Spark Makerspace Woodshop Class:
Marking Knife

Students will be taught how to make a traditional steel marking knife. This class will provide instruction on how to form, heat treat, and temper O1 steel. This two-day class will go step-by-step through the manufacture of the complete marking knife, which will be taken home at the end of class.

Materials Required:

- O1 Tool steel, 1/16” x ½” x 6”
- Brass rod, 1/8" diameter, approx 2” long
- (2) Hardwood strips, 5/8" x 3/16”, approx 4-½” long
- Epoxy

Tools Used:

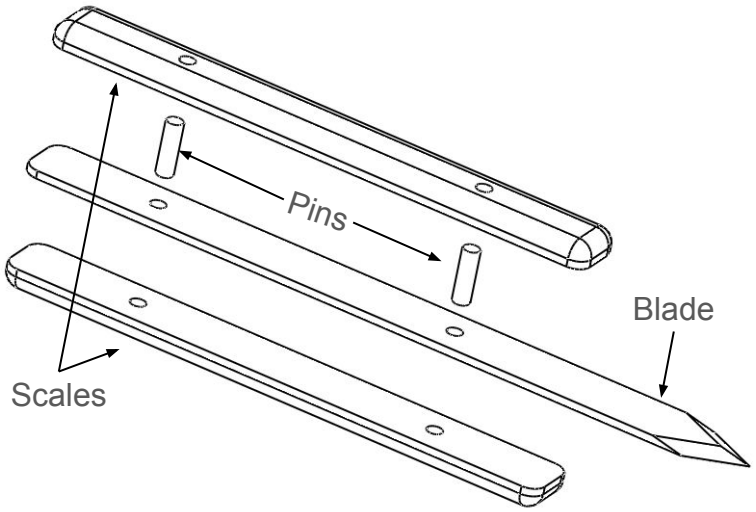
- Marker
- Ruler
- Scribe
- Hacksaw (32 tpi blade)
- File
- Center Punch
- Drill press with 1/8" bit
- Furnace/HT Oven
- Quench Oil and Can
- Tempering oven
- Sandpaper
- Sharpening block

Project Outline:

1. Day 1
   - 1.1. Mark out blade shape
   - 1.2. Cut and file blade tip
   - 1.3. Mark blade holes
   - 1.4. Drill holes for handle pins
   - 1.5. Heat and quench knife
   - 1.6. Temper knife

   Lunch

   - 1.7. Clean up knife
   - 1.8. Drill and rough shape scales
   - 1.9. Glue scales
2. Day 2
   - 2.1. Shape scales
   - 2.2. Sharpen knife



What is a marking knife?

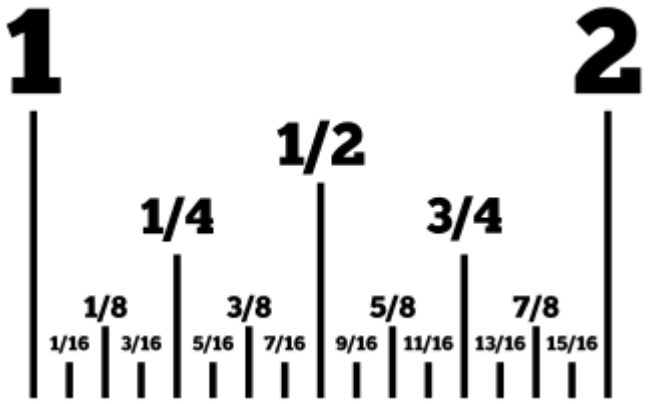
A marking knife is used to make extremely accurate marks on woodworking projects. They leave a finer line than a pencil.

Marking knives work best across the grain and leave a sharp, clean line which is then used to guide a saw, chisel, or other woodworking tool.

A marking knife usually has only one side of the blade beveled, to ensure high accuracy when held against a straight edge. The marking knife made in class has a spear point, which allows it to be used either right or left handed.

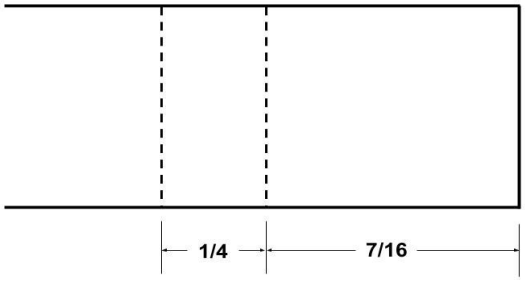
A. Marking the Blade:

The raw material for the class is a 1/16 inch thick, 1/2 inch wide, and 6 inch long piece of O1 tool steel. Choose which end will be the sharp end. Color the first inch of the sharp end thoroughly with marker or layout dye. Then, use a rule, square, and scribe to mark the point and bevels according the directions below. The fraction guide to the right may be useful for students more used to metric values.



Step 1:

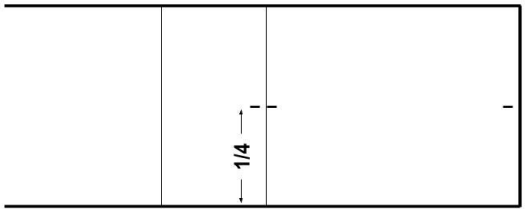
Choose which end of the steel will be the point of the blade. Mark the first inch of the pointed end with marker to darken it. If the end of the steel is particularly rough, start by scribing a line across the steel with the square. This will be the new “end” for measuring purpose.



Step 2:

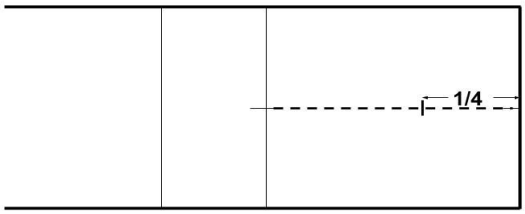
Start by marking two lines across the steel: one at 7/16-inch from the end, and one 1/4-inch past that (or 11/16-inch from the end).

It is best to make the markings by scribing the two measurements up one edge of the steel, then scribing the lines across the steel with a square.



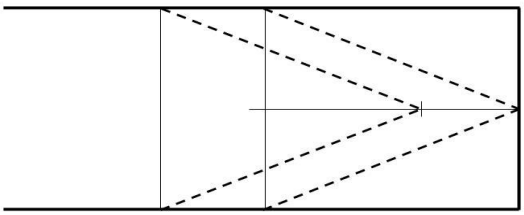
Step 3:

Scribe two midpoint marks, 1/4-inch from the edge. Make one at the end of the steel, and one at the midpoint of the first line (7/16-inch from the end).



Step 4:

Scribe the centerline by connecting the midpoints marked in Step 3. Measure along the center line 1/4-inch from the end of the steel, and scribe a mark.



Step 5:

Scribe the spear point and bevel lines by connecting the ends of the lines from Step 2 to the midpoints marks from steps 3 and 4. Use the image to the left to guide you.

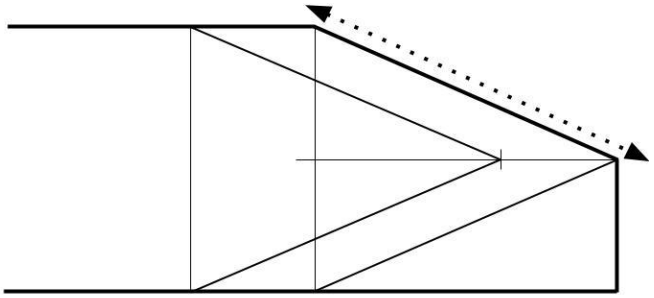
B. Cutting and Filing the Blade:

There are two tools used to do the majority of the shaping: a hacksaw, and a file. The hacksaw will be used to remove the bulk of the waste, and the file will be used for final shaping.

The blade will be clamped to a board for support. For best results, the file should be used with slow, full-length, steady strokes. Files cut on the push stroke, and should be lifted from the workpiece on the pull stroke. Cleaning the file regularly will help it work efficiently.

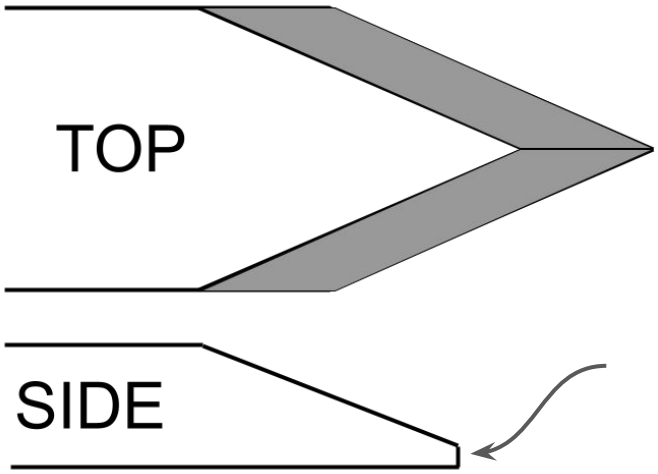
Step 1: Cut

Use a hacksaw to cut off the waste material, keeping the saw well away from the scribe lines. Then file to the scribe lines. In the image below, filing has been completed on one side. The dotted line shows where the saw cut occurred. If you're having trouble starting the saw, you can file a notch or slot to guide the saw blade.



Step 2: File

File the two bevels, leaving some thickness on the final edge as show by the arrow below. The additional thickness will reduce warping while heat treating.



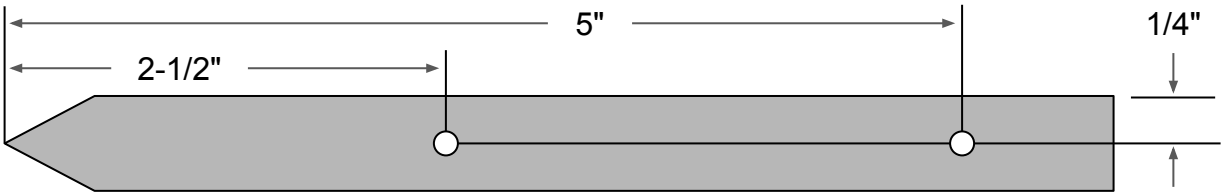
Step 3: **Clean up**

Use the file to clean up the handle end of the blade. Specific details are up to the user, but usually the end should be filed flat and square, then the corners rounded.

If the sides of the blade have sharp corners, gently run the file down the length of the edges to "break" the edge.

C. Mark and Drill Blade Holes

1. Again using marker/scribe combination, mark the centers of the handle pin holes as shown below. Accuracy of these measurements is not critical to the function of the knife, but will be visible in the final product.
2. Once marked, use a center punch on the points. Be aware that over exuberance with the punch may results in a bent blade.
3. Drill the handle holes using a 1/8-inch drill bit in the drill press. When drilling holes in metal, keep the RPM low, and use lubricant to extend the life of the drill bit.



D. Heat Treatment and Tempering

The steel being used in class, O1 oil hardening steel, is a tool steel and fairly forgiving to heat treat. While the tools at Spark allow for accurate control of each step of the heat treating process, steel can also be heat treated at home with nothing more than a plumber's blowtorch and the kitchen oven.

There are three steps to heat treating most steels: heating, quenching, and tempering. The details of the process will depend on the particular type, or alloy, of steel.

Heating:

Heating the steel breaks down the internal microscopic crystalline structure, and allows the molecules to reorganize themselves into different structures depending on the temperature.

Heating at Spark: Put the steel into the furnace at 1450°F - 1500°F for about 20 minutes.
Heating at Home: Heat the steel as evenly as possible with a torch until glowing evenly cherry red. When the steel is no longer magnetic, it's hot enough.

Quenching:

Quenching cools the steel abruptly, freezing the crystalline structure into forms which would normally disappear as the steel cooled slowly. The result is a very hard steel - usually so hard that the steel is too brittle. Depending on the steel, the quench fluid may be oil or water. The oil may be nearly any type, but for safety a high-flash point food-safe oil is recommended. Peanut and canola oil are the most common options.

Quenching at Spark: Dunk the steel in 200°F canola oil, then wipe clean and move immediately to tempering
Quenching at Home: Dunk the steel in 200°F oil, then wipe clean and move immediately to tempering.

Tempering:

Tempering reduces the hardness and brittleness of the steel. Without tempering, hardened parts can chip or break easily. To temper, the steel is heated, but to a much lower temperature than the original heating. The tempering temperature is dependent on both the steel alloy, and the final level of hardness desired.

Tempering at Spark: Heat the steel at 400°F for at least an hour in the toaster oven, then air cool to room temperature.
Tempering at Home: Heat the steel to 400°F for at least an hour in any oven which doesn't offend your cohabitants. Alternately, clean the steel well, and apply a torch well behind the cutting edges. Heat the steel until the cutting edges turn a yellow straw color, then cool.

HEAT TREATMENT SAFETY

The heat treating process requires high temperatures - often above 1500°F or 800°C. Attention to safety is required to prevent burns!

Eyes: Safety glasses are always required in the Spark shop, and should be used if heat treating at home. Additional safety measures, such as UV and IR protective glasses, are recommended around furnaces and kilns. On larger items, quenching fluids can bubble and splatter, so a face shield may be recommended as well.

Hands: It should be obvious that if the steel is glowing, it's too hot for your hands. Even metals that aren't glowing can burn you badly, however. Always use pliers or tongs to handle workpieces until you know they're cool enough to handle. Use gloves to protect hands getting close to furnaces or quenching fluids, but know that red hot steel can burn you through the gloves!

Feet: If you drop something, get your feet out of the way. Leather boots, or other heat resistant footwear, is recommended.

Body: Aprons or other clothing which might get exposed to heat should be made out of natural fibers (cotton, wool, etc). Synthetic fabrics can melt to the skin, and in extreme cases, catch fire.

E. Blade Clean Up

You've probably noticed that, after getting heat treated, your marking knife blade isn't the shiny steel you started with. The dark coating is called "scale" and is the result of surface oxidation caused by the high heat. Clamp the blade down to a hard surface, and use 320-grit wet/dry sandpaper to clean the surface. Spark recommends wrapping the sandpaper around a hard block of wood to help keep the blade faces flat.

F. Drilling and Rough Shaping the Scales

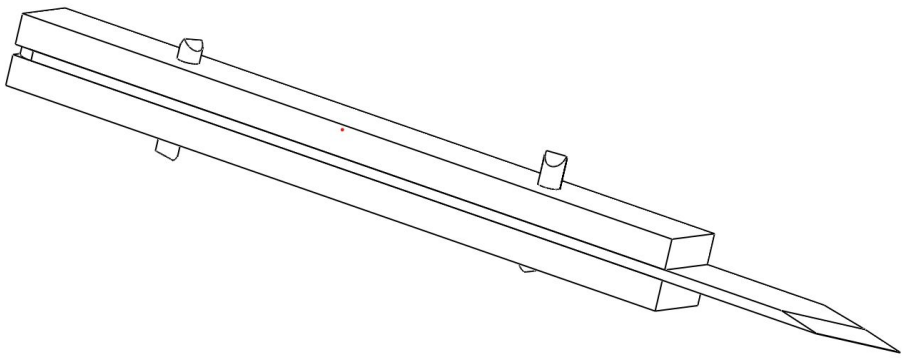
The scales are the wood sides of the tool handle. In the Spark marking knife, they're aligned with brass pins and held on with epoxy. In the class, the wood choice will vary by what materials have are available in the shop. Any hardwood will work, though open-pore woods like oak are more likely to pick up dirt if not correctly sealed.

1) The instructor should have strips of wood approximately 5/8-inch wide. The thickness may vary from 1/8-inch to 1/4-inch thick, though it will usually be around 3/16-inch. If the pieces are not already cut, cut two pieces 4-1/4-inches long.
2) Choose which side will be the outside of each scale. Mark the inside of each scale with pencil.
3) Take one scale, and place the marked side against the blade. Ensure the scale overhangs the non-pointed end and both sides of the blade. Clamp or tightly tape the scale in place.
4) Using the existing blade holes as guides, drill two 1/8-inch holes in the scales. As the drill bit won't cut the blade now that it's hardened, the blade makes a very effective alignment jig.
5) Separate the blade and scale by removing the clamp or tape. Place the two scales together, inside faces touching, and clamp or tightly tape them.
6) Using the holey scale as a guide, drill two 1/8 holes through the second scale.
7) Using heavy wire cutters or a fine tooth metal saw, cut two pieces of 1/8-inch diameter brass rod to between 3/4-inch and 1-inch long. Place these pieces through the holes in the scales.
8) Choose which end of the scales will be nearest the point of the knife. It will be hard to form these ends once the scales are glued to the blade, so clean up the blade-ends of the scales now. Using rasps, sandpaper, and files, make the ends even and smooth.

F. Gluing the Scales

Epoxy will be used to permanently attach the scales to the blade. Repeat exposure to epoxy can result in sensitive and health impacts, so Spark strongly recommends gloves and adequate ventilation whenever using epoxies.

1) Remove any bits of tape or other debris from the scales, blade, and pins. Wipe down all parts to remove dust and debris.
2) Check the fit of all parts, and ensure you've got everything aligned properly for assembly.
3) Squeeze out equal parts of the resin and hardener. Mix thoroughly for at least 30 seconds.
4) Spread a thin layer of epoxy over one side of the blade, and align the scale using the brass pins.
5) Repeat the process on the second side of the blade. Press the pins through both scales. The pins should protrude slightly from both sides.
6) Clamp or tightly tape the scales to the blade. Let the epoxy set overnight.



G. Scale Shaping

Note that while it may be tempting to use power tools, particularly Spark's large sander, for this step, many portions will include sanding on metals. Metal particles imbedded in sanding belt can transfer to someone else's project, and cause rust or corrosion spotting in their finish. While it is possible to use smaller tools such as the cordless palm sanders, the difficulty in safely holding the marking knife usually makes it more effort than it's worth.

1) Once the epoxy is set, file the protruding brass pins until they are flush with the surface of the scales.
2) Use coarse sandpaper (80 grit) to remove the overhanging sides of the scales. As you do this, try to keep the scale sides square relative to the blade faces.
3) Shape the scales with any combination of files, rasps and sandpaper until the shape is comfortable to hold. Usually, all it takes is rounding the sharp corners.
4) Sand the scales smooth using 120 then 220 grit sandpaper. As the marking knife is intended to be a working tool, there's not much advantage to going finer. Too smooth, and the knife handle will actually be less comfortable to grasp. Often 220 grit isn't even required.

H. Scale Finishing

A number of finishes are available for the scales. The scales can be left without additional finish, and will gradually take on a patina with use. However, it is more common to add a finish to prevent dirt and debris from discoloring the scales.

1. Drying oils: drying oils soak into the wood and don't leave much on the surface. This leads to good protection that doesn't' wear off easily. Common types are boiled linseed oil (BLO) or tung oil. However, many drying oils have a problem - the rags used to apply them tend to catch fire if allowed to sit in a pile. Most drying oils are banned at Spark due to fire concerns.
    - Walnut oil is similar to a drying oil, but does not have the spontaneous combustion problem. It takes longer to dry than most of the drying oils, and some brands can cause allergic reactions in sensitive individuals.
2. Non-drying oils: vegetable oils or pure mineral oil (as used on cutting boards) may be applied, but tend to dry out or break down. These oils are not usually recommended for tools handles.
3. Surface finishes: surface coatings like polyurethane can sit on the surface of the wood, resulting in a glossy surface finish which can get slippery if in sweaty hands. If a surface finish is used, it is best thinned down and allowed to soak into the wood. Shellac, an all-natural alcohol based surface finish, is available for finishing the marking knife handle.

I. Blade Sharpening

The last thing to do is sharpen the knife blade! Your class instructor will distribute a copy of the Spark sharpening handout, and demonstrate the correct sharpening techniques to bring your marking knife to razor sharpness.