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TRENDS IN MECHANICAL FASTENERS

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660<

CONTENTS

	<u>Page</u>
INTRODUCTION	2
TRENDS IN THE BUSINESS WORLD	2
Safety and Reliability	2
Maintenance and Repair	2
Competition	2
TRENDS IN MECHANICAL FASTENERS	3
Specialty Fasteners	3
Thread Rolling Screw	3
Self Drilling and Tapping Screws	4
Locking Screws	4
Tamperproof Fasteners	4
Flanged Bolts and Nuts	4
METRICATION	4
CONCLUSION	5

APPENDIX I

First Progress Report on Work of ANSI Special Committee to
Study Development of an Optimum Metric Fastener System

INTRODUCTION

Fastener manufacturers are very creative. They continually develop new products and minor variations of old products. How do you separate those which have a future from those which are only a gimmick? In most instances it takes considerable experience and testing before judgement can be passed, and the results are usually controversial. For that reason, in this brief report, we will confine ourselves to only a few new variations which should be used in ever increasing volume over the foreseeable future. This will then allow the maximum possible time to discuss the trend towards metrication.

Before discussing fastener trends, let us look at some of the trends in the business world which will influence the kinds of fasteners that we will use in the coming years.

BUSINESS TRENDS

Safety and Reliability

There is an ever increasing amount of pressure on producers to make reliable products, at a cost which will enable them to remain competitive. This need for reliability is absolutely necessary if the breakdown of a product could cause harm to people or damage to property. In addition, all new products are guaranteed for a fixed period of time. Consumer organizations and the government have been constantly demanding more liberal terms in favor of the consumer. It is profitable to have trouble free service during the warranty period to avoid repair costs which will be charged back to the parent company. This will generate a need for better quality fasteners which will incorporate many of the latest design innovations.

Maintenance and Repair

As products become more complex, it becomes increasingly more difficult and time consuming to locate individual problem areas when a breakdown occurs. When this is coupled with the rising cost of labor, it rapidly creates a condition where it is cheaper to replace than repair. By replace, it does not necessarily mean that an entire product must be discarded. There is a trend toward building products into subsections. Just that portion of the product in which the problem occurs needs to be detached and replaced. The consumer might replace the faulty section himself or if outside service is required the labor costs will be held to a minimum.

Since there will be less repairing of the small internal parts of a subassembly, there will be a trend toward permanently joining by rapid production methods such as welding. On the other hand, the larger sub-assemblies may still be joined by conventional threaded fasteners or quick release type of fasteners, such as spring clips, quarter turn, and push button designs.

Competition

The fastener industry is very competitive and the last 2 years were the toughest in recent times. The aerospace and defense business went

(Continued on Page 3)

Competition (Continued)

into a rapid decline. At the same time there was a big influx of imported fasteners. At present, imports have been limited almost exclusively to the lower quality standard fasteners. Some domestic fastener manufacturers recognize that they cannot compete in this category. They are beginning to import, rather than produce ordinary fasteners. At the same time they are giving ever increasing attention to specialty items.

TRENDS IN MECHANICAL FASTENERS

Specialty Fasteners

The vast majority of new ideas in fasteners will never enjoy wide usage. Usually the biggest handicap is cost. That is, most new developments cost more than the standard they are supposed to replace. This creates an initial resistance. Everyone is trying to cut costs. Buying a more expensive fastener subjects them to criticism from those who watch the pennies. However, there will be occasions when spending more money for fasteners is warranted:

1. Lower Assembly Cost - No one will object to spending more for a purchased part if it is less costly to install and results in a lower overall cost.
2. Improved Design - Higher initial cost can be justified if the change results in a safer and more reliable product.
3. Lower Maintenance Cost - With increased attention being paid to the cost of servicing, a higher priced fastener can justify its existence if it will reduce the time required to disassemble and reassemble a product for normal maintenance and repair.

Some of the specialty fasteners which are enjoying ever increasing usage includes the following:

Thread Rolling Screws

There are several different thread rolling screw designs which are commercially available. Each type has several contact points around the starting threads. These points gradually form a thread through interrupted contact, rather than the continuous forming principle of conventional tapping screws. These contact points or tiny lobes are generally invisible to the eye. They form threads with comparatively low torsional effort. Therefore, they require less driving torque to seat the screw. There will be a wider margin for setting the driving gun to cut off before reaching the higher torque values that can strip a thread. These screws also provide a high degree of thread engagement which produces a tight fit. This minimizes the need for lock washers or other locking devices.

Self Drilling and Tapping Screws

This type of screw combines the characteristics of yesterday's tapping screw with the best features of a factory sharpened twist drill. They drill their own pilot hole and provide their own threads in one operation. They can be placed exactly where they are wanted without the time consuming effort to align holes in mating parts. This can substantially reduce assembly cost in the factory.

Locking Screws

There is a trend toward the use of fasteners that offer some kind of locking feature to maintain preload and minimize fatigue problems. They also prevent loosening, rattles and squeaks. There are many ways to provide locking action, such as:

- Plastic pellets or strips fused to the thread
- Deformed thread
- Resilient bulge on one side of a thread
- Anaerobic adhesives (single component liquid that cures only in the absence of air)
- Two part epoxy adhesives
 - Precoat each ingredient separately on the fastener or
 - Micro-capsulation of the active ingredient

Tamperproof Fasteners

There is an increasing need for fasteners that are designed to prevent unauthorized removal. Tamperproof fasteners are needed on equipment located in public places to discourage vandalism and thievery. They are also needed on some consumer products as a safety measure to protect the amateur repairman from harming himself or causing serious damage to the equipment.

Flanged Bolts and Nuts

There is an ever increasing need for fasteners which provide a greater load-bearing area. This is especially true for bolting softer materials. A flanged bolt or nut will permit tightening to higher preloads and generally eliminate the need for washers.

Metrication

A few years ago almost everyone in the fastener industry was certain that United States would not convert to metric threaded products in their lifetime. Even today there is no great rush toward the usage of metric fasteners in this country. However, those USA companies which manufacture and market identical products in different parts of the world have three (3) choices:

1. They can standardize on inch fasteners because they are more easily purchased overseas than metric fasteners can be purchased domestically.

METRICATION (Continued)

2. They can use inch fasteners in USA production and metric fasteners in overseas production.
3. They can standardize on metric fasteners for all products, whether domestic or foreign production.

Most USA companies select either of the first two choices listed below. Nevertheless there will be a trend toward choice No. 3, as pressure is applied both from overseas customers and US proponents of the metric system.

We anticipate a very slow and gradual conversion from US customary units to metric SI units. Those concerned with measurements in USA should develop the dual capability to think in both systems. The SI system is not the old metric system with a new name. It does contain several major changes. The absolutely new units in the SI system are the Newton and Pascal. The Newton is a measurement of force and the Pascal is a measurement of stress. Another unit which will be commonly used by the fastener industry is torque measured in Newton metres. (note the new official spelling of the word "Meter".) Temperature will be measured in centigrade or kelvin units. Kelvin is the same as centigrade except that absolute zero is zero degrees K and all values are offset by 273.15 degrees.

The American National Standards Institute (ANSI) recently organized a special committee to study the development of an optimum metric fastener system. This committee will make recommendations. They will not develop standards. However, it is anticipated that these recommendations will be given serious consideration by those fastener committees that are responsible for developing industry standards. This special ANSI committee will attempt to complete its study within the next two years. They will issue progress reports at periodic intervals. See Appendix I for the first report, dated March 30, 1972.

CONCLUSION

The future for mechanical fasteners is more than the few speciality fasteners and ever increasing usage of metric units previously discussed. The ideal fastener does not yet exist. The most important need is for a fastener that can be assembled automatically. The ultimate in the assembly of parts would be a fastener which automatically falls in position and locks without individual attention. Thus requires installation machinery that is compatible with the purchased fastener. In the future fastener manufacturers must develop and sell complete systems or work very closely with their customers manufacturing engineers to develop this kind of automated equipment.

Committee Correspondence

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of an Optimum Metric Fastener System**

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March 30, 1972

FIRST PROGRESS REPORT
ON WORK OF
ANSI SPECIAL COMMITTEE TO STUDY DEVELOPMENT
OF AN OPTIMUM METRIC FASTENER SYSTEM

In July, 1971, announcement was released to the technical press in USA and Canada of appointment by the American National Standards Institute of a Special Committee to Study Development of an Optimum Metric Fastener System.

The Committee's assignment is to re-examine the engineering of mechanical fasteners, thoroughly study all of their dimensional, mechanical and performance features, and to develop an entirely new system which would be as technically superior as the state-of-the-art permits, and which would reduce to the fewest possible the number of different fasteners to be recognized as standard. All dimensions and properties of the new system will be stated in metric (SI) units.

With the July, 1971 press release was a promise to periodically inform the press of the Committee's progress and accomplishments.

- The ANSI Committee has met 4 times, and its 5 working Subcommittees have held a total of 12 meetings.

- The Committee is using as the basis for all its studies the originally proposed series of 25 diameter/pitch combinations recommended in the January, 1971 IFI Engineering Report - with the proviso that the series

would be re-examined periodically as new data is developed. The decision was influenced by a "Monte Carlo" computer program comparing the ISO series of preferred metric sizes of fasteners against the IFI series to learn the relative material wastage based on current usage by sizes and strength grades. The IFI series indicated a savings of nearly 4%.

- One of the biggest European concerns with the initial IFI recommendations was the indicated non-mating of new threads with existing ISO metric threads. An extensive analysis, involving statistical evaluation of actual thread measurements taken on over 5,000 nuts and screws as supplied by 9 producers, showed that the probability of interference between a screw with the new optimum metric high radiused root external thread and existing ISO internal threads (nuts and tapped holes) would be negligible.
- Design of the screw thread system is well advanced. The basic thread form is approved, the design form for an allowance and a non-allowance thread fit is close to completion, a technically innovative gaging practice has been designed and will be checked out with specially manufactured gages, the tolerance and allowance systems are being developed. The basics of a sophisticated technique for evaluating the merits of different diameter/pitch series have been defined and will be used to assist reaching final decisions on sizes and thread pitches.
- The advice of over 200 fastener engineers was sought on new ideas for improving the design of various fastener products. Based on this response, a comprehensive listing of criteria which must be satisfied in the design of new products has been established. A detailed computer

program is now under way to search out optimum configurations for bolt and screw heads and shanks. Dr. R. Kasuba, Professor Mechanical Engineering, Cleveland State University, has been retained as a consultant. Companion studies on nuts will start shortly.

- One of the principal goals of the study is to assure maximum utilization of material, to give designers full use of a product's inherent strength capabilities. Considerable work has been done to evaluate different concepts of approach, and an extensive fact finding research effort is now being shared by several fastener producers and users to gather data on actual mechanical properties of representative products now being manufactured and used.
- Work to establish inspection and quality assurance procedures has started, even though the need for quick accomplishment is not as urgent as other phases of the study.
- While the bulk of the work will be done analytically, physical testing of actual product will be necessary to cross check and verify. Arrangements have been made to collect quantities of inch and metric series fasteners from various countries of the world to be used in physical testing.
- A team of 6 members of the ANSI Committee will visit Europe in mid May to discuss the progress of the Committee's technical studies with representatives of European industry.

- The Committee has approved and released two recommendations - OMFS-1 "Rules for the Use of SI Units Applicable to Mechanical Fasteners" and OMFS-2 "Basic Thread Form for Optimum Metric Fastener Screw Threads." Copies of each are attached.

Single copies of these Recommendations are available without charge upon written request to Industrial Fasteners Institute, 1505 East Ohio Bldg., 1717 East 9th Street, Cleveland, Ohio 44114.

RECOMMENDATION OF THE ANSI SPECIAL COMMITTEE TO STUDY DEVELOPMENT OF AN OPTIMUM METRIC FASTENER SYSTEM

American National Standards Institute, Inc. — 1430 Broadway, New York, N. Y. 10018 U.S.A.

FOREWORD

The ANSI Special Committee to Study Development of an Optimum Metric Fastener System was appointed in April 1971. Its assignment is to develop a total system of metric module mechanical fasteners, taking advantage of every opportunity to improve fastener performance capability through product redesign and the most efficient use of materials, and to limit to the fewest possible the number of different sizes, series, grades, types and styles of fasteners necessary to adequately satisfy the engineering requirements of the majority of industrial applications. All dimensions and properties of the system will be stated in metric (SI) units.

The International System of Units (SI) is a rationalized and coherent system of measurement units based on the metric system. SI was developed by the General Conference of Weights and Measures. It was officially adopted by the Conference in 1960, and has since been accepted by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). SI is in a continuing state of review and refinement, the most recent additions and modifications being accepted by the Conference in 1971. At the present time, SI consists of seven base units, two supplementary units, a series of derived units consistent with the base and supplementary units, and a series of prefixes for the formation of multiples and submultiples of the various units. Complete details of SI can be found in ISO R1000, NBS 330, or ASTM E380.

This Recommendation was prepared by the ANSI Special Committee to guide it in the units, prefixes, and editorial style to be used in the preparation of engineering documentation resulting from its studies.

1.0 SCOPE

1.1 This Recommendation abstracts from the International System of Units (SI) the units for those quantities most commonly used to define the characteristics, dimensions, and properties of mechanical fasteners. This document also outlines editorial style rules to be followed when using SI units.

1.2 Appendix A to this Recommendation gives information on conversion of U.S. customary units to SI units. Also as an assist to familiarize fastener producers and users with relationships between SI units and customary units, the appendix presents several approximate equivalencies.

2.0 REFERENCE DOCUMENTS

The material presented in this Recommendation is abstracted from the following sources:

ISO R1000 — Rules for the Use of Units of the International System of Units and a Selection of the Decimal Multiples and Submultiples of the SI Units

NBS Special Publication 330 — The International System of Units (SI), published by U.S. Department of Commerce, National Bureau of Standards

670<

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RULES FOR THE USE OF SI UNITS APPLICABLE TO MECHANICAL FASTENERS IN THE OPTIMUM METRIC FASTENER SYSTEM

OMFS-1

Page 1 of 4

Issued: February, 1972
Revised:

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ASTM E380 (ANSI Z210.1) — Standard Metric Practice Guide (A Guide to the Use of SI - the International System of Units), published by the American Society for Testing and Materials

SAE Rules for the Use of SI (Metric) Units in SAE Reports, published by the Society of Automotive Engineers

3.0 QUANTITIES

3.1 LENGTH. The SI base unit for length is metre (m). [NOTE: The spelling "meter" should not be used.]

All linear dimensional characteristics of fasteners (diameters, heights, thicknesses, lengths, thread dimensions, etc.) shall be expressed in millimetres (mm). Tolerances shall be given in millimetres (mm), and surface roughness in micrometres (μm).

3.2 MASS. The SI base unit for mass is kilogram (kg).

The mass (commonly referred to as weight) of a fastener and masses related to fastener manufacturing and marketing shall be expressed in kilograms (kg). Alternatively, grams (g) may be used to express a small mass, and megagrams (Mg), which equals 1000 kg, may be used when expressing a large mass.

NOTE: Considerable confusion exists in use of the terms mass and weight. Mass is a property of matter to which it owes its inertia. If a body or particle of matter at rest on the earth's surface is released from the forces holding it at rest, it will experience the acceleration of free fall (acceleration of gravity). The force required to restrain it against free fall is commonly called weight. This force is proportional to the mass of the body and is often expressed in mass units (kg); but as it is a force, it should be expressed in force units (N). The acceleration of free fall varies in time and space; weight (which is proportional to it) does too, although mass does not. In common parlance the term "weight", as of a container of bolts, is used where the technically correct term is mass. Since this non-technical usage of the term "weight" is common, the term should be avoided in technical usage.

3.3 DENSITY. The SI unit for density is kilogram per cubic metre (kg/m^3) and shall be used when expressing densities related to fasteners.

3.4 TIME. The SI base unit for time is second (s). When expressing time the following units are acceptable: second (s), minute (min), hour (h), day (d), week and year.

3.5 TEMPERATURE. The SI base unit for temperature is kelvin (K).

Because of the wide usage of the degree Celsius, particularly in engineering and non-scientific areas, the Celsius scale (formerly called the centigrade scale) shall be used when expressing temperature as related to fastener manufacturing processes and to fastener application practices. The Celsius scale is related directly to the kelvin scale as follows:

one degree Celsius (1°C) equals one degree kelvin (1K), exactly

and

a Celsius temperature (t) is related to a kelvin temperature (T), as follows:

$$T = 273.15 + t, \text{ exactly}$$

3.6 PLANE ANGLE. The SI unit for plane angle is radian (rad), and is equal to $180^\circ/\pi$ (57.296°). For fasteners, plane angles shall be expressed in degrees ($^\circ$) with decimal subdivisions instead of minutes and seconds.

3.7 AREA. The SI unit for area is square metre (m^2). For fasteners, the recommended unit for expressing area is square millimetre (mm^2).

3.8 VOLUME. The SI unit for volume is cubic metre (m^3). For fasteners, the recommended unit for expressing volume is cubic millimetre (mm^3).

3.9 FORCE. The SI unit for force is newton (N). For fasteners, forces (loads) shall be expressed in newtons (N), kilonewtons (kN) or meganewtons (MN).

671<

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OMFS-1

Page 2 of 4

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3.10 STRESS. The SI unit for pressure or stress is pascal (Pa), and equals one newton per square metre (N/m^2).

For fasteners, stresses shall be expressed in megapascals (MPa).

3.11 TORQUE. The SI unit for torque is newton-metre (N·m) and shall be used for fasteners.

3.12 MULTIPLE AND SUBMULTIPLE PREFIXES. The multiple and submultiple prefixes used to quantify SI units as used for fasteners shall be as follows:

Multiplication Factor	Prefix	SI Symbol
1 000 000 = 10^6	mega	M
1 000 = 10^3	kilo	k
0.001 = 10^{-3}	milli	m
0.000001 = 10^{-6}	micro	μ

4.0 RULES FOR STYLE AND USAGE

4.1 GENERAL. The units as noted for their applicability for fasteners in Section 3 should be used.

4.2 APPLICATION OF PREFIXES. The prefixes given in 3.12 should be used to indicate orders of magnitude, thus eliminating insignificant digits and decimals, and providing a convenient substitute for writing powers of 10 as generally preferred in computation. For example —

2 N x 10^3 or 2000 N becomes 2 kN

7.2 mm x 10^{-3} or 0.0072 mm becomes 7.2 μ m

Prefixes should be applied to the numerator of compound units, except when using kilogram (kg) in the denominator. Since kilogram is a base unit of SI, this particular multiple is not a violation and should be used in preference to the gram.

With SI units of higher order such as m^2 or m^3 , the prefix is also raised to the same order; for example, mm^2 is $10^{-6}m^2$ not $10^{-2}m^2$.

4.3 SELECTION OF PREFIX. When expressing a quantity by a numerical value and a unit, a prefix should be chosen so that the numerical value prefer-

ably lies between 0.1 and 1000, except where certain multiples and submultiples have been agreed for particular use, for example MPa. The same unit, multiple, or submultiple should be used in tables even though the series may exceed the preferred range of 0.1 to 1000.

The decimal point shall be used to indicate decimal parts of a quantity. Whenever a numerical value is less than one, a zero should precede the decimal point.

4.4 CAPITALIZATION. Symbols for SI units are only capitalized when the unit is derived from a proper name; for example, N for Isaac Newton. Unabbreviated units are not capitalized, for example, kelvin and newton. Numerical prefixes given in 3.12 and their symbols are not capitalized; except for the symbol M (mega).

4.5 PLURALS. Unabbreviated SI units form their plurals in the usual manner. SI symbols are always written in singular form. For example,

50 newtons or 50 N

25 millimetres or 25 mm

4.6 PUNCTUATION. Periods are not used after any SI unit symbol, except at the end of a sentence.

4.7 NUMBER GROUPING. It is the practice in many metric countries to use a comma (instead of a decimal point) to indicate decimal parts of a quantity. Consequently, to avoid confusion, commas to separate multi-digit numbers into groupings of three shall be omitted, and digits shall be placed without spaces or other separators both to left and right of the decimal point. To facilitate convenient reading, effort should be made, through selection of appropriate prefixes, to limit the number of digits to the left of a decimal point to four or less.

4.8 DERIVED UNITS. In symbols for derived units, a center dot is used to indicate multiplication (for example, N·m), and a slash to indicate division (for example, kg/m^3). Symbols to the left of the slash are in the numerator, and symbols to the right are in the denominator.

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APPENDIX A — SI UNITS AND CONVERSIONS FOR QUANTITIES COMMONLY USED IN DEFINING CHARACTERISTICS AND PROPERTIES OF MECHANICAL FASTENERS

QUANTITY	UNIT	SYMBOL	CONVERSIONS FROM CUSTOMARY UNITS		(1)	(2)
			TO CONVERT FROM	TO		
length	metre	m	inch	mm	2.540000* E+01	25 mm = 1 in.
	millimetre	mm	foot	mm	3.048000* E+02	300 mm = 1 ft
	micrometre	µm	foot	m	3.048000* E-01	25 µm = .001 in.
mass	kilogram	kg	ounce	g	2.834952 E+01	2.8 g = 1 oz
	gram	g	pound	kg	4.535924 E-01	1 kg = 35 oz
	megagram	Mg	ton (2000 lb)	kg	9.071847 E+02	1 kg = 2.2 lbs
density	kilogram per cubic metre	kg/m ³	pounds per cubic foot	kg/m ³	1.601846 E+01	16 kg/m ³ = 1 lb/ft ³
			degrees Fahrenheit	°C	°C = 5/9 (°F - 32)*	0°C = 32°F (exact) 20°C = 68°F (exact) 100°C = 212°F (exact) 480°C = 900°F
area	square metre	m ²	square inch	mm ²	6.451600* E+02	645 mm ² = 1 in. ²
	square millimetre	mm ²	square foot	m ²	9.290304* E-02	1 m ² = 11 ft ²
volume	cubic metre	m ³	cubic inch	mm ³	1.638706 E+04	16400 mm ³ = 1 in. ³
	cubic millimetre	mm ³	cubic foot	m ³	2.831685 E-02	1 m ³ = 35 ft ³
			cubic yard	m ³	7.645549 E-01	1 m ³ = 1.3 yd ³
force	newton	N	ounce-force	N	2.780139 E-01	1 N = 3.6 oz
	kilonewton	kN	pound-force	N	4.448222 E+00	4.4 N = 1 lbf
	meganeutron	MN	pound-force	kN	4.448222 E-03	1 kN = 225 lbf
			kip (1000 lbf)	kN	4.448222 E+00	1 MN = 225 kips
stress	megapascal	MPa	pound-force/inch ² (psi)	MPa	6.894757 E-03	1 MPa = 145 psi
			kips/inch ² (ksi)	MPa	6.894757 E+00	7 MPa = 1000 psi 7 MPa = 1 ksi
torque	newton-metre	N·m	inch ounce	N·m	7.061552 E-03	1 N·m = 140 in. oz
			inch pound	N·m	1.129848 E-01	1 N·m = 9 in. lb
			foot pound	N·m	1.355818 E+00	1.4 N·m = 1 ft lb 1 N·m = .75 ft lb

- NOTES:**
- Conversion factors that are exact are followed by an asterisk. Other conversion factors have been rounded in accordance with accepted rules, and conversions will be accurate only to the sixth decimal place. Conversion factors are presented for ready adaptation to computer read-out and electronic data transmission. The factors are written as a number greater than one and less than ten with six decimal places. This number is followed by the letter E (for exponent), a plus or minus symbol, and two digits which indicate the power of 10 by which the number must be multiplied to obtain the correct conversion. For example: 6.894757 E-03 is 0.006894757. Similarly, 1.638706 E+04 is 16387.06.
 - The relationships given in this column are not exact, except for those noted. All others are rounded equivalencies and are presented strictly to give a quick appreciation of the magnitude of SI quantities in comparison with those expressed in U.S. customary units. None of these relationships should be used when making a conversion to SI units.

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OMFS - 1

Page 4 of 4

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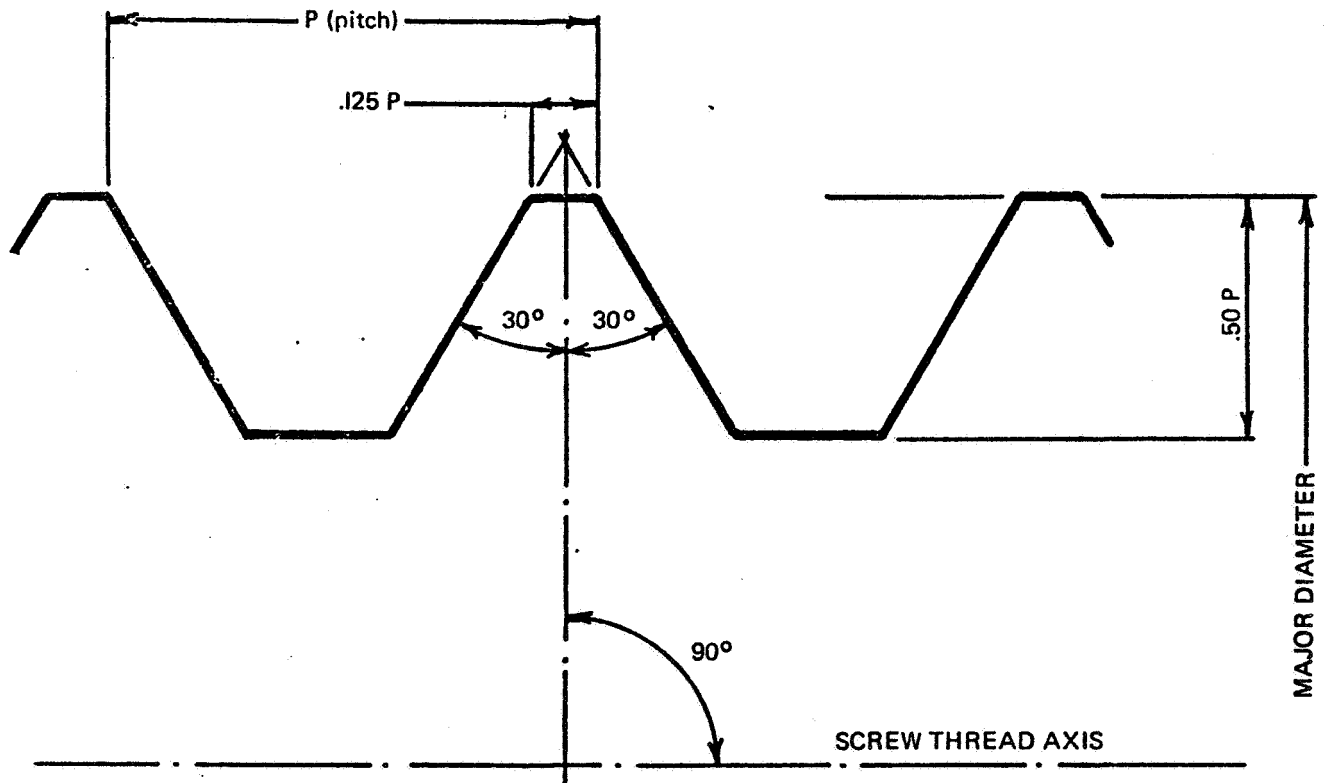
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1.0 SCOPE

1.1 This Recommendation defines the basic thread form for optimum metric fastener screw threads.

1.2 DEFINITION. The basic thread form of a thread standard is the cyclical outline, in an axial plane, of the permanently established boundary between the provinces of the external and internal threads. This boundary governs the conditions of assembleability and must be permanently respected in order to preserve the integrity of the standard. For normal fastening screw threads the basic thread form defines the theoretical maximum space which the internal thread is permitted to occupy within the basic major diameter of the externally threaded member.



674

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