RIT University
Gravure Day
March 24, 2009
Manufacturing Manager, Gravure Process

RR Donnelley - Lancaster Facility, Lancaster, PA

30 years of service with RR Donnelley, serving in several management positions over the years, almost exclusively in Lancaster, PA. My experiences also include two years in Warsaw, IN. My areas of responsibilities during the 30 years include Premedia Services, Gravure Manufacturing, and Finishing Services, in addition to Materials Management.

My current responsibilities include the gravure operation in Lancaster PA along with materials (paper and ink), by-products and maintenance.

I received a BA degree in Mathematics in 1978 from Franklin and Marshall College, Lancaster PA.
Meeting the challenges of providing gravure print product for today's magazine, catalog and retail insert markets.

This topic will include brief comments on RR Donnelley, North America's largest supplier of print and print related services. In addition, we will cover the basic differences between the gravure and offset print processes with a focus on the technology available in the gravure industry today that enables RR Donnelley to offer competitive prices and exceed customer expectations in today's challenging economy.
<table>
<thead>
<tr>
<th>RR Donnelley Corporate Headquarters</th>
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<tbody>
<tr>
<td>Headquarters: 111 South Wacker Drive</td>
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<tr>
<td>Chicago, Illinois 60606-4301</td>
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<tr>
<td>312-326-8000</td>
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<tr>
<td><a href="http://www.rrdonnelley.com">www.rrdonnelley.com</a></td>
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</table>

| 2008 sales: | $11,581 million |
| Fortune 500: | 229th          |
| Employees:  | Nearly 60,000 worldwide |

| Locations:  |
| World-wide locations, with operations in North America, Latin America, Europe, Asia and United Arab Emirates (UAE) |

| Stock trading symbol: | RRD (NYSE) |
| Year Founded:        | 1864       |
RRD provides a Portfolio of Print and Non-Print Products and Services
Blue Chip Customer Relationships

And many others...
Catalogs

RR Donnelley prints

- 9 of the top 15 catalogers
- Business-to-business & consumer
- Provide targeting tools such as CustomMessenger, which matches a preprinted customized offer with the customer’s catalog
- From photography and premedia through logistics
  - Demographic binding
  - Custom covers and imprints
  - Personalized messages
  - Dot-whacking
  - Blow-ins
  - Bind-ins
  - Mail trace and track
  - Postal monitoring

All RR Donnelley North American Catalog Facilities are Forest Stewardship Council Certified
Magazines

- RR Donnelley prints:
  - The top 5 consumer magazines
  - For 8 of the top 10 consumer magazine publishers
  - Over 1,300 consumer, trade and association publications
- Highest U.S. circulation magazine at 23 million copies per issue
- We provide end-to-end solutions for prepress/preflight, premedia, paper management, print and bind, creative print options and distribution
- Innovative programs to reduce cycle time, waste, and cost

All RR Donnelley North American Magazine Facilities are Forest Stewardship Council Certified
Retail Inserts

- RR Donnelley prints:
  - For the top 15 retailers
  - For a variety of retail sectors including big box discounters, department stores, specialty retailers and drug stores
- Flexible formats
- Robust printing infrastructure and logistics network
- Responsive print schedules and consistently reliable quality

All RR Donnelley North American Retail Inserts Facilities are Forest Stewardship Council Certified
The Gravure Challenge – The RRD Solution

**Gravure Challenge:**

- How to translate customer data files to a competitively priced printed product achieving a minimum cycle time that meets the customer’s color and mechanical reproduction requirements.

**RR Donnelley solution:**

- Industry leading craftspeople possessing the knowledge and tools needed to provide for excellent control of the print process resulting in a faithful reproduction of color and mechanics of product.
Gravure/Offset Overview
The Major Printing Processes

Relief

Gravure

Screen

Offset
Recognizing the Printing Processes

Offset (Smooth Edges)

Relief (Ring of Ink)
Rotary Letterpress

Gravure (Serrated Edges)

Screen (Screen Edges)
Offset Dot Structure

- 25%
- 50%
- 75%
- 100%

Offset
Gravure Dot Structure

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<th>Elongated</th>
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Gravure
Pre-Press Process

**Gravure**
- Cylinder Making
  - Strip Shell
  - Copper Plate & Polish
  - Engrave
  - Chrome Plate & Polish
  - Press

**Offset**
- Plate Making
  - Expose
  - Develop
  - Bake
  - Gum
  - Bend
  - Press
Gravure Press versus Offset Press

Gravure

Offset
Offset vs. Gravure Process Comparison

**Offset Advantages**
- Short runs (cycle time)
- Make-ready time
- Makeovers
- Color Corrections (within Zone)
- Highlight detail
- Sharp type
- Cycle time
- Heavy weight stock
- Cost of equipment
- Cost of support areas

**Gravure Advantages**
- Long runs (throughput)
- Make-ready waste
- Run waste
- Color Consistency (across all pages)
- Shadow detail
- Color saturation
- Ink trap
- Variable cut-off
- Light weight stock
- Thick Pagination Product
- Press Delivered Product (Stitch & Trim)
What’s that all mean?

- **Length of run, versioning/demographics**
  - **Gravure:** high initial cost, lower LOR cost, versions changes more costly
  - **Offset:** lower initial cost, higher LOR cost, versions changes less costly

- **Paper consumption**
  - **Gravure:** 1-web
  - **Offset:** 2-web, more WBs, blanket washes

- **Reproduction**
  - **Gravure:** Superb colors and high gloss on lower-grade paper
  - **Offset:** Excellent reproduction on high-grade paper

- **Variables in reproduction**
  - **Gravure:** Head balance
  - **Offset:** inking keys
  - **Gravure:** Ink adjustments by side
  - **Offset:** in-line compromises
Lancaster’s Gravure Customer Base

- Target Stores
- The New York Times Magazine
- American Media (National Enquirer, Globe)
- Harriet Carter Catalog
- JC Penney
- Kohl’s
- Best Buy
- Walgreen’s
- Reader’s Digest
- Soap Opera Digest
- Guideposts
The Making of a Gravure Cylinder
Electronic page information is received in our Digital Prep area and processed for cylinder engraving on Donnelley’s NKI System.
Thumbnail Proof of NKI Ribbon Data
Lancaster’s Fully Automated Cylinder Storage and Handling System
Cylinders are delivered to Buffer area by Shuttles
Cylinders are reused by “popping” the copper/chrome shell at the ends and then *stripping* the shell off the base cylinder. Once complete, the cylinder is ready for re-plating a fresh shell of copper.
The cylinder is sent to a degrease tank, degreased and then a separating solution is applied to the cylinder.

Next step is to a Copper tank.
We then electroplate a new copper shell onto the base cylinder. The shell is about 80 microns thick (about the same thickness as a sheet of paper).
The Basic System

Rectifier

H\textsubscript{2}SO\textsubscript{4} providing conductivity

\[ \text{Cu}^{++} \rightarrow \text{Cu} \]

Anode

Cathode

Metallic ions produced

Metallic ions plated out

C\textsubscript{uSO\textsubscript{4}} dissociated
The cylinder is polished to a smooth finish. Measurements are taken to qualify copper hardness, roughness, and final size are recorded. Also a visual inspection for any defects.

The cylinder is now ready for Engrave
K6 Engraver
The K6 has many operator functions automated. Loading and Docking of Cylinder. Lateral head placement, test cut engrave and measurement, amplifier calculations, adjustment of amplifier, and engrave start.
During engraving the copper cylinder rotates as the Helio engraves the cells. A diamond stylus vibrates to produce the cells at speeds up to 7500 per second.
**Vacuum** – The copper chips are gathered by the vacuum system below in bags for easy emptying.

**Sliding Shoe** – The shoe rides on the cylinder surface, it keeps the diamond the proper distance from the cylinder.

**Diamond Stylus** – The stylus cuts the cells into the cylinder as the cylinder rotates. The stylus receives electrical impulses that cause the stylus to vibrate. This vibration is what engraves the cells. Each head is capable of engraving 7500 cells per second.

**Burr Cutter** – The burr caused by engraving is shaved off with this diamond.
Each color engraves at different speeds to achieve different cell shapes. Therefore each color takes a different amount of time to complete. The average cylinder takes about 50 minutes to engrave. Two standard Screen Angle and Raster configurations are used.

- 63 L/cm or 160 L/in for Uncoated work
- 70 L/cm or 177 L/in for Coated work
This picture demonstrates the different shapes for each color. The top two rows of each picture are the maximum cell size for each color. The middle row is the mid-tone, bottom rows are the minimum. These cells are measured and adjusted to within 1 micron of goal.
Set Cutting Distance to Cylinder

1. Distance of Cutting Tip set for Production
2. Angle of diamond measured
3. Saved in Engrave Head memory

Measure Diamond Cutting Angle

Set Cutting Distance to Cylinder
The CellGuard System Measures Width / Length

Using the stored angle along with the length / width, the system calculates a volume for each head.

System engraves and measures all required heads until goal tolerance is achieved.
After test cuts are complete a CellGuard Certificate is printed for a record of each cylinder engraved.
Upon completion of the engraving, each cylinder is visually inspected for defects. The cylinder is then ready for the final step, Chrome Plating.
Chrome Plating

The final step in the process is Chrome Plating. This places a 6 micron hard protective finish of chrome on the engraved cylinder and protects the softer copper from extended production runs.
After Chrome Plate the cylinder is paper polished.
One final quality check and our cylinder is ready to go to press.
The automation takes over once again and delivers the cylinder to the rack. The process is now complete and cylinders are ready for press.
The Making of a Gravure Cylinder
The gravure process is divided into four sections:

1. **Incoming Page Data and Contract Proof**
2. **Prepress Color Processing**
3. **Cylindermaking and Engraving**
4. **Pressroom**
1. Incoming Data and Color Guidance

Process Map

- Page Data
  - From RRD Premedia or other outside supplier
  - Note: Digital file, no “color”

- Raster Image Processor

- Color Processor

- Digital Color Proofer
  - Ink/Toner
  - Paper / substrate

- Final proof
  - Measure Pass/Fail
  - Should match Target Color Space (TR001 for example)

Specific to a given:
- Proofer type,
- Ink/Toner/Donor type,
- Substrate,
- Target Color Space
2. Prepress Color Processing

**Process Map**

- **Incoming page data from supplier**
- **CVC4** Program which uses correction tables to do transformation
- **Processed File**
- **Apply Gradations**
- **Engrave-Ready File**

**Color correction table**
- ICC standard color correction table
- Maps YMCK(proof) -> YMCK(press)
- Specific to:
  - Proof standard
  - Ink type
  - Paper type

**Gradations**
- Maps CMYK tones to engraved gravure CMYK tones
- Match weight and color of C=M=Y
- Match weight of K
RRD Digital Test Pages - Samples
## Evaluation of Output - GCT

### Listing for the GCT Only Table

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Helio gradations

- Function
  - Four, 1-dimensional “look-up” tables to map input data to engrave data
  - Converts prepress YMCK to engraving YMCK so that
    - C=M=Y will match proof in weight and color
    - K will match proof in weight only

C=M=Y “Brown scale”
K-only scale
3. Cylindermaking and Engraving

**Process Map**

**Cylindermaking Variables**
- Copper hardness, ductility
- Surface roughness
- Chrome hardness, roughness, thickness

**Copper plating and polishing**

**Helio Variables**
- Raster
- Highlights
- Mid-tones
- Shadow
  - Width, Channel, Length
- Diamond age, wear

After amplifiers are adjusted, YMCK separations are sent to engraver.

- Engraving
- Chrome plating
- Cylinders to pressroom

From Prepress Color Processing

Engrave-Ready File
Gravure Engraved Cell Shapes

100% (Shadow)

50% (Midtone)

5% (Highlight or Light-end)

Channel

Space

Coarse  Elongated  Compressed  Fine

Cell Shapes
Color Measurement Review

- Two systems used for measuring reflective objects
  - Densitometry (densitometer)
    - Useful for quality control, statistical process control
    - Not useful for comparing two colors of different materials
  - Colorimetry (colorimeter/spectrophotometer)
    - Designed to take into account human vision, standard lighting sources
    - Can be used to compare colors of two different materials
Densitometers vs. Spectrophotometers

**DENSITOMETERS**

- Measure *density* (the amount of colorant on a proof/print)
- Good tool for -
  - bring presses up to color at the start of a run,
  - keep printers/proofers within targets
- Numbers are *not related* to visual perception
- Cannot compare numbers of two *different* types of proofs or prints

**SPECTROPHOTOMETERS**

- Useful for measuring colors *the way we see them*
  - Calculated numbers are related to visual perception under a standard illuminant, such as D5000
- Good tool to compare proof to swatch, press to proof, etc..
- System of color matching is called *Colorimetry*
Colorimetry - System

D5000 Viewing Booth

Spectrophotometer + Model of Human Vision

L* a* b*

Object - Cyan Ink on paper
CIELAB Color Space

- 3 Values, L*, a*, b*:
  - L* - Lightness (White/Black)
  - a* - Greenness/Redness
  - b* - Blueness/Yellowness
- C*, colorfullness is the distance from 0,0 on the a*b* plot
- Colors arranged in an intuitive Hue circle from R->Y->G->B
4. Pressroom

**Cylinders from Chrome Plating**

**ESA (Electro-static assist)**
Assists printout and improves smoothness in light to mid-tones

**Paper Variables**
- Basis Wt
- Surface finish
- Gloss
- Absorbtivity
- Color
- Compressibility

**Ink Variables**
- Color
- Hue
- Print curve
- Temperature

**Varnish (Extender)**
- Unpigmented Ink
- Reduces ink strength
- Dilution ratio

**Ink Formulation Variables**
- Ink:Varnish
  - Controls strength of ink
- Viscosity
  - Ink flow, print smoothness
- Strength
- Printout
- Temperature

**Solvent**
- Thins ink
- Improves flow

**Process Map**

- **ESA**
- Impression Roller
- Dr. Blade
- Paper Roll
- Running Ink
Pressroom

- Pressroom
  - Where cylinders : ink : paper : press all come together
  - *The area with the most potential variation*

- *Paper is also a variable:* but one that is assumed to be controlled, consistent

- *Ink formulation* is variable: controllable

- *Printing nip,* press variables: assumed to be controlled
Production Press – Three Color Controls

- **Ink Formula**
  - Ink set used (pigment hues, fillers, wax content, etc.)
  - Ink cut % (varnish / (ink+varnish))%
  - Varnish/extender used
  - Other additives (hardeners, waxes, defoamers, etc.)

- **Ink Viscosity**
  - Needs to be regularly measured with GS cup
  - Maintained by viscometer on press

- **ESA (electro-static assist)**
  - Electrical charge to draw ink from wells
  - Must be properly adjusted to get smooth printing highlight
Ink Formulation

Function
- To achieve target color saturation and weight at desired viscosity throughout the entire scale
Effects of Varnish Adjustment

- Varnish adjusts the color strength of the ink

![Diagram showing the effects of varnish adjustment on ink strength](image-url)

Ink:
- 100%
- 75%
- 50%
- 25%
- 5%

Varnish:
- Shadow
- Hi-Lite
Proper Viscosity Adjustment

- Solvent used to adjust the viscosity of the ink
  - Affects the flow of ink from the cells and the drying of the ink

Dry

100% Starting to screen
75% Screening
50% Screening
25% Printing rough (skip dot)
5% Not Printing

100% Flowing
75% Flowing
50% Screening
25% Printing a solid dot
5% Printing, a solid edge is visible

Normal

100% Flowing
75% Flowing
50% Screening
25% Printing a solid dot
5% Printing, a solid edge is visible

Wet

100% Flowing
75% Flowing
50% Flowing, visually stronger
25% Printing a solid dot
5% Printing, a solid edge is visible
Establishing Color OK

Press Crews:

- Verify that all ink temperatures are to standards
- Adjust all starting ink formulas to targets
- Adjust press to target speed for color
- Keep records of ink meter readings
  - Track additions, record final formulas
- Warm up press, hone in doctor blades, verify ESA
Establishing Color OK

Press Crews

- Examine the tone scales for proper screening and flow, make viscosity adjustments as necessary
- Verify mechanics (register, folds, slitter trim, cropping, scratches, skew, ESA problems, bleeding dragging, dirty impression rollers, etc.)
- Evaluate guidance, make minor ink formula adjustments
Maintaining Color

1) Input the proper batching formula
   • Use Ink, Varnish in same proportions as at Color OK

2) Control batching viscosity
   • Add proper solvent for Ink, Varnish to maintain target viscosity

3) Track print densities with the Density Collection System
Register controls

Eyemarker readers

Eyemarks

Register control system
Viscosity controls

ink cut  viscosity  temperature
Density Collection System

- Records density readings in database (100%, 75%, 50%, 25%, 5%)
- Ink cut
- Ink viscosity
- Ink temperature
- All time/date stamped
The end result