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CEYLON STANDARD FOR PREFERRED NUMBERS

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BUREAU OF CEYLON STANDARDS
53, Dharmapala Mawatha
COLOMBO 3.

Ceylon Standards are subject to periodical revision in order to accommodate the progress made by industry. Suggestions for improvement will be recorded and brought to the notice of the Committees to which the revisions are entrusted.

This Standard does not purport to include all the necessary provisions of a contract.

BUREAU OF CEYLON STANDARDS
53, Dharmapala Mawatha,
Colombo 3.

Telephone : 26055, 26054, 26051. Telegrams : " PRAMIKA "

CEYLON STANDARD FOR PREFERRED NUMBERS

FOREWORD

This Ceylon Standard was prepared under the authority of the Metric Divisional Committee of the Bureau of Ceylon Standards and was approved by the Council on 6 May 1971.

For the selection of a series of sizes as well as to secure a measure of uniformity in practice in the choice of a series, the Bureau of Ceylon Standards is propagating the use of Preferred Numbers which have been adopted by the International Organisation for Standardization (ISO). These numbers which provide a rational basis for simplification are conveniently rounded off values derived from certain theoretical geometric series. Their use in standardization work is based on the experience that consumer's requirements for a range of a product are frequently satisfied when the range follows, more or less closely, a geometric progression, even though the selection is made without any consideration of theory.

Preferred numbers were first used in France towards the end of the nineteenth century. They are often referred to as ' Renard numbers ' as a tribute to Col. Charles Renard, who first proposed the series and their various uses.

The adoption of a series of preferred numbers is to limit the unnecessary variety which will come into use in the absence of guide for the selection of sizes and not to restrict the freedom of the designer. Without the guidance of a series of preferred sizes, individual designers will tend to vary in selection of component sizes, without real necessity, and thus produce unnecessary variety.

In the preparation of this standard considerable assistance has been obtained from the following publications.

I.S.O. R 3 — Series of preferred numbers.

I.S.O. R 17 — Guide to the use of preferred numbers and of series of preferred numbers.

I.S.O. R497 — Guide to the choice of series of preferred numbers and of series containing more rounded values of preferred numbers.

1. SCOPE

This Ceylon Standard gives series of preferred numbers and recommendations as to the use of them. It consists of three parts. Part 1 lists the preferred numbers in the four principal series, R 5, R 10, R 20, and R 40, as well as the additional R 80 series intended for special applications. It also gives information regarding their derivation, together with definitions of the terms used. Part 2 gives guidance as to the use of preferred numbers and Part 3 is a guide to the choice of series of preferred numbers and of series containing more rounded values of preferred numbers.

2. TERMINOLOGY

For the purpose of this standard, the following definitions shall apply.

2.1 Theoretical values—The exact values of the terms of $(\sqrt[5]{10})^N$, $(\sqrt[10]{10})^N$ etc. These values have an infinite number of decimal places and are not suitable for practical use.

2.2 Calculated values—Values approximating to the theoretical values, expressed to 5 significant figures (the relative error in comparison with the theoretical values is less than 1/20 000).

2.3 Serial numbers—An arithmetic series of consecutive numbers indicating the preferred numbers starting with 0 for the preferred number 1.00.

PART 1

SERIES OF PREFERRED NUMBERS

3. DERIVATION OF SERIES

Preferred numbers are derived from geometric series having one of the following common ratios :—

$$\sqrt[5]{10}\ ,\quad \sqrt[10]{10}\ ,\quad \sqrt[20]{10}\ ,\quad \sqrt[40]{10}\quad \text{or}\quad \sqrt[80]{10}.$$

These ratios are approximately equal to 1.58, 1.26, 1.12, 1.06 and 1.03 respectively. Thus successive terms in the respective series increase by approximately 58 percent, 26 percent, 12 percent, 6 percent or 3 percent.

It will be noted that any series can be extended indefinitely upwards or downwards by multiplying or dividing repeatedly by 10.

4. DESIGNATION OF SERIES

The series of preferred numbers shall be designated respectively as R 5, R 10, R 20, R 40, and R 80, in which the ' R ' stands for Renard and the number indicates the particular root of 10 on which the series is based.

5. BASIC SERIES OF PREFERRED NUMBERS

5.1 The basic series of preferred numbers R 5, R 10, R 20 and R 40 and their relation to the calculated values in the corresponding geometric series are given in Table 1.

Wherever possible, the values of the R 5 series are to be given preference over those of the R 10 series and these latter over the values of the R 20 series and finally these last over those of the R 40 series. The following method of expression shall be used to indicate the limits of the series.

R 10 (1.25. . . .) Series limited to the term value 1.25 (inclusive) as the low limit.

R 20 (. . . .40) Series limited to the term value 40 (inclusive) as the high limit.

R 40 (75. . . . . .300) Series limited between the term values 75 and 300 (both values inclusive).

5.2 **Exceptional R 80 series :**—The values of the R 80 series, which are intended for use only in exceptional cases, are given in Table 2. The terms of the basic series should be given preference over the terms of the R 80 series.

6. DERIVED SERIES OF PREFERRED NUMBERS

Derived series are obtained by taking every second, third, fourth or pth term of a basic series. They are designated by the symbol of the corresponding basic series followed by the solidus division sign and the number 2, 3, 4 or p. If the series is limited, the symbol should include an indication of the limiting terms to be considered ; if it is not limited, mention should be made of at least one of the terms.

Examples

(i) R 5/2 (1 . . . . . . 1 000 000) — Derived series comprising every second term of R 5 series and limited by the terms 1 and 1 000 000 and including both these terms.

(ii) R 10/3 (. . . . . . 80 . . . . . .) — Derived series comprising every third term of R 10 series, unlimited in both directions and including the term 80.

(iii) R 40/5 (. . . . . 60) — Derived series comprising every fifth term of R 40 series and limited at the upper end by the term 60 inclusive.

6.2 General Representation

If r is the index of the basic series where r = 5, 10, 20 or 40 and p is the pitch of the derived series i.e. the number of steps in the basic series required to build up the derived series, then the ratio of the derived series is $10^{p/r}$.

On the otherhand, if N is a positive integral number, the term of identification of the derived series is $10^{N/40}$ and the derived series is designated by R r/p (. . . . . . $10^{N/40}$ . . . .) Lastly, if x is any integral number, positive, zero or negative. any term of the derived series is —

$$10^{N/40} \times 10^{(p/r)x} = 10^{\left(\frac{N}{40} + \frac{px}{r}\right)}$$

TABLE 1.

BASIC SERIES OF PREFERRED NUMBERS AND THEIR RELATION TO CALCULATED VALUES

Basic series				Serial Number	Theoretical Values		Percentage differences between basic series and calculated values
R 5	R 10	R 20	R 40		Mantissae of logarithms	Calculated values	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.00	1.00	1.00	1.00	0	000	1.0000	0
			1.06	1	025	1.0593	+ 0.07
		1.12	1.12	2	050	1.1220	− 0.18
			1.18	3	075	1.1885	− 0.71
	1.25	1.25	1.25	4	100	1.2589	− 0.71
			1.32	5	125	1.3335	− 1.01
		1.40	1.40	6	150	1.4125	− 0.88
			1.50	7	175	1.4962	+ 0.25
1.60	1.60	1.60	1.60	8	200	1.5849	+ 0.95
			1.70	9	225	1.6788	+ 1.26
		1.80	1.80	10	250	1.7783	+ 1.22
			1.90	11	275	1.8836	+ 0.87
	2.00	2.00	2.00	12	300	1.9953	+ 0.24
			2.12	13	325	2.1135	+ 0.31
		2.24	2.24	14	350	2.2387	+ 0.06
			2.36	15	375	2.3714	− 0.48
2.50	2.50	2.50	2.50	16	400	2.5119	− 0.47
			2.65	17	425	2.6607	− 0.40
		2.80	2.80	18	450	2.8184	− 0.65
			3.00	19	475	2.9854	+ 0.49
	3.15	3.15	3.15	20	500	3.1623	− 0.39
			3.35	21	525	3.3497	+ 0.01
		3.55	3.55	22	550	3.5481	+ 0.05
			3.75	23	575	3.7584	− 0.22
4.00	4.00	4.00	4.00	24	600	3.9811	+ 0.47
			4.25	25	625	4.2170	+ 0.78
		4.50	4.50	26	650	4.4668	+ 0.74
			4.75	27	675	4.7315	+ 0.39
	5.00	5.00	5.00	28	700	5.0119	− 0.24
			5.30	29	725	5.3088	− 0.17
		5.60	5.60	30	750	5.6234	− 0.42
			6.00	31	775	5.9566	+ 0.73
6.30	6.30	6.30	6.30	32	800	6.3096	− 0.15
			6.70	33	825	6.6834	+ 0.25
		7.10	7.10	34	850	7.0795	+ 0.29
			7.50	35	875	7.4989	+ 0.01
	8.00	8.00	8.00	36	900	7.9433	+ 0.71
			8.50	37	925	8.4140	+ 1.02
		9.00	9.00	38	950	8.9125	+ 0.98
			9.50	39	975	9.4406	+ 0.63
10.00	10.00	10.00	10.00	40	000	10.0000	0

TABLE 2. EXCEPTIONAL R 80 SERIES

1.00	1.80	3.15	5.60
1.03	1.85	3.25	5.80
1.06	1.90	3.35	6.00
1.09	1.95	3.45	6.15
1.12	2.00	3.55	6.30
1.15	2.06	3.65	6.50
1.18	2.12	3.75	6.70
1.22	2.18	3.87	6.90
1.25	2.24	4.00	7.10
1.28	2.30	4.12	7.30
1.32	2.36	4.25	7.50
1.36	2.43	4.37	7.75
1.40	2.50	4.50	8.00
1.45	2.58	4.62	8.25
1.50	2.65	4.75	8.50
1.55	2.72	4.87	8.75
1.60	2.80	5.00	9.00
1.65	2.90	5.15	9.25
1.70	3.00	5.30	9.50
1.75	3.07	5.45	9.75

PART 2.

GUIDE TO THE USE OF PREFERRED NUMBERS

7. PROPERTIES OF GEOMETRICAL PROGRESSION AND PREFERRED NUMBERS.

7.1 **Standard series of numbers**— In all the fields where a scale of numbers is necessary, standardization consists primarily of grading the characteristics according to one or more series of numbers covering all the requirements with a minimum of terms. These series should present the following essential characteristics ; they should

(*a*) be simple and easily remembered,

(*b*) be unlimited towards the lower as well as higher numbers,

(*c*) include all the decimal multiples and sub-multiples of any term and

(*d*) provide a rational grading system.

7.2 Characteristics of geometrical progressions which include the number 1. The characteristics of these progressions, with a ratio q, are mentioned below.

7.2.1 The product or quotient of any two terms q^b and q^c of such a progression is always a term of that progression:

$$q^b \times q^c = q^{b+c}$$

7.2.2 The integral positive or negative power c of any term q^b of such a progression is always a term of that progression :

$$(q^b)^c = q^{bc}$$

7.2.3 The fractional positive or negative power 1/c of a term q^b of such a progression is still a term of that progression, provided that b/c be an integer :

$$(q^b)^{1/c} = q^{b/c}$$

7.2.4 The sum or difference of two terms of such a progression is not generally equal to a term of that progression. However, there exists one geometrical progression such that one of its terms is equal to the sum of the two preceding terms.

Its ratio $\frac{1+\sqrt{5}}{2}$ approximates 1.6 (it is the Golden Section of the Ancients).

7.3 Geometrical progressions which include the number 1 and the ratio of which is a root of 10. The progressions chosen to compute the preferred numbers have a ratio equal to $\sqrt[r]{10}$, r being equal to 5, to 10, to 20, or to 40. The results are given hereunder.

7.3.1 The number 10 and its positive and negative powers are terms of all the progressions.

7.3.2 Any term whatever of the range $10^d \ldots 10^{d+1}$, d being positive or negative, may be obtained by multiplying by 10^d the corresponding term of the range $1 \ldots 10$.

7.3.3 The terms of these progressions comply in particular with the property given in clause 7.1, letter (c).

7.4 Rounded off geometrical progressions. The preferred numbers are the rounded off values of the progressions defined under clause 7.3

7.4.1 The maximum roundings off are :

$+ 1.26\ \%$ and $- 1.01\ \%$

The preferred numbers included in the range 1 . . . . . . 10 are given in Table 1 of Part 1.

7.4.2 Due to the rounding off, the products, quotients and powers of preferred numbers may be considered as preferred numbers only if the modes of calculation referred to under clause 9 are used.

7.4.3 For the R 10 series, it should be noted that $\sqrt[10]{10}$ is equal to $\sqrt[3]{2}$ at an accuracy closer than 1 in 1000 in relative value, so that :— the cube of a number of this series is approximately equal to double the cube of the preceding number. In other words, the Nth term is approximately double the (N – 3)th term. Due to the rounding off it is found that it is usually equal to exactly the double.—the square of a number of this series is approximately equal to 1.6 times the square of the preceding number.

7.4.4 Just as the terms of the R 10 series are doubled in general every 3 terms, the terms of the R 20 series are doubled every 6 terms, and those of the R 40 series are doubled every 12 terms.

7.4.5 Beginning with the R 10 series, the number 3.15, which is nearly equal to Π, can be found among the preferred numbers. It follows that the length of a circumference and the area of a circle, the diameter of which is a preferred number, may also be expressed by preferred numbers. This applies in particular to peripheral speeds, cylindrical areas and volumes, spherical areas and volumes.

7.4.6 The R 40 series of preferred numbers include the numbers 3000, 1500, 750, 375, which have special importance in electricity (number of revolutions per minute of asynchronous motors when running without load on alternating current at 50 Hertz).

7.4.7 It follows from the features outlined above that the preferred numbers correspond faithfully to the characteristics set forth at the beginning of clause 7.1. Furthermore, they constitute a unique grading rule, acquiring thus a remarkably universal character.

8. DIRECTIVES FOR THE USE OF PREFERRED NUMBERS

8.1 **Characteristics expressed by numerical values.** In the preparation of a project involving numerical values of characteristics whatever their nature, for which no particular standard exists, preferred numbers should be selected for these values. No deviation should be made, except for imperative reasons (see clause 11).

At all times efforts should be made to adapt existing standards to preferred numbers.

8.2 **Scale of numerical values.** In selecting a scale of numerical values that series should be chosen having the highest ratio consistent with the desiderata to be satisfied, in the order : R 5, R 10 etc. Such a scale should be carefully worked out. The considerations to be taken into account are, among others : the use that is to be made of the articles standardized, their cost price, their dependence upon other articles used in close connection with them etc.

The best scale will be determined by taking into consideration in particular, the two following contradictory tendencies : a scale with too wide steps involves a waste of materials and an increase in the cost of manufacture, whereas a too closely spaced scale leads to an increase in the cost of tooling and also in the value of stock inventories.

When the needs are not of the same relative importance in all the ranges under consideration, the most suitable basic series for each range should be slected so that the sequences of numerical values adopted provide a succession of series of different ratios permitting new interpolations where necessary.

8.3 Derived series. Derived series, which are obtained by taking the terms at every second, every third, every fourth, etc, step of the basic series, should be used only when none of the scales of the basic series is satisfactory.

8.4 Shifted series. A shifted series, that is, a series having the same grading as a basic series, but begining with a term not belonging to that series, should be used only for characteristics which are functions of other characteristics, themselves scaled in a basic series.

Example : The R 80/8 (25. 8....165) series has the same grading as the R 10 series, but starts with a term of the R 80 series, whereas the R 10 series, from which it is shifted, would start at 25.

8.5 Single numerical value. In the selection of a single numerical value, irrespective of any idea of scaling, one of the R 5, R 10, R 20, R40, basic series should be chosen or else a term of the exceptional R 80 series, giving preference to the terms of the series of highest step ratio, choosing R 5 rather than R 10, rather than R 20 etc.

When it is not possible to provide preferred numbers for all characteristics that could be numerically expressed, preferred numbers should first be applied to the most important characteristic or characteristics, the secondary or subordinate characteristics, should be then determined in the light of the principles set forth under this section.

8.6 Grading by means of preferred numbers. The preferred numbers may differ from the calculated values by + 1.26% to − 1.01%. It follows that sizes, graded according to preferred numbers, are not exactly proportional to one another.

To obtain an exact proportionality, either the theoretical values, or the serial numbers defined under clause 9 or the decimal logarithms of the theoretical values should be used.

It should be noted that when formulae are used all the terms which are expressed in preferred numbers, the discrepancy of the result, if it is itself expressed as a preferred number, remains within the range + 1.26% to − 1.01%.

$$\text{Thus}\left(A\begin{matrix}+1.26\ \%\\ -1.01\ \%\end{matrix}\right)\times\left(B\begin{matrix}+1.26\ \%\\ -1.01\ \%\end{matrix}\right)\times\ldots = C\begin{matrix}+1.26\%\\ -1.01\%\end{matrix}$$

9. RECOMMENDATION FOR CALCULATION WITH PREFERRED NUMBERS

9.1 **Serial Numbers.** It may be noted that, for computing with preferred numbers, the terms of the arithmetical progression of the serial numbers (column 5 in Table 1 of Part 1) are exactly the logarithms to base $\sqrt[40]{10}$ of the terms of the geometrical progression corresponding to the preferred numbers of the R 40 series (column 4 of the same table).

The series of the serial numbers can be continued in both directions, so that if N_n is the serial number of the preferred number n, it follows :

$$N_{1\cdot00} = 0$$

$N_{1\cdot06} = 1$	$N_{0\cdot95} = -1$
$N_{10} = 40$	$N_{0\cdot10} = -40$
$N_{100} = 80$	$N_{0\cdot01} = -80$

9.2 **Products and quotients.** The preferred number n″ which is the product or quotient of two preferred numbers n and n′ is calculated by adding or subtracting the serial numbers N_n and N_n' and finding the preferred number n″ corresponding to the new serial number thus obtained.

Example 1 : $3.15 \times 1.6 = 5$
$$N_{3\cdot15} + N_{1\cdot6} = 20 + 8 = 28 = N_5$$

Example 2 : $6.3 \times 0.2 = 1.25$
$$N_{6\cdot3} + N_{0\cdot2} = 32 + (-28) = 4 = N_{1\cdot25}$$

Example 3 : $1 \div 0.06 = 17$
$$N_1 - N_{0\cdot06} = 0 - (-49) = 49 = N_{17}$$

9.3 **Powers and roots.** The preferred number which is the integral positive or negative power of a preferred number is computed by multiplying the serial number of the preferred number by the exponent and by finding the preferred number corresponding to the serial number obtained.

The preferred number corresponding to the root or fractional positive or negative power of a preferred number is computed in the same way, provided that the product of the serial number and the fractional exponent be an integer.

Example 1 : $(3.15)^2 = 10$

$2N_{3\cdot15} = 2 \times 20 = 40 = N_{10}$

Example 2 : $\sqrt[5]{3.15} = 3.15^{1/5} = 1.25$

$\frac{1}{5}N_{3\cdot15} = \frac{20}{5} = 4 \text{ (integer)} = N_{1\cdot25}$

Example 3 : $\sqrt{0.16} = 0.16^{1/2} = 0.4$

$\frac{1}{2}N_{0\cdot16} = \frac{-32}{2} = -16 \text{ (integer)} = N_{0\cdot4}.$

Example 4 : On the other hand $\sqrt[4]{3} = 3^{1/4}$ is not a preferred number because the product of the exponent 1/4 and the serial number of 3 is not an integer.

Example 5 : $0.25^{1/3} = 1.6$

$\frac{1}{3}N_{0\cdot25} = -\frac{1}{3}(-24) = +8 = N_{1\cdot6}$

Note : The mode of calculation with the serial numbers may introduce slight errors which are caused by the deviation between the theoretical preferred numbers and the corresponding rounded off numbers of the basic series.

9.4 Decimal logarithms. The mantissae of the decimal logarithms of the theoretical values are given in column 6 of Table 1 of Part 1.

Example 1 : $\log_{10} 4.5 = 0.650$

Example 2 : $\log_{10} 0.063 = 0.800 - 2 = \bar{2}.800$

PART 3

GUIDE TO THE CHOICE OF SERIES OF PREFERRED NUMBERS AND OF SERIES CONTAINING MORE ROUNDED VALUES OF PREFERRED NUMBERS

10. ADVANTAGES OF ADHERING STRICTLY TO PREFERRED NUMBERS

The advantages of using preferred numbers, set out in Part I and Part 2 of this standard, are recalled and amplified below.

These advantages are obtained not merely in the standardization of various machine elements by themselves, but above all in the construction of complete machines when the functional characteristics, as well as the sizes of each of the various elements, are in a geometrical progression.

10.1 Best progression

Preferred numbers ensure the best progression from the point of view of regularity and the possibility of adapting them to new requirements for the creation of closer series by the insertion of intermediate values.

10.2 Universal applicability

Preferred numbers offer the most logical means of uninterrupted coverage of the complete range of requirements in a given field (powers of motors, output of pumps, etc.).

10.3 Simplification of technical and commercial calculations

Since the products and quotients of preferred numbers are by definition also preferred numbers, calculations, which should be made by using the logarithmic values or serial numbers and not the preferred numbers themselves, are considerably simplified, especially when the series of values (dimensions, list prices, etc.) are multiplied or divided in the same proportions.

10.4 Conversion into other systems of measurement

Conversion into other systems of measurement is greatly facilitated when the series of values in which the measurements are expressed comprise preferred numbers and, at the same time, the conversion factors approximate to preferred numbers.

11. EXCEPTIONAL USE OF MORE ROUNDED VALUES

11.1 In certain applications, imperative reasons prohibit the use of the preferred numbers themselves :

(i) because it is impossible or absurd to retain all the significant figures, in particular when a whole number is necessary (e.g. 32 instead of 31.5 for the number of teeth in a gear);

(ii) because, in the absence of any indication of tolerances, the number of significant figures gives the impression of a precision which is neither desired nor measurable (e.g. 1/30 instead of 1/31.5 second for time exposures for cameras or 224 for an output which in practice is verified at about 10%).

11.2 Further, during the transition period, it is possible that preferred numbers may not be accepted by certain branches of industry or by the general public, for reasons :

(*a*) of an economic nature (e.g. the wish to continue using existing tools and gauges in the factories);

(*b*) of a psychological nature (e.g. the wish to use values expressed in a more simple manner, especially when, in a given case, it may be difficult to write or say the number of figures contained in the preferred numbers themselves)*

11.3 The use of more rounded values may therefore be justified by imperative reasons (see clause 11.1), and these values should thus be used rather than dispensing altogether with the use of preferred numbers.

---

*Also, in certain cases where it is useful to have terms with additive properties, the use, which should remain exceptional, of more rounded values, such as those of the R″ series, provides a solution to the problem, to a limited extent at least, e.g.

$3 + 4 = 7$ $3 + 5 = 8$ $3 + 6 = 9$ $3 + 7 = 10$

$3.5 + 4.5 = 8$ $7 + 7 = 14$ etc.

TABLE 3 MORE ROUNDED VALUES OF PREFERRED NUMBERS

Column	1		2			3			4		5	6	7	8	9	10
Number of terms or index	5		10			20			40		Serial number	Calculated values ‡	Percentage differences between the calculated values and each value in the series			
Approximate ratio	1·6		1·25			1·12			1·06							
Series	R5	R″5	R10	R′10	R″10	R20	R′20	R″20	R40	R′40			R 5 to 40	R′ 10 to 40	R″ 20	R‴ 5 and 10
	1		1			1·0			1·0		0	1·0000	0			
									1·06	1·05	1	1·0593	+ 0·07	− 0·88		
						1·12	1·1		1·12	1·1	2	1·1220	− 0·18	− 1·96	− 1·96	
									1·18	1·2†	3	1·1885	− 0·71	+ 0·97		
			1·25		(1·2)	1·25		(1·2)	1·25		4	1·2589	− 0·71		− 4·68	− 4·68
									1·32	1·3	5	1·3335	− 1·01	− 2·51		
						1·4			1·4		6	1·4125	− 0·88			
									1·5		7	1·4962	+ 0·25			
	1·6	(1·5)*	1·6		(1·5)*	1·6			1·6		8	1·5849	+ 0·95			− 5·36
									1·7		9	1·6788	+ 1·26			
						1·8			1·8		10	1·7783	+ 1·22			
									1·9		11	1·8836	+ 0·87			
			2			2·0			2·0		12	1·9953	+ 0·24			
									2·12	2·1	13	2·1135	+ 0·31	− 0·64		
						2·24	2·2		2·24	2·2	14	2·2387	+ 0·06	− 1·73	− 1·73	
									2·36	2·4	15	2·3714	− 0·48	+ 1·21		
	2·5		2·5			2·5			2·5		16	2·5119	− 0·47			
									2·65	2·6	17	2·6607	− 0·40	− 2·28		
						2·8			2·8		18	2·8184	− 0·65			
									3·0		19	2·9854	+ 0·49			
			3·15	3·2	(3)	3·15	3·2	(3·0)	3·15	3·2	20	3·1623	− 0·39	+ 1·19	− 5·13	− 5·13
									3·35	3·4	21	3·3497	+ 0·01	+ 1·50		
						3·55	3·6	(3·5)	3·55	3·6	22	3·5481	+ 0·05	+ 1·46	− 1·38	
									3·75	3·8	23	3·7584	− 0·22	+ 1·11		
	4		4			4·0			4·0		24	3·9811	+ 0·47			
									4·25	4·2	25	4·2170	+ 0·78	− 0·40		
						4·5			4·5		26	4·4668	+ 0·74			
									4·75	4·8	27	4·7315	+ 0·39	+ 1·45		
			5			5·0			5·0		28	5·0119	− 0·24			
									5·3		29	5·3088	− 0·17			
						5·6		(5·5)	5·6		30	5·6234	− 0·42		− 2·19	
									6·0		31	5·9566	+ 0·73			
	6·3	(6)	6·3		(6)	6·3		(6·0)	6·3		32	6·3096	− 0·15		− 4·90	− 4·90
									6·7		33	6·6834	+ 0·25			
						7·1		(7·0)	7·1		34	7·0795	+ 0·29		− 1·11	
									7·5		35	7·4989	+ 0·01			
			8			8·0			8·0		36	7·9433	+ 0·71			
									8·5		37	8·4140	+ 1·02			
						9·0			9·0		38	8·9125	+ 0·98			
									9·5		39	9·4405	+ 0·63			
	10		10			10·0			10·0		40	10·0000	0			
Max irregularity of ratio, percentage (See B-1.1.2)	+ 1·42	− 5·37	+ 1·66	+ 1·66	− 5·61	− 1·83	− 1·97	− 4·48	+ 1·15	+ 2·94						

Preferred numbers ┃ More rounded values: 1st rounding │ 2nd rounding ╎

*The R″ series (values in brackets) and most particularly the value 1·5 should be avoided on account of the dangers explained in **12**.

†In exceptional cases, when a series without regression is necessary in this region for an application requiring a simple scaling of values unrelated to other data, and the preferred numbers themselves are not applicable, adopt the alternative of 1·15 for 1·18 and 1·20 for 1·25 which give, for the start of the series:

1, 1·05, 1·10, 1·15, 1·20, 1·30.

‡In certain exceptional cases (for example, for the manufacture of turbine blades) when very great precision is necessary use the calculated values.

On the other hand, the use of more rounded values should not be permitted for economic or psychological reasons (see clause 11.2) ; since these are subjective reasons and may not be the same everywhere, they could give rise to differing company or national standards, making wider national or international unification difficult.*

12. DANGERS OF USING MORE ROUNDED VALUES

12.1 The presence in a series of a single more rounded value or of an exceptional value admitted by departing from the rule, and which will not be a preferred number, may make it impossible to transfer subsequently to a series with a smaller ratio.

12.2 The scaling of series of more rounded values is not as good as that of preferred numbers series since, for some intervals, the irregularity may reach 2.94 % in the R′ series and even 5.61 % in the R″ series.

12.3 The scaling of derived series may be even poorer than that of the corresponding R′ or R″ series, if two adjacent values have been rounded towards each other, e.g. one downwards and the other upwards ; thus e.g. for the R′ 40/4 series (......1.05......) the irregularity between 1.32 and 1.7 reaches 1.26 % + 2.51 % = 3.77 % while the maximum irregularity of the original R′ 40 series is only 2.94 %; the fundamental principle of the regularity of preferred numbers series is thus destroyed.

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*The use of exceptional values which are neither preferred numbers nor more rounded values—whether for the sake of alignment with existing standards which were not formulated in accordance with preferred numbers and have not yet been revised, or to maintain particular production processes for the sake of interchangeability, or to use existing tools and gauges—renders future standardization difficult both in national and international fields and prevents the building of machines in series with geometrical scaling.

The introduction into standards of existing series of values which cannot be modified, such as physical constants, should not be regarded as an application of preferred numbers, even if these values are near to preferred numbers or more rounded values; these series may not possess all the properties of preferred numbers, and their use may create difficulties, particularly in calculations such as those envisaged in clause 10.4. The same applies to existing series of values which it is difficult to modify at present, such as gear modules.

12.4 The degree of precision of more rounded values is not as great as that of preferred numbers. In fact, this lack of precision may reach 2.51% for the values in the R′ series and 5.36% for those of the R″ series.

Further because of this fact, more rounded values cannot be used for technical projects when calculating (see clause 9 of Part 2) with aid of serial numbers given in column 5 of Table 1.

12.5 National and international collaboration in standardization work is rendered much more difficult if, instead of using preferred numbers, different people use different series of rounded values for the solution of the same problem.

APPENDIX

PRECISION OF THE VALUES AND REGULARITY OF THE RATIO

A.1 Definition

In order to understand the disadvantages and dangers of using the more rounded values and to adopt them only with full knowledge of the facts, it is important first of all to consider what may be called the **degree of precision** in relation to the corresponding theoretical value.

— of the calculated values.
— of the preferred numbers.
— of the more rounded values.

and the **degree of regularity** of the ratio of the corresponding series.

A.1.1 The **degree of precision of a term,*** in relation to the corresponding theoretical value, is characterized by the relationship, expressed as a percentage,

— of the difference between the value in question and the theoretical value,
— to this theoretical value.

*E.g. for the preferred number 8.5 ignoring the difference between the calculated value and the theoretical value, the degree of precision is :—

$$100 \times \frac{8.5 - 8.4140}{8.4140} = +1.02\%$$

These relative differences are given for the preferred numbers in column 8 of Table 1 of Part I and are repeated in Part 3 in column 7 of Table 3. This table also gives the corresponding differences for the more rounded values in columns 8 to 10.

A.1.2 The **degree of regularity of the ratio of a series, at a given point,** is characterized by the deviation, expressed as a percentage between the actual ratio at this point (relation between two adjacent terms) and the theoretical ratio.*

These deviations, and therefore the degree of regularity of the ratio between two adjacent terms, can thus be obtained by simple algebraic subtraction of the differences given in columns 7 to 10 of the table, ignoring infinitesimal values.†

The maximum irregularity of the ratio at various points in each of the R, R′ and R″ series is given at the foot of columns 1 to 4 of Table 3.

A.2 Permissible Deviations.

A.2.1 If consideration is given only to the condition that a rounded value should remain closer to the corresponding theoretical value than to the adjacent theoretical values, this condition is expressed by a maximum permissible deviation which (if the ratio $\sqrt[n]{10}$ is not too great) is approximately equal in relative value to :-

$$\pm \frac{\sqrt[n]{10} - 1}{2}$$

*E.g. in the series R 40, taking the terms 1.60 and 1.70, this deviation is

$$\sqrt[40]{10} - \frac{1.7}{1.60}$$

†E.g. the terms 1.60 and 1.70 give approximately

$$\frac{1.70}{1.60} = 1.0593 \left(1 + \frac{1.26 - 0.95}{100}\right) = 1.0593 (1 + 0.0031)$$

The exact relation is 1.0625, the exact deviation is 0.003 25 or 0.3 % to the nearest 2/10 000 (in this case).

A.2.2 At the limit, however, the relation between two successive numbers may thus become near to 1 (or twice the ratio), which is not permissible for the regularity of the series.

A.3 Actual Deviations of the Calculated Values

In Part 1, the calculated values are given in column 7 of Table 1. to five significant figures, which corresponds to a maximum deviation not exceeding 0.000 05 in absolute value, and to a relative difference of 0.0048 % in relation to the theoretical value.

A.4 Actual Deviations of the Preferred Numbers

A.4.1 In the same part, the **preferred numbers** are given to three significant figures, and the relative difference between them and the calculated values is shown in column 8.

A.4.2 This relative difference does not exceed 1.26 %, whereas the absolute error is sometimes large ; but it may be noted that the conventional roundings have been chosen in such a way that the regularity of the series, i.e. the relationship between two terms, remains very close to the theoretical ratio (maximum irregularity 1.15 % in R 40).

A.5 Actual Deviations of More Rounded Values

A.5.1 **The only more rounded values** which may be used, and then only in exceptional cases, have been formulated to give only **two significant figures,** or even only **one significant figure,** and to maintain the permissible degree of precision and of regularity in the series R′ and R″, for the constitution of which they are provided.*

*The value 1.2 provided in R′ 40 in place of 1.18 deviates from the theoretical value by + 0.97 %, and it is thus almost as acceptable as 1.18 which deviates by − 0.71 %; but, if the scaling is considered, the value 1.2 does not fit in well between 1.1 and 1.25 ; in fact, the deviation from the theoretical ratio 1.0593, obtained from the algebraic difference of the differences in columns 7 and 8, is indicated in clause A. 1.2, is modified

$$\text{between 1.2 and 1.1 by } \frac{+0.97 + 1.96}{100} = 2.93\,\%$$

$$\text{between 1.25 and 1.2 by } \frac{-0.71 - 0.97}{100} = -1.68\,\%$$

The two consecutive ratios are thus 1.0886 and 1.0425, instead of 1.0593.

A.5.2 Nevertheless, they differ from the theoretical values very much more than do the preferred numbers themselves (see columns 7 to 10 of Table 3—maximum differences in frames). The regularity of the ratio of the R′ and R″ series is similarly poorer than that of the preferred numbers series; e.g. in R″5, the maximum irregularity (see foot of columns 1 to 4 of Table 3) reaches 5.37%, compared with 1.42% in R5, while in R′ 40 it reaches 2.94%, compared with 1.15% in R 40.

A.5.3 It should be noted that for certain terms a rounding which is allowable in R″ 5 or R″ 10 is not allowable in closer series. Thus, value 1.5, differing by 5.36% from its theoretical value, entails a deviation of 5.60% in the ratio between it and the succeeding term 2.0, a permissible deviation in R″ 10, which has a ratio in the neighbourhood of 1.25 and maximum permissible deviation of 12.9%, according to clause A.2.1. But this value cannot be retained in R″ 20, which has a ratio in the neighbourhood of 1.12, as it would result in a deviation of 6.58% in relation to the succeeding term 1.8 and the maximum permissible deviation is 6.1%.

APPENDIX B

INTERNATIONAL EXAMPLES OF THE USE OF PREFERRED NUMBERS

B.1 Standard Currents

Publication 59 of the International Electrotechnical Commission gives, for standard currents, the following ratings in amperes :

1	1.25	1.6	2	2.5	3.15	4	5	6.3	8
10	12.5	16	20	25	31.5	40	50	63	80
100	125	160	200	250	315	400	500	630	800
1000	1250	1600	2000	2500	3150	4000	5000	6300	8000
10 000									

B.2 Normal Diameters of Bare Wires of Annealed Copper with Circular Cross Section. The French publication C 31—111 has adopted the following values, expressed in millimetres :

0.0315	0.112
0.0355	0.118
0.040	0.125
0.045	0.132
0.050	0.140
0.056	0.150
0.063	0.160
0.071	0.170
0.080	0.180
0.090	0.190
0.100	0.200

B.3 Rotating Speeds of Machine-tool Spindles. The Belgian standard NBN 123-1950 has adopted the R 20 series (and the R 20/2, R 20/3. R 20/4, R 20/6 derived series) for the rotating speeds of machine-tool spindles, expressed in revolutions per minute :

1	1.12	1.25	1.4	1.6	1.8	2	2.24	2.5	2.8
10	11.2	12.5	14	16	18	20	22.4	25	28
100	112	125	140	160	180	200	224	250	280
1000									

3.15	3.55	4	4.5	5	5.6	6.3	7.1	8	9
31.5	35.5	40	45	50	56	63	71	80	90
315	355	400	450	500	560	630	710	800	900

B.4 Tanks for Water under Pressure. The German Standard DIN 2760 has adopted for the nominal capacities the following values, expressed in litres :

4		6.3		10		16		25	
40		63		100	125	160	200	250	315
400	500	630	800	1000	1250	1600	2000	2500	3150
4000	5000	6300	8000	10 000	12 500	16 000	20 000	25 000	

B.5 Lifting Capacity of Cranes. The Norwegian standard NS 300 has adopted the following values for the lifting capacity of cranes, expressed in tons.

1	1.25	1.6	2	2.5	3.15	4	5	6.3	8
10	12.5	16	20	25	31.5	40	50	63	

B.6 Diameters of Cylinders for Hydraulic Equipment. A British firm manufacturing hydraulic equipment has standardized cylinder diameters in the R 40 series in order to enable a limited range of grinding, honing and gauging equipment to be stocked, to facilitate raw material supply and to enable many internal components, pistons, seals, etc. to be standardized. The comparatively small steps of the R 40 series are necessary because the hydraulic load or force involved is a function of the incremental steps of the area or of the square of the diameter (the incremental step in the R 40 series = 6% or about 12% in area).

The firm uses these diameters in all hydraulic designs, an interesting example being in hydraulic accumulators (pistons type). The main technical requirement here is displaced volume and the component parts are standardized in the R 5 series (40, 63, 100, 160. .etc. cubic inches).

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