

Guide to using pipe sizing spreadsheet by Peter Wenning

To be read in conjunction with:

- ***Pipe sizing tabulation sheet (Microsoft Excel spreadsheet)***
- ***Pipe sizing guide figures (pdf file)***
- ***“Selection and sizing of copper tubes for water piping systems” by Barrie Smith (pdf file)***
- ***AS/NZS 3500***

Australian Standards

- Cold water: AS/NZS 3500.1 specifies minimum flow rates, probable flow rates and probable demand for normal domestic situations but NOT commercial situations. The 5 m head minimum pressure requirement at the specified flow rates is unacceptable in the real world as many appliances will not function at such a low pressure.
- Hot/tempered water supply: AS/NZS 3500.4 provides guidance on some typical flow rates for calculation purposes only.

Selecting an appropriate pipe sizing method

There are numerous software packages that provide rapid pipe sizing solutions, and technical books, but some of these don't include all of the factors that contribute to professional pipe sizing. For example, cold water is more viscous than hot, therefore there is a greater pressure drop through a pipe with cold water. While some design engineers do not consider temperature when sizing pipes, it is an important factor, and there is in fact a 16% difference between sizing for 15°C and 60°C.

A good learning resource is '*Selection and sizing of copper tubes for water piping systems*'. This book was written by Barrie Smith, formerly a senior educator at TAFE NSW, and it has been used by designers around Australia for more than 20 years.

The Barrie Smith book uses *metres head* as a pressure statement. This is important for water system designers that need to merge information relating to elevation and pressure as follows:

- Water authorities issue pressure and flow reports providing the minimum and maximum pressures expressed in metres head
- Building heights and floor levels are measured in metres
- Ground levels are measured in metres in relation to AHD (Australian Height Datum)
- Lengths of piping are measured in metres

There have been many innovations, with the introduction of plastic water piping and water conservation measures, but the book remains current and is an excellent learning resource that can be adapted and used for current teaching practice. To that end, I developed a Microsoft Excel spreadsheet, and the following procedure for applying data in the book.

Step 1: Gathering information

- Dimensions of the building including floor levels and location of all plumbing fixtures.
- Location of other services and obstacles.
- Location and depth of the water main.
- Obtaining pressure and flow information from the water authority. Pipe sizing for heated and cold water is based on the minimum available head at the required flow rate. The pressure and flow reports provided by water authorities contain maximum and minimum pressures, residual pressures at specified flow rates and AHD at the tapping point. This provides comprehensive information for sizing fire services and general water supply systems.

Step 2: Planning the layout.

Determining the path of piping is critical, because the actual length of piping is an important contributing factor to the pressure losses. ***For this example see figure 1***

Step 3: Assign flow rates (*added to figure 1*)

The probable simultaneous demand (PSD) flow rates for the apartments in the example are assigned from AS/NZS 3500.1 Table 3.2. Also in the example, possible flow rates are used for a commercial laundry where all washing machines would operate simultaneously.

Step 4: Draw an internal layout and assign loading units

Draw the layout for the piping in the apartment with the most disadvantaged outlet and assign loading units from AS/NZS 3500.1 Table 3.1. The loading units are added for each section of pipe that serves more than one fixture. ***See figure 2***

Step 5: Enter basic information into spreadsheet

Enter pipe sections, loading units and flow rates for Apartment 10 into the pipe sizing tabulation sheet. The flow rates corresponding to the loading units are taken from AS/NZS 3500.1 Table 3.3. The internal cold water pipe sizing has traditionally been DN 20 to more than one fixture and DN 15 to single fixtures. ***See figure 3***

Step 6: Enter the pipe lengths, fittings and valves into the pipe sizing tabulation sheet

This includes the entire main run from water main to furthest fixture. The fittings must be related to the pipe section and flow. For example the reducer in pipe section 1 is only carrying the flow for that pipe section. ***See figure 4***

Step 7: For each pipe section, determine the velocity and enter the information into the pipe sizing tabulation sheet for each pipe section

The maximum velocity permitted by AS/NZS 3500.1 is 3 m/s; however, it is best practice to keep the flow velocity at or around 2.2 m/s. For example pipe section 2 has a flow rate of 0.14 L/s and a pipe size of DN 20, therefore the velocity will be 0.616 m/s as determined by Table 2 in the Barrie Smith book. ***See figures 4 and 5***

Step 8: For each pipe section, enter the Head loss per 100 metres into the pipe sizing tabulation sheet

This is also taken from the Barrie Smith book. See figure 5. Once the information is entered into the spreadsheet, the Head (friction) loss for the associated pipe section will be automatically calculated. For example in pipe section 2, the automatic calculation will be

$$\frac{2 \times 3.622}{100} = 0.072 \text{ m. Head } \textit{See figure 6}$$

Step 9: Enter the valve and pipe fitting 'K' factors into the pipe sizing tabulation sheet

The 'K' factor is found by locating the correct table in the Barrie Smith book. View the 'flow' column and pipe size column. The 'K' factor will be the same for any flow rate through a specific size and type of fitting. For example, in pipe section 2 there is a DN 20 flow tee, therefore, the 'K' factor will be 0.9. **See figures 7 and 8**

Once the 'K' factor is entered into the spreadsheet, the Head (friction) loss for the associated pipe fitting or valve will be automatically calculated. For example in pipe section 2, the automatic calculation for the single flow tee will be

$$0.9 \times \frac{0.616^2}{19.6} = 0.017 \text{ m. head}$$

Based on formula: $m \text{ (head loss)} = K \frac{v^2}{2g}$

Where K = head loss factor for fittings and valves

v = flow velocity in metres per second. m/s

g = gravitational acceleration. 9.8 m/s²

Step 10: Enter the pressure loss due to the elevation into the base of the pipe sizing tabulation sheet

This is the vertical height from the point at which the water pressure is known, to the highest outlet. (Normally from the water main to highest shower outlet) This figure is entered when the highest outlet is higher in elevation than the water main. **See figure 9**

Step 11: Enter the pressure gain due to the elevation into the base of the pipe sizing tabulation sheet.

This is the vertical height from the point at which the water pressure is known, to the highest outlet. This figure is **only** entered when the highest outlet is lower in elevation than the water main, and is entered as a negative figure.

Step 12: Enter the mains pressure into the base of pipe sizing tabulation sheet.

From Step 1. For the purpose of this example our mains pressure is 60 metres at more than 2.74 L/s

Step 13: Enter the pressure required at the outlets.

AS/NZS 3500.1 specifies that the minimum pressure is 5 metres; however a realistic pressure suitable for the operation of all appliances is 40 metres.

Step 14: Review and assess for adequate pipe sizing.

For the pipe sizing to be successful, we must have a zero or positive residual pressure. In our example there is a negative residual pressure of -16.738 metres head. If we altered the pressure required to 23.262 metres, then we would have a zero residual pressure. *i.e.* 60 m mains pressure minus 36.738 total pressure loss/gain minus 23.262 pressure required = zero residual pressure.

Options to achieve the pressure required

In general terms when there is a negative residual pressure, there are two solutions.

- a) Increase pipe sizes to reduce friction losses
- b) Install pumps to raise the pressure as and where required.

Consideration of pressure losses

While pipe friction and elevation contribute to the total pressure loss, other significant contributors are water meters, RPZDs (reduced pressure zone devices) and private water filtration plants. These must all be considered in the design using the relevant manufacturer pressure loss data. Increasing pipe sizes and also the size of these items can often reduce the pressure losses.

Solution to the example

In the example given, the backflow device and water meter contribute significantly to the pressure loss and negate any increase in pipe size as a viable solution to achieving zero+ residual pressure. Therefore, if the pressure required at the outlets is 40 m, the only solution is pumping.

The Plumbing Code of Australia lists one of the key objectives in the design of water services as energy conservation. Therefore, ideally only the section/s of water service that do not meet the minimum pressure requirements should be pumped.

Resources: <http://www.plumbing.org.au/>.

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