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The design, construction and evaluation of a resolution target for microfilming application

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THE DESIGN, CONSTRUCTION AND EVALUATION OF A RESOLUTION TARGET FOR MICROFILMING APPLICATION

by

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of the requirements for the degree of Bachelor of
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ABSTRACT

By designing and constructing a new resolution target for microfilming applications, it has been the goal of this thesis to overcome several problems suspected to be associated with existing methods, namely, 1) the problem of pre-knowledge of the test pattern and target array, 2) the ambiguity in determining the smallest "distinguishable" pattern, 3) the possibility of spurious resolution due to periodicity in the test pattern and 4) the lack of correlation with alpha-numeric typefaces.

The new Psi target system was constructed through a series of artwork reductions, paste-ups and further reductions, all on lithographic material.

The Psi target, a system based on the orientation of the test patterns, was tested side-by-side in a microfilming application with the German DIN microfilming target 19051, a similar orientation system. The goal of the experimentation was to compare the merits of the two systems and to establish whether one could justifiably replace the other. The variance of information capacity associated with seven viewers' evaluation of the Psi target was compared with the variance in the same viewers' evaluation of the DIN target images. This comparison was in the form of a statistical hypothesis test. In the case of the four different sized pairs of images

tested, there was no significant difference (in all four tests) between the variances of the two target systems at the 90% confidence level.

The average information capacity of each image was calculated from the seven viewers' evaluations of the four pairs of images. The information capacity of one target was then plotted against the other to determine the relationship between the two targets. A linear regression analysis was performed on these four data points and the "best fit" line was obtained. This equation, with a correlation coefficient of .97 is,

$$I_{(DIN)} = .31\ I_{(Psi)} + 12.47,$$

where I is information capacity. The standard error of the .31 slope was calculated as .052.

The final conclusion of the thesis is that, since both targets had their own faults and merits, and since both systems produce different results (as apparent from the above equation); it is not suggested that one system replace the other, but rather that each stand as a distinct microfilm resolution system.

INTRODUCTION

Suspected Weaknesses in Existing Systems

There are four basic weaknesses, some of which are suspected to be inherently associated with existing microfilming resolution methods today:

1) With systems such as the ANSI (American National Standards Institute) resolving power system, any conclusion reached by an observer as to the smallest "distinguishable" pattern, will be biased by pre-knowledge of the design and orientation of that test pattern. This pre-knowledge bias was to be avoided in the Psi target design by basing the target on an orientation system in which the orientation of the test pattern must be correctly identified in order to be considered resolved. One existing system, among others, based on such an orientation method is the German DIN standard 19051, adopted from the International Standards Organization (ISO) recommendation.

2) In any system not based on orientation of the test pattern, i.e., based on the "distinguishability" of the test pattern; the definition of "distinguishable" in the standard is usually, at best, awkward and virtually impossible for an inexperienced man to apply. This problem, again, was to be overcome by basing the Psi

target on an orientation method.

3) Any periodicity in the design of the test pattern utilized in a resolution system can yield false (spurious) resolution in slightly out-of-focus situations. Such is the case with both the ANSI and DIN systems. This effect was to be avoided by designing the Psi target test pattern free of periodicity.

4) In order for a test pattern to be applicable to microfilming use, it was a premise of this thesis that the test pattern should be representative of alpha-numeric typefaces used in printed matter. This was to be acieved by incorporating in the Psi test pattern both curved and straight elements of more than one thickness, since in most typefaces, the proportions of characters are seldom restricted to one thickness.

Choice of Comparison Target

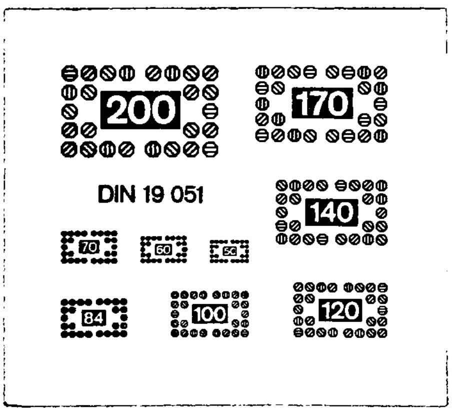
The ANSI standard target and the USAF three-bar target, are systems based on the distinguishability of the test pattern, rather than orientation. This kind of a system would be difficult to compare statistically with the Psi orientation system. The test patterns in these targets are periodic and hardly representative of letters of the alphabet. In addition, there is a good deal of pre-knowledge believed to be associated with the targets which can greatly influence evaluation.

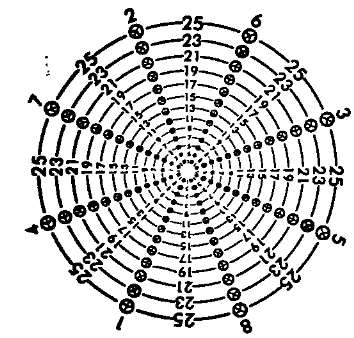
There are a number of targets comprised of alpha-numeric characters in microfilming application today; however, these targets are too easily memorized with continual use and contain an inherent inconsistency in that, some letters are more easily recognized than others.

The DIN standard microfilming target utilizes a periodic test pattern, somewhat different than the alpha-numeric characters it is supposed to represent; however, the system is an orientation system, thus lending itself to statistical comparison with the Psi target. It was therefore decided to compare these two target systems to try to determine whether the merits of one outweighs the other sufficiently to replace it.

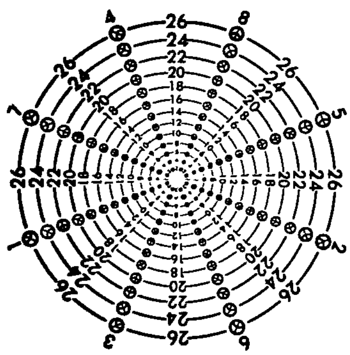
Figure 1 -

Psi and DIN Targets





PSI TARGET



It should be pointed out that the DIN target is used in practise as a go-no go gauge, i.e., a microfilm system must resolve at least down to a specified group to be acceptable. The target's use in this thesis is for statistical comparison.

DIN vs. Psi Target

The similarities and differences between the DIN and Psi targets are as follows:

Similarities

1) Both target systems are based on the determination of the orientation of the test pattern used in the target.

2) Both targets cover the same size range of test pattern reductions (a 4:1 range).

Differences

1) The DIN is a one-target system, whereas the Psi is a two-target system.

2) In the DIN target there are four possible orientations of the test pattern. In the Psi target there are eight possible orientations of the test pattern. This was done to reduce the probabilities of chance or guessing.

3) The DIN test pattern is periodic, containing four parallel bars. The Psi test pattern is completely non-periodic.

4) The array of the DIN target is such that, by

continual use, an observer could begin to memorize (consciously or not) the orientations of some of the test patterns. The array of the Psi target is designed so that the target can be used in any one of eight possible orientations, each target orientation changing the orientations of the individual test patterns, thus greatly minimizing the possibility of target memorization.

5) The DIN target uses a reduction incrementation of $\sqrt[4]{2}$ between adjacent reduction levels. The Psi system, a $\sqrt[12]{2}$ incrementation in the hope of producing a more sensitive system; one which is not restricted to coarse determinations of the true resolvable level. This will be explained more clearly at a later time.

It is of importance to note that the results obtained by using both the DIN and Psi target are not in terms of resolving power as it is defined in photographic systems, i.e., lines/mm. Instead, the capability of a tested photo-optical system (the resolution) is reported simply as the reduction level of the smallest distinguishable test patterns produced in the image.

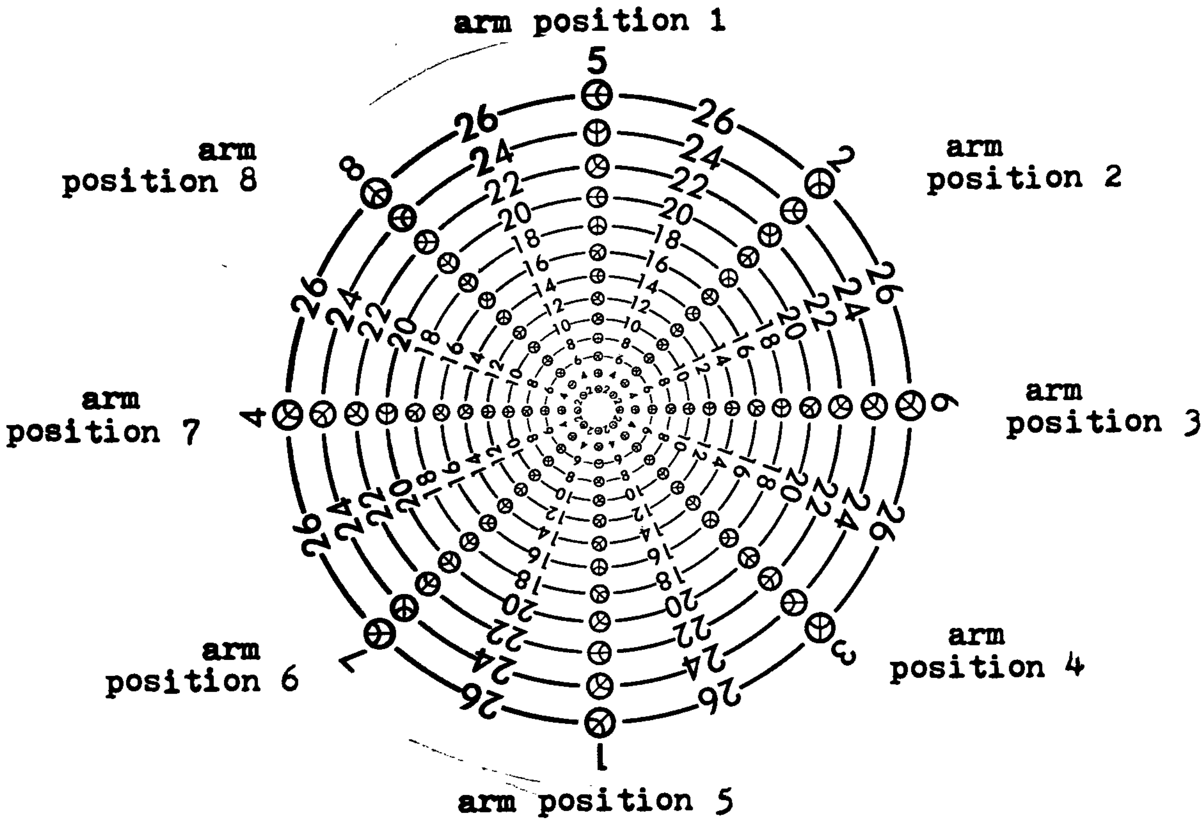
DESIGN OF THE PSI TARGET

One of the hypotheses of this thesis is that the incrementation utilized in most existing systems (DIN included) is too coarse, i.e., a true resolution may fall between two adjacent reduction levels and, because of the limitations of the target, must be interpreted as a lower resolution than it actually is. For this reason, a finer incrementation factor of $\sqrt[12]{2}$ was used in the Psi target. The test pattern size range remains the same for both the DIN and Psi targets; approximately 2.00mm diameter at the largest reduction level to .50mm diameter at the smallest reduction level.

However, in order to minimize the size of the Psi target and still be able to use the desired array, it became necessary to make the Psi target a two-target system. Each target would incorporate a $\sqrt[6]{2}$ incrementation but would be separated from the other by a factor of $\sqrt[12]{2}$, thus yielding a two-target system with $\sqrt[12]{2}$ incrementation. By minimizing the size of the target in this way, measurements of the resolution in a subject plane could be made more accurately in specific areas of interest, e.g., in measuring corner resolution.

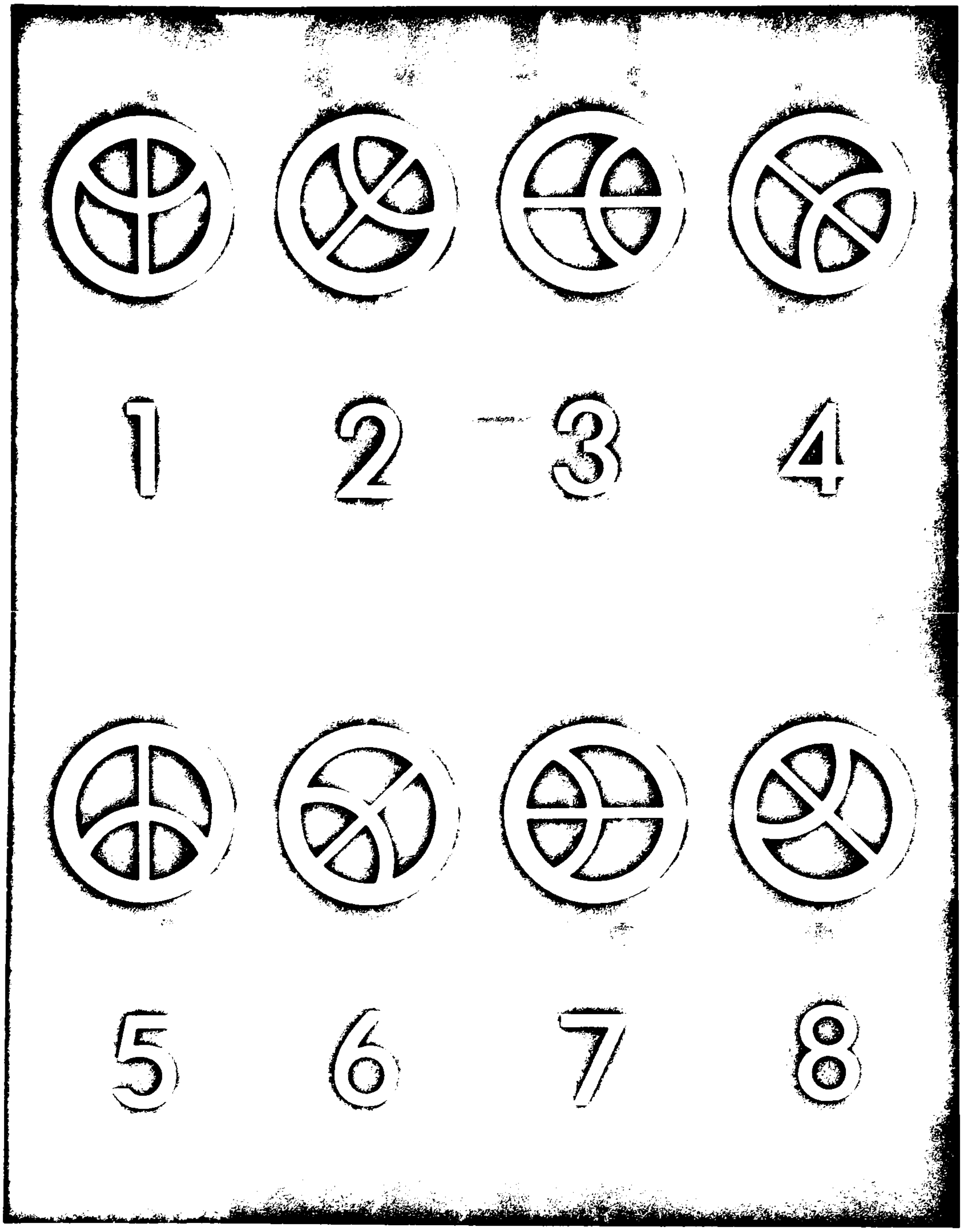
The basic Psi target array is as indicated in figure 2.

Figure 2 - Psi Target Array



Each target of the two-target system contains 104 test patterns at the appropriate size, each one oriented randomly in one of the eight orientation positions indicated in figure 3.

Figure 3 - Test Pattern Orientations



The diameters (O.D.) of the twenty-six test patterns in the final odd and even targets appear in table 1.

Table 1 - Target Test Pattern Diameters

Reduction Level		Test Pattern Diameter (mm)	
ODD Target	EVEN Target	ODD Target	EVEN Target
1		.50	
	2		.53
3		.56	
	4		.60
5		.63	
	6		.66
7		.70	
	8		.75
9		.80	
	10		.84
11		.89	
	12		.95
13		1.00	
	14		1.06
15		1.12	
	16		1.19
17		1.26	
	18		1.34

Table 1 (continued)

Reduction Level		Test Pattern Diameter (mm)	
ODD Target	EVEN Target	ODD Target	EVEN Target
19		1.42	
	20		1.50
21		1.59	
	22		1.68
23		1.78	
	24		1.88
25		2.00	
	26		2.12

The symmetrical array of the eight-arm Psi target was chosen to virtually eliminate the possibility of memorizing the test pattern orientations with continual use. In using the Psi target, any one of eight target orientation numbers (the numbers at the ends of the arms) is randomly selected and placed at the twelve o'clock position for testing. By using a different target orientation, the orientations of the 104 test patterns will also change. A set of master tables are constructed containing the true orientations of the test patterns, one table for each of eight target orientations. This is done for both the odd and even target of the two-target system.

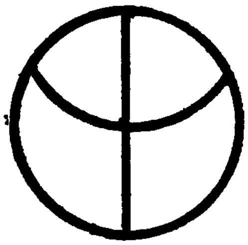
To state the orientation of any single test pattern in an image, an observer must identify 1) the target orientation number (12 o'clock position), 2) the target arm position (1-8), 3) the reduction level (1-26) and the orientation of the test pattern (1-8), read in a vertical-horizontal rectilinear plane. The experimental data can then be checked against the master tables.

The resolution of a tested photo-optical system is simply reported as the reduction level number (1-26) of the lowest level at which the viewer can correctly identify seven out of eight test pattern orientations.

PRELIMINARY EXPERIMENT

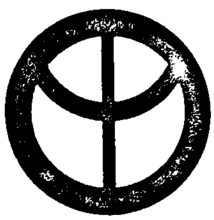
The basic Psi test pattern is of the design illustrated in figure 4. There are three basic components

Figure 4 - Basic Psi Test Pattern Configuration



of the pattern: the circular enclosure, the straight line portion and the arc portion. Seven target "roughs" were drawn (6" diameter), each having different thickness proportions for the three components. These roughs were viewed at a distance of forty feet in order to make a strictly intuitive judgment as to the best proportions for the test pattern. A circle/straight line/arc ratio of approximately 2/1/1.5 was chosen as the easiest to identify and the most representative of typeface characters. (See figure 5)

Figure 5 - Final Psi Target Test Pattern



CONSTRUCTION OF THE PSI TARGET

<u>Film</u> - All film used in the construction of the Psi target was DuPont Ortho S Litho COS 4 sheet film.

<u>Hand processing</u> - All hand processing was done as follows:

Kodalith developer A+B (1:1) @68°F, 2½ minutes, constant agitation
F-5 Fixer @68°F, 5 minutes
Wash @68°F, 15 minutes
Rinse in Photoflo solution
Dry @150°F.

<u>Automatic processing</u> - All automatic processing was done with the "Log E" automatic litho sheet film processor located in the Graphic Arts Research Center (GARC) at RIT.

Generation of Target Test Patterns

The test pattern artwork was constructed in the proportions chosen by the preliminary experiment, using India ink on smooth construction board. The outside diameter was 110.0 mm with the three component thicknesses circle/straight line/arc = 14.0/7.0/10.0 mm.

This test pattern artwork was reduced to 26.8% on litho film with the Klimsch reduction camera in GARC equipped with a Rodenstock 24" f/9 lens. The film was automatically processed.

This reduced test pattern (29.48 mm in diameter) was contact printed using the same film and processing. The resulting positive image was illuminated with a Kodak X-ray viewer (lying on its back) and reduced to 89.1%, 79.4%, 70.7%, 63.1%, 56.2%, 50.0%, 44.6%, 39.7%, 35.4%, 31.5%, 28.1%, and 25.0% with a Polaroid MP3 copy camera and a 70 mm f/4.5 lens. The litho images were hand processed. These reductions represented the $\sqrt[6]{2}$ incrementation to be used in each of the final targets (odd and even). These reductions were measured using 8" hash marks at the subject plane and measuring the resulting image on the ground glass to the nearest .005 inch.

The original reduced test pattern and the 12 reductions were each contact printed on film eight times and hand processed.

Contruction of Target Paste-up

These contact positive lithos of the thirteen reductions were "pasted up" with cellophane tape onto a matte finish acetate sheet, in the configuration described earlier (figure 4). For each of the 104 test patterns pasted up, a number from 1-8 was drawn from a random numbers table to determine the test pattern's orientation.

Table 2 contains the radii at which the thirteen reduction rings were pasted up. Each radius is a measurement from the center of the target array to the center of the test patterns of the same reduction level.

Table 2 - Target Paste-up Dimensions

reduction level	radius (mm)
1	20.00
2	35.2
3	51.3
4	68.6
5	87.0
6	106.8
7	128.1
8	151.1
9	176.0
10	203.1
11	232.6
12	264.8
13	300.0

Generation of Arcs

Arcs of the same radii as the reduction rings were cut in rubylith material for placement on the paste-up between adjacent test patterns of the same reduction level. This was done to aid in scanning the target image during later evaluation. The thicknesses of the arcs varied by an incrementation of $\sqrt[6]{2}$. Those dimensions are listed in table 3.

The arcs were cut to size and taped onto the paste-up between the proper adjacent test patterns of the same reduction level. No arcs were used for the two smallest reduction levels (1 & 2) due to space limitations.

Spaces were cut on each arc segment, bisecting the arc, to allow space for the reduction level identification numbers, to be introduced at a later time.

Table 3 - Arc Proportions

reduction level	arc thickness (in.)
3	.047
4	.053
5	.060
6	.067
7	.075
8	.084
9	.095
10	.106
11	.119
12	.134
13	.150

Generation of Odd and Even Targets

The paste-up transparency was then reduced to 50.5% and 53.5% on the Klimsch reduction camera used previously in GARC. The images were automatically processed. These two negative reductions then represented the odd and even targets to be used in the final resolution target system, the two targets being separated by a factor of $53.5/50.5 = \sqrt[12]{2}$. These odd and even targets were contact printed on litho film and hand processed to generate positive images.

Generation of Reduction Level Identification Numbers

It was then necessary to generate a series of reduction level identification numbers to be placed in the appropriate spaces provided on the arcs. Odd numbers 1-25 were to be used on the odd target and even numbers 2-26 on the even target.

A Compugraphic Headliner photographic typesetting machine was used to generate numbers from 1-26 at 60 pnt. size on 35 mm Ektamatic paper. The Polaroid MP3 copy camera with 70 mm lens was then used to reduce these numbers on litho film to suitable sizes for the odd and even targets. The reduction of each of these numbers appears in table 4.

Table 4 - Identification Numbers Reduction Series

number	reduction
1	.25
2,3	.28
4,5	.32
6,7	.35
8,9	.40
10,11	.45
12,13	.50
14,15	.56
16,17	.63
18,19	.71
20,21	.79
22,23	.89
24,25,26	1.00

Each of these reductions was contact printed on film and hand processed to yield positive images. One set of odd numbers and one set of even numbers were pasted up on a clear acetate overlay in the configuration necessary between adjacent target arms for the respective odd and even targets.

Both identification number paste-ups were contact printed on litho film (hand processed) to produce negatives. Each of these two negatives was similarly contact printed eight times to make the eight identification number overlays needed between the eight arms of each of the targets.

The eight odd identification number overlays were pasted up in the proper location on a clear acetate overlay placed over the odd target. A similar procedure was followed for the even identification numbers and the even target.

These odd and even identification number acetate paste-ups were contact printed to two generations on litho film to generate number overlays on a continuous piece of film, rather than a paste-up of eight pieces of film. Processing was automatic.

These odd and even identification number overlays were registered in contact with the respective odd and even targets.

Generation of Final Target Masternegative

The targets, with overlays in register, were then reduced to 25% by Mr. Fred Scofield at Photech of Waltham, Massachusetts. A Klimsch reduction camera was used.

This negative of the odd and even target was contact printed on 8" x 10" Ektamatic paper, processed with an Ektamatic automatic processor, fixed in F-5 fixer for five minutes, washed and ferrotyped. This print was then reduced a final 50% on a Klimsch reflex reduction camera in the Photogravure Plates lab in the School of Printing. This litho masternegative was hand processed.

The masternegative, containing both the odd and even targets, was retouched and contact printed on Ektamatic paper, processed automatically, fixed and ferrotyped. This final Psi target was dry mounted on smooth mount board.

TESTING OF THE PSI TARGET

Generation of Images

The Psi target and DIN target were each photographed with a Recordak MRD-2 Micro-file Machine at seventeen different camera-to-target distances on 16 mm Kodak Fine Grain Microfilm (without perforations).

It was discovered that the quality of the film and camera were such that even the smallest reduction levels of both targets were easily resolved. Therefore, a slide sprayed lightly with Crylon acrylic lacquer (prepared by Gary Lowe for his thesis) was placed over the lens of the microfilm camera as a blurring device, in order to produce resolutions nearer the middle of the range of the two targets. The film was processed with a Kodak Prostar automatic film processor.

Image Evaluation

Due to limitations of available time of the viewers, it was found all but impossible for any single viewer to evaluate more than four sets of images; each set consisting of an odd Psi target image, an even Psi target image and a DIN target image, all at the same reduction. Therefore, four sets of images were evaluated by seven viewers.

Viewing was done on a Recordak Magnaprint Reader (model PE-1A) with the aid of an 8X agfa loupe.

In order to compare the two target systems statistically, a common measure of both systems had to be used. Information capacity was used in the statistical analysis for this purpose.

For each Psi target image, the viewer was asked to determine the orientation of every test pattern possible in the array. These were recorded and checked against the master tables containing the true orientation of the test patterns for all possible target orientations. The number of correctly identified test patterns (out of a possible eight) was noted at each reduction level of the target.

According to information theory, each correctly identified test pattern contains $\log_2 (\bar{N})$ bits of information, where N is the number of possible orientations. So, for each correctly identified orientation, $\log_2 8 = 3$ bits of information have been received. Therefore, the number of correctly identified orientations at each level was multiplied by 3 to obtain the total information received at that level. Each of these numbers was then divided by the relative area of the corresponding test pattern (i.e., the values in table 1) to obtain the relative information/unit area at that reduction level. The maximum of these values was then taken as the <u>relative information</u>

capacity of that Psi target image.

This procedure was repeated for the seven viewers' evaluations of the four Psi target images. For each of the four images, the mean and variance of the information capacity, as determined by seven viewers, were calculated and appear in table 5.

Similarly, for each DIN target image, the viewer was asked to determine the orientation of eight specified test patterns in each reduction level (group). Since the DIN target utilizes only four possible orientations of the test pattern, the information received from each correctly identified orientation is $\log_2 4 = 2$ bits. Therefore, the number of correctly identified test patterns was multiplied by two and subsequently divided by the relative area of the test pattern at that reduction level to obtain the relative information/unit area at that level. The maximum of these values was then taken as the relative information capacity of that DIN target image.

This procedure was carried out for the seven viewers' evaluations of the four DIN target images. For each of the four images, the mean and variance, as determined by seven viewers, were calculated and appear in table 5.

Table 5 - Statistical Results of Psi and DIN Target Information Capacity

Image Number	PSI $\bar{X}$	PSI s^2	DIN $\bar{X}$	DIN s^2
16	34.41	16.98	23.44	15.56
18	29.61	17.37	21.74	12.88
20	24.12	6.93	19.42	4.28
21	20.38	5.82	19.32	6.32

STATISTICAL EVALUATION

Repeatability Hypothesis Test

A statistical hypothesis test was performed on the variances of the two target systems for each of the four pairs of images. The null and alternative hypothesis are,

Null Hypothesis: $(S_{psi})^2 = (S_{din})^2$

Alternative Hypothesis: $(S_{psi})^2 \neq (S_{din})^2$.

An F-ratio was calculated for each image pair by dividing the larger variance by the smaller of the other target, e.g., for image #16, $(S_{psi})^2/(S_{din})^2 = 16.98/15.56 = 1.09$. This calculated F-ratio was then compared with the appropriate value from a table of critical values of the F distribution at the 90% confidence level (alpha = .10). In all four hypothesis tests, the calculated F value did not exceed the critical F value, therefore the null hypothesis was accepted.

Regression Analysis

In order to determine the relationship between the information capacity of the two targets, the average information capacity of the Psi target (from table 5) was plotted against the average information capacity of the DIN target of the same image number. This plot appears in figure 6. A linear regression was performed on the data in order to determine the line of best fit.

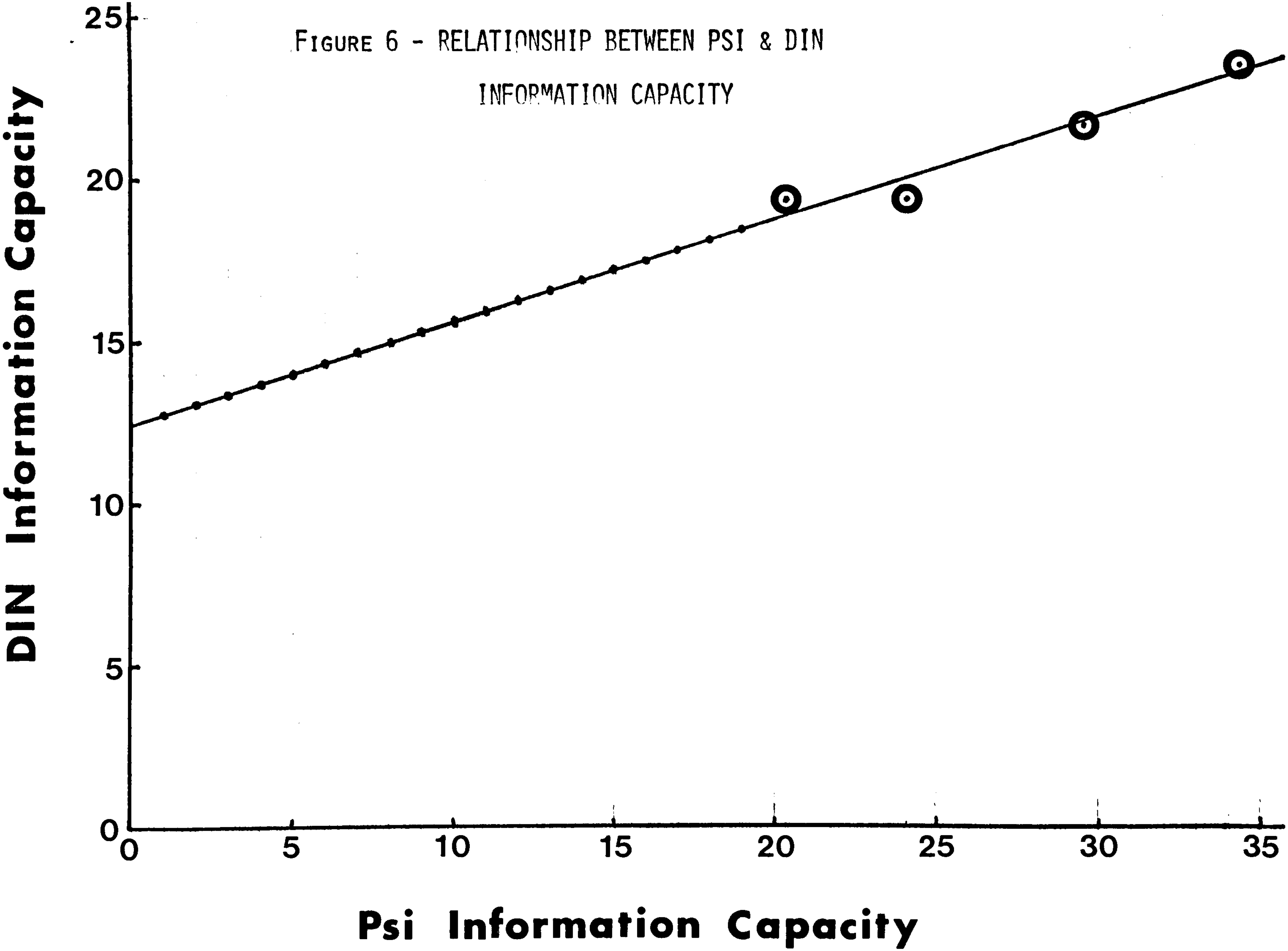


FIGURE 6 - RELATIONSHIP BETWEEN PSI & DIN INFORMATION CAPACITY

This line has been drawn in figure 6 and is of the form,

$$Y = .31\ X + 12.47,$$

where X is the information capacity of the Psi target and Y is the corresponding information capacity of the DIN target. The correlation coefficient associated with this line of best fit is .97 (out of a possible perfect fit of 1.00).

The dotted line in the figure is the extension of the calculated best fit line over the total range of information capacity.

If there had been a direct (1:1) correlation between the two targets, a 45^{o} straight line intersecting the origin would have resulted in figure 6. It was therefore decided to investigate the error associated with the calculated slope for the four-point estimate (.31), to see if a slope of 1.00 (45^{o}) was possible. The standard error of the calculated slope was found by the formula,

$$S_m = \sqrt{\frac{\Sigma(Y - Y)^2}{n - 2}} \Big/ S_x \sqrt{n - 1}\ .$$

The standard error was .052. The 99.9% confidence limits on the .31 slope were calculated by adding and subtracting three standard errors to it, i.e.,

$$m = .31 \pm (3)(.052) = .31 \pm .16.$$

This interval does not cover a slope of 1.00, therefore, there is no evidence to believe that the relationship between the two targets is a 45^{o} line for the four tested data points.

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER EXPERIMENTATION

From the results of the hypothesis tests, it can be stated with 90% confidence that, statistically, there is no difference between the variance associated with the evaluation of the Psi target and the variance associated with the evaluation of the DIN target. The ywo targets have therefore demonstrated to be equally repeatable. On the basis of repeatability, therefore, the two systems may be used interchangeably.

Several viewers evaluating the DIN target images noted that after viewing only four images, they were able to memorize the orientations of some of the test patterns in the array, without making an effort to do so. No such effect was noted for the Psi target. This indicates that the array of the Psi target has successfully reduced the possibility of target memorization.

Because of the fact that the relationship between the information capacity of the two targets was other than a 45° straight line for the four test points, it appears that the two target systems produce different results under the same conditions. Because time limitations did not permit an investigation over the total range of the two target relationship, it is suggested for further experimentation that a wider working range of the targets be tested, encompassing all possibilities of information capacity from maximum to minimum. It is unlikely that the extension of the calculated regression line for the four test points (figure 6) represents the true relationship in the untested range; since this would mean that when no information is received from the Psi target, an information capacity of 12.5 is received from the DIN system. It is more likely that a much lower information capacity would result from the DIN target (close to zero) at this level. Therefore, it is suspected that the true relationship curve will approach the origin at the lower levels of information capacity. In any case, it is apparent that the DIN and Psi targets produce different results in information capacity.

Since the Psi target is a two-target system, the odd and even target images were necessarily evaluated separately. Because of this fact, an interesting effect resulted in the evaluations. In many instances, the viewer was able to evaluate (e.g.) the even target at lower reduction levels than he did on the corresponding odd target image. Figures 7-10 represent evaluations by a sample of viewers of the four different Psi images. This two-target effect is illustrated by a zig-zagging discontinuity in the plots. (The plots illustrate the distinction between odd and even data.) Note, for example, that on the viewer #3 curve in figure 10, the peaks of the zig-zag occur at odd reduction levels (odd target evaluation) and the low points occur at even levels (even target evaluation). In figure 11, the data from this same curve is plotted separately for the odd and even target evaluation. These curves are quite continuous and closely resemble the sample plots for the DIN target in figures 12-15.

This two-target effect was neither peculiar to any particular viewers, nor consistent as to which target (odd or even) was evaluated lower. The cause of this effect is probably either a variability within viewers, or a variability between odd and even images at the same reduction, or a combination of both. To avoid this effect, a one-target Psi system might be used. The single odd or even target could perhaps serve this purpose, however, it would have to be determined if the $\sqrt[6]{2}$ incrementation would significantly alter the results obtained with the $\sqrt[12]{2}$ two-target system.

Since both the Psi and DIN systems have demonstrated their own faults and merits, and since both systems appear to produce different results in information capacity; it is not suggested that one replace the other, but rather that each stand as a distinct microfilm resolution system.

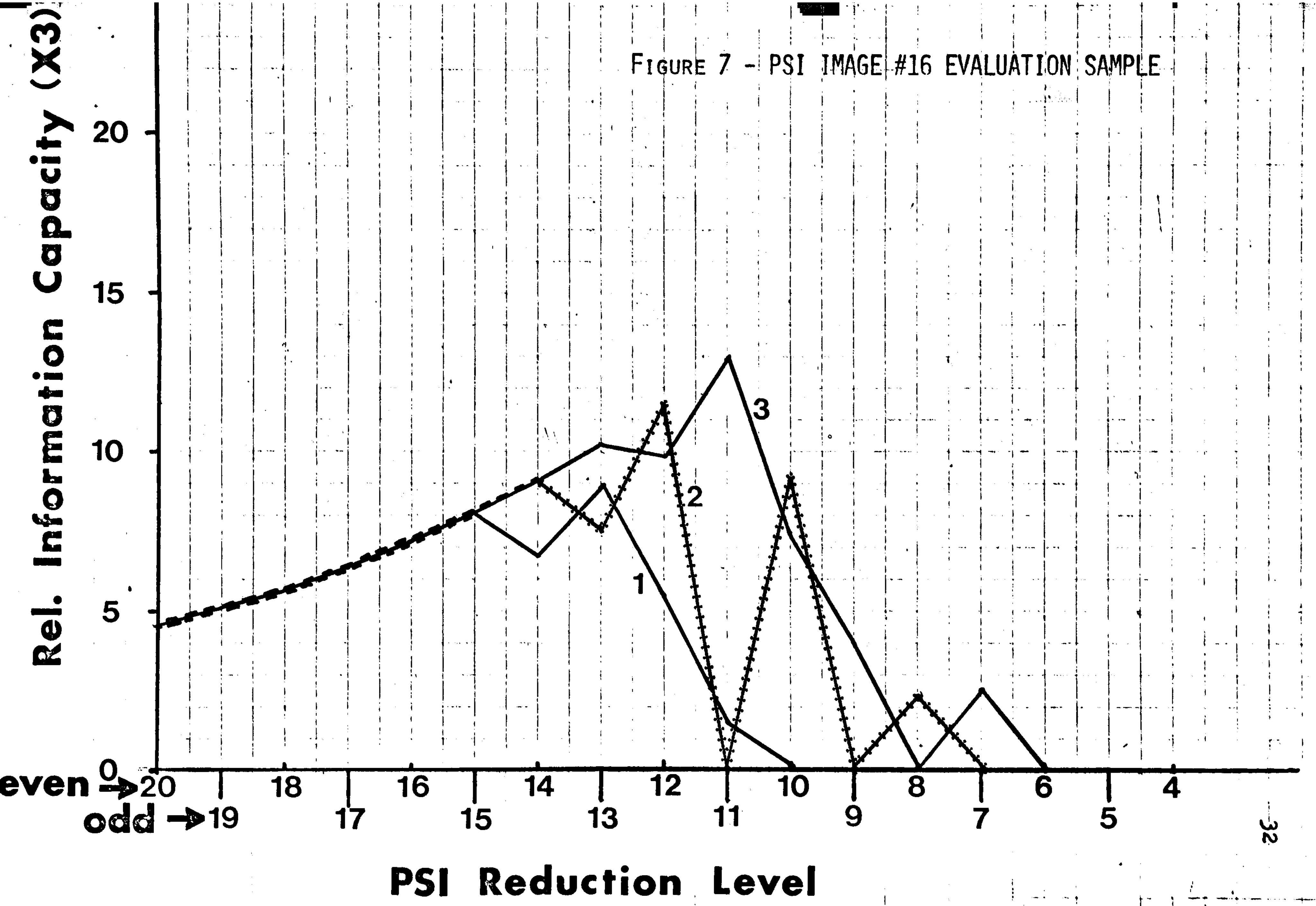


FIGURE 7 - PSI IMAGE #16 EVALUATION SAMPLE

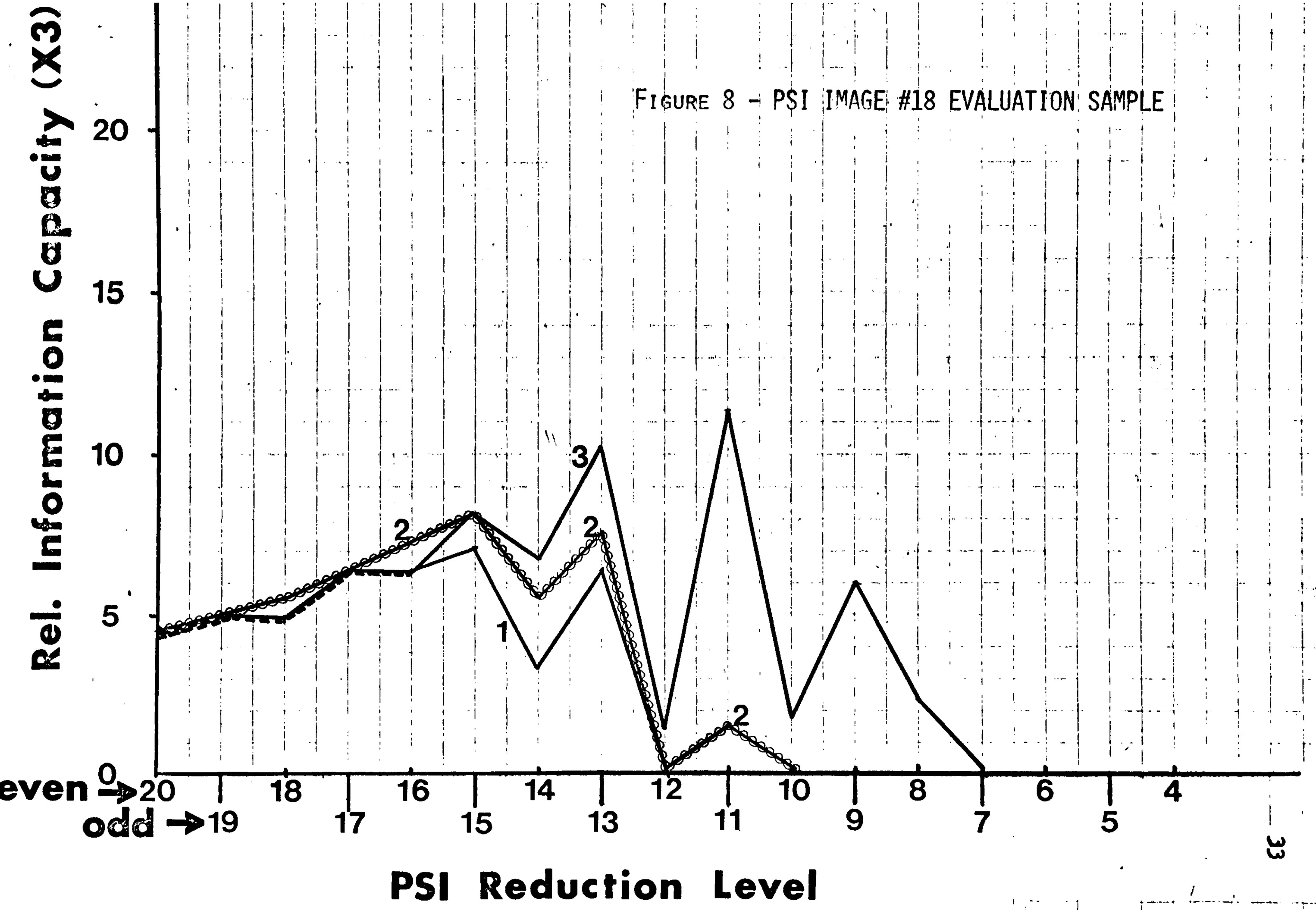


Figure 8 - PSI Image #18 Evaluation Sample
Rel. Information Capacity (X3)
0
5
10
15
20
even → 20
18
16
14
12
10
8
6
4
odd → 19
17
15
13
11
9
7
5
1
2
3
PSI Reduction Level

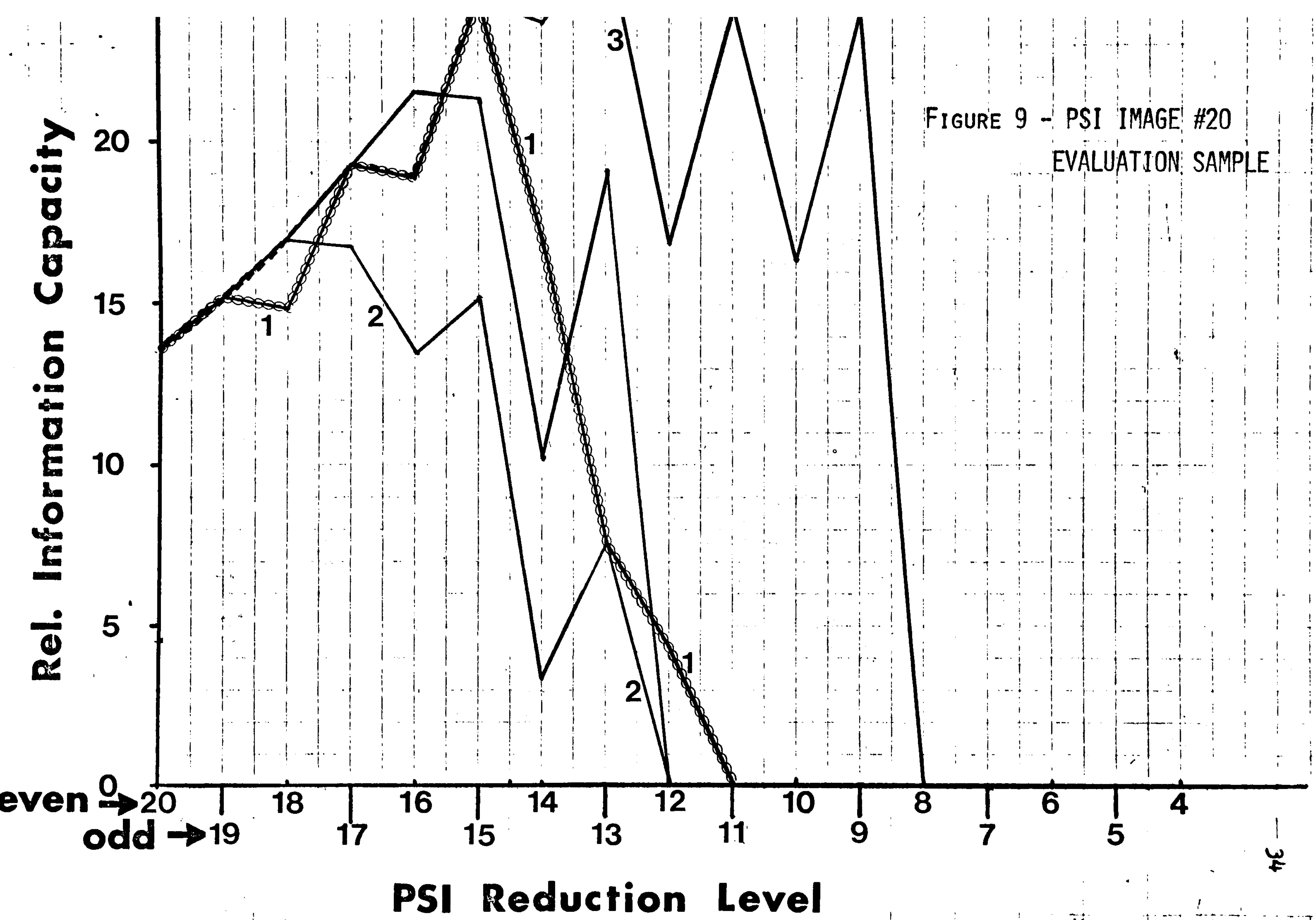


FIGURE 9 - PSI IMAGE #20
EVALUATION SAMPLE

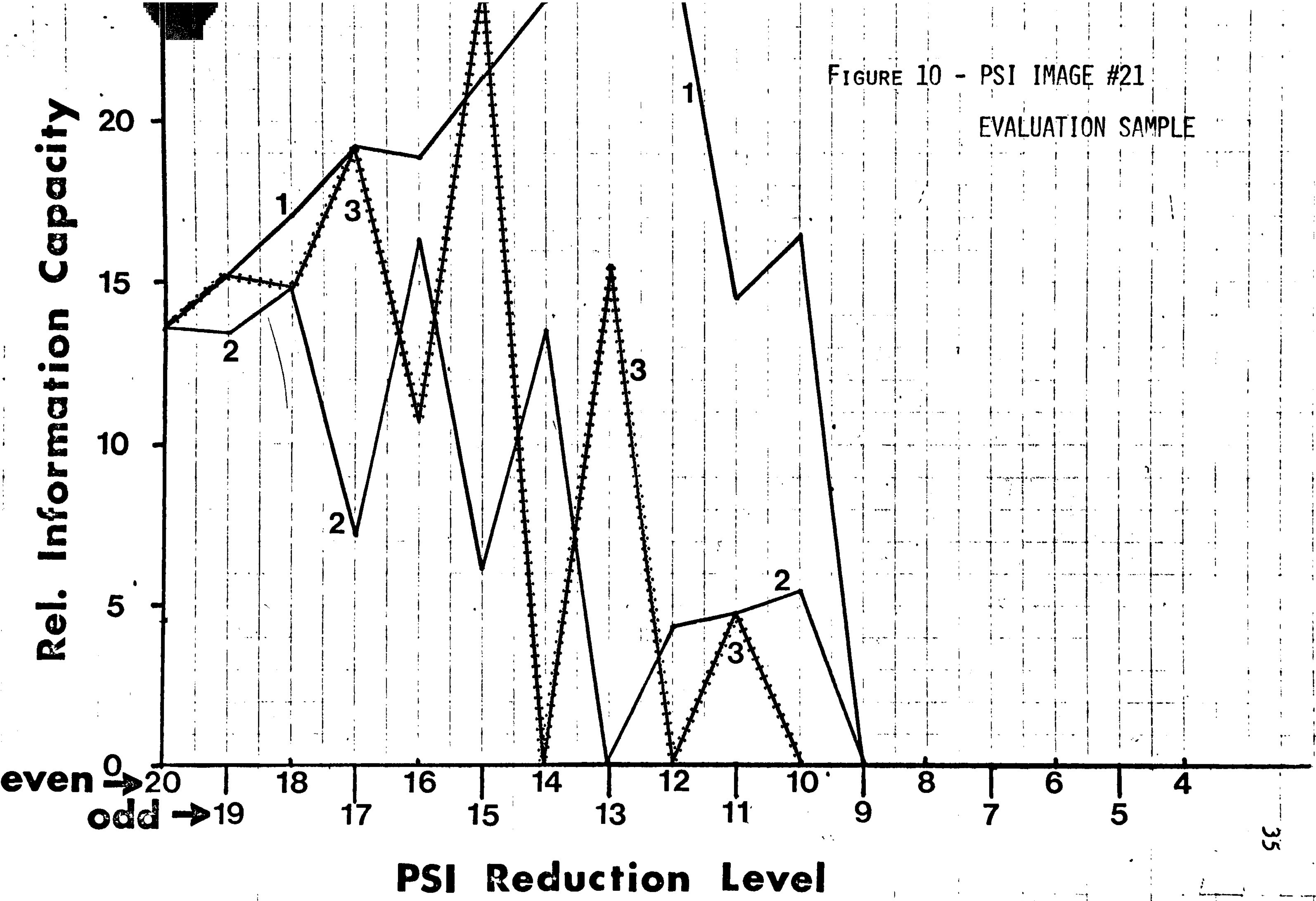


FIGURE 10 - PSI IMAGE #21
EVALUATION SAMPLE
Rel. Information Capacity
20
15
10
5
0
even → 20 18 16 14 12 10 8 6 4
odd → 19 17 15 13 11 9 7 5
1
2
3
PSI Reduction Level

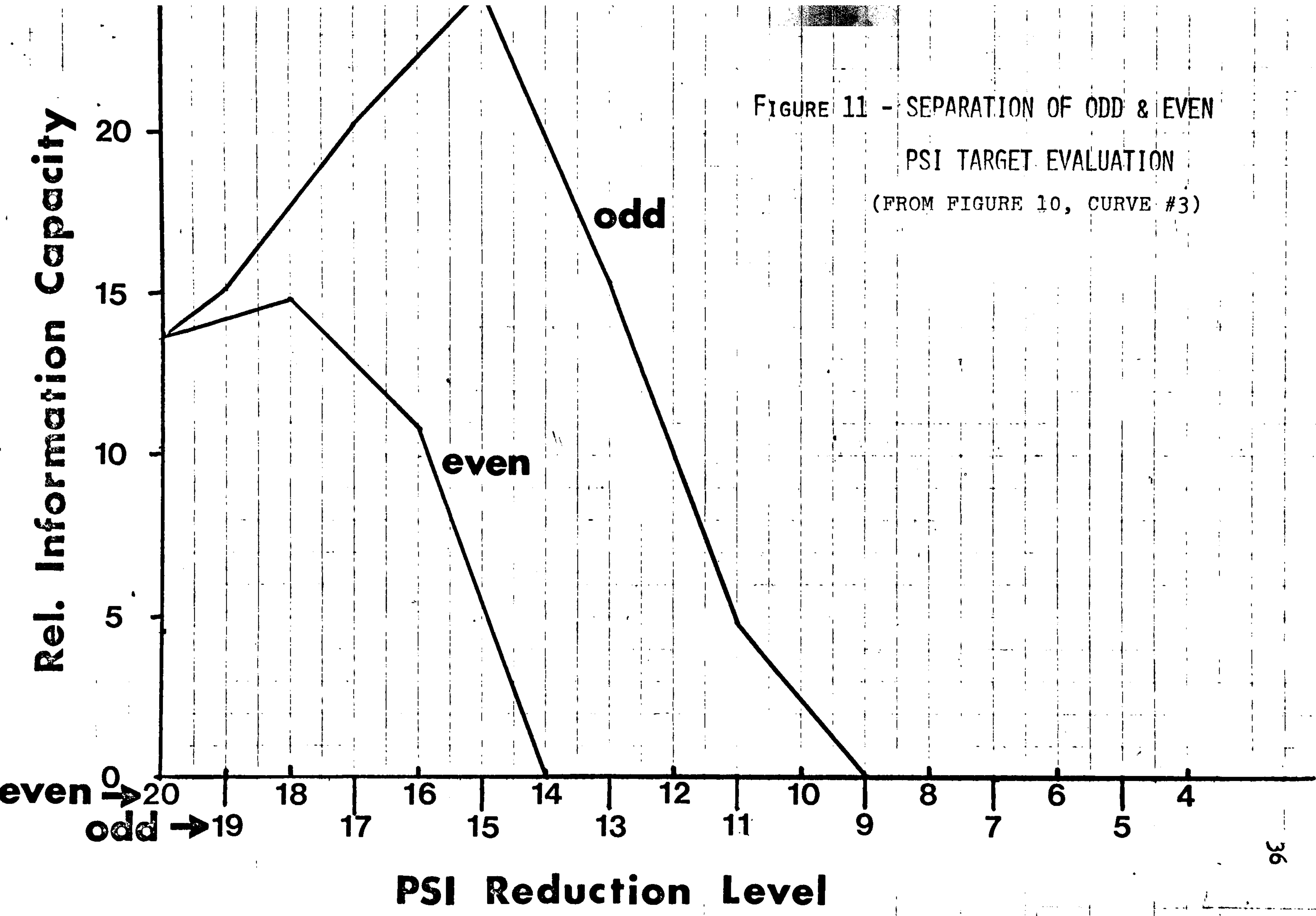


FIGURE 11 - SEPARATION OF ODD & EVEN PSI TARGET EVALUATION
(FROM FIGURE 10, CURVE #3)

FIGURE 12 - DIN IMAGE #16 EVALUATION SAMPLE

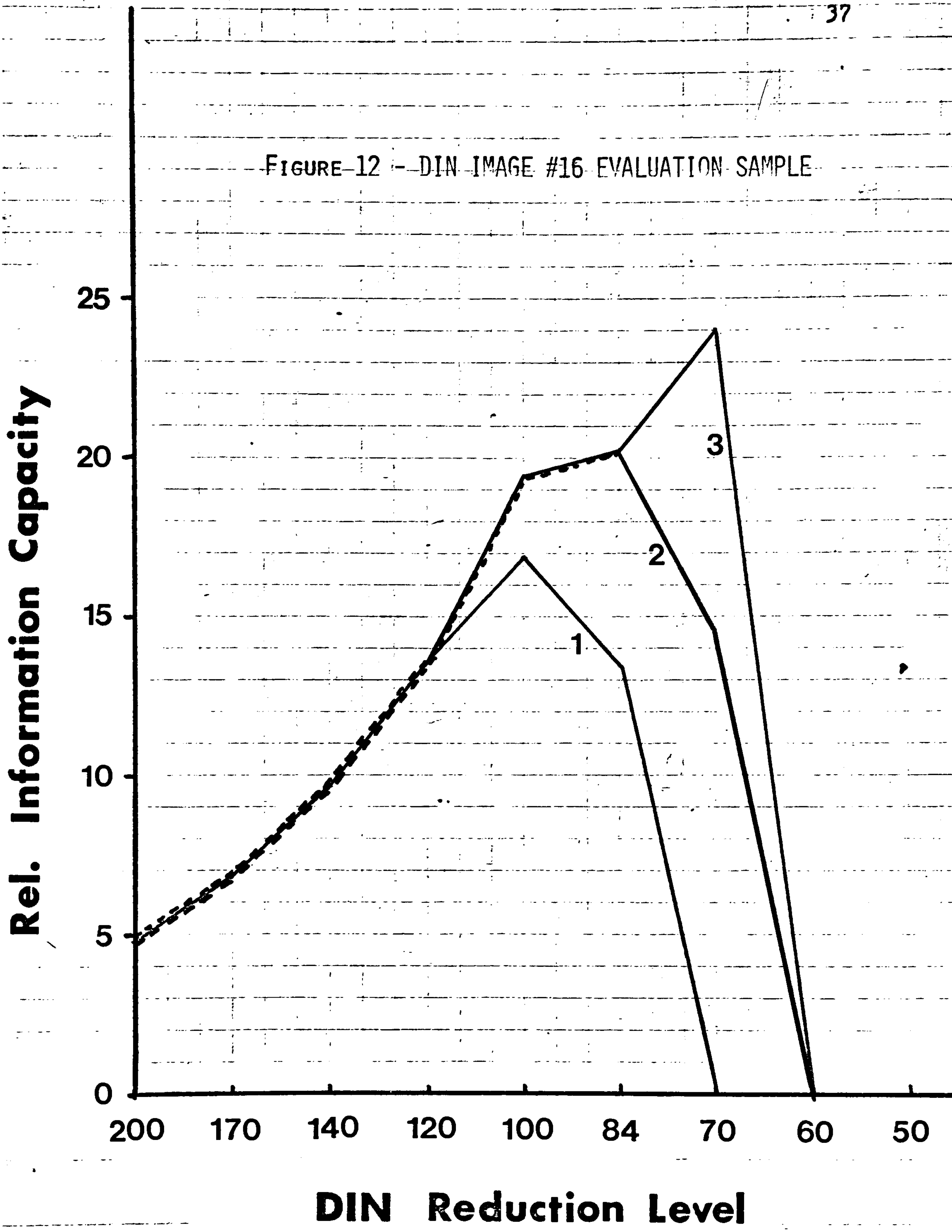


FIGURE 13 - DIN IMAGE #18 EVALUATION SAMPLE

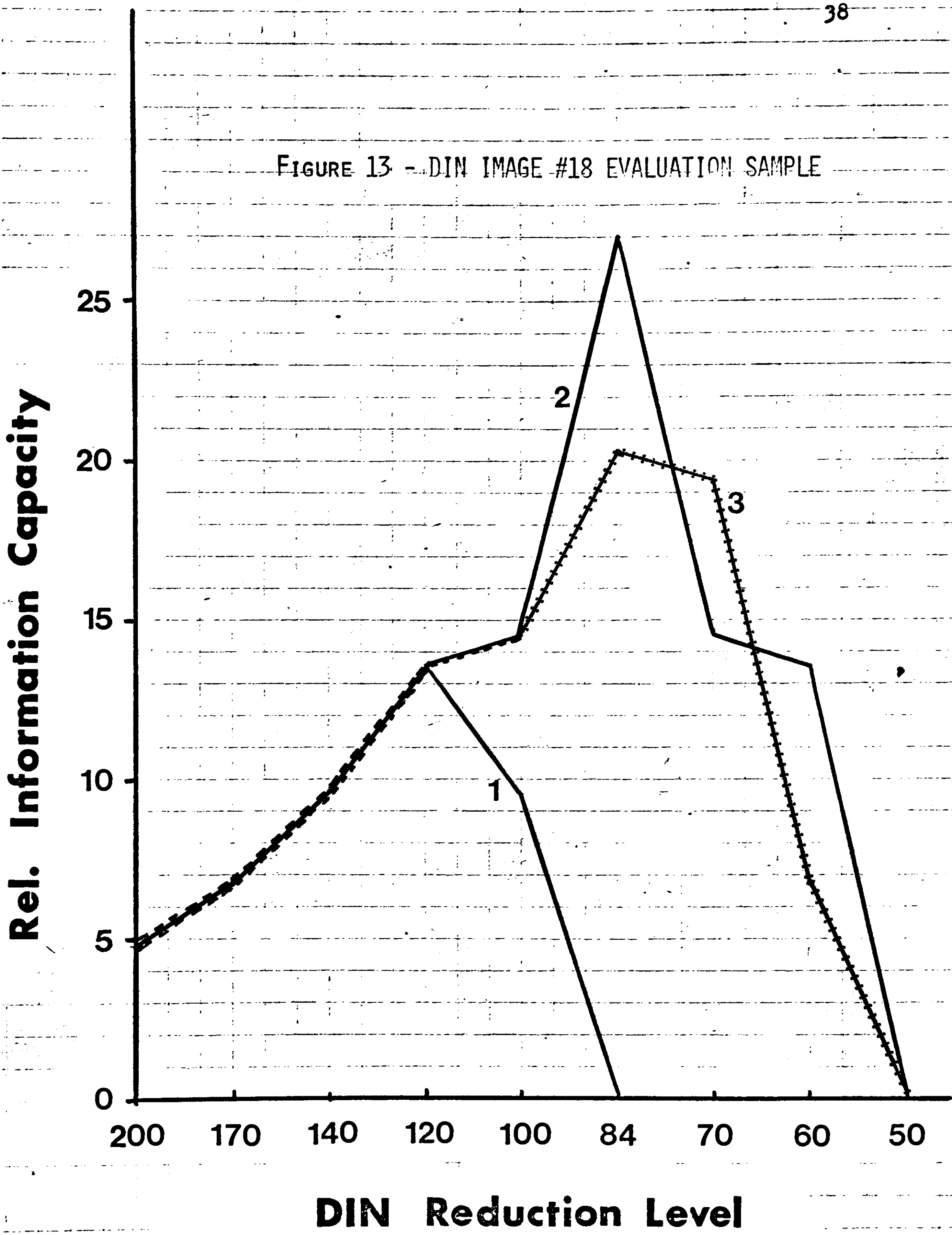


FIGURE 14 - DIN IMAGE #20 EVALUATION SAMPLE

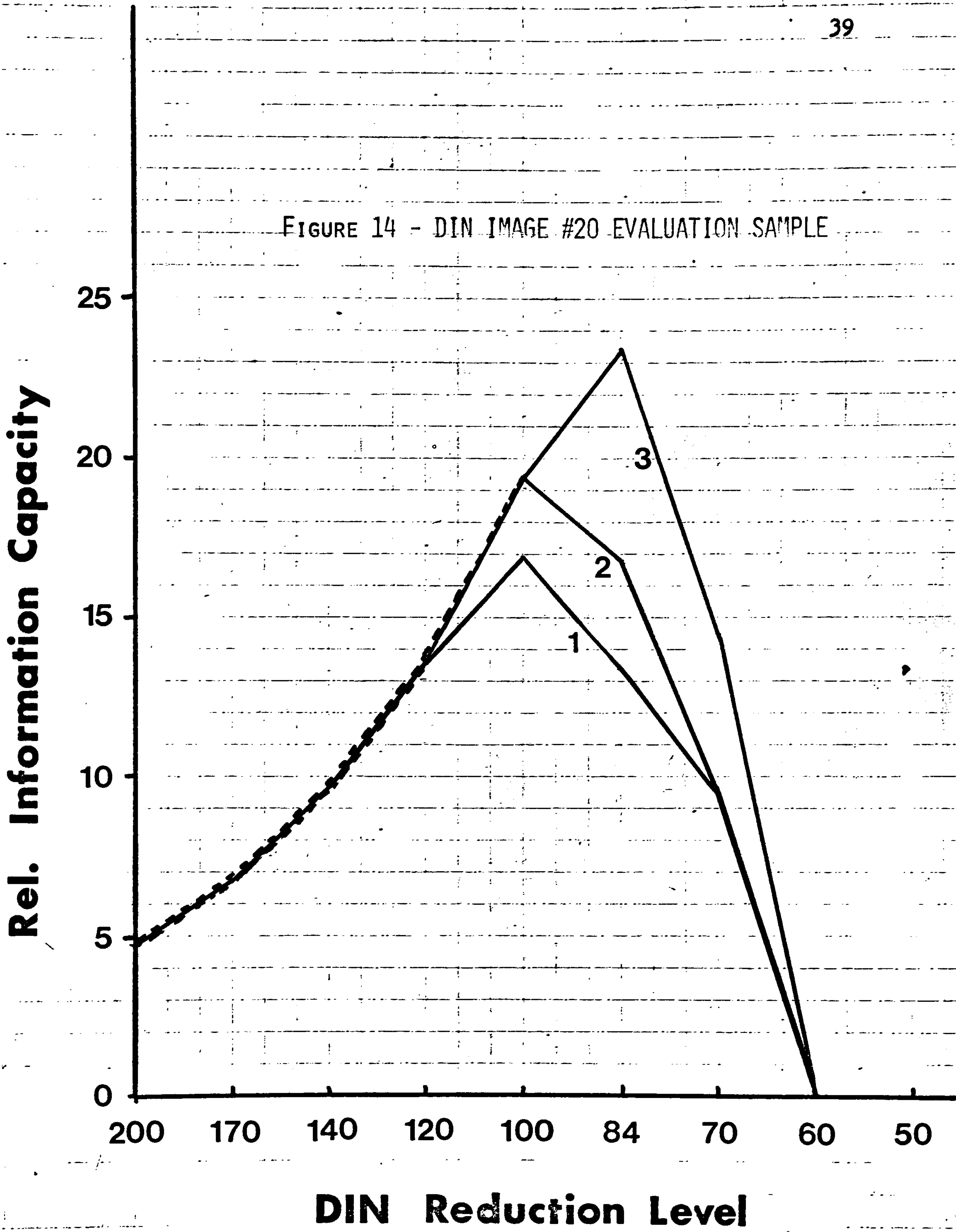
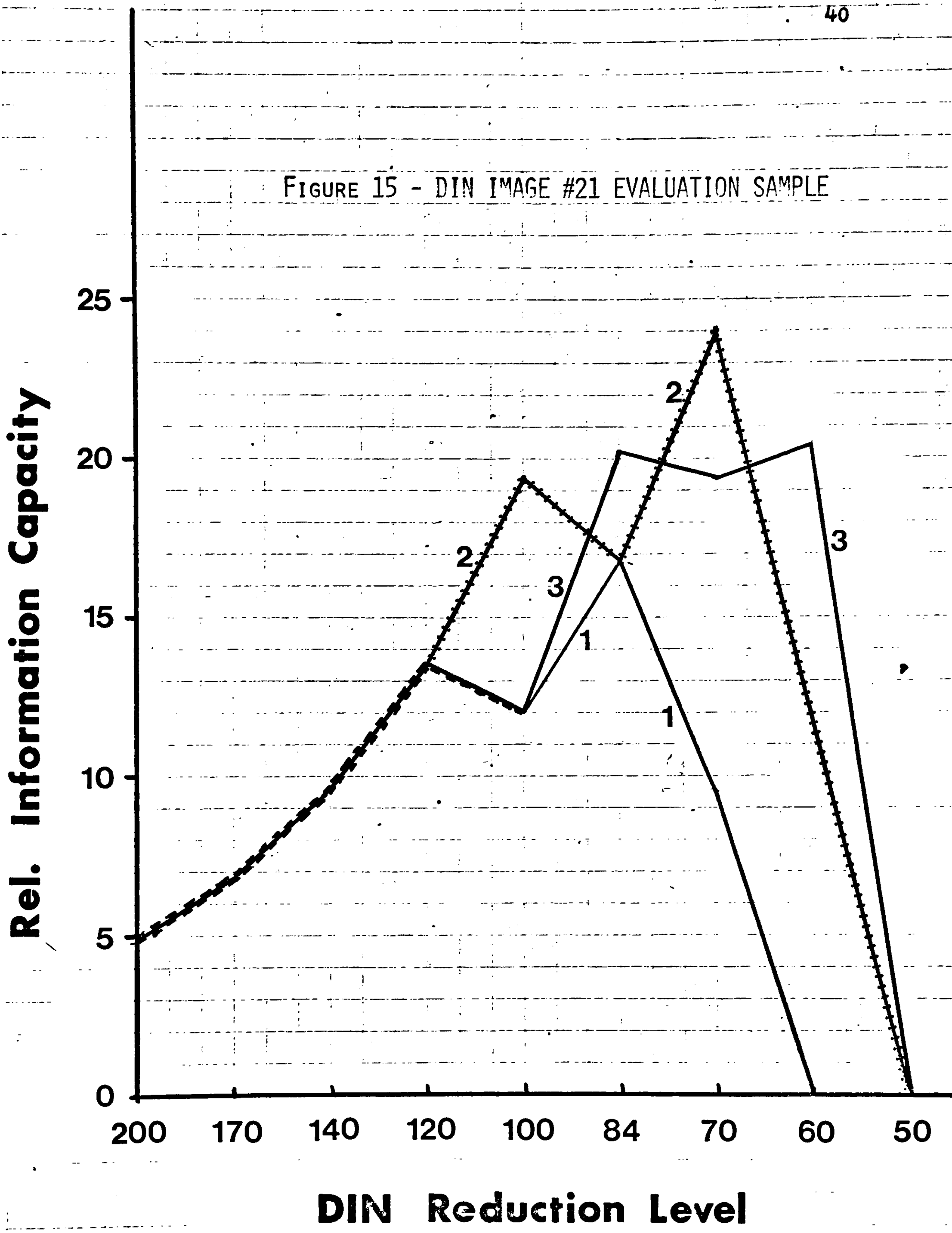


FIGURE 15 - DIN IMAGE #21 EVALUATION SAMPLE



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