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Guidelines for Metric Transition of Software

American National Metric Council, Washington, DC

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GUIDELINES FOR METRIC TRANSITION OF SOFTWARE

DATA PROCESSING/OFFICE EQUIPMENT
SECTOR COMMITTEE 2.10

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american
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The document has been prepared by the American National Metric Council (ANMC) Data Processing and Office Equipment (DP/OE) Sector Committee to assist information systems managers in understanding the effect of metric usage in software programs containing measurement-sensitive data fields. Guidelines are provided for the implementation of change. Contents: Alternative symbols for use in systems with limited character sets; An example of a unit of measure code table; List of acronyms and definitions; List of references.

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LIST OF APPENDICES

1. Introduction

This document has been prepared by the American National Metric Council (ANMC) *Data Processing and Office Equipment (DP/OE) Sector Committee to assist information systems managers in understanding the effect of metric usage in software programs containing measurement-sensitive data fields.* Guidelines are provided for the implementation of change.

Metric changeover can have a significant impact on software. For those caught unprepared, it can be a costly and time-consuming process to convert programs or to provide for dual usage (metric and inch-pound units in the same program). The costs are minimized, however, when managers are prepared to meet the challenges of incorporating metric units. With their expertise and knowledge of number systems, data processing professionals will find the International System of Units (SI) rational, consistent, and straightforward. Therein lies the opportunity for achieving substantial long-term benefits.

It is the responsibility of corporate management to decide how and when the transition should be undertaken. The ANMC helps all sectors of the economy to plan and coordinate sector conversion plans. The climate for planning and implementing metric changeover strategies has been steadily improving. In fact, most of the companies in the Fortune 1000 believe predominant metric usage is inevitable.

It is assumed that the decision for transition to the International System of Units (SI) has already been made by top management. Since computer services are an important element of any metric transition, this guide is intended to assist data processing managers, professionals, and users in:

- assessing the impacts of use of the SI metric measurement units and standards on computer software systems, and
- making the decisions necessary for efficient software conversion.

Hereafter in this document, any reference to metric measurement implies the use of Le Systeme Internationale d' Unité/SI (or, as it known in the U.S., the International System of Units).

Data Processing (DP) personnel, that is, systems programmers, application designers and programmers, and management personnel, will find that the SI system of units is a straightforward, rational system that will fit well with their skills and needs. It is in (1) the application of the SI system with proper use of its symbols and in (2) the general interaction of the measurement system, standards, and the computer system where they will find the greatest impact. Those planning issues and implementation design issues which are of major importance in assessing this impact are presented in the following guide.

This DP/Software guide will *not* concern itself with the detailed design of measurement conversion algorithms such as the conversion of metric to inch or inch to metric dimensions. Such algorithms are straightforward and many programs implementing them have already been written. Reference documents for designing such algorithms are cited in Appendix D.

2. Planning the Change to Metric

A decision to adopt the SI system will ordinarily involve a commitment for the entire organization. As such, the requirement to implement the change to metric in information processing will normally not come about as a decision of data processing management. The timing and methodology for implementation are often determined jointly by functional line organizations and the DP service organization. The task of directing and controlling the introduction of change should normally be a corporate/company metric coordination function. Depending on the size and complexity of the undertaking and the number of internal organizations affected, the coordinator may take the form of a special task force or a key individual. In fact, the DP function should play a central coordinating, if not a commanding, role in the transition. The rationale for selecting DP is that the support of essential automation services to all of the interrelated activities of the various functional organizations is focused in that organization. In the pivotal position, DP is in perhaps the best position to coordinate and monitor the change with all affected functions.

3. Assessing the DP Impact

It is assumed that either as part of the initial decision process or as a result of it, the DP organization will be called upon to determine the impact of a change to metric on the enterprise's information systems and DP's support to the various user organizations.

The quantifications of the impact will normally involve two broad investigative steps and a design and planning effort:

1. Definition of new requirements.
2. Analysis of current systems.
3. Implementation design planning.

These steps are preparatory to the establishing of scope, schedule, and resource demands for the conversion effort. Later sections of these guidelines are devoted to an examination of the requirements, analysis, and implementation planning issues. Not explicitly addressed, but certainly to be noted, are such items as the operational impact of performance changes (i.e. run-time extensions) and the facilities planning impact of possible changes to peripheral hardware or operating system software. The latter as a result of new data storage or new output device requirements.

As in any project there are tradeoffs to be considered in terms of scope, delivery dates, resources, and the quality of the deliverable. It is the responsibility of DP management to balance the constrained elements of the project to arrive at a commitment to deliver a given capability, at a given cost in terms of time and resources. An up-front statement of objective and a consensus on the constraints of the project greatly simplifies the process.

3.1 Definition of New Requirements

The major objectives of the requirements definition step are to:

1. Define the scope of change desired.
2. Identify new standards required, i.e., tolerances, data field length, computational accuracy, measurement code identifiers.
3. Identify educational program requirements for personnel.
4. Identify performance (service/response time) requirements.
5. Identify known priorities and critical delivery dates.
6. Determine the need to change historical data.

3.2 Analysis of Current Systems

The main purpose of this step, the analysis of current systems, is to determine:

1. Usage of measurement-sensitive data across program elements (modules).
2. Input/output capabilities requiring SI units specification. The analysis is then passed to the implementation design and planning step.

This information should be readily available from the data administration function (i.e., from data dictionary, if maintained). Otherwise a review of code and data may be necessary. In addition to code review, a useful analysis tool is a set of matrices - one with intercepts denoting data classes (a grouping of data elements into logically related categories) vs. data elements which are measurement-sensitive; one with intercepts denoting data classes vs. program affected; and one with intercepts of data classes vs. business process/function which requires the data. The concept here is that, in the event all portions of the conversion to metric cannot be implemented at one time, it will be possible to establish priorities for the phased support of different functional units or organizations of the business. If constraints dictate a phased implementation approach for the transition to metric, it is suggested that a data flow model for measurement-sensitive data be developed. The intent is to arrive at an implementation scheme that provides a road-map to a subsystem by subsystem conversion. (by subsystem we mean a logical grouping of programs which support a business activity.) In any system where data sharing is a requirement between subsystems the set of matrices can be used to identify the relative independence of data classes and the processes or activities they support.

3.3 Implementation Design Planning

In any type of phased approach, in the absence of any other business consideration, one would take a bottom-up approach to implementation by first choosing conversion of data classes (and subsystems that use them) which have low interaction with other data classes. Although the forgoing is aimed at the analysis of large systems, the technique is equally applicable for more narrowly defined projects (such as the conversion of a single system).

Secondary issues for the analysis that ought to be considered include:

1. The examination of program calculation logic to assess the need for change (i.e., calculation accuracy).
2. A scan of programs and data tables/files for built-in constants/data values which might require change.
3. Review of input/output format and symbol presentation.

The rationale for including analysis of the latter items is addressed more fully in the following section covering detailed implementation guidelines.

In summary, the impact on the DP organization for any transition to metric effort can be assessed and quantified after two major investigative efforts: 1. a requirements definition study; 2. an analysis of current systems. These two efforts provide the information necessary to define the project development plan which presents the impact statement in terms of schedules, resources, and deliverables.

4. Implementation Guidelines/Issues

This section is designed for the software developer or manager and for the project staff to use in determining how to implement a decision to handle metric information or metric and inch-pound information in a software system.

The guidelines and issues are covered in general terms in order that they be applied to as many different projects as possible, from scientific to administrative, from small specialized programs to be run on microcomputers to large general purpose programs to be run on mainframe computers. Illustrations and examples used are to clarify the guidelines cited and are not intended as models. Most real life situations will not be as simple nor as straightforward as these examples. It is the intent of the ANMC DP/OE Sector Committee to redefine and expand these guidelines as metric applications increase and lessons are learned.

4.1 Design Issues

The design issues include:

1. Conversion Decision
2. Development Time
3. Interface Requirements
4. Accuracy/precision
5. Performance

4.1.1 Conversion Decision

Implementing a decision to go wholly or partially metric will be more or less efficient than an inch-pound system depending on the complexity of the requirement to be metric.

At one extreme is a program required to periodically provide metric information as its output with the usual output in inch-pound units. A more difficult requirement to implement is one where data storage and/or computation and/or I/O must accommodate metric. An even more difficult decision to implement is one where the input/output will be both inch-pound and metric to varying degrees. An example is the recording in a state repository of newborn data from various hospitals - some recording mass in kilograms, some recording lengths in centimeters and some recording everything in inch-pound units.

4.1.2 Development Time

Every project is constrained by development time; the trick is to make the most efficient use of the limited time available. Development time is not likely to be affected greatly by a decision to handle only inch-pound or only metric data. It will be more affected by a decision to handle a mixture of inch-pound and metric data. Decisions on how to effect conversion between measurement systems - the location in the program where the conversions take place, which system the data bases should be designed in, and evaluating future changes that will impact the above, are just some of the additional questions that must be answered along with all the other ordinary technical decisions made before development time. For instance, information gathered from many sources, some metric and some inch-pound, may be fed into a program in the units in which it is gathered. The program then converts all inch-pound data to metric units before analyzing the data. The output may then be converted back to inch-pound units for display and stored in metric units for future analysis. Another useful rule is to convert historical information to another system of units only if there is some overriding benefit, such as an increase in performance with no loss of accuracy. (See Paragraph 4.2.5 for more detail.)

4.1.3 Interface Requirements

Both human and machine software interface requirements need to be considered in the design phase.

4.1.3.1 Human Factors

One of the more difficult areas for program developers and managers is the interface with humans. This is compounded when operating in two measurement systems. Confusion, inaccurate computations, and meaningless output will result from inputting inch-pound and metric units without adequate training and safeguards. Measurement units of certain characteristics such as pressure (inches of mercury, bars) and velocity (ft/sec, miles/hour) are ambiguous even in one system of measurement. Sometimes it will be necessary to specify, to the processor's system, the units used. This will affect performance, system design and storage requirements. Outputs will also be affected. The units of measurement ought now be (either explicitly or by differing forms) shown to reduce confusion between dual measurement schemes. Decisions must be made up front on mixed units, dual units (inch-pound and equivalent metric units side by side), use of one system exclusively, or variations as the user dictates from one application to the next. Each of these alternatives has its own advantages and disadvantages. Mixing units generally is not beneficial since it precludes user comparison of sequential values and increases the probability of confusion as users try to mentally convert units to those with which they are familiar. Dual units permit direct comparison but use valuable output space. (See Paragraph 4.2.2 for more detail.) If possible, using one system is most effective and efficient if the users can agree that one set of units is preferred. This also simplifies internal computations. Dictation of the output units by the user customizes the output to each user's needs but at the expense of performance, as added complexity is needed to convert all or most of the data prior to output. (See Section 4.2.4, Output Presentation Formats.)

4.1.3.2 Machine Software Interface Factors

Many times a system's output is required as input to other software programs, machines, or systems whose method and type of input is fixed, such as the following:

1. Numerical control machine tools.
2. Systems and programs for which source code is unavailable.
3. Systems that are already in double or extended precision.

For these situations, the developer/manager has no option but to use the current units of input as defined by the older, existing programs, machines, or systems.

If, however, the program, machine, or system is being developed in conjunction with metrication activities, then there can be more tailoring of its input and output formats, including the units in which each will converse with the other.

4.1.4 Accuracy/Precision

When involved in conversion from one system to another, the developer must consider whether or not to retain the same or similar level of accuracy and precision in the conversion results as in the original numbers. Common sense, based on knowledge and experience, should be a determinant in choosing practical, meaningful magnitudes for the specific case involved. For example, the speed limit on the nation's interstate highways is 55 mph. A precise equivalent of 88.5115 kilometers per hour results from direct mathematical conversion. A conversion to 90 kilometers per hour might be a more meaningful resulting speed limit, maintaining the original intent of the value, but not the accuracy of the translation process. In the case of converting from the inch-pound system to the metric system, retaining the original precision often results in more digits being recorded or stored. (1.0 inch = 25.4 millimeters; 1.0 mile = 1.609 kilometers.) The developer must be attentive to data storage and input/output formats to allow for this. In addition, storage of the data must be large enough to handle any increase in the number of digits necessary to maintain computational accuracy. Accuracy can be achieved by paying close attention to accurate conversion factors and conventional rounding guidelines. Federal Standard-376A is the guideline to follow for proper use of units and conversion factors. ANSI/IEEE STD-268 and ASTM E-380 also present guidelines for metric practice including rounding rules. In some instances, it may be found that some existing programs already contain metric measurement information either alone or in a dual mode. These programs may have been designed to an older metric system which does not conform to all SI requirements of style and symbology. Finding and correcting these symbols, the style, and the format to SI requirements will require programming changes and will affect field sizes and space requirements. As a rule, back and forth conversions, however, should be discouraged to reduce error compounding. In some cases, where preprinted input and/or output forms are used, the preprinting may also have to be changed. Proper usage of SI is especially important when the output is to be used in countries where SI is a legal requirement. Standards which are related to the program may also require changing. Examples of incorrect symbology for the term microfarad are: MF Mf MFD Uf UFD Mfd. The correct SI symbol for microfarad is µF. For systems with limited character sets, ISO 2955 (See Appendix D, Reference 18) permits: µf or uF. Investigations have found that handheld calculators and some conversion programs have different conversion factors programmed into them. It is important to compare the calculated results with known accurate conversions so that the desired accuracy is ensured.

4.1.5 Performance

Most decisions on how to implement both metric and inch-pound information will be driven by performance considerations. The requirement statement will help make technical decisions such as pre-processing conversion vs. post-processing conversion. The developer must trade off storage capability, processing time, and I/O time. Many times during the period of active industry and government transition to the metric system, the developer must make estimates as to future uses of the system. In the example of the newborn data used above, how the data is processed, stored, retrieved and presented to the user will depend on how often inch-pound data is inputted, and required for output and computation vs. how often metric data is inputted, outputted, or used for computation, over the life of the new system under development. For a long-lived program, the transition from inch-pound to metric could be well along toward predominate use of metric units. The developer must take care not to prematurely render the system obsolete because provisions for efficient use of metric units were not made.

4.2 Design Techniques

Programming techniques for the following areas need to be considered in the design phase:

1. Preprocessors and Post-Processors
2. Dual Units
3. Computational Operations
4. Output Presentation Formats
5. Historical Data

4.2.1 Preprocessors and Post-Processors

These are usually fairly simple programs used to perform operations on data before (preprocessors) or after (post-processors) it is acted on by the existing primary program. There are preprocessor routines which will convert SI information into non-SI information so that it may be processed by the primary program which was originally designed for non-SI dimensions. Post-processors take non-SI information and process it back into SI units for output. The use of preprocessors and post-processors is not very often a successful solution to all programs. When investigating exactly how the data is handled in the primary program, extreme care must be taken to determine whether or not it is possible to use this approach. Furthermore, when it is used, very careful attention must be given to the rules which are applied for conversion and rounding of the data to achieve the required accuracy (See Paragraph 4.1.4). An added complication arises when converting the information through both a preprocessor and again through a post-processor. The double conversion compounds the inaccuracies due to rounding and may affect the accuracy of the data which is required.

4.2.2 Dual Units

During the early phase of the changeover, many new and existing programs will need to have the capability of handling both SI and inch-pound information. For example, during the period of time when manufacturing equipment is being converted to metric or being replaced by metric equipment, both sets of measurements will be needed. This is because at any given point in time there may be only "inch" equipment, or there may be both metric and inch equipment or just metric equipment. For the first case, the inch dimension would be used. In the second case, depending on workload across the machines, either metric or inch might be necessary. Finally where metric-only machines are available, only the metric dimensions would be needed. Wherever possible, the use of dual capability should be avoided, or else be maintained for as short a time as possible. Several factors required for dual capability affect the use and cost of maintaining the capability. These factors are enumerated in the following subsections.

4.2.2.1 Unit of Measure Identifiers

The need to carry both SI and inch-pound units in the same program requires that there be a means to differentiate between the two. This may be handled by means of an unit of measure identifier. Within a specific program using only a few units of measure, this identifier may be a single numeral or alphabetic character. In situations where there are many programs using many different units of measure, the unit of measure may be converted to and processed as a code as shown in Appendix B. Use of an identifier means that an additional one or two spaces are required for both input and output - spaces which may not be readily or easily available. Also, the computer has to store and transact this additional information, thereby increasing storage cost and transaction time.

4.2.2.2 Additional Fields, Storage, and Transactions

As with the identifier mentioned previously, the need to carry both SI and inch-pound units approximately doubles the original space required in fields, storage, and time for the necessary transactions. Special planning is required to ensure that:

1. The input and output documents are revised to accommodate the extra space required for both sets of data.
2. The computer will have sufficient memory storage.
3. Allowance is made for the extra time that may be required to run the program.

4.2.2.3 Conversion of Dual Capability to Metric Only

The design of any dual capability program should include, at the outset, ability to delete the inch-pound measurements from the program automatically. Since the dual capability is needed only for an interim period during which equipment is being converted to metric capability, the automatic removal feature is desirable upon completion of that period. Including this removal feature in the original design will be easier and less costly than at a later point in time. If added later, the details of the program must be completely reviewed by the programmer to determine if and how the feature can be designed into the program. This can delay the deletion of the information beyond the time when it is needed, with the attendant costs of continued dual maintenance.

In summary, dual measurement capability may require some or all of the following:

1. New programs (when existing programs cannot be changed).
2. Program changes (to existing programs).
3. Unit of measure codes, symbols, or forms.
4. Extra fields and/or identifiers for information on input/output.
5. Additional computer storage for the parallel information.
6. Additional transactions (time).
7. Changes to forms (input and output).

8. Use of alternate symbols permitted (See Appendix D, Reference 18).
9. Programming for converting to SI mode only.

Establishing, maintaining and handling dual measurement information can create a considerable cost impact. Advance planning can reduce that impact. The best approach is to plan the changeover directly to metric measurements alone and completely avoid the need for a dual system. Since this is not always feasible, the next best approach is to design all new programs and forms to handle both systems, even if the dual need is still in the future. When planned for early, this can be done at practically no extra cost. There will still be some impact due to having to handle the extra information in space and transactions, and on new forms where dual measurements are unavoidable.

4.2.3 Computational Operations

Scientific and engineering (S&E) programs are mainly mathematical computation programs. Operational programs, on the other hand, are data manipulators although conversions may be calculated during this manipulation: that is, a measurement in one system is simply converted to a measurement in the other system. The S&E programs take measurements or other data in one measurement system and apply them to formulas with constants and/or tables of data and compute a desired result in the same measurement system. Changing these programs to use the metric system of measurement will not change the theory, but it requires that the constants and/or tables of data used in and with the formulas and programs be changed to accommodate the metric system. Preprocessing or post-processing routines might possibly be written to handle some of the conversions from one system to the other. Many formulas and programs are very complicated and only extensive modification and rewriting will serve the purpose of operating with the new system. Formulas use measurements, constants, and lookup data. If a particular constant is measurement-based, a new SI constant may need to be established. The investigator will find that considerable research may be necessary to determine the origin of some constants. Tables of data, such as shear or tensile strengths, which are based upon the present inch-pound system, must also be converted to SI or else new SI tables must be created. Introducing built-in conversion tables of inch-pound to SI values, sizes, constants, and so forth, however, will not result in conversions to exact equivalent metric values. Where accuracy is required, tables of preferred SI values should be used by programs.

4.2.4 Output Presentation Formats

The SI units are defined in ISO 1000 and further developed in ISO 31/0 through ISO 31/13. The style or format is also partially defined in ISO 1000 with detail provided in ISO 31/0. (See Appendix D, Reference 1 through 15.)

The SI units can be handled by any computer, however, the international symbols depicting the units and prefixes are required to be shown in upper and lower case roman upright type. Furthermore, one unit (ohm, Ω) and one prefix (micro, µ) are represented by Greek characters. For details, refer to the aforementioned ISO standards and the ANMC Metric Editorial Guide.

4.2.5 Historical Data

Historical data that needs to be converted may be handled in various ways. The data should be converted to SI in advance of when it is required. Because the conversion is coming about due to the organization's decision to go metric, the historical data should be converted to SI for comparison rather than converting new metric data to inch-pound units. If the output is on preprinted forms, the forms will have to be changed. On many occasions, it will be necessary to suppress the inch-pound historical data in the new program and process the current SI data, calling upon the historical data only when comparisons are required.

5. Summary

As intensive an investigation as has been espoused will undoubtedly uncover many situations where an organization can realize significant savings. This could come about through the elimination of programs which are no longer needed, by combining two or more programs to streamline operations and reduce computer time and storage, and through the elimination of redundancy in programs, tables, files and data bases. In other words, it becomes an excellent opportunity to clean house. For those who are concerned with the costs of metrication, close monitoring of the advantages gained can provide a return on investment which will in some cases easily offset the costs.

The foregoing discussion on the impact of metrication of software has revealed many aspects which must be considered to implement a successful conversion to metric. To summarize, the following aspects must be considered when changing computer systems software to metric.

- The SI System and rules of usage in new/existing programs.
- Character availability in input/output devices.
- SI symbol character alternatives.
- Need to design new programs.
- Need to modify or obsolete existing programs.
- Preprocessing or post-processing routines.
- Dual measurement transaction capability.
- System running time (input, CPU, and output).
- Field and line space requirements.
- Forms changes.
- Program interface requirements.
- Computational operations factors.
- Conversion of existing (or development of new) tables of data.
- Historical data.
- Improving operations.

A myriad of detail is covered by the above list, attention to which is crucial for any successful implementation of metric. Moreover, it is deemed important that some level of planning effort take place now, so that proposed project can be designed with metric in mind...even though full conversion may still be some time distant.

Appendix A

Alternative Symbols for use in Systems with Limited Character Sets

This table, a portion of the information in ISO 2955, shows some of the alternate symbol arrangements which may be used when the proper symbols are not available.

ISO 2955 is available from the American National Standards Institute.

<table>
<thead>
<tr><th rowspan="3">Name of Unit</th><th>International Symbol</th><th colspan="3">Representation</th></tr>
<tr><th></th><th>Form I</th><th colspan="2">Form II</th></tr>
<tr><th>(common use symbol)</th><th>(double case)</th><th>(single case lower)</th><th>(single case upper)</th></tr>
</thead>
<tbody>
<tr><td colspan="5">5.1 Base SI Units</td></tr>
<tr><td>metre</td><td>m</td><td>m</td><td>m</td><td>M</td></tr>
<tr><td>kilogram</td><td>kg</td><td>kg</td><td>kg</td><td>KG</td></tr>
<tr><td>second</td><td>s</td><td>s</td><td>s</td><td>S</td></tr>
<tr><td>ampere</td><td>A</td><td>A</td><td>a</td><td>A</td></tr>
<tr><td>kelvin</td><td>K</td><td>K</td><td>k</td><td>K</td></tr>
<tr><td>mole</td><td>mol</td><td>mol</td><td>mol</td><td>MOL</td></tr>
<tr><td>candela</td><td>cd</td><td>cd</td><td>cd</td><td>CD</td></tr>
<tr><td colspan="5">5.2 Supplementary SI Units</td></tr>
<tr><td>radian</td><td>rad</td><td>rad</td><td>rad</td><td>RAD</td></tr>
<tr><td>steradian</td><td>sr</td><td>sr</td><td>sr</td><td>SR</td></tr>
<tr><td colspan="5">5.3 Derived SI Units with special names</td></tr>
<tr><td>hertz</td><td>Hz</td><td>Hz</td><td>hz</td><td>HZ</td></tr>
<tr><td>newton</td><td>N</td><td>N</td><td>n</td><td>N</td></tr>
<tr><td>pascal</td><td>Pa</td><td>Pa</td><td>pa</td><td>PA</td></tr>
<tr><td>joule</td><td>J</td><td>J</td><td>j</td><td>J</td></tr>
<tr><td>watt</td><td>W</td><td>W</td><td>w</td><td>W</td></tr>
<tr><td>coulomb</td><td>C</td><td>C</td><td>c</td><td>C</td></tr>
<tr><td>volt</td><td>V</td><td>V</td><td>v</td><td>V</td></tr>
<tr><td>farad</td><td>F</td><td>F</td><td>f</td><td>F</td></tr>
<tr><td>ohm</td><td>Ω</td><td>ohm</td><td>ohm</td><td>OHM</td></tr>
<tr><td>siemens</td><td>S</td><td>S</td><td>sie</td><td>SIE</td></tr>
<tr><td>weber</td><td>Wb</td><td>Wb</td><td>wb</td><td>WB</td></tr>
<tr><td>tesla</td><td>T</td><td>T</td><td>t</td><td>T</td></tr>
<tr><td>henry</td><td>H</td><td>H</td><td>h</td><td>H</td></tr>
<tr><td>lumen</td><td>lm</td><td>lm</td><td>lm</td><td>LM</td></tr>
<tr><td>lux</td><td>lx</td><td>lx</td><td>lx</td><td>LX</td></tr>
<tr><td>bequerel</td><td>Bq</td><td>Bq</td><td>bq</td><td>BQ</td></tr>
<tr><td>sievert</td><td>Sv</td><td>Sv</td><td>sv</td><td>SV</td></tr>
</tbody>
</table>

Appendix B

An Example of a

Unit of Measure Code Table

An Example of a
Unit of Measure Code Table

01	piece-each
02	pair (2 pieces)
03	set
04	roll
05	sheet
06	C (100 pieces)
07	gross (144 pieces)
08	ream (500 sheets)
09	bale
10	coil
11	inch
12	foot
13	yard
14	sq yard
15	bd foot
16	sq inch
17	sq foot
18	cu foot
19	100 feet
20	fathom
21	meter (m)
22	centimeter (cm)
23	sq meter (m^2)
25	sq centimeter (cm^2)
26	millimeter (mm)
28	sq millimeter (mm^2)
31	ounce - avoirdupois
32	pound - avoirdupois
33	100 weight
34	ton - short
35	metric ton
36	ounce - troy
37	pound - troy
38	dram - avoirdupois
39	pennyweight
40	grain
41	gram (g)
42	kilogram (kg)
43	cubic decimeter (liter) (L)
44	cubic centimeter (milliliter) (mL)
45	carat
47	cubic meter (m^3)
48	cubic millimeter (mm^3)
49	milligram (mg)
51	pint
52	quart
53	gallon
54	half gallon
55	imperial pint
56	imperial quart
57	imperial gallon
58	imperial half gallon
59	fluid ounce
60	imperial fluid ounce
61	1000 pieces
62	0.1 piece
63	0.01 piece
66	cubic inch
68	dram - apothecaries
69	ounce - apothecaries
70	pound - apothecaries
71	box - package
72	carton
73	tube
74	barrel
75	drum
76	tank
77	case
78	carboy
79	keg
80	cylinder
81	dozen (12 pieces)
82	pad
83	spool
84	ball
85	jar
86	bottle
87	card
88	label
89	lot
90	can
91	tablet
92	cone

NOTE: Unit of Measures are grouped in Categories. Missing numbers will allow for additional terms to be inserted.

Appendix C

List of Acronyms and Definitions

ANMC	American National Metric Council
CPU	Central Processing Unit
CRT	Cathode Ray Tube
DP	Data Processing - the execution of a systematic sequence of operations performed upon data.
Dual Dimensioning	The practice of showing both SI and inch-pound values. 1. "Metric Prime" is SI first with inch-pound values following in parentheses. 2. "Inch-pound Prime" is inch-pound first with SI values following in parentheses.
Function	In the context of this plan, a function is one of a group of related actions contributing to a larger action.
Hardware	The physical requipment required to perform the data processing operation.
Hybrid	Metric hybrid refers to the practice of designing and manufacturing metric equipment and using inch-pound standard parts in places where it is not economical to change.
I/O	Input/Output
I/P	Inch/Pound; formally referred to as customary or conventional.
Metrication/metric conversion	The act of changeover from the use of the inch-pound system of measurements to the SI version of the metric system of measurements.
Software	The entire set of programs, procedures, and related documentation associated with a data processing system.

Appendix D

Bibliography

References

1.	ISO 31/0	- General principles concerning quantities, units and symbols.
2.	ISO 31/1	- Quantities and units of space and time
3.	ISO 31/2	- Quantities and units of periodic and related phenomena
4.	ISO 31/3	- Quantities and units of mechanics
5.	ISO 31/4	- Quantities and units of heat
6.	ISO 31/5	- Quantities and units of electricity and magnetism
7.	ISO 31/6	- Quantities and units of light and related electromagnetic radiations
8.	ISO 31/7	- Quantities and units of acoustics
9.	ISO 31/8	- Quantities and units of physical chemistry and molecular physics
10.	ISO 31/9	- Quantities and units of atomic and nuclear physics
11.	ISO 31/10	- Quantities and units of nuclear reactions and ionizing radiations
12.	ISO 31/11	- Mathematical signs and symbols for use in the physical sciences and technology
13.	ISO 31/12	- Dimensionless parameters
14.	ISO 31/13	- Quantities and units of solid-state physics
15.	ISO 1000	- SI units and recommendations for the use of their multiples and of certain other units
16.	ANSI Z210.1 (IEEE STD-268)	- Standard for metric practice
17.	ASTM E-380	- Standard for metric practice
18.	ISO 2955	- Information processing-Representation of SI and other units for use in systems with limited character sets
19.	AFWAL-TR-80-4110	- Metrication of MIL-HDBK-5C
20.	ISO 3461	- Graphic Symbols, General Principles of Presentation
21.	ANSI Y32.2	- Graphic Symbols for Electrical and Electronics Diagrams
22.	CAN-Z234.1	- Canadian Metric Practice Guide
23.	ANMC Metric Editorial Guide	- Guide to standards of format and style for metric unit display
24.	FED STD-376	- Preferred Metric Units for general use by the Federal Government