ALL ABOUT AIR series White Paper #26
PUMP UP THE VOLUME © Tom Kreher

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 sometimes referred to as Relaxation Time.

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. Also the time constant structure is consistent in both cases. The amount of time that would fill the volume to 63% of the inlet pressure [P1 x (1- e^-1) is one time constant. A total of 5 time constants will fill the volume to 99+%.

See Figure 1

Calculated Time Constant (**Tk**)

1. Chose 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. Std. Cubic Feet (**SCF) =** V(cubic feet) x P1(psig) / 14.7) filled to P1.
3. Select the orifice or device to fill the reservoir for flow rate, **SCFM**.
4. Divide **SCF x 60 / SCFM = Tk** (Time Constant) in seconds. * .

<u>V (CUFT) X P1(PSIG) X 60 / [14.7 X SCFM] =Tk(sec.)Time Constant</u>

Empirical Time Constant (Tk)

Use this method if the flow rate is known or a flowmeter is used.

FYI The initial flow rate is gradually reduced with the changing pressure ratios. The pressure in the volume at the end of the first time constant is 63% of P1. If the initial flow rate remained unchanged it would fill the volume to 99+% of P1 in one time constant. In practice 5 time constants fill the volume to P1. We can find the time constant , Tk, by simple observation as follows:

1. Note the reservoir pressure (0 psig in most cases).
2. Note the pressure to fill the reservoir.
3. Start the fill flow and the clock.
4. 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

ALL ABOUT AIR series White Paper #26
PUMP UP THE VOLUME © Tom Kreher

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)** Elapsed time “t” (sec.) divided by time constant, Tk, is negative exponent of e.

TIME DELAY [P2 = P1 x (1-e^ -t/Tk)]

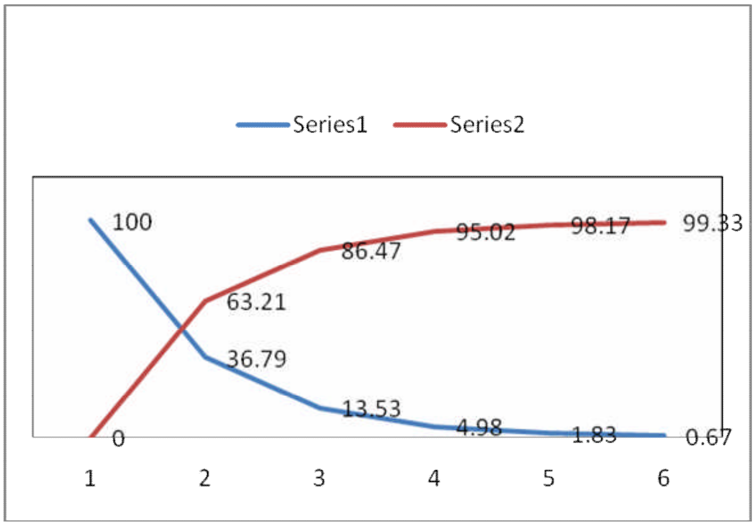

FIGURE 1

Enter the desired time, t, in the formula to determine P2 at that elapsed time.
The desired time may 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 top change P1) and adjustable flow device (needle valve).

UNKNOWN VOLUME [P1(psig), Q(scfm) known, Tk (Time to reach to .63 x P1)
A device, orifice, flowmeter with a known flow rate establishes Q(scfm).
Q(scfm) x Tk /60 = SCF

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