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# Pump Up The Volume

Pressure increase (fill rate) may be important for many of the same reasons as the rate of pressure decay. This might include pneumatic time delays, plumbing capacity, the flow or Cv of Valves, Filters and other components.

The fill rate, pump up, time can also determine the capacity and the volume of an unknown system.

Previously we explored the decay rate of compressed air. You may recall the formula for pressure decay **[P2=P1 x e^-t/Tk]** and the Time Constant concept. Now it gives me great pleasure to point out the other side of the story or the rate of pressure increase when filling a volume. The good news is that when all things are equal the fill, or pump up, rate curve is a mirror image of the decay curve.
Fortunately this makes working with both applications easier to understand and to use. See Figure 1.

**Time Constant (Tk)**

1. Choose a pressure and select a reservoir. Convert the volume to cubic feet. Many tanks and reservoirs are rated in gallons. To convert gallons to cubic feet divide gallons by 7.48. A ten gallon reservoir is 10/7.48 = 1.34 cubic ft.

2. For Standard Cubic Feet **(SCF)** (Cubic feet x P1 PSIG / 14.7).

3. Select the orifice or device to fill the reservoir for flow rate, SCFM.

4. Divide **SCF** by the flow rate, **(SCFM x 60)** for **Tk** (Time Constant) in seconds. The Time Constant, Tk, is the time to fill the reservoir at the initial rate, SCFM.

**V (CUFT) X P1(PSIG) X 60 / [14.7 X SCFM] =Tk (**TIME CONSTANT, SECONDS)

The **second method** of finding the time constant is empirical.

1. Note the reservoir pressure (0 psig in most cases).
2. Note the pressure to fill the reservoir.
3. Start the fill flow.
4. Note the time to reach 63% of inlet pressure, psig [P1x (1-e^-1) or P1x .63].

By either method this time constant (Tk) is unique to this specific volume and the key to determine all the main facts. This specific amount of time is the same for filling or discharging the pressure within it by the law of organic growth or decay. For charging (filling) the volume the formula is **P2 = P1 x (1 - e^-t/Tk)**. The elapsed time is "t", in seconds.

TIME DELAY [P2 = P1 x (1-e^ - t/Tk)]
Establish Tk (Time Constant) as outlined above selecting pressure, volume and flow rate. The desired time may then be any time equal to or less than 5 times Tk. The desired time may be selected and adjusted with a variable set point (pressure switch), variable pressure setting (regulator) and adjustable flow device (needle valve).

UNKNOWN VOLUME [ P1(psig), Q(scfm) known, Tk(sec. to .63 x P1 found).

CLOCK [Tick –Tock] Fill and turn off at high pressure. Decay and turn on at low pressure.

Figure 1.