Cylinder Specifications

Chiawei Wu
Engraving Manager
Packaging corporation of America, Waco, Texas
2010 RIT Gravure Day

1. Packaging Corporation of America (PCA)

Waco, Texas

2. Cylinder Specifications

Mechanical Engraving

Electro-Mechanical Engraving
Packaging Corporation of America

Structure & Graphic Design
Electronic Prepress

Plating & Engraving
Rotogravure Printing
Packaging Corporation of America

One – Stop Shopping

- 87-inch Langston Corrugator
- 60-inch Lux (Roll-to-Roll) Laminator
- Asitrade Litho Laminator
- 5 Single facers
- C, B, E, & F Flute
- E/B, B/C Double Wall
- Split Roll Technology
- Barrier Coatings
- Tear and Reinforcement Tapes
- Direct Drive Knife
- Narrow Roll
Rotogravure is the premier, cost effective, printing method for higher volume, high resolution packaging and displays.
Packaging Corporation of America
Packaging Corporation of America
Packaging Corporation of America
Packaging Corporation of America

Rotogravure printing
shopping bags
Accomplishments: Events in 2010

• PCA/Waco: Safety --- No Lost Time Accident

• Winner of the 2010 PLGA Print Quality Awards: Corrugated Box Category & “Best of Show”

• GAA 2010 Golden Cylinder Awards winner......

• Summer Internship --- WMU
PCA/Waco celebrated 3 million labor hours without lost time accident on March 3, 2010
Cylinder preparation workflow

1986 --- 2000
1. De-chrome plating
2. Cut off Image, Rough cut
3. Copper plating Over final size
4. Polishing to size, Rough & Fine cut
5. Light Polishing
6. Engraving
7. Chrome Plating
8. Proofing
9. Printing

2000 --- 2003
Plate to size
1. De-chrome plating
2. Cut off Image Rough & Fine cut
3. Copper plating To final size
4. Light Polishing
5. Engraving
6. Chrome Plating
7. Proofing
8. Printing

2003 --- Present
Ballard Shell
1. Peel off shell old Image
2. Copper plating To final size**
3. Light Polishing
4. Engraving
5. Chrome Plating
6. Proofing
7. Printing
Cylinder specifications

- **Part I:**
  The Five Elements of Cell Specifications

- **Part II:**
  Process Specifications & Ink Transfer from Electro-Mechanical Engraved Cell
Cylinder specifications

Part I: The Five Elements of Cell Specifications
The Five Elements of Cell Specifications

1. Stylus
2. Angle
3. Wall
4. Channel
5. Line Screen
The illustration shows a close-up of the three different varieties of cells used in gravure printing.

The cells shown above are the same in area but different in depth.

The cells shown above are the same depth but different in area.

The cells shown above are different in area and depth.
Electro-Mechanical Engraved Cell

◆ A cell is comprised of:
  2 Walls + 1 Channel + 1 Opening
◆ Cell is looked like
  the pyramid
◆ Cell depth is varied
  with cell width
Electro-Mechanical Engraved Cell continued

Measuring the cell:

- the width of the cell
- the channel
- the height of the cell
Line Screen continued

- Wall
- Cell Opening
- Channel
Measurement 101

1. Inches
2. Microns
3. Billion Cubic Microns
4. Cylinder Square Inches
5. Meters
Measurement 101 continued

1 cm = .01m = 1 x 10^{-2} m

1 mm = .001m = 1 x 10^{-3} m

1 \mu m = .000001m = 1 x 10^{-6} m

1 inch = .0254m or 2.54 x 10^{-2} m

1 inch = (x \text{ microns})

2.54 x 10^{-2} m = x(1 x 10^{-6} m)

\[
\begin{array}{c}
\times \\
\frac{2.54 \times 10^{-2} m}{1 \times 10^{-6} m}
\end{array}
\]

= \[2.54 \times 10^4 \mu m = 25,400 \mu m\]
Stylus

Besides putting holes in copper, what is its significance?

1. The stylus *DOES NOT* control cell opening.
2. The stylus *DOES* effect depth; therefore, the stylus *DOES* effect volume.
Stylus continued

The steeper the stylus angle, the greater the depth.

(Illustration based on same size cell opening.)

105°  110°  115°  120°  125°  130°

160µm

37µm  46µm  56µm

110°  120°  130°
**Cell Width vs. Cell Depth**

**Cell Depth vs. Cell Width**

For a given stylus depth, the following table shows the cell depth (in microns) when using a stylus angle of:

<table>
<thead>
<tr>
<th>Cell Width (u)</th>
<th>105°</th>
<th>110°</th>
<th>115°</th>
<th>120°</th>
<th>125°</th>
<th>130°</th>
<th>135°</th>
<th>140°</th>
<th>145°</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1.9</td>
<td>1.8</td>
<td>1.6</td>
<td>1.4</td>
<td>1.3</td>
<td>1.2</td>
<td>1.0</td>
<td>0.9</td>
<td>0.8</td>
</tr>
<tr>
<td>10</td>
<td>3.8</td>
<td>3.5</td>
<td>3.2</td>
<td>2.9</td>
<td>2.6</td>
<td>2.3</td>
<td>2.1</td>
<td>1.8</td>
<td>1.6</td>
</tr>
<tr>
<td>15</td>
<td>5.8</td>
<td>5.3</td>
<td>4.8</td>
<td>4.3</td>
<td>3.9</td>
<td>3.5</td>
<td>3.1</td>
<td>2.7</td>
<td>2.4</td>
</tr>
<tr>
<td>20</td>
<td>7.7</td>
<td>7.0</td>
<td>6.4</td>
<td>5.8</td>
<td>5.2</td>
<td>4.7</td>
<td>4.1</td>
<td>3.6</td>
<td>3.2</td>
</tr>
<tr>
<td>25</td>
<td>9.6</td>
<td>8.8</td>
<td>8.0</td>
<td>7.2</td>
<td>6.5</td>
<td>5.8</td>
<td>5.2</td>
<td>4.5</td>
<td>3.9</td>
</tr>
<tr>
<td>30</td>
<td>11.5</td>
<td>10.5</td>
<td>9.6</td>
<td>8.7</td>
<td>7.8</td>
<td>7.0</td>
<td>6.2</td>
<td>5.5</td>
<td>4.7</td>
</tr>
<tr>
<td>35</td>
<td>13.4</td>
<td>12.3</td>
<td>11.1</td>
<td>10.1</td>
<td>9.1</td>
<td>8.1</td>
<td>7.2</td>
<td>6.4</td>
<td>5.5</td>
</tr>
<tr>
<td>40</td>
<td>15.3</td>
<td>14.0</td>
<td>12.7</td>
<td>11.5</td>
<td>10.4</td>
<td>9.3</td>
<td>8.3</td>
<td>7.3</td>
<td>6.3</td>
</tr>
<tr>
<td>45</td>
<td>17.3</td>
<td>15.8</td>
<td>14.3</td>
<td>13.0</td>
<td>11.7</td>
<td>10.5</td>
<td>9.3</td>
<td>8.2</td>
<td>7.1</td>
</tr>
<tr>
<td>50</td>
<td>19.2</td>
<td>17.5</td>
<td>15.9</td>
<td>14.4</td>
<td>13.0</td>
<td>11.7</td>
<td>10.4</td>
<td>9.1</td>
<td>7.9</td>
</tr>
<tr>
<td>55</td>
<td>21.1</td>
<td>19.3</td>
<td>17.5</td>
<td>15.9</td>
<td>14.3</td>
<td>12.8</td>
<td>11.4</td>
<td>10.0</td>
<td>8.7</td>
</tr>
<tr>
<td>60</td>
<td>23.0</td>
<td>21.0</td>
<td>19.1</td>
<td>17.3</td>
<td>15.6</td>
<td>14.0</td>
<td>12.4</td>
<td>10.9</td>
<td>9.4</td>
</tr>
<tr>
<td>65</td>
<td>24.9</td>
<td>22.8</td>
<td>20.7</td>
<td>18.8</td>
<td>16.9</td>
<td>15.1</td>
<td>13.5</td>
<td>11.8</td>
<td>10.2</td>
</tr>
<tr>
<td>70</td>
<td>26.9</td>
<td>24.5</td>
<td>22.3</td>
<td>20.2</td>
<td>18.2</td>
<td>16.3</td>
<td>14.5</td>
<td>12.7</td>
<td>11.0</td>
</tr>
<tr>
<td>75</td>
<td>28.8</td>
<td>26.3</td>
<td>23.9</td>
<td>21.7</td>
<td>19.5</td>
<td>17.5</td>
<td>15.5</td>
<td>13.6</td>
<td>11.8</td>
</tr>
<tr>
<td>80</td>
<td>30.7</td>
<td>28.0</td>
<td>25.5</td>
<td>23.1</td>
<td>20.8</td>
<td>18.6</td>
<td>16.6</td>
<td>14.6</td>
<td>12.6</td>
</tr>
<tr>
<td>85</td>
<td>32.6</td>
<td>29.8</td>
<td>27.1</td>
<td>24.5</td>
<td>22.1</td>
<td>19.8</td>
<td>17.6</td>
<td>15.5</td>
<td>13.4</td>
</tr>
<tr>
<td>90</td>
<td>34.5</td>
<td>31.5</td>
<td>28.7</td>
<td>26.0</td>
<td>23.4</td>
<td>21.0</td>
<td>18.6</td>
<td>16.4</td>
<td>14.2</td>
</tr>
<tr>
<td>95</td>
<td>36.4</td>
<td>33.3</td>
<td>30.3</td>
<td>27.4</td>
<td>24.7</td>
<td>22.1</td>
<td>19.7</td>
<td>17.3</td>
<td>15.0</td>
</tr>
<tr>
<td>100</td>
<td>38.4</td>
<td>35.0</td>
<td>31.8</td>
<td>28.9</td>
<td>26.0</td>
<td>23.3</td>
<td>20.7</td>
<td>18.2</td>
<td>15.8</td>
</tr>
</tbody>
</table>
Engraved Cell Volume

**Ink Volume per Unit Area:**

Formula: \[(\text{Cell Width} \times \text{length} \times \text{Depth}) \times (\text{Vertical} \times \text{Horizontal screen}) \div 6\]

*Volume per Cell* = \((\text{Cell Width} \times \text{Cell Length} \times \text{Cell Depth}) \div 6\)

*lines per sq. inch* = \(\text{Vertical lpi} \times \text{Horizontal lpi}\)

*1 Inch* = 25,400 µm
Stylus continued

Example:

<table>
<thead>
<tr>
<th>lpi</th>
<th>angle</th>
<th>stylus</th>
<th>channel</th>
<th>wall</th>
<th>depth</th>
<th>width</th>
<th>volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>38°</td>
<td>110</td>
<td>30</td>
<td>8</td>
<td>75</td>
<td>215</td>
<td>16.0 bcm</td>
</tr>
<tr>
<td>150</td>
<td>38°</td>
<td>120</td>
<td>30</td>
<td>8</td>
<td>62</td>
<td>215</td>
<td>13.2 bcm</td>
</tr>
<tr>
<td>150</td>
<td>38°</td>
<td>130</td>
<td>30</td>
<td>8</td>
<td>50</td>
<td>215</td>
<td>10.7 bcm</td>
</tr>
</tbody>
</table>

If: stylus angle decreases from 130° to 110°

Then: depth increases from 50µm to 75µm

Therefore: volume increases from 10.7 bcm to 16.0 bcm
Angle of Compression

- Controls cell shape and depth

- Ranges from 30° to 60°
  - 30°: vertical length < horizontal width
  - 45°: vertical length = horizontal width
  - 60°: vertical length > horizontal width
Angle of Compression continued

- Cell units can vary in size, shape, & depth; not in amount per sq. inch.
Angle of Compression continued

Example:

<table>
<thead>
<tr>
<th>lpi</th>
<th>angle</th>
<th>stylus</th>
<th>channel</th>
<th>wall</th>
<th>depth</th>
<th>width</th>
<th>volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>30°</td>
<td>120</td>
<td>30</td>
<td>8</td>
<td>73</td>
<td>253</td>
<td>15.5 bcm</td>
</tr>
<tr>
<td>150</td>
<td>45°</td>
<td>120</td>
<td>30</td>
<td>8</td>
<td>54</td>
<td>187</td>
<td>11.5 bcm</td>
</tr>
<tr>
<td>150</td>
<td>60°</td>
<td>120</td>
<td>30</td>
<td>8</td>
<td>39</td>
<td>133</td>
<td>8.2 bcm</td>
</tr>
</tbody>
</table>

If: angle decreases from 60° to 30°

Then: depth increases from 39µm to 73µm and cell width increases from 133µm to 253µm

Therefore: volume increases from 8.2 bcm to 15.5 bcm
Angle of Compression continued

150lpi 30° 120(S) 30(C) 8(W) 150lpi 45° 120(S) 30(C) 8(W)

150lpi 60° 120(S) 30(C) 8(W)
Walls

- Leave them alone; 8\(\mu\)m is a great number for 100\% cell!
- The bigger the wall, the less chance of printing a solid.
Walls continued

Example:

<table>
<thead>
<tr>
<th>lpi</th>
<th>angle</th>
<th>stylus</th>
<th>channel</th>
<th>wall</th>
<th>depth</th>
<th>width</th>
<th>volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>38°</td>
<td>120</td>
<td>30</td>
<td>8</td>
<td>62</td>
<td>235</td>
<td>13.2 bcm</td>
</tr>
<tr>
<td>150</td>
<td>38°</td>
<td>120</td>
<td>30</td>
<td>16</td>
<td>55</td>
<td>219</td>
<td>10.4 bcm</td>
</tr>
<tr>
<td>150</td>
<td>38°</td>
<td>120</td>
<td>30</td>
<td>24</td>
<td>47</td>
<td>193</td>
<td>7.9 bcm</td>
</tr>
</tbody>
</table>

If:  

wall decreases from 24µm to 8µm

Then:  

depth increases from 47µm to 62µm and

cell width increases from 193µm to 245µm

Therefore: volume increases from 7.9 bcm to 13.2 bcm
Walls continued

150 lpi 38° 120(S) 30(C) 8(W)  

150 lpi 38° 120(S) 30(C) 16(W)  

150 lpi 38° 120(S) 30(C) 24(W)
Channel

- Channel measurement is not your choice
- Channel measurement is a direct result of the specified angle

  - $30^\circ : 15\%$ of the width of the cell
  - $45^\circ : 10\%$ of the width of the cell
  - $60^\circ : 2\%$ of the width of the cell
For all angles between 30° and 60°, for every 1° of change, the width of the cell changes 1/3 of one percent.

Example:

<table>
<thead>
<tr>
<th>lpi</th>
<th>angle</th>
<th>stylus</th>
<th>channel</th>
<th>wall</th>
<th>cell width</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>30°</td>
<td>120</td>
<td>43</td>
<td>8</td>
<td>240 * 0.15</td>
</tr>
<tr>
<td>150</td>
<td>38°</td>
<td>120</td>
<td>31</td>
<td>8</td>
<td>214 * 0.113</td>
</tr>
<tr>
<td>150</td>
<td>45°</td>
<td>120</td>
<td>22</td>
<td>8</td>
<td>195 * 0.10</td>
</tr>
<tr>
<td>150</td>
<td>60°</td>
<td>120</td>
<td>4</td>
<td>8</td>
<td>159 * 0.02</td>
</tr>
</tbody>
</table>

30° : 15% of the width of the cell
33° : 14% of the width of the cell
38° : 11.3% of the width of the cell
45° : 10% of the width of the cell
60° : 2% of the width of the cell
Channel continued

Example:

<table>
<thead>
<tr>
<th>lpi</th>
<th>angle</th>
<th>stylus</th>
<th>channel</th>
<th>wall</th>
<th>depth</th>
<th>width</th>
<th>volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>38°</td>
<td>120</td>
<td>10</td>
<td>8</td>
<td>68</td>
<td>235</td>
<td>14.7 bcm</td>
</tr>
<tr>
<td>150</td>
<td>38°</td>
<td>120</td>
<td>20</td>
<td>8</td>
<td>65</td>
<td>225</td>
<td>13.9 bcm</td>
</tr>
<tr>
<td>150</td>
<td>38°</td>
<td>120</td>
<td>30</td>
<td>8</td>
<td>62</td>
<td>215</td>
<td>13.2 bcm</td>
</tr>
</tbody>
</table>

If: channel decreases from 30µm to 10µm
Then: depth increases from 62µm to 68µm and cell width increases from 215µm to 235µm

Therefore: volume increases from 13.2 bcm to 14.7 bcm
Channel continued

150lpi 38° 120(S) 10(C) 8(W)

150lpi 38° 120(S) 20(C) 8(W)

150lpi 38° 120(S) 30(C) 8(W)
Line Screen

- Cell openings are always measured in microns
  1 inch = 25,400 microns
  0.001” = 25.4 µm
- Measuring methods create confusion in actual number of lines per inch

Example:
150 lpi at 45° angle = 109 cells per inch
Line Screen continued

- Equal size horizontally & vertically: 217µm x 217µm (approx.)

- Specific cell numbers in the diagonal:
  
  \[
  \frac{25,400\text{µm}}{(217 + 16 \text{ wall})\text{µm}} = 109 \text{ cells per inch (H)}
  \]

  \[
  \frac{25,400\text{µm}}{(217 + 16 \text{ wall})\text{µm}} = 109 \text{ cells per inch (V)}
  \]
Electro-Mechanical Engraving Screen Angle with Screen Factor

<table>
<thead>
<tr>
<th>Screen Angle</th>
<th>Vertical Screen Factor</th>
<th>Horizontal Screen Factor</th>
<th>Resulting Cell Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>1.303</td>
<td>0.767</td>
<td>Compressed</td>
</tr>
<tr>
<td>31</td>
<td>1.208</td>
<td>0.781</td>
<td>Compressed</td>
</tr>
<tr>
<td>32</td>
<td>1.257</td>
<td>0.795</td>
<td>Compressed</td>
</tr>
<tr>
<td>33</td>
<td>1.235</td>
<td>0.810</td>
<td>Compressed</td>
</tr>
<tr>
<td>34</td>
<td>1.213</td>
<td>0.824</td>
<td>Compressed</td>
</tr>
<tr>
<td>35</td>
<td>1.192</td>
<td>0.839</td>
<td>Compressed</td>
</tr>
<tr>
<td>36</td>
<td>1.171</td>
<td>0.854</td>
<td>Compressed</td>
</tr>
<tr>
<td>37</td>
<td>1.150</td>
<td>0.867</td>
<td>Compressed</td>
</tr>
<tr>
<td>38</td>
<td>1.130</td>
<td>0.885</td>
<td>Compressed</td>
</tr>
<tr>
<td>39</td>
<td>1.111</td>
<td>0.900</td>
<td>Compressed</td>
</tr>
<tr>
<td>40</td>
<td>1.091</td>
<td>0.916</td>
<td>Compressed</td>
</tr>
<tr>
<td>41</td>
<td>1.072</td>
<td>0.933</td>
<td>Compressed</td>
</tr>
<tr>
<td>42</td>
<td>1.054</td>
<td>0.949</td>
<td>Compressed</td>
</tr>
<tr>
<td>43</td>
<td>1.036</td>
<td>0.966</td>
<td>Compressed</td>
</tr>
<tr>
<td>44</td>
<td>1.018</td>
<td>0.983</td>
<td>Compressed</td>
</tr>
<tr>
<td>45</td>
<td>1.000</td>
<td>1.000</td>
<td>Normal</td>
</tr>
<tr>
<td>46</td>
<td>0.983</td>
<td>1.018</td>
<td>Elongated</td>
</tr>
<tr>
<td>47</td>
<td>0.966</td>
<td>1.036</td>
<td>Elongated</td>
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<tr>
<td>48</td>
<td>0.949</td>
<td>1.054</td>
<td>Elongated</td>
</tr>
<tr>
<td>49</td>
<td>0.933</td>
<td>1.072</td>
<td>Elongated</td>
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<tr>
<td>50</td>
<td>0.916</td>
<td>1.091</td>
<td>Elongated</td>
</tr>
<tr>
<td>51</td>
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<td>1.111</td>
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<tr>
<td>52</td>
<td>0.885</td>
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</tr>
<tr>
<td>53</td>
<td>0.867</td>
<td>1.150</td>
<td>Elongated</td>
</tr>
<tr>
<td>54</td>
<td>0.854</td>
<td>1.171</td>
<td>Elongated</td>
</tr>
<tr>
<td>55</td>
<td>0.839</td>
<td>1.192</td>
<td>Elongated</td>
</tr>
<tr>
<td>56</td>
<td>0.824</td>
<td>1.213</td>
<td>Elongated</td>
</tr>
<tr>
<td>57</td>
<td>0.810</td>
<td>1.235</td>
<td>Elongated</td>
</tr>
<tr>
<td>58</td>
<td>0.795</td>
<td>1.257</td>
<td>Elongated</td>
</tr>
<tr>
<td>59</td>
<td>0.781</td>
<td>1.208</td>
<td>Elongated</td>
</tr>
<tr>
<td>60</td>
<td>0.767</td>
<td>1.303</td>
<td>Elongated</td>
</tr>
</tbody>
</table>
Line Screen continued

- Much larger horizontally than vertically:
  \[166\,\mu m \times 283\,\mu m\] (approx.)
  \[217 \times 0.767 = 166\ (V)\]
  \[217 \div 0.767 = 283\ (H)\]
  \[(217 \times 1.303 = 283(H))\]

- Specific cell numbers in the diagonal:
  \[25,400\,\mu m \div (166 + 16\ \text{wall})\,\mu m = 140\ \text{cells per inch (V)}\]
  \[25,400\,\mu m \div (283 + 16\ \text{wall})\,\mu m = 85\ \text{cells per inch (H)}\]
Line Screen continued

• Much smaller horizontally than vertically:
  283µm x 166µm (approx.)
  217 x 0.767 = 166 (H)
  217 ÷ 0.767 = 283 (V)

• Specific cell numbers in the diagonal:
  25,400µm ÷ (166 + 16 wall)µm = 140 cells per inch (H)
  25,400µm ÷ (283 + 16 wall)µm = 85 cells per inch (V)
Line Screen  continued

Example:

<table>
<thead>
<tr>
<th>lpi</th>
<th>angle</th>
<th>stylus</th>
<th>channel</th>
<th>wall</th>
<th>depth</th>
<th>width</th>
<th>volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>38°</td>
<td>120</td>
<td>30</td>
<td>8</td>
<td>62</td>
<td>215</td>
<td>13.2 bcm</td>
</tr>
<tr>
<td>175</td>
<td>38°</td>
<td>120</td>
<td>30</td>
<td>8</td>
<td>51</td>
<td>176</td>
<td>10.7 bcm</td>
</tr>
<tr>
<td>200</td>
<td>38°</td>
<td>120</td>
<td>30</td>
<td>8</td>
<td>42</td>
<td>147</td>
<td>8.8 bcm</td>
</tr>
</tbody>
</table>

If:  
line screen decreases from 200 lpi to 150 lpi

Then:  
depth increases from 42µm to 62µm and
cell width increases from 147µm to 215µm

Therefore: volume increases from 8.8 bcm to 13.2 bcm
Line Screen continued

150 lpi 38° 120(S) 30(C) 8(W)

175 lpi 38° 120(S) 30(C) 8(W)

200 lpi 38° 120(S) 30(C) 8(W)
Change in line screen has the greatest impact on engraving time.

150 line screen = 22,500 cells per sq inch
200 line screen = 40,000 cells per sq inch

\[
\frac{22,500}{40,000} = 56.25 \% \quad (43.75\%)\text{faster}^* 
\]
Line Screen continued

Engraving Time Calculations:

Formula: \[
\frac{(\text{cylinder sq. inches} \times \text{lines per sq. inch})}{3,200 \text{ avg. cells per hr} \times 60 \times 60}
\]

Cylinder Sq. inches = \[
(\text{Face in inches} \times \text{circumference in inches})
\]

cylinder sq. inches = \text{Cylinder diameter} \times \pi \times \text{Cylinder face}

lines per sq. inch = \text{Vertical lpi} \times \text{Horizontal lpi}

cells per hour = \text{(Engraving cell rate/ per second)} \times 60 \times 60
Line Screen continued

Example: 150 lpi vs. 200 lpi on an overall cylinder, cylinder face = 57 inches, diameter = 8.800

Formula: \[
\frac{(\text{cylinder sq. inches} \times \text{lines per sq. inch})}{3,200 \text{ avg. cells per hr} \times 60 \times 60}
\]

<table>
<thead>
<tr>
<th>Description</th>
<th>Calculation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder sq. inches</td>
<td>(8.800 \times \pi \times 57)</td>
<td>1575</td>
</tr>
<tr>
<td>Lines per sq. inch</td>
<td>(150 \times 150 = 22,500)</td>
<td></td>
</tr>
<tr>
<td>Cells per hour</td>
<td>(3,200 \times 60 \times 60 = 11,520,000)</td>
<td>3.08 hours</td>
</tr>
</tbody>
</table>

\[
\frac{1575 \times 22,500}{11,520,000} = 3,543,750 = 3.08 \text{ hours}
\]

\[
\frac{1575 \times 40,000}{11,520,000} = 63,000,000 = 5.47 \text{ hours}
\]
Summary of Volume Increase for the Five Elements

- If values for the line screen, angle, stylus, channel, or wall decrease, volume increases.
  - If: line screen decreases from 200 l.p.I. to 150 l.p.I.
    Then: volume increases 50%
  - If: angle decreases from 60° to 30°
    Then: volume increases 89%
  - If: stylus decreases from 130° to 110°
    Then: volume increases 49%
  - If: channel decreases from 30µm to 10µm
    Then: volume increases 11%
  - If: wall decreases from 24µm to 8µm
    Then: volume increases 67%
Electro-mechanical Engraved Cell Comparsion

**Ribbon: default**
- Depth: 32.3
- Volume: 0
- Shadow Depth: 0
- Shadow Volume: 0
- Shadow Width: 0
- Shadow Length: 0
- Mid Depth: 30.6
- Mid Volume: 101350.2
- Mid Width: 116.2
- Mid Length: 187.2
- High Depth: 0
- High Volume: 0
- High Width: 0
- High Length: 0

**Differences:**
- Depth: 0%
- Volume: undefined
- Shadow Depth: undefined
- Shadow Volume: undefined
- Shadow Width: undefined
- Shadow Length: undefined
- Mid Depth: 1%
- Mid Volume: 0%
- Mid Width: 0%
- Mid Length: 0%
- High Depth: undefined
- High Volume: undefined

**Date:** 2/13/2008  
**Time:** 2:24.01 PM  
**Cylinder Number:** default  
**Take:** default

**Ribbon: default**
- Depth: 32.4
- Volume: 0
- Shadow Depth: 0
- Shadow Volume: 0
- Shadow Width: 0
- Shadow Length: 0
- Mid Depth: 30.3
- Mid Volume: 101575.2
- Mid Width: 116.2
- Mid Length: 187.1
- High Depth: 0
- High Volume: 0
- High Width: 0
- High Length: 0

**Date:** 2/13/2008  
**Time:** 2:25:36 PM  
**Cylinder Number:** default  
**Take:** default

MicroDynamics, Inc. 3D Max Laser System, Patent Pending, Copyright 2001, 4374D Shallowford Industrial Parkway, Marietta, GA 30060 (770) 926-1700
A cell is comprised of:
2 Walls + 1 Channel + 1 Opening

Cell units can vary in size, shape, & depth; not in amount per square inch.

Change in line screen has the greatest impact on engraving time.

The stylus does not control cell opening; however, it does effect depth and, therefore, volume.

Do not change the wall; 8µm is a great number!

A change to the line screen, angle, wall, or channel will change the cell opening.
Cylinder Specifications

Part II:
Process Specifications & Ink Transfer from Electro-mechanical Engraved cell
Establishing Volume Basis:

- Usually 150, 165, or 175 lpi
- Line screen in 100% dot should yield given density depending on color.

Example:

<table>
<thead>
<tr>
<th>100% Dot</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow</td>
<td>1.00</td>
</tr>
<tr>
<td>Magenta</td>
<td>1.45</td>
</tr>
<tr>
<td>Cyan</td>
<td>1.35</td>
</tr>
<tr>
<td>Black</td>
<td>1.70</td>
</tr>
</tbody>
</table>

- Reflective densitometry uses a measurement scale starting at 0.00 and ending at 2.0.
## Preventing the Moiré Effect:

**For:** Base 150 lpi
- Yellow: 122 lpi
- Black: 214 lpi

Base 165 lpi
- Yellow: 135 lpi
- Black: 236 lpi

Base 175 lpi
- Yellow: 143 lpi
- Black: 250 lpi

### Base Calculation

- **Yellow:** \[
  \frac{\sqrt{2}}{\sqrt{3}} \times \text{Base} = \frac{1.414}{1.732} \times \text{Base} = 0.816 \times \text{Base}
  \]

- **Black:** \[
  \frac{10}{7} \times \text{Base} = 1.432 \times \text{Base}
  \]

**Magenta and Cyan:** Base at 60° or Base at 30°
- **Yellow:** 0.816 x Base at 45°
- **Black:** 1.432 x Base at 30°
Equalizing Ink Volume with the Stylus & Angle:

Example:

<table>
<thead>
<tr>
<th>color</th>
<th>lpi</th>
<th>angle</th>
<th>stylus</th>
<th>channel</th>
<th>wall</th>
<th>volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>magenta</td>
<td>150</td>
<td>30°</td>
<td>130</td>
<td>35</td>
<td>8</td>
<td>12.2 bcm</td>
</tr>
<tr>
<td>cyan</td>
<td>150</td>
<td>60°</td>
<td>110</td>
<td>4</td>
<td>8</td>
<td>12.0 bcm</td>
</tr>
<tr>
<td>yellow</td>
<td>122</td>
<td>45°</td>
<td>130</td>
<td>27</td>
<td>8</td>
<td>12.4 bcm</td>
</tr>
<tr>
<td>black</td>
<td>214</td>
<td>30°</td>
<td>110</td>
<td>30</td>
<td>8</td>
<td>11.2 bcm</td>
</tr>
</tbody>
</table>

If: base equals 150 lpi
Then: choices are: magenta/cyan stylus size only, yellow/black angle and stylus size.

Therefore: bcm volume is balanced within 10%
Tone Scales:

- Why are they necessary?
- What do they mean?
- Which percents should be printed?

100% : Establishes density
75% : Prints dots
50% : Prints without flooding
25% : Prints strongly
  5% : Prints smallest dot that prints 100% of the time
  3% : Prints most, but not all, dots
Process Specifications & Ink Transfer

Considerations:

- Ink
- Substrate
- Relation of Cell Size to Dot Size
Ink Considerations:

Choice of cell and screen is dependent on the ink that is to be used.

Water based inks often require shallower cell depths than solvent based.

Fluorescent inks or metallic colors have special requirements, as do underlays and overlays such as overall under color or clear protective overlays.
Substrate Considerations:

The substrate on which the ink is being laid affects the choice of cell characteristics.

Metals or plastic films lift the ink from the cell differently than calendared paper or heavy cardboard.
Relation of Cell Size to Dot Size:

There is not a **direct** relationship between the cell size on the cylinder and the dot size on the substrate.

Very small cells do not release ink well; therefore, to begin laying down ink, minimum size cells are needed.

**Gamma correction curves are used to compensate for the irregular relationship**
Examples:

1. A 20% cell on the cylinder may be required to obtain a 3% dot on paper.

2. A cell at 95% of full size may lay down so much ink that the adjoining cells flood together and the paper is covered 100%.
Ink Transfer from Cells:

The surface of ink in a gravure cell forms a concave shape or negative *meniscus*. This meniscus is created by the ink’s surface tension and its contact with the inner cell wall.
Ink Transfer from Cells continued:

The wiping action of the doctor blade and the centrifugal force on the cylinder create an uneven distribution of the ink in the cell.

Electrostatic assist (ESA) is used to compensate for the negative meniscus.

An Explanation:
The ink first contacts the web, then transfers by capillary action. It cannot make contact and transfer when there is a void or irregularity in the substrate above the cell.
Ink Transfer from Cells continued:

Two major events happen when **ESA** is applied:

1. Electrostatic forces create pressures on the concave surface of the ink.

2. Opposite electrical charge is induced into the ink. Opposite charges attract; therefore, the ink is attracted to the impression roller and is simultaneously repelled by the gravure cylinder.
Process Specifications & Ink Transfer Review

- Volume basis is usually 150, 165, or 175 lpi.
- Line screen in 100% dot should yield given density depending on color.
- Moiré is prevented by proper choice of line screen and angle.
- Ink volume may be equalized by the stylus.
- All tone scale percents serve a specific purpose.
- Ink, substrate, and the relation between dot size and cell size effect cell characteristics.
Q&A

Thank you!