STUDIES ON THE RELATIONSHIP BETWEEN RESOLUTION DETERMINATION AND DIFFERENT LINE TO SPACE RATIOS OF RESOLUTION TARGET IMAGES FOR LITHOGRAPHIC PREPRESS PROOF MATERIALS

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ABSTRACT

Resolution has been shown to be an effective tool in the determination of the optimum exposure for graphic arts photosensitive materials. No international graphic arts standards are in existence specifying the line to space ratios for this kind of measurement.

An early study of resolving power line to space ratios by Sandvik [12] indicated a linear relationship between resolving power and the log of this ratio when applied to photographic materials. Sigg [1] found that the line to space ratio differences were not significant for [Hydrazide type] halftone films. These Hydrazide materials are characterized by their high contrast and ability to reproduce fine lines. They are also characterized by their use of "contagious development" and therefore are atypical of other graphic arts films.

Several different microline containing control targets are currently available with 1:1, 3:7, and 1:9 line to space ratios.

This paper examines the effect of different resolution line to space ratios of such targets when used to determine the optimum exposure for offset lithographic pre press proof materials. Two types of pre-press proof materials were studied: those made by the use of toner powder deposition and those made by color containing pre-sensitized laminated systems.

INTRODUCTION

The use of Microline Technology for determining optimum exposure for graphic arts materials has been detailed by Sigg [1], Fisch and Cavin [2], and Fisch and Cox [3], [4]. Microline images for insuring accurate graphic arts exposures are available from FOGRA [5], UGRA [6], Brunner [7], Dupont [8], and 3M Company [9]. Resolution targets initially described by Ross [10] are now used extensively by the Photographic and Microfilm Industry [11].

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A special Graphic Arts Microline Research Target was developed by 3M and RIT. It contains positive and negative microlines at 1:1, 3:7, and 1:9, line to space ratios. It is contact exposed from a Chromium Master onto the same photosensitive stock with identical processing to that given to the UGRA Target.

The 3M Microline Research Target was designed to include the line to space ratio features of most of the commercial targets in one piece of film. The availability of such a test tool allows for ease of handling and more precise investigation of microline photosensitive material effects.

The target film images consist of both positive and negative microlines, with line to space ratios of 1:1, 3:7, and 1:9. These line to space ratios hold throughout the range from 3 to 30 microns. Also included in the research target are halftone tints.

Tables 1a and 1b compare the microline resolution element image size, shape, and geometries of some of the commercially available graphic arts targets for exposure determination. With the exception of 3M, UGRA and FOGRA no technical literature is presented with these targets explaining their use and evaluation in determining optimum exposure.

In an earlier study Sandvik [12], studying commercial films, reported that a linear relationship existed between resolving power and the logarithm of the line to space ratio which he designated A. He reported this resolution could be expressed as $R = f(\log A)$. However Sigg [13] found little difference in microline response with changes in target line to space ratios for Hydrazide type graphic arts films.

This paper examines the relationship between resolution determination and different line to space ratios of Negative Acting Offset lithographic Pre Press Proof Materials.

EXPERIMENTAL

Sensitized Materials

The sensitized materials used for this study were Lithographic Pre Press Negative Acting Proofing Materials. Two types of pre press proof materials are generally available, these based on the use of color powder deposition to produce images and on those based on the use of laminated photomechanical resist films containing color pigments of the type used in printing inks.

A cyan color proof image was employed for ease of evaluation. All the samples were assembled so that the cyan image was in the same vertical position on the proof support as it would be in a final proof, ie. in proof position.

Exposure

All the pre press proofs were exposed in a vacuum frame in contact with the 3M / RIT Target using using a multi-spectral source sometimes referred to as a Photopolymer bulb. As is practiced in the UGRA [6], Sandvik [12] and Sigg [13] procedures, a Log exposure step and repeat series was used to determine the optimum resolution per exposure level. An exposure series from 1.2 to 2.2 LogE at 0.05 LogE increments was employed. After exposure each material was developed as per its manufacturers suggested procedures with the automatic appropriate equipment designated for that purpose.

EVALUATION

Some visual assessment and plotting techniques for evaluating microlines images to determine optimum exposure for graphic arts printing plates have been reported by Fogra [5], Sigg [1], Bosse [14], and Fisch and Cavin [2] .

As with any subjective technique, some stringent rules on evaluation need to be imposed to insure repeatability. In the case of the studies reported on in this paper which use the standardization required a 10X loupe to be used for viewing the developed images.

The order of visual assessment was standardized so that the resultant images from the exposures for a given series were viewed in the order of from those fully resolved to those not resolved.

Since the 3M / RIT Research Target uses microlines of the same value that are placed at right angles to one another a further evaluation requirement was employed. Images of the same microline values had to be present in both directions, before that microline target level was considered resolved.

Since local vacuum pressures can vary under commercial conditions and cause abnormalities, the criteria of Nelson [11], Fisch and Cavin [2], and Fisch and Cox [3] [4], using pattern recognition not line count was used. That meant each pattern need not be fully reproduced and only 2/3 need be apparent for a microline to be judged resolved.

The optimum resolution of each of the different line to space image pairs at each LogE level in the exposure series was recorded and plotted following the UGRA procedures (Figure 1) used by previous investigators.

The optimum resolution of both types of proof materials were different. The powder technique did not result in a fully clean microline image as compared to the laminated color photomechanical proof. These differences complicated the direct comparison of line to space ratios and a choice of which ratio might be most satisfactory for off press proofing targets.

Figure 2 illustrates the plotted microline data derived from the pre press images formed by powder deposition.when the UGRA plotting technique is employed.

Figure 3 is a reproduction (graph) of the Sandvik data for one film under a set of processing conditions. The ordinate of this graph represents the Log of the line to space ratio (Log A). For clarity the data lines are offset by 0.06 Log A since the plotted data would otherwise tend to fall on top or close to each other and complicate visual analysis. The points designated by a notch on each of the curves correspond to data points from the 1:1 or 50% area coverage image (or the point where Log A equals zero). The abscissa of the Sandvik graph represents resolution. The resolution values are positioned so that resolving power INCREASES as the distance from the abscissa to the ordinate intersection increases.

The routine graphic representation of graphic arts microline Response vs Log Exposure are also plotted with resolution as the abscissa. In graphic arts plots the data points of the abscissa are positioned so that resolution DECREASES as the distance from the abscissa to the ordinate intersection increases. (Figure 4).

The graphs depicting the results obtained from data collected for this paper will practice the Sandvik [12] technique that is Resolving Power vs LogA, but the abscissa data will be plotted using the graphic arts convention of resolution decreasing as the distance from the abscissa to the ordinate intersection increases.

The Sandvik [12] technique of using Log A (line to space ratio) as the abscissa allows a materials response to changes in resolution from exposure to represented as quasi-linear lines rather than a series of overlapping parabolic curves.

No change or identical response of Resolution vs Log A result in exact overlapping plots.

Figure 5 illustrates the standard (1:9) microline response of both the UGRA target and the corresponding 3M/RIT (10 and 90) area coverage images for the two types of pre press proof materials tested. Both materials appear to respond similarly to each target type. The parabola produced by the powder deposition proof appears sharper (tighter) than that of the photomechanical proof. The ability to depict both ends of a offset lithographic image reproduction (the smallest 2% highlight and the 98 % shadow dots) has been associated with the shape of this parabola, Fisch and Cox [3]. The distance between the Log exposure necessary to reproduce a highlight (2%) and shadow dot (98%) the resolution of a 15 micron line has been associated with exposure latitude, Fisch and Cox [4].

Tables 2a and 2b list the resolution response for both types of materials tested at different exposure conditions for the different line to space Ratios in the 3M/RIT target.

Figure 6 depicts the family of curves plotted from this data for the powder deposition proof. The LogA data per exposure time has been offset by 0.025 LogA for clarity. The Microline vs LogA (resolution response at different line space ratios) does not appear to approach a linear response. A bow in the curve at the 00 point (1:1 or 50% area coverage) is apparent. The change in the deviation from a linear response is also evident at the 10 and 90 levels. Lower exposure values result in the loss of resolution of the 10% area coverage, and a flattening of the 90% area coverage. Increasing exposure to allow proper reproduction (resolution) of the 10 % area coverage producing further departure from the straight line response at the upper end of the scale. A lack of exposure latitude corresponding to the information depicted in Figure 7 and 8.

Figure 9 depicts the set of curves plotted from the data of Table 2 for the photomechanical lamination color proof. The response of this proof material more closely corresponds to a linear function than those of the powder deposition proof (Figure 10).

As previously stated, the flatter the response line the less rate of change between the line to space ratios (percent area coverage) and Log Exposure changes.

For ease in visualization the first and last curves of Figure 10 and 9 are depicted in Figure 11 and 12, respectively.

The data collected indicate that the traditional microline response technique Figure 13 may not fully represent 50% area coverage (but are close to areas on either side of the 50% target). The work of Fisch and Cavin [2] concerning the Microline Response of Negative Acting Pre Sensitized Printing Plates vs Log Exposure appear to confirm this observation. A good lithographic reproduction must contain a full range of dots including at least 3% and 97% dots. Holding the 50% dot with a loss of highlight and filled in shadow detail is less acceptable than a full range of dot sizes with a slightly higher 50% dot gain.

Using the data collected it is possible to determine the relationship between the resolution of the different Microline line to space Ratios for both the powder and photomechanical laminated color negative acting pre press proof materials tested.

The relationship between the line to space microline ratios of powder developed pre press negative acting pre press proof material was found to be 19.2 + 11.5 Log A

The relationship between the line to space microline ratios of photomechanical laminated color negative acting pre press proof material was found to be 6.4 + 1.67 Log A.

CONCLUSION

Differences in the Resolution vs Log Line/Space response at different Log Exposure levels of the photographic films used by Sandvik [12] , the Hydrazide developed halftone films of Sigg [13], and the Negative Acting Pre Press Proof materials in this study were observed. The lack of bi-directional image resolution of the powder developed pre press proof material complicated the analysis for this product.

The 3M/RIT multiple line to space frequency Research Target in conjunction with the Sandvik [12] technique provided a better assessment of the exposure latitude of the different materials then did the UGRA type technique.

Neither of the two materials tested indicated a lineal response between Resolution and Log A (line/space ratio) for the various line/space frequencies tested.

The Powder Deposition Negative Acting Pre Press Proof material response was closer to that of an S shape cure. A least squares line could be drawn through the 30/ 70 area coverage response. This line however grossly departed from the 50% area coverage response. Such departure indicates a lack of correlation between exposure and the resolution (dot gain) for 50% area coverage. The spread between the results for the different exposures and the fact that one could not hold both ends of the area coverage indicates a lack of latitude of the Powder Deposition Proof.

The Photomechanical Lamination Color Pre Press Proof response was flatter in nature and allowed a better least squares fit. This fit did include the 10 and 90 percent area coverage points. The differences between the results of the different exposures were less than that of the Powder Deposition Pre Press Proof material indicting better latitude.

Earlier observations on Negative Acting Lithographic Printing Plates Resolution Responses to Log Exposure changes, Fisch and Cavin [2] which indicated that the Microline Response of a 10 and 90 percent area coverage target was different than the Microline Response for a 50% area coverage dot may be applicable to pre press proof materials as well.

SUMMARY

1. Difficulties in determining the Resolution in the Powder Deposition Prepress Negative Acting Proofs tested because of the inability to uniformly resolve both horizontal and vertical Microlines at the same exposure complicated the issue. Therefore, each type of proof was evaluated by itself.

2. Changes in exposure influence the optimum resolution values for different Log to line /space ratios.

3. A linear relationship between all the percent area coverages for a given exposure was not fully evident : especially in the case of the Powder Deposition Pre Press Negative Acting Lithographic Proof.

A least squares technique, when applied to the evidence collected indicated that:

4. The relationship between Log A (line /space microline ratios) of the Powder Deposition Pre Press Negative Acting Lithographic Proof material was
19.2 + 11.5 Log A

5. The relationship between the LogA (line /space microline ratios of Photomechanical Lamination Color Pre Press Negative Acting Lithographic Proof material was
6.4 + 1.67 Log A.

6. A multi line-to-space ratio target allows a better indication of the latitude differences between different materials.

7. A single line/space area coverage microline resolution target does not appear to indicate the optimum exposures for other line to space area coverage images.

8. The difference between the Log A ratios of different materials may be useful as a numeric indicator of a materials exposure latitude.

The observation of Fisch and Cavin [2] on the response of the traditional single line to space ratio targets and their relationship to a 50% area coverage image seems also to apply since the least squares line drawn for the Powder Deposition Pre Press Negative Acting Proof was only able to satisfy the 30 and 70 percent area coverage targets and the 50 percent coverage fell a distance from that line.

ML Containing Control Materials for Positive Acting Products

Source	Polarity	Bar/Space Ratio	Finest Microline	Microline Range	Geometry
Brunner	Positive	30 - 70	6μ	6 – 16μ	Line
DuPont	Positive	30 - 70	6μ	6 – 16μ	Line
• Fogra	Positive	10 - 90	4μ	4 – 40μ	Line one direction
• GATF	Negative/Positive	50 - 50			Line spokes fan pattern 360°
*• RIT	Negative/Positive	20 - 80	4μ	4 – 70μ	Circular
• 3M Co.	Positive	10 - 90	2μ	2 – 57μ	Octagon
*• UGRA	Negative/Positive	10 - 90	4μ	4 – 70μ	

• Same Target for Neg and Pos Materials * Soon Available

Table 1A

ML Containing Control Materials for Negative Acting Products

Source	Polarity	Bar/Space Ratio	Finest Microline	Microline Range	Geometry
Brunner	Negative	30 - 70	6μ	6 – 16μ	Line one direction
DuPont		None Available		None Available	
• Fogra	Negative/Positive	10 - 90	4μ	4 – 40μ	Line one direction
• GATF	Negative/Positive	50 - 50			Line spokes fan pattern 360·
*• RIT	Negative/Positive	20 - 80			Circular
• 3M Co.	Positive	10 - 90	2μ	2 – 57μ	Octagon
*• UGRA	Negative/Positive	10 - 90	4μ	4 – 70μ	Circular

• Same Target for Neg and Pos Materials   * Soon Available

Table 1B

POWDER DATA												
	Line/			Time in Seconds								
Dot %	Space	A	Log A	19	21	24	27	30	34	38	42	47
90	9:1	9	0.954	27μ	27μ	27μ	27μ	27μ	30μ	27μ	27μ	27μ
70	3:7	3	0.477	24	27	27	27	27	30	27	30	27
50	1:1	1	0.000	18	18	21	21	24	24	24	24	24
30	7:3	0.33	-0.481	12	12	12	10	10	10	10	10	10
10	1:9	0.11	-0.959	15	10	10	8	8	8	8	8	8

TABLE 2A

PHOTOMECHANICAL DATA															
	Line/			Time in Seconds											
Dot%	Space	A	Log A	28	31	35	39	44	48	55	62	69	77	87	97
90	9:1	9	0.954	4μ	4μ	4μ	6μ	6μ	6μ	6μ	8μ	8μ	8μ	18μ	21μ
70	3:7	3	0.477	6	6	6	8	6	8	6	8	8	6	8	15
50	1:1	1	0.000	10	8	6	6	6	10	8	10	8	8	8	10
30	7:3	0.33	-0.481	10	10	8	6	6	6	6	6	4	6	8	8
10	1:9	0.11	-0.959	8	10	6	6	6	6	6	4	4	4	4	4

TABLE 2B

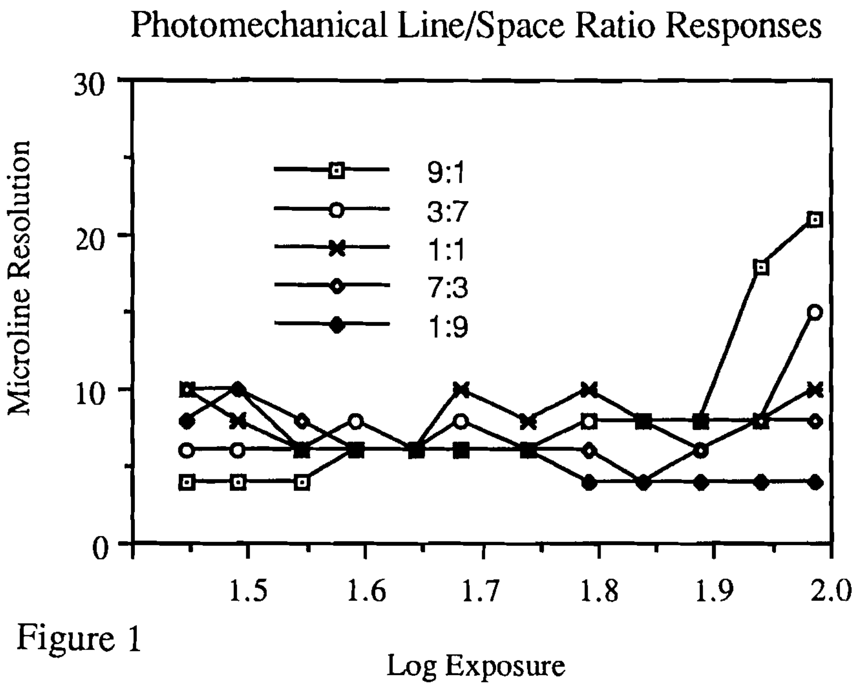


Figure 1

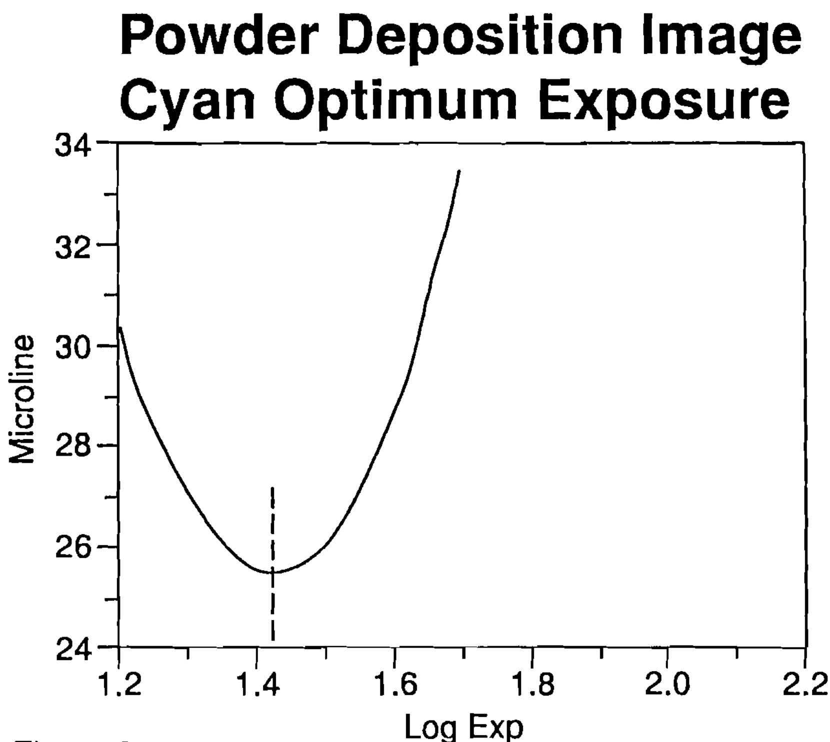


Figure 2

Sandvik: Silver Halide

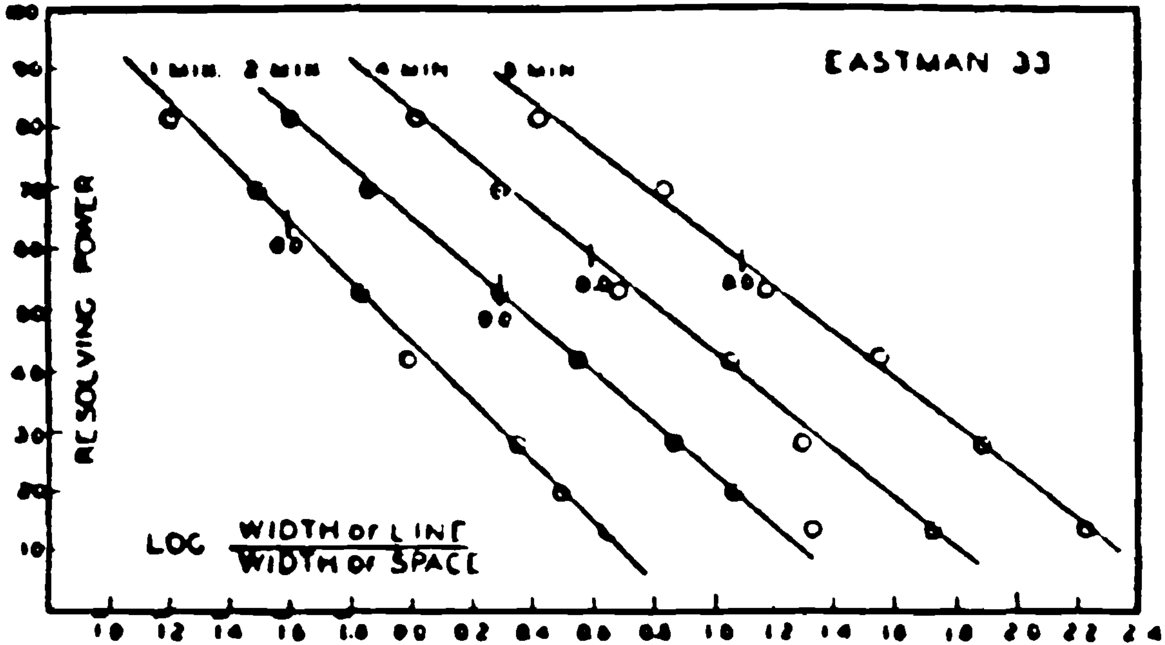


Figure 3

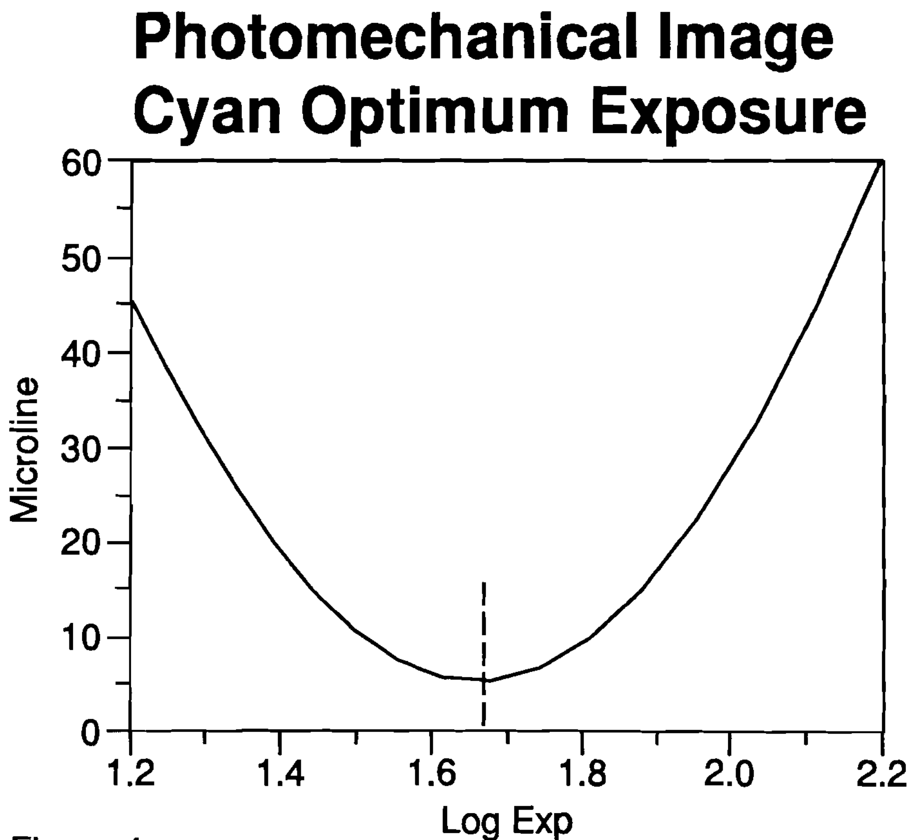

Photomechanical Image
Cyan Optimum Exposure
Microline
60
50
40
30
20
10
0
1.2
1.4
1.6
1.8
2.0
2.2
Log Exp

Figure 4

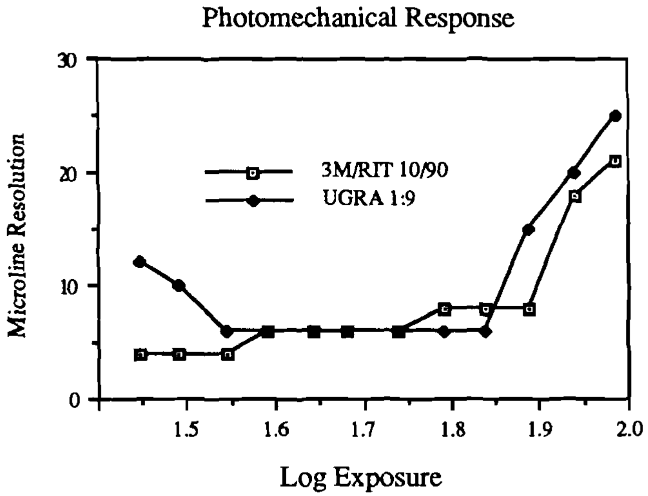


Figure 5a

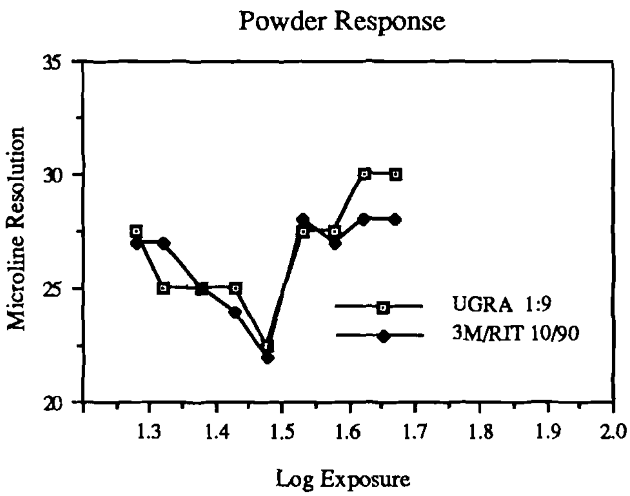


Figure 5b

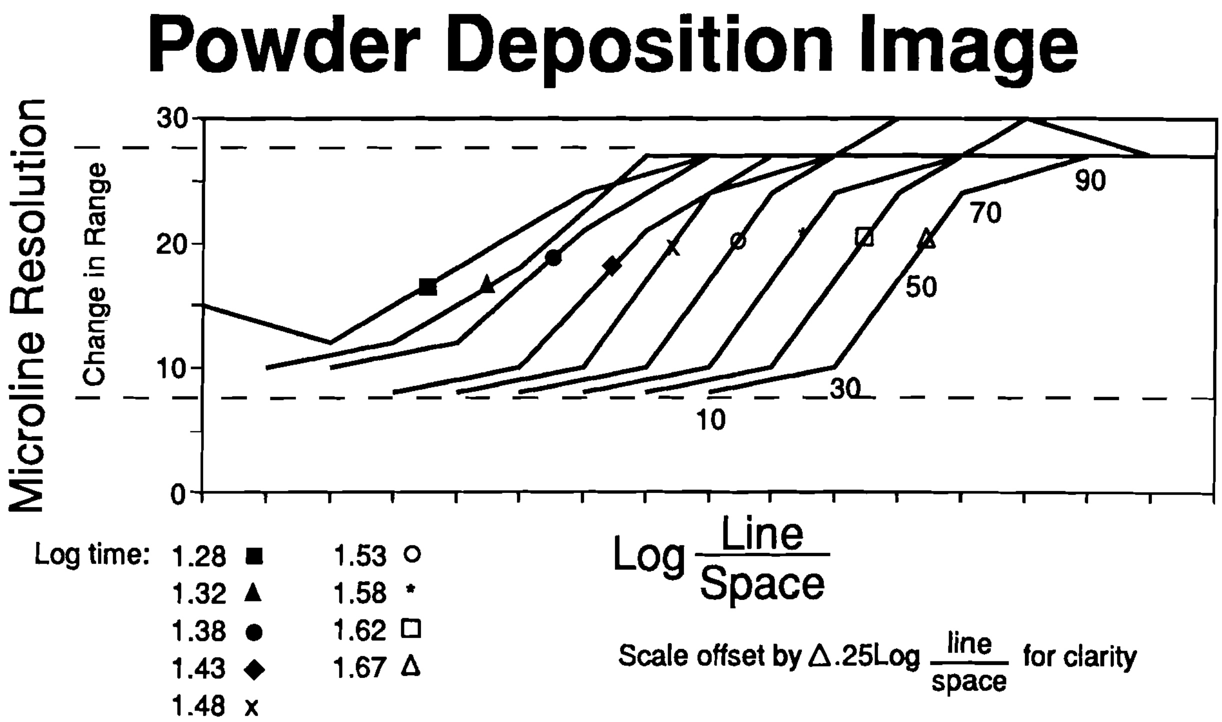

Powder Deposition Image
Microline Resolution
Change in Range
30
20
10
0
90
70
50
30
10
Log Line/Space
Log time:
1.28 ■
1.32 ▲
1.38 ●
1.43 ◆
1.48 x
1.53 o
1.58 *
1.62 □
1.67 Δ
Scale offset by Δ.25Log line/space for clarity

Figure 6

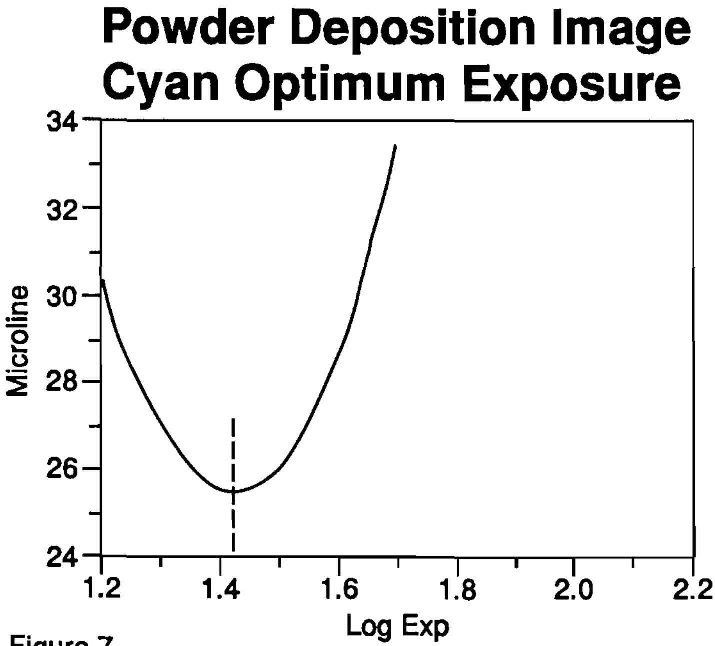


Figure 7

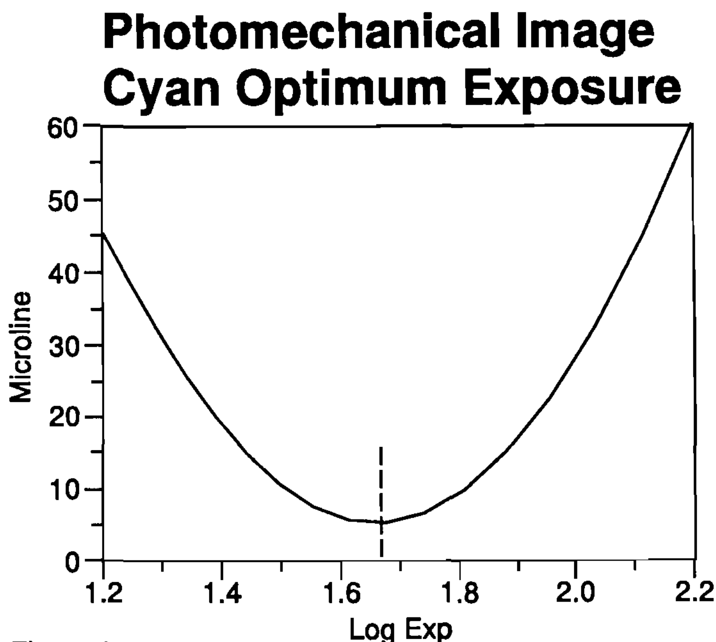
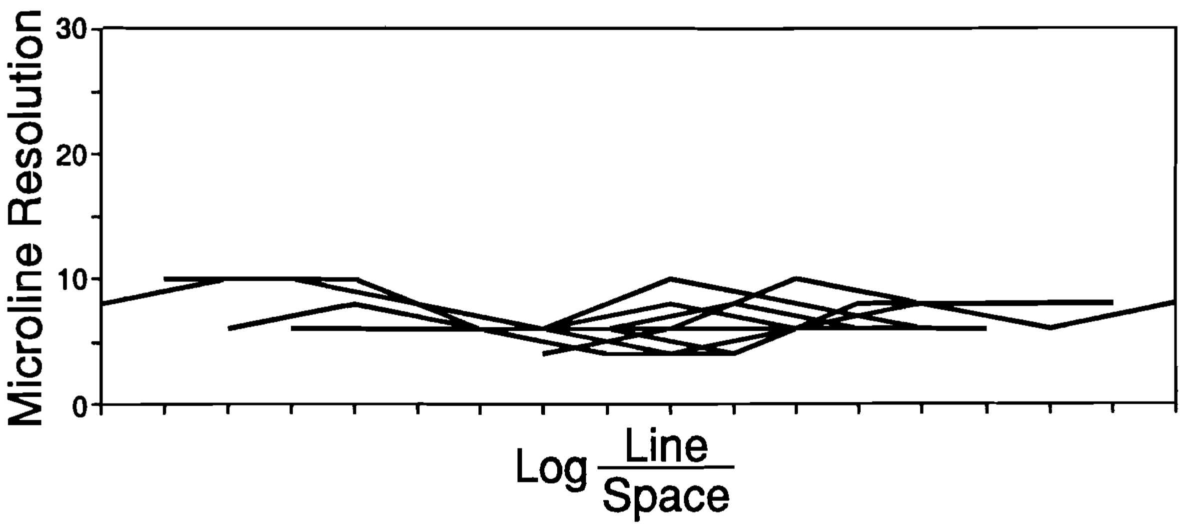


Figure 8

Photomechanical Image



Scale offset by Δ.25Log $\frac{\text{line}}{\text{space}}$ for clarity

Figure 9

Powder Deposition Image

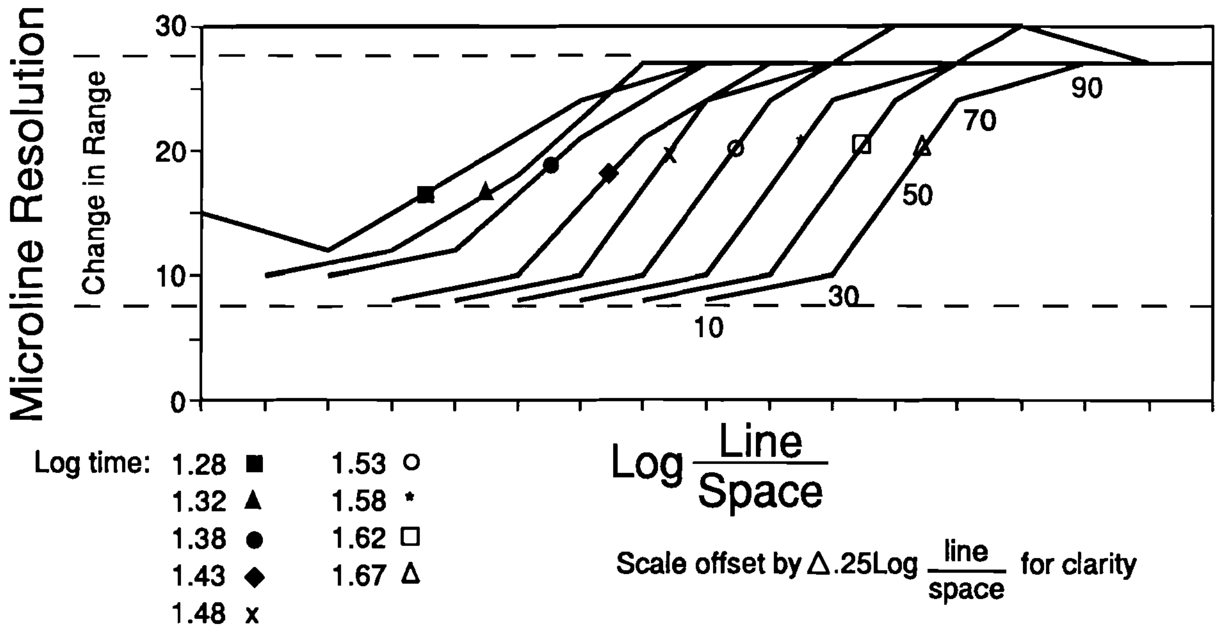
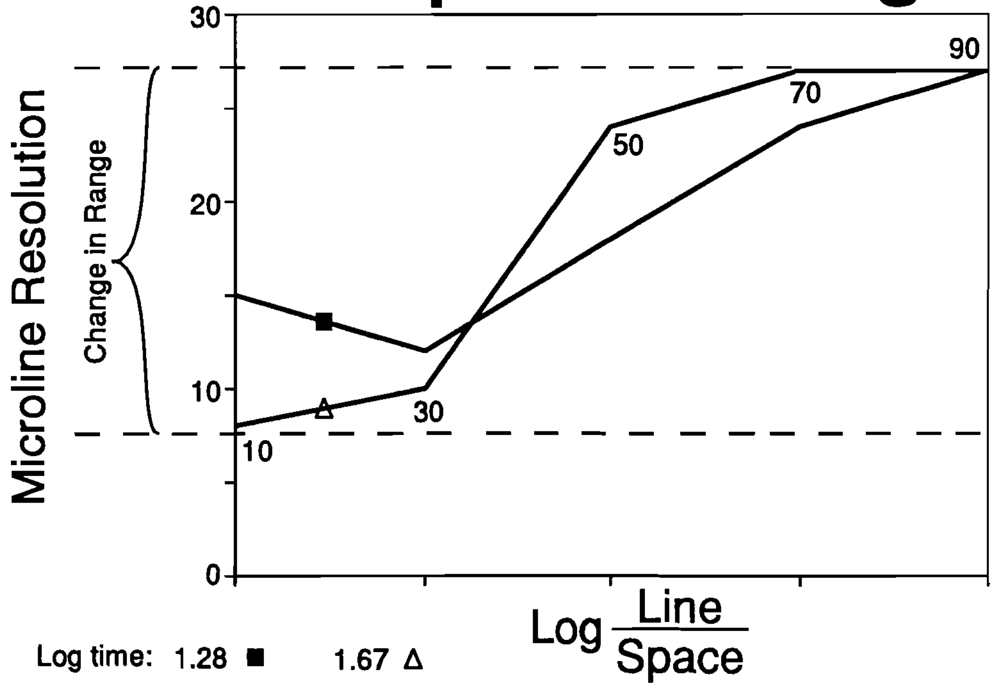


Figure 10

Powder Deposition Image



Log time: 1.28 ■ 1.67 Δ

Figure 11

Photomechanical Image

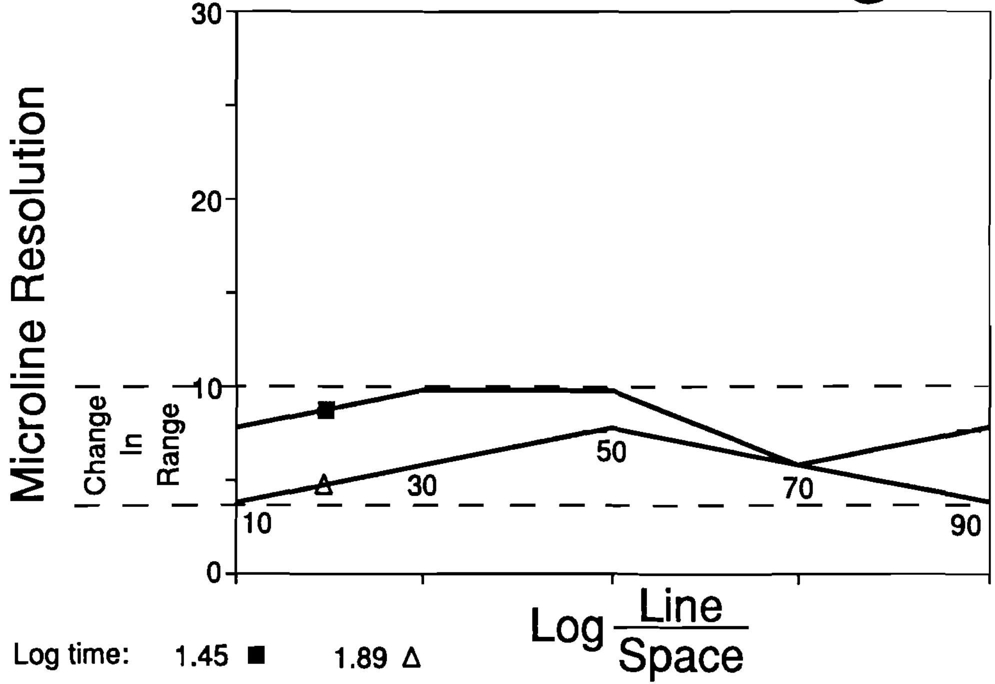
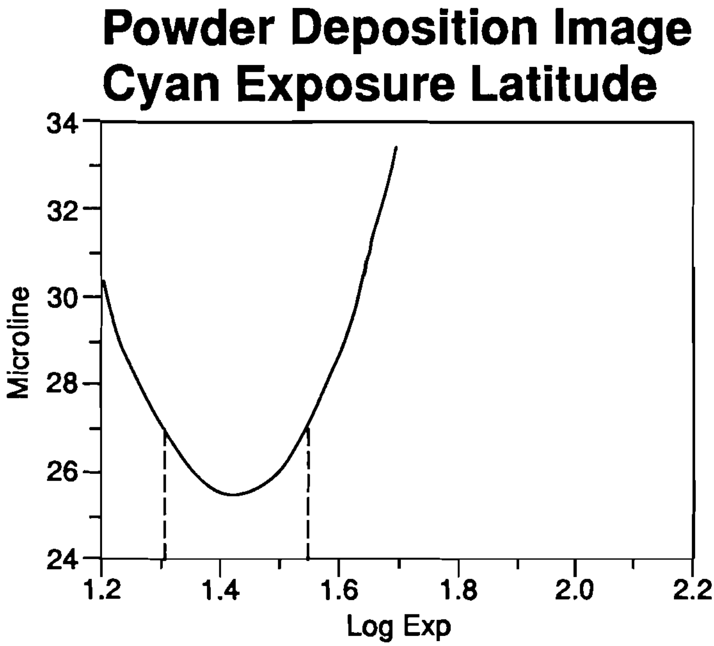


Figure 12


Powder Deposition Image
Cyan Exposure Latitude
34
32
30
28
26
24
Microline
1.2
1.4
1.6
1.8
2.0
2.2
Log Exp

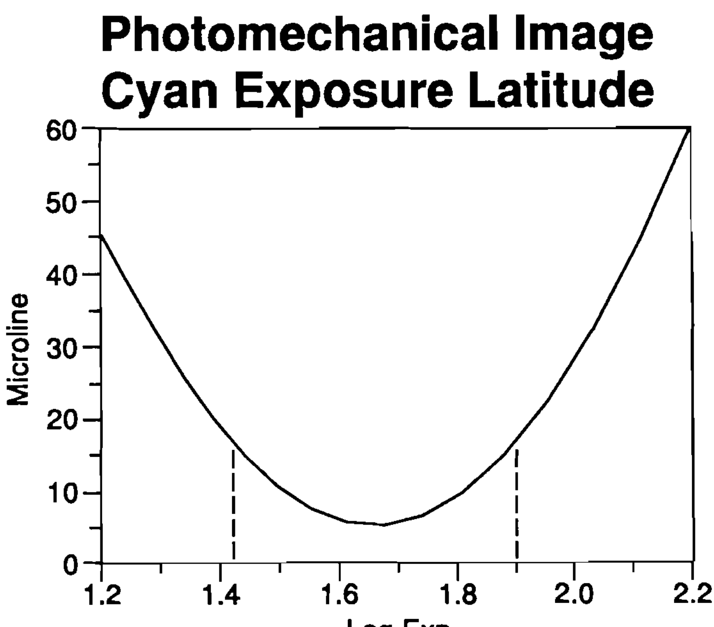

Photomechanical Image
Cyan Exposure Latitude
60
50
40
30
20
10
0
Microline
1.2
1.4
1.6
1.8
2.0
2.2
Log Exp

Figure 13

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