

# Introduction to Sheet Metal Fabrication

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## Description

Sheet metal fabrication is a very broad subject area and uses many tools, machines and joining processes. Sheet metal workers fabricate, assemble, alter and install a variety of sheet metal products. Typical jobs performed by a sheet metal worker include HVAC (Heating, Ventilation and Air Conditioning) ductwork, industrial sheet metal work and residential sheet metal work as well as aviation construction. Sheet metal smiths also work on stainless steel hospital and kitchen equipment, industrial exhaust systems and roofing and flashing (copper, aluminum, stainless steel and galvanized iron).

This Activity Plan is designed to introduce students to the various types of sheet metal as well as common introductory fabrication processes, such as measurement, layout, riveting and folding. More experienced students will also be introduced to more advanced options like brazing. The Activity Plan is flexible and allows for modification to suit individual student needs.

## Lesson Objectives

The student will be able to:

- Briefly describe what is generally meant by the term *sheet metal*
- Correctly identify common sheet metal types and describe their characteristics and properties
- Name basic fabrication equipment and list some of the operations done with them
- Complete basic fabrication processes using common sheet metal tools and equipment

## Assumptions

The teacher will:

- Be a certified technology education/industrial education teacher
- Be familiar with the metal shop that this activity plan is being produced in
- Have experience with all aspects of the given metal shop, including machines, tools and processes

The student will:

- Have an understanding of metallurgy, shapes and forms of metals
- Understand basic principles and methods of layout
- Be attentive and participatory
- Recognize that appropriate attitudes are the best insurance for safety
- Safely work in the metal shop



## Terminology

**Aluminum:** a metallic element that is used as an alloying agent for a group of alloys.

**Aviation snips:** a hand tool designed to cut sheet metal into intricate designs. Can be used to cut compound curves. Red = left cutting; Green = right cutting; Yellow = universal, able to cut in any direction.

**Bar folder:** a sheet metal machine that is used to create straight bends in sheet metal.

**Bead roller:** a hand roller designed to add raised, curved decorative hems to sheet metal.

**Beverly shear:** a small hand-operated piece of equipment that has two blades that when passed against each other shear the metal.

**Box and pan brake:** a sheet metal machine that is used to create bends, hems and boxes in sheet metal.

**Brass:** an alloy metal consisting of a mixture of copper and zinc. Gold/yellow in colour.

**Brazing:** a process in which two metals are joined using a non-ferrous filler rod that is melted at temperatures over 450°C (840°F).

**Centre punch:** a tapered piece of metal that is used to create an indent in metal to centre the drill bit while drilling.

**Cold rolled steel:** steel that has been rolled into its finished shape after it has been cooled. After this process is complete it is put through a pickling solution or dilute acid to remove the iron oxide coating.

**Combination roller:** a machine used to perform burring, crimping, wire edging and other forming techniques on sheet metal.

**Copper:** a metallic element, orange in colour. Commonly used in art metal, electrical work and as an alloying agent.

**Emery cloth:** an abrasive cloth used to remove material and smooth surfaces.

**English wheel:** a hand-operated tool that enables the formation of compound curves from flat sheets of metal.

**Expanded sheet metal:** sheets made by cutting slits into regular metal sheets and stretching them out to create numerous openings in a diamond pattern. Expanded sheets are lighter, stronger and less expensive than regular flat sheets. They also allow for the free passing of liquids, light and sound.

**Ferrous:** a metal containing high levels of iron.

**File:** a hand tool designed to shape and smooth metal. Available in a variety of shapes and sizes to fit different projects. Made of hardened steel with varying textures to remove large or very minimal amounts of material.

**Galvanized steel:** a steel sheet that is dipped in a zinc coating to protect it.

**Gauge:** the thickness of the sheet metal measured with a thickness gauge.

**Hammer:** a tool designed to give a heavy blow to an object. Made with a variety of different head materials for specific purposes.

**Hem:** a border made by folding over the edge of a piece of sheet metal to increase strength, prevent exposure of a sharp edge and increase the product's durability.

**Hot rolled steel:** steel that is formed into its finished shape while red hot. It is identified by its black oxide coating that is formed during the rolling process.

**Letter and number stamps:** hardened steel bars with letters and numbers. Used to permanently label metal projects.

**Non-ferrous:** metals that contain little to no iron.

**Oxyacetylene welding:** welding torches that use a combination of oxygen and acetylene to produce a flame hot enough to join metal together using a filler metal.

**Rivet:** a non-threaded fastener used to join metal pieces together that do not need to come apart.

**Roper Whitney punch:** a hand tool used to punch holes in sheet metal stock.

**Ruler:** a precision measurement tool that is a length of steel with marks at regular intervals.

**Scribe:** a long, pointed piece of hardened steel that is used to mark layout lines on metal.

**Sheet metal:** a term used to describe a variety of thin rolled metal sheet stock.

**Slip roller:** hand-driven equipment that contains three hardened steel rollers: a drive roller, a gripping roller and a radius roller.

**Spot welder:** a resistance welding technique.

**Squaring foot shear:** a foot-controlled machine used to cut sheet metal stock.

**Stainless steel:** an alloyed steel designed to have greatly increased corrosion resistance compared to carbon/alloy steel. Common alloying ingredients include chromium (usually at least 11%), nickel and molybdenum.

**Tin snips:** a hand tool designed to cut out layouts on sheet metal. Also called *hand shears*.

**Welding:** the process by which two or more metals are joined together by heating the metals to the point where they fuse together.

## Estimated Time

1–2 hours

## Recommended Number of Students

20, based on the *BC Technology Education Association Best Practices Guide*

## Facilities

Metal shop facility with all necessary tools, materials and equipment

## Tools and Equipment

Personal protective equipment

### Hand Tools

- Aviation snips
- Centre punch
- Emery cloth
- Coarse and smooth files
- Gauge
- Peening hammer
- Letter/number stamps
- Rivets & rivet gun
- Roper Whitney punch
- Ruler
- Scribe
- Tin snips

### Stationary Equipment

- Bar folder
- Bead roller
- Beverley shear
- Box and pan brake
- Combination roller
- English wheel
- Oxyacetylene welder
- Slip roller
- Spot welder
- Squaring foot shear

## Materials

Multiple samples of the various sheet metals you plan to introduce during the course for identification and demonstration purposes. This may include aluminum, copper, brass, galvanized sheet metal, cold rolled steel, aluminum and hot rolled steel. It is suggested that teachers demonstrate the procedures using materials that will be found in their individual shop as well as equipment that is specific to their shop.

## Resources

### Box and pan brake

<http://www.bing.com/videos/search?q=how+to+use+a+box+and+pan+brake&view=detail&mid=0B5F895025F7C74515AE0B5F895025F7C74515AE&FORM=VIRE>

### Roper Whitney punch

<http://www.bing.com/videos/search?q=how+to+use+a+whiney+punch&&view=detail&mid=94426538A09825CF06DD94426538A09825CF06DD&FORM=VRDGAR>

### Beverly shear

<http://www.bing.com/videos/search?q=how+to+use+a+beverly+shear&&view=detail&mid=EE2EE6F39C76DEA3A5DAEE2EE6F39C76DEA3A5DA&rvsmid=074FB5E6FA3B3931B7F7074FB5E6FA3B3931B7F7&fsscr=0&FORM=VDMCNR>

### Bar folder

<http://www.bing.com/videos/search?q=how+to+use+a+bar+folder&&view=detail&mid=300C3F9B87B7F4360FE7300C3F9B87B7F4360FE7&FORM=VRDGAR>

### English wheel

<https://www.youtube.com/watch?v=omRIIBONJAM>

### “HEADS UP! for Safety” handbook

<https://www.bced.gov.bc.ca/irp/resdocs/headsup.pdf>

### BC Technology Education Association Best Practices Guide

<http://www.bctea.org/best-practice-guide/>

*Modern Metalworking*, textbook by John R. Walker, copyright 2004, Goodheart-Wilcox Company Inc.

## Teacher-led Activity 1: Introduction to Sheet Metal

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1. Begin by gathering all tools, materials and equipment.
2. Introduce each type of sheet metal and give a brief description of each individual type, common uses and identifying characteristics. (See Material Identification & Stock Identification Activity Plans for more detailed information.)
3. Distribute the attached sheet metal identification/description information sheet.
4. Demonstrate how to check thickness of sheet metal stock using the thickness gauge.
5. Provide sample pieces for students to handle and become familiar with.

### Student Activity

1. Set up stations with sample pieces of sheet metal.
2. Have students identify and describe each sample, using the attached sheet metal identification worksheet.
3. Provide magnets for students to test for magnetic properties of the samples.
4. Students will also need a thickness gauge to correctly test for material gauges.

## Teacher-led Activity 2: Introduction to Fabrication Processes

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1. Set up a workstation with all hand tools commonly used in the metal shop.
2. Work through each hand tool, describing its name, use and any other specialty instructions. (See Introduction to Tools and Equipment Activity Plan and subsequent PowerPoint presentations for more detailed information.)
3. Once hand tools are complete, move the student group to each of the stationary pieces of equipment located in the metal shop. At each describe the tool name and use and demonstrate safe working practices.
4. When all tools and equipment have been appropriately and safely demonstrated, students can begin the individual hands-on portion of the activity.

### Student Activity

1. Set up workstations that include one or two of the hand tools commonly used in the metal shop (e.g., Roper Whitney punch along with rivets and a rivet gun).
2. Have students work through each station, completing the task of using the equipment on a sample piece of sheet metal.
3. Workstations should also include the stationary equipment such as squaring foot shear, box and pan break and spot welder.
4. Once students have completed each activity they should have a variety of sample pieces of sheet metal that have been cut, formed or joined in some way.
5. The attached student station worksheet will act as a guide to ensure students work through each station. More experienced students or peer tutors could be used to sign off on each student as they complete a station.

Additional stations could include combination roller, English wheel, bead roller or brazing. These additional stations may require larger sample pieces of material to ensure safe working practices.

**Note:** Both activity worksheets are general in nature and are designed to provide a guide for the student activities. They can be added to or subtracted from to suit individual teacher and shop classroom environments.

## Assessment

Consider co-creating the evaluation criteria with your students at the beginning of the activity/project. You may want to include the following:

- Safe working procedures at all times
- Personal and project management: good use of time, attitude, effort
- Accurate measurements and layout
- Appropriate use of tools
- All burrs and sharp edges are smooth
- Instructions were followed throughout the activity
- Correct identification of materials
- Description of materials is complete and includes characteristics and properties



# Sheet Metal Identification Worksheet

Name \_\_\_\_\_

Date \_\_\_\_\_

Sample number	Name of sample	Gauge/ thickness	Ferrous yes/no	Conductivity	Describe the sample (colour, texture, etc.)
#1					
#2					
#3					
#4					
#5					
#6					
#7					

# Sheet Metal Fabrication Introduction Activity

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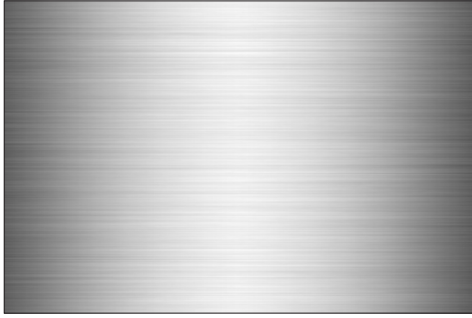
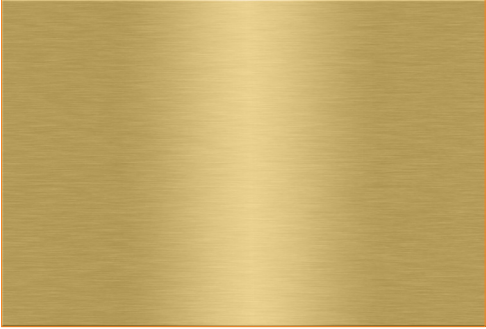
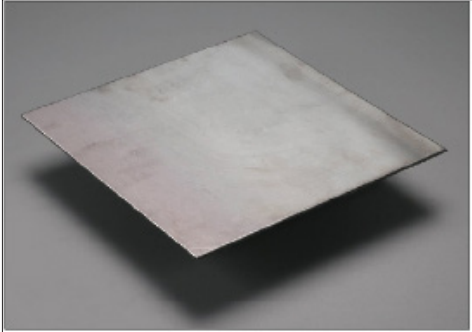
Name \_\_\_\_\_


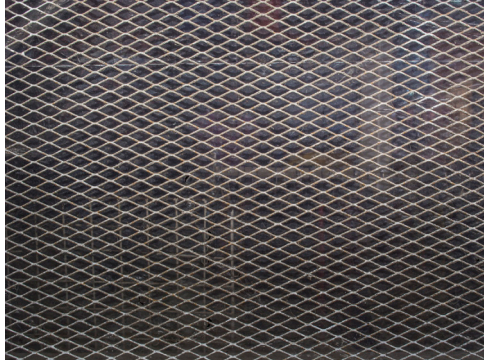
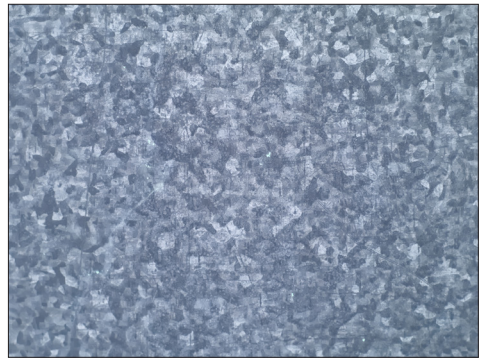
Date \_\_\_\_\_

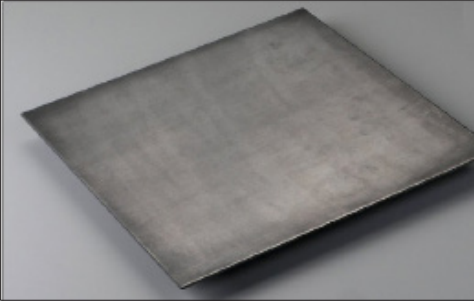
## Material: 6" × 6" sheet metal

- Station 1:** Using the materials and equipment provided, measure, lay out and scribe lines that divide your metal into nine 2" × 2" even squares.
- Station 2:** Squaring foot shear: Cut your material into three long strips. They should be 2" wide × 6" long.
- Station 3:** Tin snips and files: Using the snips, cut two of your long strips into six 2" squares. Using the files, file all edges on each square to remove all burrs and sharp edges.
- Station 4:** Beverly shear: Cut your last long strip into one piece that is 2" × 2" and a second piece that measures 2" × 4".
- Station 5:** Letter/number stamps and hammer: On each square stamp your initials and a number from 1 through 8.
- Station 6:** Centre punch, Roper Whitney punch and riveting: Centre punch two holes on each of two of your samples, for a total of four holes. Then use the Roper Whitney to punch out all four holes. Once that is complete, use the rivets and riveting gun to join your sample pieces together, aligning all the holes.
- Station 7:** Spot welder: **Be sure to use ALL safety gear.** Select two different samples of material and join them together using the spot welder. Be creative.
- Station 8:** Bar folder or box and pan brake: Fold the 2" × 4" sample piece to a 90° angle on the scribed line. Your finished product should be an L shape.
- Station 9:** Aviation snips and files: Use the snips to cut, round or create slightly curved corners on one of your sample pieces. Smooth any burrs or sharp edges on the corners using the file.
- Station 10:** Emery cloth and peening hammer: Use the hammer to texture one of your samples to create a dimpled pattern. Use the emery cloth to add patterns and texture as well as smooth the surface.
- Station 11:** Bar folder: Fold a single hem on one of the sample pieces you have not previously worked on.
- Station 12:** Roper Whitney punch: Punch a hole in one corner of each of your samples. Join your samples together using the string/wire/key ring provided and hand in to your teacher. Make sure you have completed all station tasks.

## Sheet Metal Identification: Characteristics and Properties

Sheet metal name	Characteristics and properties	Sample image
<b>Aluminum</b>	<p>A cold-rolled non-ferrous material over 0.2 mm thick but not exceeding 6 mm.</p> <p>A silver-coloured, low-density metal with a huge variety of commercial applications. Unalloyed aluminum is ductile, exhibits moderate strength and is very resistant to corrosion under most circumstances.</p> <p>Aluminum can be dramatically strengthened by the addition of appropriate alloying elements (Cu, Mg, Mn, Si, etc.) and subsequent heat/work treatments. The low density of aluminum makes it a perfect material for aerospace and in other transportation fields.</p>	
<b>Brass</b>	<p>Brass is an alloy of copper and zinc. Brass has low friction properties and acoustic properties.</p> <p>Applications include decorative and architectural uses, condenser/heat exchangers, plumbing, musical instruments, and fasteners. Non-ferrous.</p>	
<b>Cold rolled steel</b>	<p>Rolling steel at ambient temperature (or below its recrystallization temperature) increases its strength and hardness and decreases its ductility. In addition to improvement of mechanical properties, cold rolling results in more control over the shape and dimensions of the finished product.</p> <p>Cold rolled steel has an improved surface finish, which makes it common in the creation of furniture, appliances and other consumer goods. Ferrous.</p>	

Sheet metal name	Characteristics and properties	Sample image
<b>Copper</b>	<p>Excellent corrosion resistance and high thermal conductivity. Applications include architectural uses, coinage, condenser/heat exchangers, plumbing, radiator cores, musical instruments, locks, fasteners, hinges. Non-ferrous.</p> <p>Small amounts of alloying elements are often added to copper to improve certain characteristics.</p>	
<b>Expanded sheet metal</b>	<p>Sheets are made by cutting slits into regular metal sheets and stretching them out to create numerous openings in a diamond pattern.</p> <p>Expanded sheets are lighter, stronger and less expensive than regular flat sheets. They also allow for the free passing of liquids, light and sound. Ferrous.</p>	
<b>Galvanized steel</b>	<p>Hot-dip galvanizing is the process of coating iron or steel with a thin zinc layer, by passing the steel through a molten bath of zinc at a temperature of around 460°C (860°F). When exposed to the atmosphere, pure zinc reacts with oxygen to form zinc oxide, which further reacts with carbon dioxide to form zinc carbonate, a dull grey, fairly strong material that stops further corrosion in many circumstances, protecting the steel below from the elements.</p> <p>Galvanized steel is widely used in applications where rust resistance is needed, and can be identified by the crystallization patterning on the surface (often called a <i>spangle</i>).</p> <p>Ferrous.</p> <p><b><u>Technically, galvanized steel can be welded, but extreme caution is needed, as the resulting zinc fumes are lethal if inhaled.</u></b></p>	

Sheet metal name	Characteristics and properties	Sample image
<b>Hot rolled steel</b>	Hot rolling involves the production of sheet metal from billets by passing the steel through rollers while above its recrystallization temperature (over 926°C / 1700°F). Multiple passes through the rollers may be necessary to produce the final desired dimensions. It is identified by the black oxide coating that is formed during the rolling process. Ferrous	
<b>Stainless steel</b>	An alloyed steel designed to have greatly increased corrosion resistance compared to carbon/alloy steel. Common alloying ingredients include chromium (usually at least 11%), nickel and molybdenum. Ferrous.	