EVALUATION OF JPEG COMPRESSION BY USING SCID IMAGES

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Keyword: JPEG, SCID, Codec, ISDN, Image Quality

Abstract: This paper reports the evaluation results of JPEG image compression when this technology is applied to high quality images used in printing industries.
The project for evaluation has been organized by The Japan Federation of Printing Industries (JFPI).[Chair: Furuta] SCID were used for test image data. In this work, the relationship between quantization table values, compression ratios and qualities of reconstructed final images has been studied.

By using high performance codec in which the JPEG algorithm is installed, one minute real time transmission of SCID "Portrait" image via ISDN 64 kbit channel has been achieved.
A panel of experts from the prepress industry performed an subjective evaluation of the images.
The results of the experts' investigation are summarized as follows;

1) approximately 1/10 compressed image has comparable quality to the original image, and
2) compression ratio depends deeply on the density distribution of the original iamge data.

These data are depicted in this report in detail.

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1. INTRODUCTION

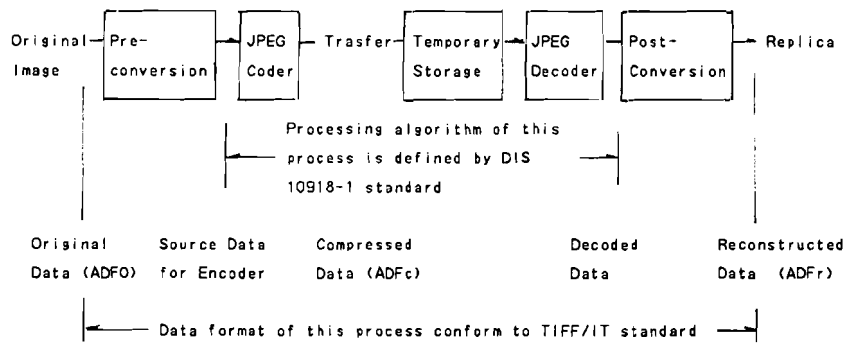
One of the most important issues in prepress field is to make it possible to exchange compressed image data between various CEPSs.
Some existing systems e.g. Crosfield system or Scitex system are able to provide the specified DCT compression algorithm and significant number of printing companies have adopted these compression algorithms.
The JFPI has taken up the task of developing high speed image data exchange systems and is concentrating on products which utilize JPEG compression techniques.

This paper details the requirements for JPEG codec, configuration of codec, the relationship between compression ratio and JPEG parameters, and the relationship between compression ratio and the reconstructed image quality.
Evaluation results indicate that the reconstructed image with 1/10 compression can not be distinguished from the original image when 400 LPI SCID image data is used.

2. CONFIGURATION AND FUNCTION

2.1 System Configuration

The data exchange system is shown schematically in Fig. 1.



ADFO: Application Data Format of Original Image Data
ADFc: Application Data Format of Compressed Image Data
ADFr: Application Data Format of Reconstructed Image Data

Fig. 1 Basic system configuration for image data flow

The compression/decompression system has two interfaces: one is the input/output through which the data stream having a defined format is applied, and the other is the interface which is connected to the transmission channel. When developing the system, the interface conditions and data formats were newly defined.

2.2 Requirements for JPEG Compression/Decompression System

The reuirements recommended by experts in prepress field are as follows:

(1) Real time compression/decompression of 1/2 - 1/50
(2) Through-put of less than one minute when SCID "Portrait" is used
(3) Adoption of JPEG algorithm for compression
(4) Ability to transmit attribute information as uncompressed data

To satisfy these requirements and to enable connection with various systems, the following functions have to be installed in the system.

(1) Color conversion from RGB and CMYK to luminance and chrominance
(2) High speed processing of JPEG algorithm
(3) Communication protocol for ISDN channel
(4) Interfacing between existing CEPSs

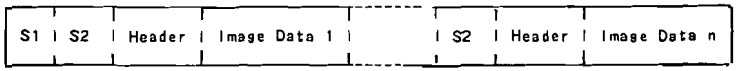
3. CONSTRUCTION OF CODEC

3.1 Data Format of ADFo and ADFr

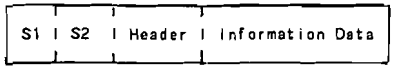
To enable the transmission of image data via a communication channel, the data formats for ADFo and ADFr, including session layer and presentation layer protocol, should be defined as a minimum.
In this system, these formats are shown in Fig. 2.
In the session layer descriptor, attributes such as destination and construction of data stream etc. are described.

In the presentation layer descriptor, attributes to provide the services to the application layer are described. Therefore, the image manipulation method, the type of data (image data, computer data or binary data),

(a) Image Data



(b) Information Data



S1 : Session layer descriptor, 512 Byte
S2 : Presentation layer descriptor 32 Byte
Header : Attribute information

Fig.2 Syntax of Data to be transferred

color sequence, interleaving of original data, restored quality etc. have to be described in this descriptor.

3.2 Block Diagram of Codec

Fig.3 shows the block diagram of codec. The components shown in Fig.3 implement the following functions.

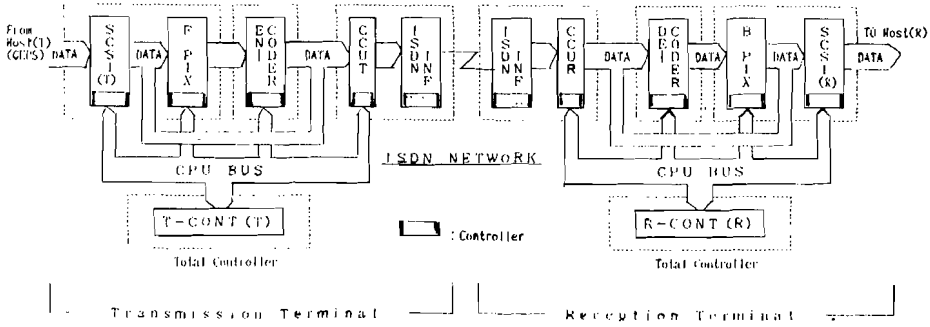


Fig. 3 Block diagram of Codec

1) SCSI(T),(R) : SCSI Interface Circuit
 * To exchange Command/Response between CEPS and Codec
 * To recognize or to add attribute information
 * To inform of alarm condition

2) FPIX : Forward Picture Data Processor

* To separate the image data to be compressed from the data stream
* To convert the original interleaving to block interleaving defined by JPEG algorithm
* To implement various conversions such as positive/negative data type, color sequence, color space etc.
* To perform subsampling if designated in presentation layer descriptor

By using these functions, image data can be converted to the most efficient data type for JPEG encoding procedure. When original color space is RGB or CMYK, the following equations (1),(2) are used for conversion.

$$\begin{aligned} Y &= 0.299\ R + 0.587\ G + 0.114\ B \\ Cr &= 0.713\ (R-Y) \\ Cb &= 0.564\ (B-Y) \end{aligned} \qquad (1)$$

$$\begin{aligned} C &= 255 - R \\ M &= 255 - G \\ Y &= 255 - B \end{aligned} \qquad (2)$$

K is treated as the fourth color component and compressed using the same tables as for the luminance data.

3) BPIX : Backward Picture Data Processor

In BPIX, the reverse operation of FPIX is implemented and the image data are restored back to their original.

4)COD : Encoding Circuit

Calculation of DCT-SQ, entropy coding of digitized DCT coefficients are executed in this portion.

5)CCUT, CCUR :Communication Control Unit

This section implements communication protocol via the ISDN channel.

6)T-CNT(T),(R): Total Control Unit

This portion controls all blocks so as to harmonize operations of all components. In particular, the analysis of input data to separate image data is performed in this unit.

4. EVALUATION OF SYSTEMS

The following two parameters determine the compression ratio.

1) Subsampling
2) Quantization table values

10 kinds of parameter combinations are prepared in this system, and SCID data are used to evaluate the characteristics of this codec system.

4.1 Quantization Tables

The quantization tables installed in the system are shown in Table-1. Alpha(α) and beta(β) are coefficients of QM1 (Luminance quantization table) and QM2 (Chrominance quantization table) shown in ISO DIS 10918-1 standard. Gamma (γ) is a coefficient of QM3 quantization table used for high quality compression.

$$QM1 = \alpha \cdot \begin{vmatrix} 10 & 0B & 0A & 10 & 18 & 28 & 33 & 3D \\ 0C & 0C & 0E & 13 & 1A & 3A & 3C & 37 \\ 0E & 0D & 10 & 18 & 28 & 39 & 45 & 38 \\ 0E & 11 & 16 & 1D & 33 & 57 & 50 & 3E \\ 12 & 16 & 25 & 38 & 44 & 6D & 87 & 49 \\ 18 & 23 & 37 & 40 & 51 & 68 & 71 & 5C \\ 31 & 40 & 4E & 57 & 67 & 79 & 78 & 65 \\ 48 & 5C & 5F & 62 & 70 & 64 & 67 & 63 \end{vmatrix}$$

$$QM2 = \beta \cdot \begin{vmatrix} 11 & 12 & 18 & 2F & 63 & 63 & 63 & 63 \\ 12 & 15 & 1A & 42 & 63 & 63 & 63 & 63 \\ 18 & 1A & 38 & 63 & 63 & 63 & 63 & 63 \\ 2F & 42 & 63 & 63 & 63 & 63 & 63 & 63 \\ 63 & 63 & 63 & 63 & 63 & 63 & 63 & 63 \\ 63 & 63 & 63 & 63 & 63 & 63 & 63 & 63 \\ 63 & 63 & 63 & 63 & 63 & 63 & 63 & 63 \\ 63 & 63 & 63 & 63 & 63 & 63 & 63 & 63 \end{vmatrix}$$

$$QM3 = \gamma \cdot \begin{vmatrix} 01 & 01 & 01 & 01 & 01 & 01 & 01 & 01 \\ 01 & 01 & 01 & 01 & 01 & 01 & 01 & 01 \\ 01 & 01 & 01 & 01 & 01 & 01 & 01 & 01 \\ 01 & 01 & 01 & 01 & 01 & 01 & 01 & 01 \\ 01 & 01 & 01 & 01 & 01 & 01 & 01 & 01 \\ 01 & 01 & 01 & 01 & 01 & 01 & 01 & 01 \\ 01 & 01 & 01 & 01 & 01 & 01 & 01 & 01 \\ 01 & 01 & 01 & 01 & 01 & 01 & 01 & 01 \end{vmatrix}$$

4.2 Quality and Compression Ratio

Table-2 shows the measured compression ratios.

Table-1 Parameter combinations

No.	Color space Conversion		Subsampled Components				Scaling Factors α	β	γ
0	--		--	--	--	--	--	--	2.0
1	CMYK	YCbCrK	--	--	--	--	0.25	0.25	--
2	CMYK	YCbCrK	--	--	--	--	0.80	0.80	--
3	CMYK	YCbCrK		Cb	Cr		0.20	0.20	--
4	CMYK	YCbCrK		Cb	Cr		0.70	0.70	--
5	CMYK	YCbCrK	--	--	--	--	1.30	1.30	--
6	CMYK	YCbCrK	--	--	--	--	2.60	2.60	--
7	CMYK	YCbCrK	Y	Cb	Cr	K	0.20	0.20	--
8	CMYK	YCbCrK	Y	Cb	Cr	K	0.60	0.60	--
9	CMYK	YCbCrK	Y	Cb	Cr	K	1.60	1.60	--

Table-2 Relationship between Q-table number and compression ratio

	High					Quality				Low
Image name	0	1	2	3	4	5	6	7	8	9
Portrait	2.4	4.6	10.1	11.8	12.9	17.6	23.3	45.6	58.3	102.2
Cafeteria	1.6	2.8	5.2	5.9	6.5	8.5	10.9	22.0	27.5	48.5
Fruit Basket	2.2	4.0	8.8	10.4	11.4	15.9	25.7	44.1	57.0	102.7
Wine & Tableware	2.5	5.0	11.0	12.8	14.0	19.1	20.5	51.7	64.9	107.2
Bicycle	2.3	4.7	9.5	11.0	11.9	15.8	20.5	41.0	50.9	85.7
Orchid	2.5	4.5	10.4	12.4	13.7	19.7	29.0	64.3	85.2	151.8

4.3 Transmission via ISDN 64 kbit Channel

Fig.4 shows the measured times needed to transmit SCID data via an ISDN 64 kbit channel. The transmission time decreased as the compression ratio was increased.
However, this trend only continued until the transmission time reached one minute which corresponds to the computing speed limit.

4.4 Subjective Evaluation of Restored Images

A subjective evaluation of the restored images has been carried out by a panel of experts in the prepress industry. Various parameters were changed and the restored images were separated, printed and evaluated.
Fig.5 is an example of the results of subjective evaluation

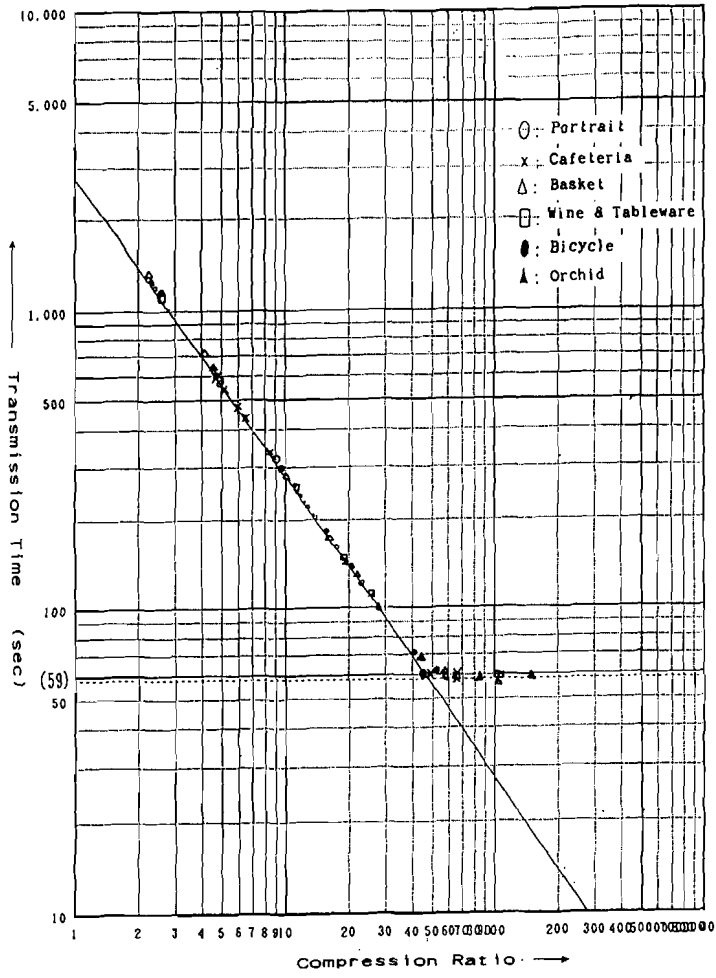


Fig.4 Measured Transmission Time

performed in total 21 experts from different printing companies.

The quality of the restored images were rated under the normal room lighting conditions.

Printed images from the restored data are compared to the image obtained from the original data and were graded according to three ranks:

very good - 2, good - 1 and limited use - 0.

Fig. 5 shows the relationship between the average scores for various coding conditions and their accumulated

frequencies.
If a 50 % value of score 2 is taken as the limit for practical use, the corresponding compression ratio are 1/25.2 for Portrait, 1/12.7 for Cafeteria, 1/8.1 for Wine & Basket and 1/9.1 for Bicycle.

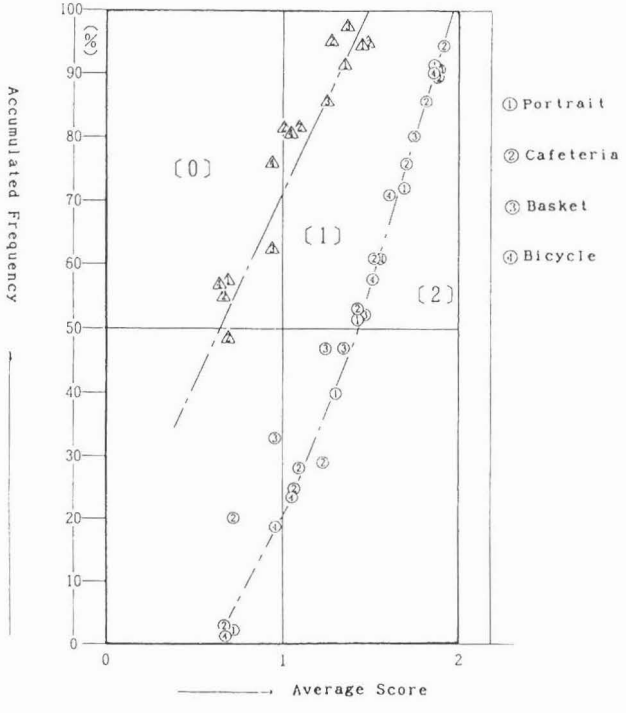
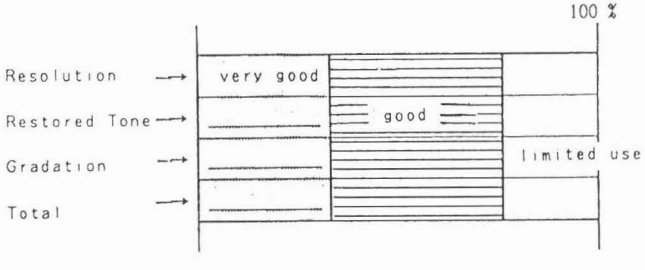


Fig. 5 Relationship between average scores and their accumulated frequencies

Fig.6 (a)-(d) depict the evaluated results of restored images.



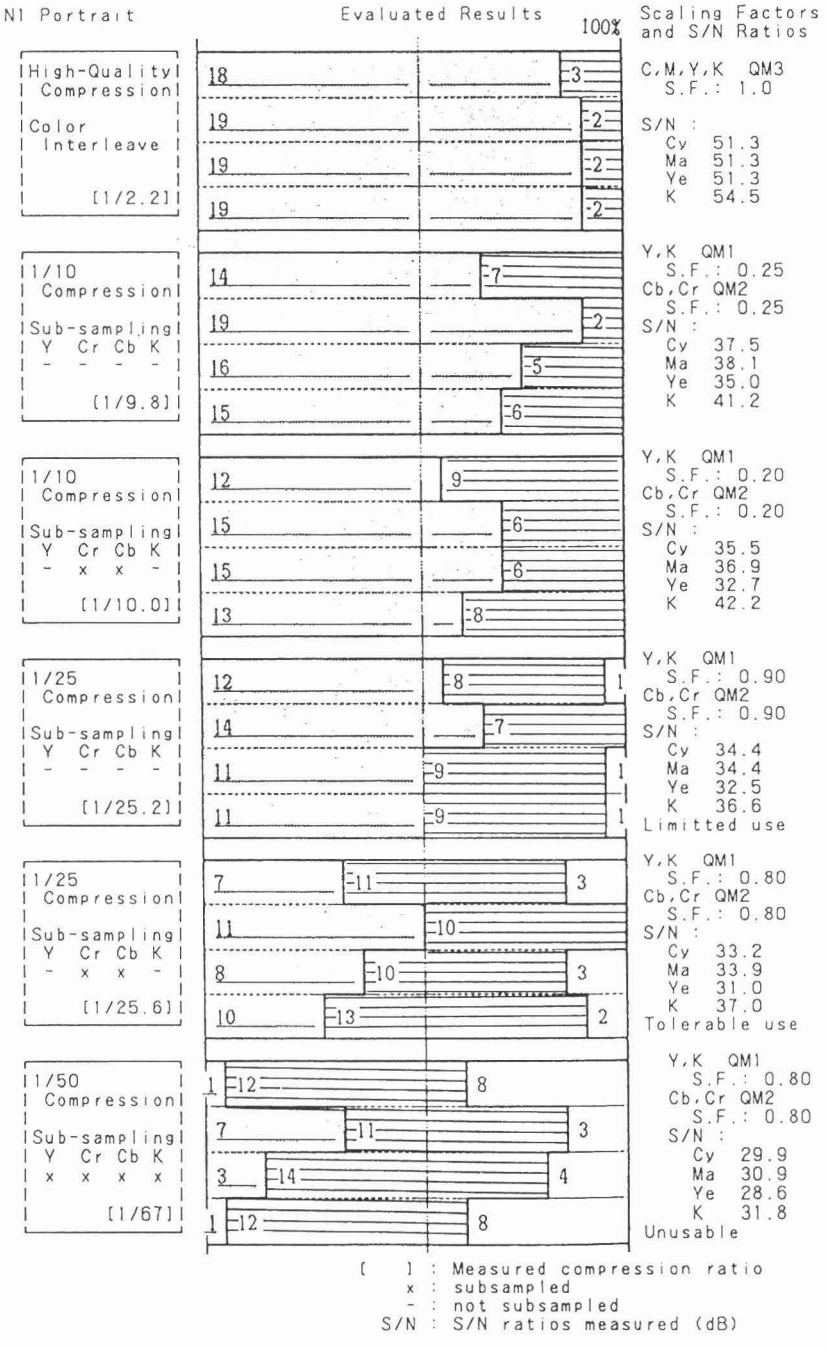


Figure 6(a) Relationship between Evaluation and Compression Ratio

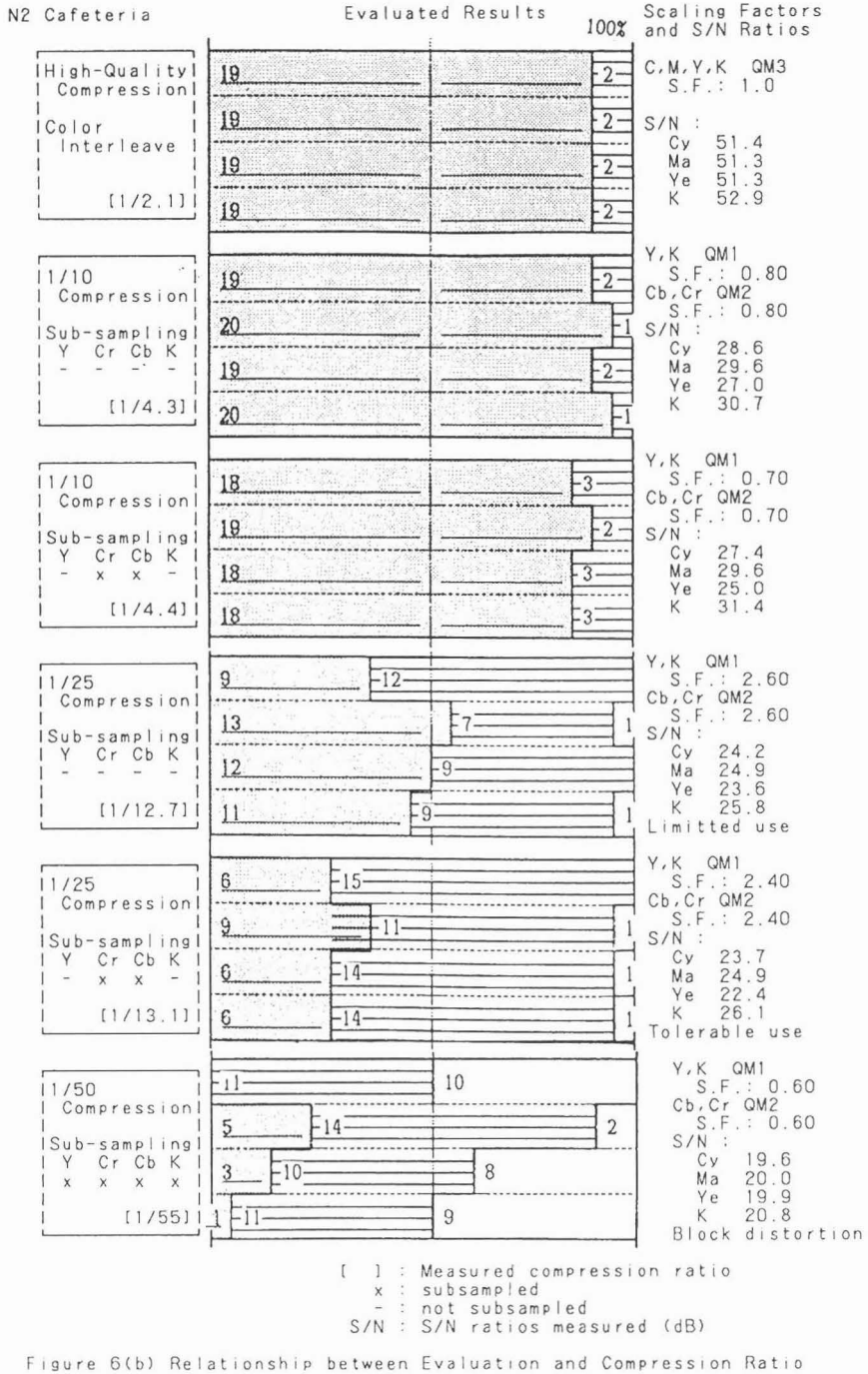


Figure 6(b) Relationship between Evaluation and Compression Ratio

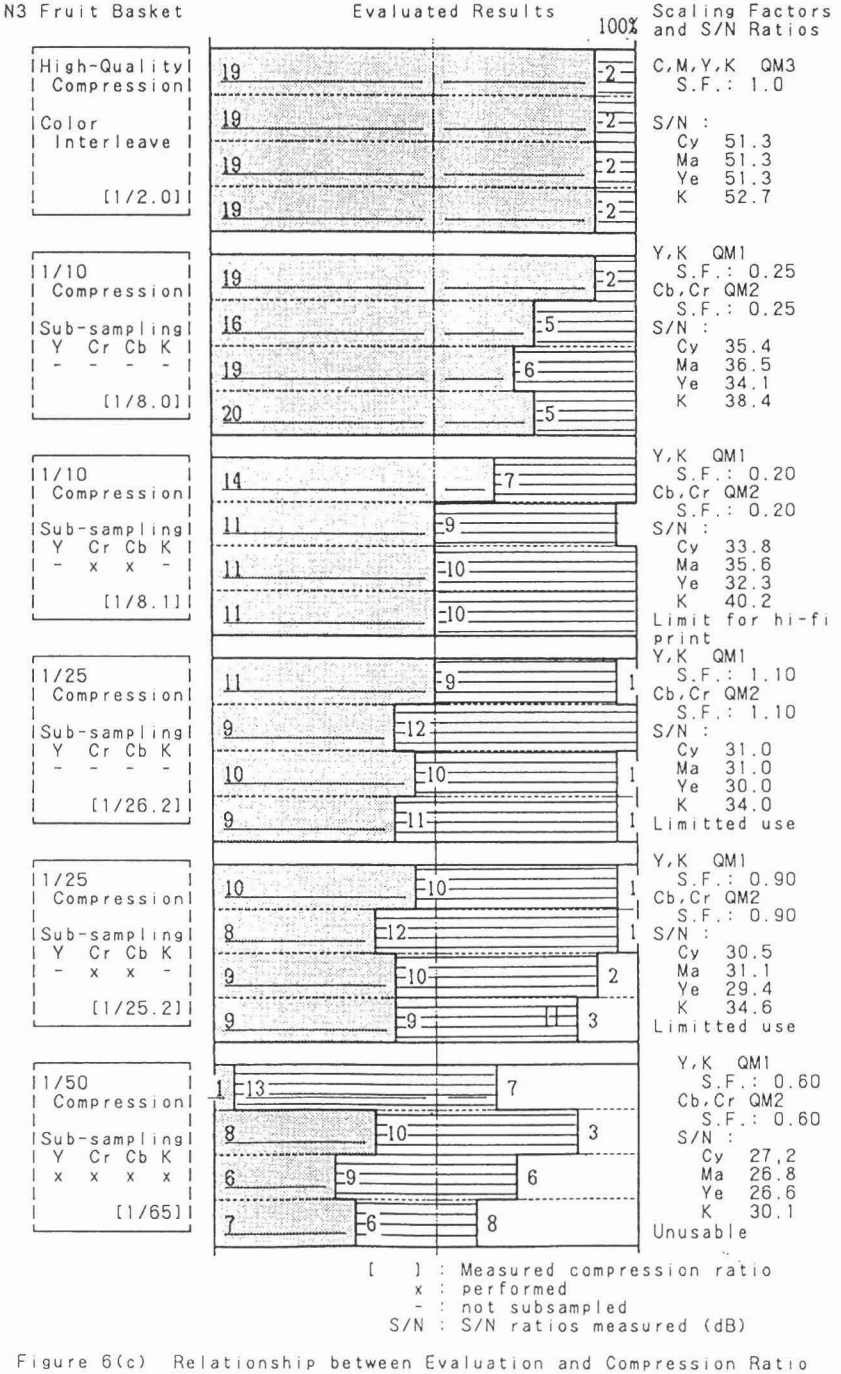


Figure 6(c) Relationship between Evaluation and Compression Ratio

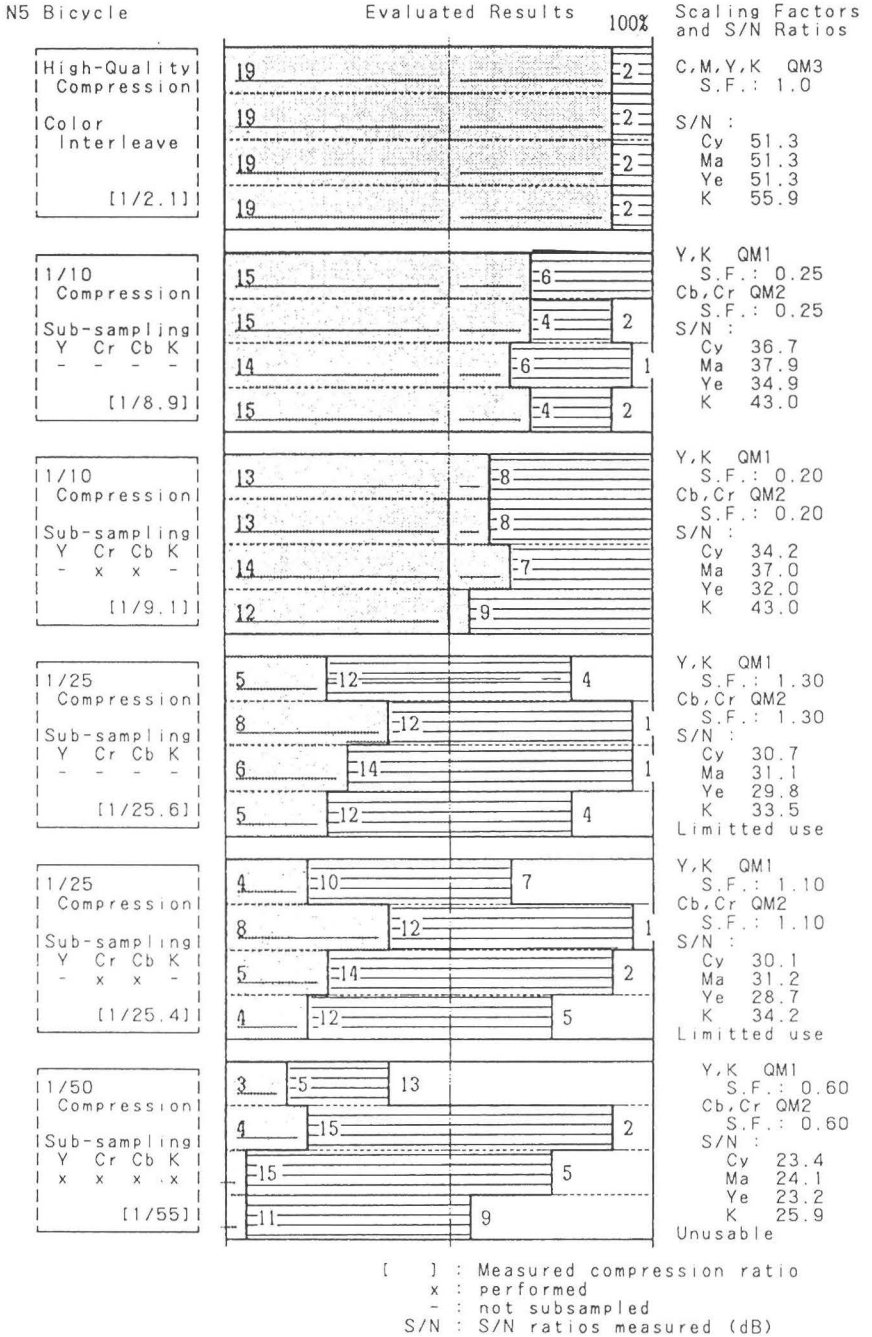


Figure 6(d) Relationship between Evaluation and Compression Ratio

5. CONCLUSION

This paper has summarized the test results of JPEG application for printing industries.
The JPEG codecs were supplied by NEC, and separations and prints were produced by Dainippon Printing Co. Ltd..
The results show that the applicable limit of compression is about 1/10.
When the S/N ratio is less than 30 db, the evaluated quality is propotional to the S/N values.
Nevertheless, the subjective quality of print from restrored data which S/N ratios are greater than 30 db does not seem to be propotional to the S/N values.
It seems to depend on the composition of the respective pictures.
In this experiment we have proved that JPEG is suitable for continuous tone pictures.
However, one important issue, the necessary criteria to define the application data format at interfaces between CEPS and the transmission channel, remain for future study.

ACKNOWLEDGEMENT

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REFERENCES

1. ISO/IEC JTC1/SC29 N 257 "Final Text of DIS 10918-1 : Digital Compression and Coding of Continuous-tone Still Images - Part 1: requirements and guidlines.
2. NEC Catalogue " Color Image Transmission System"