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IMPACT OF METRICATION
ON BUSINESS IN THE UNITED STATES

by

BARRY F. NASS

B. S. in Industrial Management

Purdue University, 1966

An Independent Study

Submitted to the Faculty

of the

University of North Dakota

in partial fulfillment of the requirements

for the Degree of

Master of Business Administration

Minot Air Force Base, North Dakota

April 1976

This independent study submitted by Barry F. Nass in partial fulfillment of the requirements for the Degree of Master of Business Administration from the University of North Dakota is hereby approved by the Faculty Advisor under whom the work has been done.

Advisor

PERMISSION

Title: Impact of Metrication on Business in the United States

Department: School of Business and Public Administration

Degree: Master of Business Administration

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ABSTRACT

This study is an examination of the Metric Conversion Act of 1975 and its resultant impact upon business and industry in the United States. The effects on business studied are international trade, ISO standards, data processing, personnel training and conversion costs. The study concludes that timely planning for the now inevitable conversion is absolutely essential to a smooth and least costly transition to the metric system. Each man must be convinced of the desirability of the change and that he should contribute his share to making the change.

CHAPTER I

INTRODUCTION

American industry is leading the United States step by step into the metric system. What must be clear is that a conscious decision on metrication on the part of the American people is late incoming. The majority of people of the world, the majority of the nations, were already using metric units before World War II. All the rest of the industrial nations have already made their committments to go metric or have in fact, already converted.

Whatever the relative merits of metric, it has won overwhelming international approval. Even in the United States, since 1893, the customary units for length and weight, the inch, yard, and pound have been defined in terms of the meter and the kilogram. Everyday use of metric units is rising steadily here, as elsewhere. The pharmaceutical and roller bearing industries have gone metric. Most recently, there has developed a strong trend toward metric conversion among industries which sell finished products on the world market. The John Deere Company, Caterpillar Tractor Company and IBM have all begun to convert. School children are taught metrics in math and science. Virtually all of the scientific disciplines and most engineering fields as well use metric language predominantly. A large fraction of United States packaged goods are dually labeled. It is estimated that some 23 percent of the cars on U.S. highways, including some popular Detroit models, contain some metric parts.[1]

Most important, there is the changing pattern of U.S. export trade toward high technology products and services, the rise of U.S. -based multinational corporations and the rising challenge of Europe and Japan in the international market.

It is essential that business managers in the United States appreciate fully the magnitude of the metric system conversion as it affects their business. They also should be prepared to take any steps that are necessary to assure that an increased use of the metric unit by their business or industry will not catch them unprepared and possibly force upon them a costly crash education or conversion program.

For company managements, one way might be to initiate training programs within their companies. If the size of the company does not warrant such a program, its management might consider participating in the training program of its trade association or a technical society. The training program need not affect the entire staff; however, participants should include all those who deal with measurement units as part of their regular work.[2]

A company's investment in equipment that might be measurement-sensitive and subject to early obsolescence when it changes over to the metric system must be considered. One consideration in purchasing new equipment would be its adaptability to the manufacture of metric-measured parts without converting metric measurements to inches on the drawing board. In any event, companies that will be working in both metrics and inch units will require sets of metric-measuring instruments in order to achieve dual capability.[3]

At present, there is relatively little demand domestically for metric-sized components except for repair of imported equipment or other articles that were made originally to metric measurement. If, however, a company is heavily involved in international trade or if the demands of the domestic marketplace begin to change, a company may wish to convert its product line from an inch to a metric base. Much, of course, will depend on the nature of the business and the demands of the particular market that the business serves. It may well be that many consumer items that are manufactured domestically will not be affected by the introduction of metric measures for several years. On the other hand, if a company is a supplier to other manufacturers that have changed their designs to a metric base, the supplier must keep pace.

Businesses can expect many changes and problems during the conversion process. To begin with, our modern technological economy consists of a complex network of producing, distributing and consuming units. In very few instances will it be possible for a company to make a change without consulting other firms or businesses. If a certain business is represented by separate producing, manufacturing and distributing outlets, all of these parties have to agree to the change-over simultaneously. The situation becomes even more complicated in industries such as machinery and appliances. Here a manufacturer of a single product may be dependent upon a dozen or more sources for his raw materials or semi-manufactured components. A change of units cannot be made at any one point without insuring changes at all other points. In these larger businesses, a great deal of central coordination and planning will be necessary.[4]

Companies and businesses are concerned with the expense incurred with metrication. The cost incurred cannot be accurately estimated merely by ascertaining the expense for each element, process, or operation and then totaling these individual items. Delays, imbalances created throughout the economy by unsynchronized changeover, continuing or even erratic inflationary spirals, and other exogenous forces have to be taken into account in determining the amount of money spent to cover long-range expenses.[5] In some instances, an accurate estimate may be impossible. Consider the predicament of the various state bureaus of highways and roads. A conversion means that every map, road sign, vehicle specification and hundreds of other items have to be changed. The number of industries involved in this one area is staggering.

To avoid expensive delays, it is mandatory that the government and individual businesses follow a pre-arranged timetable. Each step of the conversion process must be known in advance and each must be assigned an inception date. Included in this rigorously enforced schedule must be specifics regarding the educational programs to be instituted, how new equipment is to be procured, and what alterations will be forthcoming in production, warehousing, shipping and selling.

There is the ever-present and ominous threat of critical shortages. When the principal firms in the pharmaceutical industry changed to the metric system, the requirements were relatively small so there was no problem in obtaining the necessary metric weighing and measuring equipment. In the food industries, however, including all the grocery stores, chain stores, and supermarkets in the United States, arrangements have to be made long in advance to produce the necessary scales and similar equipment needed to replace all the existing equipment. In other countries this was solved by scheduling the conversion in different segments on successive dates distributed over a period of several years.[6]

Most large-scale businesses and corporate units may expect any or all of the following ancillary changes:

1. alterations in shipping containers for individual products or for specified numbers or weights of individual products.

2. revision of all sales literature, service manuals, price lists, catalogues, advertising brochures, and educational booklets.

3. stocking of dual inventories in service stations, warehouses and training of service personnel.

4. additional accountants to handle the tremendous increase in financial records and additional secretarial help to assist in the expected flood of new paperwork.

5. an overall increase in staff--especially in blue collar workers-- to relieve those who will be devoting some of their time to instructing their co-workers in the new system.[7]

The conversion to a metric metrology will be expensive, difficult and time consuming. It is far more difficult for an advanced industrial and technological society such as the United States to convert to the metric system than it would be for one that is less advanced. It will be less expensive, less troublesome and less time-consuming now, however, than it will be twenty-five years from now.

CHAPTER II

THE METRIC CONVERSION ACT OF 1975

The earliest consideration of a decimal-based metrological system dates from the last decade of the eighteenth century. In October, 1791, President Washington, in his third message to Congress, spoke of the need for metrological uniformity as outlined in the Constitution and the necessity for an invariable and universal standard.[8]

Between 1791 and 1866, the subject of weights and measures was up before Congress a substantial number of times but they took no final action. Finally on July 28, 1866, Congress declared, after two years of deliberation, that the metric system would be legal for use in the United States. The metric metrology merely gained legal status while the English system remained as the basis of our metrology.[9]

In 1875, representatives from the United States and sixteen other countries signed the 1875 Treaty of the Meter under the terms of which the International Bureau of Weights and Measures, the General Conference of Weights and Measures and the International Committee of Weights and Measures were formed.[10]

The most significant event thereafter was the Metric Study Act passed by Congress in 1968, which directed the Secretary of Commerce to arrange for a broad inquiry and evaluation of metrication in the United States. In his report to Congress on July 29, 1971 entitled

"A Metric America -- A Decision Whose Time Has Come," the Secretary of Commerce recommended that the United States change to the International Metric System deliberately and carefully.[11]

The United States Congress continued debating the metrication issue each year. The major stumbling block was that the Senetors and Representatives could not agree among themselves just who was going to pay for the conversion. The very strong labor and small business lobbies wanted the government or the employers to pay for all costs incurred to the "little man" while the majority of congressmen accepted the doctrine of "let the costs lie where they fall". The metrication issue failed to come to vote or failed passage in both houses of Congress until 1975.

On December 23, 1975, The Metric Conversion Act of 1975 was signed into Public Law 94-168 by the President of the United States. The Act was established: "To Declare a national policy of coordinating the increasing use of the metric system in the United States and to establish a United States Metric Board to coordinate the voluntary conversion to the metric system." The Act establishes the independent United States Metric Board composed of 17 individuals. This number was surprising since most previous recommendations, including the findings of Metric Study Bill of 1968, were for a Board consisting of 21 members. The Board members are to be chosen from varied interests of our Society and will be composed of:

1. The Chairman, a qualified individual who shall be appointed by the President

2. One each to be selected from lists of qualified individuals recommended by:
   a. engineers and organizations representative of engineering interests.
   b. scientists, the scientific and technical community and organizations representative of scientists and technicians.

c. the National Association of Manufacturers.

d. the United States Chamber of Commerce, retailers and other commercial organizations.

e. the National Governors Conference, the National Council of State Legislatures and organizations representative of state and local government.

f. the National Conference of Weights and Measures and standards making organizations.

g. educators, the educational community and organization representative of educational interests.

3. One to be selected from lists of qualified individuals representative of the construction industry.

4. Two each to be selected from lists of qualified individuals recommended by:

a. the American Federation of Labor and Congress of Industrial organizations who are representative of workers directly affected by metric conversion and by other organizations representing labor.

b. organizations representative of small business.

5. Four-at-large members to represent consumers and other interests deemed suitable by the President and who shall be qualified individuals.[12]

The terms of office of the members of the Board first taking office will expire: five at the end of the second year, five at the end of the fourth year, and six at the end of the sixth year. Successors to the members of the Board will be appointed to a term of six years.[13]

It was Congress's view that the Board will not need to function the entire process. After conversion plans are developed, coordination activities have made substantial progress, and public education is essentially complete, the Board can cease to function. The momentum of the conversion process should be sufficient at that time. There will most likely be many minor problems remaining, but they can be resolved without the assistance of the Board. Recognizing that the conversion may require longer or shorter than a ten-year time frame and that the valuable coordinating efforts of the Board may still be necessary, the Act specifies no definite time limit on the tenure of the Board, but provides the Board will cease to exist when the Congress determines that its function is complete.[14]

The Board will have no compulsory powers. It will be the function of the Board to devise and carry out a broad program of planning, coordination, and public education.

It is most important to note that the Act did not specify a target date for completion of the conversion. Most other nations undergoing the conversion process from the English System to the Metric System have worked with an overall time schedule of a decade. The Australian experience has demonstrated that the conversion process can occur in less than the ultimate goal; they anticipate completion two years ahead of schedule. New Zealand established a goal of eight years and is anticipating completion in seven. Although the experiences of other nations can provide guidelines, it is recognized that the United States has a greater population and a more complex industrial economy which may require greater efforts in the conversion process.[15]

The inclusion of a ten year target date for extensive adoption of the metric system was discussed very thoroughly by both the House and Senate. They acknowledged the need to give impetus to metrication so that costs and inconveniences will be minimized. However, they recognized that each sector of the national community will require a different time frame. Some sectors of the community, such as the pharmaceutical industry, are already metric. Other sectors may require years before conversion is achieved. Congress envisioned a conversion period sufficiently long so that no industry or sector of society will be unduly harmed or disadvantaged. It also desired a conversion period sufficiently short so that the social and economic costs of conversion will be reduced.[16]

Business, both large and small, now need to plan to insure that their views, interests and problems are ably expressed to the Board by their representatives. Businesses, through their numerous associations, need to self-establish an orderly process of conversion and a target date for completion since the Act did not specify the period. Once the cooperative decision has been made for the different industries and sectors of the business economy, they can be presented to the Board for their consideration and adoption. Business should take the initiative to establish their own destiny rather than sit back and wait for the Government to decide it for them.

CHAPTER III

PLANNING FOR CONVERSION

The trend toward metric conversion gains momentum day by day. As more and more industries and companies are setting up metric conversion plans, a domino effect of sorts occurs at all levels of U.S. industry. As each major corporation converts to the metric system, hundreds of that corporation's suppliers are influenced by such a move. General Motors, for example, which is converting to metric, has some 47,000 suppliers that have every good reason to follow in GM's metric footsteps.[17]

The business manager must be prepared to meet this challenge. Here are some of the questions that he must face and answer: How much time is to be allowed to convert? Is he aware of the pitfalls as well as the opportunities? How well versed is the staff in the metric system and is there a person on the staff capable of serving as a metric coordinator for the business? What is the competition doing about metrication? Where do his customers stand on metrics? These and many more knawing questions must be faced, and faced squarely from the start. There is no short cut to the work that must be done before establishing the policy for the company.

The larger companies have, rightfully, taken the lead in U.S. metric conversion but not every company can be a pacesetter. The smaller company, as so often is the case, assumes the problem of metric conversion just as it assumes technical or any other kind of change but the most important point for the smaller company is to be ready when the time for a change comes. What is the right time? Certainly, there is no benefit in going metric simply to say that you have. On the other hand, there is equally no benefit in taking a wait-and-see attitude or procrastinating unduly.

The decision as to when to begin conversion to the metric system is like making any other sound business decision. It is a matter of recognizing both the opportunities and the benefits, economic, engineering, as well as any other, and weighing them carefully as would be with any investment for a satisfactory return. It is a matter of moving with a strong trend, not too far ahead, but also not too far behind. Looking at it more closely, it boils down to competing for one's own investment funds just as one would for any other project. In short, the benefits must outweigh the disadvantages over the long run.

Once the real benefits and long-range opportunities are recognized, it becomes a matter of investing as little as is necessary to bring about conversion and with as little disruption as possible. Time-wise, plan for the shortest economic time. As an investment, metric conversion just as any other undertaking, will recover its cost and show a profit only if one plans for it properly. It will require commitment, sound decision-making, leadership, constant guidance, coordination and full cooperation from everyone assigned to the metric conversion program.

Pinpointing the costs of metrication in advance can in itself, be unnecessarily costly, inaccurate and frequently deceptive. The time consumed in such an effort might better be used to seek ways to minimize conversion costs. Trying to estimate overall costs is meaningless and whatever the costs, they can be held to a minimum by good planning, good timing and good implementation.

From a business standpoint, conversion can be accomplished sooner with a plan as opposed to a hit-or-miss approach or even going metric "by osmosis" which will take forever. To implement metric conversion, that responsibility is usually assigned to a metric coordinator. In larger companies, the activity may be headed up by a metrication task force or a metric coordination committee. But whatever the name, this individual or group provides the direction, advice, coordination and guidance that makes metrication happen. A task force or metric coordinating committee should not be so unwieldly that it can't operate efficiently. Also, if metric conversion is to be accomplished at the least possible cost, a metric committee or task force should be held to a minimum size. The persons assigned to it are those who take on metric activity as part of their normal job.

For example, at General Motors, because of its size, each of its divisions has a metric coordinator who reports directly to the general manager of that division. These metric coordinators are encouraged to solve their own problems and have the freedom to do whatever is necessary in their divisions to bring about metric conversion. The divisions, in turn, are assigned to groups, each having a group coordinator appointed by a group vice president. If divisions have similar problems, they're discussed and resolved at this group level. The group coordinators then sit with members of the financial, legal and overseas staffs on what is called the Metric Council. The council in turn, is a sub-committee of the Engineering Policy Group which made the decision to go metric in the first place. It is a complete loop.[18]

In the planning phase, the committee or task force could review and identify those areas that are metric sensitive. Then develop a specific plan for each area. The plan should probably include a very definite time frame and target date for each product division, works or department. It could also define when and how the plan is to be implemented. The three phases do not necessarily have to run concurrently throughout the entire business complex. Rather, they will vary from plant to plant, from product to product and from any subdivision to any other subdivision. The task force would coordinate these phases.[19]

A Commerce Department study furnishes evidence indicating that metrication via a coordinated program would be less costly and less confusing than an unplanned conversion.[20] Even opponents of the whole metric conversion concept agree that if the U.S. is going to metricate, it should do so by planning the conversion on a national as well as a segmented basis rather than in an unstructured manner.

CHAPTER IV

PERIOD OF INCREASED INTERNATIONAL TRADING

The United States is at this time facing a great problem in international trade. The old assumptions about American technology are in serious question. The most critical and immediate problem for U.S. technology to face up to is that the United States is losing its dominant position in the markets of the world. The balance of trade has turned to the minus side of the ledger for the first time in this century. Only recently, the massive agricultural exports have brought the United States again to the plus side of the ledger. American productivity in industrial output, quality and quantity and in the service sector of the economy is woefully weak and is being challenged by an increasing number of nations. All of these add up to a very real challenge to the vitality of our economic system.

Over the past two decades, the United States' share of the world gross national product has been shrinking from nearly 40 percent in 1950 to only slightly more than 30 percent in 1970. It is not by itself bad--the rest of the world's nations are doing better while the United States, in absolute terms, is also growing.[21]

The challenge to the United States in the world marketplace is symbolized by a net deficit in the balance of trade for manufactured goods and services. Whereas the average annual growth rate in imports exceeded the growth rate in exports only slightly in the early 1960's; by 1971, the growth rate of imports had climbed to triple the growth rate in exports. While U.S. manufacturing productivity rose 32 percent from 1960 to 1970, Japanese productivity tripled. While U.S. exports of manufactured goods rose 110 percent, Japanese exports quadrupled.[22]

One example of the pressure on United States firms exporting to other markets is the directive on measurement units issued by the European Community (United Kingdom, West Germany, France, Luxembourg, Belgium, Denmark, the Netherlands, Italy and the Republic of Ireland). Anyone trading with EC countries must, by the end of 1977 use SI metric units. The directive is limited to the language describing the product. Only sales literature, invoices, service manuals, and drawings must be expressed in metric SI units.[23]

The European Community directive is in reality merely an objective, and the difficulty will lie in the enforcement it will receive by the individual member nations. However, the European Community could take corrective action in the European Court of Justice against member countries which fail to observe the basic objectives.

The use of dual dimensioning, both inches and millimeters, could pose a problem to some exporters. Although the directive doesn't prohibit that practice, it doesn't authorize it either. Even EC officials have some doubts about what will eventually be allowed by member countries. For anyone using dual dimensioning, probably the best guideline would be to avoid any dimensioning practice that could possibly mislead.

Overall, United States industry performs and uses its research and development better than any nation in the world. In "nontechnology-intensive" manufactured goods, imports have climbed drastically since 1958, when imports equaled exports. Now exports in those products are again on the decline. The story is different, however, in the "technology-intensive" manufactured products like scientific and communications equipment where research and development investment is high. The United States still exports more than it imports, although the gap is narrowing. Obviously, those industries that rely most heavily on science and technology and are innovative do best in international trade. This is not unexpected in view of the high cost of labor in the United States.[24]

CHAPTER V

INTERNATIONAL STANDARDS

Improving the United States' competitive position in the world markets is a very demanding, tedious task. Many things must be done. Prime among those tasks is to improve the United States' effectiveness in international standards deliberations.

The distinction between two facets of metrication-- measurement language and engineering practice and design-- must be drawn and understood. The idea of changing measurement language is simple and fairly well understood. Insofar as a pounds and ounces scale can be converted to metric by changing the dial plate alone, only a language change is involved.

Engineering practices and standards are a different thing entirely. They involve the arbitrary sizes, shapes, and configurations in which we choose to make our goods. They derive from a natural human inclination to try to simplify design and to show a preference for whole numbers. Screws, bolts, and other fasteners could be made in an infinite variety of lengths. But common sense tells us that we will select a certain few conveniently spaced sizes and make only those. Some manufacturers use "dual dimensioning", expressed in both inches and millimeters for parts and machinery that they sell abroad. However, labeling a one-half inch diameter shaft as a 12.7 millimeter shaft is not true metrication. In the metric system, such a standard shaft would be either 12 mm or 13 mm because of the human preference for round numbers.[25]

Industry has been carrying on this practice of standardization for many years and it has brought great benefit to both manufacturer and consumer. At the turn of the century, light bulbs were made in an absolutely bizarre number of base sizes and threads and bulb configurations. The idea of running to a local store for a bulb to fit a lamp was unheard of. Industry, through voluntary standardization, reduced the number of different bulbs manufactured. In so doing, they simplified their manufacturing procedures, simplified the consumer's shopping and reduced the price of light bulbs dramatically.

Now industries in a country which uses the metric system will be inclined to standardize on sizes which are in whole numbers of metric units. Where United States industry may choose to make a fitting which is two inches in diameter, an industry in a metric country might prefer five centimeters. The two resulting parts would be tantalizingly close in size, but completely incompatible.

The main avenue for nations of the world to make agreements on engineering standards is through such international standards-making organizations as the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). In the working committees of such bodies, representatives of all interested nations meet to write international standards which will recognize product technology in use by the participating countries. The resulting standards often require some adjustment in the practices of the participants, but if the job is done properly, no one's products are completely excluded and the adjustments fall evenly among the participants.

The United States carries two disadvantages in this process. First, our industries do not participate to the extent that they should; second, our representatives take up much or their time worrying about the metric versus the U.S. customary unit problem. Our people must work to have measurement conversion tables included in the written standards. This sort of consideration often gets them labeled as obstructionists. At the very least it distracts from the main task which is the consideration of technology and the protection of existing United States' practices. Since the battle for international markets is fought to a great extent in these international standards deliberations and will be for years to come, it is a favorite ploy in international competition to write standards that give the home product an edge. Many United States' companies may ultimately find themselves locked into metric standards that hurt, as Timken Company did with its tapered roller bearings.[26]

When an American engineer selects a ball bearing or a cylindrical roller bearing, he specifies it in millimeters. When he specifies a tapered roller bearing, though, he does it in inches. The difference has nothing to do with technology; it just happens that the ball bearing and ordinary roller bearing originated in Europe where metric measurement prevails, while tapered bearings were invented in the United States.

Timken Company of Canton, Ohio who invented the tapered roller bearing now wants to go metric; yet, balks at accepting the standards for tapered roller bearings that Europeans developed in metric measure and that were approved by the International Standards Organization

(ISO). The ISO bearings do not measure up to the high standard of bearing design that has been developed by United States companies; so, Timken has designed a new line of metric bearings that it proposes as a superior standard.[27]

A tapered roller bearing is a cylinder with a taper that enables it to withstand "thrust" loads along its axis, as well as radial loads. An automobile contains about $40.00 worth of tapered bearings, two for each wheel. There are two million dollars' worth in a steel rolling mill. About $750 millions' worth of tapered bearings are sold annually in the United States. But the bearing business is international. Timken has plants in six foreign countries, serving not only foreign customers but also the foreign plants of multinational companies like Caterpillar and International Harvester. To meet metric competition, Timken has had to tool up in Europe for dozens of metric bearing sizes. Tooling up for just one bearing size can cost $150,000 to $300,000. It is just good business practice to invest money in tooling in optimum designs.[28]

Today's ISO standards, drawn up about twenty-five years ago, are far from optimum. To minimize the number of tools and gauges needed, the Europeans chose to specify for tapered bearings the same "envelopes" as those of ball bearings. Hence Americans say the ISO bearings contain too much metal and take up too much space. ISO standards also fail to recognize cost-cutting techniques of manufacture that the United States has developed and they impose costly and unnecessarily rigid tolerences. European manufacturers have no desire to retool to new standards; so, Timken has little hope of getting the ISO to approve its own recommendations. When the metric standards were drawn up, American companies showed little or no interest.[29]

We have every reason to expect that United States technology will eventually receive the recognition it is due if we participate vigorously in the negotiations. Today only about 2,500 international standards and recommendations have been adopted by IEC and ISO. World trade needs somewhere between 20,000 and 30,000 standards to function effectively.[30]

The industrial powers of the world now recognize the urgency of this need and are producing international engineering standards at an ever increasing rate. Most of the international standards required will probably be drafted in the next ten years.

If the United States stands by while other nations write their 10,000 metric industrial standards, the process of going metric in the United States will mean conversion to foreign industrial practice.[31] If, instead, we get our technology written into those international standards, the other nations will have to change to our technology at least as often as we do theirs. This is a major source of urgency toward getting started with developing United States national metric standards.

America's ability to produce the necessities and luxuries of life and to keep our people gainfully employed depends on our industrial ability to mass produce products for large markets. Producing products for our more than 200 million citizens in a coherent national market is the basis of our economic health.

We are not alone in understanding this principle. The nations of the Common Market and European Free Trade Association are trying to put together a market of 265 million people. To do this they must harmonize their measurement standards and engineering standards. They have all agreed to spear the same measurement language and develop common engineering standards so that they may exchange goods freely between nations.

In world trade, the issue of metrication is most important in "measurement-standard sensitive"(MSS) products, those in which dimensions and measurement units are critical, like thermometers, vacuum pumps, computers, refrigeration equipment, printing machinery and so forth. In 1969, the United States exported about $14 billion worth of MSS products and imported about $6 billion worth.[32] Obviously, this group of products is critical to our balance of trade. Until quite recently, differences in measurement systems and engineering standards did not have a major impact on world trade in that they were less important than other factors like price, reputation and reliability of the manufacturer, superior technology, and quality of the product.

Now, however, differences of engineering standards are taking on a new importance because countries abroad which want to encourage trade among each other, as in regional groups, are agreeing on common quality standards and certification programs. The agreements provide that when products are certified by the producing country as meeting the agreed engineering standards, they will be accepted without further inspection or test by all the other countries adhering to the agreement. This mechanism will increasingly serve to facilitate trade among the agreeing countries, but can inhibit imports from all other countries.

The urgent need now, if this potential nontariff barrier to trade is not to have major impact on our exports, is for our much greater participation in the development of international engineering standards and our access to the emerging certification programs.

CHAPTER VI

AFFECT ON DATA PROCESSING

The transition to the modern metric measurement system will impact data processing systems in the following areas: use of character sets, the definition of data field sizes, numeric precision or accuracy, conversion of historical data and the logic of mathematical calculation.

The International Metric System, or SI (from the French Systeme International d'Unites), requires the use of both upper and lower case alphabetic characters. These are essential in using the system's symbols for each unit. Without this distinction, it is not possible to distinguish between k (kilo) and K (kelvin) or between m (milli) and M (mega). This requirement for upper and lower case characters cannot be met by many existing data processing systems. In addition, symbols for two SI terms ohms (Ω) and micro (μ) and exponential notations are not currently available on any standard U.S. computer system. To help users cope with SI units, the American National Standards Institute (ANSI) has developed a proposed ANSI and ISO (International Organization for Standardization) standard representations for SI and other units to be used in systems with limited character sets which provides an interim solution to the problem.

Each metric unit is intrinsically more or less precise than the customary unit it replaces. Thus, centimeters are much more precise than inches; kilometers are more precise than miles; but meters are much less precise than feet and kilograms are much less precise than pounds. This difference in accuracy dictates that metric units require more or less digits than do customary units to represent the same range of values. In an overly simple example, representing 0 to 99 miles requires only two digits, while the equivalent range in metric units of 0 to 159 kilometers requires a data field of three digits. Only 62 miles, ie., 99 kilometers, can be represented by two digits. Similarly, the representation of mass in kilograms will require fewer digits than pounds for various ranges of values. Thus, 100 to 218 pounds requires three digits while the metric equivalent of 45 to 99 kilograms only uses two digits. Obviously, as we begin to process metric measurement data, the selection of appropriate field sizes will become quite significant.[33]

In a similar fashion, the inherent difference in precision also has a major impact on numeric accuracy. If, for example, one uses data in cubic inches (in.^{3}) accurate to one decimal place or $\pm$ .05 inch, the same one decimal place in cubic centimeters (cm^3) would provide $\pm$ .05 cm or $\pm$ .00305 inch, which is much more accurate than is needed. However, if one uses data in pounds accurate to one decimal place $\pm$ .05 lb., then the equivalent one decimal place in metric kilograms provides accuracy to $\pm$ .05 kg. or .110 lb. which may not be adequate. The net effect of this difference in precision of each measurement system will be an increased system sensitivity to field sizes, both to the right and left of the decimal point.[34]

Systems that generate measurement sensitive data for use in forecasting statistical analysis or other analysis will be faced with a major discontinuity in their data. It will be difficult to compare the last 5 years' automobile performance data in gallons/mile with next year's data in liters/kilometers. Cost accounting systems will suddenly generate unit costs per kilogram or cubic meter, while all the previous data is in cost per pound or cubic yard.

The typical calculations that any data processing system performs are affected by the inherent change in units and also by the elimination of many customary conversion factors. Becouse the SI system is coherent, most of the traditional conversion factors are no longer needed. For example, if one were figuring the power required to drive a generator to get X amounts of power generated, in the English system the power generated is in kilo watts but the power required to drive a generator is in horsepower so a conversion factor must be used. In the metric system the power required to generate and the power generated by the generator would both be in kilo watts so no conversion factor is needed. Clearly, the conversion to metric units will affect all systems that perform routine calculations using customary measurement units. Computer assisted design packages and other engineering/scientific data processing systems will be affected most severely.

The degree of impact from metric conversion will vary depending upon the nature of the particular data processing system. Some systems will not be affected at all or in such minor ways that they can readily accomodate the change. Other systems will have to be converted to accept and process both metric and customary data. It can be expected that some systems will be so difficult to convert that it will be more cost effective to discard them and design replacements. Systems that will be changed by metric conversion range from inventory/production control and cost accounting through computer assisted design and numerical control applications. Since the metric transition will progress in an orderly fashion over a period of years, most systems will have to process both customary and metric units during the overlapping years. Typically, an inventory system or bill of materials processor would be required to handle both customary and metric sized items. The result is a possible 10% to 30% increase in inventories or materials processed by such systems.[35] A similar requirement for dual capabilities will exist in the generation of reports and in performing design calculation.

To minimize the impact of metrication on an organization's data processing system, the data processing manager must lead the way to a structured solution. He obviously will have an uphill battle since many people are either not aware, not interested or nonbelievers as far as metric conversion is concerned. While major countries have converted to the metric system recently (ie., Great Britain, Japan, Australia, and Canada), none have been so dependent upon computers as is the United States and thus, we have no reservoir of experience from which to draw. In analyzing the metric conversion, the following major tasks become evident:

1. The data processing manager should initiate a metric awareness program at the top level of the organization. This program could include informal talks, seminars or workshops as appropriate. Essentially, everyone must be made to understand the inevitability of metrication and the degree to which it will or will not affect their operations.

2. An analysis of every data processing system application in operation or being designed should be conducted. This analysis should determine the degree to which the system's input, processing or output is dependent upon measurement sensitive data. The result of the analysis should be a classification of all systems in terms of the results of metrication. In conducting this analysis, the life-cycle of each system must be considered, since the decision to convert or redesign a system should be based on the total cost/benefit of each system decesion. The expected life of a particular system will have a significant affect on the cost/benefit analysis.

3. Each data processing manager should develop a metric conversion plan. This plan should be a major element of a corporate metric conversion plan whenever possible. The plan should show the time phasing of the metric capability for each system. Specific resources required for the change should be identified. All system users should be involved in developing this plan since they will bear the brunt of any metric transition problems.

4. All new systems being designed should reflect the results of the impact analysis study. All measurement sensitive systems should be designed with dual capabilities; ie., both customary units and metric units. The mathematical processing should be clearly separated from all logical operations to facilitate the eventual conversion to metric units. Obviously, field sizes should be selected with the eventual conversion to metric units as a primary factor.[36]

To assist American manufacturers and businesses, the Commerce Department's National Bureau of Standards has recently devised a computer program package to perform the conversion from one system to the other with carefully controlled accuracy. The package consists of separate computer programs developed by Caterpillar Tractor Company and General Motors Corporation, documentation explaining how to get the programs to permit users to verify that the programs are compatible with their computers.[37]

The Caterpillar program converts 31 different metric units to their U.S. customary equivalents. In contrast, the General Motors programs convert in both directions but work in millimeters and inches only. Their programs use rounding conventions somewhat different from those that are employed in the Caterpillar program. Both Caterpillar and General Motors programs are written in American National Standard FORTRAN and are suitable for use in a wide range of computers with little or no modification. The Caterpillar program is operated in the batch mode while the General Motors programs are interactive.[38]

The programs' main advantage is in providing the design engineer with control over the accuracy of the conversion process and the tolerances to be maintained. In this way, errors and costs that would be unavoidable in a shop where everyone makes his own conversions are eliminated. Control at the design level also increases productivity by speeding up the manufacturing process and providing an automatic self-checking system that is essentially error-free.

Clearly, the United States metric transition presents a unique challenge to the data processing industry in that it will affect the total industry, it will prceed in an orderly fashion and we are aware of it. Thus, we can and must act to meet it now. The long lead time for systems conversion and redesign combined with the rapid acceleration of metric transition dictate that the data processing professional take action now to meet the metrication challenge.

CHAPTER VII

PERSONNEL TRAINING

Because of the magnitude of this measurement change, metric training programs represent a major effort for most organizations and should be planned accordingly. In approaching a new training requirement such as metric measurement, it is appropriate to consider the major factors that will impact the program. If these factors are not considered, significant resources may be wasted and metric training will be implemented haphazardly.[39]

The adoption of metric measurement represents a major change in skills that are very basic to most individuals. The resistance to this change will be monumental and must be overcome if the program is to be successful. A metric training program must have a firm commitment from top level management and must be sold in a very positive manner to overcome this resistance.

Employees may feel threatened by the metric system but a training program that reaches the right people at the right time can put them at ease. In any changeover, designers, draftsmen and technicians come first but every employee is affected. Managers should concentrate on timing, technique, and properly meeting the employee's need to know. Timing should be influenced by what action suppliers, competitors and customers will be taking on metrication. Timing means that the basic education must be planned and scheduled far in advance.

Since the metric change will impact the whole workforce, a training program will have to address the problem of high volume training, although the training needs will vary. Virtually everyone in an organization must be exposed to metric units to some degree. Unfortunately, much of this training should also be timed to coincide with the actual use of metric units in the shop or office. It should not be attempted if little or no opportunity for practice can arise within a short period of time. If started too early, it will have to be repeated when metric useage begins. Obviously, the selection of presentation media will depend on the identification of participant groups with common needs and timing constraints. When planning is started, enlist the aid of equipment makers, trade societies and technical societies. Subtle errors in the technique that is used can render the whole plan ineffective. For example, if employees have a choice between the two measuring systems on dual measurement drawings and other business documents, chances are good that the metric system will be ignored.[40]

Because each individual uses measurement units in a variety of ways, the requirements for metric training will vary considerably. Everybody will require some basic knowledge of these metric units, ie. meters, kilograms, liters, degrees celsius (centigrade), used in daily commercial transactions. However, the skilled craftsman has to be familiar with only millimeters and kilograms in his work, while the engineer or designer must understand newtons, joules, watts and pascals. The mechanic will have to understand power in kilowatts while inventory clerks will have to understand meters, cubic meters, metric tons and liters. Metric measurement will impart all functional areas from corporate planning through design, manufacturing and axles, as well as data processing, cost accounting and marketing.

To some extent, every employer will be affected and that information will have to be fed downward in the organizational structure. The first step might be a general indoctrination of everyone through posters, work bulletins and general propagandizing throughout the business. One should not stop with just conventional wall posters containing conversion charts; enough informality and interest should be added to each metric campaign to make escape from metrication impossible.

Employers should start by marking the heights of doorways and aisles in meters, by indicating the volume of coffee dispensed from vending machines in liters, and with other signs indicating metric dimensions of common items in the worker's environment. That presents the metric system without any conversion factors and just by routine observation, employees will quickly grasp the overall relationships.

The general indoctrination at upper management levels can most likely be achieved simply through one or two days of seminars using outside lectures. By using someone not employed by the firm, partici-pation and involvement will be greatly improved. Inhibitions and the latent feeling of "I should have known that" or "People assume I do know" prevent executives from effectively responding to subordinates. The reeducation at this level should constitute a guided discussion of terms, concepts, and implications, rather than the actual teaching of technicalities.[41]

Training personnel, designers, R & D personnel, industrial engin-eering, production supervision, maintenance, and inspection personnel, all of these should quickly adapt to the new system. Here the use of training materials is important and programmed learning materials are the most effective route. Special attention should be given to the design and technical responsibilities, since that is where product or service concepts originate. Some of these people force the serious problem of going back to first principles and need to unthink a lot of what they have learned over the years.

The shop personnel present the prime problems. A natural apathy will exist toward a change in basic technical thinking. "Who wants metric?" will be their question. To involve them, the training must be kept specific to their tasks, all of the necessary conversion materials must be made available, a more thorough pre-training indoctrination must be given to them. The training should be done by their technical supervisor. The groups should be kept small and the workers separated by occupation or trade.[42]

Managers will have to evaluate the adaptability of their older craftsmen. They may or may not absorb the new standards of measurement as easily as young trainees or apprentices. They may not tolerate new problems that demand understanding. Some will just not care to learn the new system since they are so close to retirement.

Almost every business or firm will have to "sell" the acceptability of metric change to the rebel manager or union leader who see metrication as an insurmountable task. He should be reminded of how the manufacturing work force has solved similiar production dilemmas.

Shop employees will also have their opinions guided by the conversion's effects on their personal costs. Some manufacturers feel that their employees are required to have metric tools, so have felt obligated to buy them their first metric sets. If managers maximize employee good-will throughout the metric transition, opportunities for unions to be "champion" of management oversights will be minimized or eliminated.

How much employees need to know depends upon their function. Most production workers performing repetitive tasks on an assembly line will be able to perform satisfactorily with very little training, whereas process, engineering, and supervisory people will require more comprehensive education.

Despite the industry training programs, an educational gap will continue until manufacturers communicate with educators. Until the trade and vocational grammar and high schools turn out students with a metric understanding, industry will be functioning with many workers that are not comfortable in metric terminology and practice. Industry must communicate its metrication needs to educational authorities and school systems must develop and begin instructing more metric programs.

CHAPTER VIII

THE COST OF CONVERSION

The price tag for metrication is difficult, if not impossible, to project. Published estimates vary widely and are often staggering. Opponents of metrics claim that it could cost the United States as much as $200 billion over a thirty-year period.[43] Congress expected that the coordination activities of the U.S. Metric Board will contribute notably to a reduction in the overall costs associated with the conversion process. Congress has heard from other Nations currently in the conversion process such as Australia and Canada, that actual costs have been substantially less than the most modest estimates. In the United States, industry currently converting to the metric system reports costs to be much smaller than original estimates. Many firms are absorbing costs as a part of norman operating budgets without special allocations.[44] When the pharmaceutical industry went metric some years back, one of the participating companies was able to report that actual costs were one-half to two-thirds the preconversion estimate.[45]

Another company that made public a cost estimate several years ago and that now has some actual experience to compare it with and a more realistic appraisal of its requirements, is Caterpillar. Caterpillar manufactures its products in metric plants in France, Belgium and Japan, and the company is now in the process of converting its operations in the United States, the United Kingdom and Australia. Based on the criteria set by the Department of Commerce, Caterpillar originally estimated that metrication would cost the company $168 million. Now that actual planning is underway, and more realistic projections can be made, the company has determined that costs will amount to only a fraction of that figure.[46]

Tangible costs in a conversion include modification of equipment and other physical changes; intangible costs cover retraining and education. The nonmanufacturing firm would have fewer costs in machinery and tools, but would share in the costs of retraining its labor force, maintaining dual inventories and modifying measuring devices. The nonmanufacturer is primarily concerned with "soft" changes in vocabulary and labels. In those organizations where conversion would simply mean a change in vocabulay, such as the service industries, no substantial cost would be involved. Most manufacturers, however, are faced with hardware changes or redesign of physical equipment, as well as "soft" changes.

With regard to training costs, the British experience has shown that it takes less time to train workers than was originally anticipated, teaching the man On-the-job on a need-to-know basis. The U.S. pharmaceutical industry, too, found that retraining required less time than expected, and was facilitated by the use of dual-labeling to familarize workers gradually with the new terminology.

Sizeable costs have been averted by most of the companies already planning conversion by establishing the policy of using the new standards for new products and drawings, but making no change in present output. In addition, these companies do not plan a mass replacement of tools and equipment. Rather, normal replacement determined by wear or obsolescence will keep the cost minimal.

John Deere and Company has found that virtually no machine tools have had to be replaced. Conversion Charts and/ or dual demensioned drawings were used to produce items either in customary or metric units. Tool modification, changing scales or mechanical parts, is not as costly as total tool replacement. At the same time, tool replacement is a constant process in manufacturing, and metric tools can be purchased to replace customary unit tools under the normal replacement plan. Automobile mechanics, probably the trade most affected by metrication, are already purchasing tools that fit metric parts because a substantial number of the automobiles on the U.S. highways already require metric tools.[47]

During the conversion process, small businesses may be exposed to adverse situations. The Small Business Administration is to direct its financial, management, procurement and technical assistance programs to aid small business firms impacted by metrication. Some small businesses will not have the resources for necessary conversion to the metric system and may need loans from the SBA. Also, Congress expects the SBA to be vigilant that during the conversion process, federal contracts being held by small firms are protected.[48]

CHAPTER IX

SUMMARY AND CONCLUSIONS

Having presented information about the Metric Conversion Act of 1975 and six areas of concern and importance in the metric conversion process, what does this mean to the student or practitioner of business management? The Act signed by President Ford on December 23, 1975, finally commits the United States to convert to the SI metric system and to catch up with the rest of the industrial world. The Act also established a Board to coordinate the conversion process. However, no time table or target date has yet been established. We will have to wait for the Board's first report due the latter part of this year.

The initial phase of any large undertaking should rightly be the planning phase. Congress has, in essence, left the major elements of planning for metrication up to each industry, economic sector, business or whatever group or sub-group that discovers a commonality and dependence to each other. Planning will minimize confusion and minimize the cost of conversion.

Metrication has increased emphasis now that the United States is only one member, although still a very dominant participant, in a truly international economy with many countries struggling to increase their exports, their "piece of the world market pie" and their balance of national payments on the positive side of the balance ledger. The European Economic Community has stated that all literature must be metric by 1977 to trade with their bloc. This puts increased emphasis and pressure on United States business to become metric oriented.

Aligned very closely and inseparable from international trade is the establishment of international standards for industry, manufacturing, engineering as well as many other vital areas. The United States has not actively participated in establishment of the international metric standards and now finds itself subject to basically European metric standards which American industry frequently finds incompatible with its standards and which puts the United States in a less than positive position in international trade.

The United States depends very heavily on computors in its dominate world position in technological products. Existing data processing programs will need to be modified while others will need to be written with new standards and considerations to carry us through the metrication process.

Personnel training will be a major and costly consideration in the conversion process. Personnel from the top managers down through the blue collar workers will have to be trained and educated on the new measurement system. Some employees and workers are affected more than others but it will take time-phased planning to indoctrinate everyone until the high schools, trade schools and colleges produce new inputs to the work force that have been trained on the metric system.

Lastly, the cost of conversion will most likely not be as high as most experts predict it will be. Most costs can be minimized with "software" changes. Future costs will be zero because of the wearing out and replacement of existing equipment. One time costs can reap indefinite benefits.

There exists no good reason why the SI metric system has not been adopted by the people of the United States except the deep-seated quality of human nature which causes us all to put our backs up and resist changes until they are forced on us. Many American businesses and manufacturers, however, already are using the metric system of measurements today for both the production of domestic and export articles. What remains to be done is for the business manager to begin planning now and contribute his share to making the change. There is nothing so powerful as an idea whose time has come.

FOOTNOTES

[1]"U.S. Metric System Seems Certain, But Will It Come On Schedule?", Commerce Today, 5: 5-6, March 17, 1975.

[2]Roy P. Trowbridge, "Are You Ready For the Metric System," Management Review, 60: 10-11, September, 1971.

[3]Ibid., pp. 11-13.

[4]"Industry Adopts Metric in Certain Operations As U.S. Awaits New Law," Commerce Today, 3: 5-6, September 3, 1973.

[5]Ibid., p.7

[6]Ronald E. Zupko, "The Metric Conversion: Transition From the Pre-Imperial to the Metric System In the United States," Marquette Business Review, 17: 54, Summer, 1973.

[7]Ibid., pp. 54-55.

[8]Ibid., p.56

[9]Klaus E. Kroner, "Get Ready For the Metric System," Business Management, August 1971, pp. 16-17.

[10]Ibid., pp.57-58.

[11]Joseph L. Pokorney, "Metric Conversion: The Training Colossus of the Seventies," Training and Development Journal, 27: 3-4, June, 1973.

[12]U.S., Congress, House, Metric Conversion Act of 1975, Public Law 94-168, 94th Cong., 1st Sess., December 23, 1975 (Washington: Government Printing Office, 1975), p. 1007.

[13]Ibid., pp. 1007-1008.

[14]U.S., Congress, House, Committee On Commerce, Metric Conversion Act of 1975, Report, 94th Cong., 1st Sess., No. 94-369 (Washington: Government Printing Office, 1975), p. 17.

[15]Ibid., pp.17-18

[16]Ibid., p. 18

[17]John J. Obrzut, "Managers Plan and Train For A Metric Future," Iron Age, 215: 43, May 5, 1975.

[18]Ibid., p. 46.

[19]John J. Obrzut, "Canadian Metric Conversion Gets Into Full Swing," Iron Age, 214: 30, December 23, 1974.

[20]Phyllis S. McGrath, "America's Metrication Inches Along," The Conference Board Record, 10: 37, September, 1973.

[21]"Going Metric Alone Won't Solve Nation's World Trade Problems," Commerce Today, 3: 11, January 8, 1973.

[22]Ibid.

[23]"Industry Moves To Metrics--Without Congress," Industry Week, 184: 44, February 24, 1975.

[24]"Going Metric Alone Won't Solve Nation's World Trade Problems," Soc. cit.

[25]"Mounting Pressure To Go Metric," Business Week, July 24, 1971, p.54.

[26]Ibid., pp. 54-55.

[27]Ibid., p.55

[28]Ibid.

[29]Ibid., p.56.

[30]"Going Metric Alone Won't Solve Nation's World Trade Problems," op. cit., pp. 12-13.

[31]Ibid., p.13.

[32]Ibid.

[33]Joseph L. Pokorney, "Planning For the Metric Challenge," Journal of Systems Management, 24: 12, July, 1973.

[34]Ibid., p. 13

[35]Ibid., p.14

[36]Ibid., p.15

[37]"Computer Program Helps U.S. Factories During Metric Shift," Commerce Today, 4: 20, September 2, 1974.

[38]Ibid.

[39]Pokorney, "Metric Conversion: The Training Colossus of the Seventies," op. cit., p. 5.

[40]John Teresko, "Are Your Workers Afraid of the Metric System?", Industry Week, 180: 28, February 11, 1974.

[41]Ibid., p.29

[42]Ibid.

[43]McGrath, op. cit., p. 36

[44]U.S., Congress, House, Metric Conversion Act of 1975, loc. cit.

[45]McGrath, loc. cit.

[46]Ibid.

[47]"Industry Takes Initative On Metrication," Commerce Today, 3: 24, April 2, 1973.

[48]U.S. Congress, House, Metric Conversion Act of 1975, loc. cit.

BIBLIOGRAPHY

Books

Groner, Alex, and George A. W. Boehm. Going Metric- An AMA Survey Report. New York: AMACOM, 1973.

Periodicals

"Aerospace Industry Endorses U. S. Switch to Metric Measure," Commerce Today, 3: 24-25, May 28, 1973.

Cartor, Bruce J. "Meters and Liters," Newsweek, 86: 7, December 29, 1975.

Coccola, Richard A. "Towards Metrication," Factory, 7: 23, August, 1974.

"Computer Program Helps U. S. Factories During Metric Shift," Commerce Today, 4: 20, September 2, 1974.

"Drive to Put U. S. On Metric System," U. S. News and World Report, 73: 53, January 1, 1973.

"Engineers Inch Toward SI Measurement," Factory, 5: 50-51, November, 1972.

"Going Metric Alone Won't Solve Nation's World Trade Problems," Commerce Today, 3: 10-13, January 8, 1973.

"Going Metric is Easier With Good Planning," Iron Age, 215: 43-44, March 10, 1975.

Henkel, Robert W.. "Autos Become the Metric Pacesetter," Business Week, June 9, 1973, pp. 106-108.

"House Bill Calls For 'voluntary' Metric Changeover In 10 Years," Industrial Marketing, 58: 22, November, 1973.

"Industry Adopts Dual Dimensions As Metric System Inches Nearer," Commerce Today, 5: 5-7, November 25, 1974.

"Industry Adopts Metric in Certain Operations As U.S. Awaits New Law," Commerce Today, 3: 4-7, September 3, 1973.

"Industry Moves To Metrics - Without Congress," Industry Week, 184: 40-44, February 24, 1975.

"Industry Takes Initiative On Metrication," Commerce Today, 3: 23-25, April 2, 1973.

"Iron Age Metric Conversion Kit: Measuring Up to Metrics," Iron Age, 214: 41-44, September 23, 1974.

Kroner, Klaus E. "Get Ready For the Metric System," Business Management, August 1971, pp.16-17.

McGrath, Phyllis S. "America's Metrication Inches Along," The Conference Board Record, 10: 35-38, September, 1973.

Menkus, Belden. "Data Center Managers Should Prepare for the Inevitable Switch to Metric," Administrative Management, 36: 73, February, 1975.

"Metric Proposal Would Put potables In Uniform Bottles," Advertising Age, 45: 28, April 22, 1974.

"Metrics Are Coming," Changing Times, 28: 33-34, May, 1974.

"Milestone Legislation for a Metric U.S.," Science, 191: 141, January 6, 1976.

"Mounting Pressure To Go Metric," Business Week, July 24, 1971, pp. 54-56.

"Nation Preparing for a Happy Metric New Year," Commerce Today, 6:5-7, December 22, 1975.

New york Times, February 3, 1974.

New York Times, March 12, 1974.

New York Times, April 8, 1974.

New York Times, May 8, 1974.

New York Times, May 12, 1974.

New York Times, May 21, 1974.

Obrzut, John J. "Canadian Metric Conversion Gets Into Full Swing," Iron Age, 214:30-35, December 23, 1974.

Obruzut, John J. "Iron Age Metric Training Aids: Getting A Jump on Metrics," Iron Age, 215: 51-53, May 5, 1975.

Obrzut, John J. "Managers Plan and Train For A Metric Future," Iron Age, 215: 43-47, May 5, 1975.

Obrzut, John J. "Metric Units Number Inch Systems Days," Iron Age, 214: 31-38, September 23, 1974.

Obrzut, John J. "Preparing Machine Tools For the Metric Years," Iron Age, 216: 41-44, December 1, 1975.

Pacey, Margaret D. "Measured Steps," Barron's, May 14, 1973.

Pokorney, Joseph L. "Metric Conversion: The Training Colossus of the Seventies," Training and Development Journal, 27: 3-8, June, 1973.

Pokorney, Joseph, L. "Planning For the Metric Challenge," Journal of Systems Management, 24: 11-15, July, 1973.

"Reading the Meter," Newsweek, 83: 64-65, February 18, 1974.

Revett, John. "Marketers View Ad Opportunities In A 'Silly Millimeter Longer' World," Advertising Age, 42: 33, August 9, 1971.

Schultz, Gregory V. "A New Look At the U.S. Switch to Metrics," Factory, 5: 27-33, March, 1972.

Sharf, Dr. John M. "Keynote to Metrication For Glass Industry Ties in Technical Policy Review," Commerce Today, 2: 15-18, December 25, 1972.

Smith , Robert M. "Commerce Official Asks Plan For 'Inevitable' Metric Conversion Now," Management Advisor, 6: 14, March-April, 1972.

Tereske, John. "Are Your Workers Afraid of the Metric System?" Industry Week, 180: 28-30, February 11, 1974.

Trowbridge, Roy P . "Are You Ready for the Mentric System," Management Review, 60: 10-13, September, 1971.

"U. S. Industry Moving to 'Inevitable' Metric System," Industrial Marketing, 58: 52, 56, 58, October, 1973.

"U.S. Metric System Seems Certain, But Will it Come on Schedule?," Commerce Today, 5: 5-8, March 17, 1975.

"U.S. Steelmen Edge Into Metric Measures," Industry Week, 185: 65-66, May 19, 1975.

"Wait for Metric Steel Comes to An End," Iron Age, 216: 37-38, June 27, 1975.

Weimer, George A. " Can Business Adopt Meter Without Tripping On Its Feet," Iron Age, 212: 55, November 15, 1973.

"What Will Our Lives Really Be Like Under the Metric System?," Iron Age, 214: 50, September 16, 1974.

Zupko, Ronald E. "The Metric Conversion: Transition From the Pre-Imperial to the Metric System In the United States," Marquette Business Review, 17: 49-58, Summer, 1973.

Other

Bowen, John T. "The Metric Conversion in the United States," Unpublished Master's Independent Study, University of North Dakota, May, 1967.

"Moving Toward Metrics," Bulletin To Management, No. 1235, October 11, 1973, p.8.

Small Business Administration. The Metric System and Small Business, (by Louis E. Barbrow), Management Aids for Small Manufacturers No. 214. (Washington: Government Printing Office), 1972.

U.S. Congress. House. Committee on Commerce. Metric Conversion Act of 1975, Report, 94th Congress, 1st Session, No. 94-369. Washington: Government Printing Office, 1975.

U.S. Congress. House. Metric Conversion Act of 1975, Public Law 94-168, 94th Congress, 1st Session, December 23, 1975. Washington: Government Printing Office, 1975.

U.S. Congress. Senate. Committee On Commerce. Metric Conversion Act of 1972. Hearing, 92nd Congress, 2nd Session, on S2483, to establish a national policy relating to conversion to the metric system in the U.S., February 29 and March 1, 1972. Washington: Government Printing Office, 1972.

U.S. Congress. Senate. Committee On Commerce. Metric Conversion Act of 1973. Hearing, 93rd Congress, 1st Session, on S. 100, to provide a national program..., November 2, 1973. Washington: Government Printing Office, 1973.

U.S. Congressional Record. Vol. CXXI.

U.S. Department of Commerce. Brief History of Measurement Systems with A Chart of the Modernized Metric System, National Bureau of Standards Special Publication 304A. (Washington: Government Printing Office) 1972.

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