Pasture Pipelines – Pipe Sizes Explained

Many products have a standard name that reflects the size of the product. Although the precise size of an item might vary slightly depending on the intended application or material comprising it, for convenience, a single name is used which only approximates the item's size. For example, a two-by-four is not a piece of lumber that measures two inches by four inches, but it's close. Such dimensions are referred to as "nominal" dimensions, and, as the dictionary definition implies, are dimensions in name only.

Pipe is one such product that is described by nominal dimensions. There are many varieties of pipe available, and to ensure that all components fit together when developing a piping system, it is important to understand naming conventions when ordering pipe and fittings.

How did all this confusion start?

When notions of developing standards for mass production of piping material first began to emerge, there was one predominant material used for the manufacture of pipes; cast iron. Mass production of cast iron pipe also happened to coincide with the development of analytical methods for hydraulic analysis of piping systems. These methods identified internal diameter of the pipe as the critical dimension for hydraulic considerations. Therefore, nominal pipe dimensions were based on cast iron pipes which had internal dimensions that matched the nominal dimension; the outer diameter was determined by the required pipe thickness for cast iron, and was slightly larger than the nominal dimension.

Over time, other materials began to see widespread use in the manufacture of pipes, and pipes began to be manufactured with a variety of strength characteristics. To ensure that new and old pipe would be able to fit together, the *outer* diameter of the old cast iron pipes became the standard for subsequent manufacture of pipes composed of other materials. Because other materials had mechanical characteristics that differed from those of cast iron, and because pipe was manufactured with a variety of pressure ratings, the required wall thickness varied. Adoption of the outer diameter of the old cast iron pipe as a standard meant that variations in wall thickness were achieved by varying the *internal* diameter of the pipes. This resulted in pipes with a given nominal dimension having both inner and outer diameters that differed from the nominal dimension. Thus, in many cases, neither the inner or outer diameters of, say, a ½-inch pipe would measure ½ inch.

Over time, variations in materials, the intended application, and the method of manufacture have resulted in the evolution of a number of standards. Pasture pipelines are intended to convey water at moderate pressures, and usually consist of plastic material (Polyvinyl chloride (PVC) or polyethylene (PE)). Within the limits defined by these criteria, the sizing standards that are most likely to be encountered include: Cast Iron Outer Diameter (CIOD); Copper Tubing Size (CTS); and Iron Pipe Size (IPS).

What are the pipe sizes that correspond to the various standards?

The table on the following page lists, for illustration purposes, the differences between the salient dimensions for each of the previously-mentioned pipe standards. The range of sizes is limited to those that might typically be used for pasture pipelines. Note that the IPS standard has two methods for defining the reference dimension of the pipe; ID-based and OD-based. Also note that the thickness of the pipe wall, which will determine the inside diameter (or outside diameter for OD-based IPS pipe) will depend on the material comprising the pipe, and the internal pressure the pipe is capable of withstanding. PVC pipe is generally available primarily in OD-based IPS pipe sizes, although it is also available in CIOD sizes for larger-diameter pipes. Polyethylene pipe that is most commonly used for pasture pipeline applications is available as either ID-based or OD-based IPS sizes, or CTS sizes if referred to as "tubing".

Reference Dimensions for Various Pipe Size Designations

Iron Pipe Size (IPS) (OD Based)	
Nominal Pipe Size (inches)	Outside Diameter (inches)
½	0.840
¾	1.050
1	1.315
1½	1.900
2	2.375
2½	2.871
3	3.500
4	4.500

Iron Pipe Size (IPS) (ID Based)	
Nominal Pipe Size (inches)	Inside Diameter (inches)
½	0.622
¾	0.824
1	1.049
1¼	1.380
1½	1.610
2	2.067
2½	2.469
3	3.068

Copper Tubing Size (CTS)	
Nominal Pipe Size (inches)	Outside Diameter (inches)
¾	0.875
1	1.125
1¼	1.375
1½	1.625
2	2.125

Cast Iron Outside Diameter (CIOD)	
Nominal Pipe Size (inches)	Outside Diameter (inches)
4	4.800

What is "Schedule" pipe?

Schedule pipe is typically used only in industrial applications, although it may be encountered in pasture pipeline applications if the user is purchasing previously-used pipe. Plastic Schedule pipe is available in both polyvinyl chloride (PVC) and polyethylene (PE). For nominal pipe sizes 12 inches and smaller, outer diameters of schedule pipe are the same as those of IPS pipe; for schedule pipes larger than 12 inches nominal diameter, the OD is the same as the nominal diameter. Unlike other pipe standards which fix one dimension and allow the other to vary depending on the pressure capability of the pipe, the "Schedule" system fixes both the inside and outside diameter of the pipe for a given nominal diameter.

For steel pipe, the schedule number originally reflected the pressure capacity of the pipe, and was approximated as 1000 times the ratio of working pressure to allowable stress of the material comprising the pipe. Now, however, because schedule numbers define pipe having fixed outer and inner dimensions, regardless of the material used to manufacture the pipe, pressure capabilities vary with nominal diameter and with material comprising the pipe.

The following table lists dimensions for Schedule pipe:

Dimensions of Schedule Pipe

Nominal Pipe Size (inches)	Outside Diameter (inches)	Schedule 40	Schedule 80
		Inside Diameter (inches)	Inside Diameter (inches)
½	0.840	0.602	0.526
¾	1.050	0.804	0.722
1	1.315	1.029	0.936
1¼	1.660	1.360	1.255
1½	1.900	1.590	1.476
2	2.375	2.047	1.913
2½	2.875	2.445	2.290
3	3.500	3.042	2.864
4	4.500	3.998	3.786

Are there any other aspects of pipe nomenclature that might be confusing?

The strength or pressure ratings of plastic pipe are sometimes used to classify the pipe, and are referred to in a number of ways. For pipe using the "Series" or "Class" designation, the number following these classification labels indicates the maximum working pressure (in pounds per square inch) for the pipe, within a defined temperature range. In the SDR (Standard Dimension Ratio) system, for a given SDR number, all pipes composed of a given material will have the same pressure rating. However, it should be noted that PE and PVC pipe having the same pressure rating will have different SDR numbers because the mechanical characteristics of the material comprising them are different. It should also be noted that regardless of the "Class", "Series" or "SDR" designation, the pipe in question will conform to one of the sizing standards described previously.

While the "Series" and "Class" designations are relatively straightforward, the SDR designation might benefit from additional explanation. SDR is defined as the ratio of the outside diameter to the wall thickness of the pipe. For example, consider a PVC pipe with a nominal size of 2 inches and a Series designation of 160. For this pipe, the "Series 160" means that it is rated for a working pressure of 160 pounds per square inch (psi). The manufacturer's literature indicates that this pipe would have the following dimensions:

Outside Diameter (OD): 2.375 in.
Wall Thickness (t): 0.091 in.

$$SDR = \frac{OD}{t} = \frac{2.375}{0.091} \cong 26$$

By comparison, consider high-density PE pipe having the same Series rating (160) and nominal diameter. For this pipe:

Outside Diameter (OD): 2.375 in.
Wall Thickness (t): 0.175 in.

$$SDR = \frac{OD}{t} = \frac{2.375}{0.175} \cong 14$$

Note that both of these pipes are OD-based IPS sizes.

The Bigger Picture

A pasture pipeline can consist of pipe composed of various materials and sizes. To ensure that all of the components comprising the system fit together, it is important to know which standards the pipe and fittings were manufactured to meet. For other information relating to the planning and

development of pasture pipelines, as well as for additional information on livestock watering, refer to other fact sheets in this series or contact your local AAFC-PFRA office.

UNIT ABBREVIATIONS

psi - pounds per square inch	kPa - kilopascal	gpm - gallons per minute
mm - millimetre	m - metre	ft - feet
in - inches	km - kilometre	L/s - litres per second

UNIT CONVERSIONS

1 US gallon = 3.785 litres	1 cubic metre (m^3) = 1,000 litres	1 metre (m) = 3.28 feet
1 Imperial Gallon = 4.546 litres	1 kilometre = 1,000 m = 0.62 miles	1 psi = 6.985 kPa
1 inch = 25.4 mm	1 psi = 2.307 ft of water	

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