ST FASTENING SYSTEMS ENGINEERING MEMORANDUM

MAXX DRILL SCREWS
INSTALLATION DRILL SPEED GUIDELINES

Considerable information exists regarding the speed at which metal can be cut, reamed or drilled. The metal working industry has always known that large diameter drill bits require a much slower drill speed than does a smaller bit in order to cut efficiently. We have also known that soft material can be drilled more easily than harder material. There is nothing revolutionary in these established principles.

Self-drilling fasteners are essentially drill bits. The established principles therefore must apply. Self-drilling screw manufacturing and use over the years has confirmed that these principles are valid. The speed at which a cutting tool removes metal efficiently has been discussed in detail in publications such as Machinery's Handbook for various alloys and hardness of steel being cut. The relationship of hardness, drill speed, and drill size can be expressed in a simple formula, $N = 12V \div \pi D$, where N equals the spindle (drilling) speed in revolutions per minute (RPM), V equals the cutting speed in feet per minute, D equals the diameter of the cutter (drill bit) in inches and $\pi = 3.14$.

We also know that the speed at which a material can be drilled is a function of the material hardness. Relatively soft material (with hardness equal to or less than HRb 70) can be cut efficiently at a speed of approximately 100 feet per minute. As the hardness is increases from HRb 70 to HRb 89, the cutting speed reduces to 70 feet per minute. When the hardness of the steel reaches HRb 90 or higher, the cutting speed reduces to 70 feet per minute. These hardness / cutting speed relationships are valid for plain hot rolled carbon steels used to fabricate purlins, girts and other structural shapes normally found in metal building systems.

Until recent years, enough margin existed between the hardness of the steel and the drill point diameter of the self-drilling fasteners that allowed 2500 RPM tools to perform reasonably well with only occasional problems due to substrate hardness. Until recent years, the specified yield strength of the steel purlins and girts had been 50,000-55,000 PSI. Hardness was generally HRb 60 to HRb 80 with only occasional hardness in the upper HRb 80 range. Recently, however, we see that steel is being specified with yield strength in the upper 50,000 PSI range with occasional yield to 70,000 PSI. Hardness has been found in some cases to be in the low to mid-HRb 90 range.

As a result of this increased hardness and tensile strength, the formerly acceptable drill speeds are to fast for efficient drilling. A drill speed of 2500 RPM has been proven to be too fast for #12 diameter self-drilling fasteners in harder material.

The fastener manufacturing industry recognizes SAE J78 (IFI 113) standards as the standards covering self-drilling fastener's dimensional and performance requirements. Little has changed in these standards since the mid-1970's. Even then, their standards for testing recognized the need for adjusting drill speeds in order to appropriately assess the overall performance of the self-drilling fastener. The IFI Standard recommends 2500 RPM for fastener sizes through #10 diameter. Fastener sizes of #12 and #1/4 require 1800 RPM test speed to prevent excessive heat build-up due to speed. The SAE J78 standard specifies only 16 ga. (0.062") thickness for testing all self-drilling fasteners. The drill speed / diameter principles recognized by these standards apply even more critically today.

The following illustrations review the concept of cutting speed. As you recall, the circumference, C is the distance around a circle (C = π x diameter). A point on the circle, therefore, will travel a distance equal to its circumference in one revolution.

Point on
Circle
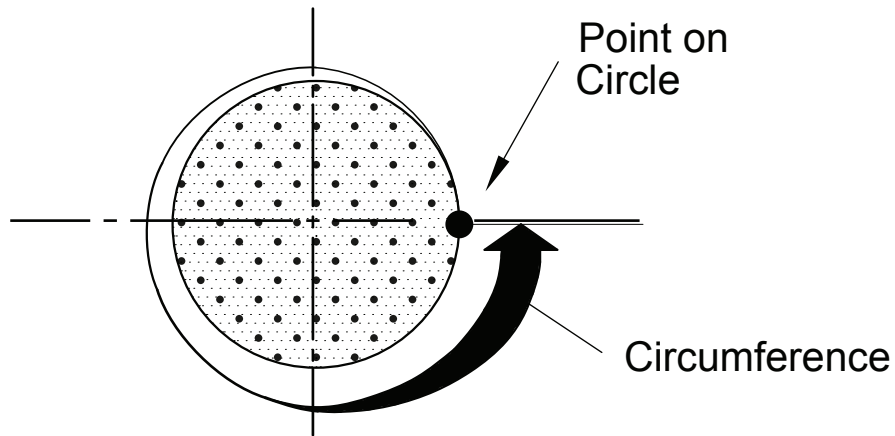
Circumference

The outer tip of a drill point's cutting edge is similar to the point on the circle in the previous illustration. It travels a circular distance equal to the drill point's circumference in one revolution. For example, the outer tip of the drill point's cutting edge whose point diameter is 0.170" travels approximately 1/2" (or 0.54".)

Outer tip of the
Cutting Edge

Circumference (C)

$$C = \pi \ D$$

C = 3.14 x 0.170 =

0.54 inches
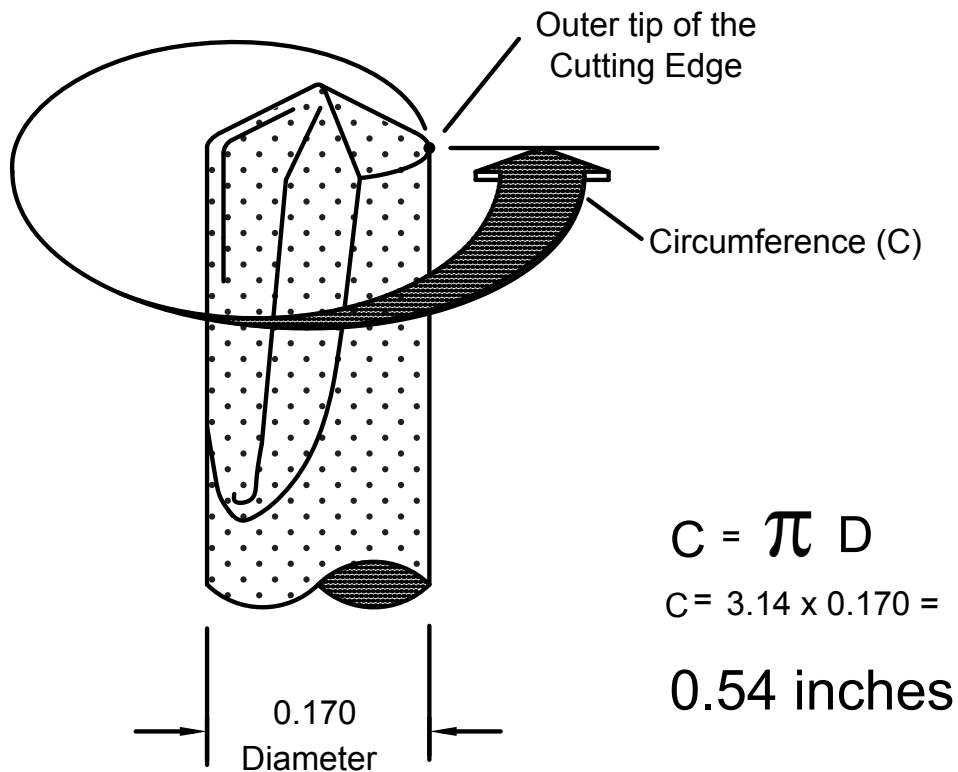
0.170
Diameter

Steel material with hardness in the mid-HRb 80's can be efficiently drilled at approximately 90 feet per minute. The correct tool speed for optimum efficiency, therefore, is expressed by the formula:

$$N = 12V \div \pi D$$
$$N = \frac{(12)\,(90)}{(3.14)\,(0.170)}$$
$$N = 2000 \text{ Revolutions per minute (approx.)}$$

The attached graph shows the recommended drilling speed for maximum efficiency for the respective drill bit diameters based upon the formula previously described. The drill bit diameter can be equated to the point diameter of a self-drilling fastener. The RPM values shown on the left side of the graph represent the drill speed of the installation tool. One must keep in mind that a drill bit normally used to drill multiple holes in steel plate is manufactured from a much different alloy and has a much higher efficiency than does a conventional 1022 carbon steel self-drilling fastener that is designed to drill but one hole. Therefore, the efficiency of a self-drilling fastener tip must be optimized to assure the acceptable field performance expected of the selected self-drilling fasteners.

The cutting speed represented by the curved red, blue, and green lines in the chart is in terms of feet per minute (FPM) as measured at the outer tip of the cutting edge as it rotates during drilling. That tip, incidentally, is the fastest moving part of the drill point and consequently suffers the first damage when drill speed is too fast for the material being drilled. Once sufficient dulling of the outer tip has occurred, the efficiency deteriorates and drilling eventually stops. Continued spinning of the fastener will create enough heat to cause the fastener to turn bright red and eventually melt.

The material hardness represented by the curved lines on the graph is consistent with those found in evaluating hot rolled steel girt and purlin material commonly used in metal building systems. The majority of steel used today falls within the hardness range of 70 to 90 HRb requiring an efficient cutting speed of 90 feet per minute. An occasional hardness of HRb 90 or greater occurs which requires a cutting speed of 70 feet per minute.

The yellow vertical bands on the graph represent the point diameter tolerance range for the respective fastener noted within the yellow band.

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RPM vs. POINT DIAMETER
MAXX SELF DRILLING FASTENERS
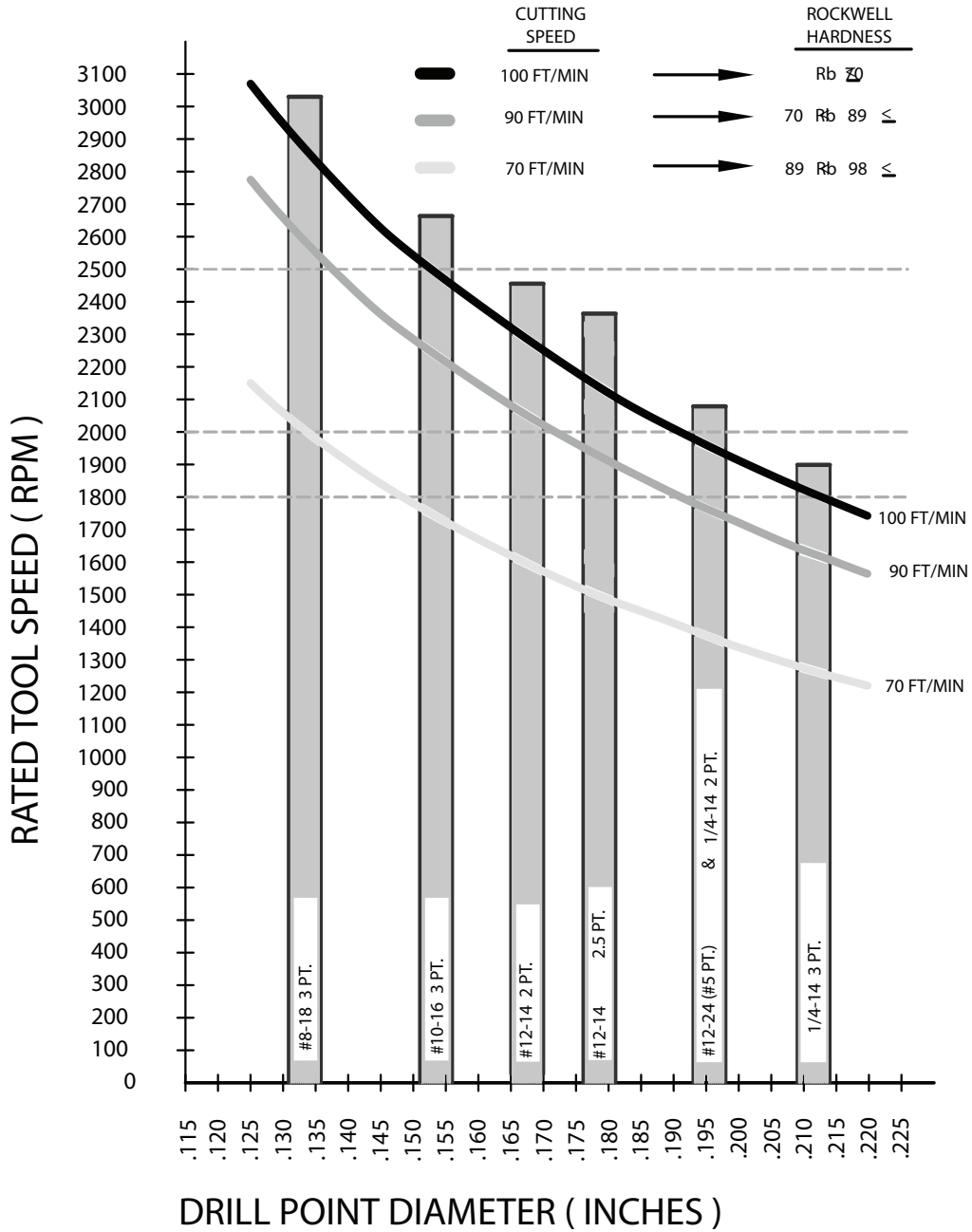
The most common fasteners used in metal building systems construction for panel and/or clip attachment are #12 and #1/4 diameters. The most efficient and most practical drill speed for fasteners up to and including #12 fasteners is 2000 RPM .   The #1/4 diameter self-drilling fasteners require slower speed for optimum efficiency as indicated on the chart. Obviously, some latitude exists in the individual curves (+/- 200-300 RPM) without drastically changing the expected drilling performance. A selection of 1800-2000 RPM installation tools represents the most practical speed for the popular #12 self-drilling fastener. The installer must exercise special care when using #1/4 diameter fasteners in the harder purlin and girt material to maintain efficient installation of the larger fastener.

   As the graph indicates, a drill speed of 2500 RPM is most efficient for the smaller #8 and #10 diameter fasteners. A 2500 RPM tool also has applications for installing small diameter fasteners in curtain wall construction and sheet metal duct work applications. Even in these applications, a 2000 RPM tool is acceptable for use. However, 4000 RPM tools commonly used for drywall applications should never be used for installing #12 and #1/4 diameter fasteners used for metal building components.

   In summary, increasing the RPM of an electric screw driver does not mean that it will always drill faster than a slower one. In most cases, the opposite is true. Based upon laboratory and field evaluation of self-drilling fastener installation and based upon the speed/diameter/hardness relationships described in this article, the following recommendations apply to self-drilling fasteners installed in metal building girt and purlin systems.
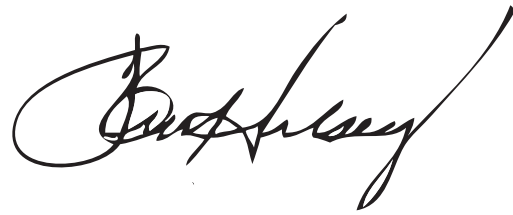
NOMINAL FASTENER DIAMETER	RECOMMENDED SPEED RATING (RPM)
#6	
#8	2500 Maximum
#10	
#12	1000 to 2000
#1/4	Maximum

Additional efficiency can be realized by the proper selection of extension cords used to power the electric screw drivers. Significant power loss can occur if the extension cord's wire size is too small for its length and the amperage requirement that must be delivered to the screw driver. Tool manufacturers generally recommend extension cord wire sizes as shown in the chart below. When using more than one extension cord to make up the total length, make sure that each cord is at least the minimum recommended wire size. When using an extension cord for more than one tool, add the rated tool amperes and use the sum to determine the minimum wire size. In all instances, the specific tool manufacturer's recommendations must be followed to prevent electric shock or other injury to the installer.

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RECOMMENDED MINIMUM WIRE GAUGE* FOR EXTENSION CORDS

RATED TOOL AMPERES	EXTENSION CORD LENGTH					
	25'	50'	75'	100'	150'	200'
Through 5	16	16	16	14	12	12
5.1 - 8.0	16	16	14	12	10	na
8.1 - 12.0	14	14	12	10	na	na
12.1 - 15.0	12	12	10	10	na	na

*Tool manufacturer's recommended size based upon limiting the line
voltage drop to 5 volts at 150% of rated amperes.

Tom Hulsey
Director, Technical Services &
Applications Engineering
ST Fastening Systems