Effect of Various Contaminants on Ink Jet Photo Prints

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RESEARCH

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The Questions

- What is a photo?
- Is inkjet ‘as good as’ silver halide?

What is a Photo?

- Generally accepted as defined by silver halide print suppliers over a 100 year period
- Close to a faithful 2D reproduction of a scene
  - Image quality – color, density, detail
- Available to all
  - Cost
  - Convenience
- Has a look and feel
  - Weight
  - Appearance
  - Portability
  - Durability

Can Inkjet Make Good Photos?

- Image quality, appearance, cost, convenience are adequately addressed by many others
- Durability has been partially addressed and has two components
  - Image permanence
  - Ability to withstand pollutants and contaminants

Summary of Durability Testing

- Accelerated fade testing by UV exposure
  - Wilhelm
  - RIT Image Permanence Institute
- Ozone exposure
  - RIT Image Permanence Institute
- Temperature and Humidity
  - Very few results or comparisons available
- Effect of overcoats, glass protection
  - Very few results or comparisons available
- Common contaminants
  - No results available

Common Durability Factors

- UV Exposure
- Pollutant Gas Exposure
- Temperature
- Humidity

Purpose of this Test

- Directly compare AgH and Inkjet
- Include overcoated samples
- Test permanence by common durability factors
- Test exposure to a range of likely casual contaminants
- Lay the groundwork for a Standard Test Methodology

Casual Contact Materials

- Handling and Accidental Contaminants
  - Hand lotions, Spillage
- Writing Contaminants
  - Inks
- Storage Contaminants
  - Envelopes, plastic, glues

Handling and Accidental Contaminants

- Skin oil
- Hand lotion
- Deodorant
- Antiperspirant
- Acetone
- Lighter fluid
- Denatured alcohol
- Windex
- Isopropanol
- Water

Writing Contaminants

- Ball point pen
- Fountain pen
- India ink
- Permanent marker
- Water-based marker
- Dry erase marker

Storage Contaminants

- PVC
- Acetate
- Post-it Note
- Scotch tape
- Glue stick
- Rubber cement

Printers Used for the Test

- Silver Halide
  - Commercial digital photo print services
- Thermal Inkjet Photo Printers
  - HP Photosmart 1215
  - Kodak PM 200
- Piezo Inkjet Photo Printer
  - Epson Stylus Photo 2000

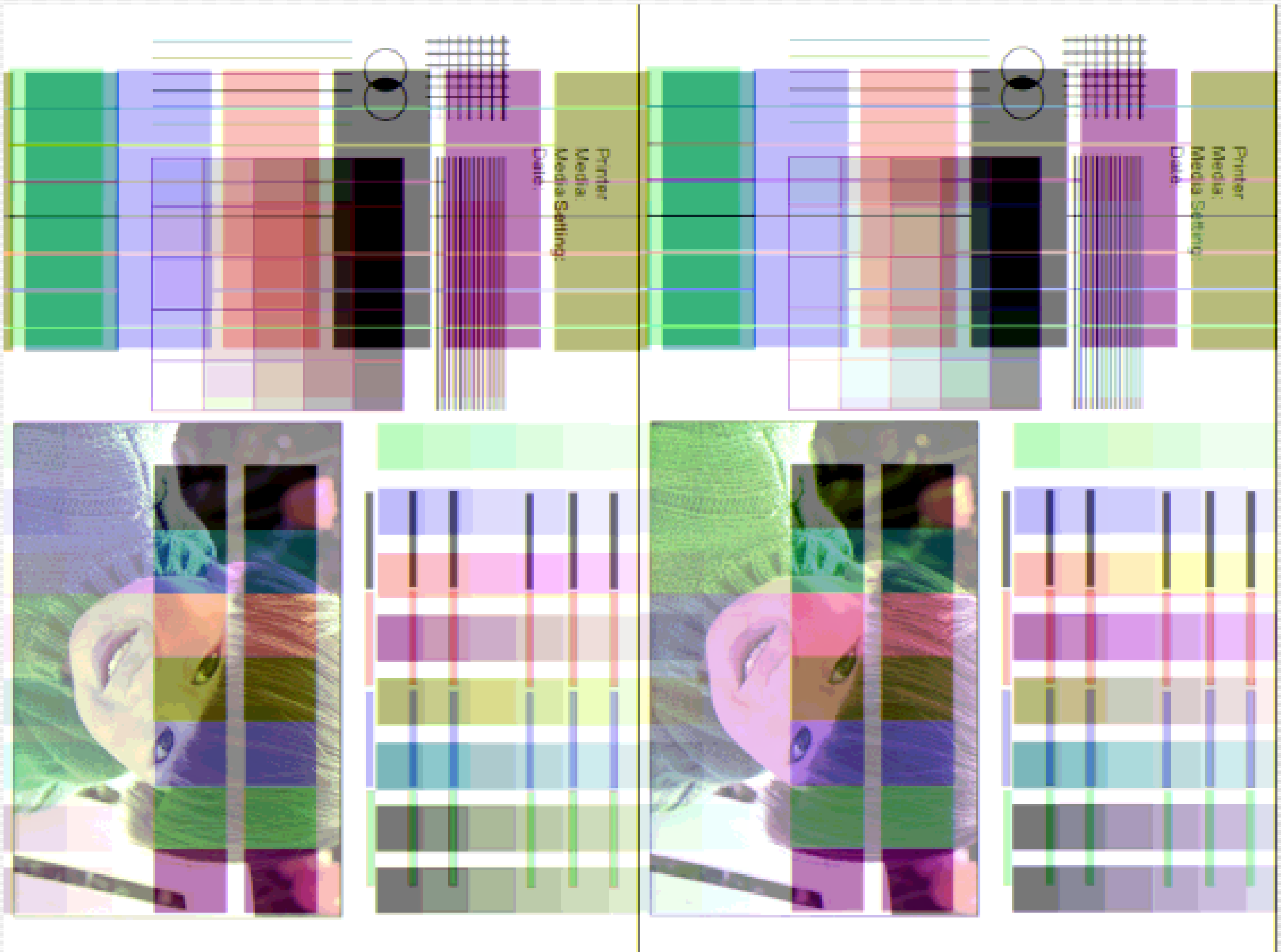
Papers Used for the Test

Silver Halide	HP 1215	Kodak PM200	Epson 2000P
Kodak Professional	HP Colorfast	Kodak InkJet Photo	Epson Premium Luster
Fuji Crystal Archive	HP Premium Plus Photo	Kodak Premium Picture	Epson Premium Glossy
			Epson Archival Matte
			Epson Prof Glossy

Protections Tested

- Unprotected – All prints
- Protected by glass – All prints
- Lacquer-Mat Pearl High Gloss – All Prints
  - Solvent based (Toluene/Ethyl Acetate +)
  - Spray coated 7” 35 psi air sprayer
- Accutech Acculac Hydroluster – Some Prints
  - Water based
  - Roll coated
  - Cannot be used on thermal inkjet prints

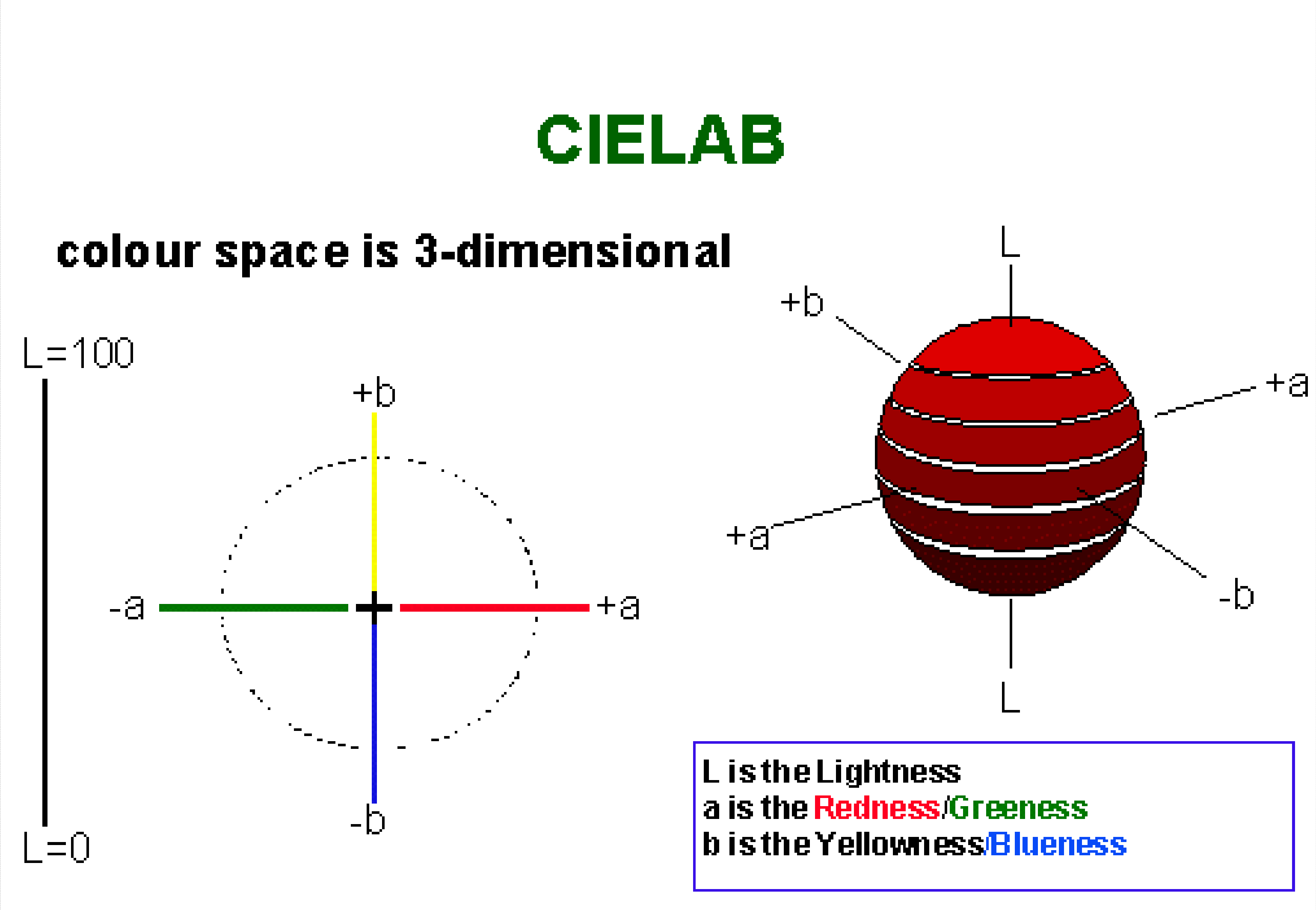
Test Pattern Used – Digital File



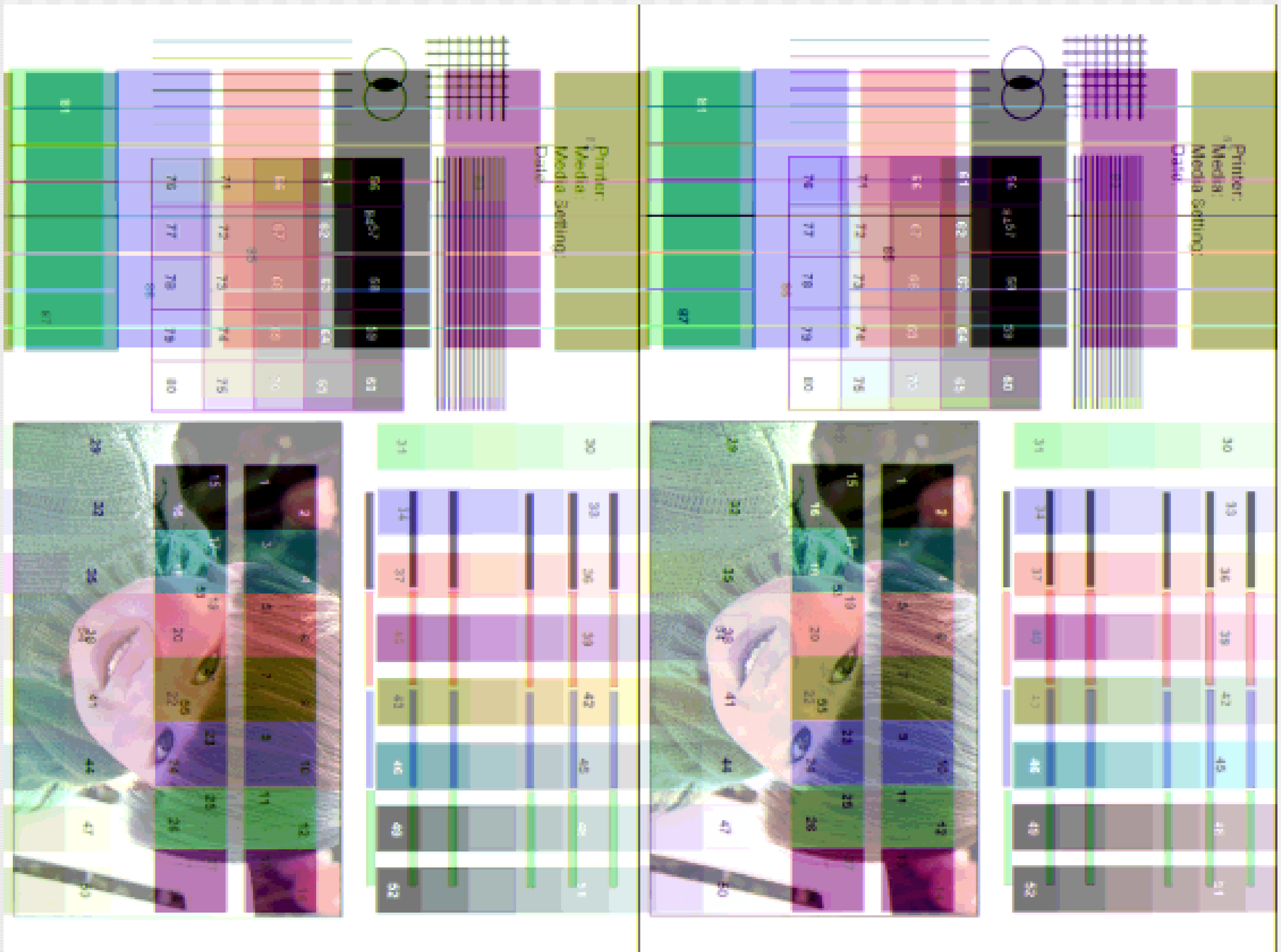
Measurement Objective

- Assess user perception of color change
- Determine change in L*a*b* values
    - L* relates to lightness
    - a* relates to redness/greenness
    - b* relates to yellowness/blueness
  - Relate L*a*b* values to noticeable change
- Assess other visual changes
  - Bleed
  - Smear
  - Curl
  - Edge and surface deterioration

CIE L*a*b* Color Space Definition



Test Points Map



Measurement Methods

- Control prints
  - Measured within 1 day of printing and/or overcoating
  - Stored in individual acid and lignin free envelopes
  - Stored at 72°F, 60% RH
- L*a*b* Measurement with X-Rite Model SP760 spectrophotometer
- Other
  - Subjective viewing in artificial daylight
  - Gretag-Macbeth Model Judge II-S at 6500°K

Color Change Measurement Method

- Absolute change of 3 or less in L* a* or b* is usually unnoticeable to the eye even under controlled lighting.
- In some cases, the eye cannot detect changes up to 6.
- To obtain a single rating system for each paper/overcoat combination, the overall value is given by:
- $(\Sigma(\Delta L^*>3))(\Delta L^*_{avg}) + (\Sigma(\Delta a^*>3))(\Delta a^*_{avg}) + (\Sigma(\Delta b^*>3))(\Delta b^*_{avg})$
- This combines the frequency of changes greater than 3 in each site on the map, and the average value of those changes.

UV exposure Method

- High level indoor exposure is 450 lux
- TPR fixture, same design as used at RIT Image Permanence Institute
- Simulates daylight exposure
- 100,000 lux for 192 hours
- Intended to correlate to 10 years at 450 lux for 12 hours per day

Ref: ***Zinn, Nishimura, Reilly IS&T NIP-15 1999***

UV Exposure Equipment

Ozone exposure Method

- Ozone incubation chamber at IPI
- Constant 75 °F and 60% RH
- 0.025 ppm is peak indoor level in polluted areas
- 10 ppm Ozone for 14 days
- Airflow through chamber
- Intended to correlate to 15 years exposure at .025 ppm

Ref: ***Zinn, Nishimura, Reilly IS&T PICS 1998***

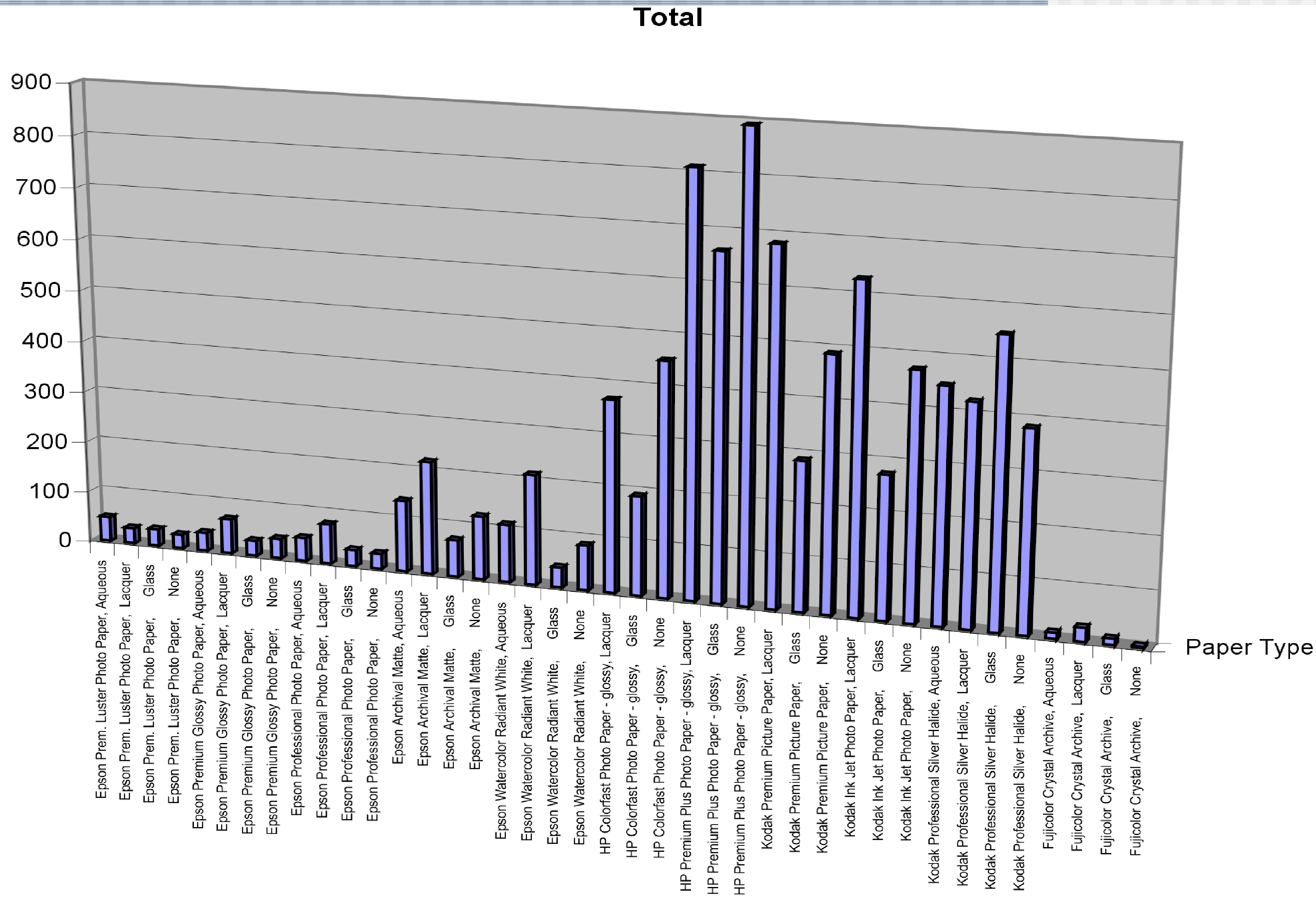
Temperature & Humidity Method

- TPR environmental chamber
  - Tenney BenchMaster BTRS
- 120°F 85% RH for 168 hours
- Two conditions were examined:
  - Single unconstrained sheets
  - Weighted stacks
    - 13 oz uniformly distributed on A4 size
    - Simulates 10 photo album pages
    - Stack includes 3 prints
    - Face to face and back to face

Contaminant Method

- Two samples used for each contaminant
- Two application methods for each
  - Contaminant applied by foam brush, print allowed to dry.
  - Foam brush followed by wiping with pH neutral inorganic wipe to simulate removal of accidental exposure.
- Measurements confined to solid color areas

UV Results Summary

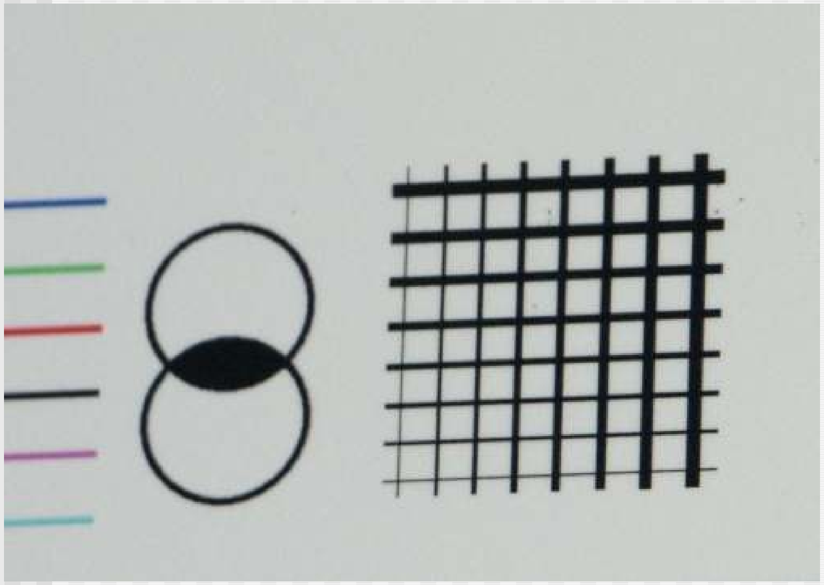


Typical UV Induced Image Fade

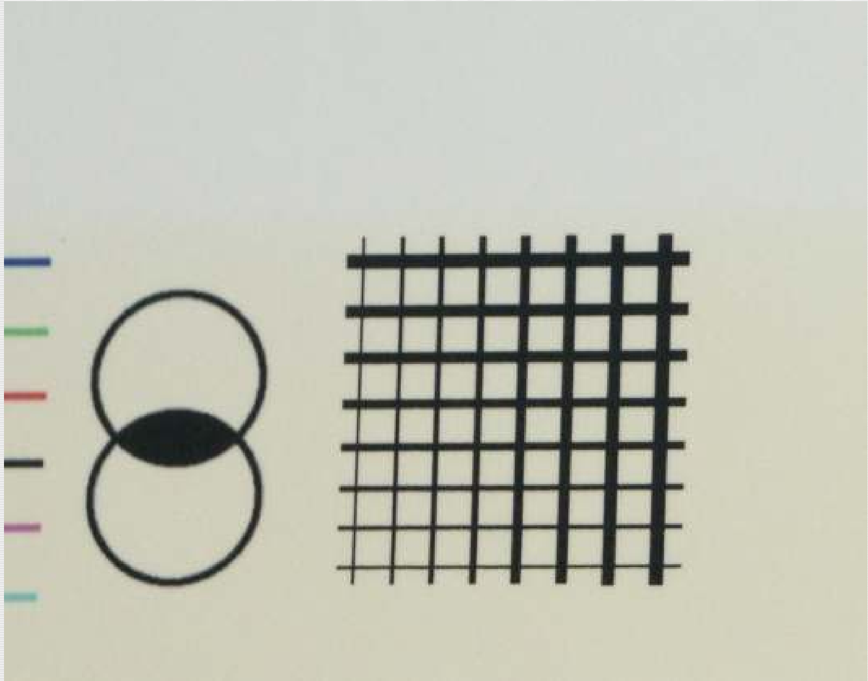
Control Print

Test Print

UV Induced Paper Background Fade



Control Print

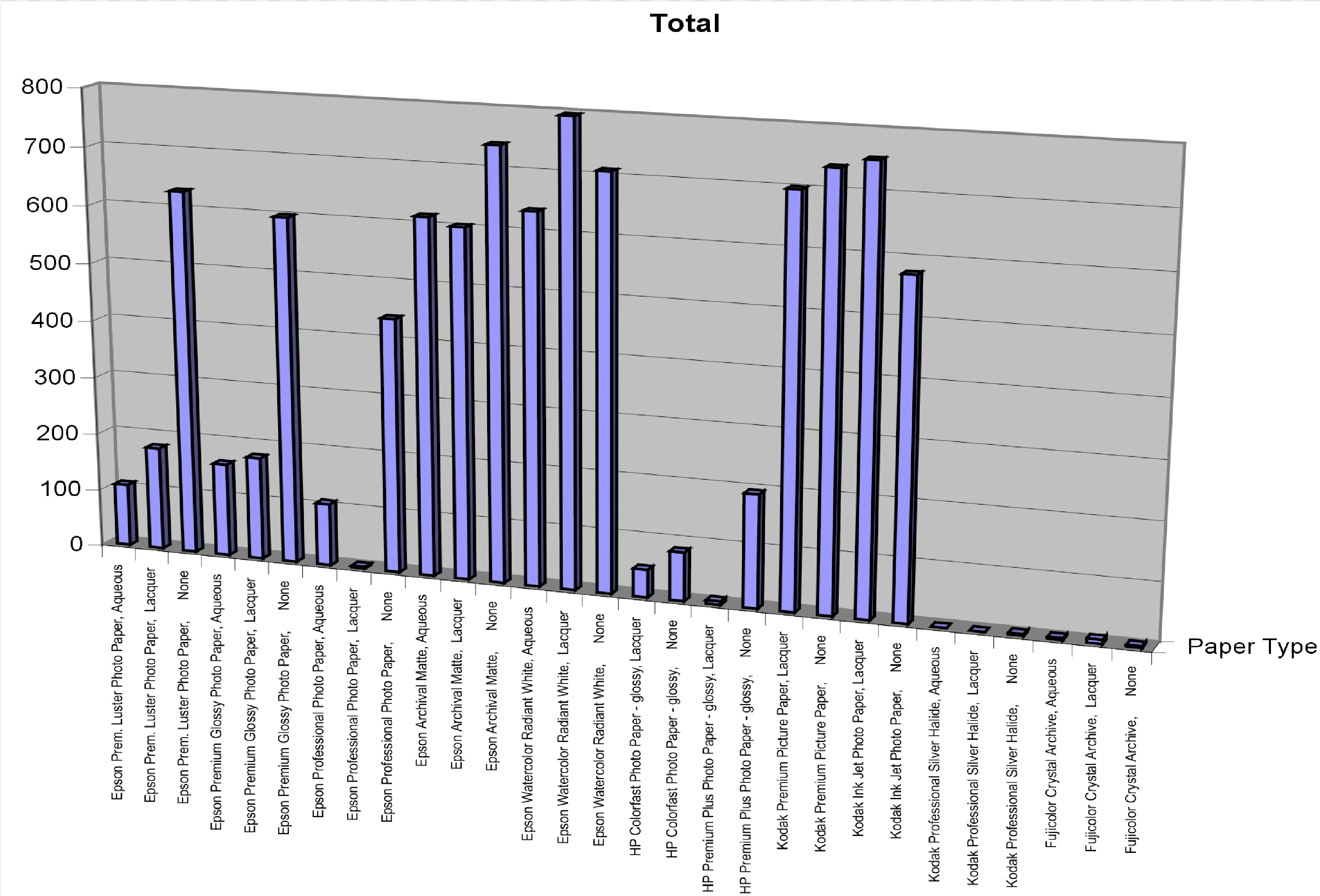


Test Print

UV Results Interpreted

- OBJECTIVE
  - Single L*a*b* values did not exceed 8 on any image
- SUBJECTIVE
  - No noticeable changes in Epson or Fuji prints,
  - Noticeable changes in all others
  - Most noticeable change was uniform fade/lightness and paper background color change
  - All changes were slight
  - Glass appears to offer the best protection
- CORRELATION
  - Noticeable changes occurred when the number of changes >3 was higher than 40 in a single image

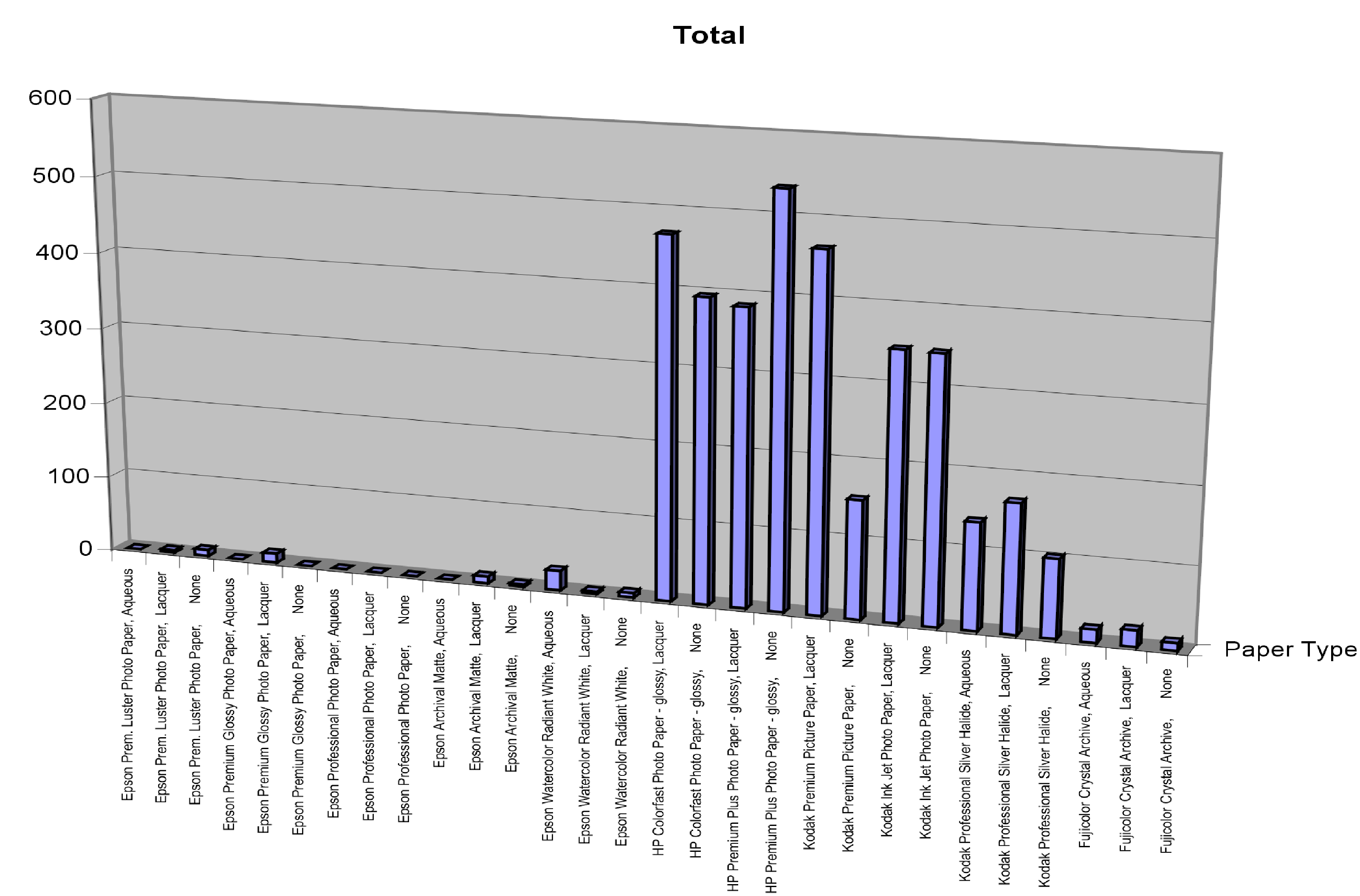
Ozone Results Summary



Ozone Results Interpreted

- OBJECTIVE
  - Single L*a*b* values did not exceed 8 on any image
- SUBJECTIVE
  - No noticeable changes in HP inkjet or Fuji and Kodak AgH prints
  - Noticeable changes in Epson and Kodak inkjet prints
  - Positive and negative color changes were noticeable
  - Relative color changes were noticeable
  - Changes were generally slight
  - Lacquer overcoat appears to offer the best protection
- CORRELATION
  - Noticeable changes occurred when the number of changes >3 was higher than 40 in a single image

T&H Results Summary – Single Sheet



T&H Results Summary – Weighted

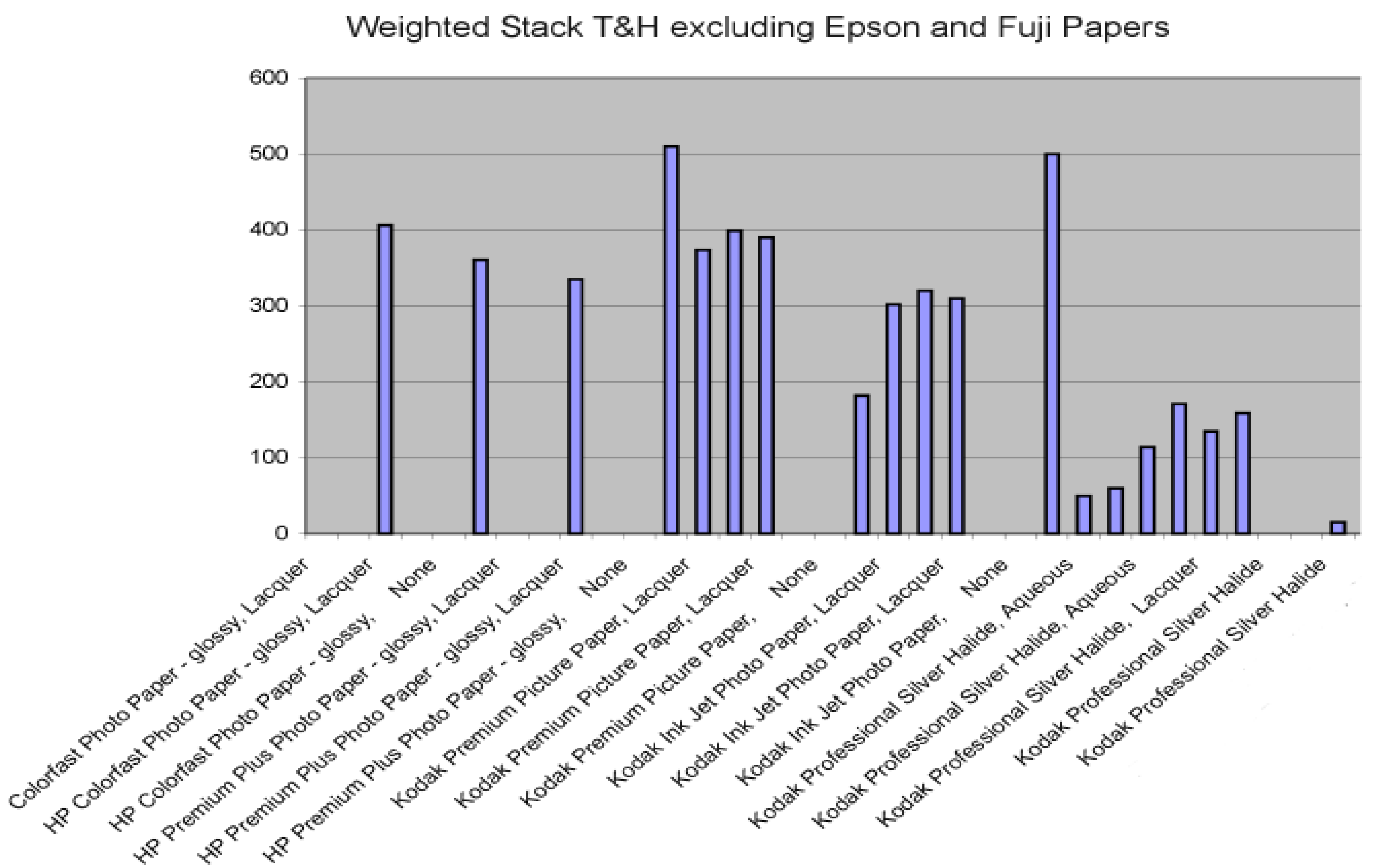


Image Color Change and Bleed

Control Print

Test Print

T&H Results Interpreted

- OBJECTIVE
  - Single L*a*b* values did not exceed 8 on any image
- SUBJECTIVE
  - No noticeable changes in Epson inkjet or Fuji AgH prints
  - Noticeable positive and negative color changes changes in HP and Kodak inkjet and Kodak AgH prints were all slight
  - Significant color bleed on HP and Kodak inkjet single sheet prints
  - Significant color bleed and ink transfer on HP and Kodak inkjet weighted stack prints
  - Lacquer overcoat gave the most protection but did not prevent bleed or transfer

Accidental Contaminant Results

- Significant objective damage to a wide range of prints
  - Hand Lotion
  - Windex
  - Deodorant
- Objective damage to some prints
  - Water — HP and Kodak inkjet prints unprotected
  - Denatured alcohol — Most inkjet prints
  - Acetone — Most inkjet prints
- Little or no damage to any prints
  - Isopropanol
  - Lighter fluid
  - Paint thinner

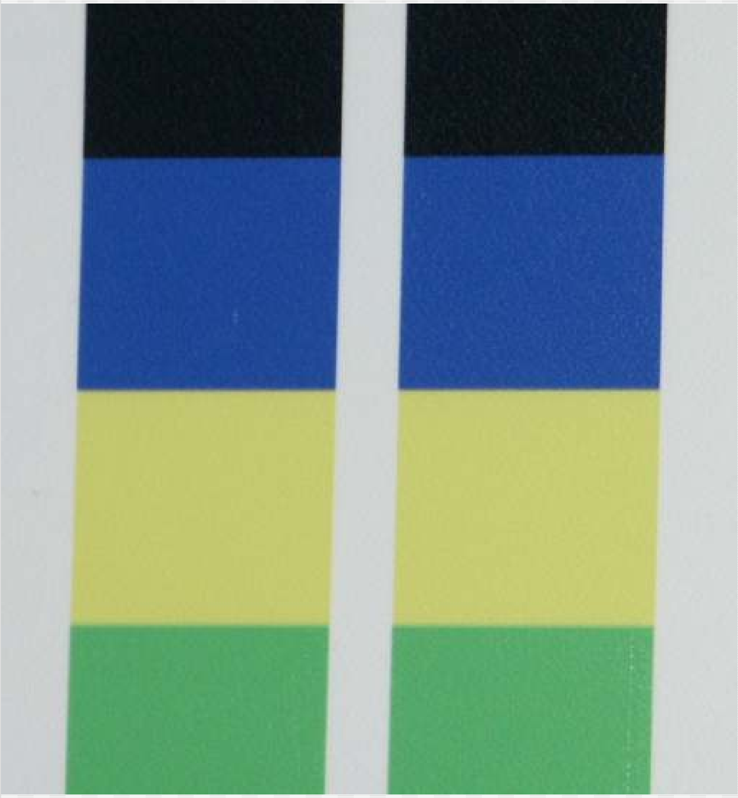
Writing Contaminant Results

- Little or no damage to any prints
  - Ball point pen, fountain pen., India ink
  - Markers, permanent, water-based, dry erase

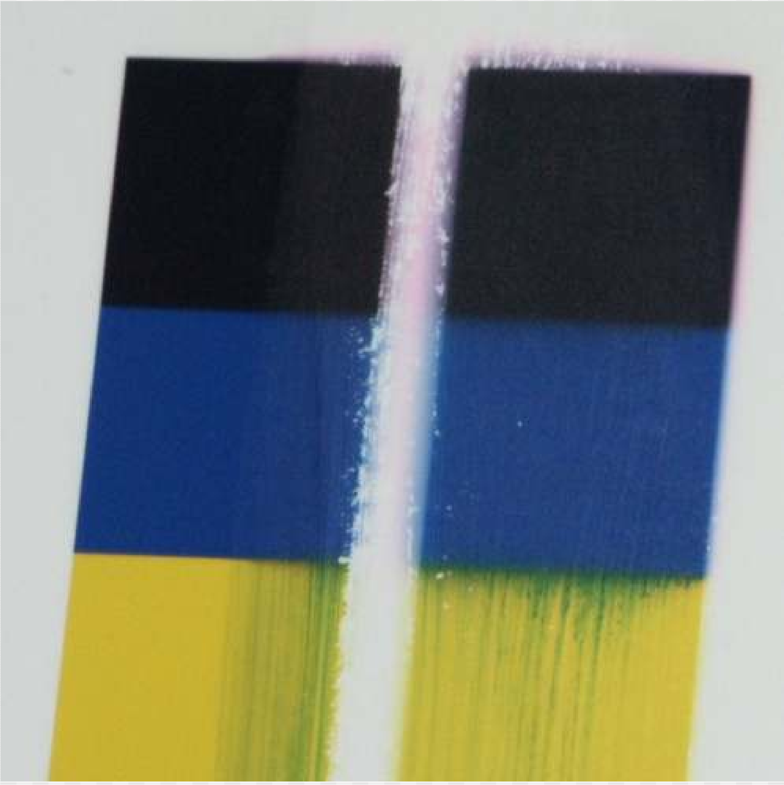
Storage Contaminant Results

- Significant objective damage to a wide range of prints, inkjet and silver
  - Glue Stick
- Objective damage to some prints
  - Tape, mainly to Epson prints
  - Rubber cement, to all inkjet prints
- Little or no damage to any prints
  - Post-it notes
  - Acetate
  - PVC

Typical Image Smear



Control Print



Test Print

Summary Observations Overcoats

- Glass is the best protection for UV exposure
- Lacquer offers the best protection for ozone
- Water based inks are not significantly protected from humidity effects by overcoating
- Overcoats offer protection against many casual contaminants but usually little or no protection against organic solvents

Summary Observations Inkjet vs. Silver Halide

- **UV Fading** - the best inkjet is as good as the best silver halide
- **Ozone** – silver halide is significantly better than most inkjet in resisting color change
- **Temp and Humidity** – the best inkjet is as good as the best silver halide
- **Casual contaminants** – inkjet prints are variously affected by contaminants, silver halide is almost impervious

Summary Observations
Pigment or Dye inkjet inks

- CAVEATS
  - Tests were performed on commercial systems in 2000/2001
  - Epson is pigment, HP and Kodak are dye
  - Epson is piezo, HP and Kodak are thermal ejection
  - Ink solvent may have as much influence as colorant
  - Ink/media interactions also play a part
- Aqueous dye based inks are subject to damage from water and humidity, piezo pigmented are not
- Aqueous dye based inks more subject to fading than piezo pigmented inks
- Both types can be affected by ozone
- There is no pattern in the data for casual contaminants

Conclusion

- This work is a first attempt at developing standard tests for durability, additional work is needed
- In general, inkjet prints will perform acceptably for most photo requirements
  - Display
  - Storage
- Exposure to water and humidity should be avoided