**Youth Explore Trades Skills Metal Work – Welding**

**Make a Safe**

# Description

Welding is a vast area in the metalworking field and a widely used joining process for metal. In this activity plan students will learn how to MIG weld (GMAW). Students will cut and weld pieces together to fabricate a safe according to drawings and specifications. Further extensions to this activity could be to introduce other types of joints or welding processes.

# Lesson Objectives

The student will be able to:

* Identify common metals
* Demonstrate appropriate shop behaviour
* Demonstrate safe and appropriate use of shop equipment
* Demonstrate proficient welding technique
* Demonstrate a variety of cutting processes

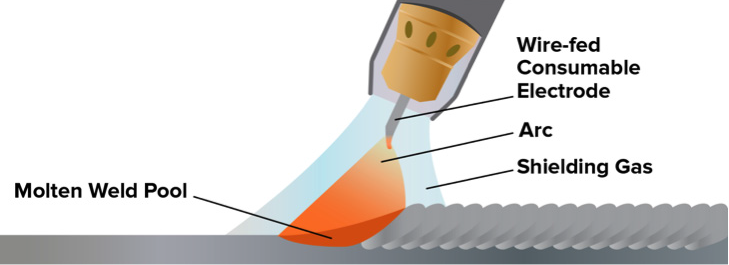
# Assumptions

The student:

* Knows basic metallurgy
* Knows basic measurement
* Know various cutting processes
* Understands basic layout techniques
* Understands basic welding concepts

# Terminology

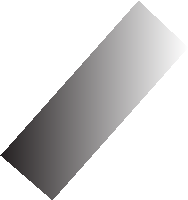
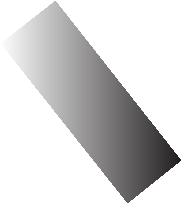
**MIG welding (GMAW)**: a welding method in which electric current flows through the filler metal wire to maintain the arc. An inert or semi-inert gas shields the arc from outside air. MIG is an abbreviation of “metal gas welding,” and GMAW is an abbreviation of “gas metal arc welding.”





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**Outside corner joint**: a welding orientation where outside edges of two plates butt up to each other, leaving a groove to weld.



**Tap drill chart**: a chart used to determine the size of drill bit required for the specified size and thread of bolt you want to use. The chart is read by first determining what size of bolt and thread pitch you want to use. Next, look to the left to see the decimal equivalent of the drill bit size to use. Looking to the left once more, you will see the alphabetical, numerical, or standard drill bit size to use. Once the hole has been drilled to the correct size, a tap of the size required for the bolt will fit inside to create threads.

# Estimated Time

5–10 hours

The time for this activity will depend on the familiarity of students with tools and the scope of the project (how much teachers prepare for students ahead of time, or how far they take the finishing portion of the project), and the availability of tools/equipment.

# Recommended Number of Students

20, based on *BC Technology Educators’ Best Practices Guide*

# Facilities

Secondary school metal shop or equivalently equipped technology education shop

# Personal Protective Equipment

* + Welding coat
  + Welding gloves
  + Welding helmet

# Equipment/Machinery

* + Angle grinder
  + Horizontal band saw
* MIG welder
* Plasma cutter or cutting torch

# Tools

* Ball peen hammer
* Files
* Steel scale
* Square
* Tap handle
* Tap

# Materials

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Item** | **# of pieces** | **Material** | **Thickness** | **Width** | **Length** |
| Safe body | 1 | 6" square tubing hot rolled steel | ⅛" wall | 6" | 6" |
| Safe backing plate | 1 | ⅛" hot rolled steel plate | ⅛" | 6" | 6" |
| Safe door | 1 | ⅛" hot rolled steel plate | ⅛" | 6" | 6" |
| Handle | 1 | ⅜" hot roller round | ⅜" | ⅜" | ¾" |
| Lock plates | 2 | ⅛" hot rolled steel flat bar | ⅛" | 1" | 1¼" |
| Hinge pin | 1 | ⅜" hot rolled round | ⅜" | ⅜" | 5¼" |
| Hinges | 2 | ½" round tubing | 100" wall | ½" | 1½" |
| Hinges | 1 | ½" round tubing | 100" wall | ½" | 2" |

4 – ¼" UNC bolts

1 – ¼" UNC tapered tap 1 – #7 drill bit

# Resources

## How to use an angle grinder

https://[www.youtube.com/watch?v=t08VRlFptKw](http://www.youtube.com/watch?v=t08VRlFptKw)

## How to use a horizontal band saw

https://[www.youtube.com/watch?v=CWbn7ZeNoV4](http://www.youtube.com/watch?v=CWbn7ZeNoV4)

## How to MIG weld

https://[www.youtube.com/watch?v=ZqoFseN17DA](http://www.youtube.com/watch?v=ZqoFseN17DA)

## How to thread with a tap

https://[www.youtube.com/watch?v=U5QU\_3qUigk](http://www.youtube.com/watch?v=U5QU_3qUigk)

# Teacher-led Activity

Demonstrate the following steps to fabricate a metal safe. Students will then replicate the processes to create their own safes.

## Body of Safe

1. Obtain 6" square tubing for safe body.
2. Teacher demonstrates how to use horizontal band saw.
3. Measure and lay out a 6" length and use the band saw to cut.
4. Use a rough file to remove all sharp edges from both sides of tubing.
5. Choose a side to create the bottom and lay out drill holes as per drawing.
6. Centre-punch four drill marks.
7. Teacher demonstrates how to use a drill press and read a tap drill chart.
8. Set up drill press with a #7 drill bit, and drill four marks.
9. Clamp body of safe in a vise with drill holes facing up.
10. Acquire a ¼" UNC tap, tap handle, and threading fluid.
11. Teacher demonstrates how to thread a hole with a tap.
12. Tap four drill holes with ¼" tap.
13. Thread four bolts into holes.

## Back and Door for Safe

1. Obtain a piece of ⅛" plate for backing plate and door of safe.
2. Lay out two 6" squares.
3. Teacher demonstrates a plasma cutter or cutting torch to students.
4. Cut out squares using a plasma cutter or cutting torch.
5. Teacher demonstrates the bench grinder. If a bench grinder is not available, use an angle grinder or files.
6. Grind and file edges of plates to match tubing outer profile.
7. File all edges with a smooth file to remove burrs and sharp edges.

## Door Hinge

1. Obtain a piece 3⁄16" round stock.
2. Lay out and cut a 5¼" length of 3⁄16" round stock using a hacksaw.
3. Obtain a piece of ½" tubing.
4. Cut a 2" length and two 1½" lengths of ½" tubing using a hacksaw.
5. File ends of all pieces flat and smooth.
6. Teacher demonstrates the hammering process for the hinge.
7. Clamp round stock vertically in a vise.
8. Use a ball peen hammer to hammer around one outer edge of round stock.
9. Turn over round stock so hammered end is on the bottom and place tubing pieces over round stock, ensuring the 2" piece is in between the shorter pieces.
10. Carefully clamp hinge vertically in a vise, and hammer outer edge of round stock to capture tubing pieces.

## Assembling Safe

1. Teacher demonstrates MIG welding (GMAW) to students.
2. Place backing plate on tubing
3. Tack weld backing plate to safe body and check fit.
4. Weld outside corner joint around backing plate.
5. Grind or file any high spots of weld down to body of safe.
6. Prepare safe to attach hinge by sitting the safe on its backing plate and placing the door on top so it aligns with the body. Use a welding magnet to place hinge in correct position on the safe, making sure it is centred vertically along the door and centred between the door and body of the safe.
7. Tack the shorter pieces of tubing to body of safe.
8. Tack weld wider middle piece of tubing to door of safe.
9. Remove welding magnet and test hinge to ensure the door swings open and shut, and door is aligned.
10. Finish welding the hinge on to door and body of safe. Be sure to only weld on the side that the tack welds are, otherwise the safe will not open.

## Door Handle

* 1. Obtain a piece of ⅜" round stock. Measure and cut a piece ¾" long.
  2. Round edges of one end to a small radius. This will be the front of the handle.
  3. File other end flat.
  4. Lay out position of handle on door.
  5. Tack weld handle on door, ensuring the flat side sits on the door.
  6. Fillet weld around base of handle to door.
  7. File any sharp or uneven edges.

## Lock Plates

1. Obtain a piece of ⅛" thick 1" flat bar. Measure and cut two 1¼" long pieces.
2. File both ends of each piece flat and smooth.
3. Lay out and centre-punch a mark ½" down and in from one end on each piece.
4. Drill holes with a ¼" drill bit.
5. Remove any burrs from drilled holes.
6. Tack weld one piece to side of the lid plate, in the centre, ensuring the hole is toward the outside.
7. Tack weld the second piece to the side of the safe, directly below the piece attached to the lid so that the drill holes match up.
8. Weld the two lock plates in place once they match up.
9. Use a padlock or combination lock to protect the contents of your safe.

## Finishing

1. Clean any grease, dirt, or scratches off metal using emery cloth.
2. Choose an appropriate method of finishing (painting, powder coating, etc.).

## Evaluation

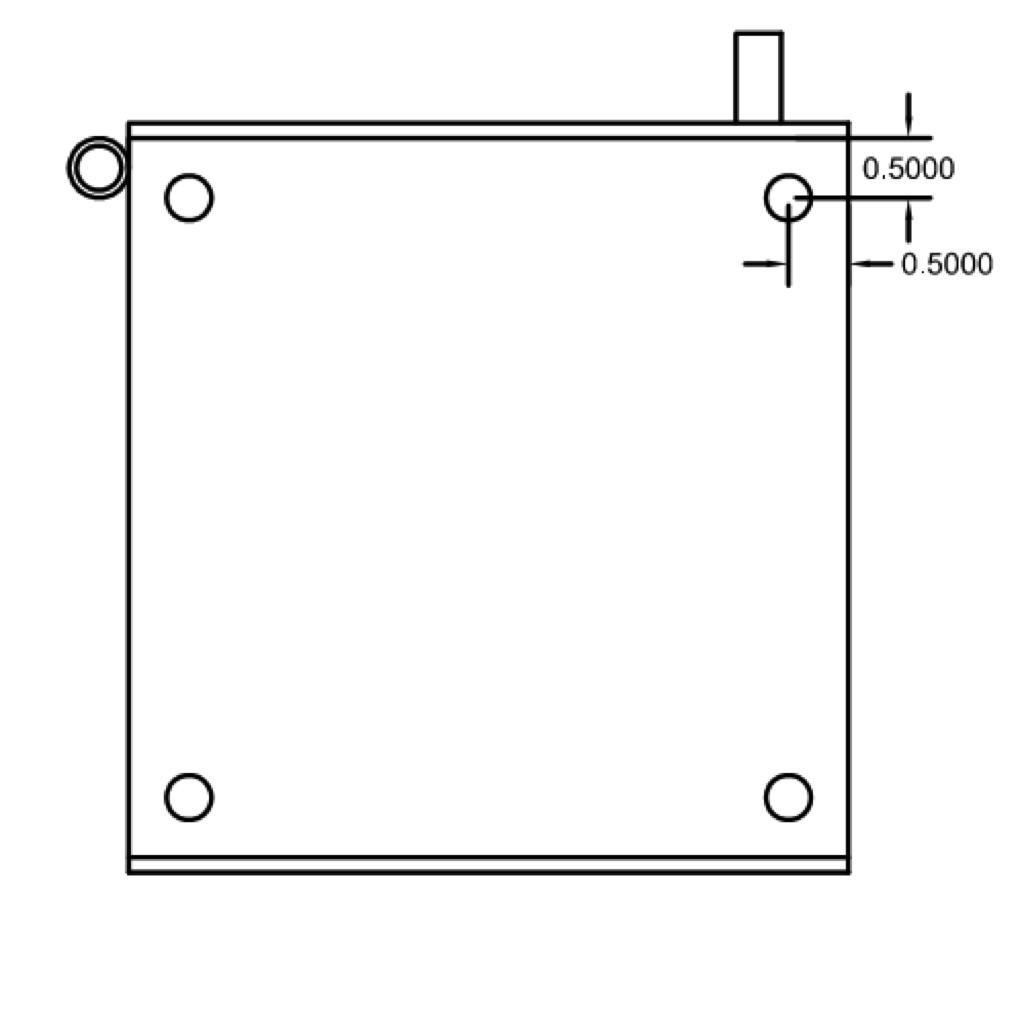
Consider co-creating the evaluation criteria with your students at the beginning of the activity/ project. You may want to include the following:

* + Safe is square on both sides and within 1⁄16" of length
  + Backing plate is within 1⁄16" on all sides, and four corners match the profile of safe body
  + Backing plate welds have consistent penetrating bead on all four sides, with uniform width and thickness on all sides
* Hinge size is within 1⁄16" of length
* Hinge closes without squeaking or catching
* Hinge is welded correctly to allow door to open, and welds are secure and consistent in width and length
* Door lies flat against safe body
* Door size is within 1⁄16" on all sides, and four corners match profile of safe body
* All four feet thread in and out easily
* All four feet are within 1⁄16" of layout spots
* Door handle is within 1⁄16" of length, and is welded square and securely
* Both locking plates are welded square and securely, and lock holes line up
* Finish: all welds are ground down to blend into safe body; sanding is uniform on all sides; no deep file marks or holes left

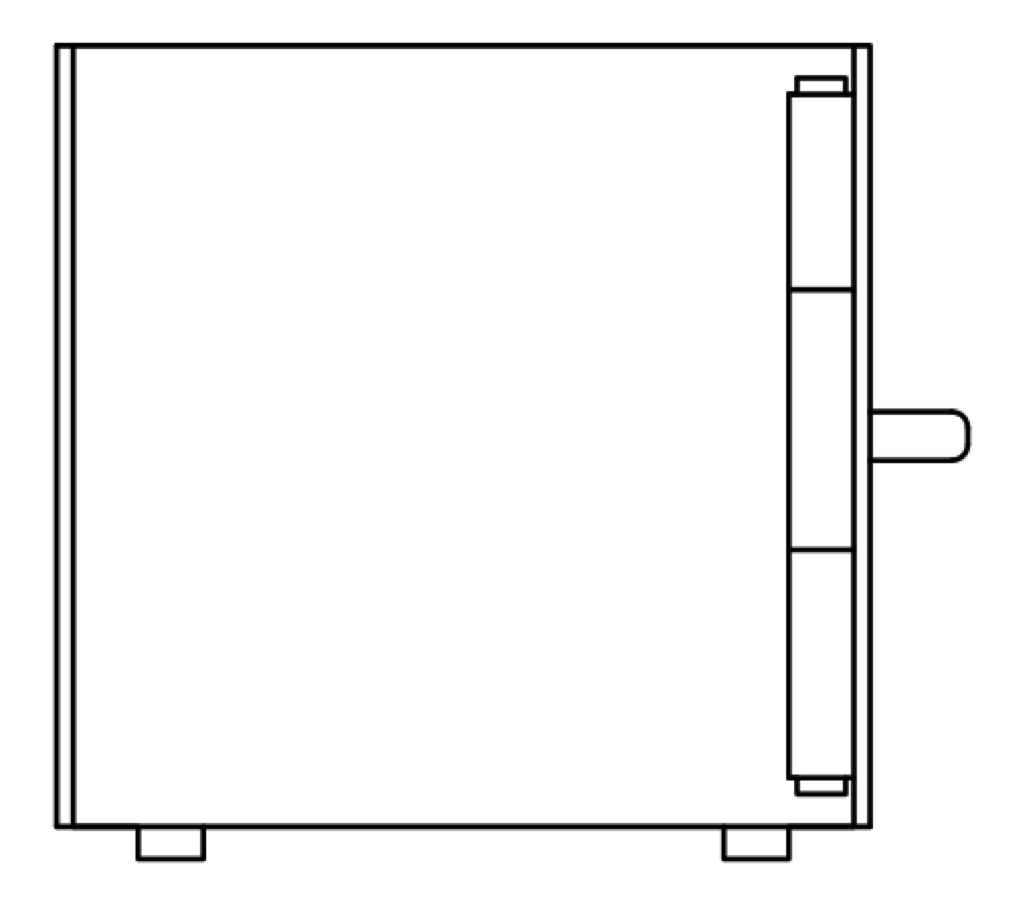
# Optional Extension Activity

If time permits and the required equipment is available, students could be introduced to other types of joints or welding processes.

# Safe bottom view – drill layout



**Safe side view**



# Safe front view

