QUARTERLY REPORT

ON

"PRACTICAL EVALUATION OF FILM-PROCESSING SYSTEMS (RED DOT TESTS)"

(PAR 24, CONTRACT EB-1492)

17 January 1964

PART A

Density Data Reduction

1. SUMMARY

Large quantities of density data obtained from actual mission material must be analyzed to more fully understand the variable involved in the exposure and interrupted processing of high altitude reconnaissance photography. A data collection and reduction program using a punch card system was organized for this purpose.

A single program handles data related to exposure, density, scene brightness, and processing, thus affecting over-all economy and flexibility. In addition, the data has been collected in such a manner that it may be used in the future for experiments in the automation of production operations.

2. INTRODUCTION

To improve the quality of space reconnaissance now using very fine grain, slow speed, short exposure latitude film, methods to optimize exposure are being determined through investigation. Optimization of exposure to some extent offsets the severe restrictions placed on photographic acquisition by this type of sensitized material. Duplication of this material to provide maximum information, also requires extensive investigation to determine optimum density and contrast levels that are dictated by requirements of the viewer and sensitometric parameters of the negative and duplication materials.

Both the original negative and duplication materials require the examination of large quantities of data obtained by objective and subjective observations upon the films. Storage and processing of data are being accomplished with punch cards and data processing equipment. This procedure saves time and allows a more convenient and thorough data study to be made. Several computer programs were written to retrieve and operate on the stored data.

The rules for collection of density data from original negative material, categorization with respect to scene subject matter, and (to a limited extent) classification of atmospheric conditions at acquisition time, were established.

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Considerable thought is being given to develop the concept of a master data card deck, which essentially contains the same type of data that is used in research projects, to aid in automating the production of duplicate copies. Conceivably, printing schedules, can labels, film identifying leaders and trailers, shipping manifest information and reproduction history, could be produced from computer operations performed on a single data deck.

3. ORIGINAL NEGATIVE DENSITY DATA SELECTION AND COLLECTION

Mission passes are divided into groups of four passes each and data selection is weighted so that material exposed at a sun angle less than 15 degrees will provide an adequate sample size. The material in these groups is scanned and a selection of one of the four passes is made on the basis of freedom from cloud cover and system malfunction defects. This material in turn is broken down to include one-third of the frames in each pass and the selection is weighted to insure that at least ten density samples will be included for each sun angle, for each pass selected. The following rules are then applied to select densities to be read:

a. Three or four minimum and maximum densities will be selected in each frame.

b. The densities will be selected in an area five inches inside the format in the longitudinal direction and one-quarter inch inside the format in the transverse direction.

c. Minimum densities of the following types will be read (if present) in each frame:

   1. Cloud shadow.

   2. Object shadow.

   3. Non-shadow minimum which may be used to determine printing exposure level.

   4. Absolute minimum density.

d. Maximum densities of the following types will be read (if present) in each frame:

   1. Several maximum densities which could be used to determine printing exposure.

2. Maximum density from a specular reflection; e.g., from water, snow, or ice.

3. Absolute D max which can come from (2) or a cloud, if the value is higher.

Each density collected is identified as to type by a four digit scene code, and a density type code along with other pertinent data related to acquisition and processing. The information is punched on an IBM card when the density readings are taken.

4. IBM MASTER DATA CARDS

The layout of the master data card is described below and the card is illustrated in Figure 1.

4.1 Camera

Data from 10 separate cameras may be recorded. Currently, the forward camera is designated as (0), and the aft camera as (1).

4.2 Pass

Capacity for 9999 passes is available with a one-digit prefix to indicate direction of orbit (from the equator) or other information.

4.3 Frame Section

This section is required in special cases such as the "G" type system where it is necessary to break down brightness data within a frame. Space is provided for 2 digits, thus allowing for a 99 frame-section capacity.

4.4 Frame Number

Frame number capacities of 9999 or 999 plus a prefix are available.

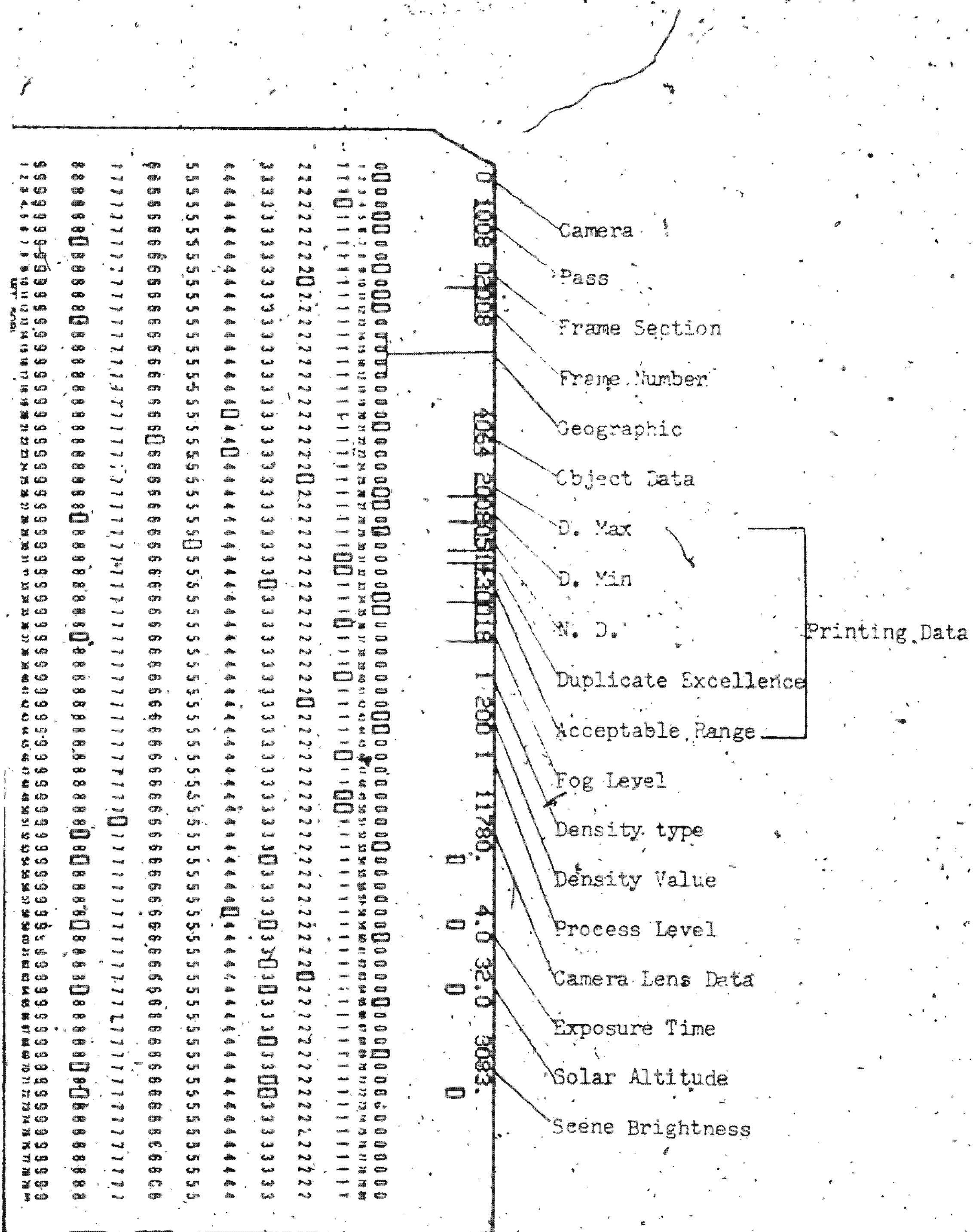

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ILLUSTRATION #1

4.5 Climatic/Geographic (optional)

Climatic, geographic or other indices not exceeding four digits may be recorded.

4.6 Object Data

Object data one divided into four separate sections (4.6.1 through 4.6.4) that are listed below.

4.6.1 Date

The months of the year are divided in six groups of two months each as follows:

Month	Code
Dec, Jan	1 _ _ _
Feb, March	2 _ _ _
April, May	3 _ _ _
June, July	4 _ _ _
Aug, Sept	5 _ _ _
Oct, Nov	6 _ _ _
(Additional numerals for code growth)	

4.6.2 Atmospheric Conditions

The second digit describes atmospheric conditions and some effect of terrain on the incident light. Atmospheric conditions and their corresponding codes are listed below:

Direct Sunlight	_ 0 _ _
Cloud shadow, haze	_ 1 _ _
Object shadow, haze	_ 2 _ _
Sunlight, haze	_ 5 _ _
Cloud shadow, haze	_ 6 _ _
Object shadow, haze	_ 7 _ _
(Additional numerals for code growth)	

4.6.3 Subject Surround Type

The third digit describes the surround of the area for which a density is to be taken.

Description	Code
Urban	_ _ 0 _
Industrial	_ _ 1 _
Airport	_ _ 2 _
Agriculture	_ _ 3 _
Mountain	_ _ 4 _
Forest	_ _ 5 _
Lowlands	_ _ 6 _
Valley	_ _ 7 _
Desert	_ _ 8 _
Coastal Area	_ _ 9 _

4.6.4 Subject Type

The fourth digit describes the area for which a density reading is to be taken.

Description	Code
*Digit three sufficient	_ _ _ 0
Sparce Vegetation	_ _ _ 1
Heavy Vegetation	_ _ _ 2
Water	_ _ _ 3
Snow and Ice	_ _ _ 4
Clouds	_ _ _ 5
Sand, Gravel	_ _ _ 6
Concrete	_ _ _ 7
Buildings	_ _ _ 8
Additional space	_ _ _ 9

*Subject surround type code sufficiently explains subject type code "0".

4.7 Duplicate Data

This section has four subdivisions that contain information concerning printing data for duplication of the original. Data is punched on only one card per part. The information will be used to aid in testing automatic exposure control printer formulae and to assess duplicate excellence in general. The subdivisions are listed below.

4.7.1 Density Data

The minimum and maximum densities used to calculate the printing exposure level are listed by multiplying the densities by 100 and truncating the products to 2 digits.

4.7.2 Printing exposure Level

The printer attenuator density (2 digit mantissa) multiplied by 100 and trancated to 2 digits is listed.

4.7.3 Duplicate Excellence

A measure of excellence, not yet agreed upon in form, will be recorded. One digit will be alloted for this quantity.

4.7.4 Acceptability Range

This measure will be used with the duplicate excellence measure to determine the limits of printer exposure about a level which produces the most excellent print. The limits are expressed as the log attenuation to the source multiplied by 10 and one digit is provided for each limit.

4.8 Fog Level

This card section is provided for radiation and process level studies. A three-digit space is provided.

4.9 Negative Density Data

This section is primarily used with the Object Data Section to select particular types of scene densities. A secondary use is the statistical examination of the processing of the original negative material. This section is divided into three subsections listed below.

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4.9.1 Density Type

Currently, densities are classified in five categories:

Category	Code
Minimum Detail Density	0
Maximum Detail Density	1
Special Interest Density	2
Absolute Minimum Density	3
Absolute Maximum Density	4

A two-digit space is provided which allows for 100 classification types.

4.9.2 Density Value

The optical density of the specified subject multiplied by 100 is listed and three digits are provided for the data.

4.9.3 Process Level

The data are intended for use primarily with three condition processes. This information is necessary in computing scene brightness and process evaluation data. The three condition processes and their respective codes are as follows:

Process	Code
Primary	0
Intermediate	1
Full	2

4.10 Camera Lens Data

This section provides a six digit space for a transmission factor which includes information on lens, vehicle window (if any), and filters. The data are used in scene brightness computations.

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4.11 Exposure Time

Exposure time is expressed in milliseconds and four-digit, one-decimal space is provided. This information is required for scene brightness computations.

4.12 Solar Altitude

Solar altitude is recorded in degrees and a three-digit, one-decimal space is provided.

4.13 Scene Brightness

Scene brightness in apparent foot lamberts is computed from object data, density type, density, process level, camera lens data, and exposure time data. A six-digit space is provided for this quantity.

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5. SCENE BRIGHTNESS PROGRAMS

Two computer programs were written to calculate and present scene brightness information. The first program computes the scene brightness in apparent foot lamberts from the data contained on master data cards. The second program performs various statistical calculations on the output of the first program and presents the data in a set of tables numerically arranged according to sun angle.

5.1 Brightness Calculations

The card output format for this program is the same as the master data deck, except that scene brightness is added. The description of this value as stored on the card is discussed in the Master Data Card Section. When this card deck is generated, it supercedes the old master data deck.

The computation of scene brightness requires information in addition to that stored on the original data card. This information is log exposure values that correspond to particular densities at the several processing levels. Density-log exposure curves are stored in the computer program as several sets of tables - one set for each level of processing and each sensitized material used to obtain the original negative. The process level code number on the card calls in the appropriate curve data for the density listed on each separate card.

A sample of the listed output for a typical deck is shown in Figure 2.

5.2 Statistical Program for Scene Brightness Information

This program uses the output from brightness calculations to compute the mean, standard deviation, and maximum and minimum values for the minimum brightness, maximum brightness, and brightness range at each sun angle for which there is sufficient data.

The program parameters may be changed readily to generate information for 3000 scene brightness categories.

Example of program output is illustrated in Figure 5 3.

6. PROCESS EXPOSURE EVALUATION PROGRAM

This program computes the minimum and maximum density, means, and standard deviations for each processing level performed on the original negative material. The program is intended to aid in an evaluation of processing with regard to process level selection; i.e., primary, intermediate, or full. In addition, the program can indicate to some extent the correctness of original exposure, since the process can be "subtracted-out." A sample of the program output is illustrated in Figure 4.

7. CONCLUSIONS

Considerable man-hours can be saved by using the punch card system in the Scene Brightness Program. In the past, approximately five man-days (40 hours) were required to reduce 2400 pieces of data by hand. Using the system described in this report, the same number of data (2400 pieces) can be reduced on the IBM 1620 Computer in about fifty minutes.

Firm conclusions concerning scene brightness levels at various sun angles have not been reached since the data collected are still too small to allow a conclusion.

The data collection and processing procedures were "de-bugged" and several operators were trained to obtain the data by the rules described in this report.

The effectiveness of the Process Exposure Evaluation Program is now under study. Correlation between the photographic result and the numerical output of the program has not been completed.

PART B

Color Processing

1. RAGDOLL

A Kodachrome type process was established on the Ragdoll processor at a machine speed of three feet per minute. This processor is the only one in existence that is capable of handling widths greater than 35mm. Whereas the simplier Ektachrome process develops the couplers already in the film in a single step, in the Kodachrome process (the most complex in commercial use), reaction of the dye forming couplers takes place selectively, layer by layer. As a result, the reaction rate controlled by time, temperature, agitation and chemistry is very critical during the first five stages of the process.

Development work on this system has been underway for some time, but the decision to run practical tests of this type film in the "G" Program drastically changed the urgency of this activity. Control of the process proved to be a major problem because of the number of variables involved. After a long shakedown, the principle causes of erratic behavior were discovered and corrected to a reasonable degree. Mechanical changes to further improve the operation are in progress.

Information received before the first "G" color mission indicated that the film would be considerably overexposed. An intensive effort was made to reduce film speed by changing the process and a 0.30 log E reduction was achieved for the process. Image quality of the test material, although not equal to that obtained with High Definition Aerial Film Type 4404, was judged remarkedly good. Evaluation of the photography indicated that the material, because of its short latitude would have been hardly usable had the process not been modified to compensate for incorrect exposure.

Duplicate copies were produced using another experimental Kodachrome type color product. The Ragdoll processor was modified to provide removal of the rem-jet backing on this product.

The further increase in exposure planned for the second "G" test required additional testing to determine what further process modifications could be made. These efforts were only partially successful and the test was processed at conditions similar to the previous one. Because of problems elsewhere, no usable photography was obtained.

Despite its complexity, the Kodachrome process was originally selected because the highest definition taking color film that the Company Research Labdratory could produce was a Kodachrome type material. Since that time, an Ektachrome type taking film having similar definition is under development. Samples should be available for flight tests during the coming quarter. In the foreseeable future, however, it appears that only the Kodachrome type films will be satisfactory for duplicating this quality level. For this reason, further development of this process appears to be justified.

2. GRAFTON

An Ektachrome type process was established on the Grafton processor at 4.5 feet per minute with considerably less difficulty. An experimental high temperature process (100 F) was chosen to achieve reasonable machine speed.

Fabrication of the experimental processor was just completed when the color Brass Knob mission was flown. Maximum effort was put on the Grafton to deliver the original and duplicates within a reasonable time. Color quality was the best to date for high altitude photography, but image quality was not equal to expectations. During the end of the quarter, preliminary tests were conducted on the Grafton to determine specifications for an improved definition taking film. Assuming reasonable success, samples will be available for flight tests in the near future.

PART C

Photography

1. Night Photography

Laboratory tests indicated that the exposure required for night photography could be reduced if a uniform exposure was applied simultaneously with image exposure. A breadboard device was fabricated for a small hand-held camera and actual flight tests were conducted to evaluate the practical advantage of this technique. A report is being prepared.

2. Flight Testing

Fabrication of the control circuit and mounting brackets for the pair of Maurer Model P-222 (KB-8A) Cameras for the high altitude research vehicle should be completed during the next quarter. This system will provide a means of acquiring photography that simulates the C and G systems. Tests planned for the 3rd and 4th quarters, principally in the areas of exposure determination and color, will be postponed unless additional funds are available.

1	1006	143	4060	0	126	1	11780.	7.6	19.0	692.
1	1006	143	4090	1	160	1	11780.	7.6	19.0	977.
0	0047	51	4060	0	70	2	11780.	3.2	20.0	570.
0	0047	51	4044	1	200	2	11780.	3.2	20.0	2666.
1	0044	48	4050	0	82	2	11780.	4.6	20.0	455.
1	0044	48	4064	1	222	2	11780.	4.6	20.0	2873.
1	0044	52	4060	0	87	2	11780.	4.6	20.0	476.
1	0044	52	4064	1	180	2	11780.	4.6	20.0	1375.
1	0030	50	4060	0	140	2	11780.	4.5	21.0	887.
1	0030	50	4064	1	225	2	11780.	4.5	21.0	3147.
1	0047	55	4063	0	87	2	11780.	6.1	21.0	359.
1	0047	55	4064	1	206	2	11780.	6.1	21.0	1533.
1	1006	135	4060	0	106	1	11780.	7.6	21.0	562.
1	1006	135	4090	1	144	1	11780.	7.6	21.0	832.
1	0047	58	4063	0	78	2	11780.	6.0	22.0	341.
1	0047	58	4064	1	186	2	11780.	6.0	22.0	1129.
1	0001	23	4053	0	90	2	11780.	4.9	25.0	468.
1	0001	23	4093	1	118	2	11780.	4.9	25.0	647.
1	0033	36	4063	0	166	2	11780.	4.3	25.0	1252.
1	0033	36	4064	1	240	2	11780.	4.3	25.0	6422.
0	0001	24	4030	1	113	2	11780.	4.7	26.0	615.
0	0001	24	4093	0	79	2	11780.	4.7	26.0	435.
1	0033	47	4063	0	98	2	11780.	4.2	26.0	599.
1	0033	47	4064	1	232	2	11780.	4.2	26.0	4344.
0	0001	31	4693	0	176	2	11780.	4.6	27.0	1283.
0	0001	31	4064	1	224	2	11780.	4.6	27.0	3078.
0	0001	33	4693	0	135	2	11780.	4.6	27.0	809.
0	0001	33	4064	1	224	2	11780.	4.6	27.0	3078.
0	0001	35	4063	0	175	2	11780.	4.6	27.0	1254.
0	0001	35	4044	1	244	2	11780.	4.6	27.0	6098.
0	0001	37	4044	1	227	2	11780.	4.6	27.0	3223.
0	0001	37	4063	0	179	2	11780.	4.6	27.0	1313.
0	0033	44	4093	0	150	1	11780.	4.3	27.0	1540.
0	0033	44	4064	1	220	1	11780.	4.3	27.0	4243.
0	0001	39	4044	0	202	2	11780.	4.5	28.0	1940.
0	0001	39	4044	1	223	2	11780.	4.5	28.0	2937.
0	0001	41	4063	0	190	2	11780.	4.5	28.0	1614.
0	0001	41	4044	1	225	2	11780.	4.5	28.0	3147.
0	0033	52	4093	0	110	1	11780.	4.2	28.0	1066.
0	0033	52	4064	1	215	1	11780.	4.2	28.0	3697.
0	3004	2	4693	0	136	1	11780.	2.4	29.0	2403.
0	3004	2	4064	1	224	1	11780.	2.4	29.0	8529.
0	3004	4	4093	0	114	1	11780.	2.4	29.0	1954.
0	3004	4	4064	1	224	1	11780.	2.4	29.0	8529.
0	3004	6	4093	0	67	1	11780.	2.4	29.0	1177.
0	3004	6	4064	1	224	1	11780.	2.4	29.0	8529.
0	3004	8	4093	0	72	1	11780.	2.4	29.0	1261.
0	3004	8	4064	1	222	1	11780.	2.4	29.0	7960.
0	3004	10	4193	0	65	1	11780.	4.3	29.0	657.
0	3004	10	4064	1	226	1	11780.	4.3	29.0	5101.
0	3004	12	4093	0	73	1	11780.	4.3	29.0	704.
0	3004	12	4064	1	218	1	11780.	4.3	29.0	3959.
0	3004	14	4093	0	108	1	11780.	4.3	29.0	1017.
0	3004	14	4064	1	224	1	11780.	4.3	29.0	4760.
0	3004	18	4093	0	158	1	11780.	4.3	30.0	1689.
0	3004	18	4064	1	224	1	11780.	4.3	30.0	4760.

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Illustration 4

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MEAN PLUS 2 SIGMA	1674.	4560.	3996.
MEAN MINUS 2 SIGMA	26.	-1281.	-1719.
MAX.X	1748.	6347.	4599.
MIN.X	500.	845.	288.
SUM.X	935700.E-02	213090.E-01	910900.E-02
SUM.X SQUARES	965588.E+01	605258.E+02	246646.E+02
SUM.X SQUARED	875534.E+02	454073.E+03	829738.E+02

35.0 H

	YMIN	YMAX	YDELTA
OBSERVATIONS	22.	20.	14.
MEAN	1142.	1540.	573.
VARIANCE	500014.E-00	602256.E-00	457621.E-00
STD.DEV.	707.	776.	676.
MEAN PLUS 2 SIGMA	2556.	3092.	1926.
MEAN MINUS 2 SIGMA	-271.	-11.	-779.
MAX.X	3142.	3436.	2811.
MIN.X	520.	751.	158.
SUM.X	251350.E-01	308100.E-01	803500.E-02
SUM.X SQUARES	392170.E+02	589056.E+02	105605.E+02
SUM.X SQUARED	631767.E+03	949254.E+03	645611.E+02

36.0 H

	YMIN	YMAX	YDELTA
OBSERVATIONS	17.	24.	16.
MEAN	1058.	1598.	371.
VARIANCE	184571.E-00	874592.E-00	792412.E-01
STD.DEV.	429.	935.	281.
MEAN PLUS 2 SIGMA	1917.	3468.	934.
MEAN MINUS 2 SIGMA	198.	-272.	-191.
MAX.X	2108.	4853.	1310.
MIN.X	549.	693.	76.
SUM.X	179890.E-01	383540.E-01	594900.E-02
SUM.X SQUARES	219886.E+02	814085.E+02	340052.E+01
SUM.X SQUARED	323603.E+03	147102.E+04	353905.E+02

37.0 H

	YMIN	YMAX	YDELTA
OBSERVATIONS	23.	27.	14.
MEAN	1036.	1528.	627.
VARIANCE	177237.E-00	520333.E-00	767025.E-00
STD.DEV.	420.	721.	875.
MEAN PLUS 2 SIGMA	1878.	2971.	2378.
MEAN MINUS 2 SIGMA	194.	85.	-1124.
MAX.X	1637.	4019.	3411.
MIN.X	334.	637.	89.
SUM.X	238420.E-01	412700.E-01	877800.E-02
SUM.X SQUARES	286140.E+02	766106.E+02	154751.E+02
SUM.X SQUARED	568440.E+03	170321.E+04	770532.E+02

38.0 H

	YMIN	YMAX	YDELTA

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Minimum Density

Intermediate Process — MIN. X — Full Process
Primary Process
Total of all three process

	COND. 1	COND. 2	COND. 3	LUMPED
		Density Times 100		
OBSERVATIONS	10.	40.	87.	137.
MEAN	83.	99.	88.	91.
STD. DEV.	23.	23.	24.	24.
MEAN PLUS 2 SIGMA	130.	147.	138.	140.
MEAN MINUS 2 SIGMA	36.	51.	38.	41.

Maximum Density

MAX. X

	COND. 1	COND. 2	COND. 3	LUMPED
OBSERVATIONS	13.	42.	101.	156.
MEAN	123.	128.	132.	130.
STD. DEV.	38.	25.	30.	29.
MEAN PLUS 2 SIGMA	199.	179.	193.	190.
MEAN MINUS 2 SIGMA	46.	77.	72.	71.

ILLUSTRATION #4