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# Comparative Durability Analysis

## General Handling, Automation Compatibility, and Heat Fastness

Output Comparison of Toner vs. Solid Ink

### HP Color LaserJet 4700 vs. Xerox Phaser 8860

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# Agenda

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## Executive Summary

- Project Objectives
- Test Results Overview

## Test Results

### Methodology

#### General Durability and Handling Testing

- Scratch Test
  - *Elcometer Scratch Test*
  - *Fingernail Scratch Test*
  - *Paper Clip Scratch Test*
- Abrasion Test
- Fold/Crease Test
  - *Fold Test With Crease*
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- Erasure Test
- Write Through Test
- Write Test
- Data Removal Test
- Shuffling Test

#### Automation Compatibility Testing

- Postal Collation Test
  - *Letters*
  - *Postcards*
- ADF Automation Test

#### Heat Fastness Testing

- Environment Simulation Test
- Lamination Test



# Executive Summary — Project Objectives

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## Independent third-party Comparative Test and Analysis of *output* from the *toner-based* HP Color LaserJet 4700 vs. *solid ink-based* Xerox Phaser 8860

### Areas of Focus

#### °General Durability and Handling Testing

- Typical office environment durability tests, including scratch resistance, folding, erasure, writing, taping, and handling

#### °Automation Compatibility Testing

- Movement through the U.S. Postal Service of documents in envelopes and printed postcards
- Automatic Document Feeder (ADF) testing

#### °Heat Fastness Testing

- Simulation of high heat environments, such as tropics or summertime vehicle
- Lamination of printed materials



HP CLJ 4700



Xerox 8860



# Executive Summary — Test Results Overview

## Comparative Test and Analysis

Overall, the *HP Color LaserJet 4700 prints were more durable and more fit for typical office usage than the Xerox Phaser 8860 prints*

*The HP Color LaserJet 4700 prints were able to tolerate automation and high heat environments without issue; Xerox 8860 prints displayed print output distortion and loss of data*

### General Durability & Handling Testing

- ✓ *Scratch Test*
- ✓ *Abrasion Test*
- ✗ *Fold/Crease Test*
- ✓ *Erasure Test*
- ✓ *Write Test*
- ✓ *Write Through Test*
- ✓ *Data Removal Test*

### Automation Compatibility Testing

- ✓ *Postal Collation Machine Test*
- ✓ *ADF Automation Test*

### Heat Fastness Testing

- ✓ *Environment Simulation Test*
- ✓ *Lamination Test*

✓ HP advantage

✗ Xerox advantage



# Executive Summary — Methodology

## Test Documents

- *Selected from the SpencerLab Printer Test Suite*
  - Range of test documents, covering a variety of printing requirements
  - Produced on each of the printers, using latest available drivers, in their respective default modes for paper type
  - Printed using Adobe Reader 8.1.1

## Test Media

- *Plain Paper*
  - Hammermill 24# Laser Print Paper
- *Glossy Paper*
  - HP LaserJet Glossy Brochure Paper on CLJ 4700
  - Xerox Professional Solid Ink Glossy Paper on Phaser 8860
- *Postcard Media*
  - Avery 5889 Postcard Media
  - Xerox Postcard Media

## Analysis Procedure

- *Files printed on appropriate media, with clean copies kept for comparison to files following Durability Tests*
- *Pristine files used for Individual Durability Tests*



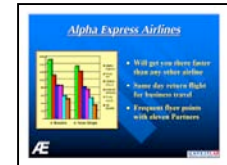
SpencerLab 5%  
Monochrome Letter



Enhanced Black



Postcard Coupon



Presentation



Color Spectrum



Color Swatches



# Executive Summary — Methodology

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## General Durability and Handling Tests

### *Elcometer Scratch Test*

A pencil point with a constant force of 7.5N at an angle of 45° is run across solid print band areas of the test prints, either leaving a superficial trace or causing destruction down to the substrate level. Tests are run with a series of 14 pencils, ranging from 6B (softest) to 6H (hardest) hardness values. The softer the pencil needed to mar the substrate, the more prone the sample is to scratching.

### *Fingernail Scratch Test*

A fingernail is run across solid print band areas of the test prints, either leaving a superficial trace or causing destruction down to the substrate level.

### *Paper Clip Scratch Test*

A #1, smooth paper clip is used to join two sheets of the *Presentation* test document at the upper left corner, overlapping the printed area, and removed after 30 minutes. The paper clip is then used to rejoin the two test documents at the upper right corner, then swiveled back and forth in place and removed.

### *Abrasion Test*

Test documents are collated, handled, and shuffled over a period of time.

### *Fold Test Without Crease*

Individual test documents are folded in thirds without forcefully creasing the fold lines.

### *Fold Test With Crease*

Individual test documents are folded in thirds with the fold lines forcefully creased.

### *Erasure Test*

Strikethrough marks are written in #2 (HB) pencil across printed text on test documents, then erased with a Pink Pearl eraser.

### *Write Test*

Characters are written across printed areas of test documents in #2 (HB) pencil, ballpoint pen, and red felt-tip pen.

### *Write-Through Test*

Phrases are written on a blank sheet of plain paper placed atop printed test documents in #2 (HB) pencil, ballpoint pen, and red felt-tip pen.

### *Data Removal Test*

Post-It Notes and Scotch Tape are placed on printed areas of test documents and removed after 30 minutes.



# Executive Summary — Methodology

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## Automation Compatibility Tests

### *Postal Collation Test — Letters*

Multi-page test documents are folded in thirds, then inserted into envelopes and processed through the U.S. Postal Service.

### *Postal Collation Test — Postcards*

Test documents are printed on two types of postcard media and processed through the U.S. Postal Service.

### *ADF Automation Test*

Twelve pages of test documents, on both plain and glossy media, are stacked and placed in the ADF unit of a copier, and a request is made for one copy of each page. Testing includes ADF units of both belt-fed and roller-fed machines.

## Heat Fastness Tests

### *Environmental Simulation Test*

Individual document test entails individual test documents placed into a heat chamber maintained at 160°F ±3°F for 30 minutes. Upon removal, documents are analyzed for toner/ink adhesion.

Stacked document test includes ten copies of test documents stacked and placed into the heat chamber for 30 minutes. Upon removal, documents are separated and analyzed for toner/ink transfer.

### *Lamination Test*

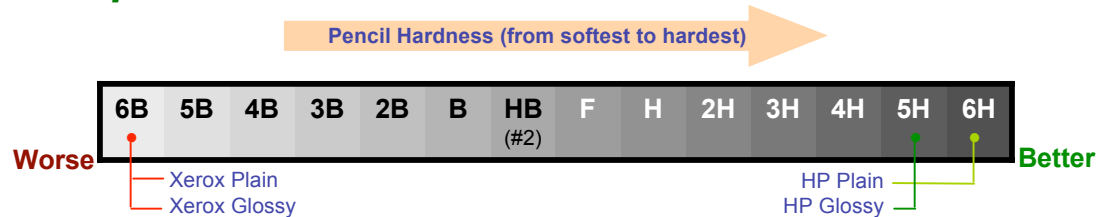
Test documents are laminated by technicians at commercial retail copy centers.



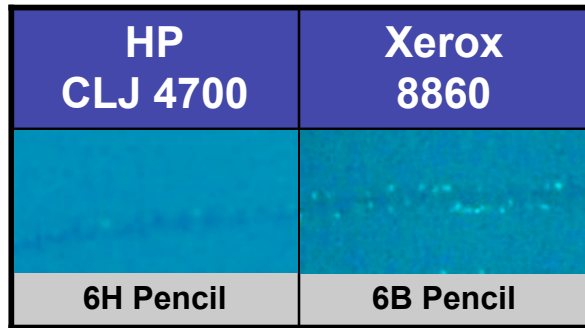
# General Durability and Handling — Scratch Test

## Elcometer Scratch Test

The HP CLJ 4700 test documents were more resistant to scratching—hence more durable—than comparative Xerox test documents on both Plain and Glossy paper

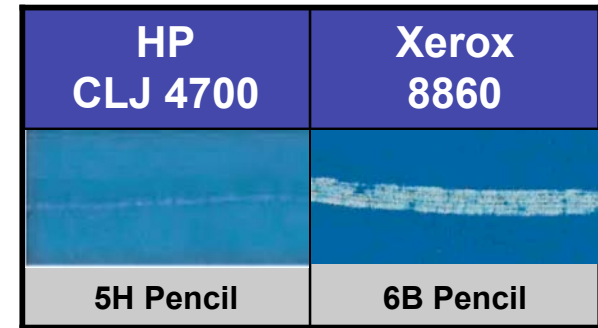


### Plain Paper



100% Cyan samples of  
Color Swatches test file

### Glossy Paper



#### HP CLJ 4700

- Print Scoring (scratch) occurred only when using the hardest pencil (6H)

#### Xerox 8860

- Print Scoring occurred with the softest pencil (6B) on 100% Cyan, Red, and Blue bands
- Small flecks of solid ink separated from the media
- Printed surface was easily damaged

#### HP CLJ 4700

- Print Scoring first occurred with the second-hardest pencil (5H)

#### Xerox 8860

- Print Scoring occurred using the softest pencil (6B) on thirteen out of sixteen bands
  - Solid ink scratched off the media very easily and contiguously
  - Printed surface was easily damaged



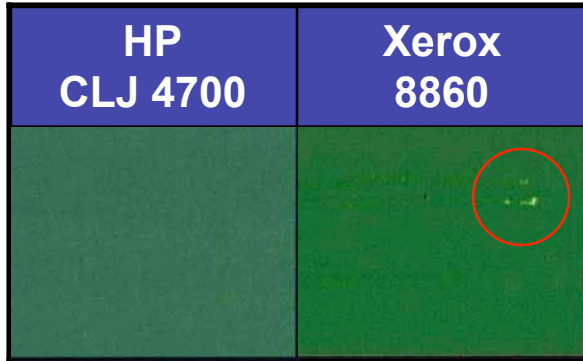



# General Durability and Handling — Scratch Test

## Fingernail Scratch Test

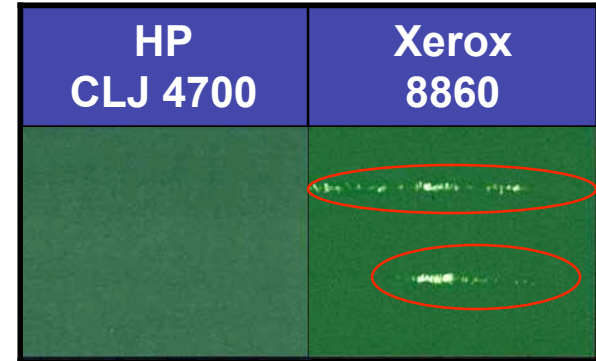
*The HP test documents were more resilient to scratching than comparative Xerox test documents on both plain and glossy paper*

### Plain Paper



 = Visible fingernail scratch on high coverage color bands of Color Swatches test file

### Glossy Paper



#### HP CLJ 4700

- ° Fingernail scratches did not appreciably damage the color bands
- ° Only when the paper was angled beneath a light source scratches could be seen

#### Xerox 8860

- ° Color bands were scratched easily, and scratches were visible when viewed directly
- ° Magenta, Red, Green, Blue, Pure Black, and Composite Black scratched to the point where the underlying media was visible

#### HP CLJ 4700

- ° Fingernail scratches were slightly more visible than on comparative HP plain paper samples

#### Xerox 8860

- ° All bands exhibited scratches that revealed the underlying media



# General Durability and Handling — Scratch Test

## Paper Clip Scratch Test

**On both the HP CLJ 4700 and the Xerox 8860, the paper clip left scratches on the output but did not substantially decrease print quality**

### HP CLJ 4700

#### Plain Paper

- The paper clip did not leave any appreciable creases or impressions on the paper after thirty minutes
  - Removal of the paper clip did not scratch the printed area or the media substrate
- Swiveling the paper clip in place creased the media slightly, but had no effect on print quality

#### Glossy Paper

- The paper clip left no creases or impressions on the paper after thirty minutes
  - Removal of the paper clip marred the surface of the glossy paper, but toner was not displaced, and print quality is not affected
- Swiveling the paper clip in place left minor scratches on the surface of the printed area and media

### Xerox 8860

#### Plain Paper

- The paper clip did not leave any appreciable creases or impressions on the media after thirty minutes
  - Removing the paper clip did not scratch printed area or the media substrate
- Swiveling the paper clip in place left minor scratches on the printed area of the test file
  - Though scratches are evident, they are to a lesser degree than seen on the Elcometer or Fingernail Scratch Tests

#### Glossy Paper

- The paper clip left no creases or impressions on the paper after being left for thirty minutes
  - Removal of the paper clip left minor scratches on the surface of the glossy paper
- Swiveling the paper clip in place left minor scratches in the surface of the printed area of the file and minor creases in the media
  - Scratches are not as severe as those seen in the Elcometer or Fingernail Scratch Tests
  - Scratches are slightly more obvious on the Xerox 8860 samples than those of the comparative HP samples, since the Xerox solid ink prints have a higher gloss finish



# General Durability and Handling — Abrasion Test

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## ***Abrasion Test***

***The HP test documents were more resilient to scratching than comparative Xerox test documents on both plain and glossy paper***

### *HP CLJ 4700*

#### ***Plain & Glossy Paper***

- High density coverage areas tend to exhibit minor scratches and fingerprints after handling
- No toner was transferred between adjacent documents during shuffling
- Print quality was unaffected by handling and shuffling

### *Xerox 8860*

#### ***Plain Paper***

- High density coverage areas exhibited fingerprints and folds after handling
  - Scratches on high coverage areas were minor, but more visible than on comparative HP samples
- Very minor solid ink transfer was evident between adjacent documents after shuffling

#### ***Glossy Paper***

- Scratches on high coverage areas were more evident than on comparative HP and Xerox samples
  - Fingerprints and minor folds were also more evident on glossy paper than on plain paper
- Some solid ink transfer was evident between adjacent documents after shuffling

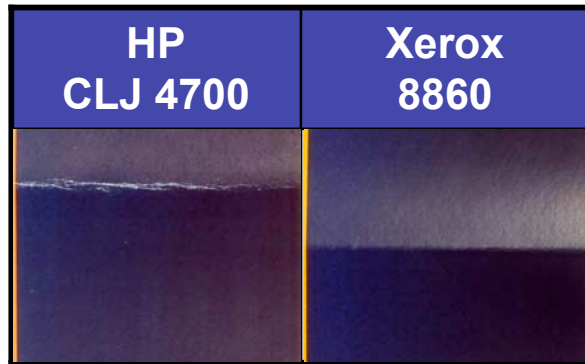


# General Durability and Handling — Fold/Crease Test

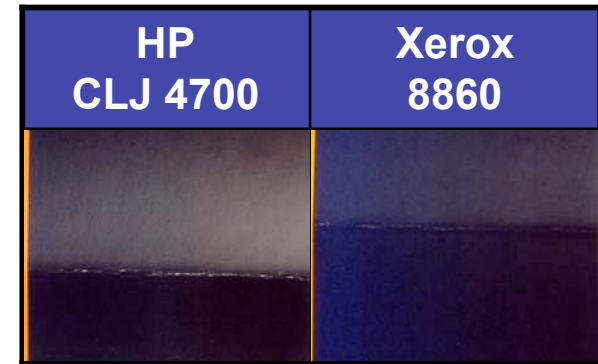
## Fold Test Without Crease

**Xerox 8860 prints stand up to folding and creasing better than HP CLJ 4700 prints, which exhibited visible fold lines and minor separation of toner from the media**

### Plain Paper



### Glossy Paper



Fold lines across high coverage areas of *Presentation* test file

### HP CLJ 4700

#### Plain & Glossy Paper

- Folding had minimal effect on print quality of text and low coverage areas of the test documents
  - A small amount of toner did dislodge from the substrate, but the effect was negligible
- High coverage areas exhibit some degradation in print quality, with a small amount of toner separation from the media along the fold lines
- Fold lines are visible in high coverage areas despite not being forcefully creased

### Xerox 8860

#### Plain & Glossy Paper

- Folding had little to no effect on print quality of text and low density coverage areas of the test documents
- On plain paper, no ink separation from the media occurred along fold lines, even in high density coverage areas
- On glossy paper, a small amount of ink separated from fold lines, but with negligible effects on print quality
- Fold lines are very pronounced due to the thickness of the solid ink on the paper, but still are less distracting than fold lines on comparative HP samples

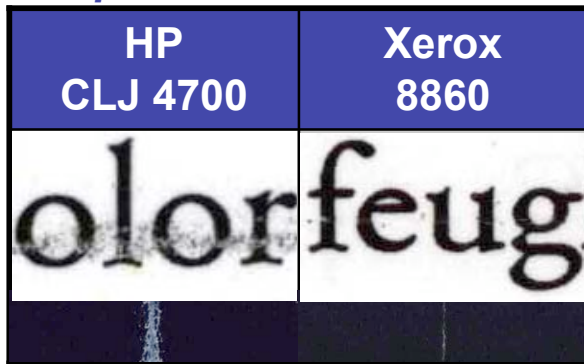


# General Durability and Handling — Fold/Crease Test

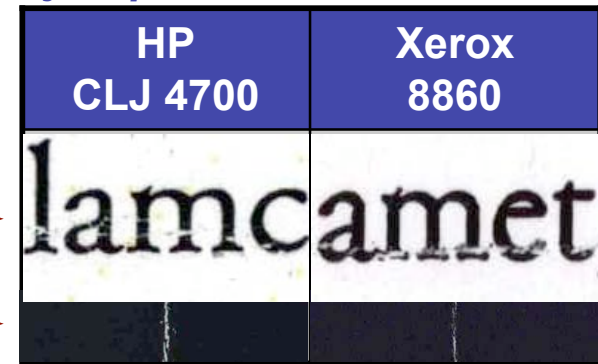
## Fold Test With Crease

**Xerox 8860 prints stand up to folding and creasing better than HP CLJ 4700 prints, which exhibited visible fold lines and separation of toner from the media**

### Plain Paper



### Glossy Paper



Crease lines across:

Text of  
*SpencerLab 5%  
Monochrome  
Letter* test file

High coverage  
areas of  
*Presentation* test file

### HP CLJ 4700

#### Plain & Glossy Paper

- Text and low density coverage areas of the test documents exhibit print quality defects and legibility problems
  - More toner separated along the crease lines than in the folds of the Fold Test
  - On the *SpencerLab 5% Monochrome* test document, toner separation on the crease resulted in dropouts on some text characters, affecting legibility
- Effects on high density coverage areas are more noticeable than effects of the Fold Test
  - Crease lines are more pronounced due to a greater degree of toner separation
  - Loose toner transferred to testers' hands and also settled on other areas of the document
- Print quality degradation is evident on glossy paper, but is less pronounced than on comparative plain paper samples

### Xerox 8860

#### Plain & Glossy Paper

- Print quality was minimally affected in text and low density coverage areas of the test documents
- Very little solid ink separated from the test document along crease lines
- Crease lines are visible, but are generally less distracting than comparative HP samples
  - Crease lines on glossy paper are more distracting than comparative plain paper samples, due to more pronounced wrinkles on plain media

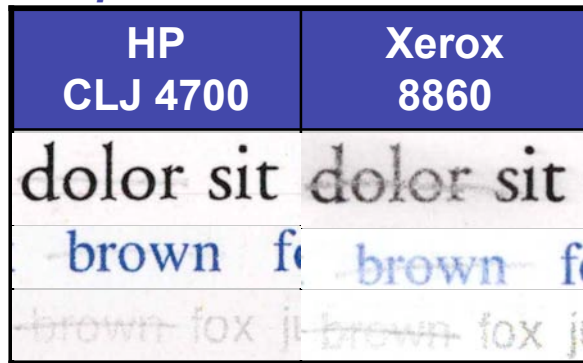


# General Durability and Handling — Erasure Test

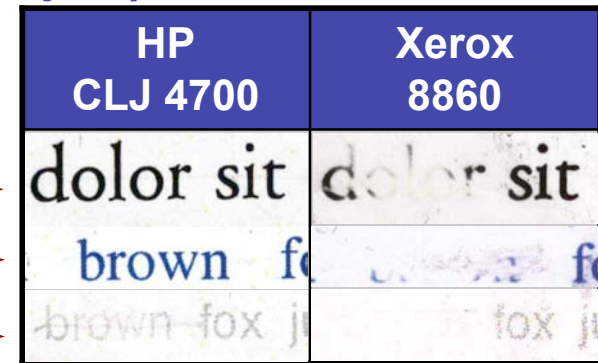
## Erasure Test

**Erasures did not smudge printed characters or affect legibility on HP CLJ 4700 prints; Xerox 8860 prints smudged and printed output was erased from the page**

### Plain Paper



### Glossy Paper



Strikethrough erasures of *Color Spectrum* test file:



### HP CLJ 4700

#### Plain & Glossy Paper

- Black Text did not smudge or lighten visibly when the strikethrough mark was erased
- Color Text did not smudge, but did lighten somewhat
  - Light Gray Color Text was almost completely erased

### Xerox 8860

#### Plain & Glossy Paper

- Black and Color Text smudged when the strikethrough mark was erased, adversely affecting legibility
  - Black and Color Text on glossy paper smudged the worst out of all comparative samples
  - Light Gray Color Text was almost completely erased while erasing strikethrough marks on both plain and glossy paper samples
  - All Color Text on glossy paper could be completely erased
- Erasures on Xerox prints were generally harder to clean than comparative HP samples
  - Due to the solid ink adhering to the eraser, the eraser had to be cleaned repeatedly or replaced in order to complete the Color Text Erasure Test on plain paper
  - Eraser "crumbs" adhered to the surface of the prints and could not be brushed away easily
  - Erased areas of glossy paper test prints had a rubbery, somewhat sticky texture



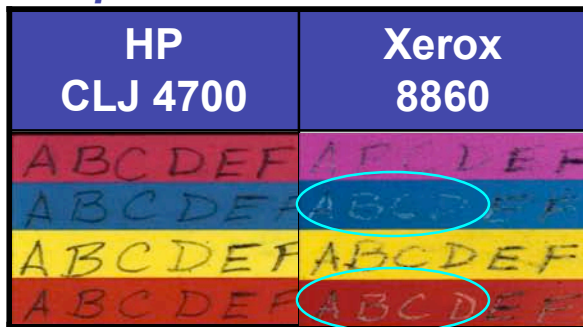


# General Durability and Handling — Write Test

## Write Test

**HP CLJ 4700 prints on both plain and glossy media can be written upon without difficulty; writing on Xerox 8860 prints was troublesome, print quality issues arose**

### Plain Paper



Text written in #2 pencil across color ramps of *Color Spectrum* test file

○ = scratch through print surface

### Glossy Paper



### HP CLJ 4700

#### Plain & Glossy Paper — all writing implements

- Written text is visible and legible across all tested print quality elements, utilizing all three writing implements

### Xerox 8860

#### Plain Paper

- Text written in pencil scratched through high density coverage areas of the solid ink and is not uniformly legible
- Text written in ballpoint pen and felt-tip pen is visible and legible on all tested print quality elements

#### Glossy Paper

- Text written in pencil and ballpoint pen scratched through the solid ink, more so than on plain paper
  - Notations made on some areas of the test documents are only legible and visible due to the scratching of the solid ink, no graphite or ink is visible
  - Strikethrough marks written in pencil and ballpoint pen on Black Text are light and hardly noticeable
- Text written in felt-tip pen is legible and visible on all tested print quality elements
  - Some strokes scratched through high density coverage areas of the test documents

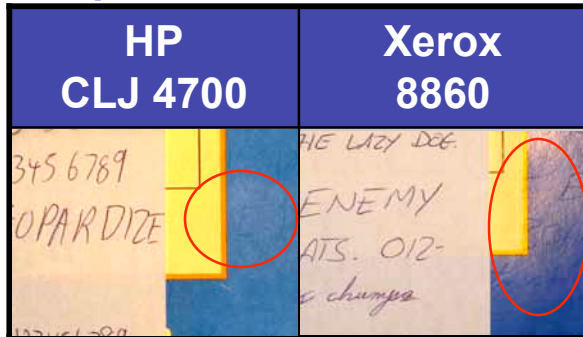


# General Durability and Handling — Write-Through Test

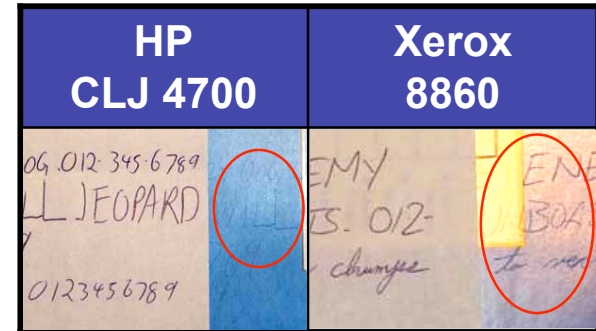
## Write-Through Test


**Xerox 8860 prints show a greater tendency to capture information through pressure transfer than HP CLJ 4700 prints — a potential breach of security and privacy**

### Plain Paper



### Glossy Paper



 = information captured via pressure transfer of text written on plain paper atop test documents

### HP CLJ 4700

#### Plain & Glossy Paper

- Text did not show through on the test documents when written in pencil or felt-tip pen
- Text was lightly imprinted onto the test document when ballpoint pen was used
  - Write-through text is visible in high density coverage areas and only when viewed at a specific angle
  - Write-through text is lightly visible on the media surface (unprinted areas) of glossy paper test documents
- There was no toner transfer from the test documents to the back of the writing sample paper

### Xerox 8860

#### Plain & Glossy Paper

- All writing implements produced visible write-through on high density coverage areas
- Write-through is most visible when using ballpoint pen, followed to a lesser extent with pencil, and felt-tip pen
- On glossy paper test documents, write-through is lightly visible on unprinted areas of the media surface
- A small amount of solid ink from the test document was transferred to the back of the writing sample paper from high coverage areas



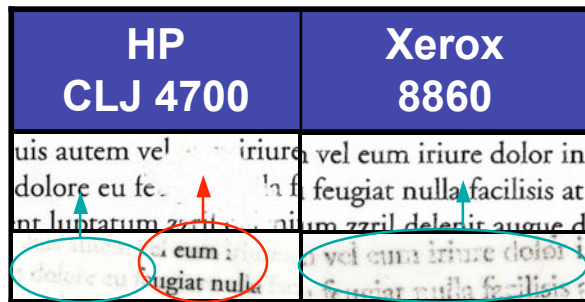


# General Durability and Handling — Data Removal Test

## Data Removal Test

**Xerox 8860 solid ink allows for document content removal using Scotch tape**

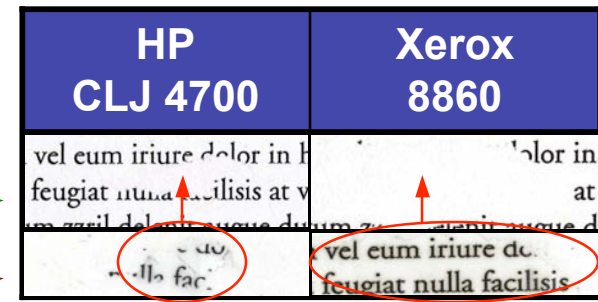
### Plain Paper



= Tape removed top layer of media with printed text  
 = Tape removed Solid Ink/Toner with data content without damaging media

Document   
 Scotch Tape

### Glossy Paper



#### HP CLJ 4700

- Media was damaged when the Scotch tape was removed
- Light toner transfer occurred from the test document to the Scotch tape
  - Toner on removed Scotch tape is barely legible

#### Xerox 8860

- Media was not damaged when the Scotch tape was removed
- Moderate solid ink transfer from the test document to the Scotch tape
- Solid ink transferred to tape is very legible

**Output from both the HP CLJ 4700 and the Xerox 8860 were unaffected in Data Removal Tests utilizing Post-it Notes**

#### HP CLJ 4700

- Media was damaged when the Scotch tape was removed
  - Adhesive residue remained around the damaged area of the printed document
- Negligible toner transfer from the test document to the Scotch tape
  - Toner transfer to tape is illegible

#### Xerox 8860

- Media ripped egregiously when Scotch tape was lifted
  - Legible words on the Scotch tape (as seen in the illustration above) are attributable to media damage, not solid ink transfer
  - Adhesive residue remained around the damaged area of the print
- Solid ink transfer from the test document to the Scotch tape was minor

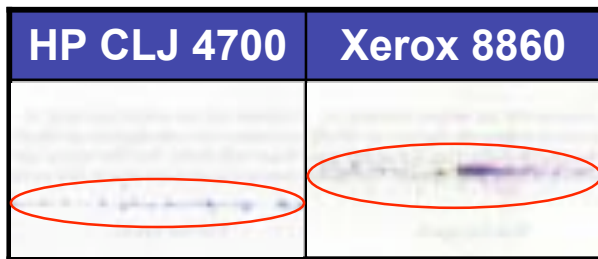



# Automation Compatibility Testing — Postal Collation Test

## Postal Collation Test — Letters

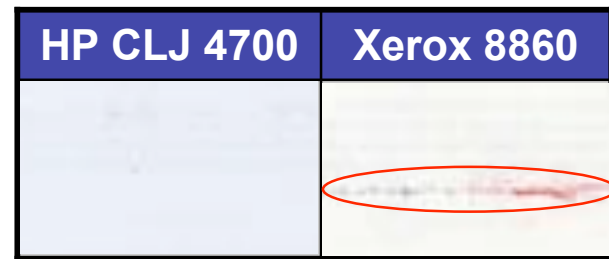
**When mailing documents, Solid Ink/Toner transfer between printed pages is worse on Xerox 8860 prints than on HP CLJ 4700 output**

### Plain Paper



 = Solid Ink/Toner transfer to the back of test documents along crease lines

### Glossy Paper



#### HP CLJ 4700

- Some toner transfer occurred between test documents
- Print quality degradation along crease lines was more noticeable on high density coverage areas
  - Text and low density coverage area folds were comparable to Crease Test results

#### Xerox 8860

- Solid ink transfer between documents was comparatively worse than HP samples
- Print quality degradation along crease lines was more noticeable on high density coverage areas
  - Text and low coverage area folds were comparable to Crease Test results

#### HP CLJ 4700

- Less toner transferred between test documents than comparative HP plain paper samples
- Print quality degradation along crease lines was more noticeable on high density coverage areas
  - Text and low coverage areas folds were comparable to Crease Test results
- Some crimping occurred along crease lines that were situated along the bottom edge of the envelope

#### Xerox 8860

- Solid ink transfer between documents was worse than seen on Xerox plain paper samples
- Print quality degradation along crease lines was more noticeable on high density coverage areas
  - Text and low density coverage area folds were comparable to Crease Test results
- Some crimping occurred along crease lines that were situated along the bottom edge of the envelope

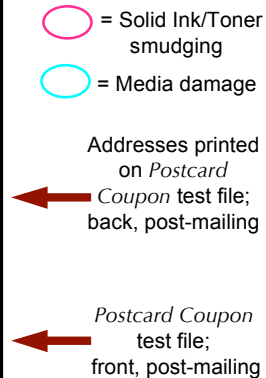
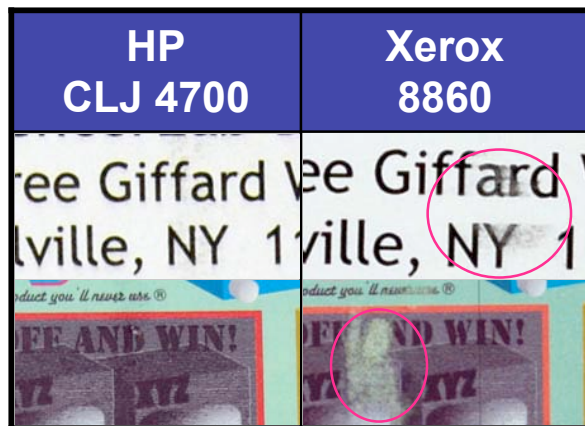


# Automation Compatibility Testing — Postal Collation Test

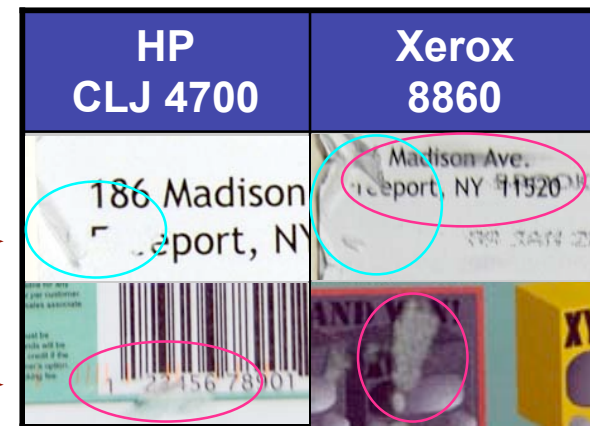
## Postal Collation Test — Postcards

**Postcards produced by the HP CLJ 4700 endured postal handling with less impact to document integrity than those produced by the Xerox 8860**

### Avery Postcard Media



### Xerox Postcard Media



#### HP CLJ 4700

- Some machine roller marks are visible on the postcard, but toner smudging is minimal, and all printed content is intact
  - Some minor folds in the media are present, but they do not adversely affect print quality

#### Xerox 8860

- Solid ink is smudged on both sides of the postcard,
- In some sections of the postcard, printed elements are almost completely removed
  - Some minor folds in the media are present, but they do not adversely affect print quality

#### HP CLJ 4700

- Toner smudging was infrequent, but worse than comparative samples on Avery Postcard Media

#### Xerox 8860

- Solid ink smudged on both sides of the postcard, and was almost completely removed in some areas
  - Comparatively worse than Xerox prints on Avery Postcard Media
  - Return address was half-removed, in one particularly bad instance



# Automation Compatibility Testing — ADF Automation Test

## ADF Automation Test

**Xerox 8860 prints consistently jammed in a belt-fed Automatic Document Feeder; HP CLJ 4700 prints copied without incident on both belt-fed and roller-fed Automatic Document Feeder units**

### Belt-fed Copier (Sharp AR-336)

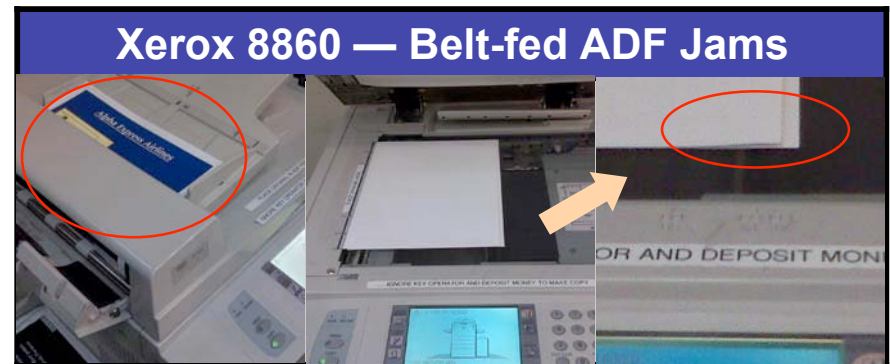
#### Plain & Glossy Paper

- All HP test documents fed through the ADF properly
- Xerox test documents invariably jammed in the copier, irrespective of media type or page coverage
  - Some documents jammed in the ADF unit
  - Others fed through the ADF but adhered to the scanning platen
  - In a copy shop or library with a self-service copier with click charges, misfeeds such as this can cost the consumer additional fees to re-print and cost the vendor added consumables

### Roller-fed Copier (Ricoh Aficio MP C3500)

#### Plain & Glossy Paper

- All HP test documents fed through the ADF properly
- All Xerox test documents fed through the ADF properly



Left: Xerox print jammed in the belt-fed ADF

Middle: Xerox prints adhere to the scanning platen and each other after passing through the ADF

Right: Close-up of the middle picture



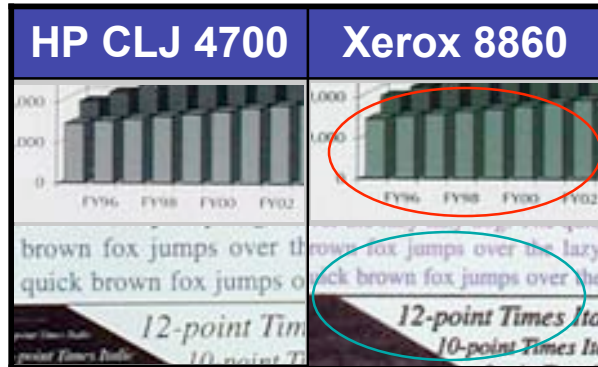


# Heat Fastness Testing— Environmental Simulation Test

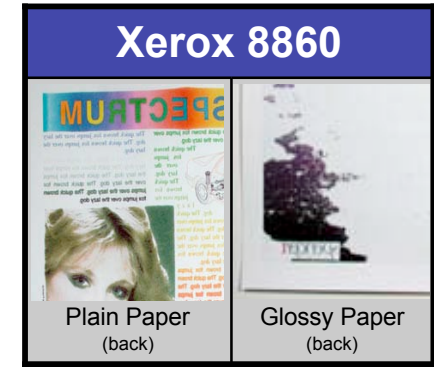
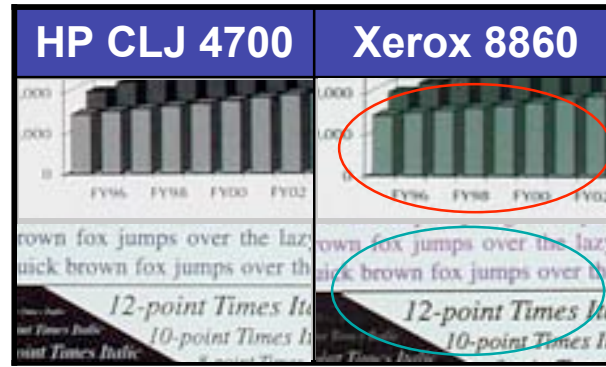
## Environmental Simulation

**HP CLJ 4700 prints endured temperatures up to 160°F; Xerox prints manifested discoloration at 120°F and additional print quality issues at 150°F**

### Plain Paper



### Glossy Paper



### HP CLJ 4700

#### Plain & Glossy Paper

- ° Temperatures up to 160°F produced negligible changes in print quality
- ° When documents were stacked and heated, there was negligible toner transfer between adjacent documents

### Xerox 8860

#### Plain & Glossy Paper

- ° Composite Black areas discolored at 120°F and exhibited green colorcasts
- ° Fine details and text edges blurred above 150°F, as the solid ink liquefied and bled into and through the media
  - ° While also present on the glossy paper samples, these defects are worse on plain paper samples
- ° When documents were stacked and heated, there was excessive solid ink transfer between adjacent documents
  - ° Solid ink transfer is especially noticeable on glossy paper, with documents adjacent to high coverage areas

= Xerox Composite Black areas turned green when heated past 120°F

= Xerox text lost sharpness when heated past 150°F

Left: Solid Ink bled through Xerox plain paper prints upon temperature increase  
Right: Solid Ink transferred to adjacent, stacked Xerox glossy paper prints upon temperature increase

## High-Temperature Environments

### Car Interiors

Ambient temperature inside a car can exceed outdoor temperature by 40°F or more<sup>†</sup>

### Fire Safes

UL-rated fire safes of Classes 125, 150 and 350 allow interior temperatures up to 125°F, 150°F and 350°F<sup>‡</sup>

### Climate Extremes

Arid, tropical and subtropical climates; especially relevant in countries without wide-spread air conditioning

<sup>†</sup> Source: <http://www.roadandtravel.com/automotive/newsviews/2005/sunshades.aspx>

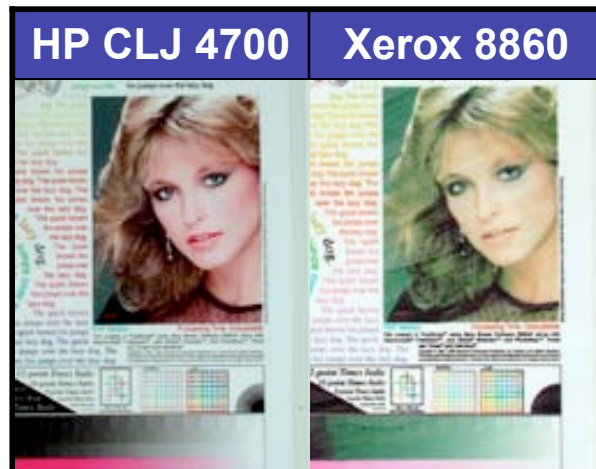
<sup>‡</sup> Source: <http://www.ul.com/newsroom/urban/safes.html>

# Heat Fastness Testing— Lamination Test

## Lamination Test

**Xerox 8860 solid ink prints were not fit-for-purpose after being subjected to commercial lamination services**

### Plain Paper



HP CLJ 4700

#### Plain & Glossy Paper

- HP test documents were perfectly compatible with widely-available, commercial heat-based lamination services
- No apparent degradation of print quality

#### Xerox 8860

#### Plain & Glossy Paper

- Solid ink smudged on plain paper samples and bled through the media
- Green color casts are visible on Composite Black areas of the laminated Xerox test documents
- Laminated Glossy Paper samples are unusable and illegible
  - *Solid ink ran and dripped out of the sides of the lamination sheets*
- Laminating Xerox prints can cause damage to the lamination machine
  - *One clerk refused to continue the lamination job after processing two Xerox glossy paper samples, citing damage to the lamination machine's rollers*
  - *Other clerks were hesitant to continue, and only reluctantly finished laminating the Xerox samples*

### Glossy Paper

