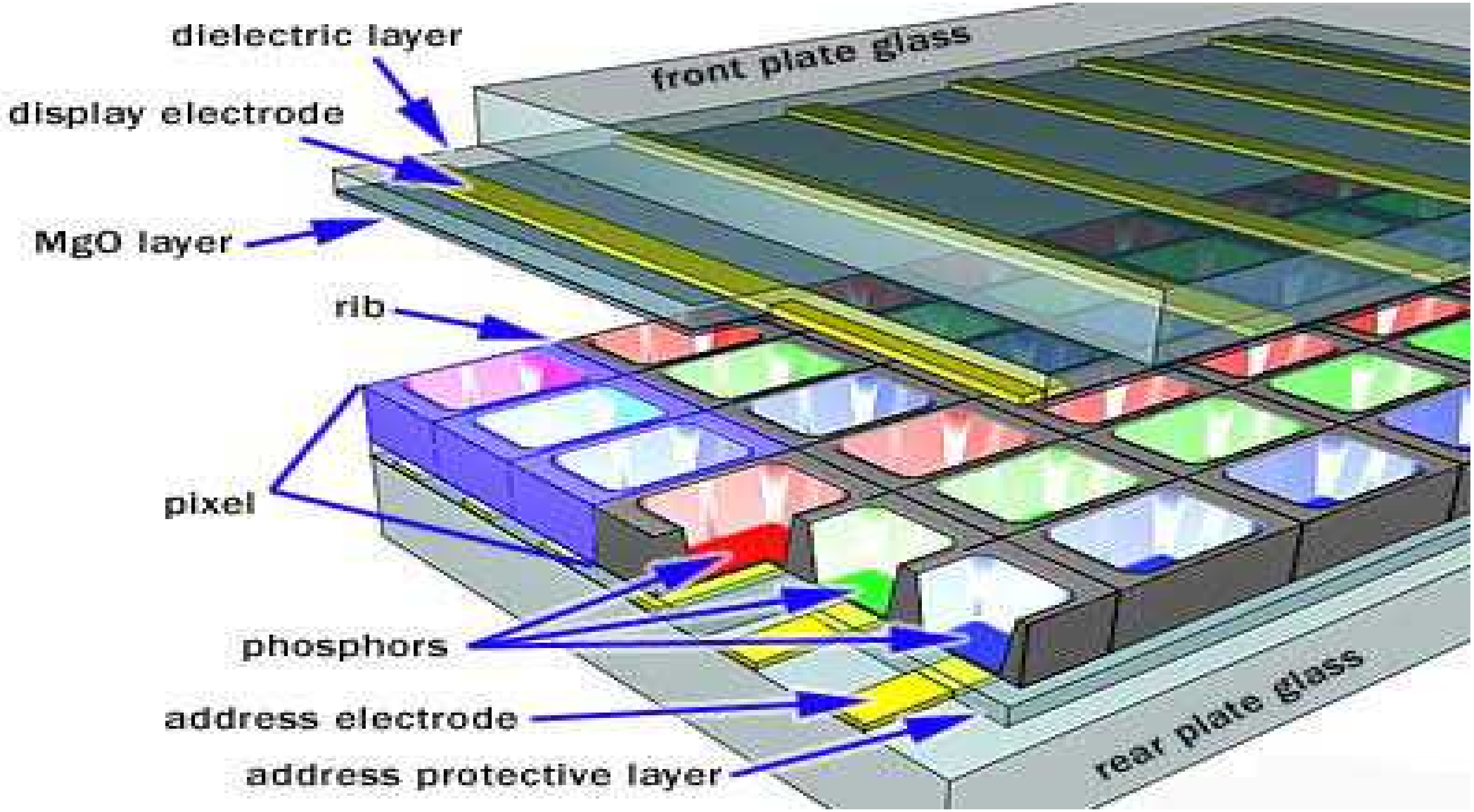
Display Technology

- Projectors – digital
  - Pros – larger screens available
  - Cons – poor dynamic range, less resolution
- CRT – analog
  - Pros – brighter, no viewing angle issues
  - Cons – bulky, subject to distortion, subject to burn in
- LCD/LED – digital
  - Pros – sharp image, no issues with burnin
  - Cons – restricted viewing angle
- Plasma - digital
  - Pros – good contrast, no viewing angle issues
  - Cons – subject to burn in, only used for televisions

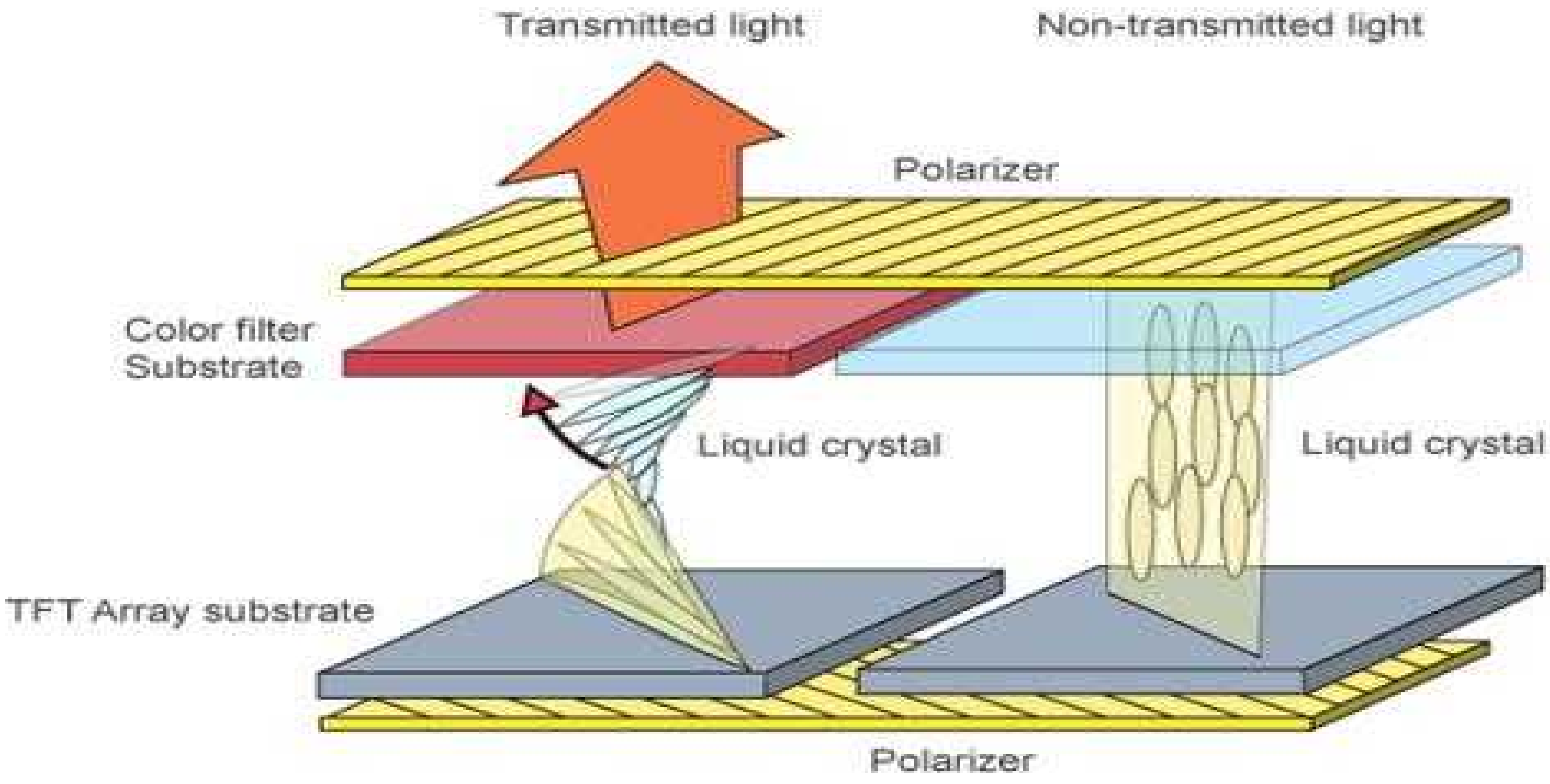
CRT Displays



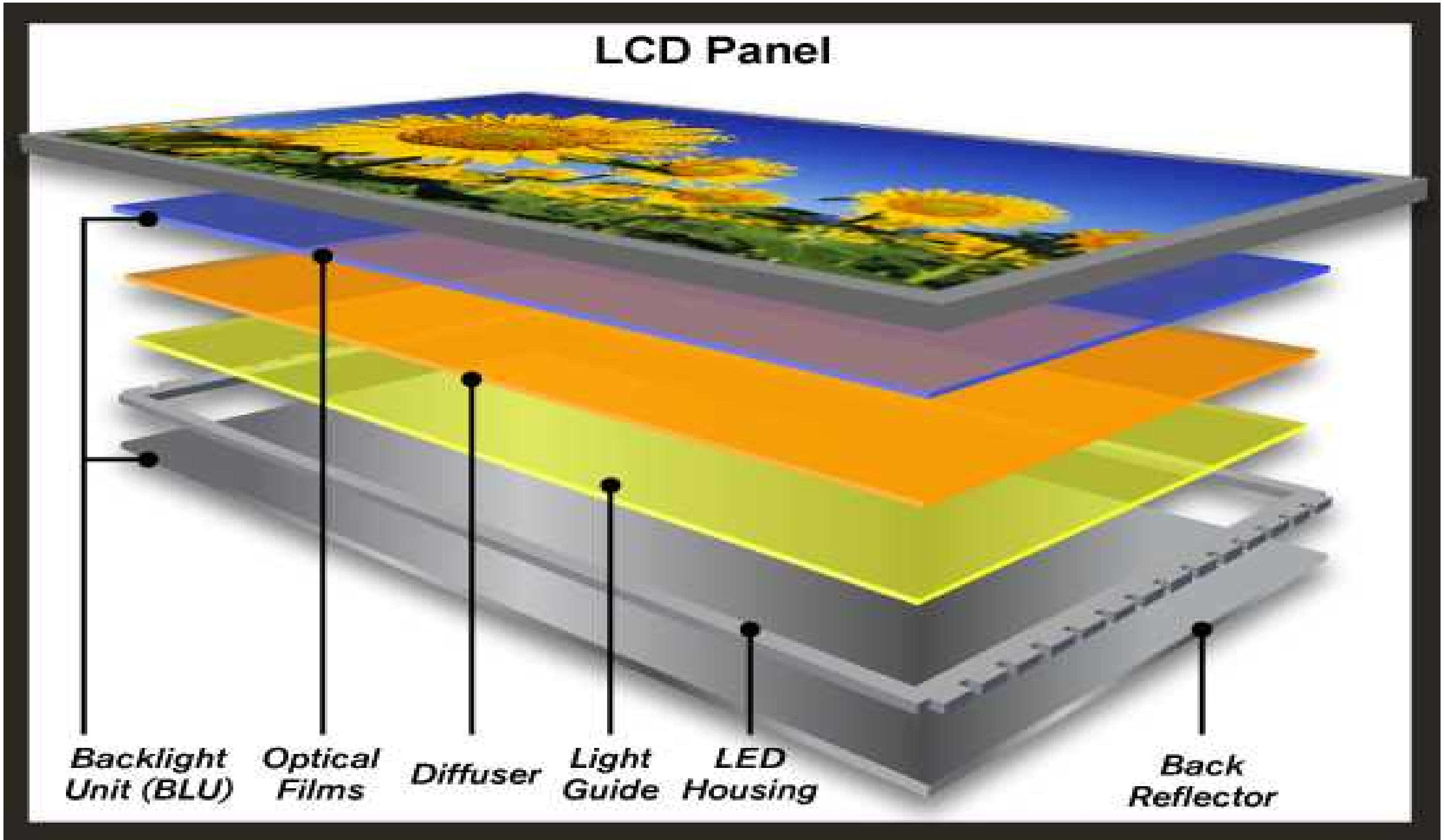
Plasma Displays



LCD Displays

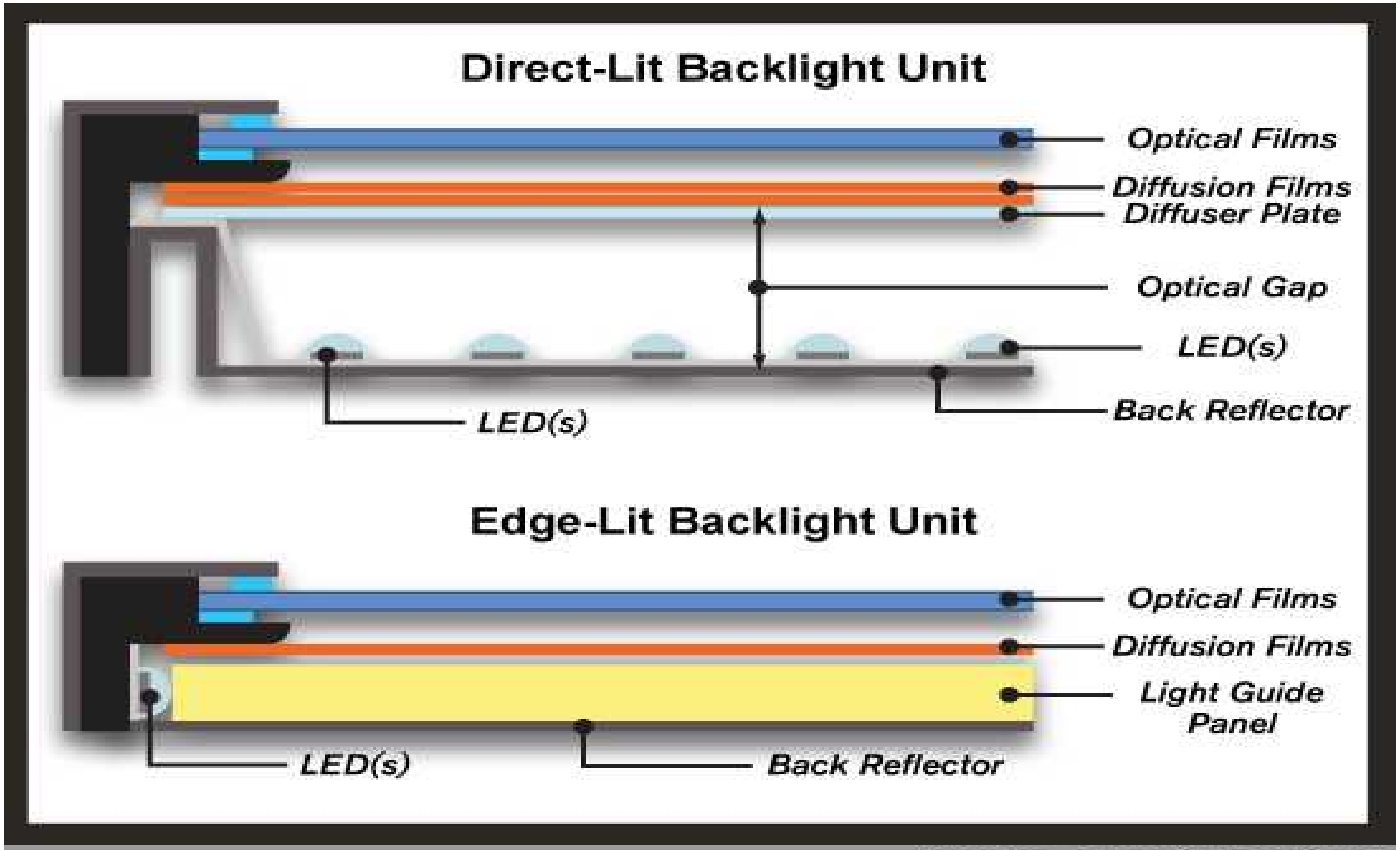


LED Displays



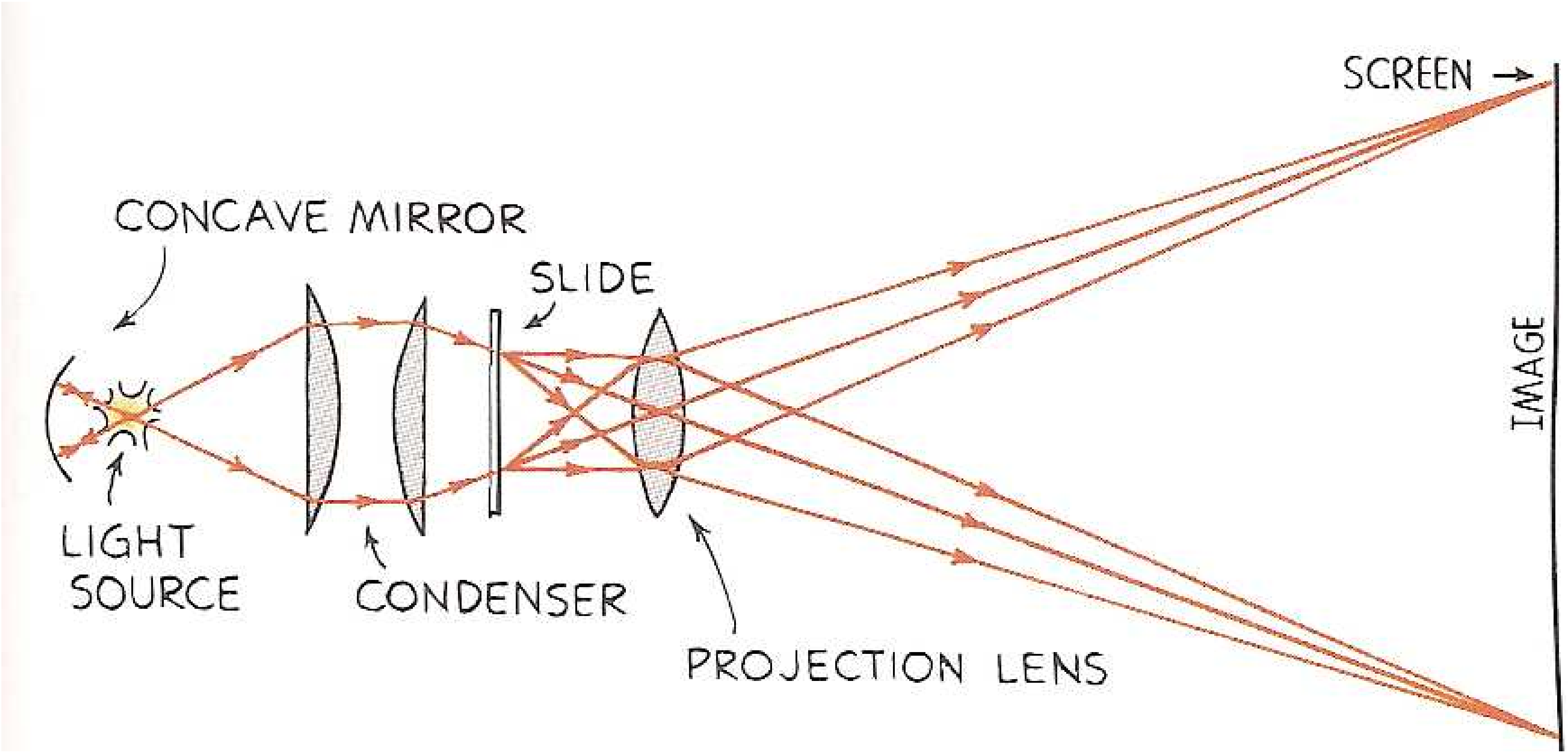
Components of an LED backlit LCD display

LED (Edge vs Backlit)



Array vs. edge-lit backlights

Projectors & Projection TVs



Monitor Specifications

- Pixel pitch
- resolution
- Luminance
- Contrast
- Viewing angle

Monitor Selection

- Varies by inspection requirements
- Highly dependent on sensitivity requirements (more sensitive -> better monitor needed)
- Involves risk – may cause possible false positives or negatives during inspection
- Complex, critical, or large variety of items tends to drive requirements to higher end display monitors

Primary Concerns

- Color vs greyscale (application specific, high brightness-> higher cost, brighter the better, color convergence, pixel size-maintain appropriate visual accuity, bad pixels,)
- Medical vs industrial (Primarily brightness, calibration, DICOM compatibility, cost,)
- Brightness (may need additional light meter to determine,)
- Resolution (dot pitch does not need to go beyond nominal visual acuity, pixel count should correlate with monitor size)
- Software Compatibility (Application specific)
- Size (pixel count and resolution are related to monitor size, bigger is not always better, multiple applications images vs. Bright high contrast, portrait vs landscape)
- Application (CR/DR/CT/visualization)
- Field application vs facility based (environmental conditions, **lighting**)

Monitor Qualification

•*Does NOT vary by inspection* requirements (do not requalify the monitor for each inspection?, the monitor should be qualified for the most stringent application,)

•Representative bad part images (defect specimens), test patterns used for qualification, IQI clarity in very **limited** conditions

•Local area monitor degredation may need to be addressed (test in several areas of the monitor)

•A qualification plan should be used

•Light meter readings?

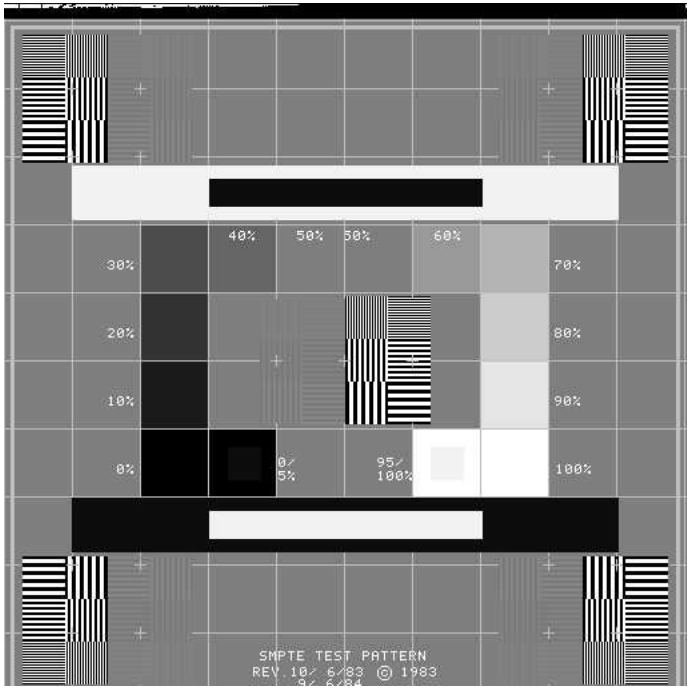
•Viewing environment conditions are inherently part of monitor qualification (lighting, viewing distance/angle, etc.)

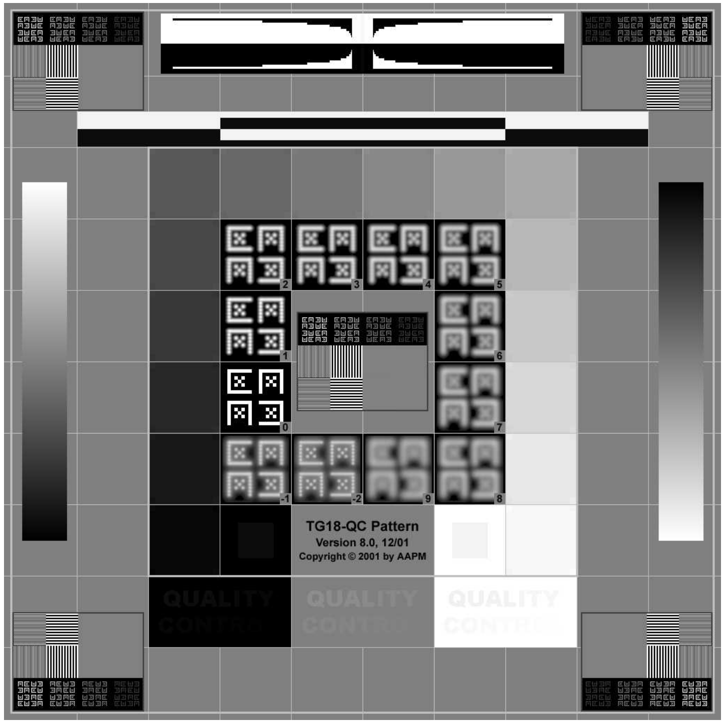
Viewing Room

- Room temperature 63-75° F
- Humidity 20-60%
- Task lighting
  - Computer Tasks
  - Reading Tasks
  - Balanced brightness in the field of view
  - Control of monitor reflection/surface glare

“The future NDE radiography department”, P. Berry, D. Summa, K. Vansyoc, Materials Evaluation, November 2007

Test Patterns





Recommendations

- Monitor needs to meet individual inspection requirements
- Drive monitor at a native resolution
- Minimum 8 bit greyscale or 24 bit color
- For color, use True Color (24 or 32 bit) rather than high color (16-bit) or pseudo color (8-bit) (Windows video driver settings)
- Avoid use of projectors and television monitors
- Avoid use of privacy filters
- Clean the monitor regularly

Recommendations (cont)

- Color vs greyscale is application dependent (color and pseudocolor should not be used on greyscale monitors)
- Use known image defect standards to validate monitors
- Use test patterns to qualify monitors and to verify continued performance

Conclusion

- Monitor selection depends on inspection requirements (no general solution)
- Reading environment still important
- White Paper draft is under review
- Check for updates: http://www.dwgndt.org/fwgidr.htm

Future Efforts

- Finalize white paper
- Perform measurements on available monitors
- Test Patterns testing and evaluation

Questions and Comments

Kyle Thompson krthomp@sandia.gov
Scott McClain scott.h.mcclain@us.army.mil