University of Delaware Engineering Student Machine Shop

Basic Machine Shop Knowledge

Steve Beard

Basic Shop Knowledge

What is Machining?

In the same way that a sculptor carves a statue from a slab of marble, a machinist removes material from a work piece until it resembles the drawing of the part that is being machined. It is by its very nature, a subtractive process although separate machined parts can be fastened to each other to make an assembly.

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What is Machining?

The material being machined can be almost anything that is rigid enough to hold its shape and can be cut or shaped successfully. Most metals can be machined, as well as some plastics, some ceramics, some composite materials, and even wood.

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What is Machining?

Material is removed from the work piece using hand and machine tools. Two of the machines that are most commonly used to fabricate parts in the shop are:

- **Milling Machines**
- **Lathes**

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What is Machining?

Some of the machining operations that can be performed using a milling machine or lathe are:

- **Drilling and Reaming**
- **Milling**
- **Turning, Facing**
- **Threading with taps and dies**

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What is Machining?

These machining operations can generate heat which can have these adverse effects:

- **Tool damage or breakage.**
- **Poor surface finish on work piece.**
- **Inaccurate or out of tolerance results in forming the work piece.**

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What is Machining?

To remove heat from the machining process one can use several methods:

- **Flooding cutting tool with coolant.**
- **Air or Mist cooling of cutting tool.**
- **Use of various cutting oils or fluids designed specifically for that purpose.**

The last two of these methods are the ones you will most often use in the Student Machine Shop.

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What is Machining?

- Let's take a look at the following machining operations:
- Drilling
- Reaming
- Milling
- Turning
- Threading

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Drilling

Drilling is usually accomplished by using a helical twist drill to remove material to form a cylindrical hole.

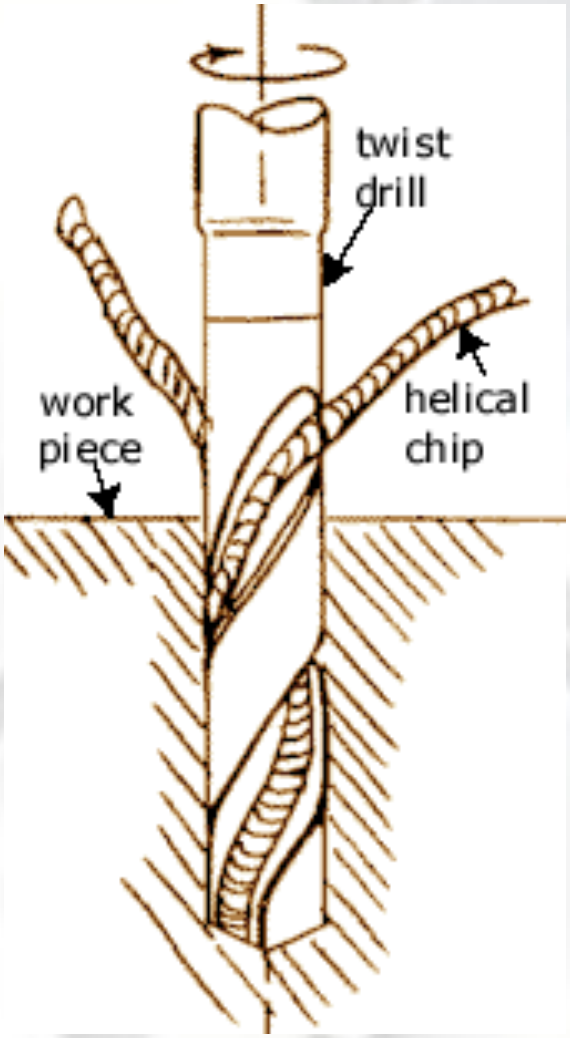

Illustration: RHM Fluid Power Inc.

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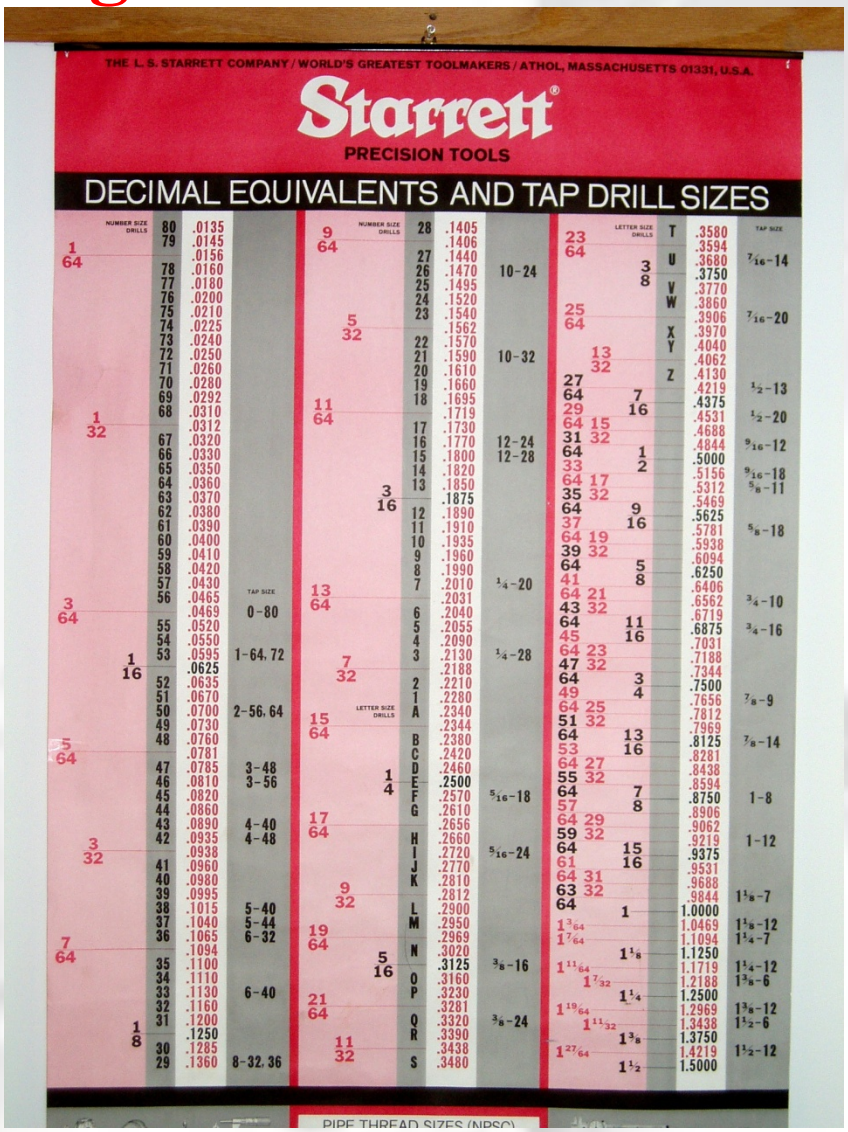
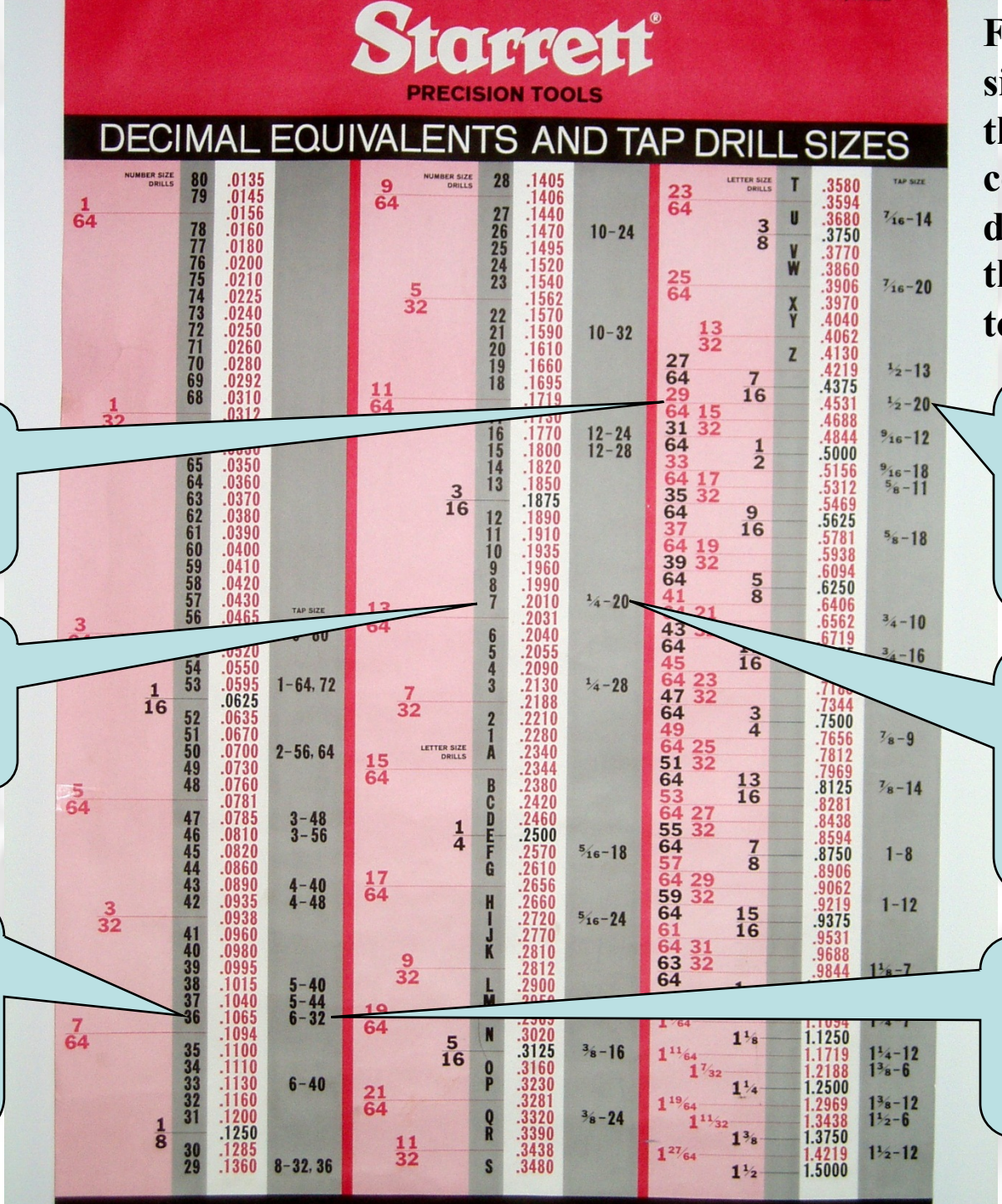
Drilling

A Drill Chart like this is found on the shop wall. It shows all of the English Standard drill sizes available. It also shows the tap drill sizes for standard screw threads.



Tap Drills



Find the thread size in one of the gray columns on the drill chart, and the tap drill is to the left

29/64" Tap Drill

Number 7 Tap Drill

Number 36 Tap Drill

½-20 Thread Size

¼-20 Thread Size

6-32 Thread Size

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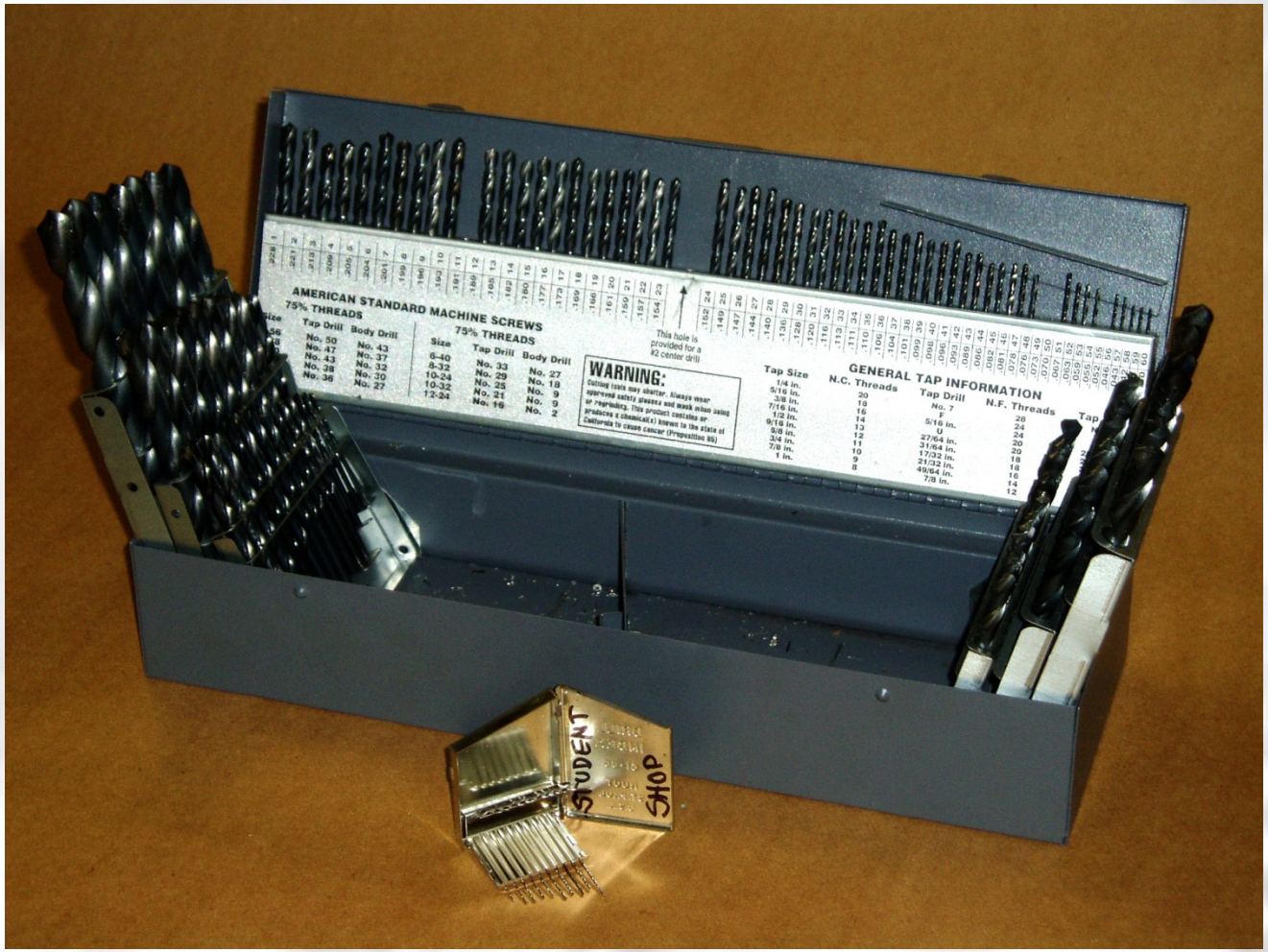
Drilling



Three in One Drill Index

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Drilling

Center Drills

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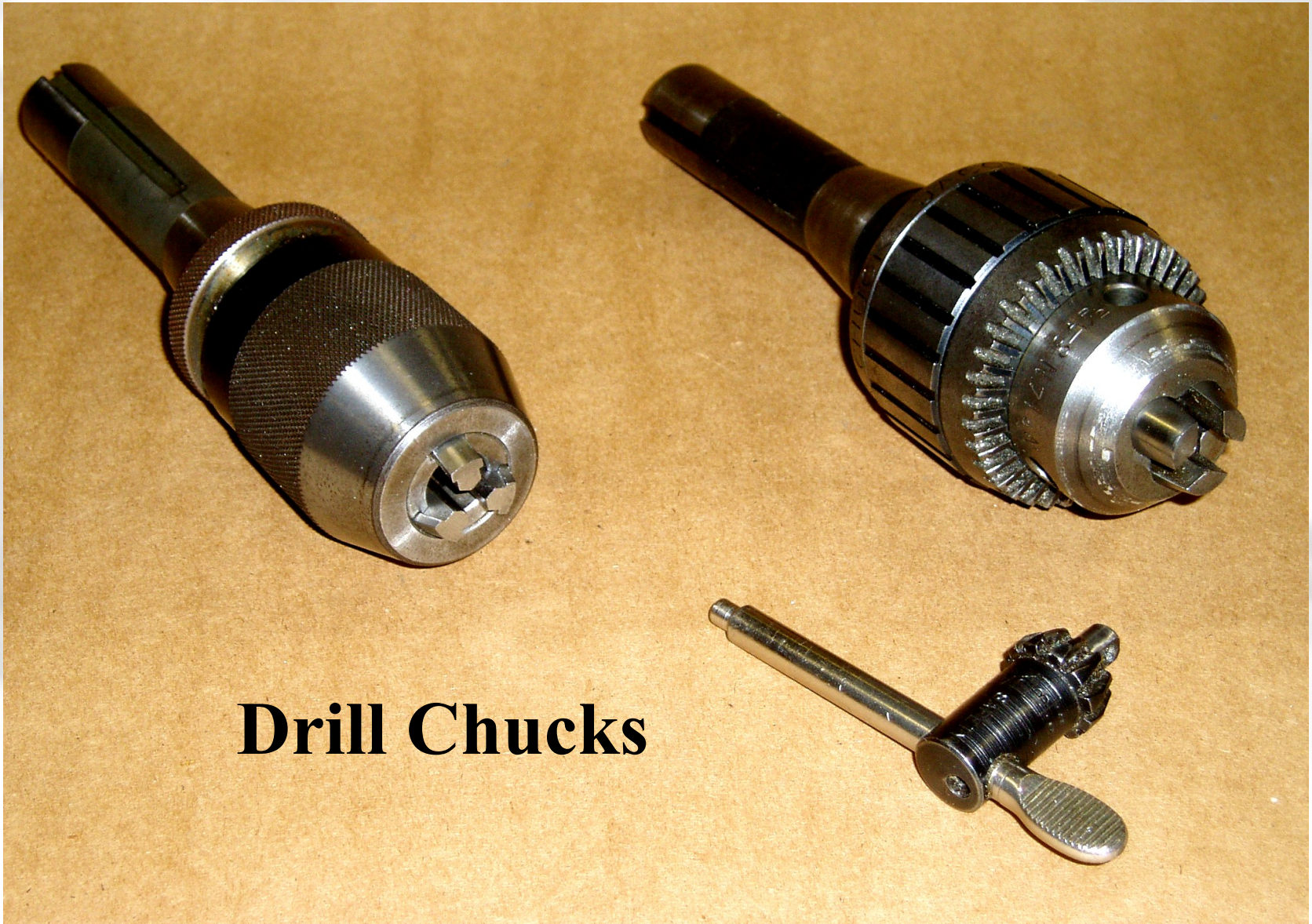
Drilling



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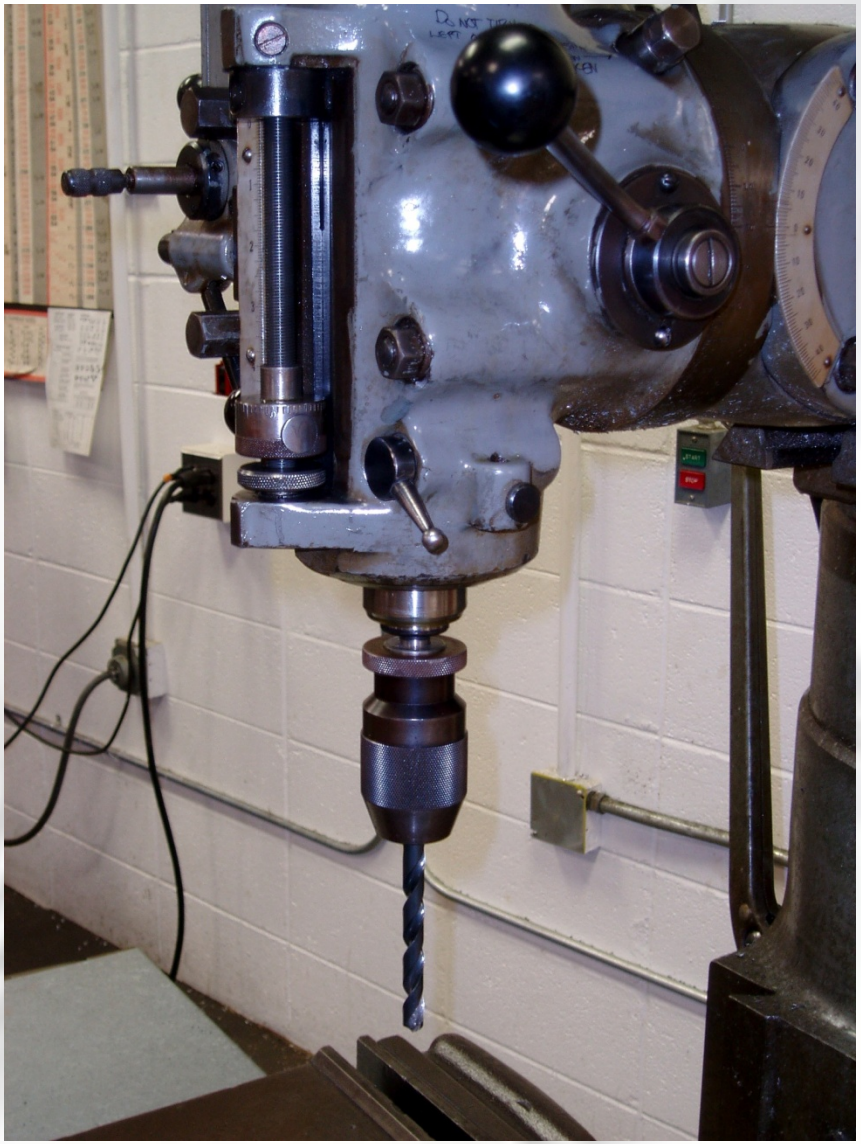
Drilling

A twist drill mounted in a keyless chuck in a Bridgeport Milling Machine



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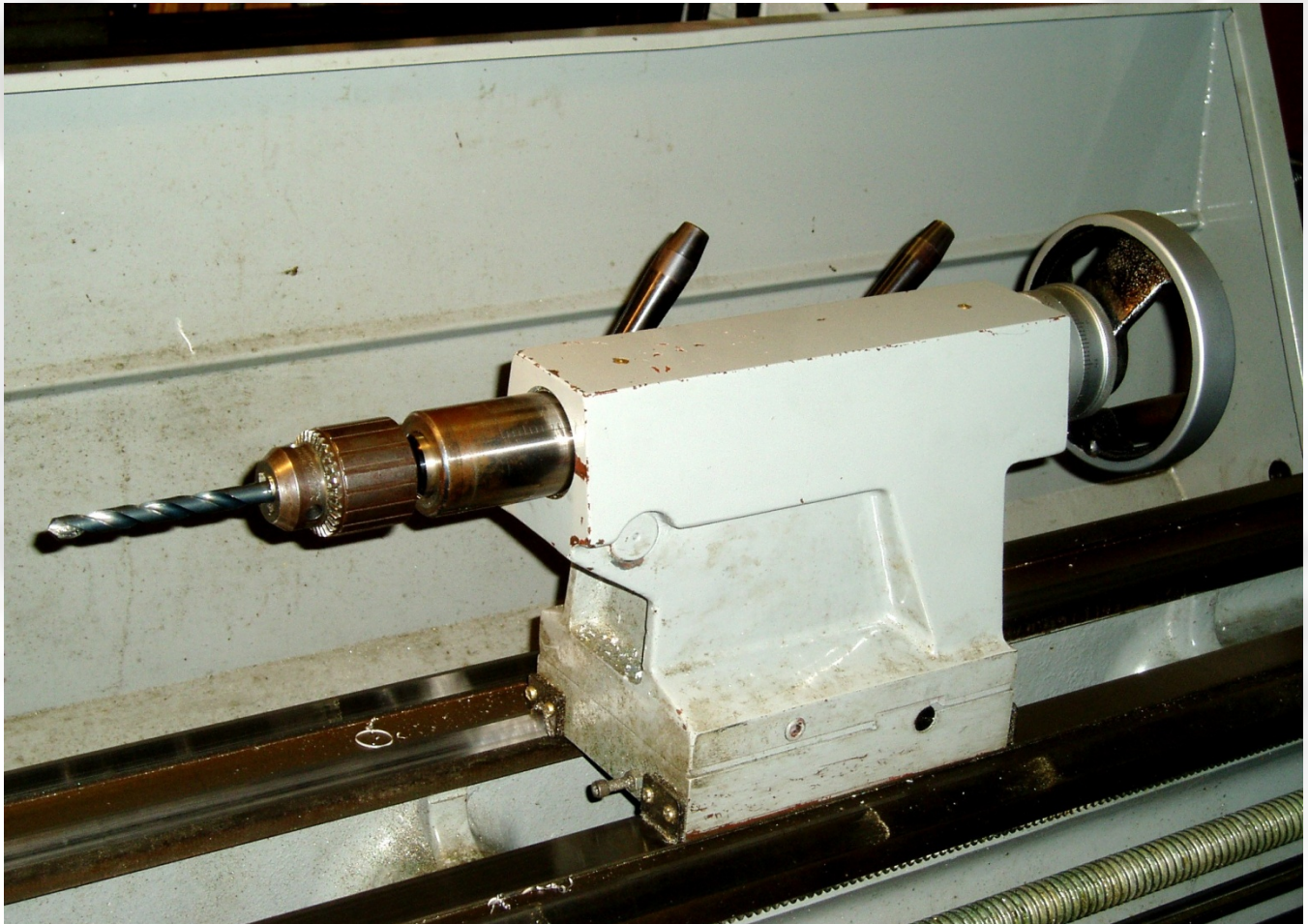
Drilling

A Twist Drill Mounted in a Keyed Chuck in the Tailstock of a Lathe



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Reaming

Reaming is a process which slightly enlarges a pre-existing hole to a tightly toleranced diameter.

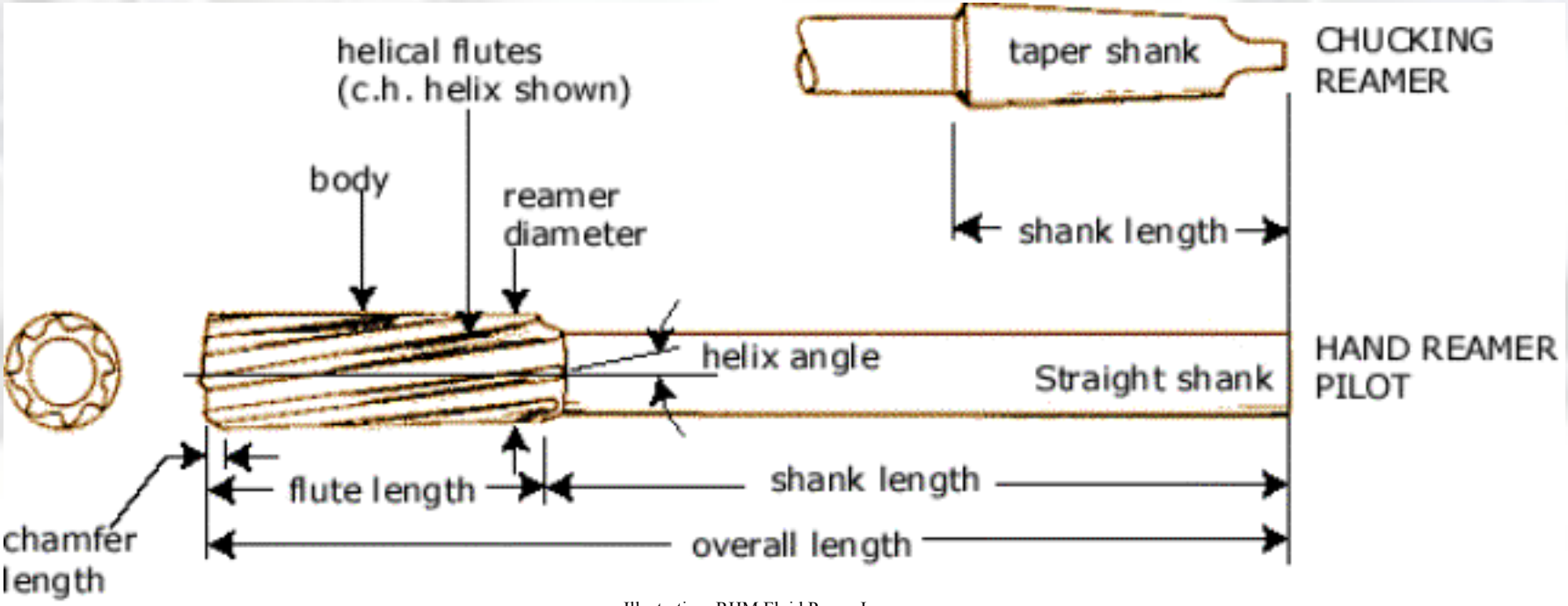

Illustration: RHM Fluid Power Inc.

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Reaming

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Milling

In a Milling Machine, the rotating tool is generally stationary and the work piece is moved against it to remove material.

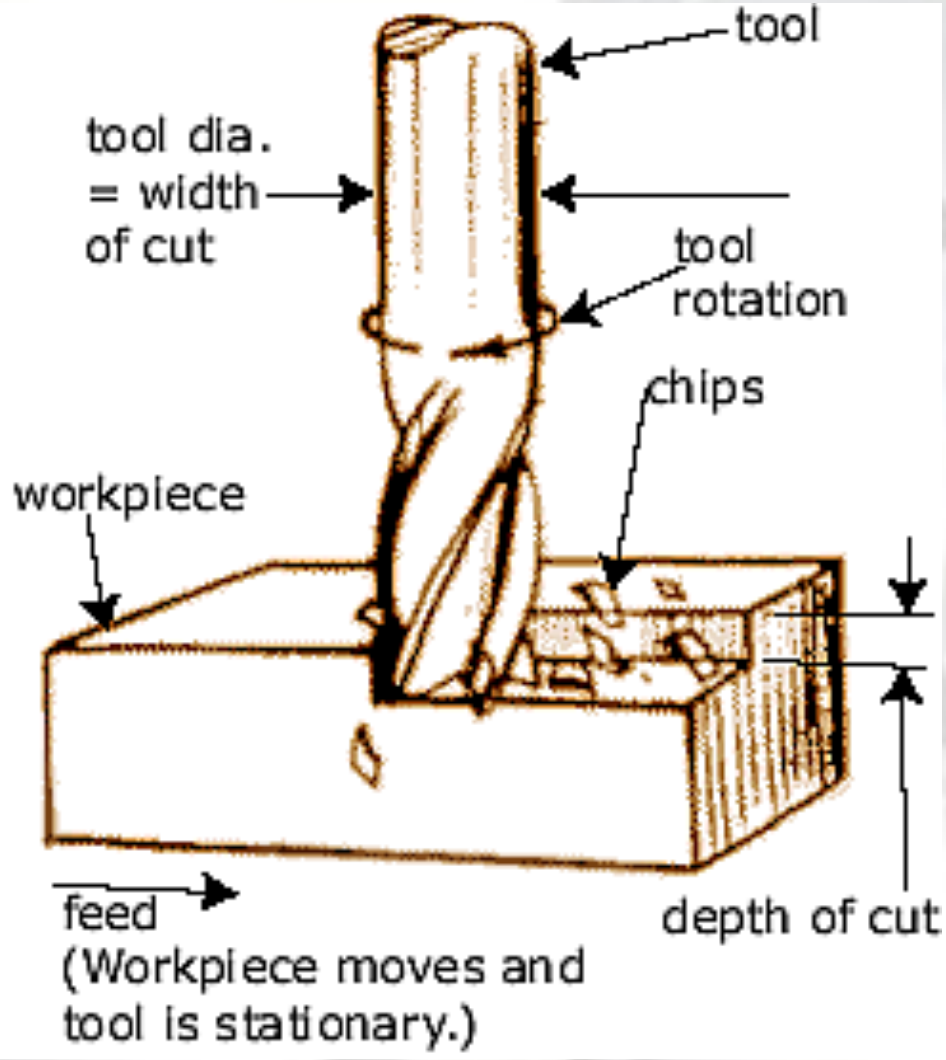

Illustration: RHM Fluid Power Inc.

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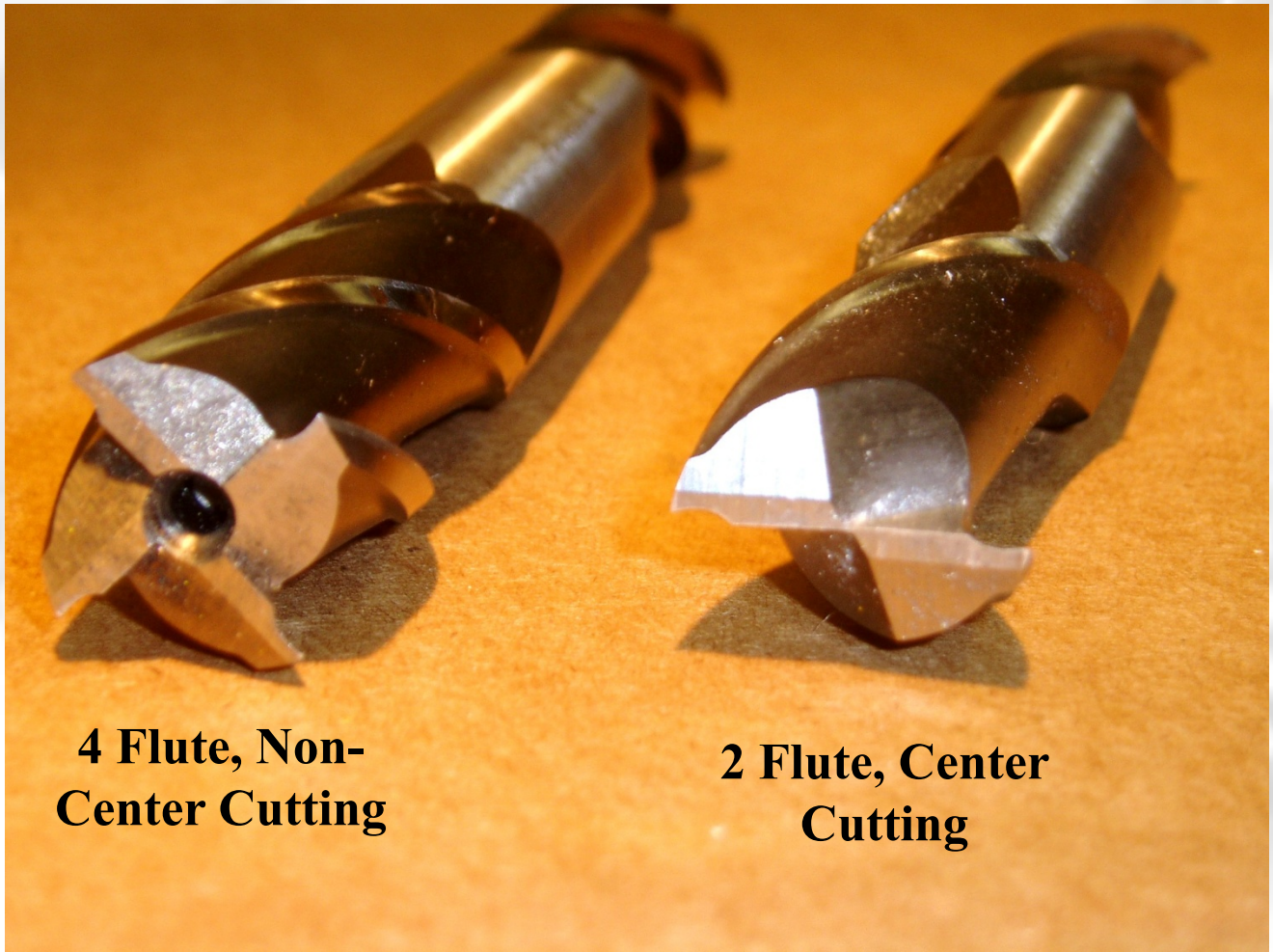
Milling

End Mills



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Milling

A Student Using a Milling Machine

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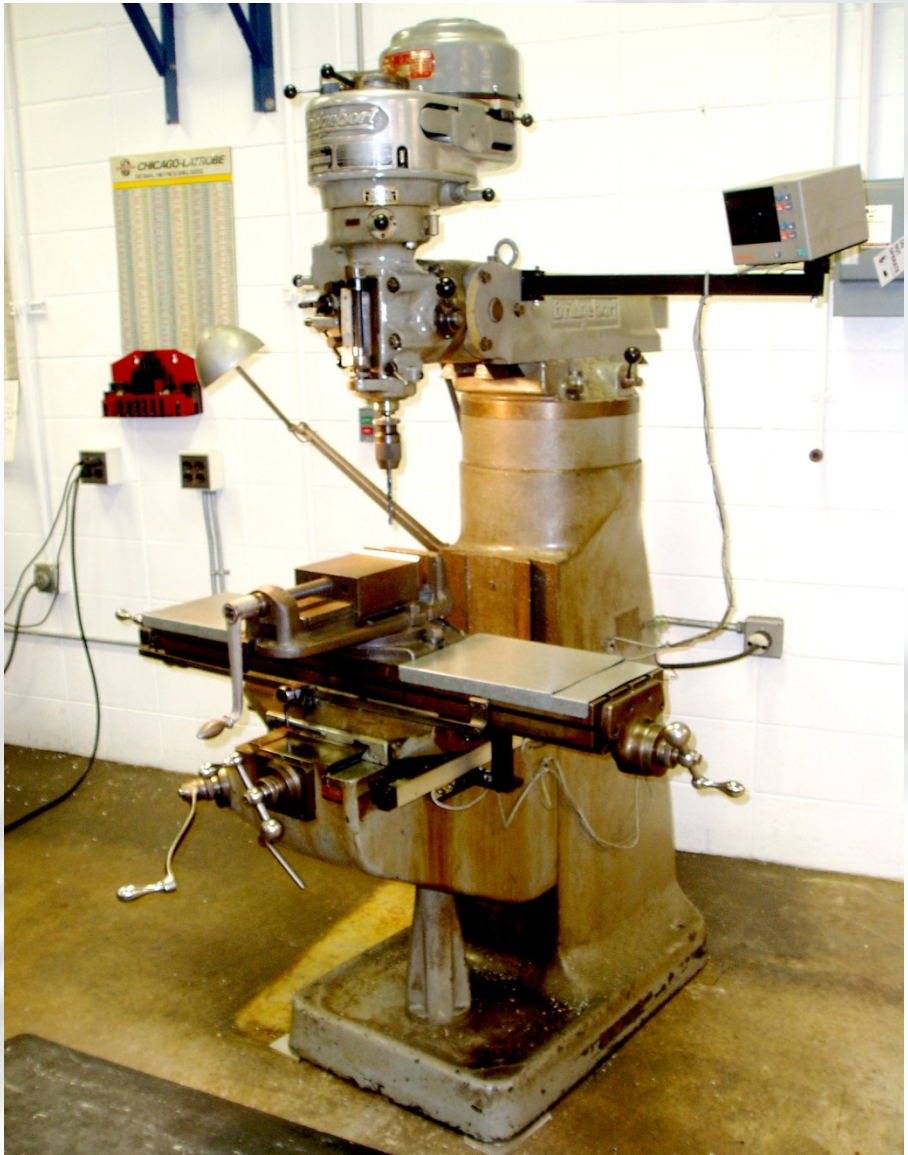
Milling

An Older Manual Bridgeport Milling Machine



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Milling

A Newer Computer Numerical Control (CNC) Milling Machine

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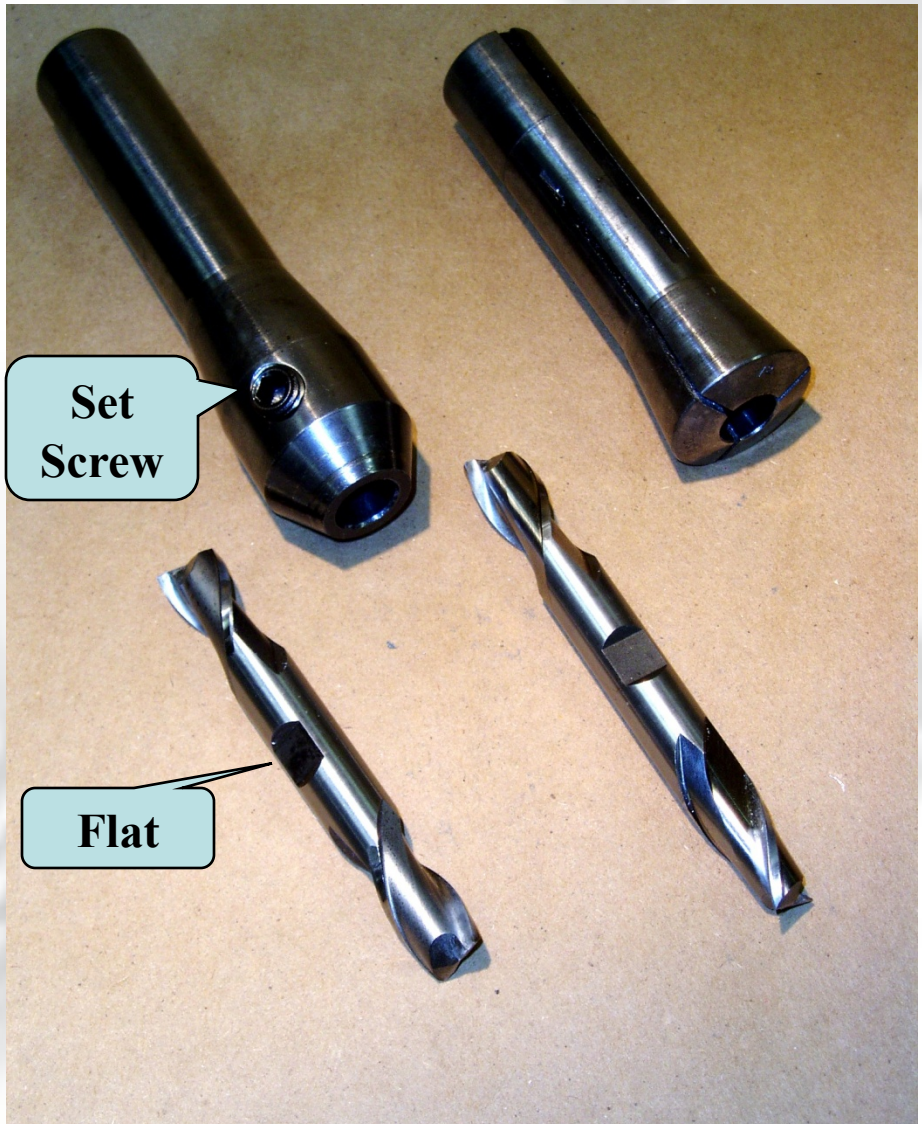
Milling

Two ways to hold an end mill in a milling machine.

•Tool Holder (Left) – End mill is clamped into the tool holder with a set screw that seats on the flat of the tool shank.

•Collet (Right) – End mill is held in place by friction as the collet is drawn up into the tapered spindle by the drawbar. This compresses the collet onto the tool shank.



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Milling

Fly Cutters

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Turning (Lathe Work)

Turning is performed on a machine called a lathe in which the tool is stationary and the part is rotated.

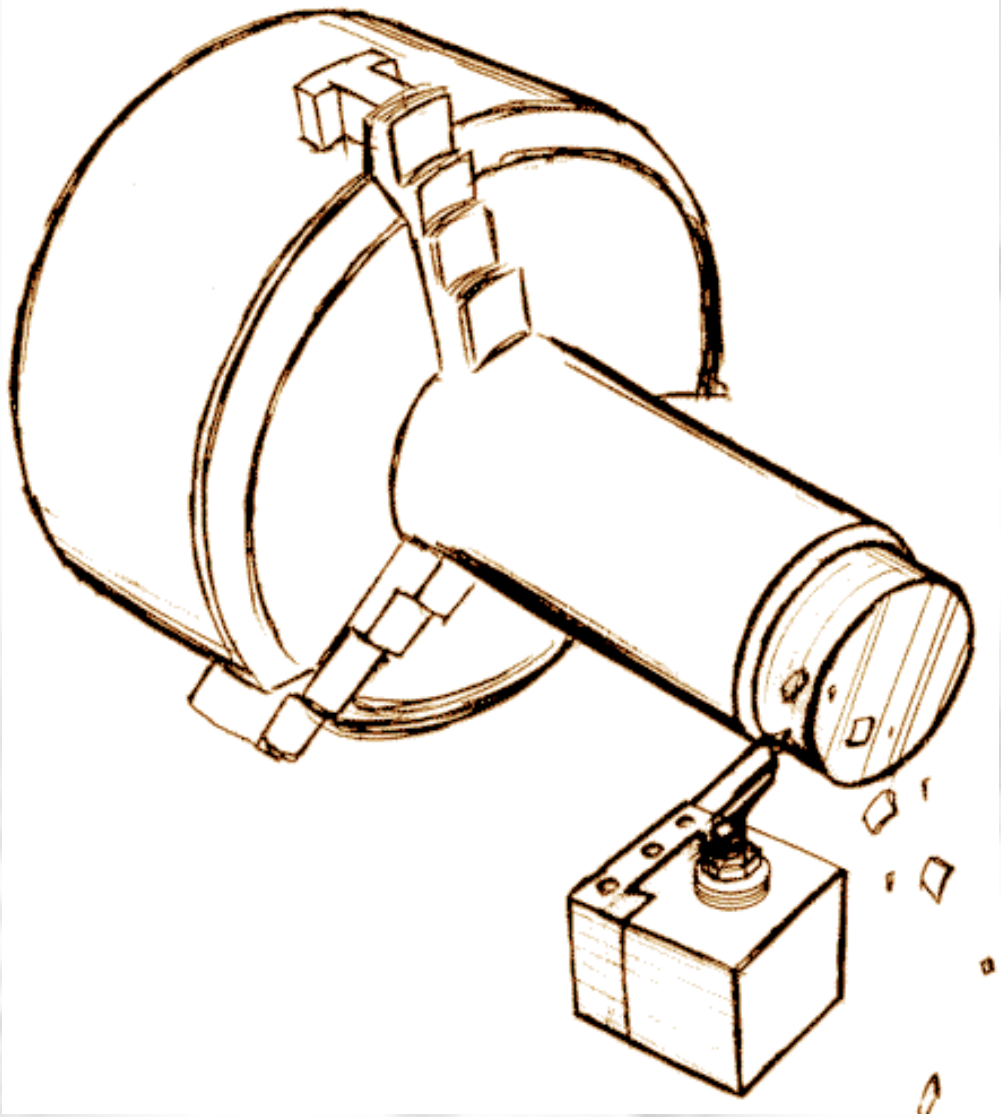

Illustration: RHM Fluid Power Inc.

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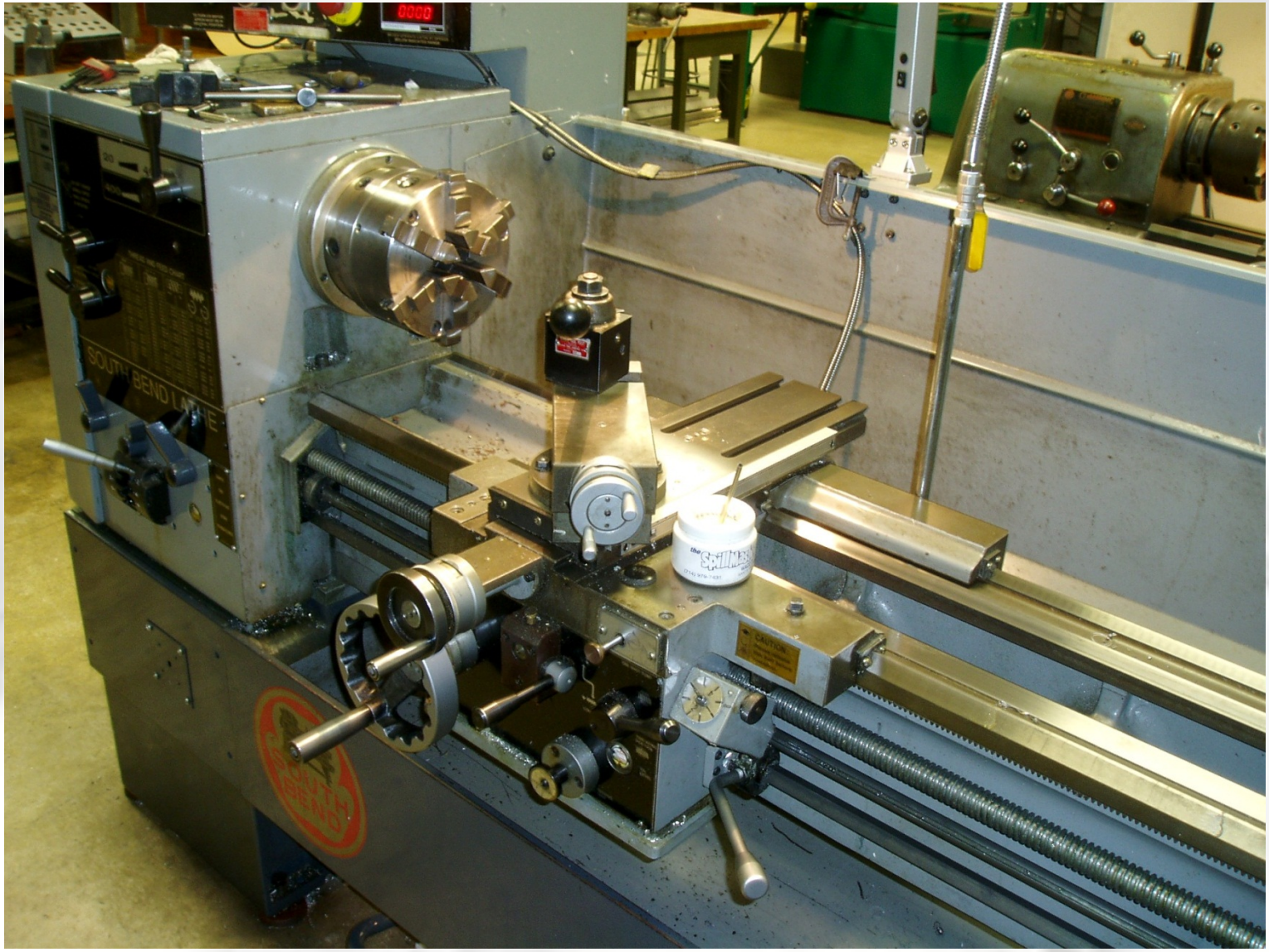
Turning (Lathe Work)



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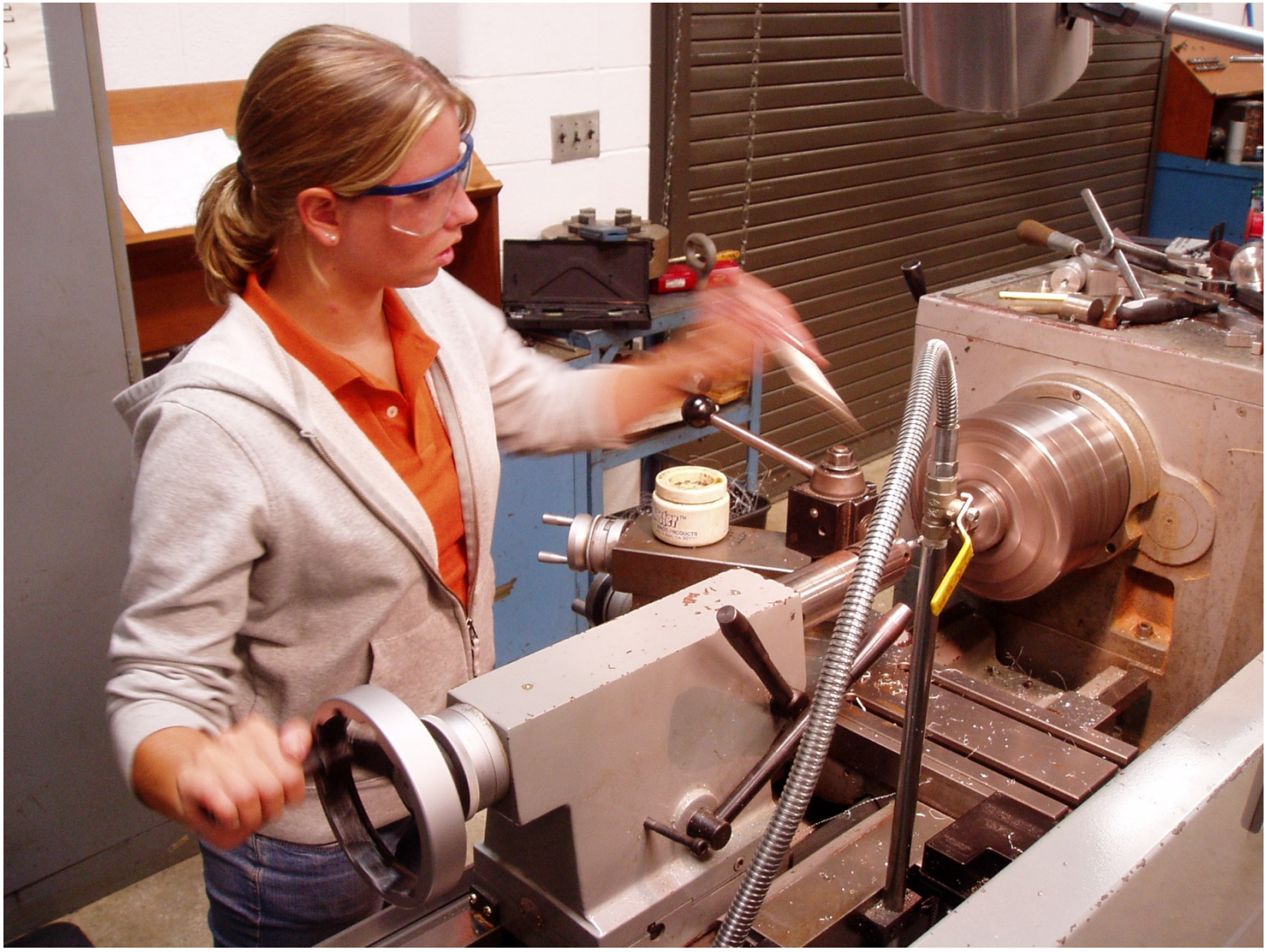
Turning (Lathe Work)



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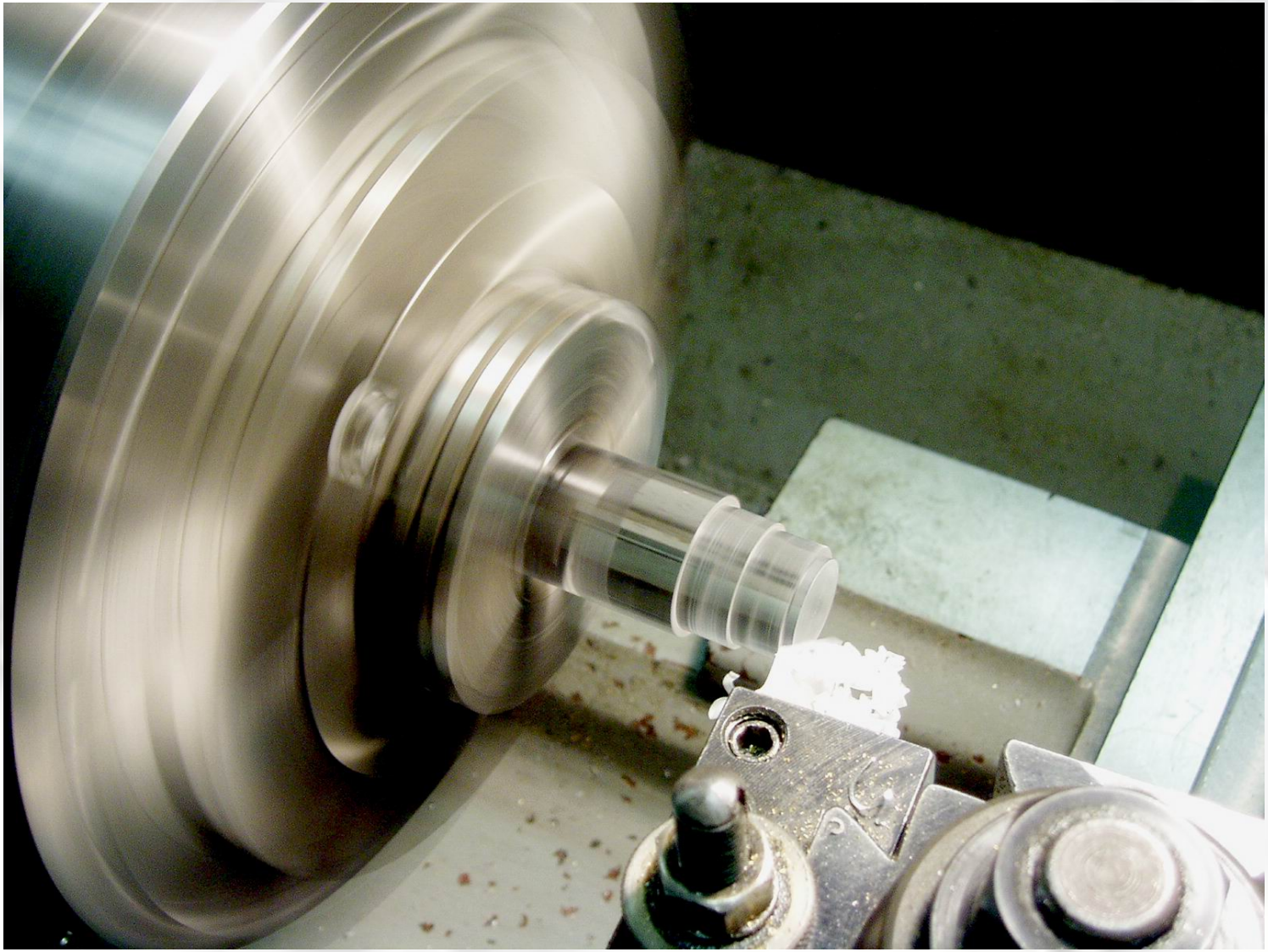
Turning (Lathe Work)



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Turning (Lathe Work)

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Turning (Lathe Work)

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Threading

Machine screw sizes less than ¼ inch in diameter are designated by the numbers 0 through 14, with the even numbers being the most commonly used. A machine screw is designated by the size (number or diameter) followed by the number of threads per inch.

Examples:

6-32, 10-24, ¼-20, ½-13 etc.

MACHINE SCREWS

NO. SIZES OF TAPS	THREADS PER INCH	DRILLS TAP	DRILLS Clearance
0	80	3/64	No. 52
1	72	No. 53	No. 48
2	56	No. 50	No. 43
2	64	No. 50	No. 43
3	48	No. 47	No. 38
3	56	No. 45	No. 38
4	36	No. 44	No. 32
4	40	No. 43	No. 32
5	40	No. 38	No. 30
6	32	No. 36	No. 28
6	40	No. 33	No. 28
8	32	No. 29	No. 19
10	24	No. 25	No. 10
10	32	No. 21	No. 10
12	24	No. 16	No. 2
14	20	No. 10	1/4
14	24	No. 7	1/4

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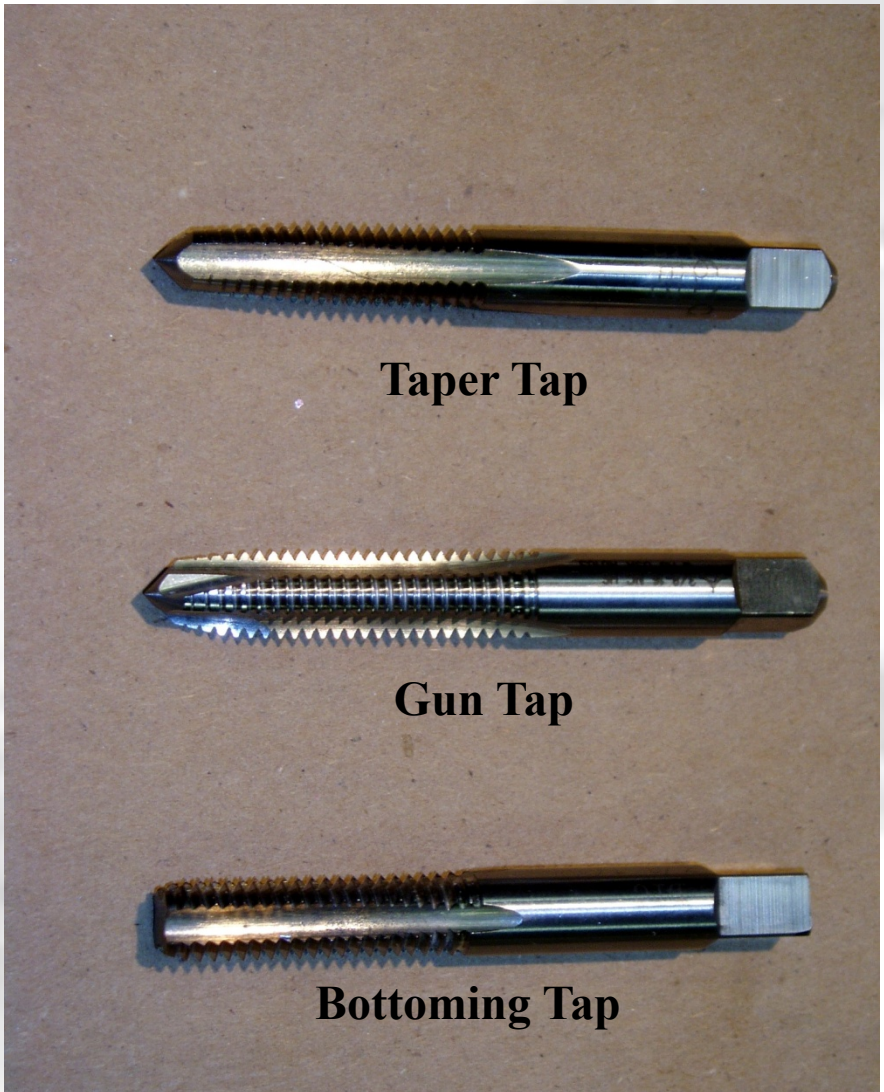
Threading

There are different screw taps for different tapping applications. The taper tap is the most common and versatile. The gun tap is used to tap primarily through-holes, and the bottoming tap is used to cut threads as close as possible to the bottom of a blind hole.



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Threading

Taps are held and turned using tap wrenches of the appropriate size

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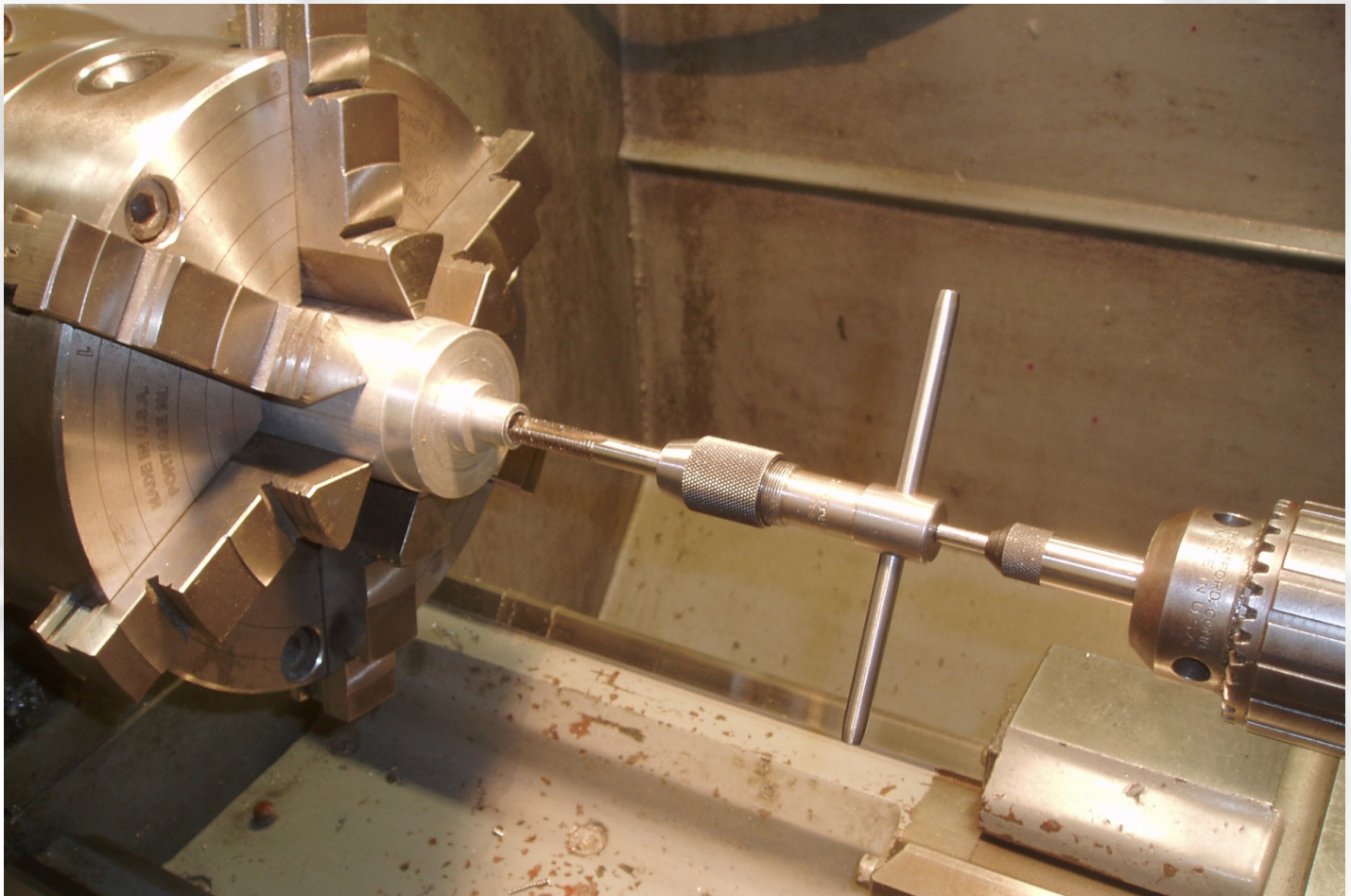
Threading

A spring loaded center (or tap guide) is used to keep a tap aligned when tapping on a lathe.



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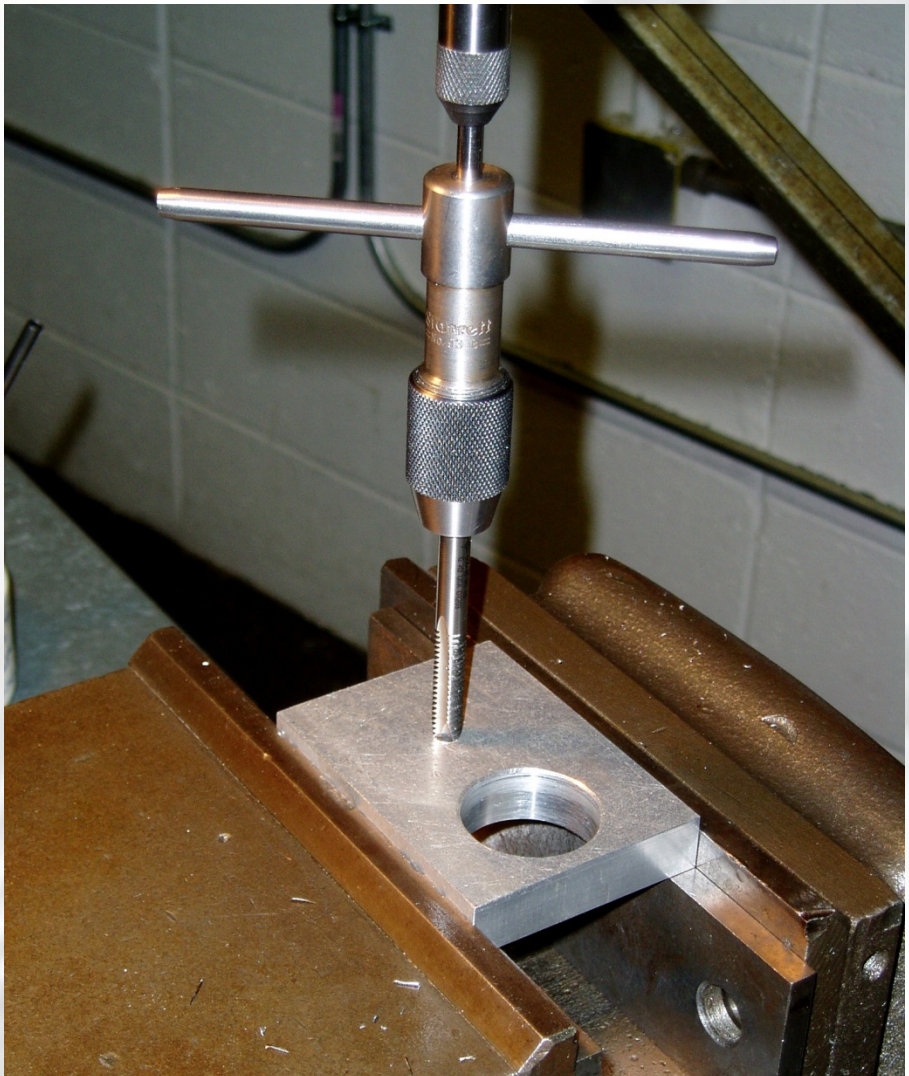
Threading

Likewise, a tap guide is used to keep a tap aligned when tapping on the milling machine.



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Threading

Pipe threads differ from machine screw threads. The first part of the designation refers to the nominal <u>inside</u> diameter of the pipe. The second part of the designation refers to the number of threads per inch.

PIPE THREAD SIZES (NPSC)

THREAD	DRILL	THREAD	DRILL
1/8-27	11/32	1 1/2-11 1/2	1 3/4
1/4-18	7/16	2-11 1/2	2 7/32
3/8-18	37/64	2 1/2-8	2 21/32
1/2-14	23/32	3-8	3 1/4
3/4-14	59/64	3 1/2-8	3 3/4
1-11 1/2	1 5/32	4-8	4 1/4
1 1/4-11 1/2	1 1/2		

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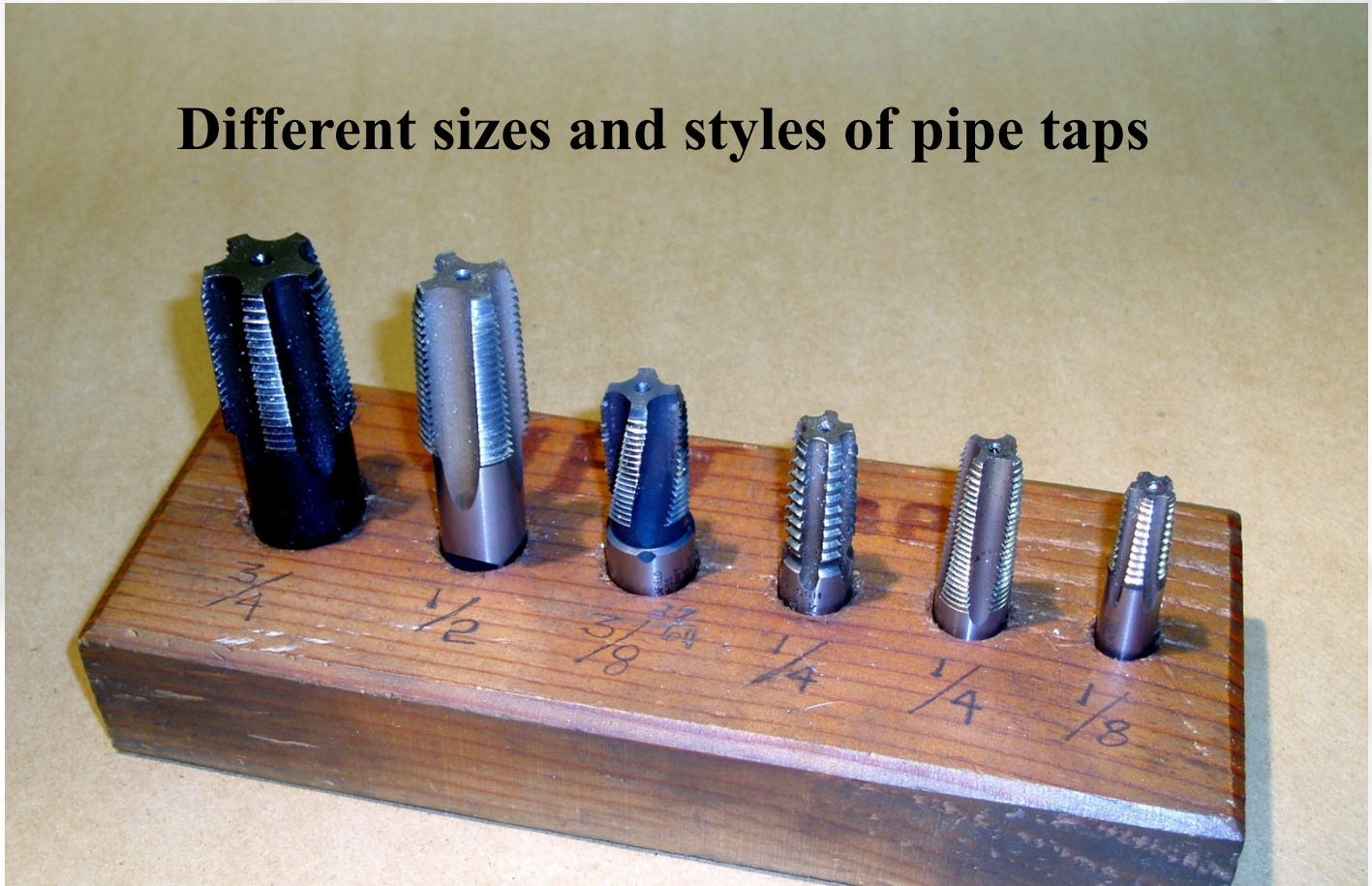
Threading

Pipe threads are usually tapered so that the seal gets tighter as the joint is screwed together.



Different sizes and styles of pipe taps

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Threading

Dies are used to cut male threads on the outside of a shaft

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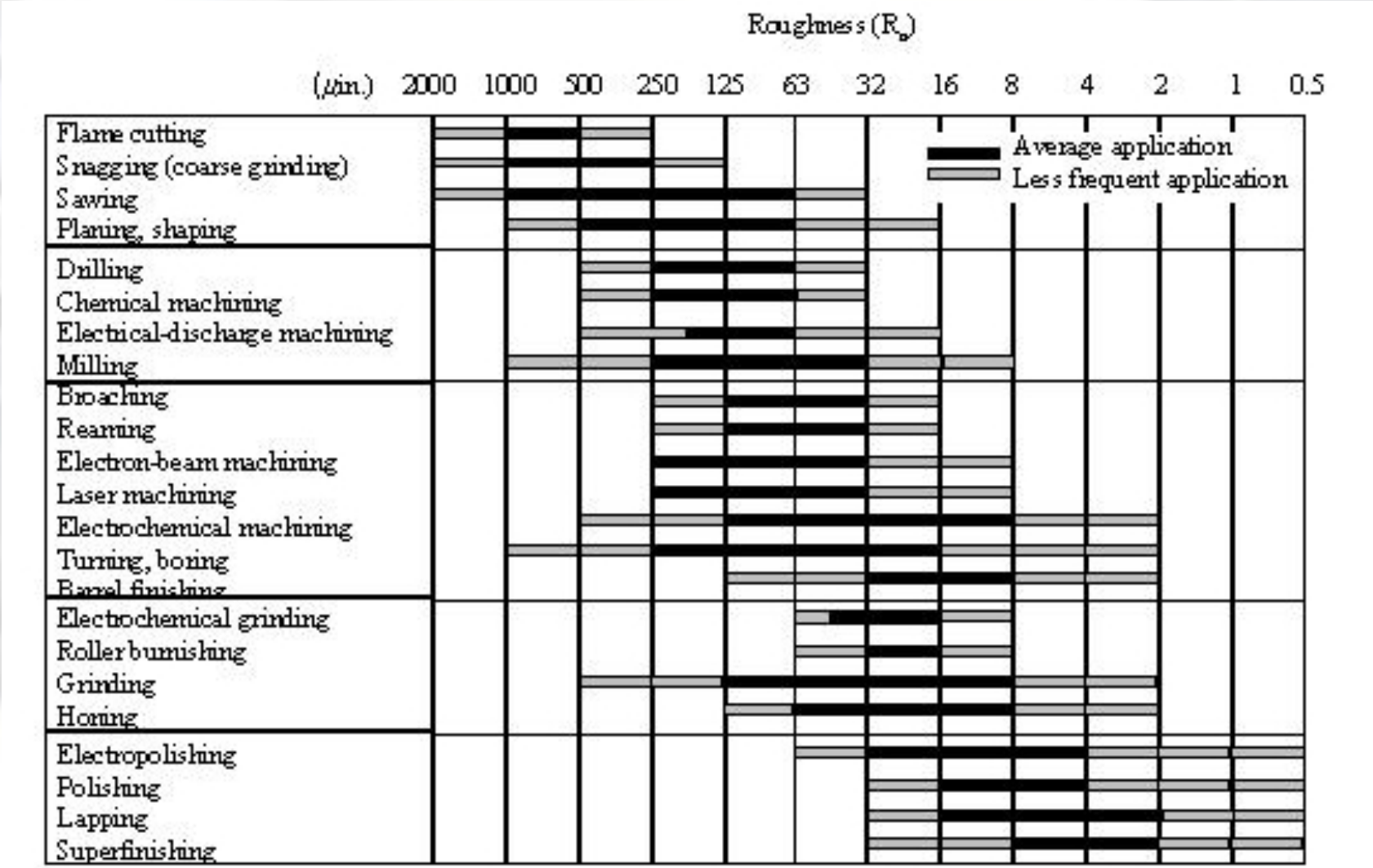
Surface Finish of Various Machining Processes



Source: S. Kalpakjian, Manufacturing Engineering and Technology, 3rd ed. Addison-Wesley, 1995.

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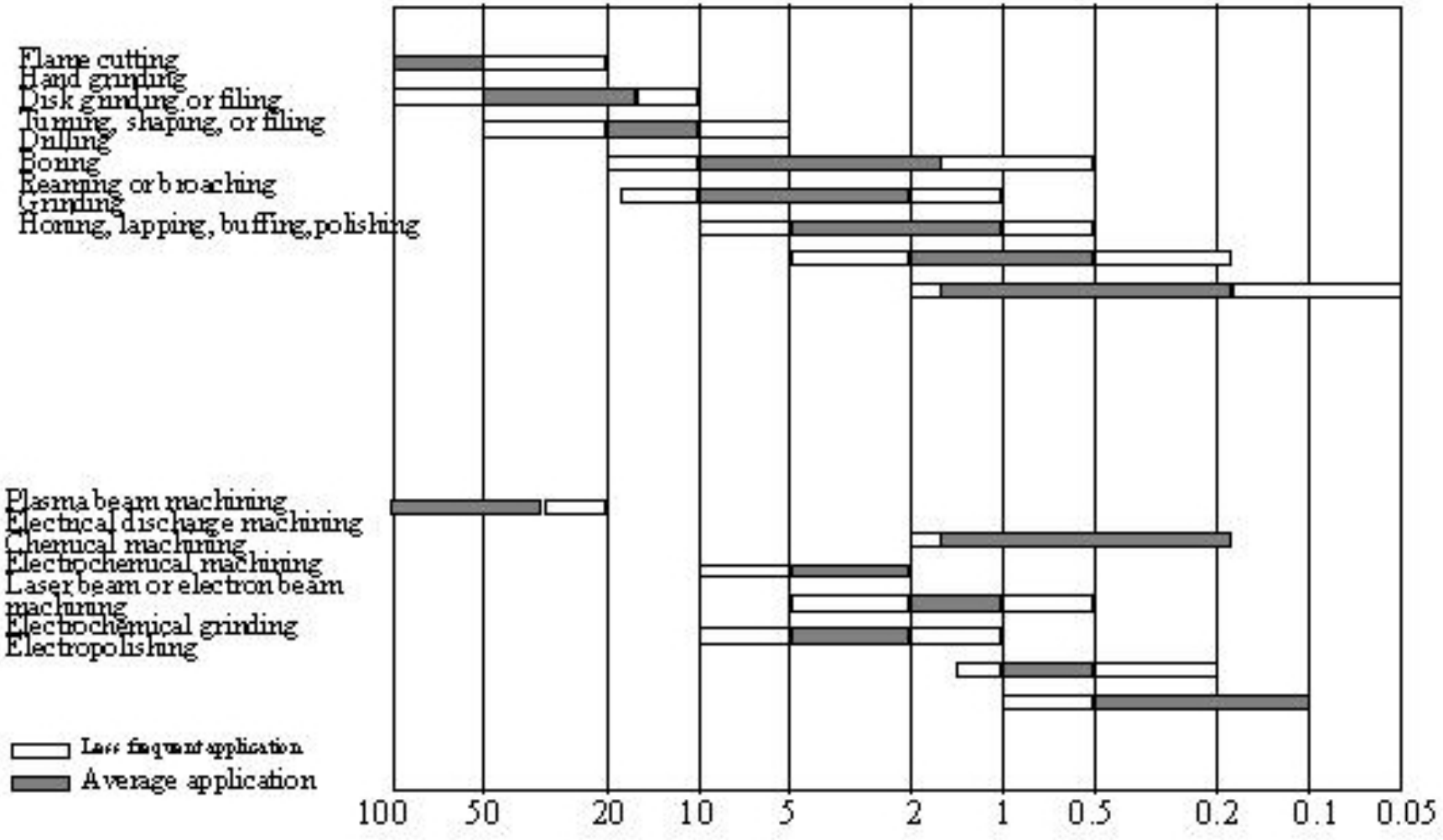
Tolerances of Various Machining Processes



Source: S. Kalpakjian, Manufacturing Engineering and Technology, 3rd ed. Addison-Wesley, 1995

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Types of Cylindrical Fits

- **Slip or Locational fit – When the male cylindrical part is .001” or more smaller than the female part.**
- **Press fit or Interference Fit – When the male cylindrical part is .001” or more larger than the female part. A mechanical or hydraulic press is required to force these two pieces together.**
- **Shrink fit – When the male cylindrical part is so much larger than the female part that the male part must be cooled to shrink it to the size where it can be pressed into the female part.**

These are just general descriptions of types of fits. There are engineering organizations (such as ANSI) that set forth standards for the allowances and tolerances for different types of fits.

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Types of Cylindrical Fits

Over and Under Reamer Sets are a common tool for achieving slip and press fit tolerances for common fractionally sized shafts. There is one reamer .001” smaller and one reamer .001” larger than each of the following shaft sizes:

1/8th inch - .124”, .126” reamers

3/16th inch - .1865”, .1885”

¼ inch - .249”, .251”

5/16th inch - .3115”, .3135”

3/8th inch - .374”, .376”

7/16th inch - .4365”, .4385”

½ inch - .499”, .501”

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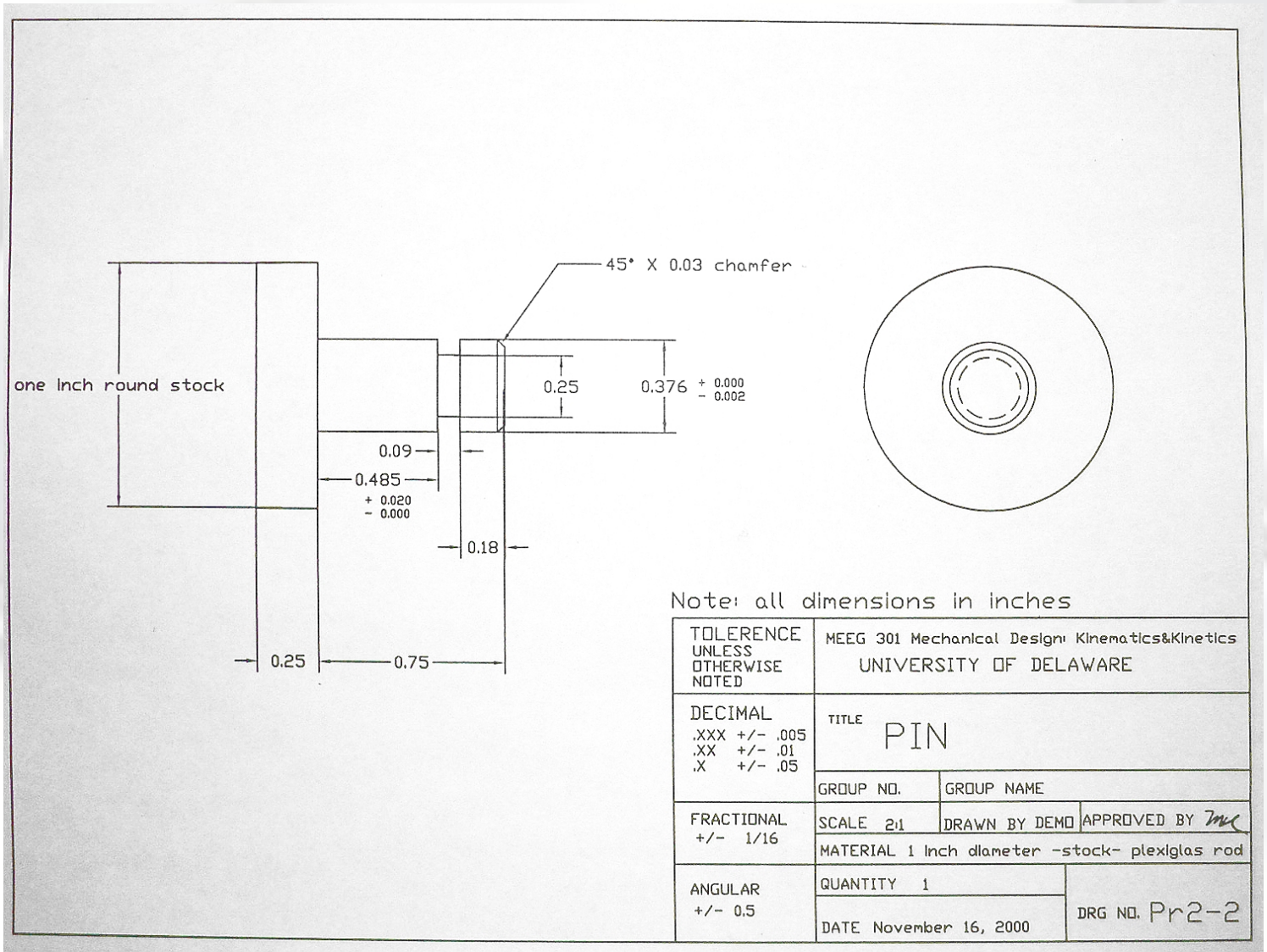
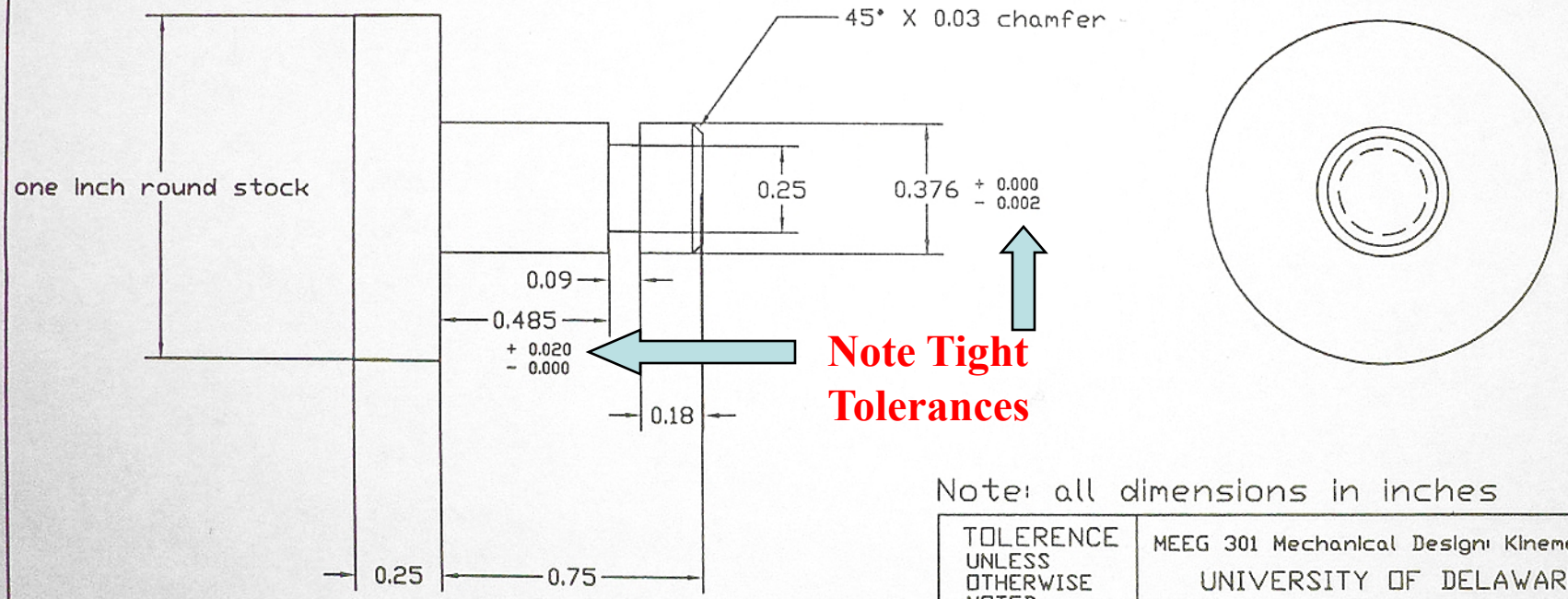
Things to consider when designing a part

Specify your tolerances as needed.





Note Tight Tolerances

Default Tolerances

Note: all dimensions in inches

TOLERENCE UNLESS OTHERWISE NOTED	MEEG 301 Mechanical Design: Kinematics&Kinetics UNIVERSITY OF DELAWARE		
DECIMAL .XXX +/- .005 .XX +/- .01 .X +/- .05	TITLE PIN		
	GROUP NO.	GROUP NAME	
FRACTIONAL +/- 1/16	SCALE 2:1	DRAWN BY DEMO	APPROVED BY
	MATERIAL 1 inch diameter -stock- plexiglas rod		
ANGULAR +/- 0.5	QUANTITY 1		DRG NO. Pr2-2
	DATE November 16, 2000		

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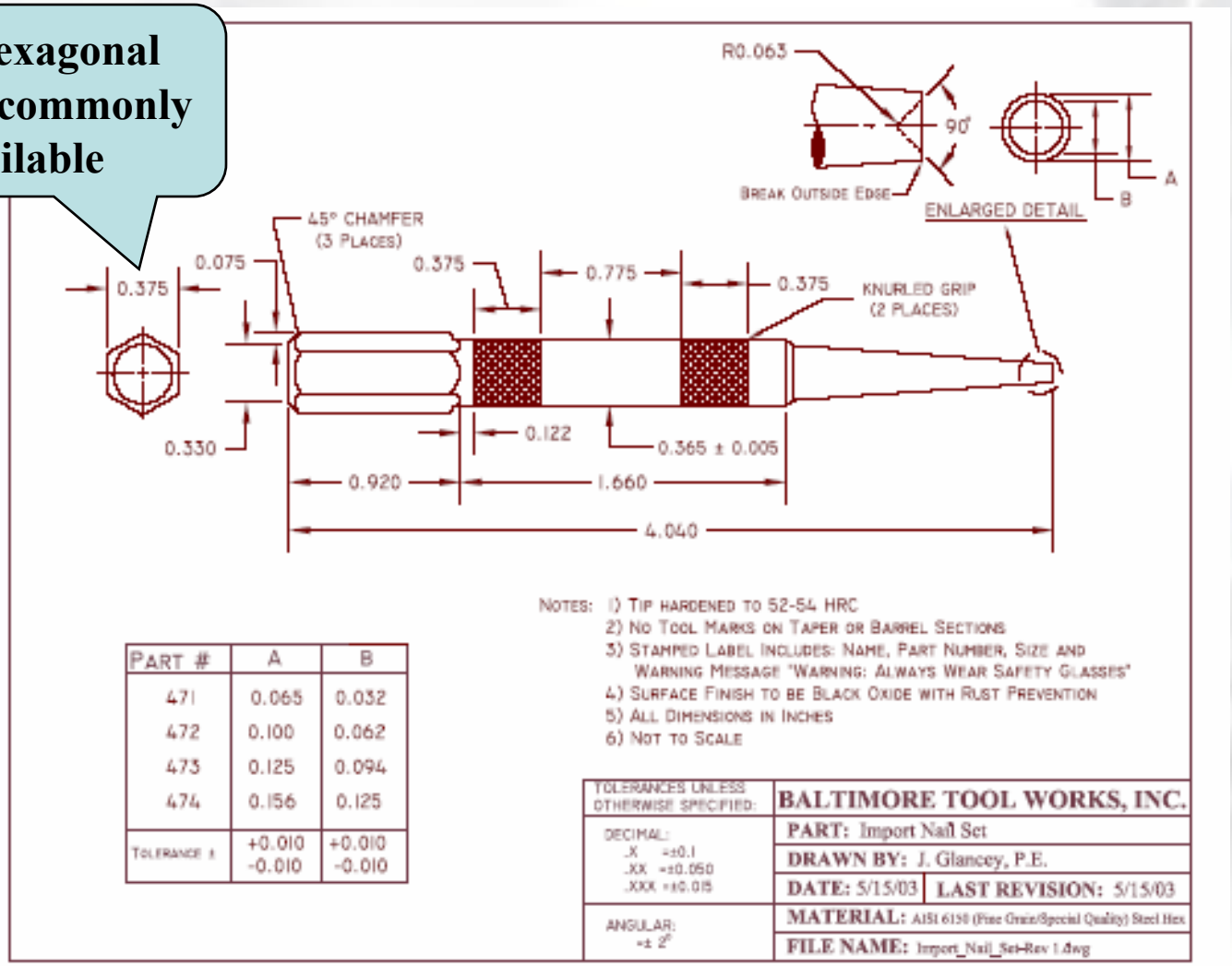
Things to consider when designing a part

Incorporate stock size material into the design when possible.

3/8” hexagonal stock is commonly available



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Things to consider when designing a part

Don’t reinvent the wheel! Make it easy on yourself. Before starting a design, find out how others have addressed the same problem. Use these resources:

- **Your professors or advisors**
- **The machinists in the shop**
- **Fellow students**
- **Design reference texts etc.**

Shop Resources

Steps to qualify to use a Milling Machine or Lathe

- Pass the online quiz.
- Create drawings of the part(s) to be fabricate:
  1. Use standard UD drawing template.
  2. Use good engineering drawing practices and procedures.
  3. Have drawings reviewed by team member.
  4. Have drawings signed by your instructor.
- Sign up for a two hour time slot to work in the shop.
- Bring two copies of your signed drawings when working in the shop.

Shop Links

Where does one find more information?

Engineering Student Shop Webpage:

http://www.engr.udel.edu/shop/student/index.html

or

E-mail:

snelson@udel.edu