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TECHNICAL NOTE

INSTRUMENTATION AND STANDARDS SUPPORT

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[redacted] STAT

November 25, 1963

by

[redacted] STAT

[redacted] STAT

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Declassified in Part - Sanitized Copy Approved for Release 2012/10/18 : CIA-RDP79B00873A000800010044-8

TABLE OF CONTENTS

Declassified in Part - Sanitized Copy Approved for Release 2012/10/18 : CIA-RDP79B00873A000800010044-8

Declassified in Part - Sanitized Copy Approved for Release 2012/10/18 : CIA-RDP79B00873A000800010044-8

SECTION I

INTRODUCTION

The purpose of this report is to explain the instrumentation and standards support program required to adequately control the production, testing, and quality evaluation functions.

The program is most easily explained by means of the system flow diagram of Figure 1. A detailed explanation of the diagram is given in Section III of this report. This is a flow diagram for the products of the system. The products consist of processed original film, duplicates in several generations of the original film, reports giving mission performance in terms of information derived from the film, plus a compilation of other data furnished for each particular mission.

There has been a continuous upgrading of environment, equipments, and procedures to better the product of this system. The flow diagram represents the system as it will be by the end of 1964.

The measurements necessary to support the flow diagram fall into the following general categories: temperature, light, distance, flow, pressure, humidity, dust, plus a category that can be classified as chemical measurement. This latter category consists of all measurements necessary to support the photo processing operation and will be handled as a separate report. The above mentioned measurements are primary measurements and do not include the measurement equipment required to maintain the instrumentation. Maintenance

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of the instrumentation is to be considered separately from the procedures required for calibration of instrumentation.

Following is a table showing the seven most important measurables for quality control and evaluation, which require measurement procedures and calibration standards.

The upper row is the quantity to be measured. The second row is the type of instrumentation on which the measurement is carried out. The third row is the type of standard required and the quality required (primary, secondary, etc.). The fourth row is the source of reference for the standards.

It is planned to have standards for all measurements in sufficient quantities that a constant cross comparison can be made with a number of users to assure the required order of accuracy for all measurements. The standards will be designated as primary standards when certified by the Bureau of Standards. They will be designated as secondary when they have been compared against a primary standard by [redacted] and certified as a secondary standard with accuracy values included for each. Standards of special nature, for which no primary standard is available, will be calibrated by means of suitable instrumentation against a primary standard. This will then be known as a master standard and will be so certified by [redacted] Secondary masters will be those whose calibrations have been established by comparison against the master standard.

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INSTRUMENTATION DESCRIPTION AND MEASUREMENT ACCURACY REQUIREMENTS. The instrumentation with the most immediate requirements for standards and calibrating procedures fall in the following categories:

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Declassified in Part - Sanitized Copy Approved for Release 2012/10/18 : CIA-RDP79B00873A000800010044-8

Measurement Objective	Displacement or Distance	Resolution	Density	Light	Temperature	Humidity	Dust
Instrumentation Used	Microscopes Microcomparators Measurement Tables	Microscopes Micro-Analyzers	Densitometer Micro-Analyzers Microdensitometers	Photometer Micro-Analyzer Spectrophotometer Sensitometer Radiometer	Thermometers Thermocouples	Hygrometers	Dust Counters
Standards Req'd	Master Scales Master Grids Secondary Scales Secondary Grids	Master Scales Master Grids Secondary Scales Secondary Grids	Primary Light Std Primary Density Std Secondary Density Std	Primary Light Std Calibrated Trans-mission Std Calibrated Narrow band Filter Std	Master Thermometers	Dew Point Detectors Master Thermometer	Ionization Type Dust Counter
Type of Standardization Master Source	Bureau Standards Direct Comparison	Bureau Standards Direct Compari-son	Bureau Standards Light Source Density by trans-mission Calibration	Bureau Standards Light Source Calibration by Spectrophotometer Comparison	Bureau Standards Direct Compari-son	Direct deter-mination Dew Point	Calibration by Microscopic Analysis

Declassified in Part - Sanitized Copy Approved for Release 2012/10/18 : CIA-RDP79B00873A000800010044-8

Declassified in Part - Sanitized Copy Approved for Release 2012/10/18 : CIA-RDP79B00873A000800010044-8

1. Linear measurement devices including measuring microscopes, microcomparators, image quality evaluation tables, and automatic scanning micro-analyzers. The measurement accuracies for these instruments fall in one of the following five categories:

	RANGE	ACCURACY OF MEASUREMENT
a.	0 to 500 μ	± .2 μ
b.	0 to 10 mm	± 1 μ
c.	0 to 250 mm	± 1 μ
d.	0 to 2 meters	± 5 μ
e.	0 to 250 mm	± .1 μ

2. Density reading devices, including densitometers, microdensitometers, micro-analyzers, plus automatic recording densitometers. The standards required for these instruments are as follows:

a. Master step wedges with densities of 0 to 3.0 steps of approximately .15± .01 density and calibration accuracy to .001 density or .1%, whichever is larger. Density to be calibrated in terms of diffuse density and no step to have a greater density deviation over its area when read with a 5 micron spot than that specified by the tolerance. Secondary master step wedges with accuracy values of .05 density or .5%, whichever is larger.

b. Master step wedges with density range of 0 to 5. Steps to be .25 ± .02 and calibration accuracy to .001 or .1% whichever is larger. Density to be calibrated in terms of diffuse density and no step to have a greater density deviation over its area when read with a 25 micron spot than that specified by the tolerance. Secondary master step wedges as above, but with accuracy

Declassified in Part - Sanitized Copy Approved for Release 2012/10/18 : CIA-RDP79B00873A000800010044-8

Declassified in Part - Sanitized Copy Approved for Release 2012/10/18 : CIA-RDP79B00873A000800010044-8

values to .05 or .5% whichever is larger.

c. Master step wedges 0 to 3.0 same as paragraph "a" with the exception that the total size shall not exceed 2 mm x 20 mm.

d. Secondary master step wedges 0 to 3.0, 2 mm x 20 mm with tolerances as specified for secondary masters in paragraph "a" above. The secondary masters must be made of the same film materials as the original taking materials and duplicating materials, and process control must be such as to cause no difference in diffuse reading characteristics from those of the original or duplication materials.

e. Master set of specular density plates steps of .1, calibration accuracy .1%, range 0 to 5, plates to be neutral density as nearly as possible.

f. Secondary master set of specular density plates, steps of .1 calibration accuracy .5%, range 0 to 5, plates to be neutral density as nearly as possible.

g. Master set of color plates, specifications will be prepared for these in the near future.

3. Light measurement devices plus light emanating devices including sensitometers, spectro sensitometers, photometers, radiometers, micro-analyzers, and spectrophotometers. The standards for this class of instrumentation will consist of Bureau of Standards light sources plus standardized filter masters permitting illumination of known spectral characteristics and radiation energy content over the entire visible light band and future extension into the far infrared and ultraviolet regions. A light standards laboratory at

Declassified in Part - Sanitized Copy Approved for Release 2012/10/18 : CIA-RDP79B00873A000800010044-8

Declassified in Part - Sanitized Copy Approved for Release 2012/10/18 : CIA-RDP79B00873A000800010044-8

[redacted] will maintain calibrated sources to cover specific color plus energy ranges for secondary calibration reference standards. It is planned to meet with the Bureau of Standards to discuss the possibility of establishing primary standards for such sources. STAT

The calibration of special targets for resolution testing, etc., requires combinations of the above mentioned standards, measurements of density, linear distance, and possibly transmission are required to calibrate such devices. They will necessarily come under the category of master plus secondary master standards, since their calibration will be by comparison with primary standards. A calibration laboratory at [redacted] will maintain calibration and certification of such targets. STAT

The remaining measurables of temperature, pressure, humidity, flow and dust are not particularly problem areas with the exception of dust. The accuracy requirements for calibrating flow, temperature, pressure, and humidity are easily satisfied by commercial equipment and require no special procedures or techniques. The standardization of dust counters, however, is a complex problem which has no satisfactory answers to date. [redacted] STAT is working on an ionization type counter which contains a self-calibration feature. It is felt that this is more satisfactory than existing smoke tests, spot tests, etc., because it calibrates in terms of the type of dust in the location in which it is used. If a high order of accuracy is demanded, the calibration sample can actually be microscopically counted, or particle analysis may be carried out.

Declassified in Part - Sanitized Copy Approved for Release 2012/10/18 : CIA-RDP79B00873A000800010044-8

Declassified in Part - Sanitized Copy Approved for Release 2012/10/18 : CIA-RDP79B00873A000800010044-8

SECTION II

PROGRAM STATUS - INSTRUMENTATION AND STANDARDS

Standards for immediate use are available for linear measurement calibration involving distances less than 5 centimeters. Certification of these standards as secondary standards will not be accomplished until procurement of suitable primary standards certified by the Bureau of Standards. Specifications for these standards are completed. Standards for certification of linear measurements greater than 5 centimeters remain to be procured. Specifications for these standards are being prepared.

Density standards for micro-analyzer and microdensitometer calibration are currently being made. Calibration for immediate use will be by Densichron comparison against transmission calibrated neutral density filters. Meetings are to be held with Bureau of Standards to determine if they will certify density filters as standards rather than reference such standards against certified light sources. The basic problem to be resolved is that present certified light sources are approximately 3% accurate, whereas comparison means exist using radiant energy thermopiles which are capable of measuring light reduction to .1%. It would, therefore, be desirable to standardize neutral density filters against a precise light standard to permit density standard calibration accuracy to the same magnitude of accuracy.

Light standards are currently available at [redacted] together STAT
with suitable instrumentation such as integrating spheres, Hilger Watts spectro-

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photometer, and considerable special instrumentation for permitting standardization of light sources as secondary standards.

HIGH ACCURACY LINEAR MEASUREMENT SYSTEM

Linear measurement of photographic images by means of the Micro-Analyzer permits a calibration technique not available to normal measurement devices. This technique is an "on-the-fly" measurement. One basic error in all measuring devices is the ability to set and read a dial when the comparison reticle or center finder is at the precise measurement point. The error involved is caused by oil film thickness and static friction on the read-out mechanism. It has been shown that the repeatability of the finest microcomparator is in the order of one micron. This is realized under ideal conditions with a highly skilled operator. A test was made with a Micro-Analyzer using a quartz measurement reference standard as a reference indicator to see how precisely the measurement of a 1 centimeter bar space could be repeated by scanning "on-the-fly" and measuring on the chart recorder the repeatability of the scan test. The results showed the repeatability was higher than .1 micron. This is an order of magnitude greater than can be realized by reading out and hand setting on the same device.

The technique of measurement "on-the-fly" could be considerably improved by using a pressure lubricated driving nut with temperature controlled constant flow lubrication. It is believed that with these special provisions plus a systematic error analysis correction, that absolute displacement measurements of film images can be made to an accuracy of .1 micron. The systematic error correction would be programmed through the IBM 1620 now located at the

Declassified in Part - Sanitized Copy Approved for Release 2012/10/18 : CIA-RDP79B00873A000800010044-8

Declassified in Part - Sanitized Copy Approved for Release 2012/10/18 : CIA-RDP79B00873A000800010044-8

6594th Test Squadron.

Procurement of this machine has been initiated and delivery is anticipated in August of 1964.

The instrument is essentially a Micro-Analyzer in optical capability corresponding to that of the existing machine. Automatic scanning will be on the x acis only; however, manual scan to 1 micron accuracy will be furnished on the y axis. Film 9-1/2" on rolls can be automatically scanned on the x axis over a 250 mm length. Y scan in manual mode will be approximately 70 mm; however, the 9-1/2" width film can be repositioned to permit scanning on any portion.

The basic purpose of this instrument is twofold. It will provide a test bed for the high accuracy measuring capability as well as being an extremely accurate sensor for density analysis. Edge positioned step wedges can be read on automatic scan with a density data digitizer and the output transmitted directly to the data processing center.

MEASUREMENT OPTICS

Procurement of high quality four color corrected lenses for four new quality evaluation tables has been completed. 4 power, 10 power, and 25 power lenses have been obtained. The 8x and 16x eyepieces with micrometer screw readout are on order. Fine focus microscope bodies for the lens are being investigated.

Declassified in Part - Sanitized Copy Approved for Release 2012/10/18 : CIA-RDP79B00873A000800010044-8

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SECTION III

METHODS AND EQUIPMENT USED IN ANALYSIS

Figure 1 illustrates the desired flow pattern for production testing and evaluation to be achieved within the next two year period. Blocks shown in red are the main product flow of the system.

The sections following give a detailed description of the anticipated functions to be performed at each step of the diagram and the equipments on which the function shall be performed. The pattern of the system is so arranged that the adoption of each step can be preceded by a parallel operation of the new equipments to prove function and reliability as a permanent block in the system. Blocks shown in green are anticipated as completely automated steps for data evaluation while the others shown in blue may have semi-automatic instrumentation to perform routine tasks, but will require trained personnel to assure performance of the outlined functions. Future developments will be pointed toward the optimizing of automated procedures for the remaining blocks of the system.

It is necessary to establish calibration procedures for the equipments now used and those currently anticipated to maintain the accuracy to perform their required function. The standards control program detailed in Section I is an outline of the calibration standards control to be used in conjunction with the system flow diagram of Figure 1. Complete specifications for each of the standards will be written, and their use as cross control standards with other organizations is anticipated.

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The description of the flow diagram which follows will be keyed to the diagram of Figure 1 to give the reader the continuity of the overall system.

Red Block Path - Flow Path of "Product"

First Block: This block is the unexposed film to be used on a mission. This film requires two operations to permit the maximum benefit for later evaluation. The first operation is that it have exposed on an edge or other position where it will not interfere with the imagery an accurately controlled sensitometric exposure. These exposures should be at least every 50 feet. The size of the complete sensitometric strip need not be larger than 2 x 10 mm. The second operation for block 1 is to procure unexposed samples of film for later sensitometric evaluation. This film must be stored and handled under carefully controlled conditions to permit meaningful analysis at the testing location.

Second Block: This block represents the film after exposure on the mission. The only requirement at this point is to secure unexposed film from the trailer and leader from which to make sensitometric evaluations to compare with those obtained from block 1.

Third Block: This block represents the processing of the exposed film. The information required at this step will come from two sources. The first source will be external to the organization and will give the type of film, exposure data, mission data, and any incidental or abnormal situations which may affect processing. The second source will be internal to the organization and will be derived from the sensitometric analysis of the two groups of film samples obtained in blocks 1 and 2.

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The information from these samples will divulge any circumstances during the mission which could alter the characteristics of the film. Analysis of differences will dictate corrections for processing.

It will be noted that information is shown leaving the block during processing. This is information gathered from imagery and sensitometric strips when stepped development processing is used permitting preliminary evaluation before final development is completed.

Fourth Block: This block represents the original processed film from which it is necessary to obtain density information for duplication purposes and, in certain specific cases, image quality information which may be required to assure duplication quality. If additional generations of duplication material are made beyond first generation duplicates, they are inserted at this point.

Fifth Block: This block represents the duplication process. Control for the printing and processing is derived from the processed data gathered from block 4. The duplicates from this block represent the end product of the system. One set is used for the detailed quality evaluation, the other sets are sent to inspection.

Sixth Block: This block represents the final inspection of the product to assure the reproduction accuracy of the original material. After this inspection, material is packed and shipped to using agency.

Detailed Description of Sub-block Flows:

1A through 1E: The flow line from block 1 leads to blocks 1A, 1B, 1C, 1D, and 1E. This flow line prepares film samples for sensitometric testing at 1A. The strip is exposed at 1B, processed at 1C, information is read out

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at 1D and transferred to 3B as a part of the overall sensitometric evaluation. Fade and chemical testing takes place at 1E, and the results are entered in the final report.

2A through 2E: This flow line is identical to 1A through 1E. The only difference is that post-mission unexposed film is used instead of the previously mentioned pre-mission film used in 1A through 1E.

3A, 3B: These blocks represent the processing of data derived from the flow lines of blocks 1 and 2. The data is processed in 3B. The control constants derived from the processing are available at 3A at which point they determine and/or control the processing constants for the original material processing.

3C: Block 3C shows information flow derived from the material of block 3 during stepped processing procedures. This information consists of transmission data of the imagery or sensitometric wedges as read with infrared at various stages of development. While this data is important for the completion of the processing, it is also valuable in subsequent steps for final product assessment and reporting. Information from block 4 is derived from the sensitometric exposure of block A.

4A: This block is the data tabulation block for two main areas. Measurements are made and recorded which are indicative of the quality of the original material, and measurements are made and transferred to block 5A for control of duplication processing.

5A: This block determines and/or controls the printing and processing constants for the duplication of the original negatives or for additional duplicates

Declassified in Part - Sanitized Copy Approved for Release 2012/10/18 : CIA-RDP79B00873A000800010044-8

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which may be added at block 4. It uses information obtained from the sensitometric characteristics evaluation of block 3B and block 3C.

5B: At this point determination of the mission performance is made. No attempt is made to interpret what is recorded, but exacting measurement of how well it is recorded is extracted at this point. Direct comparison of first generation quality is made to assure duplication quality.

6A: The chemical and physical characteristics of representative samples of the final product are tested at this point to assure that the archival, dimensional, and quality characteristics required for the using agency are fulfilled. The report block is, of course, the compilation of the data for the product run. It includes sensitometric data, chemical data, and quality data for both original and duplicated materials. It also includes mission data pertinent to using agencies and final product data useful for specific evaluation of using agencies.

Declassified in Part - Sanitized Copy Approved for Release 2012/10/18 : CIA-RDP79B00873A000800010044-8

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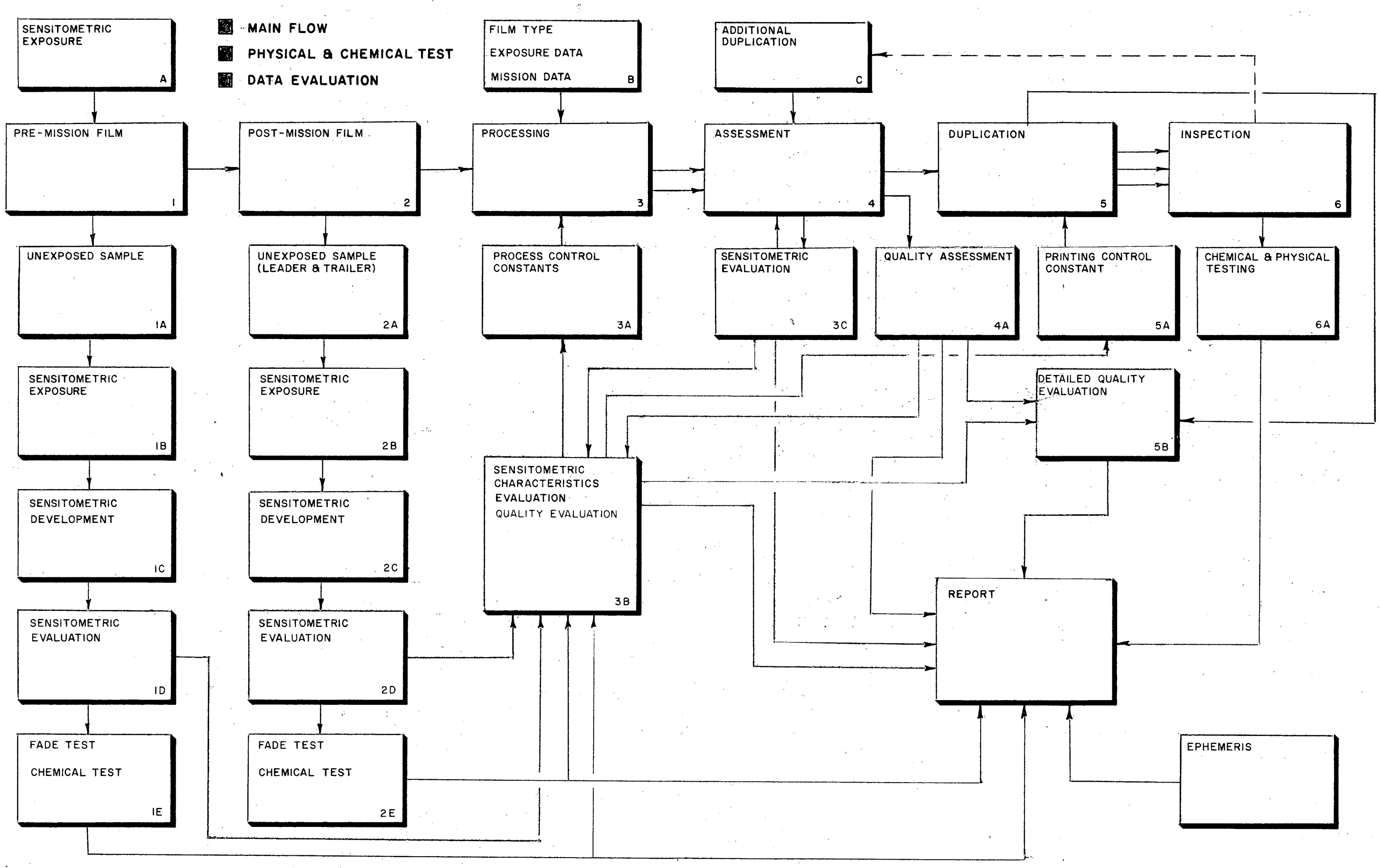
SYSTEM FLOW DIAGRAM



Declassified in Part - Sanitized Copy Approved for Release 2012/10/18 : CIA-RDP79B00873A000800010044-8

Declassified in Part - Sanitized Copy Approved for Release 2012/10/18 : CIA-RDP79B00873A000800010044-8

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Declassified in Part - Sanitized Copy Approved for Release 2012/10/18 : CIA-RDP79B00873A000800010044-8