AN OCCUPATIONAL ANALYSIS MODEL TO DETERMINE METRIC MEASUREMENT COMPETENCIES FOR PRE-SERVICE AND IN-SERVICE EDUCATION AS APPLIED TO THE GRAPHIC ARTS INDUSTRY

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ABSTRACT

AN OCCUPATIONAL ANALYSIS MODEL TO DETERMINE METRIC MEASUREMENT COMPETENCIES FOR PRE-SERVICE AND IN-SERVICE EDUCATION AS APPLIED TO THE GRAPHIC ARTS INDUSTRY

By

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The central purpose of this study was to develop an analysis model which could be used to determine projected SI (Système International d'Unités) metric measurement competencies for selected industrial occupations. The model was applied specifically to selected skilled trades of the printing industry to project metric content suitable for use in pre-service and in-service industrial education programs.

This analysis model focused on the following six major objectives:

1. Conduct an occupational analysis of an industry and subdivide its work force into appropriate comprehensive occupational titles;

2. Identify present customary measurement competencies needed in each selected occupation;

3. Identify corresponding SI metric measurement competencies needed in each selected occupation;
4. Establish the extent of commonality of customary and SI metric measures among selected occupational groups;
5. Identify necessary levels of competency for SI metric measures in each selected occupation, and
6. Recommend appropriate examples of performance objectives suitable for implementation of instructional activities.

The study was conducted within the state of Michigan during the summer of 1974 and involved nineteen occupational titles. Twelve participating plants provided a data source for ninety-one personal interviews by the researcher. This model, as developed and applied, classifies this study as developmental and descriptive.

Use of the following steps and procedures provided a systematic flow of information in building a seven matrix model structure: (1) a general review of literature and research, (2) identification of selected occupational titles for Matrix I, (3) construction of the analysis instrument detailing customary measurement activities, tools, and terms for Matrices II, III, and IV, (4) instrument validation, (5) identification of the study participants, (6) collection of the data,

(7) processing the data, (8) utilization of the remaining model components to complete the metric-related Matrices V-VII, (9) validation of the SI metric Matrix V, and (10) analysis and implications of the complete model application.

Additionally, four levels of metric competency were identified with regard to SI metric measures and these suggested an appropriate placement for each occupation. In a culminating sequence, examples of general and specific metric performance objectives were presented.

The following conclusions relating to the model structure and its general application were drawn:

1. The work force of an industry can be subdivided into appropriate occupational titles.

2. Measurement competencies can be analyzed and identified by isolating activities, tools, and terminologies in actual occupational settings.

3. An occupation may exhibit different responses across identical measurement competency headings: i.e. an occupation may use measurement terms involving power but use no power-related measuring tools or activities. The occurrence of such differences may prove valuable for directing the focus of future SI metric measurement training.

4. Differences and commonalities in the measurement needs of each occupation are readily identified by this analysis model. Such an analysis substantiates specific competencies and establishes the precise application of measurement under each job title.

5. Occupations can be clustered according to measurement needs and find common placement in coherent groups to receive SI metric training.

6. Upon establishment of the customary measurement competencies for an occupation, comparable SI metric equivalents can be determined.

7. Differentiated metric competency levels are identifiable, thus allowing specific occupational placement and accommodation of needs for each selected occupation or occupational grouping.

8. The inherent simplicity of the model structure as a means of fulfilling the six major analysis objectives has proven quite adequate in addressing a complicated problem: identification of industrial metrication education needs for adults.

As a vehicle for this initial metric model application, the graphic arts industry was used as a data source. The following conclusions are drawn as a product of this specific graphic arts industrial research and pertain to the nineteen occupations as researched in this study:

1. Pressmen, as a group, should receive an in-depth exposure to SI metrics as they exhibit the greatest need for occupational measurement.

2. Pasteup-copy preparation, imposition and lockup, and stripping occupations should require the least amount of SI metric training when compared to the other occupations researched in this study.

3. SI metric measures involving length and thickness, mass, temperature, area, volume, and pressure should receive strong emphasis in graphic arts metrication instructional programs for the occupations researched in this study.

4. SI metric measures including force, viscosity, density, and flow should receive isolated recognition and emphasis only where pertinent for a particular occupation.

5. For the graphic arts occupations studied, three levels of metric competency, as previously defined, are necessary to insure success in the transition between customary and SI metric measurement. These levels are the awareness level, the conceptual level, and the working level.

6. To fulfill the objectives of this analysis model, the factors which were used to identify the study participants in the printing industry proved quite satisfactory and provided a rational and operational data source.

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CHAPTER I

STATEMENT OF THE PROBLEM

Introduction

Documented throughout history is the persistent problem of man's need for accurate and uniform measurement. Internationally, no single system of measurement has ever been accorded universal acceptance. Today, however, over 90 percent of the world's population and 80 percent of its trade utilize the metric system of measurement.[1] The United States does not.

Changing a nation's predominant system of measurement can have profound effects. Economic, educational, and psychological implications most likely will cause disruptions and discomfort to all concerned. Hence, initial public opposition to such a wide-ranging decision is likely to occur. Past efforts to establish metric measurement and international standardization in the United States met with such opposition. Predictably both public and private attempts to bring about metrication in the U.S. have resulted in failure.

Private endorsement of a changeover to metric measurement within the United States is now, however, a

reality. In so doing, the United States will be the last major industrial nation to initiate such a move. Strong industrial commitments and direction during the past two years leave little doubt regarding the fact that metrication is upon us. The realities of planning for a constructive, efficient, and successful metric changeover are now of paramount importance.

Sporadic legislative efforts to bring about metrication in the United States are documented throughout the past century.[2] Many have failed to gain formal legislative acceptance for a variety of reasons. Legislation in the form of HR 11035, sponsored by Representative Olin Teague and others, was subjected to thorough House committee review.[3] Political events of the day, however, coupled with legislative inactivity, did not generate a favorable climate for rapid passage during 1974. Legislation during 1975 remains as yet an uncertainty.

As a consequence, private industry has now assumed a posture of direct involvement to help execute a reasonable transition from customary to metric measurement. Formation of the American National Metric Council by the American National Standards Institute has now provided the impetus for decisive coordination apart from governmental legislation.[4]

Public educational involvement and readiness are also becoming evident. In Michigan, for example, the State Board of Education has formally stated that all mathematics and science textbooks purchased after June 1976 shall contain SI (Système International d'Unités officially called SI) metric units as the dominant measurement system.[5] The impact of such a statement will touch many areas of concern within a school system.

Consumer awareness campaigns are also in evidence. Road signs, packaging, and weather reports in metric units are beginning to serve as preludes to the upcoming metric conversions.

The success of such a massive endeavor will depend in part upon meaningful conversion education programs for the adult population of the United States. Since adult needs relate initially to job performance, the role of industry looms as being vitally important in generating a tolerable conversion climate for the many adults long separated from formal educational settings.

Purpose and Objectives

The central purpose of this study is to develop a model which can be used to determine metrication competencies that are necessary for selected industrial occupations. This model focuses on the following major objectives:

1. Conduct an occupational analysis of an industry and subdivide its work force into appropriate comprehensive occupational titles;
2. Identify present customary measurement competencies needed in each selected occupation;
3. Identify corresponding SI metric measurement competencies needed in each selected occupation;
4. Establish the extent of commonality of customary and SI metric measures among selected occupational groups;
5. Identify necessary levels of attainment for SI metric competency in each selected occupation; and
6. Recommend appropriate examples of performance objectives suitable for implementation of instructional activities at predetermined levels of attainment.

Thus, the principle outcome of this study will comprise a model suitable for identifying specific training needs in metric conversion programs. This model will be applied to the graphic arts industry.

Importance

As the large industrial sectors begin to consider a metric measurement system, each sector must focus on

its own needs and training programs. To accommodate a meaningful transition, considerable foresight and planning for on-the-job measurement applications is necessary. In assessing the experiences of five foreign countries regarding industrial training the American Institute of Research cites two important factors in completing a successful conversion: (1) teach only what the individual occupation-related activities require for metric measurement and (2) coordinate on-the-job training in SI metrics to coincide with actual industrial implementation.[6]

Implied within the above factors are several key problems for which a meaningful and expeditious industrial metric conversion must search out solutions. The specifics of who, how much, to what extent, etc., all need immediate attention. An occupational analysis model for a particular industry detailing current occupational titles, customary measurement competencies, projected SI metric measurement competencies, and stratified levels of attainment could aid in providing cogent direction for addressing such industrial metrication training problems.

The graphic arts industry is a measurement-oriented industry. A large percentage of its occupations deal in some way with linear measure, volume, light intensities, pressure, weight, etc. in a rather precise manner. For a successful and meaningful metric

changeover, the individual worker must learn to internalize an entirely new measurement system. The problems inherent in such an undertaking cannot be minimized nor should they be over-inflated. The following may help illustrate the nature of this potential internalization problem as the various occupational roles begin to require the use of the metric measurement language.

The SI metric measurement system is a modern-day version of several older metric schemes. Adopted by the 11th General Conference of Weights and Measures in 1960, the SI metric system is now rapidly becoming a universal measurement language for over 90 percent of the world's population.[7] Seven base units form the foundation for the entire system: metre, kilogram, second, ampere, kelvin, mole, and candela. There are also two supplementary units; the radian, for measuring plane angles, and the steradian for measuring solid angles.

Numerous derived units may be expressed in terms of the base units; e.g. the derived unit of area originates from the square metre and is symbolized by m^2. The derived unit for force is the newton and is symbolized by N, with an accompanying formula m•kg•s (see Appendix A). Not only are unfamiliar numerical prefixes required--milli, kilo, centi, etc.--to add to the conceptual problem but a new style of writing numbers is now called for. No longer is the comma to be used as

a device for numerical separation. Hence, the number one million is now to be written as 1 000 000. Blank spaces will replace the use of commas. These and numerous other metric measurement changes, if not handled appropriately in occupational settings, most certainly form potential conversion roadblocks.

To change such a basic concept as measurement for an adult tradesman clearly dictates the need for an understanding regarding measurement use in each occupational title of an industry. The development of this occupational measurement analysis model, as applied herein to the graphic arts industry, could also be applied as an analysis device to any other appropriate manufacturing industry.

The inherent simplicity of such a model may also help ease metrication apprehensions by illustrating the practical nature of such an educational undertaking. The use of this model will provide a specific metric content base from which planned pre-service and in-service educational programs can be implemented.

Limitations of the Study

This study will be conducted within the following limitations:

1. Metric spellings such as metre and litre will conform to current international English spelling not yet formally adopted by the United States.

2. Measurement competencies for SI metric measurement will be inventoried for the skilled trades only in the specified major industry classifications of the graphic arts industry.

3. Measurement competencies for SI metric measurement will be determined for only the selected graphic arts occupational titles as delineated in this study.

4. The occupational titles used in this study will not reflect the possibility that one person may fill more than one occupational title; e.g. in a small establishment one person may perform a variety of jobs.

5. The measurement competencies determined by this study are to be considered independently of the persons involved in the occupational titles; e.g. a cameraman could also perform as a pressman but still exhibit a need for identical measurement competencies as compared to a counterpart who may perform in a singular job role on a full-time basis.

6. The uneven distribution of persons interviewed across the various occupational titles reflect the current status of declining numbers among

several traditional occupations and corresponding increases in contemporary phases of the graphic arts industry.

7. The performance objectives as set forth in this dissertation are provided strictly as discrete examples and are not intended to provide comprehensive coverage for all of the listed graphic arts SI metric measurement competencies.

Definition of Terms

Metric System.--For the purpose of this study "metric system" refers to the modernized metric system of measurement units, Système International d'Unités, commonly known as SI.

ISO.--The International Standards Organization functions strictly as an international standards writing body for SI metric measurement. The ISO issues agreed standards for materials, dimensions, and processes adopted by member countries as criteria for their industrial production.

ISO Standards.--The physical dimensions of manufactured items and artifacts agreed upon by the members of the ISO are internationally referred to as ISO Standards.

Major Industry Classification.--For the purpose of this study "major industry classification" refers to the type of production printing most predominant in a particular plant: e.g. newspaper, in-plant work, etc.

Skilled Occupations.--This includes nonmanagement production personnel related to the graphic reproduction processes, ranging from trainee to craftsman.

Printing Occupations.--Included here are occupational groups primarily concerned with reproducing data or designs by mechanical transfer of ink or dye to the surface of materials with the aid of type, plates, rolls, and similar mediums. Also included are occupations concerned with type and plate preparation as well as mechanical bookbinding.[8]

Graphic Arts.--Generally considered to be synonymous with the term "printing," this study shall interpret graphic arts to include all those occupations directly related to the production of printed materials; e.g. layout and design, lithographic strippers, etc. as well as the more commonplace occupational titles of platemaker, pressman etc.

Matrix.--For purposes of this study a matrix shall be defined as a two-dimensional table or group

of tables specifically designed to display common relationships of relevant model components.

Procedures

Use of the following steps and procedures provided a systematic flow of information in building the matrix structure:

1. A general review of pertinent literature and related research;

2. A review and identification of selected occupational titles providing data for Matrix I;

3. Construction of an analysis instrument containing appropriate customary measurement activities, tools, and terminologies utilized within the industry to provide data for Matrices II, III, and IV;

4. Validation of the instrument;

5. Identification of participating companies used in the generation of data;

6. Collection of data through interview and observation visitations;

7. Processing and tabulating the data;

8. Utilization of the remaining model components to complete the metric-related Matrices V-VII through data analysis;

9. Validation of the SI metric matrix by appropriate metric organizations;

10. An analysis of the complete model and its implications for future use.

Model Components

The following analysis model matrices were constructed and applied as the structural means of fulfilling the six major objectives of this study:

Matrix I. Who is involved?

"An inventory of occupational titles occurring in selected major industry classifications"

Matrix II. What is measured?

"An inventory of customary measurement activities occurring in selected occupational titles"

Matrix III. How is measurement accomplished?

"An inventory of the predominant customary measurement tools used by tradesmen in selected occupational titles"

Matrix IV. How is customary measurement communicated on the job?

"An inventory of customary measurement terminology occurring in selected occupational titles"

Matrix V. <u>How does measurement take place in the SI metric system</u>?

"An inventory of the projected SI metric measurement units needed in selected occupational titles"

Matrix VI. <u>What commonality exists</u>?

"A determination of the areas of commonality for customary and SI metric measurement-related competencies of selected occupational titles"

Matrix VII. <u>What are the projected training needs</u>?

"A determination of appropriate levels of attainment needed for selected occupational titles"

The above matrices derive their meaning from being linked to the six major objectives of this study (see Figure 1). Matrix I isolates and establishes the work force to be studied as called for in objective one. Matrices II, III, and IV address the second objective which calls for an identification of specific customary measurement competencies as utilized in the selected occupations. Utilizing predominately similar measurement headings in all three matrices; e.g. linear, temperature, weight, power, etc., these measurement

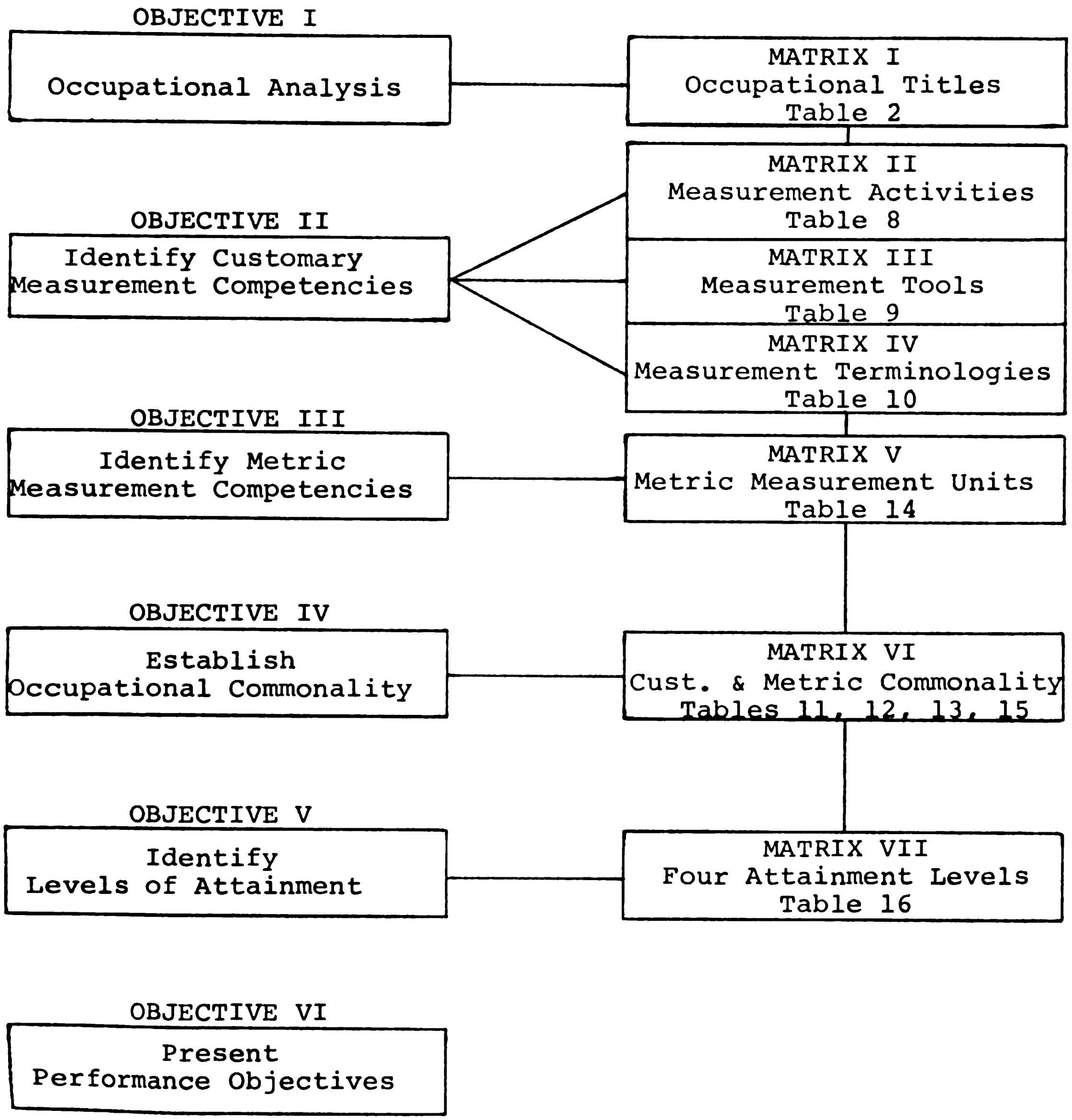

Fig. 1. A graphic presentation relating the six major objectives of the study to the seven analysis model matrices

competencies were subdivided into specific measuring activities, tools, and terms for each occupation under study.

Matrix V presents a unique display of SI metric measurement units and sub units specifically identified for the needs of the occupations in question. This matrix corresponds with objective three. A fourth objective, namely locating commonality among measurement-related competencies of the selected occupational groups, is fulfilled in Matrix VI. The final matrix, Matrix VII, indicates projected levels of attainment for SI metric competency as called for in the fifth major objective. The sixth objective which calls for recommended performance objective examples for implementation of instructional activities at the predetermined levels of attainment is fulfilled outside the formal matrix structure. Presented in Chapter V, these performance objective examples are exhibited as a culminating transitional step towards implementation of the complete model in an appropriate industrial climate.

Data Sources

For the purpose of developing this analysis model, occupational titles occurring in printing companies involved in the following selected major industry classifications were researched: (1) in-plant printers, (2) general commercial printers, (3) newspaper,

(4) trade plant operations, (5) business forms printing, and (6) packaging printing. Current industry statistics reflect that 76 percent of production printing occurs in the above classifications.[9] Since most graphic arts occupational titles; e.g. cameraman, web offset pressman, etc., are commonly defined across the United States and also show little variability across the major industry classifications, it was reasoned that a single geographical area such as the state of Michigan is a valid industrial source in which to apply this analysis model. Participating companies were arbitrarily chosen by the researcher to reflect a variety of the major industry classifications thus providing a straightforward systematic coverage of the current graphic arts industry.

Additional factors which were also applied in identifying industry participants included: (1) number of skilled personnel employed in specific occupations, (2) diversity and complexity of plant operations, (3) predominant method of production, (4) production volume, and (5) geographical location.

Data Collection

An extensive review of literature was conducted to ascertain the immediate parameters of the graphic arts industry. Since definitions of such an industry were numerous and often too comprehensive, a determination of boundaries was substantiated for this study.

Upon the establishment of a graphic arts industry operational definition, broad occupational titles were identified. Nineteen titles such as hot type compositor, black and white cameraman, etc. were identified and grouped into seven comprehensive groups completing Matrix I.

Determination of occupational titles within the major industry classification types thus enabled an occupational measurement analysis to be conducted. An appropriate survey instrument was constructed to identify measurement uses in on-the-job settings for the occupational groups. Validation of the instrument was done by a panel of experts. Minor modifications in the instrument design were made as a result of suggestions provided during the actual on-the-job interviews and observation periods.

The instrument was used by this researcher using interview and observation methods in actual on-the-job settings. Verification of plant classification and the existence of the appropriate occupational titles was done with management-level personnel. A personal interview was conducted with at least one tradesman in the available occupational areas within each company. During this interview and observation period, a specific measurement inventory was made using the survey instrument. The data thus generated enabled the

researcher to construct Matrices II-IV. The content of Matrices V, VI, and VII was formulated by this researcher's interpretive efforts within the structured confines of the previously collected data as displayed in earlier matrices.

This analysis model, as applied to the graphic arts industry, classifies this study as both developmental and descriptive in nature.

Organization

Chapter I of this study is an elaboration of the problem statement. Included in the discussion are the purpose and objectives of the study, importance, limitations, definition of terms, procedures, model components, data sources, data collection methods, and the organization of the study.

A review of pertinent literature concerning the major topic headings of metric system, task analysis and model development, and the graphic arts is presented in Chapter II.

Chapter III includes a detailed description and explanation of the data collection procedures used in assembling the matrices for this study.

The statistical results of the investigation and an analysis and discussion of the data compiled within the model comprise Chapter IV.

Chapter V includes a detailed description of the balance of the final model and its application resulting from the data collection interviews and observations. Included within this chapter is Matrix V which presents projected SI metric measurement units, Matrix VI which displays areas of commonality, and Matrix VII which illustrates projected SI metric levels of attainment for the selected graphic arts occupational titles. Suggested performance objectives are also set forth as a guide for metric instructional guidance.

The summary, conclusions, implications, and recommendations are presented in the final section of this dissertation (Chapter VI). The Appendices and Bibliography follow the final chapter.

CHAPTER I--NOTES

[1]Clive A. Cameron, Going Metric With the U.S. Printing Industry (Rochester: Graphic Arts Research Center, Rochester Institute of Technology, 1972), p. 34.

[2]U.S. Department of Commerce, Report to Congress: A Metric America--A Decision Whose Time Has Come (Washington, D.C.: Government Printing Office, July, 1971).

[3]U.S. Congress, House, A Bill to Declare A National Policy of Converting to the Metric System in the United States, and to Establish a National Metric Conversion Board to Coordinate the Voluntary Conversion to the Metric System Over a Period of Ten Years, H.R. 11035, 93rd Congress, 1st Session, 1973.

[4]Malcolm E. O'Hagan, "The American National Metric Council--A Catalyst for Orderly Change," School Shop, 23 (April 1974): 56.

[5]State of Michigan Board of Education Resolution, "Adoption of Metric Textbooks" (Lansing, Michigan, September 12, 1973), p. 1.

[6]Albert B. Chalupsky, Jack L. Crawford, and Edwin M. Carr, Going Metric: An Analysis of Experiences in Five Nations and Their Implications for U.S. Educational Planning (Palo Alto: American Institutes for Research, Project No. 3-2173, 1974), p. 86.

[7]Cameron, Going Metric, p. 19.

[8]U.S. Department of Labor, Dictionary of Occupational Titles (Washington, D.C.: Government Printing Office, 1965, Vol. I), 134.

[9]Kodak Graphic Arts Industry Manpower Study, Complete Report (Rochester: Eastman Kodak Co., Department 454, 1973), p. 45.

CHAPTER II

REVIEW OF THE LITERATURE

The review of literature and related research is presented in three major sections: (1) the nature of the metric system and potential conversion problems, (2) the graphic arts industry, and (3) industrial in-service education program models relevant to the design of this study.

The Nature of the Metric System and Potential Conversion Problems

U.S. Historical Perspective

To fully appreciate America's legislative dilemma with regard to metrication, a synopsis of past historical events is essential. The metric system of measurement has been considered for decades not only in the United States but abroad.[1] A brief outline of past significant metric considerations in the United States is cited by Viets: in 1790 George Washington called for uniformity in weights and measures, in 1821 John Quincy Adams advocated adoption of the metric system, in 1866 Congress authorized the use of the metric system within

the U.S. by law, in 1875 the International Bureau of Weights and Measures was established, in 1893 the metre and kilogram were defined and standardized, in 1894 the U.S. War Department adopted the metric system for medical work, in 1902 the metric system was adopted by the U.S. Health Department, in 1926 a major metric bill before Congress was defeated, in 1968 Congress approved passage of the U.S. Metric Study and in 1971 the Report of the U.S. Metric Study was delivered to Congress.[2] Subsequent action by the Senate on August 18, 1972 saw the Metric Conversion Act approved.[3] Similar legislative action in the House of Representatives failed, however, and as such the 92nd Congress expired without joint congressional approval of formal metric legislation.[4]

During 1973, twelve metric related bills were introduced for legislative consideration. Predominant among Senate bills was S-100 sponsored by Senator Claiborne Pell.[5] H.R. 11035, introduced by Representative Olin Teague, has endured and is presently matched as the House counterpart to S-100.[6] Both bills maintain decisive similarities. The Teague bill specifically calls for:

1. A voluntary conversion to metric measures over a ten-year period;

2. The establishment of a twenty-one member National Metric Conversion Board to guide implementation;

3. The establishment of immediate public educational programs dealing with metric information; and

4. The exclusion of any Federal subsidy to cover private financial costs incurred in making the conversion to metrics.[7]

This exclusion of government monetary subsidies for tool replacement, etc., has compelled strong lobbying efforts against such legislation by many labor unions. On May 7, 1974 the U.S. House of Representatives defeated a motion to suspend the rules to consider H.R. 11035 without any amendments being attached.[8] While not completely killing the bill, little optimism remains for passage during the current legislative session since the bill sponsors remain unyielding to compromise on adding financial amendments.

The apparent inability of the current legislative process to formally adopt metric measurement for the U.S. places in perspective the lengthy struggle metric proponents have encountered for nearly two centuries. Louis E. Barbrow, coordinator for metric activities at the National Bureau of Standards, now predicts that the Federal Government will begin to play a rather passive role in any U.S. metric changeover.[9] Legislation, when it passes, will only create a mechanism for planning the changeover and will in no way mandate compulsory metrication for individuals and businesses. By allowing a nongovernment initiative to bring about the expected conversion, the role of legislation becomes increasingly secondary to private industry efforts and needs.

SI Metric Delineation

Examination of the controversy surrounding a U.S. metric conversion precipitates a need to establish precisely the nature of the metric system under discussion. Prior to 1960, the metric system was considered, in effect, to be a European measuring system by most Americans. Often designated as the cgs (centimeter, gram, and second) metric system, many educational programs in the U.S. included cursory instruction in its use.

Proposed in 1670 by Gabriel Mouton of France, the original decimal system of weights and measures defined its basic unit of length, the metre, as a fraction of the length of a great circle of the earth.[10] Hence, the first attempt was made to base a measurement quantity on a definable standard. Numerous adaptations followed.[11]

In 1960 the Système International d'Unités (International System of Units) and the international abbreviation SI was used for the systematically organized system of units introduced by the 11th General Conference of Weights and Measures.[12] In an attempt to set forth an international measurement language of units, all participants at the conference initiated an updated

version of the historical cgs system. Placing great emphasis on the metre, kilogram, second, and ampere, coupled with the kelvin, candela, and mole has garnered the label mksA for the most recent version of metric measurement.

This updated SI system incorporated three classes of units: (1) base units, (2) supplementary units, and (3) derived units.[13] Working definitions for each of the base units are as follows:

1. The metre (m), the standard unit of length in the SI metric system, is defined as 1 650 763.73 wave lengths in vacuum of the orange-red line of the spectrum of krypton 86.
2. The kilogram (kg), the standard unit of mass in the SI metric system, is equal to the mass of the international prototype of the kilogram. This is the only base unit originating from an artifact.
3. The second (s), the basic unit of time in the SI metric system, is defined as the duration of 9 192 631 770 periods of radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium-133 atom.
4. The ampere (A), the basic unit of electric current, is defined as the amount of current that will produce a force of 2×10^{-7} newtons between two wires one metre apart, in a vacuum, for each metre of length.
5. The kelvin (K), or unit of thermodynamic temperature, is used to measure temperature in the SI metric system. The kelvin is defined as 1/273.16 of the thermodynamic temperature of the triple point of water. The temperature scale for common usage will be the degree Celsius (°C).
6. The candela (cd), the basic unit of luminous intensity in the SI metric system, is defined as the intensity of 1/600 000 of a square metre of the cone of light emitted by a black body that has been heated to 2 042 kelvins under a pressure of 101 325 newtons per square metre.

7. The mole (mol), the standard SI metric unit for the amount of a particular substance, is defined as the amount of a substance in a system that contains as many elementary entities as there are atoms in 0.012 kilograms of carbon 12.[14]

Two additional units, labeled supplementary units, involve angular measurement. The radian (rad) is defined as the plane angle between two radii of a circle which cut off, on the circumference, an arc equal to the radius. The steradian (sr) is the solid angle which, having its vertex in the center of a sphere, cuts off an area of the sphere equal to that of a square with the sides of length equal to the radius of the sphere.[15]

Derived units have their origin in the base units (see Appendix A).[16] They are generally compound units formed by algebraic combinations of base units, supplementary units, or other derived units. Numerous units in this class have special names and symbols. The remaining derived units are identified by the names and symbols of the given algebraic expression.[17] A brief explanation of the common derived units follows.

Units derived from the base unit metre are the units of area:square metre (m^2) and the hectare (h^2) used for measuring land area which equals 10 000 m^2. Volume and capacity in the SI metric system are properly measured in cubic metres (m^3).

The litre was defined in 1964 as equaling 1 000 cubic centimetres (cm^3). The litre is not a legal unit in the SI metric system since the centimetre (cm) is not a basic unit. The litre, however, is currently used as a unit of liquid volume or capacity in many countries and will undoubtedly endure as such.[18]

The derived units of mass include force, work (energy), power, and pressure. Force is measured in newtons (N), work is measured in joules (J), power is measured in watts (W) and pressure is measured in pascals (Pa).

Units derived from the base unit of time, the second, are velocity (m/s), acceleration (m/s^2), and the hertz (Hz).

The base unit ampere provides the derived units volt (V), ohm (Ω), farad (F), coulomb (C), henry (H), weber (Wb), and siemens (S).

The final derived units are the lux (lx) and lumen (lm) which utilize luminous intensity as their base.

The prefix scheme of the base units used in SI is the scientific notation system.[19] This notation system utilizes a base 10 function and allows for a less error-prone method of calculation than some others. There are six prefixes for the multiples of the base units and eight prefixes for the submultiples of the base units (see Appendix A). By coupling numerical prefixes with unit abbreviations such as mm (millimetre), an entire new measurement language is formulated. Once learned, this language affords simplicity and ease of manipulation on a universal level.

Argumentation Regarding U.S. Adoption of SI Metrics

Literature pertaining to industrial metrication arguments generally reflects the following as items of major concern: (1) costs, (2) resistance to change, (3) coordination and planning, (4) establishment of metric standards, and (5) retraining. A further condensation of the above renders discussion in two general arenas: financial and educational.

The financial implications of metrication in the United States have drawn much debate. Very little substantiated evidence exists, however, and thus most estimates are merely a matter of prejudiced conjecture.[20] The position of the Federal Government has been to let costs lie where they fall.[21] By so doing, inflated costs will tend to be reduced and the costs will gravitate towards those who benefit the most from metric conversion. As stated earlier, organized labor has lobbied strongly to write Federal subsidies into legislation for the reimbursement of small businesses and workmen who are forced into conversion. A compromise of sorts is the most likely result.

Dollar estimates of total conversion costs for the United States currently range from $4 billion to $100 billion.[22] Such a wide disparity can only indicate that early dollar estimates are in fact highly inaccurate.

Willard Rockwell, Board Chairman of North American Rockwell Corporation, cites a balance of payments problem due to slackening foreign trade as the motivation for most manufacturing interest in metric conversion.[23] Multinational industrial firms offer little argument concerning the fact that metric conversion will be expensive. They also point out that it will be far more expensive if the United States does not convert and thus alienates itself from world trade.

In dealing with another metrication concern, resistance to change, Frank Donovan in reviewing a Gallup Poll on metrication observes: "It is an interesting commentary on one aspect of human nature--the desire to retain that which is familiar regardless of its merits--that although 9 out of 10 of the least educated group said that they did not know what the metric system is, over half of them did not want to use it."[24]

Donovan suggests, however, that resistance to the measurement change can be attacked and successfully combated by not only teaching and stressing the mechanics of metric measurement but by inducing workers to accept it.[25] Such an inducement may well be the absurdity of

our present measurement system. Jones points out that we currently use "two kinds of pounds, two kinds of ounces, two types of miles, dry and liquid quarts, eight kinds of tons, and 56 sizes of bushels."[26]

Ballow, in addressing the issue of possible public resistance, suggests that we eliminate all ideas of a literal conversion scheme from customary to SI metric measurement.[27] The merits of the metric system cannot be exploited if dependence upon conversion thinking and manipulation is perpetuated, thus providing a confusing array of terms and formulas.

Similar sentiments are expressed by Catlett:

> Our goal in metrication should be to think as instinctively in metric terms as we do now in customary terms. . . .
>
> Despite certain objections, it is undeniable that the metric system is simpler. The constant of proportionality between various quantities is always unity. Calculations are much easier, and errors are reduced. Even older employees, when taught to think metric, have found the conversion easy.[28]

The imperative need for stringent planning is often cited by metric opponents as a major peril in adopting the system. Dr. Lewis M. Branscomb, former director of the National Bureau of Standards, views the role of the Federal Government as being instrumental in this vital planning role:

> Going metric is not really something the Federal Government can do for the country. People and companies will have to make the change themselves, relying on government only to bring groups together to coordinate their plans.[29]

In summarizing the advantages of adopting the SI metric system in the U.S., Westbrook offers several cogent points: the SI metric system (1) is nearly universal, (2) easy to learn, (3) allows fast mathematical calculations because of decimals, (4) promotes low chance for computational errors, (5) eliminates common fractions, (6) encourages complete interchangeability of machine parts, (7) encourages standardization of tools and gauges, (8) encourages the elimination of the double measuring system, (9) makes allowance for future standardization of many tools, materials and processes, and (10) increases export potential for the U.S.[30]

A summary of key points in opposition to a compulsory metric adoption by the U.S. are cited by Wiggin: (1) Congressional bills to this point have been compulsory, (2) English-units are used currently in all metric countries, (3) loss of foreign trade will not result, (4) many internal metric conversions are poor, (5) many scientists use nonmetric measurement, (6) SI is not 21st century, and (7) people simply do not want to change.[31]

Opponents of metric adoption appear, however, to be sounding a muted call. The literature sources currently provide overwhelming evidence of concerns focused on actuating the changeover, rather than debating the merits of making the change.

Adult Metric Education Implications

The U.S. Metric Study Interim Report:Education cites a tight link between occupational education instruction and usage of measurement, to practices within an occupation.[32] Such being the case, educational changes not only within schools but also within each industry will have to be instituted to accommodate adult needs.

Odom, in discussing educational implications for the adult population, points out: "Accompanying metrication would have to be an extensive and intensive program of educating the public on the nature and merits of the metric system, the areas where change would take place, the reasons for the change, and the proposed outcome, including advantages."[33]

Chalupsky and Crawford also consider the plight of adults having to undergo a metric conversion: "Most adults, including teachers, desperately require reassurance that this change will not be too difficult or threatening to them personally. . . ."[34]

To help accommodate an awareness of adult concerns regarding metrication, in-plant education programs can potentially serve a vital role for the average employee.[35] An obvious role of implication and importance for adult education must also be filled by structured adult education classes. Cortright quotes a recent NEA paper on The Education Implication of Metrication:

> The kind and amount of education which will be needed for the effective use of the metric system by adults familiar only with the current system is an important consideration in converting to SI. Adult education classes must help bring the present generation up to date in their knowledge of the metric system.[36]

In studying key issues regarding metrication implications for exceptional children, Fineblum (1970) concludes that exclusive use of the metric system is preferred over using both metric and customary units in combination with each other.[37] Her conclusions are based on research conducted with lower I.Q. children of elementary grades. Practicality would suggest, however, that complete avoidance of the present customary measurement systems with adults in occupational settings is not a realistic possibility. By conducting a measurement needs inventory, a moderate transitional period for working adults may serve to foster easier adaptability to metric measures.

Metric Teaching Strategies Research

Since metric conversion proposes to be a sensitive issue with public acceptance undoubtedly related to positive perceptions of it, the lack of contemporary research in this area is surprising. This literature review will thus present that research which does exist and is remotely pertinent to this dissertation.

Yorke published a report in 1944 which reported the effects of compulsory use of the metric system in

certain European and South African countries.[38] She concluded from reviewing three studies that compulsory use of metric weights and measures made learning measurement and conversion more difficult for children.

McFee (1967) investigated whether instruction with or without simultaneous conversion to English measures was more effective in improving the ability of students to perform tasks in the metric system.[39] Six science classes at the seventh grade level were participants in the study. Results indicated no significant difference between students instructed in metric measures plus conversion and students instructed in metric measures without conversion in their ability to perform tasks in metric measuring.[40]

Murphy and Polzin reported in 1969 on a review of research studies dealing with metric teaching strategy.[41] A limited number of works were reported with most being conducted during the 1920's-1940's. None studied the effects of teaching the metric system to adults.

Exum (1972) attempted to determine the effectiveness of a metric supplement book when used in conjunction with a course textbook in student performance of metric measurement tasks and intuitive thinking.[42] The author concluded that the use of the metric booklet, when used as a supplementary teaching device, was an effective method for teaching students to work and think in the metric system.[43] The experimental groups were composed mainly of college freshmen.

In attempting to determine appropriate grade levels for the introduction of specific metric concepts, Bargmann (1973) constructed and implemented a complete metric unit for grades three through six.[44] His findings revealed that there were differences in achievement at various grade levels regarding the students' ability to learn and use the metric system of measurement.[45]

Educational research studies concerned with the metric system are few. Those that have been completed totally ignore the working adult population. An assessment of adult on-the-job measurement needs in a specific industry could help to begin filling this void and provide groundwork for further methodology research and analysis model refinement.

The Graphic Arts Industry

Graphic Arts Industry Definition

Inherently when the terms "graphic arts" and "printing" are used, a synonomous nature is normally accorded to both. In attempting to gain a measure of specificity regarding each, however, it is possible to differentiate between the two by using the term "graphic arts" broadly to denote a visual means of communication involving any graphic exhibit. George Stevenson in

his Graphic Arts Encyclopedia defines the graphic arts in such a manner: "Arts represented by drawing or imposing on a flat surface an image that communicates a message; also the methods, processes and techniques employed in these arts."[46]

This broad interpretation does include, however, a provision for the literal reproduction process and as such segments and separates the initiator from the reproducer of visual images.

In a landmark book describing the printing industry, Victor Strauss (1967) observes that the term "graphic arts" has become simply a different name for the printing industry.[47] He further describes the industry: "The printing industry is a collective name for a wide variety of different industries, crafts, and trades which belong together because they all serve fundamentally similar and related purposes within our modern communications system."[48]

Strauss, in yet a later work, structured the graphic arts industry into four broad segments, one of which is the printing industry: (1) The communicators, those actively interested in the nature and appearance of communication, (2) the end-users of graphic communication, (3) the equipment and materials suppliers, and (4) the printing and allied industries which convert text and illustrations as prepared by the communicators into printed materials.[49]

As a consequence of the foregoing literature search, no definable consensus seems apparent regarding suitable definitions of either term. Henceforth, this dissertation shall use the terms synonomously with the implication understood that the printing industry is a segment of the more inclusive graphic arts industry. Trade vernacular, however, generally renders both terms one and the same.

The Structure of the Graphic Arts Industry

With historical roots grounded well back into the times of Johann Gutenburg (1452), the printing process is essentially a means of transferring inked impressions of words, numerals, symbols, and photographs or other illustrations to paper, metal, or other materials. The most prevalent methods of printing are labeled letterpress, lithography, gravure, flexography, and screen printing. Each method maintains special advantages and remains unique from its counterparts.

The printing industry is essentially classified as being composed of numerous small businesses. Recent government data indicate an industry which includes 37,989 establishments, 1,082,000 employees, and $25 billion dollars in shipments for 1972.[50] The U.S. Department of Commerce in its latest Census of Manufacturers lists the printing and publishing industry as

a major group under the Standard Industrial Classification number 27.[51] Comprised of fifteen different industries, they are organized and listed by their products, printed objects, or materials (see Appendix B). Included in this listing is the printing and publishing of newspapers, magazines, books, and advertising matter; the production of business forms; the production of greeting cards and gift wrappings; commercial or job printing; bookbinding; and the provision of typesetting, photo-engraving, platemaking, and other printing services, primarily for printing establishments.

Eastman Kodak (1973) recently published results of a comprehensive national graphic arts industry manpower study. Included was a percentage listing of companies in the study which were active in each of the above major industry classifications. Survey respondents indicated that 20 percent were involved in in-plant printing (captive), 51 percent were classed as general commercial printers, 23 percent published newspapers and books, 14 percent performed trade-plant functions, 15 percent printed business forms, and 4 percent produced greeting cards.[52] Numerous companies, of course, are represented in more than one classification.

Representative Occupational Titles

In assessing the occupational titles included within this industry, the Dictionary of Occupational

Titles provides a detailed description and classification for each specialized work category differentiating on the basis of skill level, subject matter/industry, and process/activity.[53] A more generalized approach is presented by the U.S. Department of Labor in grouping printing trade occupations under three major categories: (1) job printing, (2) newspaper publishing, and (3) lithography.[54] Included, among others, are titles involving artists, compositors, cameramen, strippers, electrotypers, photoengravers, platemakers, pressmen, and bindery and finishers.

Using a demographic approach, the Bureau of the Census developed an index primarily to define the industrial and occupational classification systems adopted for the 1970 census. Under its broad industrial classification system, newspaper publishing and printing was given number 338 and a second number, 339, was applied to all other printing, publishing, and allied industries.[55] The index used this rather atypical grouping to then classify occupational titles involving printing skilled tradesmen. Titles such as bookbinders, compositors, electrotypers, engravers, pressmen, and numerous others were classified.

The widely acclaimed manpower study by Eastman Kodak (1973) identified seven major production areas and categorized twenty-two individual production areas

within them: layout and design, hot metal composition, photographic and strike-on composition, imposition and lock-up, pasteup and copy preparation, camerawork, stripping, offset platemaking, letterpress platemaking, flexographic platemaking, gravure platemaking, screen process platemaking, sheet-fed offset presswork, web-fed offset presswork, letterpress presswork, flexographic presswork, screen process presswork, gravure presswork, bindery and finishing, sales, management, and miscellaneous.[56]

Representative of today's printing industry occupations, the above titles provide a broad spectrum of diverse occupational roles. There was, however, no analysis of occupational operations and competencies involved in each job. The matter of metrication within the industry also was not a consideration of the study. Thus, as a matter of logical extension, the determination of a graphic arts measurement inventory coupled with a metric identification of conversion needs would not only extend the Kodak data but would serve as a curriculum base supplementing an already useful study.

Competency-Based Graphic Arts Research

There appears to be a complete void entailing research which involves the metric system and its application to the graphic arts industry. Numerous research

efforts have been utilized to identify competencies connected with various graphic arts occupations. Frantz (1967) conducted a study to identify occupational competencies required for a cluster concept in graphic arts through a system analysis approach.[57] A task inventory, consisting of precise statements describing activities of each occupation, was used to identify job entry tasks. The occupational competencies that were identified were then clustered into four broad graphic arts occupations thus providing a learning sequence for the secondary school level.

A comprehensive literature survey provided Deady (1970) with a rating of technical graphic arts competencies found in appropriate texts and reference books.[58] This study was an attempt to provide empirical information necessary in the planning of pre- and in-service education programs for high school journalism and graphic arts teachers.

In a similar study, Fecik (1970) through a literature survey, organized the comprehensive field of graphic communications in terms of the common elements of the technology of the graphic arts industry.[59] Through a process of identification and classification, the study provided a structure upon which the common elements of the graphic reproduction processes could be determined to maintain comprehension and lessen ambiguity. The study concluded that a need was apparent for industry and graphic arts educators to agree on terminology and thus foster a better understanding of each other.

In an effort to produce a comprehensive curriculum resource for graphic arts educators, Banzhog (1972) studied the technology of the graphic arts.[60] This research provided a detailed, chronological description of the tools, materials, processes, and equipment utilized by the graphic arts industry.

In summarizing this general review of literature relative to the graphic arts industry, an effort has been made to determine a workable understanding regarding the nature of the industry. Included is a discussion relative to a definition, a categorical breakdown of the structure of the industry, an overview of the occupational titles which make up the industry, and a presentation of pertinent graphic arts related research. The lack of any measurement-related research is noteworthy.

Selected Industrial In-Service Education Program Models

The Need for Metric Education Program Planning

Cameron, during 1971, conducted a survey to appraise the consensus of opinion within the graphic communications industry regarding the metric system.[61] He reported a favorable display of attitudes toward

United States adoption of the metric system for the graphic arts. Eighty-five percent of the respondents clearly cited metric conversion benefits for the United States and the industry and a willingness to participate in such a move.[62] Paradoxically, for an industry which cited early approval of the metric conversion, very little activity is currently apparent. Any time-related benefits which were available three years ago for unhurried program planning efforts may now be negated once the tempo of metric conversion is increased.

A recent search by this author in conjunction with this dissertation has failed to pinpoint evidence of graphic arts industry metrication planning on the part of trade unions and associations, industrial organizations, and employers. The prevailing attitude of "wait and see" seems predominant within the printing industry at the present time.

In supporting the need for general in-plant education, Smith criticizes the printing industry.

> The printing industry has lagged behind other industries in the development of a training and educational philosophy. Not only has this philosophy, or staff of life, been neglected, but the utilization of proven educational tools has been overlooked.[63]

A random and unplanned approach to metric education certainly would not accomplish an overall coordinated effort at the least possible cost for any industry.

Outside the immediate printing industry, several comprehensive metric education packages are currently in the developmental stages. General Motors, Caterpiller Tractor Co., Xerox, International Business Machines, and others have all produced metric packages for their own internal needs. Most show evidence of having been planned to meet specific goals and are designed to acquaint and retrain individuals with specific occupational needs in their respective manufacturing industries. The availability of such metric learning packages has been heretofore restricted to in-house use due to the untried nature of each.

Assessment of Metric Program Components

An obvious need arises when designing an educational package to survey and analyze the general program parameters. Dieffenderfer, after conducting a metric contingency study for vocational education, elaborates: "The general areas of analysis to be conducted by industrial groups will include (1) determining the impact of metrication on the area, (2) establishing a time period within which metrication will take place, (3) defining metric standards practice for the area, (4) identifying areas requiring metric instruction, and (5) developing the specific SI metric instructional units required."[64]

Phillip Markstrom, IBM Metrication Program Manager, describes his company's approach in determining program direction and coordinating its timing:

> Underlying all these activities are the needs for general awareness and educational programs to insure that our people are informed. These areas are too often thought of first and implemented early, however too much too soon can be as bad a thing as too little too late. These programs bear close attention if real benefits are to occur without needless costs. Notice too, that these are really two different programs; nearly everyone can benefit from an awareness program but not all areas need education to the same degree or training at the same time.[65]

The British Metrication Board, currently overseeing Britain's industries in their metrication changeover, suggests an elementary in-service education plan for action. Determine who needs training, identify what needs to be learned, establish when the program should be initiated, and coordinate how the educational material is to be presented; self-teaching, in-company training, external courses, or by printed materials.[66]

Determination of Educational Program Levels and Objectives

Educational psychologist, Jum Nunnally, in a discussion of intellectual objective types, suggested a method for breaking intellectual objectives into meaningful subdivisions.[67] In an effort to construct workable model objectives for metric conversion programs his suggested levels of intellectual functioning seem quite appropriate.

1. Memory for facts
2. Understanding of simple principles
3. Understanding of complex principles
4. Use of principles to evaluate proposed solutions to problems
5. Use of principles to solve problems
6. Inventive extension of old principles to the development of new principles[68]

The six levels of intellectual functioning stated above constitute a range from simple content memorization to creative building of new knowledge. Levels two and three require more than memorization by utilizing principles at work in various ways. All levels above three are concerned with the evaluation or production of new knowledge. In determining specific program objectives, all six levels must be considered.[69]

In designing a program to aid in understanding SI units of measurement, Pitney Bowes, a large multinational company, " . . . established a foundation from which various levels of metric learning could grow."[70]

IBM, in a similar approach, has chosen what they term as a classification involving four levels of knowledge. "The classification levels provide common points of departure for metric program planning, analysis, and development."[71] Entitled (1) awareness, (2) conceptual, (3) working, and (4) developmental, the four levels each contain individual characteristics coupled with some overlap as a means of maintaining program continuity.[72] Composed of specific behavioral objectives, each level follows a building block sequence from simple to complex.

Exhibiting features which are conducive to the needs of this model, these four levels shall be adapted for use within this study.

Indicating a task analysis structure seemingly influenced by Robert Gagné, the IBM package ranges from problem solving at its developmental or highest level to lower levels where facts, concepts, and principles are employed.[73]

Chalupsky, Crawford, and Carr (1974), in a comprehensive analysis of foreign experiences regarding industrial metrication education, detailed a job-related approach quite common among existing programs:

> As a start toward a more detailed examination of training needs, it was suggested that the work force be divided into appropriate categories.
> Personnel requiring a full working knowledge of calculations, e.g., engineers. . . .
> Personnel requiring a working knowledge of simple calculations, e.g. supervisors, technicians, etc., may require specific training. . . .
> Personnel requiring simple basic knowledge for reference purposes, such as clerks, typists, etc. . . .[74]

A British metrication training board, in addressing itself to a determination of program objectives, uses a simplified competencies approach. The board suggests that an analysis should identify types of knowledge or skill needed for metric units in each particular job.[75] Five metric ability groups are defined:

1. ability to name metric quantities
2. ability to type or write metric units
3. ability to calculate metric quantities

4. ability to convert between customary and metric units
5. ability to explain relationships between customary and metric measures[76]

Each identified job category is then rated against these abilities.

Pursuant to the development of any educational program structure is the critical need for stated objectives. The nature and form of such objectives is derived mainly from one's perspective regarding learning theory, instructional styles, and other educational concerns. The foregoing citations are an attempt to establish a base from which the program structure for this dissertation model will emanate.

Analysis Techniques

In an attempt to validate occupational analysis as a suitable model construction tool, literally hundreds of studies were encountered. Many employed the use of similar analysis techniques. Frykland, in describing the analysis technique for teachers, defines occupational analysis as: " . . . a technique by which essential elements of an occupation, or any part of an occupation or activity, are identified and listed for instructional purposes."[77]

In establishing an occupational analysis procedure for vocational education curricular development, Davis and Smith (1973) conclude:

1. Using a skill-job matrix arranged by occupational categories and by individual skills it was possible to identify skills common to more than one occupational category together with the relative priority among ten occupational titles.
2. A skill component matrix permitted identification of potential relationships among skills with skill clusters identified within each category.[78]

Using a comparable matrix methodology, Lynn (1967) investigated the training and skill requirements of industrial machinery maintenance workers.[79] By employing the interview method, Lynn analyzed data from this survey to identify specific knowledge, skill, and training required of maintenance workers.

In 1970, Englebart developed an individualized instructional model for occupational areas.[80] Among his findings was the observation that competencies needed in various job titles can be sequenced and identified through comprehensive literature reviews and appropriate interview inventory instruments.

In an attempt to isolate specific analysis technique research directly related to metrication, this literature review was unsuccessful in locating any studies even remotely germane. Two examples of analysis studies dealing with mathematical competencies do, however, lend support and help substantiate the construction of this researcher's analysis model.

In a study of mathematical skills needed for entry-level employment in a cluster of

electricity-electronics occupations, LeDoux used an inventory of mathematics skills to help establish a curriculum base for pre- and in-service educational programs.[81] Investigating a comprehensive occupational field, electricity-electronics, LeDoux identified key occupations and inventoried a range of math skills for each. A comparable study conducted by Johnson (1972) presented an analysis of mathematical competencies necessary for certain health occupations.[82] Once again a large occupational field was investigated in an attempt to establish specific mathematics competencies and the amount of commonality that existed across jobs. Results identified groups of basic knowledges from the areas of systems of weights and measures, temperature conversions and basic arithmetic concepts for the pertinent occupations in the study.

Model development employing the use of occupational analysis techniques has been widely established in educational research. Numerous variations abound with each researcher adopting a rationale and procedure best suited to a particular need. In assessing the array of present occupational analysis studies this literature review has endeavored to focus on those works which have provided impact and direction in developing the construction of this researcher's analysis model.

The general process of structuring an industry according to occupational titles, of inventorying and sequencing specific tasks and skills, and the use of actual industrial settings to generate curriculum updating for pre- and in-service education programs is, to be sure, not without precedent. The unparalleled nature of this model, however, evolves through the addition of its concern for the impending metric conversion in the United States.

The problems centering around the SI metric system and its potential effect in industrial job settings requires intensive investigation. This dissertation gives attention to the question of what aspects of the SI metric system are appropriate for use in the various skilled trades of the graphic arts industry.

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CHAPTER III

DESIGN OF THE STUDY

The purpose of this chapter is to describe: (1) an overview of procedures used to formulate critical aspects of the model, (2) the sources from which data were gathered, (3) the methods utilized to collect data, and (4) the data analysis process to be followed herein.

Procedures Used in Developing the Model

Objectives of the Model

In addressing the procedural structures of this analysis model a restatement of purpose is appropriate. The central purpose of this study is to develop a model which can be implemented to determine metrication competencies that are necessary for selected industrial occupations. Specifically, this model will be applied to the graphic arts industry focusing on the following major objectives:

1. Conduct an occupational analysis of an industry and subdivide its work force into appropriate occupational titles;

2. Identify present customary measurement competencies used within each occupation;

3. Identify corresponding SI metric measurement competencies needed for each occupation;

4. Establish the extent of commonality of customary and SI metric measures among occupational groups;

5. Identify necessary levels of attainment for SI metric competency in each occupation; and

6. Recommend appropriate examples of performance objectives suitable for implementation of instructional activities at predetermined levels of attainment.

Results of this study should be applicable to pre- and in-service graphic arts industrial metric education programs.

Critical Procedural Components of the Model

Although all aspects of the model are vital, certain components maintain a critical posture and thus form the basis for the entire framework being potentially applicable to the analysis of other industries. In describing a model for task analysis in agribusiness, Berkey (1972) stressed the vital nature of certain procedural elements: (1) selection of representative firms from which data will be drawn, (2) the completeness of the inventory or task lists, (3) a readily usable instrument design, (4) a forthright interviewing technique, and (5) the organization of data into a usable form.[1] The analysis model used in this study shall maintain adherence to the above elements as procedural guideposts in carrying through an analysis of the printing industry and its projected metrication needs.

Model Development Procedures

This study progressed in a predetermined sequence of steps designed to foster a systematic flow of information:

1. A general review of literature and related research;
2. A review and identification of selected occupational titles providing data to fulfill objective one and complete Matrix I;
3. Construction of an analysis instrument containing appropriate customary measurement activities, tools, and terminologies utilized within the industry to provide data for Matrices II, III, and IV;
4. Validation of the instrument;
5. Identification of companies participating in the generation of data;

6. Collection of data through interviews and observation visitations;

7. Processing and tabulating data to complete objective two which includes Matrices II, III, and IV;

8. Utilization of the remaining model components and its accompanying metric-related Matrices V, VI, and VII through data analysis procedures thereby completing objectives three, four, and five;

9. Validation of the SI metric matrix by appropriate metric organizations;

10. An analysis of the complete model and its implications for future use including representative performance objectives as called for in the sixth and final major objective of the study.

The overview sequence listed above was drawn from procedures used by numerous researchers in constructing analgous analysis models. Two of importance are Sprankle and Englebart. Sprankle conducted a task analysis study directed towards identification of skills and knowledge required for occupations included in the electronics industry.[2] Also lending firm support to the use of such procedures is a study by Englebart in which he developed a vocational education curriculum model.[3]

Both studies served as procedural influences on this measurement competency analysis model. The forthcoming discussion will expand and present in detail procedures which were used to structure the model and its necessary components.

The initial step in formulating a basis for this research was a comprehensive literature search. Three major foci were identified and investigated: (1) metrication and its adjacent concerns, (2) a study of the structure of the graphic arts industry, and (3) employment of analysis techniques and model development. Presented in the previous chapter, this literature review did in fact establish the existing need for metric-related research and more importantly, link such research to contemporary industrial applications and educational programs.

Since the broad graphic arts industry maintains a differentiated production field, certain specific industrial classifications had to be established. A literature search identified six major production printing classifications: (1) in-plant printers, (2) general commercial printers, (3) newspaper publishing, (4) trade plant service operations, (5) business forms printing, and (6) packaging printing. Seventy-six percent of production printing in 1973 was produced by plants found in one of the above classifications.[4] Recognizing that additional classifications do exist, this researcher has deemed the above to be sufficient in establishing the credance of this model for the graphic arts industry.

Upon establishing the basic framework of the printing industry through a definition of its major components, nineteen individual occupational areas were specified as called for in the first major objective of the study. Occupations were chosen which were found to be present in one or more of the major industrial classifications previously indicated. Numerous statistical reports and indices were used to document the validity of these occupational areas as previously discussed in Chapter II.

A survey instrument was constructed to identify measurement uses in on-the-job settings for the selected occupational titles in an attempt to assess customary measurement competencies. The instrument was designed to isolate measurement activities, tools, and terminologies used by the nineteen occupations specified under the six major industry classifications. A detailed description of the instrument occurs under a separate heading on page 72 within this chapter.

The instrument was validated by a panel of experts including two vocational printing instructors, two tradesmen, two professional graphic arts consultants, a metric consultant, and an educational researcher (see Appendix C).

Upon agreement and general consensus by the reviewers regarding the instrument inventory lists, the instrument was piloted. For an expanded treatment of the pilot procedure see page 74. Appropriate adjustments were made upon completion of the pilot research interviews and observations.

Interview and observation visitations were then scheduled at selected printing plants in the state of Michigan during the summer of 1974. An elaboration on how these plants were selected follows discussion of the general procedures used to formulate this model on page 68.

Upon collection by the researcher, the data were then processed and tabulated in a straightforward manner to facilitate ease of interpretation and usage within the industry concerned. Once established, the data provided an information base which allowed for the construction of Matrix II which assessed graphic arts measurement activities, Matrix III which assessed graphic arts measurement tools, and Matrix IV which assessed graphic arts measurement terminologies. In a combined sequence, these three matrices together fulfill objective two of this analysis model as reported in Tables 8, 9, and 10.

Data analysis of the above measurement competencies inventory (Matrices II-IV) thus yielded the information necessary for this researcher to address the remaining objectives of the study and thereby develop and construct the final matrix components of the model, namely:

Matrix V. "An inventory of the projected SI metric measurement units needed in selected occupational titles"

Matrix VI. "A determination of the areas of commonality for customary and SI metric measurement-related competencies of selected occupational titles"

Matrix VII. "A determination of appropriate levels of attainment needed for selected occupational titles"

Designed to complete objective three, Matrix V was derived through this researcher's interpretation of the data as generated in the aforementioned matrices and tables. In presenting an SI metric measurement inventory for the graphic arts industry, Matrix V will coordinate exhibited measurement needs with a radically new and different measurement system. Since few if any reported validation methodologies exist regarding such a specific industrial metrication effort, several organizations of recent metrication importance were used as reviewers to enhance validation.

Information pertaining to the commonality aspect of the model, as expressed in Matrix VI, was ascertained through the use of significant percentage data. Representing areas of commonality within and across the occupational groups, the data were reported for measurement activities, tools, and terminologies as used within the graphic arts skilled trades. In fulfilling the fourth objective of the study, Matrix VI was utilized to show both the commonality of customary measurement competencies and the commonality of SI metric measurement needs. Tables 11, 12, 13, and 15 represent this matrix.

Matrix VII, which illustrates suggested levels of attainment needed within specific printing occupations as set forth in objective five, is once again a product resulting from this researcher's data analysis efforts. Undoubtedly all occupations will not need metrication training to the same degree of specificity. Thus, based upon similar educational programs as presented in Chapter II, four major levels of attainment have been identified to accommodate the needs of the printing industry and the selected occupational groups. The levels are: awareness, conceptual, working, and developmental.

Deriving strong direction from the International Business Machines Corporation attainment levels concept, this final analysis matrix is designed to mate the accumulated data results with the suggested attainment levels.[5] Each occupational group will be placed at a specific SI metric attainment level predicated upon each occupation's exhibited customary measurement needs as reported in Tables 8-13.

A graphic presentation relating the six major objectives of the study to the seven model matrices is presented in Figure 1 on page 14.

Data Sources

Selection of Participants

To maximize the predictive value of the accumulated data, interviews were obtained from employees in modern leading-edge companies in which the nature of the present work is most likely to represent that prevailing within the industry for the immediate future. Each of the twelve firms chosen was selected arbitrarily by this researcher. This procedure stems from several concerns. The printing industry is ubiquitous in the sense that virtually every locale across the United States includes one or more printing establishments. The printing processes employed in today's plants are generally the same, be they located in Michigan or elsewhere. Current printing occupations also coincide and reflect little variability across different geographical locations. One may therefore expect a leading industrial state, such as Michigan, to exhibit not only a variety

of major industry classifications but a corresponding diversity of occupations within the industry. Noting that the intention of this study is not to establish a unique research policy but instead to produce a defendable systematic coverage of contemporary industry occupations and classifications, this researcher has, therefore, selected a manageable geographical region containing the occupational elements proposed for study. Although no inferences will be drawn beyond the occupations involved, it is assumed that the model will have pertinent applications in similar geographical and industrial situations elsewhere.

In selecting specific firms for participation, the following factors were considered: (1) major industrial classification, (2) number of skilled personnel employed in specific occupations under study, (3) diversity and complexity of plant operations, (4) production volume, (5) predominant method of production, and (6) geographical location. The grouping of the selected interviews within the various plants is summarized in Table 1.

A total of twelve firms was included, with eight employing between 26 and 143 employees in the trade. Berkey suggested six distinct advantages in choosing mainly large firms from which to draw interviews in constructing a similar model:

TABLE 1

GROUPING OF INTERVIEWS IN SELECTED PLANTS

Kind of Plant	Number of Plants Interviewed	Number of Interviews	Number of Occupations Interviewed
In-plant printers	1	11	9
General commercial	4	18	11
Trade plant operations	2	21	12
Newspaper	2	14	9
Packaging printing	2	16	8
Business forms	1	11	9

1. Specialists are likely to be knowledgeable about their particular occupation
2. Facilities and processes within the plants are likely to be modern
3. Conducting numerous interviews in one location becomes more feasible
4. Tasks are essentially the same from one plant to another
5. The large plants are likely to need and use the final model instrument
6. The large plants are likely to need and use any resulting training program.[6]

A potential group of thirty-nine printing establishments was formulated initially. The twelve included in the study were derived by application of the aforementioned selection factors and their willingness to participate.

The study focused its investigation on nineteen occupations within the printing industry. Table 2 summarizes the occupations involved including a

TABLE 2

SUMMARY OF THE OCCUPATIONAL TITLES INTERVIEWED WITHIN THE MAJOR INDUSTRY CLASSIFICATIONS

Occupational Title	Inplant Printing	Commercial Printers	Trade Plants	Newspaper Publishers	Packaging	Business Forms
Layout and Design Artist		2	2	1	1	
Hot Metal Compositor	1		2			1
Strike-on and Photo Comp.	1	1	1	2		1
Imposition and Lockup		1	1		1	
Pasteup and Copy Prep.	1		1	4		1
Stripper	1	1	3	1		
Camera Operator	1		2	1	1	1
Platemaker-Offset	1	2	2		1	1
Letterpress		1	2	1		
Flexographic			3			
Gravure					3	
Screen Process		3				
Pressman-Offset sheet fed	2	1	13			1
Offset web fed				2	2	2
Letterpress	1	1	1	1		1
Flexographic					4	
Gravure					3	
Screen Process		4				
Bindery and Finishing Oper.	2	1		1		2

delineation of the placement of these occupations within the major industry classifications for this research. Table 2 is Matrix I.

To facilitate interpretation of the data the nineteen occupations were further combined into seven major groups as listed in Table 3.

Data Collection Procedures

Instrument Construction

In the development of this measurement competencies instrument three major concerns were investigated. Specific analyses of graphic arts measurement activities, measurement tools, and measurement terms provided a basis for the instrument construction. Included within each of the above were identifiable measurement headings comprising transferability aspects common to all three. Headings such as linear, weight, pressure, and temperature measurement, etc. each involved an activity, tool, and/or special terminology. Of further importance were the specific individual tasks, tools, and terms related to each occupational function which were employed by tradesmen in their on-the-job roles. The instrument was thus designed to identify and accumulate information about the major types of measurement competencies which were utilized in selected printing occupations. A copy of the complete instrument is provided in Appendix D.

TABLE 3

IDENTIFICATION OF SPECIFIC OCCUPATIONS WITHIN MAJOR GROUPS

Group Number	Group Name	Occupations Within Each Group
I	Layout and Design	Layout and design artist
II	Composition	Hot metal compositor
		Strike-on and photo compositor
III	Pre-Plate Prep.	Imposition and Lockup
		Pasteup and copy preparation
		Stripper
IV	Photographic	Black and white cameraman
V	Platemaking	Offset platemaker
		Letterpress platemaker
		Flexographic platemaker
		Gravure platemaker
		Screen process platemaker
VI	Presswork	Sheet-fed offset pressman
		Web-fed offset pressman
		Letterpress pressman
		Flexographic pressman
		Gravure pressman
		Screen process pressman
VII	Bindery	Bindery and finishing operator

Initial instrument content was obtained by reviewing job descriptions, training manuals, technical literature, and other pertinent materials. A diligent effort was made to isolate and compile each measurement-related activity germane to the selected occupations. Corresponding item searches were made relative to measurement tools and terminologies used within the selected occupations.

Validation efforts were conducted by distributing initial copies to teams of graphic arts specialists. Two vocational printing instructors, two tradesmen, and two professional graphic consultants were asked to review the proposed instrument for completeness and accuracy (Appendix C). Upon revision, according to the suggested changes, an educational measurement researcher and a metric consultant were asked for review comments and additional suggestions.

Since the design of the instrument was an important component of the total model, emphasis was placed on producing an instrument which fostered ease of administration, simplicity, accuracy, and reliability. A check-list format was adopted whereby the interviewer progressed down the various lists and checked each appropriate cell for the occupation in question.

A pilot study was conducted using the original instrument design in a midwest university campus production printing facility. Twelve of the total nineteen occupations were represented in this comprehensive plant. The production operations under one roof, represented segments of four of the major industry classifications: (1) in-plant, (2) general commercial, (3) newspaper publishing, and (4) business forms printing. Additional instrument modifications and adjustments were made prior to beginning the actual study.

Interview Method

Twelve plants, including ninety-one separate interviews, were visited by this researcher to accumulate data. A total of at least three trade persons in each occupational grouping was established as the minimum number from which a generalization could be drawn regarding occupational information. A personal interview with at least one individual in the available occupational areas within most companies was conducted. During this interview and observation period, the researcher completed the measurement inventory instrument with each individual trades person.

An analysis study of this nature necessitates the preparation of a detailed instrument and uniform data collection where possible. For these reasons, the personal interview technique was selected as the prime method of data collection. An additional advantage of this methodology was the immediate first-hand knowledge the researcher derived from conducting the field work. By going directly to the respondents, the researcher came in direct contact with questions that arose concerning the instrument and its content.

A letter of introduction and a copy of the instrument were sent initially to potential participants asking permission to include their facility in the study. Upon acceptance, a visitation time was arranged which would not interfere with nor disrupt production work schedules.

At the outset of an interview session, page one of the instrument was completed from information generally gained from the plant production manager. Specific occupations in each plant and the numbers employed therein were thus determined. Since unrestricted movement through a large production facility by a stranger is normally not permitted, the production manager usually arranged for a guide or in some instances made the introductions in person. Each tradesperson was given a free choice in deciding upon his cooperation in the research. No one indicated an unwillingness to participate.

Where possible, personal interviews were conducted in a separate room or area apart from the busy production activity. After a general introduction and explanation of this researcher's objectives, each interview using the instrument took an average of twenty minutes to complete.

When the instrument was completed, an additional thirty to forty minutes were spent observing and conversing with the participant in his or her actual job setting. Numerous additions were made to the data as a result of this procedure.

Being cognizant of the fact that each production facility was physically unique and required certain variances in conducting the data collection procedures, the researcher did attempt to offer a standard introduction prior to the interview. There were times, however, when conducting an interview adjacent to a large web press, that conditions left something to be desired and exact duplication was virtually impossible.

Data Analysis Process

Organization of the Data

The prime function of the measurement inventory instrument was to identify specific measurement activities, tools, and terminologies used in selected graphic arts occupations. This information was then organized to aid in the development of the total metrication planning model under study by this researcher.

Each major measurement activity, tool, and terminology was subdivided into major headings. The occupations were surveyed to document the usage frequency under each of these headings to locate where the highest percentage areas were concentrated.

The frequency was reported according to a percentage of the total number of cells per individual measurement heading. Any cells which did not exceed a reporting rate of 30 percent were discarded. This significant percentage was arbitrarily chosen by the researcher to reflect a realistic usage factor for any of the separate occupations. Since the number of tradesmen interviewed varied across the nineteen occupations, the percentage data were used to demonstrate figuratively and compare specific customary measurement activity, tool usage, or terminology usage for an occupation.

The general adaptability of this analysis model structure allows for the discretionary use of any significant percentage data which may suit the needs of a particular industry. The 30 percent figure was chosen here to reflect the fact that in several of the reported occupations three tradesmen were interviewed. Thus by using a significant percentage of less than 33 percent the researcher can report significance if only one out of three tradesmen indicated the need for a particular competency. A metric training program must be responsive to the occupational needs of a tradesman if in fact the need is representative of his job.

A search for commonality across occupational groups utilized a comparison of each group's percentile rating. Thus, any groups showing commonality of measurement competencies could derive metric training from common educational programs as reported in Tables 11, 12, 13, and 15.

In summarizing the thrust of this chapter several major features of the model design have been presented. Six major objectives have been set forth, generating a model structure designed to fulfill each major objective in an inter-related fashion. A presentation of the model developmental procedures follows by specifying how each component of the model was determined and utilized. The nature of the data sources was then discussed, including a determination of the specific occupations around which the model structure was formulated. Of further import was a discussion relative to the exact data collection procedures used by this researcher in obtaining information from the study respondents through the use of the instrument and interview visitations. The final part of this chapter presented the nature of the data analysis process to be followed throughout the remainder of the study.

CHAPTER III--NOTES

[1]Arthur L. Berkey, and others, A Model for Task Analysis in Agribusiness (Ithaca, N.Y.: State University of New York, 1972), p. 46.

[2]Norman H. Sprankle, "A Task Analysis Study Directed to Identify Electronic Skills and Knowledge Required for Occupation in Industry" (Ph.D. dissertation, University of California, Los Angeles, California, 1971).

[3]Leon Prange Englebart, "Developing a Vocational Education Curriculum Model" (Ph.D. dissertation, The University of Nebraska, Lincoln, Nebraska, 1970).

[4]Kodak Graphic Arts Manpower Study, p. 45.

[5]Wong, "IBM Goes Metric," pp. 3-4.

[6]Berkey and others, A Model for Task Analysis, p. 28.

CHAPTER IV

RESULTS OF THE STUDY

Included within this chapter, as a matter of preliminary discussion, is a general description of certain characteristics of the printing establishments which participated in this study. Following this, the specific usages of customary measurement activities, tools, and terms are reported and compared between nineteen occupations within the graphic arts industry as called for in the second major objective of the study. Another objective, that of determining areas of commonality, is then fulfilled in part by a presentation of data which groups clusters of occupations and shows common measurement competencies across these groupings. A discussion of these statistical findings thus leads into the final model development in the following chapter. Tables 4-13 may be found within this chapter fulfilling in part Matrices II, III, IV, and VI.

Analysis of Data

In assembling an information profile relative to the structure of the businesses involved in this study, the following data were obtained from management personnel in each company. Table 4 presents the number of trades people employed by the twelve plants included in the study. The majority of companies or 66.7 percent employed more than twenty-five trades people in the occupations being researched. Predominately large companies were sought out for this analysis model for reasons explained in the previous chapter. Of the companies researched, five or 41.7 percent employed fifty-one or more employees.

TABLE 4

SIZE DISTRIBUTION OF TRADES PEOPLE
EMPLOYED BY STUDY PARTICIPANTS

Number of Tradespeople	Number of Plants	Percentage of Plants
1-9	3	25.0
10-25	1	8.3
29-50	3	25.0
51-100	3	25.0
101-	2	16.7

Labor unions were represented in 41.6 percent of the participating plants. Table 5 provides information relative to labor's representation in the plants under study. Nonunion employees were interviewed in seven plants or 58.3 percent of the total group.

The lower peninsula of the state of Michigan was used as a source for data gathering since a variety of contemporary industry representatives was readily available. This researcher attempted to choose diverse geographical areas within the state in an attempt to isolate and negate the effects of potential concentrations or pockets of unreliable data in the form of antiquated processes and operations. The following cities were included: Flint, Grand Rapids, Kalamazoo, Battle Creek, Jackson, and Gaylord. A predominance of metropolitan centers provided a prime source for contemporary occupations within the industry.

TABLE 5

TRADE UNION STATUS AS REPRESENTED IN PARTICIPATING PLANTS

Trade Union Status	Number of Plants	Percentage of Plants
Union	4	33.3
Nonunion	7	58.3
Union and Nonunion	1	8.3

The number of years of experience exhibited among the employees of the participating companies indicated that 75 percent of the interviewed people were employed in their trade between six and fifteen years. No literal verification of these data was made by the researcher. Instead, management personnel were asked to estimate representative figures for their plants. Table 6 indicates that trades people within the participating plants remain for rather lengthy time periods with only a minor influx of newcomers into their trade ranks. Over 58 percent of the interviewed tradesmen exhibited between ten and twenty years of experience.

TABLE 6

YEARS OF EXPERIENCE REPRESENTED IN SKILLED TRADES OF PARTICIPATING PLANTS

Number of Years of Experience	Number of Plants	Percentage of Plants
1-5 years	1	8.3
6-10 years	4	33.3
11-15 years	5	41.7
16-20 years	2	16.7

In response to the question regarding how the specified skilled trades have received training in the individual plants, all twelve employers cited on-the-job training as the major educational source. Company sponsored in-house training programs were also utilized by two participants while trade union and private and public school programs served as supplements in several other companies. The overwhelming source for skilled trades education was structured around on-the-job training in the companies surveyed. See Table 7.

TABLE 7

SOURCES OF SKILLED TRADES OCCUPATIONAL TRAINING AS REPORTED BY STUDY PARTICIPANTS

Education Source	Number of Plants	Percentage of Plants
Trade Union	1	8.3
Trade Association	0	0.0
Company In-House Program	2	16.7
On-Job Training	12	100.0
Public Schools	1	8.3
Private Schools	1	8.3
Equipment School	2	16.7

Measurement Activities Performed by Selected Graphic Arts Occupations

Table 8 is a composite analysis of significant customary measurement activities performed by the designated occupations within the printing industry. Significance has been accorded to any measurement activity reportedly used by 30 percent or more of the persons interviewed within each occupation. Reference to the columns of measurement activities and frequency of performance by the various occupations gives basis for comparison of similarity and differences in job-related measurement functions both within and across the occupations.

TABLE 8

COMPARATIVE PERCENTAGES OF SIGNIFICANT CUSTOMARY MEASURING ACTIVITY HEADINGS WITH OVER 30 PERCENT PARTICIPATION OF 19 OCCUPATIONAL TITLES IN THE PRINTING INDUSTRY

Customary Measuring Activity Heading	Total Activities Available	Layout & Design Artist		Hot Metal Compositor		Strike-on & Photo Compositor		Imposition & Lockup		Pasteup & Copy Preparation		Stripper		Camera Operator Black & White	
		n=6		n=4		n=6		n=3		n=7		n=6		n=8	
		A	%	A	%	A	%	A	%	A	%	A	%	A	%
Linear	36	21	58	12	33	15	42	17	47	15	42	19	53	12	33
Weight	7	0	0	0	0	0	0	1	14	0	0	0	0	1	19
Temperature	18	0	0	1	6	2	11	0	0	0	0	1	6	7	39
Pressure	10	0	0	2	20	0	0	1	10	0	0	2	20	2	20
Dry Volume	4	0	0	0	0	0	0	0	0	0	0	0	0	1	25
Liquid Cap.	6	0	0	1	17	1	17	1	17	0	0	0	0	1	17
Time	2	0	0	0	0	2	100	0	0	0	0	2	100	2	100
Photo Speed	5	0	0	0	0	2	40	0	0	0	0	2	40	4	80
Velocity	6	0	0	0	0	1	17	0	0	0	0	0	0	1	17
Energy	6	0	0	0	0	2	33	0	0	0	0	1	17	2	33
TOTAL USED		1		4		7		4		1		6		10	

Customary Measuring Activity Heading	Offset Platemaker		Letterpress Platemaker		Flexographic Platemaker		Gravure Platemaker		Screen Process Platemaker		Offset Pressman sheet fed	
	n=8		n=3		n=3		n=3		n=3		n=7	
	A	%	A	%	A	%	A	%	A	%	A	%
Linear	13	36	14	38	10	27	14	38	18	50	12	33
Weight	0	0	0	0	0	0	1	14	1	14	2	28
Temperature	1	6	2	11	4	22	6	33	5	27	1	6
Pressure	1	10	2	20	3	30	2	20	3	30	6	60
Dry Volume	1	25	1	25	0	0	0	0	1	25	1	25
Liquid Cap.	2	33	3	50	0	0	2	33	2	33	4	67
Time	2	100	0	0	1	50	2	100	2	100	0	0
Photo Speed	1	20	0	0	0	0	3	60	3	60	0	0
Velocity	0	0	0	0	0	0	0	0	0	0	1	17
Energy	0	0	2	33	0	0	4	67	0	0	1	17
TOTAL USED	7		6		4		8		8		8	

Customary Measuring Activity Heading	Offset Pressman web fed		Letterpress Pressman		Flexographic Pressman		Gravure Pressman		Screen Process Pressman		Bindery & Finishing Operator		Total Occupations Responding
	n=4		n=5		n=3		n=3		n=4		n=6		n=19
	A	%	A	%	A	%	A	%	A	%	A	%	
Linear	17	47	17	47	11	31	13	36	12	33	12	33	19
Weight	2	28	1	14	1	14	2	28	1	14	1	14	11
Temperature	5	18	2	11	4	22	4	22	8	44	2	11	16
Pressure	9	90	7	70	9	90	8	80	2	20	5	50	16
Dry Volume	2	50	1	25	0	0	0	0	1	25	0	0	8
Liquid Cap.	5	83	2	33	1	17	3	50	3	50	1	17	15
Time	0	0	0	0	0	0	0	0	0	0	0	0	7
Photo Speed	0	0	0	0	0	0	0	0	1	25	0	0	7
Velocity	2	33	1	17	2	33	2	33	1	17	0	0	8
Energy	3	50	0	0	4	67	4	67	0	0	0	0	9
TOTAL USED	8		7		7		7		8		5		

Legend:
A = Number of activities representing 30 or more percent participation by members of the occupations interviewed
% = Percentage of activities representing 30 or more percent participation by members of the occupation interviewed
n = Number of people interviewed within each occupation

Appendix E provides a data source for the reader to construct a composite analysis of significant customary measurement competencies by utilizing any additional desired significant percentages based upon individual needs. Included in Appendix E are the full tables (Table 17-Table 19) representing the total responses as recorded in each interview.

A comprehensive listing of each specific measurement activity, tool, and term which comprises the measurement headings as shown in the left-hand column of Tables 8-13 is also available in Appendix E.

The reported data for Tables 8-13 included in this chapter reflect two factors:

1. Due to an unequal number of respondents interviewed within each occupation, only those competencies which represent 30 percent or more participation by members of the particular occupation were considered significant and reported as such under column A or T whichever applies.

2. Due to an unequal number of items per competency heading, the reported percentages reflect those which represent 30 percent or more participation by members of the occupation for the available items under each heading.

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Since a major objective of this research was to determine where and the extent to which a particular occupation conducts measurement activities, a review of Table 8 will locate for each occupation the customary measurement activity headings most used in each job. Linear measuring activities (using distances, sizes, etc.) were conducted under all the identified occupational titles within the study. Of the total available linear measuring activities, a majority of the occupations indicated the use of 33 or more percent for their respective jobs. Linear measuring activities were the only activities cited by all the surveyed occupations.

Weight and its determination thereof was identified as being utilized by eleven of the total nineteen occupations. A large number of the occupations involved, however, reported using only one or 14 percent of the possible weight measurement activities. All of the press occupations, imposition and lockup, camera, and bindery occupations reported the use of weight measurement activity in their jobs.

Temperature-derived measuring activities were identified as being used in all but three occupations; layout and design, imposition and lockup, and pasteup occupations. Camera operators, gravure platemakers, and bindery operators used between 33-44 percent of

the available temperature-related activities. Temperature information was thus important to a majority of the listed occupations.

The determination and use of pressure was widely used among the bindery and press occupations. Percentages ranging between 60 and 90 percent were indicated for all pressmen excluding the screen process group which reported a 20 percent activity usage. Evidence of a minor number of pressure-related activities was also indicated for numerous other occupations as well.

Eight occupations reported the measurement of dry volume being conducted as a part of their job requirements. Of a possible four measurement activities incorporating the use of dry volume measurement, a majority of the eight occupations cited utilized one or 25 percent of the available activities. Liquid capacity and adjoining measurement was a significant activity for fifteen of the nineteen total occupations. Several of the press and plate occupations showed evidence of heavy usage while numerous others seemed to indicate limited needs in this area. It was apparent that both volume and capacity were used among the occupations and hence will be of importance in a metric conversion education program.

The calculation and measurement of time was conducted in seven of the researched occupations. It should be noted that this activity involved more than the cursory use of a time piece merely to establish the time of day. The activities specified within the interview instrument required the use of calculations involving units of time. Table 8 indicates that virtually all of the occupations utilizing photographic emulsions have denoted a large percentage of time measuring activities as a part of their job. The measurement of time will be one of the few activities which will not change in a conversion to SI.

Measuring activities encompassing the use of photographic speed represented a similar reporting percentage as those under the time heading. Only minor differences in responding occupations were reported between the two headings even though the items listed within each heading reflect different activities.

Included under the heading of velocity, eight occupations showed evidence of usage needs and activity. All the press occupations reported some form of velocity measurement as a prerequisite function for their job performance. None of the occupations depended heavily on such activities since most reported using only one out of a possible six activities.

The measurement of energy was reported as a necessary activity in nine of the total nineteen occupations. Pressmen and platemakers tended to dominate here with most of the specified occupations reporting between 33 and 67 percent usage of the available activities. The manipulation and control of energy through appropriate measuring activities found frequent usage by members of the gravure platemakers, gravure pressmen, and flexographic pressmen. They reported using 67 percent of the listed energy measurement activities. Table 8 now assumes the identity of Matrix II and thus completed in part objective two.

Measurement Tools Used by Selected Graphic Arts Occupations

Table 9 is a composite analysis of significant customary measurement tools which were used by selected occupations within the printing industry. Significance has been accorded to any measurement tool reportedly used by 30 percent or more of the persons interviewed within each occupation. Reference to the columns of measurement tools and frequency of usage by the various occupations gives the reader basis for comparison of similarities and differences both within and across the selected occupations.

Tools which were used to determine linear distances received frequent usage by the study respondents. Each of the occupations surveyed reported using one or more such tools. Several of the occupations used four or more linear measurement devices. Generally, the

TABLE 9

COMPARATIVE PERCENTAGES OF SIGNIFICANT CUSTOMARY MEASUREMENT TOOL HEADINGS WITH OVER 30 PERCENT PARTICIPATION OF 19 OCCUPATIONAL TITLES IN THE PRINTING INDUSTRY

Customary Measuring Tool Heading	Total Tools Available	Layout & Design Artist		Hot Metal Compositor		Strike-on & Photo Compositor		Imposition & Lockup		Pasteup & Copy Preparation		Stripper		Camera Operator Black & White		Offset Platemaker		Letterpress Platemaker		Flexographic Platemaker		Gravure Platemaker		Screen Process Platemaker		Offset Pressman sheet fed		Offset Pressman web fed		Letterpress Pressman		Flexographic Pressman		Gravure Pressman		Screen Process Pressman		Bindery & Finishing Operator		Total Occupations Responding
		n=6		n=4		n=6		n=3		n=7		n=6		n=8		n=6		n=3		n=3		n=3		n=3		n=7		n=4		n=5		n=3		n=3		n=4		n=6		n=19
		T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	
Linear	6	4	67	4	67	3	50	4	67	3	50	4	67	4	67	4	67	3	50	1	17	4	67	2	33	2	33	3	50	3	50	3	50	3	50	2	33	2	33	19
Thickness	9	1	11	4	44	1	11	3	33	0	0	0	0	0	0	2	22	6	67	2	22	2	22	1	11	3	33	5	56	2	22	6	67	6	67	3	33	3	33	16
Time	2	0	0	0	0	1	50	0	0	0	0	0	0	1	50	1	50	1	50	1	50	1	50	1	50	0	0	0	0	0	0	0	0	1	50	1	50	0	0	9
Liquid Cap.	3	0	0	0	0	2	67	0	0	0	0	0	0	2	67	2	67	3	100	0	0	2	67	2	67	2	67	2	67	1	33	3	100	3	100	2	67	1	33	13
Weight	2	0	0	1	50	0	0	1	50	0	0	0	0	0	0	1	50	0	0	1	50	1	50	2	100	1	50	1	50	1	50	1	50	1	50	1	50	1	50	13
Temp. & Humid.	3	0	0	2	67	2	67	0	0	0	0	0	0	1	33	1	33	3	100	2	67	2	67	1	33	1	33	1	33	0	0	1	33	2	67	1	33	0	0	13
Angles	4	3	75	0	0	2	50	1	25	2	50	2	50	2	50	0	0	0	0	0	0	3	75	3	75	0	0	0	0	0	0	0	0	0	0	1	25	0	0	9
Light-Density	6	0	0	0	0	1	17	0	0	0	0	1	17	5	83	4	67	1	17	0	0	4	67	2	33	2	33	2	33	0	0	1	17	1	17	0	0	0	0	11
Power	4	0	0	0	0	1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	25	0	0	0	0	1	25	0	0	1	25	2	50	0	0	0	0	5
Pressure	2	0	0	1	50	0	0	0	0	0	0	0	0	0	0	0	0	1	50	1	50	1	50	0	0	1	50	1	50	0	0	1	50	2	100	0	0	0	0	8
Vacuum	1	0	0	0	0	0	0	0	0	0	0	0	0	1	100	1	100	0	0	0	0	1	100	1	100	1	100	1	100	1	100	1	100	1	100	1	100	1	100	11
TOTAL USED		3		5		8		4		2		3		7		8		7		6		11		9		8		9		5		9		10		8		5		

Legend:
T = Number of tools representing 30 or more percent participation by members of the occupation interviewed
% = Percentage of tools representing 30 or more percent participation by members of the occupations interviewed
n = Number of people interviewed within each occupation

platemakers, pressmen, and bindery operators used fewer linear measuring devices than the occupations concerned with preparing art work, composition, and negatives. Linear measuring devices represent the only tools used by all of the listed occupations in Table 9.

Devices and tools for measuring thickness also represented a high frequency of usage. Sixteen of the total nineteen occupations employed the use of some form of a thickness measuring instrument. Four of the press occupations in particular indicated usage of between 56 and 67 percent of the nine listed tools included under this heading.

Nine occupations used a mechanical timing device in the performance of occupational duties. As noted earlier, all occupations using photographic emulsions employed the use of timers and timing devices. Since time and its notation will not change upon SI metric measurement implementation, all tools and devices incorporating its use thereof will remain unchanged.

Further review of Table 9 denotes the fact that thirteen occupations identified a significant usage percentage for tools under the separate headings of liquid capacity, weight, and temperature and humidity. Liquid measurement devices found notable use in all of the press occupations and a wide dispersion among several others. Any occupations which process photo emulsions listed these tools as being significant in their work.

The determination of weight through the use of a spring scale was reported by thirteen occupations. Occupations which were involved in the plate production and press areas were noted as users of such equipment. A wide disparity was evident in the quality and accuracy of the scales this researcher saw in the various plants. The fact was obvious, however, that a majority of the graphic arts occupations did use devices to determine weight even though at times certain tradesmen were oblivious to the lack of accuracy in such determinations.

The effects of temperature and humidity on the total printing process can have wide-spread ramifications regarding the production sequence. Thirteen occupations used at least one measurement device related to the measurement of either temperature or humidity in their immediate work area. On a number of occasions opinions were expressed regarding the importance of control and measurement in this area when, in fact, very few tradesmen were able to regulate and change temperature or humidity at their work station. Press occupations and photo compositors were conscious of a need for measuring equipment and controls of temperature and humidity.

Measuring aids and tools which could be used to work with angles and determine accurate measurements of them were found to be used by nine occupations. Predominant use occurred in the occupations which precede the making of plates. Exceptions, however, indicate that the gravure and screen process platemakers used 75 percent or three of the four tools listed as common tools of their trade. The lack of angular measurement tools within the ranks of the press occupations was evident with only screen process pressmen reporting the usage of one such device.

Of the eleven trades reporting the use of tools and aids designed to measure light and density, the camera operators showed a significant percentage for five of the six listed devices, or 83 percent. A slightly lower figure of 67 percent was reported for the offset and gravure platemakers in their use of such equipment. All of the press occupations except letterpress pressmen showed a significant percentage under this heading.

Regarding tools which could be utilized to measure power, only five of the designated occupations showed a response. Of these respondents, four of the occupations showed a minimal use of one tool or 25 percent of the total listed on the survey instrument. A common explanation for this low percentage which was frequently cited was the fact that, even though many of the occupations were concerned with power and its precise measurement, most trades people simply relied on maintenance and repair personnel to make such measurements and adjustments.

In assessing the use of devices related to the measurement of pressure, eight occupations reported the use of at least one. The majority of those reporting were classified under the plate and press occupational titles. The tool most commonly cited was the pressure gauge.

The survey instrument listed a single tool under the heading of vacuum. Eleven occupations indicated a significant percentage of usage for a vacuum gauge which was utilized in most platemaking and pressroom occupations. Camera operators and bindery operators also reported the use of the same device. Table 9 may thus assume the identity of Matrix III as it has now partially completed the second major objective of the study.

Measurement Terms Used by Selected Graphic Arts Occupations

Table 10 is a composite analysis of significant customary measurement terminologies which were utilized by selected occupations within the printing industry. Significance has been accorded to any measurement term reportedly used by 30 percent or more of the persons

TABLE 10

COMPARATIVE PERCENTAGES OF SIGNIFICANT CUSTOMARY MEASUREMENT TERMINOLOGY HEADINGS WITH OVER 30 PERCENT PARTICIPATION OF 19 OCCUPATIONAL TITLES IN THE PRINTING INDUSTRY

Customary Measuring Terminology Heading	Total Terms Available	Layout & Design Artist		Hot Metal Compositor		Strike-on & Photo Compositor		Imposition & Lockup		Pasteup & Copy Preparation		Stripper		Camera Operator Black & White		Offset Platemaker		Letterpress Platemaker		Flexographic Platemaker		Gravure Platemaker		Screen Process Platemaker		Offset Pressman sheet fed		Offset Pressman web fed		Letterpress Pressman		Flexographic Pressman		Gravure Pressman		Screen Process Pressman		Bindery & Finishing Operator		Total Occupations Responding
		n=6		n=4		n=6		n=3		n=7		n=6		n=8		n=6		n=3		n=3		n=3		n=3		n=7		n=4		n=5		n=3		n=3		n=4		n=6		n=19
		T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	T	%	
Linear	12	9	75	9	75	9	75	10	83	6	50	6	50	4	33	1	8	4	33	2	17	4	33	2	17	2	17	5	42	7	58	2	17	4	33	2	17	4	33	19
Thickness	6	3	50	2	33	0	0	3	50	0	0	1	17	2	33	3	50	2	33	2	33	4	67	1	17	4	67	4	67	2	33	3	50	4	67	3	15	3	50	17
Time	5	0	0	2	40	3	60	3	60	2	40	3	60	3	60	3	60	0	0	2	40	4	80	3	16	3	60	3	60	2	40	3	60	3	60	2	40	2	40	17
Weight	5	2	40	0	0	1	20	3	60	0	0	0	0	1	20	2	40	0	0	2	40	2	40	2	40	3	60	4	80	3	60	4	80	4	80	2	40	4	80	15
Area	6	2	30	2	33	3	50	3	50	2	33	2	33	1	17	2	33	1	17	2	33	1	17	2	35	0	0	0	0	1	17	1	17	2	33	2	33	0	0	16
Temperature	4	0	0	1	25	1	25	0	0	0	0	0	0	1	25	1	25	1	25	1	25	2	50	1	25	1	25	0	0	1	25	1	25	1	25	1	25	0	0	13
Liquid Cap.	6	3	50	0	0	4	67	2	33	0	0	0	0	4	67	5	83	5	83	1	17	6	100	4	67	4	67	4	67	1	17	6	100	5	83	4	67	4	67	16
Power	3	0	0	2	67	1	33	0	0	0	0	0	0	1	33	0	0	1	33	1	33	1	33	0	0	2	67	2	67	1	33	3	100	3	100	1	33	1	33	13
Pressure	2	0	0	1	50	0	0	0	0	0	0	0	0	0	0	1	50	1	50	1	50	0	0	0	0	2	67	0	0	1	50	2	100	2	100	0	0	1	50	9
Vacuum	1	0	0	0	0	0	0	0	0	0	0	0	0	1	100	1	100	0	0	0	0	1	100	0	0	0	0	1	100	0	0	0	0	0	0	1	100	1	100	6
Velocity	2	0	0	0	0	1	50	0	0	0	0	0	0	1	50	1	50	0	0	0	0	1	50	0	0	1	50	2	100	1	50	2	100	2	100	1	50	1	50	11
Flow	2	0	0	0	0	0	0	0	0	0	0	0	0	1	50	1	50	1	50	0	0	1	50	0	0	0	0	0	0	0	0	2	100	2	100	0	0	0	0	6
Miscellaneous	5	2	40	1	20	1	50	1	20	1	20	1	20	2	40	1	20	2	40	0	0	2	40	1	20	3	60	2	40	1	20	2	40	1	20	2	40	1	20	18
TOTAL USED		6		8		9		7		4		5		12		12		9		9		12		8		10		9		11		12		12		11		10		

Legend:
T = Number of terms representing 30 or more percent participation by members of the occupations interviewed
% = Percentage of terms representing 30 or more percent participation by members of the occupations interviewed
n = Number of people interviewed within each occupation

interviewed within each occupation. Reference to the columns of measurement terms and frequency of usage by the various occupations gives the reader basis for comparison of similarities and differences both within and across the selected occupations.

Terminology which was used to communicate and denote linear measurement received frequent usage by all of the occupations which were studied. Significant percentages for particular terms under the linear heading received responses ranging from a high of 83 percent by the imposition and lockup trade to a low of 8 percent by the offset platemakers. Seven of the total nineteen occupations used 50 percent or more of the twelve linear measurement terms listed on the interview instrument. Linear terminology was used heavily by the occupations which were concerned with generating art work and composition or primarily those occupations which precede the production of printing plates. Note should also be made of the fact that both letterpress pressmen and the related imposition and lockup trades showed a high percentage factor for many of the unique linear measuring terms common only to this particular method of printing. Contemporary printing processes did not reflect a comparable number of highly significant percentages for this linear terminology heading.

Because of the nature of its basic process, the printing of an image on a variety of different surfaces must contend with the measurement and control of thickness. As such, seventeen of the investigated occupations used terminologies which denote thickness in some manner. All of the press occupations reported between 50 and 67 percent usage of the stated thickness terms. It should be noted that several of the thickness terms represent different words with synonomous meanings. In several instances occupational trade jargon employed the use of a specific word with a certain meaning, while another occupation utilized a second word to convey the same thickness designation. The terms "thousandths" and "mils" were cited as examples of such an occurrence.

Table 10 also indicates that terminology which was used to designate time received a large response from the various occupations. Seventeen trade areas used significant percentages of the terms under the time heading as a part of their work performance in on-the-job settings.

The communication of weight either through manipulation or interpretation was used by fifteen of the various occupations. Several of the press occupations showed a 60 percent or more usage rate for terms involving weight. Minor numbers of weight terms were found in other isolated occupational situations.

Terminology denoting area was reportedly used by sixteen of the total nineteen occupations. Predominant usage occurred in several of the occupations which produced pre-press operations and materials. The composition areas of both hot metal and photo composition indicated a significant 50 percent usage listing.

All but one of the reporting thirteen occupations using terms relating to temperature indicated that they used a single term in a significant amount. The term "Fahrenheit" appeared to be the only customary designation among the occupations for conveying temperature communication.

Response to the use of liquid capacity terms was widespread among the occupations under study. Six different terms were listed with one occupation reporting the use of all six. An 83 percent significance rating was produced by offset and letterpress platemakers and gravure pressmen while seven other occupations used four or 67 percent of the total available choices. A frequent use of liquids in a majority of the selected occupations accounted for such high usage percentages regarding this terminology grouping.

Of the three available choices regarding terms denoting power, thirteen occupations used a minimum of one on their job. With a heavy concentration in the plate and press area, the composition occupations also reported a need for such terminology. As previously noted in Table 9, only five of the occupations reported using tools to measure power; however, the evidence from Table 10 suggests a need of at least thirteen occupations to communicate using power-related terms.

The terms relating specifically to pressure and vacuum are reportedly used by nine and six of the respective occupations. Under the pressure heading, a majority of the occupations which make plates and operate presses utilized terms germane to pressure.

A contradiction of note was apparent when comparing responses dealing with vacuum tools and vacuum terms. Table 9 pointed out that eleven occupations reported using a vacuum gauge as a tool while Table 10 relayed that only six occupations used the term "inches of mercury" correctly in reference to vacuum applications.

The headings labeled velocity and flow represent similar measurement terms. Under the velocity heading eleven occupations indicated a significant percentage while the flow heading was cited by six occupations as being used as a part of the occupational terminology. Velocity terminology denoting speed was used mainly by the press and bindery trades. Flow terminology, which usually denotes cubic volume movement, was used by platemakers and gravure and flexographic pressmen.

The final measurement term heading of "miscellaneous" included five rather diverse terms: "durometer," "gamma," "ream," "ph," and "degrees" of an angle. So placed because of their incompatability under any of the previous headings, each term represents an isolated example of an endless array of terms that could be listed but are so specific in nature that little if any interconnection exists across the occupations.

Eighteen occupations cited one of the above terms as significant while offset pressmen indicated a usage of three of the terms as listed. Further analysis of a particular occupation's response to any of the above terms may be obtained from Appendix E, Table 19. Table 10 may now assume the identity of Matrix IV as it has fulfilled in part the second major objective of the study.

Summary of Occupational Groups Regarding Commonality of Customary Measurement Competencies

Tables 11-13 present data for nineteen occupational titles as combined into seven comprehensive groups. Each of the three tables reported percentage data relative to areas of commonality both within and across the occupational groups for customary measurement activities, tools, and terms.

The reported data were obtained by initially combining each of the individual nineteen occupations into appropriate groups as designated in Table 3. An arithmetic average was then derived by combining the significant percentage entries across the occupations within a group for each measurement heading as reported in Tables 8-10.

Occupations providing the composition of the seven groups are as follows:

Group I - Layout and Design Artist

Group II - Hot Metal Compositor
Strike-on and Photo Compositor

Group III - Imposition and Lockup Person
Pasteup and Copy Preparation Person
Lithographic Stripper

Group IV - Camera Operator - Black and White

Group V - Offset Platemaker
Letterpress Platemaker
Flexographic Platemaker
Gravure Platemaker
Screen Process Platemaker

Group VI - Sheet-fed Offset Pressman
Web-fed Offset Pressman
Letterpress Pressman
Flexographic Pressman
Gravure Pressman
Screen Process Pressman

Group VII - Bindery and Finishing Operator

Table 11 indicates that as a group, layout and design artists utilized only linear measuring activities in significant numbers in performing their job. Group II, or the composition occupations, used all of the measuring activities except weight and dry volume

TABLE 11

A PERCENTAGE COMPARISON OF SIGNIFICANT CUSTOMARY MEASUREMENT ACTIVITIES WITH OVER 30 PERCENT PARTICIPATION FOR SEVEN GRAPHIC ARTS OCCUPATIONAL GROUPS

Customary Measuring Activity:	Group I n=6	Group II n=10	Group III n=16	Group IV n=8	Group V n=18	Group VI n=27	Group VII n=6
Linear	58	38	47	33	38	38	33
Weight	0	0	4	17	9	21	14
Temperature	0	9	2	39	20	21	11
Pressure	0	10	10	20	22	68	50
Dry Volume	0	0	0	25	15	21	0
Liquid Cap.	0	17	6	17	30	67	17
Time	0	50	33	100	70	0	0
Photo. Speed	0	20	13	80	80	4	0
Velocity	0	9	0	66	0	25	0
Energy	0	17	6	33	20	28	0
TOTAL USED:	1	8	8	10	9	9	5

Legend:

Group I = Layout and Design
Group II = Composition
Group III = Pasteup, Lockup, and Stripping
Group IV = Camerawork
Group V = Platemaking
Group VI = Presswork
Group VII = Bindery and Finishing

n = Total number of tradesmen interviewed

measurement. The occupations comprising Group III used all the measuring activities except those involving measurement of dry volume and velocity.

Groups IV and V were composed of camera occupations in IV and platemaking in Group V. Both groups indicated a significant usage percentage in all of the listed measurement activity headings.

The presswork occupations, which make up Group VI, reported using every measuring activity heading with the exception of the time heading. The bindery and finishing people of Group VII indicated a significant usage of measuring activities in the following areas: linear, weight, temperature, pressure, and liquid capacity measurement.

Table 12 indicates that Group I employed the use of only three different forms of measuring tools: linear, thickness, and tools to measure angles. Group II utilized measurement tools in each category with the exception of vacuum measurement devices.

In Group III less than 50 percent of the listed headings indicated a significant percentage. This group employed tools for measuring linear distance, thickness, weight, angles, and light or density. Camera operators from Group IV indicated a need for tools in seven of the eleven headings available. The press and platemaking occupations displayed a significant usage percentage

TABLE 12

A PERCENTAGE COMPARISON OF SIGNIFICANT CUSTOMARY MEASUREMENT TOOLS WITH OVER 30 PERCENT PARTICIPATION FOR SEVEN GRAPHIC ARTS OCCUPATIONAL GROUPS

Customary Measuring Tool	Group I n=6	Group II n=10	Group III n=16	Group IV n=8	Group V n=18	Group VI n=27	Group VII n=6
Linear	67	58	61	67	47	44	33
Thickness	11	27	11	0	29	47	33
Time	0	25	0	50	50	17	0
Liquid Cap.	0	33	0	67	60	72	33
Weight	0	25	17	0	50	50	50
Temp.-Humid.	0	67	0	33	60	33	0
Angles	75	25	41	50	30	4	0
Light-Density	0	9	6	83	37	17	0
Power	0	13	0	0	30	42	0
Pressure	0	25	0	0	30	42	0
Vacuum	0	0	0	100	60	100	100
TOTAL USED:	3	10	5	7	11	11	5

Legend:

Group I = Layout and Design
Group II = Composition
Group III = Pasteup, Lockup, and Stripping
Group IV = Camerawork
Group V = Platemaking
Group VI = Presswork
Group VII = Bindery and Finishing

n = Total number of tradesmen interviewed

in all of the measuring tool categories. Numerous percentages exceed the 50 percent mark which would indicate heavy reliance upon certain tools by these two occupational groups.

The bindery and finishing group (Group VII) recorded significant data in five of the eleven tool headings. Only one heading reached the 50 percent usage level thus indicating a minor role for measurement tools within this occupational group.

The significant usage of measurement terms as reported for the occupational groups in Table 13 shows a moderate response for Group I. This layout and design group communicated measurement terminology in the areas of linear, thickness, weight, liquid capacity and two in the miscellaneous listing. Occupations involving the composition trades (Group II) exhibited a need for measurement terms in eleven of the thirteen separate headings. They reported no need for terms under the vacuum and flow headings.

Group III displayed a significant response for over 50 percent of the terminology headings. One category, linear, reported a 61 percent usage factor whereas the remaining six categories showed significant percentages of lower than the 55 percent mark.

The camera operators (Group IV) did not show a use of measurement terms under the pressure heading.

TABLE 13

A PERCENTAGE COMPARISON OF SIGNIFICANT CUSTOMARY MEASUREMENT TERMS WITH OVER 30 PERCENT PARTICIPATION FOR SEVEN GRAPHIC ARTS OCCUPATIONAL GROUPS

Customary Measuring Terminology	Group I n=6	Group II n=10	Group III n=16	Group IV n=8	Group V n=18	Group VI n=27	Group VII n=6
Linear	75	75	61	33	22	31	33
Thickness	50	16	22	33	40	56	50
Time	0	50	53	60	48	53	40
Weight	40	10	20	20	32	67	80
Area	30	41	39	17	27	17	0
Temperature	0	25	0	25	30	21	0
Liquid Cap.	50	33	11	67	70	67	67
Power	0	50	0	33	17	67	33
Pressure	0	25	0	0	30	53	50
Vacuum	0	0	0	100	40	33	100
Velocity	0	25	0	50	20	75	50
Flow	0	0	0	50	30	33	0
Miscellaneous	40	35	20	40	24	37	20
TOTAL USED:	6	11	7	12	13	13	10

Legend:

Group I = Layout and Design
Group II = Composition
Group III = Pasteup, Lockup, and Stripping
Group IV = Camerawork
Group V = Platemaking
Group VI = Presswork
Group VII = Bindery and Finishing

n = Total number of tradesmen interviewed

All other headings indicated a significant percentage for this group of tradesmen. Both Group V and VI reported measuring terminology needs in every heading used in the instrument. Several of the areas showed percentages in excess of 67 percent, thus indicating large-scale usage.

Bindery and finishing operators (Group VII) indicated using ten of the thirteen available listings. Terms relating to area, temperature, and flow were omitted from their occupational needs while the remaining terminologies were reported as receiving significant usage. Tables 11, 12, and 13 may now assume the partial identity of Matrix VI. Yet to be included within this completed matrix is the aspect of commonality regarding SI metric group needs. Table 15 in the forthcoming chapter will provide this information.

Discussion

Unequal numbers of measurement activity, tool, and term headings in the appropriate left-hand columns of Tables 8-10 are the result primarily of instrument modification throughout the interview process. Suggestions were often made as to the correct labeling of specific measurement items. The researcher attempted to weave pertinent modifications into the instrument design wherever substantive changes would not alter or change the data collection. As such, Table 8 employs ten headings, Table 9 employs eleven headings, and Table 10 employs thirteen headings. The same information is contained throughout; however, the precise labeling may differ across the individual tables.

In surveying the accumulated data results presented in the previous chapter, several aberrations seem apparent. When comparing the total number of terms in Table 10, representing 30 or more percent participation of the interviewed occupations across all the occupations, the reporting rate is quite high. These same occupations, however, show far lower totals for the corresponding headings which involve specific measuring activities and measuring tools listed in Tables 8 and 9.

This difference in total numbers between knowing and using measurement terminology and using the accompanying measurement tools may be accounted for in part by a frequent observation of the study respondents. They often cited the fact that many sophisticated measurement devices and tools were used by specialized maintenance people and not by the printing tradesmen during equipment repair and setup. Thus a graphic arts trades person may have to communicate by using specific measurement terminology on the job and not exhibit a need for related measurement tools and activities as an integral function of that same occupation.

An example of such a difference can be located by referring to Tables 9 and 10. Five separate occupations reported the use of tools related to measuring power in Table 9. This same power measurement heading in Table 10 reveals, however, that thirteen occupations used power-related terminology in performing occupational duties. It is thus apparent that eight occupations used measurement terms pertaining to power but used no tools to measure it.

While collecting the data for this research, the researcher was impressed by the fact that most of the unique linear measuring terms ("picas," "points," etc.) common to the historical letterpress production printing process were no longer used among many of the contemporary processes. Table 19, Appendix E, indicates that the letterpress oriented imposition and lockup trade and the letterpress press occupations reported strong usage of the traditional measuring terms. These same terms received only cursory use by camera operators and those occupations primarily concerned with lithographic and screen process printing.

By combining the nineteen individual occupations as researched in this study into seven major groups, Tables 11, 12, and 13 reveal a further point of interest. Tables 12 and 13 indicate that both Groups V and VI (platemaking and presswork) utilized the highest total of measurement tools and terms, while they did not conduct the highest number of measurement activities. The camera group (Group IV) reported, however, usage of measurement activities in every heading of Table 11 while in Table 12 this group reported using fewer measuring tools than the composition, platemaking and presswork groups.

It thus becomes apparent that every occupational group is not necessarily consistent in its reported needs for equal representation under each of the customary measurement activities, tools, and terminologies sections within the instrument.

Contingent upon the findings of the survey instrument data analysis are the remaining matrices of this analysis model. Chapter IV has reported the findings as summarized from the in-plant interviews conducted by this researcher. Data have now established the principle occupations which compose the graphic arts industry, how these occupations conducted measurement activities, which measurement tools were significant, and the significant measurement terms as used by the researched skilled trades. Further, this chapter has reported data relative to commonality among occupational groups regarding customary measurement activities, tools, and terminologies as used in the graphic arts industry. The ensuing discussion segment of this chapter focuses on several apparent breaches in the measurement competencies which were reported by the selected occupations. Note should also be made that Matrices II, III, and IV have now been completed in this chapter with the development of the final metric-related matrices to yet be accomplished in Chapter V.

CHAPTER V

TOTAL MODEL UTILIZATION

This chapter includes a detailed description of the final model application resulting from the previously reported data collection matrices. Documented within Chapter IV were the quantitative aspects of this analysis model. Yet remaining for consideration within this chapter are the model components that serve as necessary prerequisites for the implementation of an SI metric industrial educational program. As a transitional device, Matrix V will present a projected inventory of SI metric units pertinent to the selected graphic arts occupations investigated within this study. The as yet uncompleted matrix, Matrix VI, will establish areas of commonality for SI metric training among the selected occupational groups. Matrix VII will then elaborate on the needed SI metric level of attainment needed specifically for each occupation. Accompanying a general discussion of the total model concept will be appropriate general and specific performance objectives suggested for an SI metric instructional program in the graphic arts.

Discussion of the Findings

As a prelude to further model development and utilization, a brief examination of the findings thus far would seem imperative. Placed in simple perspective, this model was primarily concerned with developing an efficient analysis approach to a very practical matter: an industrial SI metric changeover. Once the parameters of the problem were defined, an analysis model structure which would lay bare the requirements of the primary objectives was deemed necessary. The first four matrices have in fact established the prerequisites of determining who is involved, what is measured, how is measurement accomplished, and how measurement is communicated within the printing industry. All of the above objectives and matrices have endeavored to determine the status quo by presenting the quantitative aspects of this analysis model. The remainder of the chapter will address the issue of a viable SI metric instructional program based on the preceding matrices.

The importance and relevance of Matrices V and VII are focused upon the fact that all previous data collection procedures are now culminated into this conversion effort. Previous matrices have ascertained customary measurement competencies of the industry under consideration. Matrices V and VII now synthesize the previous findings and report the projection of SI metric measurement educational needs for the graphic arts occupations under study. Matrix V specifically attends to the third major objective of study by identifying SI metric measurement competencies to be needed in each selected occupation. Matrix VII completes objective five by identifying necessary levels of attainment for SI metric competency in each selected occupation.

Matrix V--An Inventory of Projected SI Metric Measurement Units Needed in Selected Graphic Arts Occupational Titles

Matrix V of this measurement analysis model is composed of two interrelated segments. Table 14 presents information directly pertaining to SI metric measurement units and multiples thereof and the projected use of these SI units by the nineteen investigated occupations within the graphic arts industry. A second table (Table 15) summarizes, into a consolidated inventory, the common SI metric units and where the seven comprehensive occupational groupings will find a needed use for the projected metric units. Additionally, Table 15 is also unique in that it completes the commonality aspect of Matrix VI.

Table 14 is derived and maintains its genesis purely through the interpretation of previously collected data by this researcher. Tables 8-13 were used by this investigator to determine within the confines of the SI

TABLE 14

AN INVENTORY OF PROJECTED SI METRIC MEASUREMENT UNITS AND SUBUNITS FOR USE IN NINETEEN SELECTED GRAPHIC ARTS OCCUPATIONS

	I	II		III			IV	V					VI						VII
SI Metric Measurement Units and Subunits / *OCCUPATIONAL TITLES*	Layout & Design Artist	Hot Metal Compositor	Strike-On & Photo Compositor	Imposition & Lockup	Pasteup & Copy Preparation	Stripper	Camera Operator Black & White	Platemaker - Offset	Letterpress	Flexographic	Gravure	Screen Process	Pressman - Offset - sheet fed	Offset - web fed	Letterpress	Flexographic	Gravure	Screen Process	Bindery & Finishing Operator
LENGTH	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
kilometre																			
metre[a]																			
centimetre																			
millimetre																			
THICKNESS:	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
millimetre																			
micrometre																			
MASS:	x	x	x	x		x	x		x	x	x	x	x	x	x	x	x	x	x
megagram or metric ton[b]																			
kilogram[a]																			
gram																			
milligram																			
TEMPERATURE:		x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x
degree Celsius																			
kelvin[a]																			
TIME:		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
hour[c]																			
minute[c]																			
second[a]																			
millisecond																			
microsecond																			

[a]Base Unit

[b]Acceptable alternative

[c]While hours and minutes are not SI units, they are acceptable alternatives for measures of time.

TABLE 14--Continued

SI Metric Measurement Units and Subunits / OCCUPATIONAL TITLES	I	II		III			IV	V					VI						VII
	Layout & Design Artist	Hot Metal Compositor	Strike-On & Photo Compositor	Imposition & Lockup	Pasteup & Copy Preparation	Stripper	Camera Operator Black & White	Platemaker - Offset	Letterpress	Flexographic	Gravure	Screen Process	Pressman - Offset - sheet fed	Offset - web fed	Letterpress	Flexographic	Gravure	Screen Process	Bindery & Finishing Operator
AREA:	x	x	x	x	x	x	x	x	x	x	x	x			x	x	x	x	x
hectare																			
square metre																			
square centimetre																			
square millimetre																			
VOLUME:	x	x	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x
cubic metre																			
cubic decimetre or litre[b]																			
cubic centimetre or millilitre[b]																			
PRESSURE:		x		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
kilopascal																			
VELOCITY:			x				x	x			x	x	x	x	x	x	x	x	x
kilometre per hr.																			
metre per minute																			
metre per second																			
FORCE:													x	x	x	x	x	x	x
newton																			
ENERGY & WORK			x			x	x		x		x		x	x		x	x		
kilojoule																			
joule																			
kilowatt-hour[b]																			

[b]Acceptable Alternative

TABLE 14--Continued

SI Metric Measurement Units and Subunits / *OCCUPATIONAL TITLES*	I	II		III			IV	V					VI						VII
	Layout & Design Artist	Hot Metal Compositor	Strike-On & Photo Compositor	Imposition & Lockup	Pasteup & Copy Preparation	Stripper	Camera Operator Black & White	Platemaker - Offset	Letterpress	Flexographic	Gravure	Screen Process	Pressman - Offset - sheet fed	Offset - web fed	Letterpress	Flexographic	Gravure	Screen Process	Bindery & Finishing Operator
POWER:		x	x				x		x	x	x		x	x	x	x	x	x	x
kilowatt																			
watt																			
TORQUE:		x		x					x	x	x		x	x	x	x	x	x	x
newton-metre																			
VISCOSITY:											x		x	x	x	x	x	x	x
(kinematic) metre squared per sec.																			
DENSITY:													x	x	x	x	x		x
kilogram per cubic metre																			
gram per litre																			
FLOW: Air										x	x			x		x	x		
cubic metre per second																			
ANGLES:	x		x	x	x	x	x				x	x						x	
degrees[b]																			
ILLUMINATION:			x			x	x		x	x	x	x	x	x				x	
lux (lumen per square metre)																			

[b]Acceptable non-SI unit

TABLE 14--Continued

SI Metric Measurement Units and Subunits / OCCUPATIONAL TITLES	I	II		III			IV	V					VI						VII
	Layout & Design Artist	Hot Metal Compositor	Strike-On & Photo Compositor	Imposition & Lockup	Pasteup & Copy Preparation	Stripper	Camera Operator Black & White	Platemaker - Offset	Letterpress	Flexographic	Gravure	Screen Process	Pressman - Offset - sheet fed	Offset - web fed	Letterpress	Flexographic	Gravure	Screen Process	Bindery & Finishing Operator
ELECTRIC CURRENT:		x	x				x	x	x		x		x	x		x	x		x
ampere[a]																			
milliampere																			
TOTAL USED:	6	11	14	9	4	9	14	10	13	13	17	11	16	17	14	17	17	15	15

[a]Base Unit

metric system, which occupations needed specific SI units to fulfill on-the-job measurement requirements. Each occupation was reviewed to ascertain its use of customary activities, tools, and terms for which an SI metric unit equivalent was to be identified. Every significant percentage response was reviewed in the aforementioned tables. Wherever a response was recorded for any customary measuring activity, tool, or term an appropriate metric conversion unit was set forth in Table 14.

This metric matrix is unprecedented in the sense that only minor validity can be accorded to it since no industrial graphic arts effort has yet begun to initiate a metric conversion. As such, validation was attempted by seeking review and advisory efforts from currently acknowledged SI metric practioners to avoid error and legislate a measure of reliability into this projection. After the initial table was constructed by this researcher, a copy was distributed to three nationally recognized groups currently engaged in assisting U.S. industrial metric conversion efforts (see Appendix C). Only one copy was distributed among these groups with the intention that collectively each could improve upon the others' alterations. Where appropriate, the adjustments were blended into Table 14 as presented in this analysis model.

Table 14 proposes only the projected SI units relevant to the printing occupations and is selective in suggesting realistic multiples and sub-multiples for graphic arts occupational use. Appendix A presents a comprehensive display of the interrelationships between all of the SI base units and derivations thereof including prefixes and common conversion factors. Consideration shall now be given to the analysis of Table 14 and its contents.

The base unit of linear measurement in the international metric system is the metre. Accompanied by appropriate prefixes, the metre can represent large and small distances. The graphic arts occupations as listed in Table 14 are projected to all require a need for measurement competencies with regard to the measurement of length. The measurement of thickness, using subdivisions of the metre, is projected to be a requirement necessary for predominately all occupations except the pasteup-copy preparation people.

Three occupations did not exhibit a projected need for an occupational use regarding the unit of mass: pasteup-copy preparation, strippers, and letterpress platemakers. Mass is simply defined as the quantity of matter in an object. Often confused with the customary measurement unit of weight, mass negates the effects of gravitational pull and thus is measured accurately in grams by using a balance.

The measurement of temperature provides another radical departure from customary measurement practices. Use of the Celsius scale, formerly called centigrade, places the freezing point of water at its zero mark and a temperature of 100 degrees is assigned to the boiling point of pure water at one standard atmosphere of pressure. The intervening scale is divided into 100 equal parts. Three occupations did not utilize temperature in performing their jobs: layout and design artist, imposition-lockup, and pasteup-copy preparation and hence have no need for training in this area.

The determination of time is related specifically to all graphic arts occupations except the layout and design artist. The measurement of time will remain the same in SI metric and hence presents no transition problems for the trades under study.

A majority of the graphic arts occupations indicated a projected need for the measurement of area as is shown in Table 14. Both the square metre and square millimetre should find common application among many of the investigated occupations. Principally founded on the metre, the measurement of area should present no immediate conflicts with current customary procedures.

The determination of volume under the new SI metric system is shown to be excluded from only two occupations: pasteup-copy preparation and stripping. Volume is used to measure and designate the amount of space occupied by solids, liquids, and gases. Volume is literally the measurement of enclosed space and is generally denoted through cubic divisions of the metre. By combining dry and liquid volume, the metric system will require a restructuring of many customary terms and practices.

An understanding for and a use of the unit of pressure will not be vital to the occupations of layout and design artist, strike-on and photo composition, and pasteup-copy preparation. The word "pressure" is used to indicate a force acting over a specified area. In the SI metric system the basic unit of force is the newton. Coupled with the square metre, these units express pressure in the form of pascals.

A related unit, force, is shown by Table 14 to be projected for SI metric use in all of the presswork occupations and bindery operations. The unit of force denotes a push or pull and is called a newton.

The measurement of speed or velocity in SI metric requires only a change in terminology as related to current customary speed measurement. Projected for use in twelve of the nineteen occupations investigated, velocity measurement is merely the product of combining distance traveled in a specified amount of time: e.g. metre per second.

Table 14 reveals that eleven of the total nineteen occupations will need competence in occupational use of the SI metric designation for energy. Energy can be defined as the capacity for performing work or the energy expended when a force acts through a distance. Since force is expressed in newtons and distance in metres, work and energy have units of newton-metres, properly called joules. The concept of power is identified for use in thirteen graphic arts occupations. Closely allied to work and energy, power is defined as work done in a given time. Hence, in metric units, power is computed in units of joules per second and is defined as watts of power. The power output of all mechanical and electrical devices will now be expressed in watts thus eliminating terms such as "horsepower," "calories," etc.

Highly specialized SI metric units dealing with torque, viscosity, density, and flow are likely to be required only in isolated occupations. Table 14 pinpoints projected occupational usage under each appropriate SI metric heading. Of the occupations proposed to need training under the above headings, most occur under either the platemaking or presswork grouping.

The remaining metric units in Table 14 pertain to angular and electrical measurement. No major changes are currently proposed to alter the present customary measurement practices involving industrial applications of these metric units.

A review of the row summarizing the total number of SI units projected for use by the various occupations reveals a need for metric training in seventeen of nineteen units for three presswork occupations and gravure platemaking. The pasteup-copy preparation group is shown to have a small projected need of four units and thus should require a minimal amount of occupational education regarding industrial SI metric use. Thus, in partially completing Matrix V, Table 14 has presented projected metric applications that are likely to occur within the selected graphic arts occupations.

In completing the second portion of Matrix V, Table 15 presents a condensed inventory of SI metric measurement units as proposed by this researcher for use in seven graphic arts occupational groups. Each comprehensive occupational group, as previously defined in Table 3, is identified along with a corresponding projection with regard to SI metric measurement unit requirements. An examination of Table 15 will be included under the Matrix VI heading immediately following.

Matrix VI--A Determination of the Areas of Commonality for Customary and SI Measurement-Related Competencies of Selected Graphic Arts Occupational Titles

Maintaining a unique dual identity, Table 15 addresses the SI metric needs of Matrix V and the commonality needs of Matrix VI. As such, a review of the "total used" row reveals that as a group, press occupations (Group VI) will require competence in more SI metric units than any other group. The platemaking (Group V), composition (Group II), camera (Group IV), and bindery (Group VII) occupational groups follow in decreasing rank order by exhibiting needs ranging from sixteen to thirteen SI units. Each of the aforementioned occupational groups, however, has a need for a slightly different SI metric emphasis in its occupational application of the new measurement system as indicated by the SI metric unit column in Table 15.

Two remaining groups, layout and design (Group I) and the pre-camera, lockup, and stripping occupations (Group III) will need only minimal readjustment efforts. Showing measurement competency needs in six and four units, respectively, each occupational group should find learning and using the metric system to be only a minor inconvenience for future on-the-job performance due to the low number of occupational measurement applications.

The SI metric measurement units which were reported for use in five or more of the occupational

TABLE 15

AN INVENTORY OF SI METRIC MEASUREMENT UNITS AS PROPOSED FOR USE IN SEVEN GRAPHIC ARTS OCCUPATIONAL GROUPS

SI Metric Measurement Units	Group I	Group II	Group III	Group IV	Group V	Group VI	Group VII
Length	x	x	x	x	x	x	x
Thickness	x	x		x	x	x	x
Mass	x	x		x	x	x	x
Temperature		x		x	x	x	x
Time		x	x	x	x	x	x
Area	x	x	x	x	x	x	
Volume	x	x		x	x	x	x
Pressure		x		x	x	x	x
Velocity		x		x	x	x	x
Force						x	x
Energy-Work		x		x	x	x	
Power		x		x	x	x	x
Torque		x			x	x	x
Viscosity						x	x
Density						x	x
Flow					x	x	
Angles	x	x	x	x	x		
Illumination		x		x	x		
Electric Current		x		x	x	x	
TOTAL USED	6	15	4	14	16	17	13

Legend:

Group I = Layout and Design; Group II = Composition; Group III = Pasteup, Lockup, and Stripping; Group IV = Camerawork; Group V = Platemaking; Group VI = Presswork; Group VII = Bindery and Finishing.

groups in Table 15 are: length, thickness, mass, temperature, time, area, volume, pressure, velocity, power, and angles. The metric units pertaining to force, energy-work, torque, viscosity, density, flow, illumination, and electric current were indicated as necessary measures for less than five occupational groups.

In completing Matrix V, Table 15 has presented a summarized listing of pertinent SI metric measurement units, thereby completing the third major objective of the analysis model. The fourth major objective of this study has likewise been fulfilled in that a determination of the areas of commonality for customary and SI metric measurement related competencies have now been identified across seven occupational groups. A fifth objective, which relates to SI attainment levels for the occupations in question, is focused upon through the use of Matrix VII.

Matrix VII--A Determination of Appropriate SI Levels of Attainment Needed by Selected Graphic Arts Occupational Titles

The culminating matrix of this measurement analysis model is provided as an example to enable virtually any industry to isolate specific knowledge levels considered important in a metrication effort. Upon establishment of the precise nature of measurement competence and usage within an industry, the potential metrication effects must be considered. The change to SI metric measurement will affect virtually all occupations in some manner. The probable impact on each employee is likely to vary from minor to significant. Coupled with the inherent natural resistance to change and the uniqueness of the knowledge involved, the importance of proper communication and appropriate education loom large. Not only will people need metric training prior to occupational usage but they will need training at a level commensurate with their identified occupational measurement competencies.

Matrix VII presents the projected SI metric knowledge levels of attainment for the selected graphic arts occupations as studied within this dissertation. Being principally derived from definitions as proposed by Wong in an IBM working paper on metrication, these levels ascertain a point of departure for metric program planning, analysis, and development.[1]

The four levels, ranging from low to high, were identified as: (1) awareness, (2) conceptual, (3) working, and (4) developmental.[2] Each knowledge level serves a prerequisite function for its predecessor, thus creating a learning sequence designed to progress from simple memorization of facts to conceptual development at the highest level.

The awareness level was designed primarily to accommodate the unskilled occupations within an industry. These occupations perform little if any measurement on the job. A training program which emphasizes the frequently used base units and rudimentary SI metric terminology for use in a conversion application should serve the needs of this group adequately. This level embodies strictly an awareness of the SI metric changeover and aids in a literal conversion of units by emphasizing the use of reference charts, conversion calculators, and similar devices.

The conceptual knowledge level was concerned with internalization of simple base unit concepts. Occupations which require measurement usage on a nominal basis will find placement at this level. The ability to readily convert from customary to metric measures, usage of communicating measurement information in an occupational role, and a need for marginal measurement competencies identify occupations requiring placement at this knowledge level. Minimal dependence upon conversion techniques and gadgets should be stressed at this level.

The working knowledge level identifies occupations readily utilizing measurement competencies in their daily job role. This attainment level presupposes the importance of the individual and his ability to internalize the specifics of SI metrication. Performance of metric communication practices, understanding the entire system pertinent to his or her occupational role, and utilization of measurement manipulation with specific tools, all determine occupational placement at this level.

The final level, developmental, dominates all others by accentuating a composite need for cognitive, affective, and psycho-motor aspects of learning and using the impending metric system. Placement at this level isolates occupations which initiate research oriented measurement-related concepts. In a definitive sense, measurement is the major component of the occupation. Hence, the need for problem-solving abilities via measurement applications of the SI system specify placement of an occupation at this particular level.

The placement at a specific level for each of the nineteen occupations included within this study is presented in Table 16. Procedures which were used to determine such placement by this researcher include the following:

1. A determination of the quantity or frequency of customary measurement competencies as reported in Matrices II, III, and IV;

2. An analysis of the job requirements as related to the attainment level definitions;

3. The researcher's perception of the nature of the job activities as gathered in conducting the job interviews.

TABLE 16

PROJECTED LEVELS OF ATTAINMENT NEEDED BY SELECTED GRAPHIC ARTS OCCUPATIONAL TITLES

Occupational Title	Awareness Level	Conceptual Level	Working Level	Developmental Level
Layout and Design Artist		x		
Hot Metal Comp.		x		
Strike-on and Photo Compositor			x	
Imposition and Lockup		x		
Pasteup and Copy Preparation		x		
Stripper		x		
Camera Operator			x	
Offset Platemaker		x		
Letterpress Plate.			x	
Flexographic Platemaker			x	
Gravure Platemaker			x	
Screen Process Platemaker		x		
Sheet-fed Offset Pressman			x	
Web Offset Press.			x	
Letterpress Press.			x	
Flexographic Press.			x	
Gravure Pressman			x	
Screen Process Press.			x	
Bindery and Finishing Operator			x	

Table 16 indicates evidence that all of the skilled trades included in this study should be placed under either the conceptual or working attainment levels. Each selected job exhibits measurement competencies which exceeded the bounds of the lowest or awareness level. Designed to acquaint primarily unskilled personnel with metrication, the awareness level was not appropriate as a terminal point for metric education activities within the investigated occupations of the graphic arts.

Seven occupations were judged to require SI metric competencies unique to the conceptual level of attainment. Included here were the occupations of: (1) layout and design artist, (2) hot metal compositor, (3) imposition and lockup, (4) pasteup-copy preparation, (5) stripper, (6) offset platemaker, and (7) screen process platemaker.

A majority of the occupations studied were clustered under the working level of attainment. Exhibiting a need for metric communication, manipulation, and conceptualization of major segments of the SI scheme were the following occupations: (1) strike-on and photo compositor, (2) camera operator, (3) letterpress platemaker, (4) gravure platemaker, (5) flexographic platemaker, (6-11) all presswork occupations, and (12) bindery and finishing operators.

The lack of response at the developmental level can be attributed to the fact that none of the listed occupations performed occupational duties related to the defined limits of this attainment level.

The results of this segment of the measurement analysis model (Matrix VII) have indicated some job-level differences in competency achievement necessary to gain a working grip on the metric system. Based upon the guidelines as presented earlier, it was possible to identify occupational attainment levels which seemed appropriate for teaching various phases of the SI metric system to industrial workers in the printing industry. Though all four levels were not specifically germane to the printing industry, they were presented here as necessary segments of the full model which may be applied elsewhere.

Suggested General Performance Objectives

The concluding objective of this analysis model called for the construction of sample performance objectives suitable for implementation activities at the predetermined levels of attainment used within this study. In an effort to present workable model objectives for the different industrial metrication knowledge levels, recognition of several factors became important. A vast array of intellectual differences and requirements

is likely to be encountered. By patterning performance objectives to mesh with the appropriate knowledge levels as previously defined, a utilitarian metric program is likely to result. Conducive metric learning environments must be cognizant of performance objectives which endeavor to: (1) relate a metric changeover to one's occupation, (2) accommodate factual memorization, (3) encourage measurement manipulation and understanding, (4) promote conceptual changes, and (5) encourage problem solving through the use of a new measuring concept.

A significant effort must be maintained to blend reasonable amounts of cognitive, affective, and psychomotor concerns into a metric education program for working adults. The suggested general performance objectives are mated to each level of knowledge, with the cumulative result being that each level is superimposed upon its predecessor in building block fashion. Not intended to be all inclusive, these objectives are provided as representative examples suitable for SI implementation activities.

The suggested general performance objectives for the awareness, conceptual, working, and developmental levels are as follows:

A. AWARENESS LEVEL

Upon completing one in-service session the employee will be able to:

1. state three reasons for changing from customary to SI measurement

2. identify three personal occupational benefits resulting from changing to SI

3. define the term "metrication"

4. identify five base units of SI

5. identify and define three common base unit prefixes

6. operate and read SI conversion aids and reference charts.

B. CONCEPTUAL LEVEL

Upon completing two in-service sessions the employee will be able to:

1. fulfill all objectives of the awareness level

2. define and recognize the SI base units

3. define and recognize commonly used SI metric derived units

4. define and recognize acceptable alternative non-SI units

5. spell and properly punctuate SI metric units

6. define and recognize common SI metric symbols

7. define and use common prefix notation scheme

8. demonstrate arithmetic skills utilizing decimals

9. apply calculations in determining length, mass, and area

10. read SI metric literature with comprehension

11. perform common metric writing practices

C. WORKING LEVEL

Upon completing three in-service sessions the employee will be able to:

1. fulfill all objectives of the awareness and conceptual level

2. state a rationale regarding how SI metric measurement implements the concept of standardization

3. perform SI metric computational techniques regarding rounding of numbers etc.

4. define the characteristics of specialized SI units needed in his or her particular occupational setting

5. manipulate specialized SI units common to a particular occupation

6. demonstrate an ability to think metric versus maintaining a reliance upon conversion techniques

7. use metric tools and equipment

8. interpret metric drawings and instructions.

D. DEVELOPMENTAL LEVEL

Upon completing three in-service sessions the employee will be able to:

1. fulfill all the objectives of the awareness, conceptual, and working levels

2. apply principles of customary measurement toward invention within SI metric units

3. problem solve using metrication as a measurement source

4. communicate in speciality areas of measurement research and design

Applicability of these and numerous other general objectives pertinent to learning the metric system can be utilized for any pre-service or in-service industrial education program. The specificity of each can be condensed or broadened to enable realistic fulfillment by employees or students of the occupations in question. A discussion involving a series of specific objectives follows.

Examples of Specific Performance Objectives

The Michigan Department of Education through the Vocational Education and Career Development Service recently established a performance objective model for maintaining a high level of specificity with regard to writing vocational performance objectives.[3] Three criteria were cited as necessary components for inclusion within an acceptable vocational performance objective to enable it to communicate the following:

1. what the learner will do (performance)
2. under what circumstances will the learner perform (conditions)
3. how well must the learner perform (criteria).[4]

The objective model was constructed to subdivide itself into two segments: an introductory statement and the listing of specific performance objectives. The following performance objective examples were provided as a guide for structuring a total learning package involving specific occupations at predetermined metric attainment levels and were derived by utilizing the above model.

At the "conceptual" attainment level:

1. Introductory statement

By the end of the second conceptual level SI metric instructional session, the tradesman employed as a hot metal compositor will have the following skills, understandings, and attitudes as measured by a teacher-made test:

2. Specific performance objectives

   a. With the aid of any available metric conversion calculator or chart this employee will be able to define and identify in writing all eleven SI metric units and symbols common to his/her occupation

   b. With the aid of any metric conversion device this employee will be able to correctly complete three arithmetic calculations in determining length, mass, area using SI metric units within a ten-minute period.

At the "working" attainment level:

1. Introductory statement

   By the end of the third working attainment level SI metric instructional session, the tradesman employed as a sheet-fed offset pressman will have the following skills, understandings, and attitudes as measured by a teacher-made test:

2. Specific performance objectives

   a. Given three sheets of paper of varying thickness, this employee will be able to determine the thickness of each sheet in millimetres using a metric micrometer with accuracy to the nearest tenth of a millimetre.

   b. Given a customer order for 5,000 sheets of A4 size paper, this employee will be able to calculate exactly how many A0 size sheets are needed to fill the order requirements excluding waste.

The above objectives provide a workable approach to careful planning for a metric instructional program and were developed to emphasize the importance of

forethought in connection with metric conversion efforts. Haphazard, untimely, and ill-prepared instructional sessions involving the metric system will more than ever create undue hardships for industrial employees. Well—written specific performance objective statements, as included within this analysis model structure, could adroitly serve to foster meaningful learning outcomes.

The entire framework and components of this measurement analysis model are now complete. The appropriate matrices have been constructed to enable a systematic review of an industry's measurement needs to go forward. Simple, yet functional, elements of the model have allowed the researcher to ascertain specifics regarding measurement applications in a typical industrial setting. Transitional SI metric measurement units were suggested as a means toward fulfillment of a successful metric instructional program involving a potential reluctant adult population. General and specific performance objectives suitable for future program guideposts were presented as examples of the formal educational planning which must precede a sound metric education attack.

Matrices V, VI, and VII were formalized according to the appropriate major objectives of the study. Additionally, a sixth objective focusing on performance objectives was completed outside the formal confines of the model but yet within its realm.

CHAPTER V--NOTES

[1]Wong, "IBM Goes Metric," p. 3.

[2]Ibid., p. 4.

[3]Michigan Department of Education, Vocational Education and Career Development Service, "Guidelines for the Performance Objectives Development Project," by Philip T. Bailey, David H. Bland, and Dan Brown, September, 1972, p. 30.

[4]Ibid., p. 31.

CHAPTER VI

SUMMARY, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

In this chapter, the dissertation study is summarized and pertinent conclusions derived from the model application are stated. Selected implications of the study for implementation of pre-service and in-service education programs are then considered. The final section of this chapter presents recommendations for further study regarding the implementation of additional considerations for teaching the SI metric system to adult industrial workers.

Summary

The general purpose of this study was to develop a model which could be used to determine metric measurement competencies for selected industrial occupations. More specifically, the study applied a measurement analysis model aimed at identifying customary measurement competencies used within a specific industry in an effort

to isolate and project necessary SI metric content suitable for use in pre-service and in-service industrial education programs.

The study was carried out within the state of Michigan during the summer of 1974 and involved nineteen occupations selected from within the graphic arts industry. Twelve participating firms provided a source for ninety-one personal interviews by the researcher. An instrument was constructed which assessed the needs and uses of customary measurement activities, tools, and terminologies of the trades people interviewed.

Factors which were applied in identifying participating firms for inclusion within the study were: (1) number of skilled personnel employed in specific occupations, (2) diversity and complexity of plant operations, (3) predominant method of production, (4) production volume, (5) geographical location, and (6) the major industry classification.

In determining and assessing future SI metrication needs, this analysis model identified six major objectives:

1. Conduct an occupational analysis of an industry and subdivide its work force into appropriate occupational titles;

2. Identify present customary measurement competencies used within each occupation;

3. Identify corresponding SI metric measurement competencies needed for each occupation;

4. Establish the extent of commonality of customary and SI metric measures among occupational groups;

5. Identify necessary levels of attainment for SI metric competency in each occupation; and

6. Recommend appropriate examples of performance objectives suitable for implementation of instructional activities at predetermined levels of attainment.

The following measurement analysis model matrices were constructed to fulfill the major objectives of the study:

Matrix I. Who is involved?
"An inventory of occupational titles occurring in selected major industry classifications"

Matrix II. What is measured?
"An inventory of customary measurement activities occurring in selected occupational titles"

Matrix III. How is customary measurement accomplished?
"An inventory of the predominant customary measurement tools used by selected occupational titles"

Matrix IV. How is customary measurement communicated on the job?

"An inventory of customary measurement terminologies occurring in selected occupational titles"

Matrix V. How does measurement take place in the SI metric system?

"An inventory of the projected SI metric measurement units needed in selected occupational titles"

Matrix VI. What commonality exists?

"A determination of the areas of commonality for customary and SI metric measurement-related competencies of selected occupational titles"

Matrix VII. What are the projected training needs?

"A determination of appropriate levels of attainment needed for selected occupational titles"

Figure 2 is a duplicate graphic representation as shown in Chapter I relating the above six major objectives of the study to the seven analysis model matrices.

Development of the above matrices was accomplished by designing the study to proceed in a

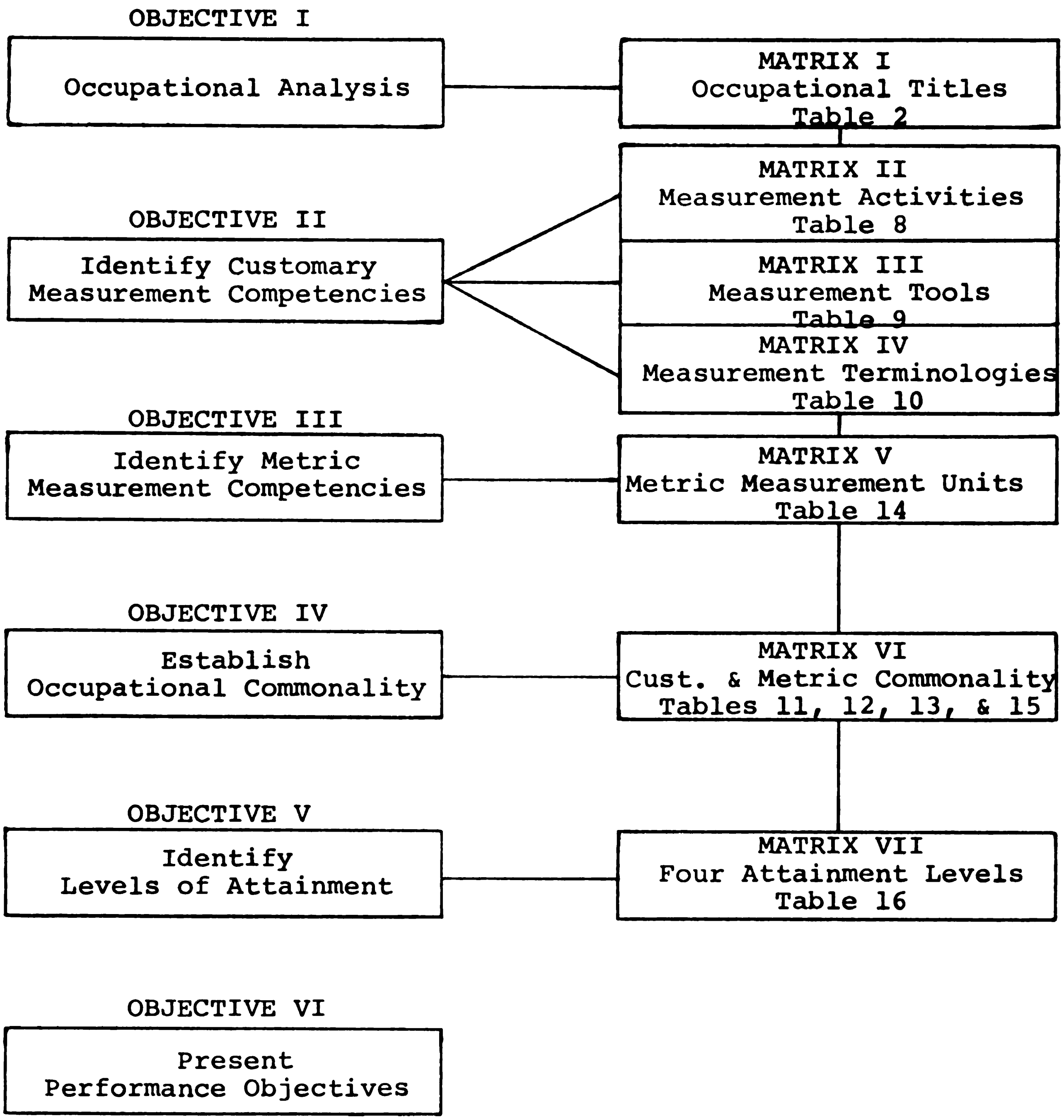

Fig. 2. A graphic presentation relating the six major objectives of the study to the seven analysis model matrices

predetermined sequence, thus creating a systematic flow of information. These model development procedures were:

1. A general review of literature and related research;

2. A review and identification of selected occupational titles providing data to fulfill objective one and complete Matrix I;

3. Construction of an analysis instrument containing appropriate customary measurement activities, tools, and terminologies utilized within an industry to provide data for Matrices II, III, and IV;

4. Validation of the instrument;

5. Identification of companies participating in the generation of data;

6. Collection of data through interviews and observation visitations;

7. Processing and tabulating data to complete objective two which included Matrices II, III, IV;

8. Utilization of the remaining model components to complete the accompanying metric-related Matrices V, VI, and VII through data analysis procedures thereby completing objectives three, four, and five;

9. Validation of the SI metric matrix by appropriate metric organizations;

10. An analysis of the complete model and its implications for future use including representative performance objectives as called for in the sixth and final major objective of the study.

Conclusions

Based upon the results obtained from applying this measurement analysis model to a specific industry, conclusions are drawn in two general areas. Those conclusions which address the nature of the model structure itself and conclusions which may be garnered through having the model applied to a specific group of occupations within the graphic arts industry.

Conclusions relating to the model structure and its general applicability are as follows:

1. The work force of an industry can be subdivided into appropriate occupational titles.

2. Measurement competencies can be analyzed and identified by isolating activities, tools, and terminologies in actual occupational settings.

3. An occupation may exhibit different responses across identical measurement competency headings: i.e. an occupation may use measurement terminology involving power but use no power-related measuring

tools or activities. The occurrence of such differences may prove valuable for directing the focus of future SI metric measurement training.

4. Differences and commonalities in the measurement needs of each occupation are readily identified by this analysis model. Such an analysis substantiates specific competencies and establishes the precise application of measurement under each job title.

5. Occupations can be clustered according to measurement needs and find common placement in coherent groups to receive SI metric training. Time and finances virtually mandate such action and a model structure such as this coordinates common occupational objectives for learning the metric system.

6. Upon establishment of the customary measurement competencies for an occupation, comparable SI metric equivalents can be determined. Generally assumed to be cumbersome and voluminous in nature, this model has shown the SI equivalents to be concise and relatively uncomplicated for many of the occupations involved within this study.

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7. Differentiated metric competency levels are identifiable, thus allowing specific occupational placement and accommodation of needs for each selected occupation or occupational grouping.

8. The inherent simplicity of the model structure as a means of fulfilling the six major analysis objectives has proven quite adequate in addressing a complicated problem: identification of industrial metrication education needs for adults.

As a vehicle for this initial metric model application, the graphic arts industry was used as a data source. The following conclusions are drawn as a product of this specific graphic arts industrial research and are assumed to pertain to the nineteen occupations as researched in this study:

1. Pressmen, as a group, should receive an in-depth exposure to SI metrics as they exhibit the greatest need for occupational measurement.

2. Pasteup-copy preparation, imposition and lock-up, and stripping occupations should require the least amount of SI metric training when compared to the other occupations researched in this study.

3. SI metric measures involving length and thickness, mass, temperature, area, volume, and pressure should receive strong emphasis in graphic arts metrication instructional programs for the occupations researched in this study.

4. SI metric measures including force, viscosity, density, and flow should receive isolated recognition and emphasis only where pertinent for a particular occupation.

5. For the graphic arts occupations studied, three levels of knowledge competency, as previously defined, are necessary to insure success in the transition between customary and SI metric measurement. These levels are the awareness level, the conceptual level, and the working level.

6. To fulfill the objectives of this analysis model, the factors which were used to identify the study participants in the printing industry proved quite satisfactory and provided a rational and operational data source.

Implications of the Model Application

The development of metric skills and conceptual understandings in occupational settings can be accomplished when adults participate in related instructional

activities which are founded upon a discernible needs structure. This measurement analysis model lends stability to such a structure. The model provides a measure of precision to a training program ultimately concerned with the precise measurement of physical quantities.

If forced or cajoled into compliance, the tradesmen are likely to resist. To be sure, the metric system has evoked a voluminous measure of debate. Much of this debate has so far been restricted to nontechnical situations and as yet has caused only minor speculation and conjecture at the tradesman level of industry. Resistance to the metric change could quickly become an emotional issue with tradesmen because for most, it will require a change regarding knowledge accumulated over a long period of time. Occupational groups with vested interests in long-standing knowledge and trade skills will now be required to venture into educational areas of uncertainty, which at best is considered to be a risky endeavor.

An analysis model such as this, which differentiates between occupational titles and measurement tasks, recognized that many trades are likely to have metric needs which differ in scope and depth. A unique tailoring of metric education to nurture the individual tradesman can greatly enhance motivation and interest toward learning this new measurement concept.

An important implication of this model structure relates to the data collection process. The interview method employed for the data collection in this study served the needs of this researcher well. Completion of the model matrices necessitated an instrument design which evolved into a lengthy device. By personally carrying such a device into the various plant situations, the researcher was readily available to respond to all questions posed by the participants. Further, the researcher was able to gain insights and understandings relative to the study participants and their work environments through this personal contact. Such insights contributed toward the formulation of Matrices V, VI, and VII.

Implications of further import regarding this analysis model stem from a concern for program flexibility. After the implementation of a measurement analysis within an industry, possible direction may be obtained relative to the timing of specific training programs. It is imperative that learning be timed to coincide with on-the-job reinforcement.[1] This may in turn legislate a need for flexibility regarding product conversion and more importantly, worker adjustment via metric education programs. Model-directed content, as has been illustrated within this study, may well determine a sequence for the presentation of metric information and thus help coordinate needs assessment and implementation activities. Only the minimum metric training for an occupation should be considered.[2] Over training will only cause confusion and needless hardship for many employees.

One further general implication of this study must be recognized. Pre-service education must grapple with this issue immediately. The circumstance of non-recognition of metric education by public school vocational and industrial educators would be inexcusable, particularly in light of rapidly increasing industrial metric in-service activity. By acting as a hands-on device, this model as applied here and potentially to similar industries could serve to initiate a curriculum pattern for metrication competencies.

Implications of this research which bear directly on the printing industry and its metrication needs would seem to indicate a call for action. As determined within this study, metric education for many of the investigated occupations within the graphic arts should be comprehensive and further involve each skilled trade within the industry to at least a minor degree.

Without question, this particular industry will be a necessary tool in a U.S. metric conversion effort. Untold amounts of printed communication, both new and old, will be generated to replace written customary measures with metric counterparts. Circumstances would be most unfortunate if the tradesmen involved in generating this new printed material did not understand and use SI metrics as a measurement language.

Recommendations for Implementation and Further Study

The results of this measurement analysis model point to a need for implementation and further research regarding the following:

1. Replication of this model using a different industry as an information source;

2. The inclusion of skilled maintenance and repair occupations within a metrication instructional program;

3. The usage of groups or clusters of related occupations as a replacement for studying numerous individual occupations when measurement analysis needs and competencies are being ascertained for an industrial metrication program;

4. A determination of motivational factors involved in adult conversion attitudes regarding occupational metrication;

5. A determination of teaching methods and materials which are appropriate for teaching the metric system to diverse occupational groups;

6. A determination of where prospective in-service metric trainers will receive metric training, materials, and facilities to conduct occupational metrication programs;

7. Replication of this basic model structure as a means of ascertaining the metric needs of supervisory and management-level people for the graphic arts industry;

8. A complete listing and delineation of appropriate specific performance objectives for potential metric instructional activities.

CHAPTER VI--NOTES

[1] Chalupsky, Crawford, and Carr, Going Metric, p. 86.

[2] Ibid., p. 86.

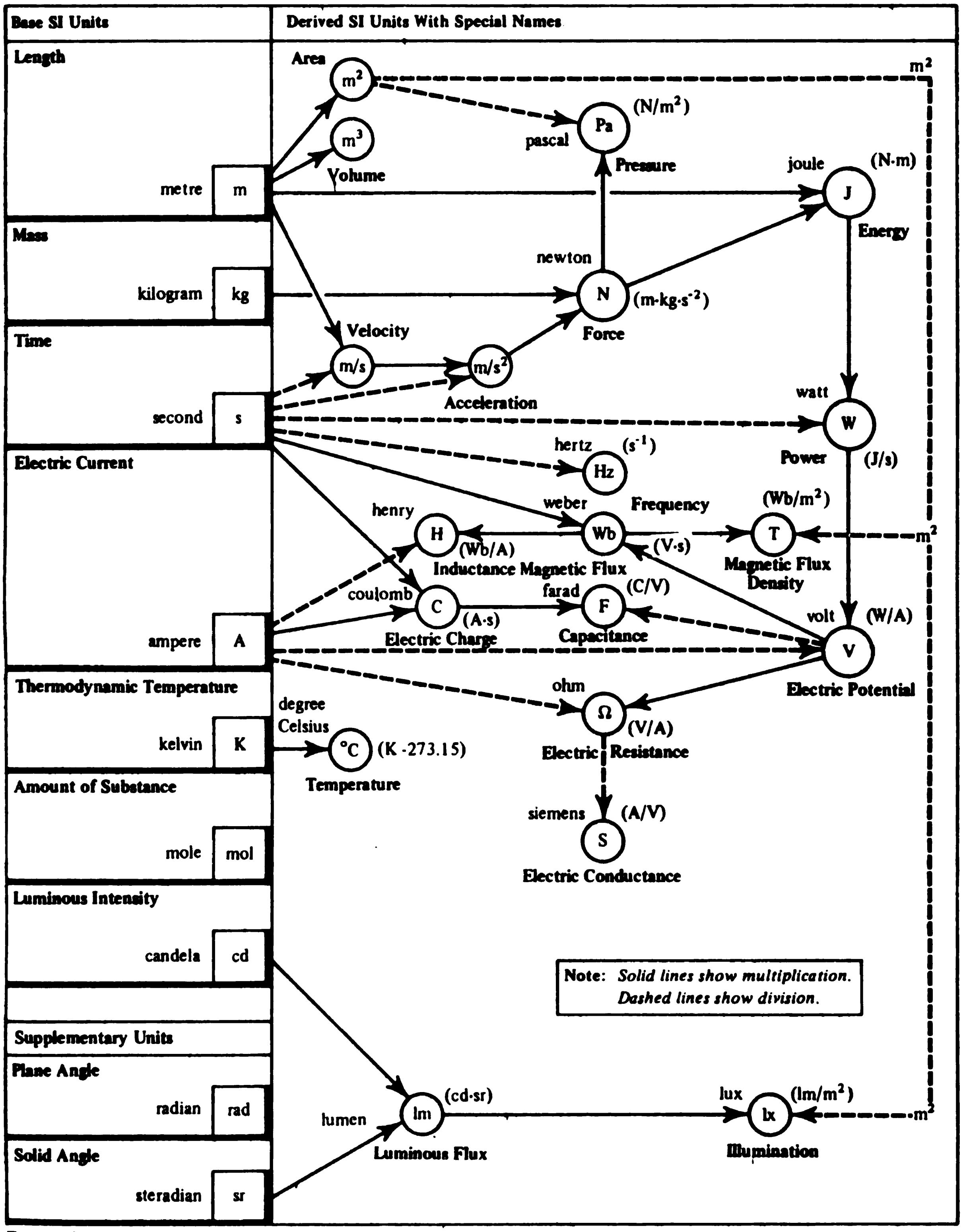
APPENDICES

APPENDIX A

SI METRIC UNITS, PREFIXES OF SI UNITS, AND COMMON METRIC CONVERSION FACTORS

APPENDIX A

SI Units



From "The Metric System" a 3-part article published 1972 in *Engineering Digest*, Toronto, Canada.

PREFIXES OF SI UNITS

Prefix	Symbol	Multiplication Factor	Definition
tera	T	1 000 000 000 000 = 10^{12}	One trillion times
giga	G	1 000 000 000 = 10^{9}	One billion times
mega	M	1 000 000 = 10^{6}	One million times
kilo	k	1 000 = 10^{3}	One thousand times
hecto	h	100 = 10^{2}	One hundred times
deka	da	10 = 10	Ten times
deci	d	0.1 = 10^{-1}	One tenth of
centi	c	0.01 = 10^{-2}	One hundredth of
milli	m	0.001 = 10^{-3}	One thousandth of
micro	μ	0.000 001 = 10^{-6}	One millionth of
nano	n	0.000 000 001 = 10^{-9}	One billionth of
pico	p	0.000 000 000 001 = 10^{-12}	One trillionth of

APPENDIX A

COMMON CONVERSION FACTORS

Quantity	Customary Unit	Metric Unit	Conversion Factors (Approximate): Customary to Metric Units	Conversion Factors (Approximate): Metric to Customary Units
LENGTH	inch (in)	millimetre (mm) or centimetre (cm)	1 in = 25.4 mm	1 mm = 0.0394 in. 1 cm = 0.394 in
	foot (ft)	centimetre or metre (m)	1 ft = 30.5 cm	1 m = 3.28 ft
	yard (yd)	metre (m)	1 yd = 0.914 m	1 m = 1.09 yd
	mile	kilometre (km)	1 mile = 1.61 km	1 km = 0.621 mile
	(for navigation)	international nautical mile (n mile)	1 n mile = 1852 m	
MASS	ounce (oz)	gram (g)	1 oz = 28.3 g	1 g = 0.353 oz
	pound (lb)	gram (g) or kilogram (kg)	1 lb = 454 g	1 kg = 2.20 lb
	ton	tonne (t)	1 ton = 1.02 t	1 t = 0.984 ton
AREA	square inch (in^2)	square centimetre (cm^2)	1 in^2 = 6.45 cm^2	1 cm^2 = 0.155 in^2
	square foot (ft^2)	square centimetre (cm^2) or square metre (m^2)	1 ft^2 = 929 cm^2	1 m^2 = 10.8 ft^2
	square yard (yd^2)	square metre (m^2)	1 yd^2 = 0.836 m^2	1 m^2 = 1.20 yd^2
	acre (ac)	hectare (ha)	1 ac = 0.405 ha	1 ha = 2.47 ac
	square mile	square kilometre (km^2)	1 square mile = 2.59 km^2	1 km^2 = 0.286 sq. mi.
VOLUME	cubic inch (in^3)	cubic centimetre (cm^3)	1 in^3 = 16.4 cm^3	1 cm^3 = 0.0610 in^3
	cubic foot (ft^3)	cubic metre (m^3)	1 ft^3 = 0.0283 m^3	1 cm^3 = 35.3 ft^3
	cubic yard (yd^3)	cubic metre (m^3)	1 yd^3 = 0.765 m^3	1 m^3 = 1.31 yd^3
	bushel (bus)	cubic metre (m^3)	1 bus = 0.364 m^3	1 m^3 = 27.5 bus
VOLUME (fluids)	fluid ounce (fl oz)	millilitre (ml)	1 fl oz = 28.4 ml	1 ml = 0.0352 fl oz
	pint (pt)	millilitre (ml or litre (l)	1 pt = 568 ml	1 litre = 1.76 pt
	gallon (gal)	litre (l) or cubic metre (m^3)	1 gal = 4.55 litre	1 m^3 = 220 gal
FORCE	pound-force (lbf)	newton (N)	1 lbf = 4.45 N	1 N = 0.225 lbf
	ton-force (tonf)	kilonewton (kN)	1 tonf = 9.96 kN	1 kN = 0.100 tonf

COMMON CONVERSION FACTORS (con't.)

PRESSURE	pound per square inch (psi)	kilopascal (kPa)	1 psi = 6.89 kPa	1 kPa = 0.145 psi
	atmosphere (atm)	kilopascal (kPa) or megapascal (MPa)	1 atm = 101 kPa	1 MPa = 9.87 atm
	ton per square inch (ton/in^2)	megapascal (MPa)	1 ton/in^2 = 15.4 MPa	1 MPa = 0.0647 ton/in^2
	(for meteorology) inch of mercury (inHg)	millibar (mbar)	1 inHg = 33.9 mbar	1 mbar = 0.0295 inHg
			1 mbar = 100 Pa	
VELOCITY	mile per hour (mph)	kilometre per hour (km/h)	1 mph = 1.61 km/h	1 km/h = 0.621 mph
	(for navigation)	knot (kn)	1 kn = 1.85 km/h	
TEMPERATURE	temperature (°F)	temperature (°C)	°C = 5/9 (°F - 32)	$°F = \frac{9 \times °C}{5} + 32$
DENSITY	pound per cubic inch (lb/in^3)	gram per cubic centimetre (g/cm^3) = tonne per cubic metre (t/m^3)	1 lb/in^3 = 27.7 t/m^3	1 t/m^3 = 0.0361 lb/in^3
	ton per cubic yard	tonne per cubic metre (t/m^3)	1 ton/yd^3 = 1.33 t/m^3	1 t/m^3 = 0.752 ton/yd^3
ENERGY	British thermal unit (Btu)	kilojoule (kJ)	1 Btu = 1.06 kJ	1 kJ = 0.948 Btu
	therm	megajoule (MJ)	1 therm = 106 MJ	1 MJ = 9.48 x 10^3 therm
	(for electrical energy)	kilowatt hour (kWh)	1 kWh = 3.60 MJ	
POWER	horsepower (hp)	kilowatt (kW)	1 hp = 0.746 kW	1 kW = 1.34 hp
TIME		second (s)		
		minute (min)	1 min = 60 s	
		hour (h)	1 h = 3600 s	

APPENDIX B

STANDARD INDUSTRIAL CLASSIFICATION OF THE PRINTING AND PUBLISHING INDUSTRY BY THE U.S. DEPARTMENT OF COMMERCE

APPENDIX B

STANDARD INDUSTRIAL CLASSIFICATION OF THE PRINTING AND PUBLISHING INDUSTRY BY THE U.S. DEPARTMENT OF COMMERCE

SIC No.	Industry	No. of Establish-ments	No. of Employees
2711	Newspaper Pub.	8,094	354,000
2721	Periodical	2,510	84,000
2731	Book Publishing	1,022	54,000
2732	Book Printing	744	45,200
2741	Misc. Printing	1,493	34,400
2751	Comm. Printing	12,098	173,500
2752	Comm. Lith. Printers	6,822	159,800
2753	Engraving & Plate	577	10,100
2761	Manifold Bus. Forms	542	38,000
2771	Greetings Cards	222	28,200
2782	Blank Books & Binders	444	24,200
2789	Book Binding	1,018	31,200
2791	Typesetting	1,535	27,100
2793	Photoengraving	735	13,800
2794	Electrotype & Stereo.	133	3,300

APPENDIX C

PANEL OF INSTRUMENT REVIEWERS AND METRIC REVIEWING AGENCIES FOR TABLE 14

APPENDIX C

PANEL OF INSTRUMENT REVIEWERS

1. Mr. Russell Hover
   Trade and Technical Teacher in vocational printing at the Michigan Rehabilitation Institute, Pine Lake, Michigan

2. Mr. Carl Gower
   Trade and Technical Teacher in vocational printing at the Michigan Rehabilitation Institute, Pine Lake, Michigan.

3. Mr. John Visser
   Printing Tradesman for 25 years at the Kalamazoo Gazette, Kalamazoo, Michigan.

4. Mr. Jack Richerts
   Printing Tradesman and foreman for 20 years in numerous commercial printing establishments.

5. Dr. Jack Simich
   Educational Director of the Graphic Arts Technical Foundation, Pittsburg, Pennsylvania.

6. Dr. William Schaeffer
   Director of Research for the Graphic Arts Technical Foundation, Pittsburg, Pennsylvania.

7. Dr. Jack Asher
   Director of Institutional Research, Western Michigan University, Kalamazoo, Michigan.

8. Dr. John Lindbeck
   Director, Center for Metric Education and Studies, Western Michigan University, Kalamazoo, Michigan.

METRIC REVIEWING AGENCIES FOR TABLE 14

1. National Bureau of Standards, Metric Information Office, Washington D.C.

2. American National Metric Council, Metric Practices Committee Member, Washington D.C.

3. Center for Metric Education and Studies, Western Michigan University, Kalamazoo, Michigan.

APPENDIX D

MEASUREMENT COMPETENCIES SURVEY FORM

FOR THE GRAPHIC ARTS INDUSTRY

APPENDIX D

MEASUREMENT COMPETENCIES SURVEY FORM
FOR THE GRAPHIC ARTS INDUSTRY

Time taken in interview________________ Code No.__________

Number of people interviewed________________ Date__________

I. GENERAL INFORMATION (from management personnel)

1. Business Name________________________________
2. Number of Employees 1 - 9_____, 10 - 25 _____, 26 - 50_____, 51 - 100_____, 101 - _____
3. Union ________, non-union ________, both ________
4. Geographical location ________________________________
5. What is the average number of years experience represented in your plant?________________
6. How do the skilled trades in your plant receive training?

_____ Trade union

_____ Trade association

_____ Company in-house program

_____ On-job-training

_____ Public schools

_____ Private schools

_____ other

II. MAJOR INDUSTRY CLASSIFICATION and OCCUPATIONAL TITLES

Directions: Record the number of skilled employees currently employed in each occupational title below.

	I	II		III			IV	V					VI						VII	
OCCUPATIONAL TITLE	Layout & Design Artist	Hot Metal Compositor	Strike-on & Photo Compositor	Imposition & Lockup Man	Pasteup & Copy Prep. Person	Stripper	Camera Operator - Blk. & White	Platemaker - Offset	Letterpress	Flexographic	Gravure	Screen Process	Pressman - Offset sheet fed	Offset web fed	Letterpress	Flexographic	Gravure	Screen Process	Bindery & Finishing Operator	TOTAL
MAJOR INDUSTRY CLASSIFICATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
Inplant Printing																				
General Commercial Printing																				
Trade Plant (typesetting, platemaking, etc.)																				
Newspaper Publishing																				
Packaging																				
Business Forms Printing																				

III. MEASUREMENT ACTIVITIES

Directions: Identify the measurement activities performed in on-the-job settings for each appropriate occupational title group that has been observed.

	I	II		III			IV	V					VI						VII	
MEASUREMENT ACTIVITIES / *OCCUPATIONAL TITLES*	Layout & Design Artist	Hot Metal Compositor	Strike-On & Photo Compositor	Imposition & Lockup	Pasteup & Copy Preparation	Stripper	Camera Operator Black & White	Platemaker - Offset	Letterpress	Flexographic	Gravure	Screen Process	Pressman - Offset - sheet fed	Offset - web fed	Letterpress	Flexographic	Gravure	Screen Process	Bindery & Finishing Operator	TOTAL
A. Linear Measurement																				
uses layout dimensions																				
uses basic paper sizes																				
calculates page sizes																				
measures line lengths																				
uses different film sizes																				
uses type sizes																				
calculates magnifications																				
determines f stops																				
uses screen rulings																				
measures type height																				
calculates vertical leading																				
performs copyfitting																				
determines page proportions																				
calculates margins & trims																				
calculates form impositions																				
measures linear distances																				
uses focal lengths																				
calculates & uses angles																				
calculates escapement values																				
uses tape calculations																				
establishes register marks																				
uses different plate sizes																				
uses imposing furniture																				
uses different mask sizes																				
uses various press sizes																				
measures roller diameters																				
measures roll diameters																				
measures plate etch depths																				
measures plate coating thickness																				
uses various fabric openings																				
measures screen dimensions																				
uses paper drill sizes																				
calculates paper stretch																				
locates folds & scoring rule positions																				
calibrates instruments																				
measures paper caliper																				

III. MEASUREMENT ACTIVITIES (cont.)

ACTIVITIES / OCCUPATIONAL TITLES	I	II		III			IV	V					VI						VII	
	Layout & Design Artist	Hot Metal Compositor	Strike-On & Photo Compositor	Imposition & Lockup	Pasteup & Copy Preparation	Stripper	Camera Operator Black & White	Platemaker - Offset	Letterpress	Flexographic	Gravure	Screen Process	Pressman - Offset - sheet fed	Offset - web fed	Letterpress	Flexographic	Gravure	Screen Process	Bindery & Finishing Operator	TOTAL
B. Weight Measurement																				
mixes ink components																				
calculates paper weights																				
calculates freight costs																				
calculates viscosity																				
weighs type metal & forms																				
weighs chemicals																				
weighs mail																				
C. Temperature Measurement																				
uses water temperature																				
determines chemical temperatures																				
monitors room temperatures																				
monitors relative humidity																				
uses temp. in platemaking																				
uses temperature-controlled storage																				
uses temp. sensitive emulsions																				
uses thermographic powders																				
calculates film drying																				
calculates print drying																				
uses hot stamping dies																				
applies heat sensitive adhesives																				
uses temperature in drying ink																				
uses color temperature of lights																				
regulate hot metal temperatures																				
vulcanizes rubber																				
uses chilling rolls																				
regulates oven & drying temperatures																				
D. Pressure Measurement																				
adjusts for plate thickness																				
calculates packing thickness																				
gauges impression & squeeze																				
uses film base thicknesses																				
regulates air pressure & volume																				
regulate oil pressures																				
regulates vacuum																				
determines roller pressures																				
regulates hydraulic pressures																				
uses scoring & perforating pressures																				

III. MEASUREMENT ACTIVITIES (cont.)

ACTIVITIES / OCCUPATIONAL TITLES	I	II		III			IV	V					VI						VII	
	Layout & Design Artist	Hot Metal Compositor	Strike-On & Photo Compositor	Imposition & Lockup	Pasteup & Copy Preparation	Stripper	Camera Operator Black & White	Platemaker - Offset	Letterpress	Flexographic	Gravure	Screen Process	Pressman - Offset - sheet fed	Offset - web fed	Letterpress	Flexographic	Gravure	Screen Process	Bindery & Finishing Operator	TOTAL
E. Dry Volume Measurement																				
mixes photo chemicals																				
measures cubic capacity																				
calculates air volume																				
measures spray powders																				
F. Liquid Measurement																				
mixes plate chemicals																				
mixes photo chemicals																				
mixes press chemicals																				
uses lubricants																				
uses solvents																				
determines ph																				
G. Time																				
calculates exposure times																				
calculates development times																				
H. Photographic Speed																				
uses filter factors & ratios																				
interprets ASA film ratings																				
uses light-sensitive emulsions																				
uses halftone screens																				
monitors film processing equipment																				
I. Velocity																				
calculates shutter speeds																				
calculates press speeds																				
calculates typesetting speeds																				
calculates RPM																				
calculates impressions per hour																				
calculates auto paster speeds																				
J. Energy Measurement																				
measures density																				
calculates voltages																				
calculates amperages																				
calculates wattages																				
measures resistance																				
uses an oscilloscope																				

IV. MEASUREMENT TOOLS and DEVICES

Directions: Identify the measurement tools and devices being used in on-the-job settings for each appropriate occupational title groupthat has been observed.

	I	II		III			IV	V					VI						VII	
MEASUREMENT TOOLS / *OCCUPATIONAL TITLES*	Layout & Design Artist	Hot Metal Compositor	Strike-On & Photo Compositor	Imposition & Lockup	Pasteup & Copy Preparation	Stripper	Camera Operator Black & White	Platemaker - Offset	Letterpress	Flexographic	Gravure	Screen Process	Pressman - Offset - sheet fed	Offset - web fed	Letterpress	Flexographic	Gravure	Screen Process	Bindery & Finishing Operator	TOTAL
A. Linear																				
Rule or drafting scale																				
Line gauge																				
Proportional scale																				
Vernier scale																				
Register devices																				
Composing stick																				
B. Thickness																				
Type height gauge																				
Micrometer																				
Packing gauge																				
Wire gauge																				
Thickness gauge																				
Feeler gauge																				
Dial indicator																				
Depth gauge																				
Ink & film thickness gauge																				
C. Time																				
Darkroom timer																				
Stop watch																				
D.Liquid Capacity																				
Measuring graduate																				
Flow cup																				
Gallon container																				
E. Weight																				
Spring scale																				
Balance scale																				

IV. MEASUREMENT TOOLS and DEVICES

OCCUPATIONAL TITLES / MEASUREMENT TOOLS	I	II		III			IV	V					VI						VII	
	Layout & Design Artist	Hot Metal Compositor	Strike-On & Photo Compositor	Imposition & Lockup	Pasteup & Copy Preparation	Stripper	Camera Operator Black & White	Platemaker - Offset	Letterpress	Flexographic	Gravure	Screen Process	Pressman - Offset - sheet fed	Offset - web fed	Letterpress	Flexographic	Gravure	Screen Process	Bindery & Finishing Operator	TOTAL
F. Temperature & Humidity																				
Thermometer																				
Pyrometer																				
Hygrometer																				
G. Angles																				
Protractor																				
Triangles																				
Drafting machine or lineup table																				
Screen angle indicator																				
H. Light & Density																				
Densitometer																				
Density guide																				
Exposure calculator																				
Light meter																				
Data chart																				
ph meter																				
I. Power																				
Ohm meter																				
Volt meter																				
Potentiometer																				
Oscilloscope																				
J. Pressure																				
Pressure gauge																				
Mullen tester																				
K. Vacuum																				
Vacuum gauge																				

V. MEASUREMENT TERMINOLOGY

Directions: Identify the measurement terminology being used in on-the-job settings for each appropriate occupational title group that has been observed.

	I	II		III			IV	V					VI						VII	
MEASUREMENT TERMS / OCCUPATIONAL TITLES	Layout & Design Artist	Hot Metal Compositor	Strike-On & Photo Compositor	Imposition & Lockup	Pasteup & Copy Preparation	Stripper	Camera Operator Black & White	Platemaker - Offset	Letterpress	Flexographic	Gravure	Screen Process	Pressman - Offset - sheet fed	Offset - web fed	Letterpress	Flexographic	Gravure	Screen Process	Bindery & Finishing Operator	TOTAL
A. Linear Measure																				
Picas																				
Points																				
Nonpareils																				
Agates																				
Inches																				
Characters per pica																				
Escapement units																				
Type high																				
Basic size of papers																				
Column inch																				
x-height																				
Lines per inch																				
B. Thickness																				
Thousandths .000																				
Mils																				
Plies																				
Caliper																				
Point .001																				
Microns																				
C. Time																				
Microsecond																				
Millisecond																				
Second																				
Minute																				
Hour																				
D. Weight																				
Ounces																				
Pounds																				
Tons																				
Basis weight																				
Hundred weight																				

V. MEASUREMENT TERMINOLOGY (cont.)

OCCUPATIONAL TITLES	I	II		III			IV	V					VI						VII	
MEASUREMENT TERMS	Layout & Design Artist	Hot Metal Compositor	Strike-On & Photo Compositor	Imposition & Lockup	Pasteup & Copy Preparation	Stripper	Camera Operator Black & White	Platemaker - Offset	Letterpress	Flexographic	Gravure	Screen Process	Pressman - Offset - sheet fed	Offset - web fed	Letterpress	Flexographic	Gravure	Screen Process	Bindery & Finishing Operator	TOTAL
E. Area																				
Ems																				
Ens																				
Square inches																				
Square feet																				
MM paper size system																				
f stop																				
F. Temperature																				
Fahrenheit																				
Centigrade																				
Kelvin																				
BTU																				
G. Liquid Capacity																				
Ounces																				
Pints																				
Quarts																				
Gallons																				
Barrels																				
Cubic Inches																				
H. Power																				
Horsepower																				
Kilowatts																				
BTU's per minute																				
I. Pressure																				
Pounds per square inch																				
Nip																				
J. Vacuum																				
Inches of mercury																				
K. Velocity																				
Feet per minute																				
Impressions per hour																				

V. MEASUREMENT TERMINOLOGY (cont.)

	I	II		III			IV	V					VI						VII	
MEASUREMENT TERMS / *OCCUPATIONAL TITLES*	Layout & Design Artist	Hot Metal Compositor	Strike-On & Photo Compositor	Imposition & Lockup	Pasteup & Copy Preparation	Stripper	Camera Operator Black & White	Platemaker - Offset	Letterpress	Flexographic	Gravure	Screen Process	Pressman - Offset - sheet fed	Offset - web fed	Letterpress	Flexographic	Gravure	Screen Process	Bindery & Finishing Operator	TOTAL
L. Flow																				
Cubic feet per minute																				
Gallons per minute																				
M. Miscellaneous																				
Durometer																				
Gamma																				
Ream																				
ph																				
Degrees of an angle																				

APPENDIX E

COMPOSITE SUMMARY TABLES

APPENDIX E

TABLE 17

A COMPOSITE SUMMARY OF CUSTOMARY MEASUREMENT ACTIVITIES AS USED BY 19 SELECTED OCCUPATIONAL TITLES IN THE PRINTING INDUSTRY

MEASUREMENT ACTIVITIES / OCCUPATIONAL TITLES	Layout & Design Artist	Hot Metal Compositor	Strike-On & Photo Compositor	Imposition & Lockup	Pasteup & Copy Preparation	Stripper	Camera Operator Black & White	Platemaker - Offset	Letterpress	Flexographic	Gravure	Screen Process	Pressman - Offset - sheet fed	Offset - web fed	Letterpress	Flexographic	Gravure	Screen Process	Bindery & Finishing Operator
A. Linear Measurement																			
1. uses layout dimensions	6	4	6	3	7	6	6	4	3	3	3	3	5	2	3	4	3	4	3
2. uses basic paper sizes	5	1	3	2	2	3	2	2		3	3	1	6	4	5	4	3	4	3
3. calculates page sizes	6	2	3	3	5	4	1	3			3	1			1				4
4. measures line lengths	5	4	6	3	7	6	4	2			3	2	4	2	3			1	3
5. uses different film sizes			1		1	6	6	4			3	3						2	
6. uses type sizes	5	4	6	2	5	5	5	1		3		1			2			2	
7. calculates magnifications	5	1	3		7	4	7					1						2	
8. determines f stops						1	7					1						1	
9. uses screen rulings	3		1		1	5	7	1			3	3		2	1	3	3	2	
10. measures type height		4		3					3	2					5				
11. calculates vertical leading	4	4	6	3	7	3									2				
12. performs copyfitting	5	4	5	1	5	2	1		2									2	
13. determines page proportions	4		1	1	4			1											
14. calculates margins & trims	5	1	2	2	7	5	2	4	3	3	3	3	7	4	3	4	3	4	6
15. calculates form impositions	2	1	2	3	4	5	1	4	2		3	3	6	3	3	3	3	1	6
16. measures linear distances	6	4	6	3	7	6	8	6	3	3	3	3	7	4	5	4	3	4	6
17. uses focal lengths							6												
18. calculates & uses angles	6	3	3	2	5	6	7		2		3	1	1	2	2	4	3	2	4
19. calculates escapement values	4	2	6	1	5	1													
20. uses tape calculations			1																
21. establishes register marks	4		1		4	5	5	2	1				1						
22. uses different plate sizes	2		1			2	2	6		3	3	2	6	4	2	2	1		
23. uses imposing furniture		2		3											4				
24. uses different mask sizes	2		1		1	4	2	6				3	1	2				1	
25. uses various press sizes	3					3		4	3				7	4	5	1	1	1	
26. measures roller diameters		1							1				7	4		3	3		2
27. measures roll diameters														3	5	3	3		
28. measures plate etch depths								1	1	3	1					1	2		
29. measures plate coating thickness									2										
30. uses various fabric openings												2						4	
31. measures screen dimensions								1				3						3	
32. uses paper drill sizes																			2
33. calculates paper stretch													1	2					1
34. locates folds & scoring rule positions	2	1	1	3	4	4		1				1	5	2	5				6
35. calibrates instruments	2	2	2		1		4	2	3	2	2		6	2	2				
36. measures paper caliper		1	2	1	2	1		1	2	3	1		6	4	4	2	3		5
CELLS USED	21	19	23	17	21	22	19	20	14	10	14	18	16	17	19	13	13	17	13

TABLE 17--Continued

ACTIVITIES / OCCUPATIONAL TITLES	Layout & Design Artist	Hot Metal Compositor	Strike-On & Photo Compositor	Imposition & Lockup	Pasteup & Copy Preparation	Stripper	Camera Operator Black & White	Platemaker - Offset	Letterpress	Flexographic	Gravure	Screen Process	Pressman - Offset - sheet fed	Offset - web fed	Letterpress	Flexographic	Gravure	Screen Process	Bindery & Finishing Operator	
B. Weight Measurement																				
1. mixes ink components													7	4	4	4	3	4		
2. calculates paper weights	1														1					
3. calculates freight costs																			1	
4. calculates viscosity														2		1	3			
5. weighs type metal & forms		1		2																
6. weighs chemicals			1				4				2	2	3					1		
7. weighs mail	1																		2	
CELLS USED	2	1	1	1	0	0	1	0	0	0	1	1	2	2	2	2	2	2	2	
C. Temperature Measurement																				
1. uses water temperature		1	1			2	8		3	3	3	3						2	1	
2. determines chemical temperatures			1			1	7	2			3	2	1					2	2	
3. monitors room temperatures			4			1	2	1			3			2				1		
4. monitors relative humidity			4			1	1		2		3			4		2	2	2		
5. uses temp. in platemaking								1		3		3						2		
6. uses temperature-controlled storage			1				7				2									
7. uses temp. sensitive emulsions			2				8	1			2	3								
8. uses thermograghic powders															2					
9. calculates film drying							7					2						3		
10. calculates print drying							3													
11. uses hot stamping dies																				
12. applies heat sensitive adhesives	1				1	1													1	
13. uses temperature in drying ink													3	4	2	2	3	3	2	
14. uses color temperature of lights							3													
15. regulate hot metal temperatures		3																		
16. vulcanizes rubber										3										
17. uses chilling rolls														3		3	3	2	1	
18. regulates oven & drying temperatures										3				4		4	3	4	1	
CELLS USED	1	2	6	0	1	5	9	4	2	4	6	5	2	5	2	4	4	9	6	
D. Pressure Measurement																				
1. adjusts for plate thickness				2				1	2	3			4	4	5	3	3	1		
2. calculates packing thickness													7	4	5	3				
3. gauges impression & squeeze													6	2	3	3	3	1	4	
4. uses film base thicknesses			1			2	3				3	2								
5. regulates air pressure & volume	1	2						1	1			2	3	4	2	3	3	2	4	
6. regulate oil pressures								6		2			1	2		2	2			
7. regulates vacuum			1			2	7				3	2	6	4	4	2	3	4	6	
8. determines roller pressures			1										6	4	5	3	3	1	6	
9. regulates hydraulic pressures		2					1			3				4		2	3	1		
10. uses scoring & perforating pressures		1												3	5	3	3	1	6	
CELLS USED	1	3	3	1	0	2	3	3	2	3	2	3	7	9	7	9	8	7	5	

TABLE 17--Continued

ACTIVITIES / OCCUPATIONAL TITLES	Layout & Design Artist	Hot Metal Compositor	Strike-On & Photo Compositor	Imposition & Lockup	Pasteup & Copy Preparation	Stripper	Camera Operator Black & White	Platemaker - Offset	Letterpress	Flexographic	Gravure	Screen Process	Pressman - Offset - sheet fed	Offset - web fed	Letterpress	Flexographic	Gravure	Screen Process	Bindery & Finishing Operator
E. Dry Volume Measurement																			
1. mixes photo chemicals			1				5	4	2			3						2	
2. measures cubic capacity																			
3. calculates air volume		1												2					
4. measures spray powders													3	2	3				
CELLS USED	0	1	1	0	0	0	1	1	1	0	0	1	1	2	1	0	0	1	0
F. Liquid Measurement																			
1. mixes plate chemicals								4	3		3	1		3				3	
2. mixes photo chemicals			5		2	1	8	1			3	3						3	
3. mixes press chemicals													7	4		1	3	3	
4. uses lubricants		2						1					7	4	3	4	3		3
5. uses solvents			1	1				2	3				3	4	2	1	3	1	
6. determines ph							1		1				7	4				1	
CELLS USED	0	1	2	1	1	1	2	4	3	0	2	2	4	5	2	3	3	5	1
G. Time																			
1. calculates exposure times			5			2	8	6		3	3	3						1	
2. calculates development times			4			2	8	5			2	3						1	
CELLS USED	0	0	2	0	0	2	2	2	0	1	2	2	0	0	0	0	0	2	0
H. Photographic Speed																			
1. uses filter factors & ratios			1			1	8				2	1							
2. interprets ASA film ratings							2												
3. uses light-sensitive emulsions			6			2	8	6			2	3						1	
4. uses halftone screens						1	8	1			2	2						2	
5. monitors film processing equipment			4			7	1												
CELLS USED	0	0	3	0	0	4	5	2	0	0	3	3	0	0	0	0	0	2	0
I. Velocity																			
1. calculates shutter speeds			1				4												
2. calculates press speeds														4		4	3		
3. calculates typesetting speeds		1	4										1						
4. calculates RPM		1																	1
5. calculates impressions per hour															2			2	
6. calculates auto paster speeds													4	3		2	3		
CELLS USED	0	2	2	0	0	0	1	0	0	0	0	0	2	2	1	2	2	1	1
J. Energy Measurement																			
1. measures density			3			3	8				3		3	1		4	3		
2. calculates voltages		1	2				4		2		3			2		4	3		
3. calculates amperages									2		3		1	2		4	3		
4. calculates wattages							2							2					
5. measures resistance			1																
6. uses an oscilloscope											2					3			
CELLS USED	0	1	3	0	0	1	3	0	2	0	4	0	2	3	0	4	4	0	0

TABLE 18

A COMPOSITE SUMMARY OF CUSTOMARY MEASUREMENT TOOLS AND DEVICES AS USED BY 19 SELECTED OCCUPATIONAL TITLES IN THE PRINTING INDUSTRY

MEASUREMENT TOOLS / OCCUPATIONAL TITLES	Layout & Design Artist	Hot Metal Compositor	Strike-On & Photo Compositor	Imposition & Lockup	Pasteup & Copy Preparation	Stripper	Camera Operator Black & White	Platemaker - Offset	Letterpress	Flexographic	Gravure	Screen Process	Pressman - Offset - sheet fed	Offset - web fed	Letterpress	Flexographic	Gravure	Screen Process	Bindery & Finishing Operator
A. Linear																			
1. Rule or drafting scale	6	4	6	3	7	6	8	6	3	3	3	3	7	4	5	4	3	4	6
2. Line gauge	3	4	6	3	7	5	5	3	3		2		3	4	4			1	2
3. Proportional scale	5	2	3		5	2	8					2						1	
4. Vernier scale						1	1	3	2		3					3	3		
5. Register devices	2		1	2	1	6	4	5			3		1	4	2	4	3	3	1
6. Composing stick		2		3															
CELLS USED	4	4	4	4	4	5	5	4	3	1	4	2	3	3	3	3	3	4	3
B. Thickness																			
1. Type height gauge		4		3					3	1					4				
2. Micrometer	2	3	2	3			2	4	3	3	3		7	4	5	4	3	2	3
3. Packing gauge													4	4		3			
4. Wire gauge																		1	2
5. Thickness gauge		2	1	1					3			2	2	3	1	2	2	3	3
6. Feeler gauge		2							2				3	4	1	3	2	2	1
7. Dial indicator									2		2		3	2		4	2		
8. Depth gauge								2	3							2	3		
9. Ink & film thickness gauge													2			1	1		
CELLS USED	1	4	2	3	0	0	1	2	6	2	2	1	6	5	4	7	6	4	4
C. Time																			
1. Darkroom timer			3			1	8	6	3	3	3	3						2	
2. Stop watch			1														2		
CELLS USED	0	0	2	0	0	1	1	1	1	1	1	1	0	0	0	0	1	1	0
D. Liquid Capacity																			
1. Measuring graduate			2		1		8	6	3		3	3	8	4		4	3	4	1
2. Flow cup									3				1			2	3		
3. Gallon container		1	2		1		6	6	3		3	3	7	4	3	4	3	2	2
CELLS USED	0	1	2	0	2	0	2	2	3	0	2	2	3	2	1	3	3	2	2
E. Weight																			
1. Spring scale		2		2			1			1		1	1		1	1			2
2. Balance scale	1						2	2			2	2	6	4	2	2	3	3	1
CELLS USED	1	1	0	1	0	0	2	1	0	1	1	2	2	1	2	2	1	1	2

TABLE 18--Continued

MEASUREMENT TOOLS / OCCUPATIONAL TITLES	Layout & Design Artist	Hot Metal Compositor	Strike-On & Photo Compositor	Imposition & Lockup	Pasteup & Copy Preparation	Stripper	Camera Operator Black & White	Platemaker - Offset	Letterpress	Flexographic	Gravure	Screen Process	Pressman - Offset - sheet fed	Offset - web fed	Letterpress	Flexographic	Gravure	Screen Process	Bindery & Finishing Operator	
F. Temperature & Humidity																				
1. Thermometer	1	3	4			1	8	3	3	3	3	3				4	3	3	1	
2. Pyrometer		2	1					1	3	3										
3. Hygrometer			2					1	2		3		7	4			2			
CELLS USED	1	2	3	0	0	1	1	3	3	2	2	1	1	1	0	1	2	1	1	
G. Angles																				
1. Protractor	5		3		5	2	2	1			1	1								
2. Triangles	5		4	1	6	6	3	1			3	3						2	1	
3. Drafting machine or lineup table	4				1	4						2						1		
4. Screen angle indicator			1		1	4	6				3	1								
CELLS USED	3	0	3	1	4	4	3	2	0	0	3	4	0	0	0	0	0	2	1	
H. Light & Density																				
1. Densitometer			1			2	8				3		4	4		3	2			
2. Density guide			3			1	7	4			3									
3. Exposure calculator			1				6	2			3	3						1		
4. Light meter			1			1	3	2												
5. Data chart			1				6	4			3	2								
6. ph meter								1	1				4	4						
CELLS USED	0	0	5	0	0	3	5	5	1	0	4	2	2	2	0	1	1	1	0	
I. Power																				
1. Ohm meter													1							
2. Volt meter		1	3				2						1	4						
3. Potentiometer																				
4. Oscilloscope											2					4	2			
CELLS USED	0	1	1	0	0	0	1	0	0	0	1	0	2	1	0	1	1	0	0	
J. Pressure																				
1. Pressure gauge		2	1					3	3	3	3		3	2		4	3		1	
2. Mullen tester													1	1			1			
CELLS USED	0	1	1	0	0	0	0	1	1	1	1	0	2	2	0	1	2	0	1	
K. Vacuum																				
1. Vacuum gauge			1			2	4	6			3	3	3	2	2	4	2	4	4	
CELLS USED	0	0	1	0	0	1	1	1	0	0	1	1	1	1	1	1	1	1	1	

TABLE 19

A COMPOSITE SUMMARY OF CUSTOMARY MEASUREMENT TERMINOLOGIES AS USED BY 19 SELECTED OCCUPATIONAL TITLES IN THE PRINTING INDUSTRY

MEASUREMENT TERMS / *OCCUPATIONAL TITLES*	Layout & Design Artist	Hot Metal Compositor	Strike-On & Photo Compositor	Imposition & Lockup	Pasteup & Copy Preparation	Stripper	Camera Operator Black & White	Platemaker - Offset	Letterpress	Flexographic	Gravure	Screen Process	Pressman - Offset - sheet fed	Offset - web fed	Letterpress	Flexographic	Gravure	Screen Process	Bindery & Finishing Operator	
A. Linear Measure																				
1. Picas	4	4	5	3	5	6	5	1	3		2		2	2	4		2		2	
2. Points	4	4	5	3	3	6	5	1	3		2		1		4		2		2	
3. Nonpareils		2	2	1	1										2					
4. Agates			1		2		1													
5. Inches	6	4	6	3	7	6	8	6	3	3	3	3	7	4	5	4	3	4	6	
6. Characters per pica	3	4	6		5	3	1								1					
7. Escapement units	2	2	3	1	1	1														
8. Type high		4		3					3	3					4					
9. Basic size of papers	3			1		1							5	3	3				2	
10. Column inch	3	1	4	1	5	4	1							2	1					
11. x-height	3	3	2	2	2	1									1					
12. Lines per inch	5	2	6	3	6	4	5	1			3	3	2	3	2	4	3	4		
CELLS USED	9	10	10	10	10	9	7	4	4	2	4	2	5	5	10	2	4	2	4	
B. Thickness																				
1. Thousandths .000	3	3	1	3	1	3	8	5	3	3	3	2	6	4	5	4	3	4	6	
2. Mils	2	2	1	3			1	1			3		1	2	1				3	
3. Plies					1		1								1			2	3	
4. Caliper	1						2	2					7	3	2	3	3		1	
5. Point .001	2	1	1	3		1	3	3	3	3	1		5	2	1	3	3	2	1	
6. Microns											3		4				2			
CELLS USED	4	3	3	3	2	2	5	4	2	2	4	1	5	4	4	3	4	3	5	
C. Time																				
1. Microsecond																				
2. Millisecond											2			1						
3. Second			2	1		3	8	5		3	3	2	4	2		4	3			
4. Minute	1	3	5	3	4	3	8	6		2	2	3	6	4	4	4	3	4	6	
5. Hour	1	3	5	2	4	3	3	4			2	2	6	4	4	4	3	3	6	
CELLS USED	2	2	3	3	2	3	3	3	0	2	4	3	3	4	2	3	3	2	2	
D. Weight																				
1. Ounces	3	1	4	1		1	7	6		3	3	2	7	3	3	2	2	2	3	
2. Pounds	2	1	1	2			2	2		3	3	2	6	4	4	4	3	4	3	
3. Tons		1		1									3	4	1	4	3		3	
4. Basis weight														2	2	2	2		3	
5. Hundred weight																				
CELLS USED	2	3	2	3	0	1	2	2	0	2	2	2	3	4	4	4	4	2	4	

TABLE 19--Continued

MEASUREMENT TERMS / OCCUPATIONAL TITLES	Layout & Design Artist	Hot Metal Compositor	Strike-On & Photo Compositor	Imposition & Lockup	Pasteup & Copy Preparation	Stripper	Camera Operator Black & White	Platemaker - Offset	Letterpress	Flexographic	Gravure	Screen Process	Pressman - Offset - sheet fed	Offset - web fed	Letterpress	Flexographic	Gravure	Screen Process	Bindery & Finishing Operator	
E. Area																				
1. Ems	3	3	6	3	5	2	1								3					
2. Ens	1	3	5	3	5	1	1								1		1			
3. Square inches	5		4	3	2	4	6	3	3	3	3	3	1	1	1	4	2	4	1	
4. Square feet	1				1			2		3				1		1		4		
5. MM paper size system																				
6. f stop							7					1								
CELLS USED	4	2	3	3	4	3	4	2	1	2	1	2	1	2	3	2	2	2	1	
F. Temperature																				
1. Fahrenheit	1	3	2				8	2	3	3	3	3	3	1	2	4	3	3		
2. Centigrade			1				2				2									
3. Kelvin						2														
4. BTU		1																		
CELLS USED	1	2	2	0	0	0	3	1	1	1	2	1	1	1	1	1	1	1	0	
G. Liquid Capacity																				
1. Ounces	3		5			1	7	6	3		3	3	6	2		4	3	3	3	
2. Pints	2	1	3			1	7	6	3	1	3	3	6	2		3	3	3	3	
3. Quarts	2	1	5	3		1	8	6	3		3	3	7	2	1	4	3	4	3	
4. Gallons	1		5	1			8	6	3		3	3	7	2	2	4	3	4	4	
5. Barrels		1						2			3		2	1	1	4	3		1	
6. Cubic Inches							1	1	2		3			1		2				
CELLS USED	4	3	4	2	0	3	5	6	5	1	6	4	5	6	3	6	5	4	5	
H. Power																				
1. Horsepower		2	1				1	1					3	2	3	3	3	1	3	
2. Kilowatts		3	4				5	1	3	3	3		3	2		4	3	2		
3. BTU's per minute													1			2	2			
CELLS USED	0	2	2	0	0	0	2	2	1	1	1	0	3	2	1	3	3	2	1	
I. Pressure																				
1. Pounds per square inch		3	1				1	5	1	1			4	1	2	3	3		3	
2. Nip													4	1	1	4	3		1	
CELLS USED	0	1	1	0	0	0	1	1	1	1	0	0	2	2	2	2	2	0	2	
J. Vacuum																				
1. Inches of mercury						1	4	4			1	1	1	2				2	2	
CELLS USED	0	0	0	0	0	1	1	1	0	0	1	1	1	1	0	0	0	1	1	
K. Velocity																				
1. Feet per minute			3				4	3			1			4		4	3		2	
2. Impressions per hour													7	2	5	2	2	4		
CELLS USED	0	0	1	0	0	0	1	1	0	0	1	0	1	2	1	2	2	1	1	

TABLE 19--Continued

MEASUREMENT TERMS / OCCUPATIONAL TITLES	Layout & Design Artist	Hot Metal Compositor	Strike-On & Photo Compositor	Imposition & Lockup	Pasteup & Copy Preparation	Stripper	Camera Operator Black & White	Platemaker - Offset	Letterpress	Flexographic	Gravure	Screen Process	Pressman - Offset - sheet fed	Offset - web fed	Letterpress	Flexographic	Gravure	Screen Process	Bindery & Finishing Operator	
L. Flow																				
1. Cubic feet per minute													1			2	2			
2. Gallons per minute							3	2	2		1					3	3			
CELLS USED	0	0	0	0	0	0	1	1	1	0	1	0	1	0	0	2	2	0	0	
M. Miscellaneous																				
1. Durometer													4	2	1	3				
2. Gamma							3				2									
3. Ream	2												7		4	2		4	2	
4. ph								3	1				7							
5. Degrees of an angle	4	2	2	1	5	5	4		2		3	2			1		3	4		
CELLS USED	2	1	1	1	1	1	2	1	2	0	2	1	3	2	3	2	1	2	1	

APPENDIX F

LETTER

APPENDIX F

ENGINEERING DIGEST

Head Office: 46 St. Clair Ave. East, Toronto, Ont. M4T 1N2 • Phone (416) 962-4771
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November 8, 1974.

Mr. Arvon D. Byle,
Associate Professor,
Dept. of Industrial Education,
Western Michigan University,
Kalamazoo, Mich. 49001

Dear Mr. Byle:

Regarding your letter of November 5, I have enclosed a reprint from the three-part article "The Metric System" published in 1972 in Engineering Digest.

Please feel free to use the material, but a credit line, as shown in the IBM Reference Manual, should be given.

Good luck to you in completing your doctoral dissertation.

Best regards,

ENGINEERING DIGEST

Werner H. Meyfarth,
Editor.

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