THE RESPONSE OF AN INFORMATION CENTRE TO METRIC CONVERSION (LA CONVERSION METRIQUE: UN EXEMPLE DE L'EFFORT REQUIS)

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ABSTRACT

Canada is now committed to metric conversion. This decision will result in demands being made on libraries and/or information groups for assistance in achieving this change. Three levels of activity will be required. First the relevant literature must be searched out and obtained. Secondly the accessioning of material in SI (metric) units must begin. Thirdly, material which is now available only in English units often must be converted to the SI system. There are difficulties and pitfalls inherent in this third level of activity. A conversion to SI units of selected portions of the ASME Pressure Vessel and Boiler Code, is presented to illustrate the problems encountered. (Le Canada a décidé d'adopter le système métrique. Cette décision donnera lieu à des demandes faites aux bibliothèques et aux services informatiques, d'aider les personnes chargées de la conversion au système metrique. Cet effort s'effectuera à trois niveaux. Premièrement, il faut rechercher et acquérrir les documents appropriés. Deuxièmement, il faut commencer à obtenir les materiaux dans lesquels on utilise les unités metriques. Troisièmement, il faut convertir les materiaux courants qui utilisent le système Anglais. A titre d'exemple de cette dernière activité, on présente une conversion qu'on a faite récemment de quelques sections du 'ASME Pressure Vessel and Boiler Code', avec quelques-unes des difficultés qu'on a rencontrées.)

second (time), ampere (electrical current), kelvin (temperature), candela (luminous intensity), and mole (amount of substance). The supplementary units are the radian (plane angle) and the steradian (solid angle). A more comprehensive description of the SI system is given elsewhere (Canadian Standards Association, 1973; Whittier, 1972).

DIFFICULTIES OF CONVERSION

Any conversion from the English system to the SI system presents difficulties. The rank and file engineer, draftsman, worker, etc., is unfamiliar with SI. One commercial difficulty is that even though a company may wish to use SI, their suppliers may want to remain entirely within the English system. Specifications issued in SI, or orders for material in SI sizes, are not likely to receive favourable response. During the changeover to the SI system, these problems may be alleviated by dual dimensioning - that is the side by side use of English and SI units. This will be useful only where it does not complicate the situation - for example blueprints must be large enough to be uncluttered, and tool scales should not lose readability.

The library can assist by having on hand and making readily available articles and books explaining and detailing the trend toward metrication. In this phase of adaptation by Whiteshell Nuclear Research Establishment to SI units, some forty-six significant publications were accessioned[1].

A much more frustrating problem may be the lack of standards expressed in the SI system. If the legal standard regulating an industry is available only in English units, then there is great resistance to the conversion to SI. Since it is estimated (Sokol, 1973) that there are some 10,000 standards regulating North America industry, it will be some time before SI-based standards could be produced for all of these. It follows that the industrial library must accession all standards that apply to areas of interest of its company. At Whiteshell we have accessioned ten standards[1]. Somewhat similarly, we have accessioned seven standard reference books in SI units[1].

ACTIVE INVOLVEMENT IN CONVERSION

What additional services can the information centre provide? In some cases no material is available in any metric form - a situation which can slow, or even halt, the pace of conversion. Either one merely waits until the data become available in SI units or one produces a conversion of the source data. The second course is not without difficulty or danger, as illustrated by the following example.

The Project and Design Engineering Branch in WNRE asked Technical Information to find metric equivalents for the engineering source data that they normally use. These data include such things as property tables

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[1]A list of these is available on request from the authors.

METRIC CONVERSION

INTRODUCTION

Canadians have begun to adapt to a logical and simple metric system of measurements known as "Système International d'Unités" (SI system). Some industries are merely informing themselves so that when the time comes, they will be ready to act; some are using the English system and the C.G.S. system of metric units side by side; some, including the Whiteshell Nuclear Research Establishment site of Atomic Energy of Canada, Ltd., are already using SI units for design, in specifications, and in written communications.

In all of these stages of adaptation, Information Centres (including libraries) have a responsibility to assist their users by identifying and accessioning the rather large amount of material about conversion. This material takes the form of books, journal articles, wall charts, etc. In addition they should accession material printed in the metric system. These two steps in the response are expected and conventional. A third step will often be required if the Information Centre is to provide the most useful service. In it, information specialists will be called upon to convert material in English units to metric equivalents for use by design engineers, personnel in operations, research staff, and others. This will be necessary since it will take a long time for codes, standards, tables of properties, safety criteria, etc. to be converted to metric units by the groups responsible for them. Once metrication begins in earnest there will be a demand for these metric versions before they are available.

The Technical Information Services group at Whiteshell has been involved in all these phases of the adaptation of a metric system. We think our experience may be of interest to you. Particularly, we think the experience of our Technical Information group in converting Section III of the Pressure Vessel and Boiler Code of the American Society of Mechanical Engineers from English units to SI units will be useful.

THE SI SYSTEM

The metric system was introduced in France after the revolution. Initially, the French were not able to interest other countries in the metric system, but in 1875 the Treaty of the Metre, which established international definitions for the metre and the kilogram, was signed by 18 countries, including Russia, the United States, and Germany. Britain signed the treaty in 1884. The signing of this treaty also marked the beginning of the General Conference of Weights and Measures. This group meets periodically to consider and amend metric practice. The Eleventh General Conference meeting in 1960 brought forth "Le Système International d'Unités" or "SI" system, wherein units were chosen to minimize the need for conversion factors. Those remaining are generally powers of ten.

Briefly, the system has seven base units, two supplementary units, a series of units derived from the base units, and a series of prefixes for multiple formation. The base units are metre (length), kilogram (mass), for steel, thermodynamic data for steam, standard sizes of tubing, etc. The first line of attack was to search the available literature for SI or metric equivalents of these source data, not only in Canada and the U.S., but also in Britain, France, and Germany. Only a few such equivalents were located, but our library accessioned a substantial number of useful articles about metrication.

Since metrication is important in AECL, it was decided that we should prepare our own SI versions of these source data. Conversion of all of this material is a task beyond the limits of our available manpower, but we can expect, by our example, to stimulate conversion work elsewhere. A code of great importance to our industry is the ASME Pressure Vessel and Boiler Code, Section III (1971 edition) and the following Addenda. It was decided to convert this code. However, since an updated version is scheduled for release in the summer of 1974, only the major tables and some of the graphs of the 1971 edition and the Addenda were to be converted.

What problems arise when a conversion is attempted? The following five were found to be important and each will be discussed.

(i) kind of conversion
(ii) rounding off
(iii) conversion of a safety limit
(iv) conversion of numbers relating to another code
(v) graphs

(i) Kinds of Conversion

Three kinds of conversion are possible: soft, hard, and rationalized soft. Soft conversion entails simply converting the English units to their SI equivalents, with due consideration being given to accuracy and rounding-off. The soft conversion is not very useful because convenient whole numbers become inconvenient numbers, perhaps fractional (e.g. 50°F is 283K). The term hard conversion is a misnomer since it relates not to the conversion of the original English unit code, but rather to the writing of a new one on the basis of SI units and material in SI sizes. The new code is written without reference to the original one. This approach is the best one possible since it produces a fundamentally sound, coherent code. However, it is properly the responsibility of the standards writing organization or the professional society.

The rationalized soft conversion stands between these two extremes. The end result of this process is material expressed in whole, convenient SI units whenever this is possible. This is accomplished by a conversion of the English units followed by interpolation to convenient SI units. For example, values given at 50F° increments will be converted to values at 25K increments; 400°F will be converted to 200°C. While this greatly enhances its useability, the basis of the code is still the English system and anomalies arise, e.g. screw thread sizes often prove to be impossible to convert. The main advantage of the rationalized soft conversion is that since it can be produced quickly, it can be useful until the new standard (hard conversion) makes its appearance. We decided to use the rationalized soft conversion approach on the ASME code.

(ii) Rounding Off

The rule regarding rounding off is (Whittier, 1972): in general, the metric figure must not imply a larger or smaller precision than the original one. The rounding off must be done so that the tolerance range is decreased rather than increased. If no tolerance is given and the dimension is not approximate, the converted dimension should be given to one additional significant digit when its first digit is smaller than the first digit in the dimension being converted, e.g. 5.4 in = 137 mm. However, when the first digit in the SI value is larger, it should have the same number of significant digits as the number being converted, e.g. 2.3 in = 58 mm.

A difficulty arises when the significance of a given number is not obvious. For example, 1500 psi could be a number between 1000 and 2000 psi, or 1.5×10^3 psi, or 1500 ± 0.5 psi. Whenever such a doubt arose, it was decided that the safest course was to assume that all figures given were significant. Then 1500 psi means 1500 ± 0.5 psi. However, if such an assumption should have important consequences, the opinion of an authority should be sought.

(iii) Conversion of a Safety Limit

The safety limit may or may not be an accurate number, so a converted figure may or may not be adequate. The only sure course is to consult an authority when a safety limit or any safety related number is to be converted.

(iv) Conversion of Numbers Relating to Another Code

Often a code or standard will make use of values, or sizes which are specified in another code or standard. If these are converted, the relationship to the second code or standard will be lost. Two ways of dealing with such cases were found. First, the value is not converted, but is left in English units to indicate its greater significance. Second, the converted value is followed by its English equivalent in brackets, again to indicate its greater significance.

Nominal sizes or values fall in the first catagory. These are not converted since they are merely names used to identify standard objects. However, when the nominal size is used to identify only the approximate size of the object, it should be converted.

The following table shows how this principle was applied to the ASME code conversion. The conversion of the table, Table NB-3542-1, was relatively straightforward. Both the diameter and the wall thickness were converted to centimeters. It will be noted that there are several pressure ratings for which the wall thickness must be specified. These "Primary Pressure Ratings" have not been converted to SI units because they are nominal pressure ratings which are defined in another code (ANSI B165.5-1961).

TABLE NB-3542-1
VALVE BODY MINIMUM WALL THICKNESS

Inside Diameter, d_m (cm)	Primary Pressure Rating, P_r	Minimum Wall Thickness, t_m (cm)						
		150 lb.	300 lb.	400 lb.	600 lb.	900 lb.	1500 lb.	2500 lb.
0.25		.26	.26	.26	.26	.26	.26	.26
0.50		.26	.26	.26	.26	.26	.26	.31
0.75		.26	.26	.26	.26	.31	.31	.45
1.00		.26	.26	.33	.33	.40	.40	.58
1.25		.26	.26	.41	.41	.48	.48	.68
1.50		.26	.30	.41	.41	.53	.53	.76
1.75		.28	.35	.41	.41	.56	.56	.83
2.00		.33	.41	.43	.43	.61	.61	.91
2.25		.38	.44	.46	.46	.66	.66	1.00
2.5		.41	.48	.49	.49	.70	.71	1.11
5.0		.41	.64	.64	.64	1.17	1.16	1.98
7.5		.56	.71	.78	.78	1.08	1.66	2.86
10.0		.56	.79	.96	.96	1.28	2.09	3.69
12.5		.71	.96	1.11	1.11	1.58	2.56	4.53
15.0		.72	.97	1.12	1.26	1.86	3.03	5.38
17.5		.76	1.04	1.26	1.43	2.09	3.53	6.28
20.0		.79	1.11	1.41	1.59	2.33	3.99	7.09
22.5		.84	1.19	1.58	1.76	2.59	4.41	7.93
25.0		.86	1.26	1.74	1.93	2.83	4.86	8.78
27.5		.91	1.34	1.82	2.13	3.11	5.31	9.63
30.0		.96	1.41	1.89	2.31	3.38	5.78	[illegible]
[illegible]		1.01	[illegible]	[illegible]	2.44	3.66	[illegible]	
		[illegible]			[illegible]	[illegible]		

(v) Graphs

In some cases the conversion of a graph presented no difficulty, requiring only the conversion of the axes. This was done by overlaying a grid of the required dimensions in SI units and transferring the line. Graphs which present a family of lines were more complicated. When each of the lines represented a specific condition (e.g. temperature), the most reasonable course was to produce an SI grid with a rounded SI equivalent of the given condition. Thus a series of lines labelled 800°F, 850°F, 900°F and 950°F would be relabelled 700K, 728K, 755K, and 783K.

Actual conversion of tables was done with the aid of a computer. The programs used each contained the subprogram "AIKINT" by which the input data could be both converted and interpolated. Thus a set of English unit values defined for conditions specified in convenient English units was changed into an SI set of values defined for convenient SI conditions. An example of this is given in the following tables. The upper table is taken directly from the original ASME code. There are seven sets of psi values for the modulus of elasticity each at a given Fahrenheit temperature. The lower table is the final conversion result, with seven sets of gigapascals values for the modulus of elasticity, and

TABLE I-6.0
MODULI OF ELASTICITY OF MATERIALS FOR GIVEN TEMPERATURES

Material	Modulus of Elasticity, E = Value Given X 10^6 (psi) for Temperature of										
	−325	−200	−100	70	200	300	400	500	600	700	800
FERROUS MATERIAL											
Carbon Steels with carbon content 0.30% or less, 3½% Ni	30.0	29.5	29.0	27.9	27.7	27.4	27.0	26.4	26.7	24.8	
Carbon steels with carbon content above 0.30%	31.0	30.6	30.4	29.9	29.5	29.0	28.3	27.4	26.7	25.4	
Carbon-moly steels, low chrome steels through 3% Cr	31.0	30.6	30.4	29.9	29.5	29.0	28.6	28.0	27.4	26.6	
Intermediate chrome steels (5% Cr through −9% Cr)	29.4	28.5	28.1	27.4	27.1	26.8	26.4	26.0	25.4	24.9	
Austenitic steels (TP304,310,316,321,347)	30.4	29.9	29.4	28.3	27.7	27.1	26.6	26.1	25.4	24.8	24.1
Straight chromium steels (12% Cr, 17% Cr, 27% Cr)	30.8	30.3	29.8	29.2	28.7	28.3	27.7	27.0	26.0	24.8	23.1
NONFERROUS MATERIAL											
(Nickel-Chrome-Iron) (Nickel-Iron-Chrome) (Nickel-Copper)				31.7	30.9	30.5	30.0	29.6	29.2	28.6	27.9

TABLE I-6.0
MODULI OF ELASTICITY OF MATERIALS FOR GIVEN TEMPERATURES

MATERIAL	Modulus of Elasticity, E, expressed in GPa for a temperature (°C) of															
	-200	-150	-100	-50	0	20	50	100	150	200	250	300	350	375	400	425
FERROUS MATERIAL																
Carbon Steels with carbon content 0.30% or less, 3½% Ni	206.9	204.4	201.7	198.3	193.5	192.5	191.8	190.7	188.9	186.4	182.8	178.5	173.5	170.6		
Carbon steels with carbon content above 0.30%	213.8	211.8	210.3	208.8	206.9	206.2	205.1	203.0	199.9	195.5	190.0	185.4	179.0	174.5		
Carbon-moly steels, low chrome steels through 3% Cr	213.8	211.8	210.3	208.8	206.9	206.2	205.1	203.0	199.9	197.4	193.8	190.1	185.7	183.0		
Intermediate chrome steels (5% Cr through -9% Cr)	202.9	198.1	195.1	192.6	190.0	189.0	188.1	186.6	184.7	182.2	179.8	176.3	173.0	171.4		
Austenitic steels (TP304,310,316,321,347)	209.7	207.2	204.4	201.0	196.6	195.2	193.6	190.5	186.8	183.7	180.6	176.5	172.6		168.6	166.3
Straight chromium steels (12% Cr, 17% Cr, 27% Cr)	212.4	210.0	207.2	204.4	202.3	201.4	200.0	197.5	195.0	191.3	187.0	181.3	174.5		165.3	159.6
NONFERROUS MATERIAL																
(Nickel-Chrome-Iron) (Nickel-Iron-Chrome) (Nickel-Copper)						218.7	216.1	212.7	210.2	207.1	204.6	202.1	198.8		194.8	192.5

they are nominal pressure ratings which are defined in another code (ANSI B165.5-1961).

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Inside Diameter, d_m (cm)	Primary Pressure Rating, P_r	Minimum Wall Thickness, t_m (cm)						
		150 lb.	300 lb.	400 lb.	600 lb.	900 lb.	1500 lb.	2500 lb.
0.25		.26	.26	.26	.26	.26	.26	.26
0.50		.26	.26	.26	.26	.26	.26	.31
0.75		.26	.26	.26	.26	.31	.31	.45
1.00		.26	.26	.33	.33	.40	.40	.58
1.25		.26	.26	.41	.41	.48	.48	.68
1.50		.26	.30	.41	.41	.53	.53	.76
1.75		.28	.35	.41	.41	.56	.56	.83
2.00		.33	.41	.43	.43	.61	.61	.91
2.25		.38	.44	.46	.46	.66	.66	1.00
2.5		.41	.48	.49	.49	.70	.71	1.11
5.0		.41	.64	.64	.64	1.17	1.16	1.98
7.5		.56	.71	.78	.78	1.08	1.66	2.86
10.0		.56	.79	.96	.96	1.28	2.09	3.69
12.5		.71	.96	1.11	1.11	1.58	2.56	4.53
15.0		.72	.97	1.12	1.26	1.86	3.03	5.38
17.5		.76	1.04	1.26	1.43	2.09	3.53	6.28
20.0		.79	1.11	1.41	1.59	2.33	3.99	7.09
22.5		.84	1.19	1.58	1.76	2.59	4.41	7.93
25.0		.86	1.26	1.74	1.93	2.83	4.86	8.78
27.5		.91	1.34	1.82	2.13	3.11	5.31	9.63
30.0		.96	1.41	1.89	2.31	3.38	5.78	[illegible]
[illegible]		1.01	[illegible]	[illegible]	2.44	3.66	[illegible]	
		[illegible]			[illegible]	[illegible]		

(v) Graphs

In some cases the conversion of a graph presented no difficulty, requiring only the conversion of the axes. This was done by overlaying a grid of the required dimensions in SI units and transferring the line. Graphs which present a family of lines were more complicated. When each of the lines represented a specific condition (e.g. temperature), the most reasonable course was to produce an SI grid with a rounded SI equivalent of the given condition. Thus a series of lines labelled 800°F, 850°F, 900°F and 950°F would be relabelled 700K, 728K, 755K, and 783K.

Actual conversion of tables was done with the aid of a computer. The programs used each contained the subprogram "AIKINT" by which the input data could be both converted and interpolated. Thus a set of English unit values defined for conditions specified in convenient English units was changed into an SI set of values defined for convenient SI conditions. An example of this is given in the following tables. The upper table is taken directly from the original ASME code. There are seven sets of psi values for the modulus of elasticity each at a given Fahrenheit temperature. The lower table is the final conversion result, with seven sets of gigapascals values for the modulus of elasticity, and

TABLE I-4.0
MODULI OF ELASTICITY OF MATERIALS FOR GIVEN TEMPERATURES

Material	Modulus of Elasticity, E = Value Given X 10⁶ (psi) for Temperature of										
	–325	–200	–100	70	200	300	400	500	600	700	800
FERROUS MATERIAL											
Carbon Steels with carbon content 0.30% or less, 3½% Ni	30.0	29.5	29.0	27.9	27.7	27.4	27.0	26.4	25.7	24.8	
Carbon steels with carbon content above 0.30%	31.0	30.6	30.4	29.9	29.5	29.0	28.3	27.4	26.7	25.4	
Carbon-moly steels, low chrome steels through 3% Cr	31.0	30.6	30.4	29.9	29.5	29.0	28.6	28.0	27.4	26.6	
Intermediate chrome steels (5% Cr through –9% Cr)	29.4	28.5	28.1	27.4	27.1	26.8	26.4	26.0	25.4	24.9	
Austenitic steels (TP304,310,316,321,347)	30.4	29.9	29.4	28.3	27.7	27.1	26.6	26.1	25.4	24.8	24.1
Straight chromium steels (12% Cr, 17% Cr, 27% Cr)	30.8	30.3	29.8	29.2	28.7	28.3	27.7	27.0	26.0	24.8	23.1
NONFERROUS MATERIAL											
(Nickel-Chrome-Iron) (Nickel-Iron-Chrome) (Nickel-Copper)				31.7	30.9	30.5	30.0	29.6	29.2	28.6	27.9

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MATERIAL	Modulus of Elasticity, E, expressed in GPa for a temperature (°C) of															
	-200	-150	-100	-50	0	20	50	100	150	200	250	300	350	375	400	425
FERROUS MATERIAL																
Carbon Steels with carbon content 0.30% or less, 3½% Ni	206.9	204.4	201.7	198.3	193.5	192.5	191.8	190.7	188.9	186.4	182.8	178.5	173.5	170.6		
Carbon steels with carbon content above 0.30%	213.8	211.8	210.3	208.8	206.9	206.2	205.1	203.0	199.9	195.5	190.0	185.4	179.0	174.5		
Carbon-moly steels, low chrome steels through 3% Cr	213.8	211.8	210.3	208.8	206.9	206.2	205.1	203.0	199.9	197.4	193.8	190.1	185.7	183.0		
Intermediate chrome steels (5% Cr through -9% Cr)	202.9	198.1	195.1	192.6	190.0	189.0	188.1	186.6	184.7	182.2	179.8	176.3	173.0	171.4		
Austenitic steels (TP304,310,316,321,347)	209.7	207.2	204.4	201.0	196.6	195.2	193.6	190.5	186.8	183.7	180.6	176.5	172.6		168.6	166.3
Straight chromium steels (12% Cr, 17% Cr, 27% Cr)	212.4	210.0	207.2	204.4	202.3	201.4	200.0	197.5	195.0	191.3	187.0	181.3	174.5		165.3	159.6
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each at a given Celsius temperature. These Celsius temperatures are whole, round, convenient numbers. (It should be noted that degrees Celsius is a non-SI metric unit belonging to that group of units which, since they enjoy widespread use, have been retained with the SI system. It was used in this case because its use will receive more ready acceptance by engineers who have already been working with this unit.)

LIMITATIONS OF THE CONVERSION

The rationalized soft conversion presents some anomalies since the basis of the standard or code is still the English system. Under some circumstances a number may be impossible to convert. Also a very important limitation is that while the original code may have the force of law, the SI conversion would have no such status. It must therefore be used with care. It is emphasized that although the tables and figures which have been converted to date have been issued as a report, "A Conversion to SI Units of Some Portions of the ASME Pressure Vessel and Boiler Code, Section III (1971 Edition)", AECL-4585, it is intended only as an interim working tool for use by design engineers. This type of conversion is undertaken either to speed up or to maintain the rate of metrication; it is not a substitute for a new standard, written on an SI basis.

CONCLUSIONS

Metrication has become a fact of Canadian life, and a conversion to SI units is now, or soon will become, a necessity for many Canadian companies. In this conversion process, the information group can play a useful role. The library should accession books, pamphlets, wall charts, etc. concerning this conversion process as well as reference material which makes use of SI units. The accessioning of standards or codes written in SI is a very important function. Information specialists will assist in acquainting company personnel with the SI system. As well, they may be called on to convert material now in English units to SI units. Such conversions must be undertaken with a knowledge of the limitations and problems exemplified in our rationalized soft conversion of the ASME Pressure Vessel and Boiler Code, Section III, and our solutions to them.

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