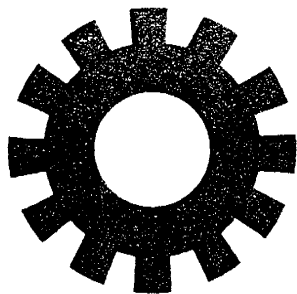
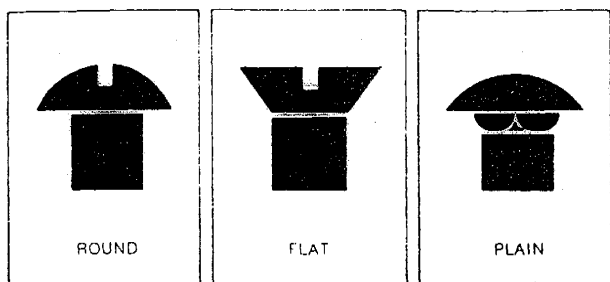


STAINLESS STEEL FASTENERS A SYSTEMATIC APPROACH TO THEIR SELECTION



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Preface

There was a time when the periodic repair of mechanical and electrical components was taken for granted. Today, with labor costs at record levels and going up, greater consideration at the design level is being given to the reduction—or even elimination—of maintenance. In cases where a joint must be taken apart and reassembled, the corrosion resistance of the fastener is particularly important so that corrosion will in no way hamper or prevent its removal. The cost of removing rusty bolts, and replacing them with new ones, is more expensive than using corrosion resistant fasteners to begin with.

Other costs resulting from fastener failure, such as downtime and lost production, make an even stronger case for stainless steel fasteners.

A systematic approach to stainless steel fastener selection

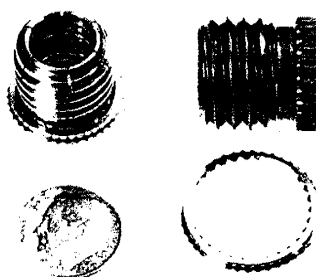
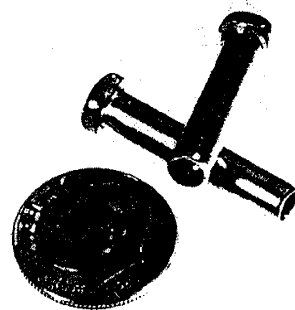
Selecting the optimum fastener can be an awesome task for any designer. There is a staggering diversity of fastener types available (over 500,000 standard items), and for any one type there can be a large number of sizes from which to choose. For example, one of the smallest standard fasteners has a head of 0.01 inch (.254mm); the largest has a head 4 feet (1.219m) in diameter. To further complicate the problem of fastener selection, there are special designs, which are not considered to be "off-the-shelf" items, and a wide variety of different materials.

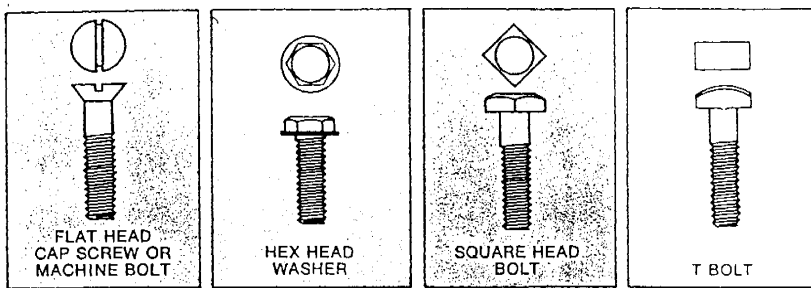
Stainless steel is one of these fastener materials, and it is used extensively throughout industry for both original equipment manufacture as well as for replacement. The purpose of this publication is to help designers trace an orderly path through the fastener complexity to arrive at a stainless steel fastener system that best fills the need.

The designer should consider a fastener as a system, and regard the assembled joint as a critical and integral portion of the design—not as an afterthought—because the joint is normally an area under highest stress and often the place where failure is most likely to occur. A designer should start with the optimum fastener and design the joint around that, rather than starting with the joint and then looking for the fastener that seems most adequate.

Fastener materials

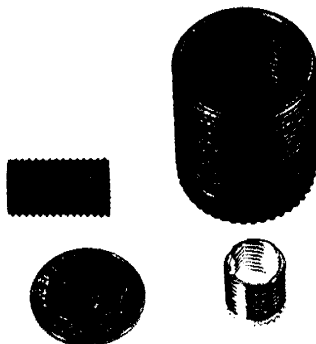
Fasteners have been made of a vast number of materials for one reason or another. The designer





can specify anything from hard oak to Invar, a low coefficient-of-expansion material. There are indeed many cases wherein an exotic material must be used because of design requirements.

However, the common materials used to produce both standard and special fasteners should be considered first. The common materials are a first choice because of the ease in manufacturing fasteners from these materials, because they provide adequate physical characteristics at more economical cost, and because they are readily available from suppliers throughout the United States and Canada. The brief outline which follows identifies some different common fastener materials.



CARBON STEELS (AISI Type):

1008, 1010, 1015 are low-carbon steels used for the great majority of machine screws, wood screws, etc. Sometimes called mild steel, they have a tensile strength of about 55 ksi (379MPa), which cannot be increased by heat treatment.

1018, 1020, 1022 are medium low-carbon steels that can be heat treated for strength to a minor degree (except 1018), and they can be case hardened to form an outer layer of hard, tough, but brittle carburized steel. They are used for sheet metal screws, thread-cutting screws, and for grade 2 (bright) hexhead cap screws. About 59 ksi (407MPa) is the usual tensile strength for these materials.

1035, 1038 are high-carbon, medium alloy steels that can be heat treated to 120 ksi (827MPa) tensile strength. Cap screws are a typical use.

ALLOY STEELS (AISI Type):

4037, 4137 are molybdenum alloy steels that can be heat treated to 150 ksi tensile (1034MPa) and above. Typical uses include hex socket and cap screws and for spline fasteners.

FREE-CUTTING STEELS (AISI Type):

1110, 1112, 1113 are low-carbon, free-machining steels used for low-strength nuts that are used in all but critical applications.

STAINLESS STEELS (AISI Type):

303, 304, S30430 (UNS), 305 are in the "18-8" family of stainless steels that have tensile strengths in the 80 ksi (552MPa) and up range.

They are not hardenable by heat treatment but are hardenable by cold working, such as by heading and thread rolling. They are nonmagnetic in the annealed condition and only slightly magnetic in the cold worked condition.

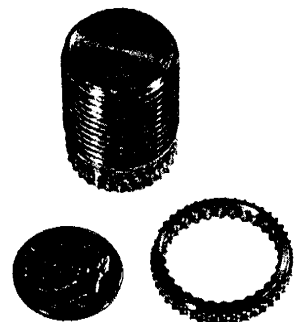
384 is a stainless steel that has lower work-hardening characteristics than Type 305. It is in the 18-8 family of stainless steels and is included in most AN and MS specifications.

316 stainless steel has the highest degree of corrosion resistance of the commonly-used 18-8 stainless steels.

410, 416, 430 are magnetic stainless steels having less corrosion resistance than the 300 Series types. Types 410 and 416 are hardenable by heat treatment to 125-180 ksi tensile (862-1241MPa).

Designers also have choices to make from among a large group of nonferrous fasteners, and fasteners that have been plated either for purposes of corrosion protection or for appearance.

This publication is concerned only with stainless steels; however, some comments will be made concerning the other materials





because an evaluation requires a comparison of available materials.

Stainless steels

Stainless steel is a family of iron-base alloys containing about 10.5% chromium or more, plus other alloying elements such as nickel, manganese, molybdenum, sulfur, selenium, titanium, etc. The chromium is chiefly responsible for corrosion and heat resistance; the other alloying elements are present in stainless steel to enhance corrosion resistance and to impart certain characteristics with respect to strength and fabricability.

A total of 57 commercial stainless steel types are designated by

the American Iron and Steel Institute as standard compositions. A complete listing of all AISI stainless steels and a description of each are contained in the AISI publication, "Steel Products Manual—Stainless and Heat-Resisting Steels, December 1974."

In addition to the standard AISI types, many special analysis and proprietary stainless steels are produced in the United States and Canada.

Identification

Most AISI stainless steels are identified by a system of numbers that are in either 200, 300, or 400 Series. In addition, all are identi-

fied by the new Unified Numbering System (UNS), which encompasses all commercial metals and rare earths. For example, Type 304 is Type S30400 in UNS. Special analysis and proprietary stainless steels are identified by trade names, some of which may resemble AISI numbers.

The terms *austenitic*, *martensitic*, *ferritic* and *precipitation hardening* serve to identify categories of stainless steels on the basis of their metallurgical structure. Designers should recognize these terms and understand what they mean, because stainless steels so classified tend to have similar characteristics with respect to corrosion resistance, hardenability, and fabricability.

Austenitic stainless steels are chromium-nickel-manganese and chromium-nickel compositions identified by 200 and 300 Series numbers, respectively. They are hardenable only by cold working and are non-magnetic in the annealed condition. Typical of the austenitic group is Type 304, which contains nominally 18% chromium and 8% nickel, hence the 18-8 name.

Ferritic stainless steels are straight-chromium steels in the 400 Series that are not hardenable by heat treatment and only slightly hardenable by cold working. All are magnetic. Type 430 is typical of this group.

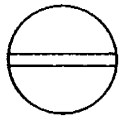
Martensitic stainless steels are straight-chromium, 400 Series that can be hardened by heat treatment only. All are magnetic. Type 410 is typical of this group.

Precipitation hardening stainless steels are hardenable by a combination of a low temperature



FASTENER BASICS

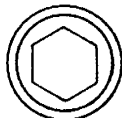
Driving Recess



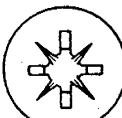
SLOTTED



PHILLIPS



HEX SOCKET



POZIDRIV



CLUTCH



FREARSON

Head Styles



HEX



ROUND (BUTTON)



BINDING



TRUSS



OVAL



HEX WASHER



SQUARE



PAN



FILLISTER



FLAT
COUNTERSUNK



ROUND WASHER

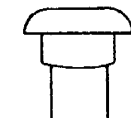
Shoulder Form



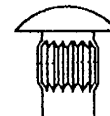
SQUARE



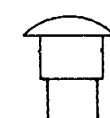
FIN NECK



OVAL

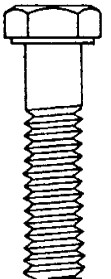


RIBBED

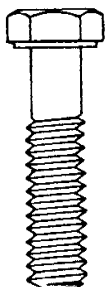


ROUND

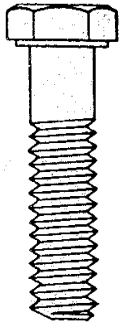
Shank Types



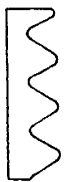
FULL SIZE



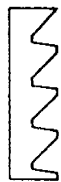
UNDERSIZE



Thread Form



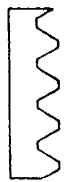
WHITWORTH



BUTTRESS



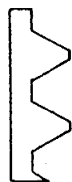
METRIC



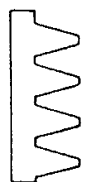
AMERICAN
UNIFIED
STANDARD



WOOD
SCREW



TAPPING



ACME



BRITISH

Point Styles



OVAL



SPHERICAL



PILOT



CHAMFER



CONE



CUP



FLAT



NEEDLE



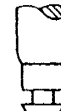
NAIL



GIMLET



HEADER



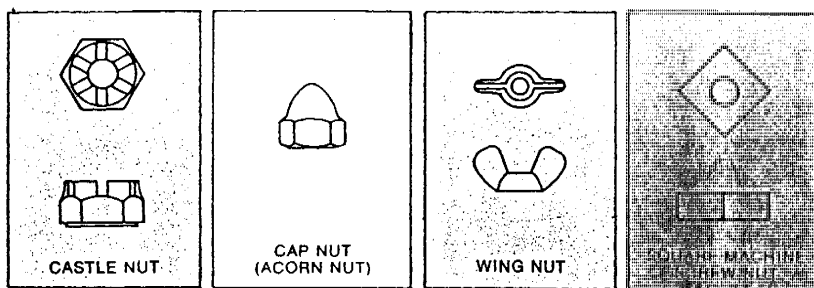
SPECIAL

An analysis of standard fasteners, such as bolts and screws, reveals that all have certain characteristics in common. Further, their differences can be classified as shown here. Each bolt and screw is, in effect, made up of a series of component parts; thus, the fasteners may have some or all of these: (a) a head; (b) a driving recess; (c) a shoulder; (d) an unthreaded shank; (e) a threaded shank; and (f) a point.

Certain combinations of these components, because of usage are considered standard. Others are non-standard, but nearly any combination can be readily produced.

This analysis of fastener parts is presented in the hope that it will assist the user in understanding and specifying bolts and screws.

Source: ITT Harper



aging treatment and cold working. The AISI types are identified by UNS numbers only (such as Type S17400), although many are referred to in literature by proprietary trade names such as 17-4PH. The precipitation hardening stainless steels are especially useful because fabrication can be completed in an annealed condition and uniform hardening achieved without a high-temperature treatment that can result in distortion and scaling.

Choosing the right stainless steel

The stainless steels used most frequently as fasteners are Types 303, 304, UNS-S30430, 305, 384, 410, 416, and 430. Selection of the right type for a fastener application is greatly simplified when they are classified according to metallurgical categories described on page 5.

Austenitic —Types 303, 304, UNS-S30430, 305, 384, and 316

Ferritic —Type 430

Martensitic—Types 410 and 416

The selection process is further simplified when the designer understands the characteristics of each category and the relationship of alloys to one another in that group.

The austenitic stainless steels are characterized as having excellent corrosion resistance, with the higher alloyed materials accordingly having superior resistance. For example, Type 304 is the most widely used material that withstands ordinary rusting. It is virtually immune to foodstuffs, sterilizing solu-

tions, most organic chemicals and dyestuffs, and a wide variety of inorganic chemicals. It resists nitric acid well, the sulfur acids moderately, and the halogen acids poorly. It is used for cryogenic applications, and is easily fabricated.

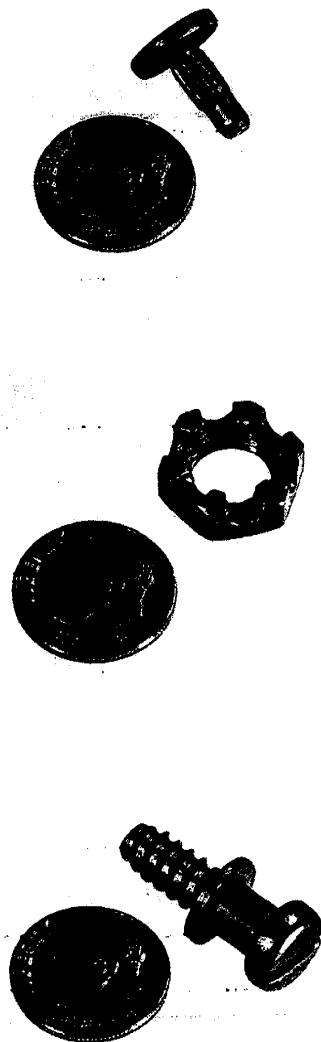
Types 303, UNS-S30430, 305, and 384 are variations of Type 304 that were developed to meet specific manufacturing requirements. For instance, Type 303 has a con-

siderably higher sulfur content that enhances machining characteristics. If a fastener is made by machining, such as large bolts or specials that cannot be cold headed, more than likely it will be Type 303. On the other hand, Types UNS-S30430, 305, and 384 were developed specifically for cold-forming operations. Type UNS-S30430 contains copper and is *used for cold headed fasteners*.

Regardless of the diversity in numbering, the above-mentioned stainless steels are essentially 18-8 materials in that their composition is very close to the nominal composition of Type 304, which is 18% chromium and 8% nickel. Because they have similar corrosion resistance properties, these 18-8 materials are usually interchanged in fastener applications. If an application calls for Type 304, the designer can generally specify an 18-8 fastener material.

However, it should be recognized that while the 18-8 stainless steels are considered to have similar corrosion-resistance properties, they are not identical. The sulfur in Type 303, for example, causes it to have somewhat lower corrosion resistance than Type 304, especially when in direct and continuous contact with water or some chemical solution. Accordingly, a designer should specify Type 304 when it is known that Type 303 is not suitable for the application. When in doubt, the designer should consult with a corrosion engineer.

If an application calls for a material with corrosion resistant properties better than that of Type 304, Type 316 is the next logical candidate. Type 316 stainless steel is a higher alloyed material containing 2-3% molybdenum, which gives



it corrosion-resistant properties superior to Type 304, especially in environments containing chlorides. It has wide application in pulp and paper mills, for example, because it is more resistant to sulfurous acid compounds. It is also widely used in phosphoric and acetic acids that tend to cause pitting corrosion in the 18-8 types.

Many fastener applications do not require the high degree of corrosion resistance offered by the 18-8 stainless steels or the higher

alloyed types, in which case the designer can consider one of the straight-chromium types, some of which may be lower in cost. For example, Type 430 stainless steel contains about 18% chromium, but no nickel. Although it has lower corrosion-resistance properties than the 18-8 types, it has wide application for decorative trim because when it is buffed it closely resembles a material that has been chromium plated. Typical applications include trim on automobiles,

cameras, vending machines, counters, appliances, showcases, and a host of other products that need dressing up or "eye appeal" to increase their salability.

On the other hand, there is Type 410, which contains 11.5-13.5% chromium, and accordingly has lower resistance to corrosion than Type 430 or the 18-8 materials. It will resist corrosion in mild atmospheres, fresh water, mine water, steam, carbonic acid, crude oil, gasoline, blood, alcohol, ammonia,

TABLE 1—CHEMICAL COMPOSITION LIMITS OF RAW MATERIAL (IFI-104)

GRADE	GENERAL DESCRIPTION OF MATERIAL	SPECIFICATIONS ¹ COVERING RAW MATERIALS REQUIREMENTS	CHEMICAL COMPOSITION, % MAX (UNLESS SHOWN AS MIN OR MAX/MIN LIMITS GIVEN)									
			STAINLESS STEEL									
			C	Mn	P	S	Si	Cu	Mo	Ni	Cr	Other
303	Austenitic Stainless Steel	ASTM A276 Type 303 QQ-S-764 Class 303 AISI 303	0.15	2.00	0.20	0.15 min	1.00	—	0.60 ²	8.00 to 10.00	17.00 to 19.00	See Note (3)
304	Austenitic Stainless Steel	ASTM A276 Type 304 QQ-S-763 Class 304 AISI 304	0.08	2.00	0.045	0.030	1.00	—	—	8.00 to 12.00	18.00 to 20.00	—
305	Austenitic Stainless Steel	ASTM A276 Type 305 QQ-S-763 Class 305 AISI 305	0.12	2.00	0.045	0.030	1.00	—	—	10.00 to 13.00	17.00 to 19.00	—
316	Austenitic Stainless Steel	ASTM A276 Type 316 QQ-S-763 Class 316 AISI 316	0.08	2.00	0.045	0.030	1.00	—	2.00 to 3.00	10.00 to 14.00	16.00 to 18.00	—
XM7*	Austenitic Stainless Steel	ASTM A493 Type XM7	0.10	2.00	0.045	0.030	1.00	3.0 to 4.0	—	8.00 to 10.00	17.00 to 19.00	—
384	Austenitic Stainless Steel	AISI 384	0.08	2.00	0.045	0.030	1.00	—	—	17.00 to 19.00	15.00 to 17.00	—
410	Martensitic Stainless Steel	ASTM A276 Type 410 QQ-S-763 Class 410 AISI 410	0.15	1.00	0.040	0.030	1.00	—	—	—	11.50 to 13.50	—
416	Martensitic Stainless Steel	ASTM A276 Type 416 QQ-S-764 Class 416 AISI 416	0.15	1.25	0.06	0.15 min	1.00	—	0.60 ²	—	12.00 to 14.00	—
430	Ferritic Stainless Steel	ASTM A276 Type 430 QQ-S-763 Class 430 AISI 430	0.12	1.00	0.040	0.030	1.00	—	—	—	14.00 to 18.00	—

NOTES TO TABLE 1

1. Legend of specification designations —
ASTM—American Society for Testing and Materials
AISI—American Iron and Steel Institute
QQ-X-XXX—Federal Government

2. May be added at manufacturer's option.

3. ASTM A276 permits addition of molybdenum, and also 0.12/0.30% lead at manufacturer's option. AISI requires the addition of molybdenum but permits no lead.

* Type S30430



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