Threaded Connections

Description
Students will learn to use pipe wrenches to work with threaded pipe. Students will measure accurately and determine fitting allowance.

Lesson Outcomes
The student will be able to:

• Use pipe wrenches to assemble and disassemble threaded piping systems
• Accurately measure centre-to-centre dimensions
• Calculate fitting allowances

Assumptions
The teacher is familiar with:

• Use of pipe wrenches
• Imperial measurement system (i.e., fractional parts of an inch)
• Threaded fitting and pipe terminology

Terminology
Female thread: internal threads on the inside of a fitting.
Fitting allowance: the dimension from the end of a pipe inserted into a fitting to the outlet of the fitting.
Male thread: external threads on the outside of a pipe.
Nipple: a piece of pipe threaded on both ends with a length of 12" or less.
Thread engagement: the length of pipe inserted into a fitting to the point where the threads are snug and a watertight seal can be achieved.

Estimated Time
2–3 hours

Recommended Number of Students
Activity could be done individually or in pairs.
Facilities

- Shop setting with flat, stable working surface (student benches).
- The preferred method of holding pipe is in a chain vise (available in portable or bench top versions).

![Figure 1—Portable chain vise for holding pipe](image)

Tools

- 14” pipe wrenches. 2 per group (Figure 2)
- A 14” pipe wrench is recommended for up to 1” pipe
- Imperial tape measure

![Figure 2—Pipe wrench](image)
Optional

- Threading equipment
- Reamer
- Pipe cutter
- Oil
- Ridgid thread cutting oil

In this activity, students are required to disassemble, measure, and assemble threaded pipe and fittings. Due to the high cost of threading equipment, it is suggested the teacher prepare the threaded connections for the students. Should resources be available, the industry standard for cutting threads is the Ridgid Model 300. The carriage includes a cutter, reamer, and die head. A more cost-effective method for teaching students is a hand threading set such as the Ridgid Model 00-R. However, because it is rarely used in industry it has limited usefulness.

Figure 3—Ridgid Model 300 power threader
Materials

- An assortment of ½” and ¾” malleable iron pipe fittings. Quantity and type dependent on activity.

- Threaded pipes (known as nipples) are readily available in lengths up to 60". Quantity and type dependent on activity.

- If threading equipment is available, ½” and ¾” schedule 40 malleable iron pipe (typically available in 21’ lengths). Schedule refers to the wall thickness of the pipe.

Resources

Safety tips for using pipe wrenches
http://www.ccohs.ca/oshanswers/safety_haz/hand_tools/pipetools.html

Pipe fitter’s Handbook
Activity 1: Determining Fitting Allowance

A common dimension required for the assembly of threaded steel projects is the fitting allowance. The following can serve as a guide for introducing this concept in an activity format.

Students work in pairs and are given an assortment of malleable iron (commonly known as steel or black) nipples. See the “Fitting Allowances” table below as a sample worksheet for collecting data. Once all nipples have been measured and recorded, students are asked to tighten a single 90° elbow onto one end of the nipple using a chain vise and two pipe wrenches. An accurate dimension from the end of the nipple to the centre of the outlet is then measured. This is repeated for each of the nipples. The difference between the end-to-end measurement and the end-to-centre (of the 90°) measurement is the fitting allowance.

<table>
<thead>
<tr>
<th>End-to-centre</th>
<th>Fitting allowance</th>
</tr>
</thead>
<tbody>
<tr>
<td>End-to-end</td>
<td></td>
</tr>
</tbody>
</table>

Fitting allowance can be seen as the “extra” length that is added to a pipe that must be taken into account when assembling a piping system. If a centre-to-centre measurement is required, two fitting allowances need to be taken into account to determine the correct length of the pipe.
Taking an End-to-Centre Measurement

Correct technique involves hooking the tape measure over the end of a pipe, aligning the tape to be parallel with the pipe, and measuring to the nearest \( \frac{1}{8} \)".

Fitting allowance is an important concept for young people investigating trades to understand. Initially, it is important for students to be able to use this information to assemble piping projects. Because most dimensions in the plumbing trade are centre-to-centre, plumbers must be able to calculate end-to-end measurements. Further discussion can be tied to Social Studies curriculum and the Industrial Revolution. Because global standards for manufacturing tolerances have been established, fittings and pipe from around the world can be expected to fit together.

**Figure 6**—Correctly taking an end-to-centre measurement.

**Figure 7**—Care should be taken to keep the hook of the tape measure on the end of the pipe.
Fitting Allowances

<table>
<thead>
<tr>
<th>Organize your assigned pipe nipples and measure their length.</th>
<th>Tighten elbows onto one end of your pipes and record the end-to-centre measurement below.</th>
<th>Record the difference between the measurements in the column below.</th>
</tr>
</thead>
<tbody>
<tr>
<td>End-to-end length</td>
<td>End-to-centre length</td>
<td>Fitting allowance</td>
</tr>
<tr>
<td>______________________</td>
<td>______________________</td>
<td>______________________</td>
</tr>
<tr>
<td>______________________</td>
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</tr>
</tbody>
</table>

Demonstration of Proper Pipe Wrench Technique

Threaded fittings should be assembled using one wrench to tighten a fitting, and another to hold the pipe against the direction of the tightening while a chain vise supports the work. This method ensures a controlled tightening using the strength of arms, shoulders, and chest.

Figure 8—Controlled movement of pipe wrenches is accomplished with two wrenches and good hand placement.
Key points are:
- Stable stance to maintain balance
- Wrenches within shoulder width apart aligned to move in opposite directions
- Jaws of wrenches centred over pipe or fittings
- Controlled movement of wrenches so strength of entire upper body is used

Figure 9—The chain vise is only used to support the work. The tightening of the fitting is accomplished by moving the two wrenches in opposite directions.

Once students have experimentally determined a consistent fitting allowance for the pipes they were working with, the teacher can share manufacturer’s documentation that indicates the theoretical fitting allowance. Many sources for this can be found within manufacturers’ documentation. The fitting allowances for common pipe sizes are listed below:

<table>
<thead>
<tr>
<th>Pipe diameter</th>
<th>Fitting allowance (to nearest (\frac{1}{16})”)</th>
<th>Fitting allowance (to nearest (\frac{1}{8})”)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\frac{1}{2})”</td>
<td>0.69” = (1\frac{1}{16})”</td>
<td>(\frac{3}{4})”</td>
</tr>
<tr>
<td>(\frac{3}{4})”</td>
<td>0.81” = (1\frac{1}{16})”</td>
<td>(\frac{7}{8})”</td>
</tr>
<tr>
<td>1”</td>
<td>0.92” = (1\frac{1}{16})”</td>
<td>1”</td>
</tr>
</tbody>
</table>
Possible discrepancies between theoretical and practical measurements are:

- Student has over-tightened or under-tightened the fitting. Hand tight plus two full rotations is typical. The term *snug* is used in the trade to describe a fitting that is tightened to the point where a leak would not occur.

- Malleable iron fittings can be stretched if they are over-tightened. As the pipe is forced into the fitting, the shoulder is stretched permanently and will alter the thread engagement for future use. The fitting is still usable but will not give accurate fitting allowances.

- If students have threaded the pipe, the length of the thread must be done consistently and precisely to produce accurate thread engagement and fitting allowances.
**Activity 2: Threading Project**

Students work in pairs to:
- Accurately measure
- Assemble a threaded project
- Calculate fitting allowances
- Disassemble a threaded project

Due to the expensive nature of threading equipment as discussed above, it is recommended that the teacher prepare a small piping system such as the one described in Figure 12. All fittings should be tightened to the point of snug—that is, tight enough that the fittings cannot be turned by hand and at least two threads are still showing.

*Figure 10—Close-up of tapered pipe threads*

*Figure 11—Thread engagement*
Measure and Wrench

Figure 12—Piping system for threading project

- Measure all indicated pipes and record in the table that follows. All measurements must be to the nearest \( \frac{1}{8} \)”.
- Disassemble your project and complete the table.
- Show your teacher all pieces.
- Reassemble and ensure correct dimensions.

All joints must be tight.
All pipes should be aligned using two pipe wrenches.
Complete the following table (to the nearest \(\frac{1}{8}''\)).

<table>
<thead>
<tr>
<th>Assembled project</th>
<th>Unassembled project</th>
<th>Difference 2 fitting allowances</th>
<th>Difference divided by 2 1 fitting allowance</th>
</tr>
</thead>
<tbody>
<tr>
<td>A:________________</td>
<td>_________________</td>
<td>______________________________</td>
<td>__________________________________________</td>
</tr>
<tr>
<td>B:________________</td>
<td>_________________</td>
<td>______________________________</td>
<td>__________________________________________</td>
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<tr>
<td>C:________________</td>
<td>_________________</td>
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<tr>
<td>D:________________</td>
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<tr>
<td>E:________________</td>
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<td>F:________________</td>
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<td>G:________________</td>
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</tbody>
</table>

A correctly engaged fitting should be turned three to four turns by hand and two to three turns with pipe wrenches, with two imperfect threads still showing. The taper (or angle) of the threads ensures a watertight seal when the pipe is wedged into the fitting.

**Evaluation Guidelines**

The student:

- Demonstrates ability to use an imperial tape measure to take accurate measurements.
- Uses pipe wrenches correctly.
- Assembles pipe and fittings to specification within \(\frac{1}{4}''\) on all measurements.