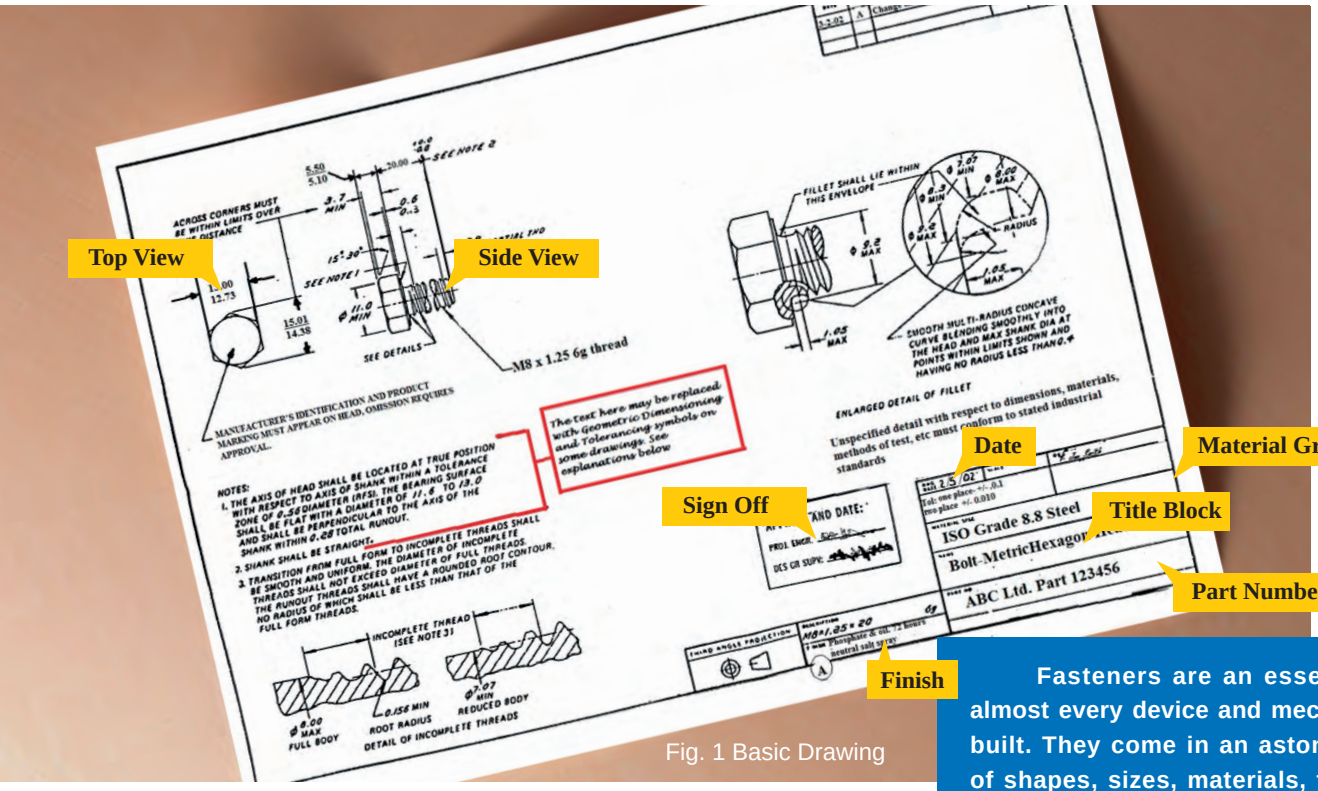


Fig. 1 Basic Drawing

Blueprints

by Thomas Doppke

A Communication Document

Fasteners are an essential part of almost every device and mechanical thing built. They come in an astonishing array of shapes, sizes, materials, finishes, and so on. How does the fastener user convey his requirements to the manufacturer? When fasteners were first used there was little choice, the maker (usually the village blacksmith) made a bolt with a matching nut to fit it. Fasteners came in sets and woe to you if you lost a piece. The blacksmith may have had an extra set on hand, maybe it was larger or smaller but that was about the extent of available variety. The application was adapted to fit the parts available.

Enter the Industrial Age, as machines expanded in numbers and variety, the parts needed to build them did also. Some sort of communication was needed to tell the maker what it was that the user wanted. Thus was invented the blueprint's ancestor. While the generic term, blueprint, came about much later; paper, vellum and other materials were used to make drawings of machines, processes, buildings, and ships for centuries before. These "Plans" were communication documents which directed how everything was to be built. The detailing of the fastener came somewhat later.

While the drawing communicates what and how the fastener is and performs, many drawings exceed the necessary information needed to define the product. The amount of information listed should fit the intended use of the part to avoid cost proliferation.

Even today it is not uncommon for a customer to call up and just ask for a 12 mm bolt. Maybe he'll even add the required length. Needless to say, what he would get would probably not be what he had in mind if it wasn't for the skill of the order desk clerk. Chaos would reign in the fastener industry. Rather than list the various facets of a fastener, this article will generally discuss what information is required (and what is superfluous) on a drawing (Fig.1).

Information on Drawings

First, the basic drawing should have a part number identification which makes tracing of the part possible. This is required to keep track of inventory, to re-order, to allow users, customers and the manufacturer to keep the part separate from all the other similar parts in the system. A simple box or note "XYZ Company part 12345" is usually sufficient for

most small users. Large companies have their own elaborate systems for part's identification.

The title block should note what the part is, to save time in looking over the entire print each time it is referenced. For example, "Hexagon Head Bolt, M12 x 1.75 x 50" is adequate for a title. It should have a **date** as revisions made to parts may result in mixed fasteners in the plant as old and new stock is used. Also useful are notations as to **material grade** or composition. Many countries have standards which define a package of properties; DIN, JIN BSA, SAE, ASTM, and ISO being a few more common ones. Where such a package specification is not listed the required properties (tensile strength, yield strength, hardness, and so forth) must be listed to insure what the customer wants is known to the maker. Failure to so will result in a fastener not at all as imaged by the user.

Not of major importance but good to have is a sign off on the drawing, showing who has authorized this part to be made. Many fastener drawings are made up by the engineering departments of the customer's company. There may be several copies, revisions, pre-production drawings all in circulation at the same time. Confusing, yes! Although you may have a purchase order to make the part, exactly which revision of the part is required may be unclear. The **date and revision date** on the drawing is the ideal judge of what is required and can protect the maker from claims that the part received is not to specification.

Almost all fasteners today are coated with some sort of **protective finish**. Listing it or "plain finish" again insures what is desired is stated.

A certain number of dimensions should be included. The hexagon head width (across flats) is needed for correct socket

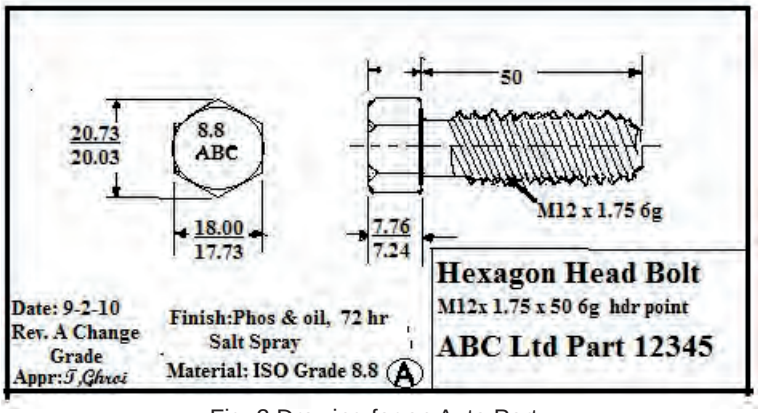


Fig. 2 Drawing for an Auto Part

tooling selection by the assembly line. There are various hex head sizes available; choosing one up front is mandatory. Cross corners dimension insures that the hexagon is indeed a true hexagon lest poor geometry jam sockets and do not fit standard tools. Head height insures adequate height for a socket to torque the part without rounding corners. Although this drawing is a minimal specification it does contain enough information to produce a bolt which can be used in most non-critical areas.

Drawing Features for Critical Parts

Many fasteners require control of critical dimensions and properties when used in areas where a failure would cause serious damage or an accident. These items have additional notes and requirements. It is joked that aerospace, aircraft, military parts are often accompanied with more paperwork than the parts weight themselves. This is because the parts MUST not fail. Testing of exemplars will bring a degree of assurance that the next part in line will also perform correctly (hopefully) but still doubt exists. The more tests and samples run, the more dimensions checked, the better the chances that the parts are consistent. Fasteners used in areas critical to fit, form or function also need to have additional controls. The illustration **(Fig.2)** below shows a typical automotive part whose usage is probably critical.

Of general information required on drawings of parts which require stricter controls the following features are often added. Some of these items may seem very evident but history shows that mistakes are common.

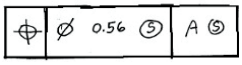
1. The drawing should have at least two views; a side and a top view are common unless there is some unusual feature that more detail would clarify. The notation "third angle projection" (Ⓐ) found at the bottom of the illustration means that the part shown was drawn to show the top and the side as the side view of the part is rotated to the right. Other projections are possible but this the most common.

2. Performance requirements are either specified via an industry specification (i.e., ISO, JIN, etc.) or actually detailed (a great amount of work would be involved and an industry specification is very much easier). To avoid unnecessary text additions a general statement that unspecified details shall conform to accepted standards may be added (see illustration print).

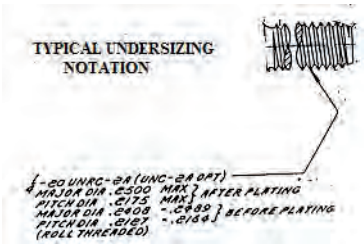
3. As mentioned before, **the finish, whatever it is, or the notation "plain" or "unfinished" is necessary.** As many articles here in Fastener World have shown, the finish on a part affects the final joint clamp load and torque 100% or more.

4. The thread class is necessary to insure a proper fit. In addition, many current coatings, used for increased corrosion protection, are very heavy and the thickness necessitates undersizing of the threads to insure fit into mating threads. In cases where heavy finishes are used there may even be a thread dimensional callout to accommodate the undersizing.

5. Much of the text shown typical drawings references dimensional controls. There are numerous instances of bolt heads being off angle to the shanks (nor perpendicular), crooked shanks (especially on long shank bolts), heads being non-concentric to shanks, washers with non-parallel sides and non-concentric holes, and so on. These irregularities arise from the varying methods of manufacture. A recent case of holes being off-center in a washer was traced to the fact that the manufacturer did not use progressive stamping techniques but had the holes stamped out of the formed blank as a secondary process. His reply was that there was nothing on the print that defined where the internal hole was to be in reference to the outside diameter. Text notes like numbers 1 and 2 control some potential bolt conditions. To lessen the amount of text on drawings a form of "shorthand" notation has been developed. It comes from the work of planning engineers whose job is to see that metal and parts fit within the tolerances of manufacture. A typical block which would replace the first sentence on the noted area on the print would show a block located at the thread callout -A- with the words **Major diameter** to denote that the reference datum was the thread major diameter. Below the "across flats" dimension a symbol block would show the variation permissible, for example here,



This shown notation contains the same information as listed in the first three lines in text note 1 on the drawing. For a complete discussion on geometric dimensioning and tolerancing consult any of the several sources available in the industry or check the internet for the topic.



Undersizing Notation

6. Of major importance are the tolerances of the various dimensions. No part can be made to a zero tolerance (i.e., 0.10 +/- 0.0). Variations in tooling, operation, material, etc. will cause some plus and minus to occur. Good manufacture can control these variations somewhat but they will still be present. A look at dimensional tables shows thread dimensions as ranges due to this variation in production. While most common build usages allow sufficient space to accommodate build variations in fasteners, many critical designs do not. Weight and space considerations have forced the use of fasteners designed to engage with minimal thread protrusion. The old adage of "2-3 threads sticking out" is no longer a safe bet. Designs with almost flush ends are seen routinely and a minus tolerance on a joint could reduce the clamp load to less than design intent. Remember, the first few

threads are partially formed and usually do not engage the mating threads. The notation on our sample drawing shows a partial thread length of as great as 1 ¾ mm is allowed. A quick calculation shows that a joint of 12mm size engages in a nut of minimal height of 0.6 D or 7.2 threads for full strength. The loss of 1.75 threads (our partial thread dimension) reduces the clamping load by almost 25%). A potential failure?

Drawings may have a tolerance block or statement added which denotes the allowable tolerance for those dimensions not already noted on the drawing. Two place, three place and angular tolerances are normally given.

7. Details of the underhead fillet may be detailed as shown on the sample drawing if there is a concern that the hole into which the bolt may install could be too small. Interference with the underhead fillet has been known to be the cause of several head failures caused the interaction with the sharp edge of a hole wall.

While adding more detail and dimensions insures a tighter quality controlled part there are many negatives factors that should be considered. To add any item to a fastener drawing, be it test, dimension or handling*, entails added cost and time. Samples to be taken from the various stages of manufacture, records to be generated and kept, quality control systems (both internally and the customers) to be satisfied, the cost of a test laboratory along with required calibration records and procedures to insure accuracy of the test. Space and personnel additions also raise costs.

So what items are necessary on a drawing? For starters, the basic print that we began with will cover all the normal requirements for most general usage fasteners. Few additional notes may be asked for, these being that tolerances, properties, and dimensions meet industrial standards. The manufacturer should also consider how to protect himself from future concerns by the addition of those notes that define what it is that he is selling to the customer. In disputes over "I wanted this, you made that" the manufacturer will rarely win any argument without concrete proof (a drawing?) that the submitted part is what the customer signed off on.

Critical parts should be designated as such by the customer. They may require certification that all parts are from same lot manufacture to insure commonality. The exact requirements should be by agreement and additional cost for such certification noted officially.

Conclusion

A drawing is both a plan on what is wanted and a contract on the manufacture of that part. Listing the requirements needed and to be supplied, it is as important as a house mortgage or car purchase. Inattention to detail can result in great loss of time, the making of unusable parts and a great expenditure of money of parts that are probably scrap.

*A recent drawing was submitted that stated "If the parts are to be robotically fed and installed, 100% sorting certification is required". Since a wrong part can jam a robotic installation and stop an assembly line dead for minutes or longer, running the parts through a sorting line (usually electronic as human sorting is only about 65% accurate) at least twice is probably as expensive as making the things to start with. Purchasing approval for the extra cost is necessary but, in view of current economic conditions, not likely to happen.