Pump ED 101

Planning for System Growth – Doubling Time

Joe Evans, Ph.D http://www.pumped101.com

The small town of Groin MO has an excellent source of water. The water board says that their wells and distribution system are loafing along at about half their maximum capacity. Since demand is growing at less than 2% per year, they feel comfortable that the current system should be more than adequate for many years to come. The city council; however, has concerns. Groin is increasing in popularity with many families who are tired of the crowding in the city of St. Louis about thirty miles away. Their survey data indicate that Groin's population could increase by 5% per year. If we assume that water usage in the future will be directly proportional to the number of residents, how long will their existing system last? But, what if our assumption of water usage is incorrect? After all, as a population grows more than just individual consumption must be satisfied. With a greater number of residents, there will be more swimming pools and hot tubs and irrigation will increase dramatically. If actual demand were to increase by 7% annually, how long will the current system last?

Certain types of change, such as population growth, can be difficult to fully comprehend. On the other hand, changes that occur in some straight forward proportion are much easier to grasp. For example, if I said that gas prices increased from $2.00 to $4.00 per gallon during 2008 you would immediately recognize that they doubled. This is not necessarily the case when change is continuous and steady over some long term. When change occurs at a steady rate, we refer to it as exponential. The affinity laws, for instance, tell us that the head developed by a centrifugal pump varies as the square of a change in speed while horsepower varies as the cube. We think we understand the effect of these exponents, but do our brains really comprehend their magnitude? The following exercise will introduce you to their often unexpected influence.

Take a plain sheet of 8.5 X 11 inch copier paper and fold it in half from top to bottom. Fold it in half again from side to side. Continue folding it in this fashion until you have completed ten folds. Go ahead and do it now before reading any further.

Now, if you somehow knew that this exercise was an impossible task, you may already have a good understanding of the exponential function. If, however, you forged ahead on faith alone, you should definitely continue reading. What you probably noticed as you folded the paper was that it went pretty smoothly for the first four or five iterations. The sixth fold was more difficult and the seventh was virtually impossible. In attempting to fold the paper back upon itself you were witnessing the exponential function in action. Each time you folded it, the number of layers and therefore its overall thickness doubled. After one fold there were two layers of paper (2^1), after two folds there were four (2^2), after three folds - eight layers (2^3), and so on. Had you been able to fold it nine times (2^9) there would be 512 layers -- about the thickness of a ream of copier paper (2"). That tenth fold (2^{10}) would have produced the equivalent of two reams! All in all, your single sheet would result in a pile almost four inches thick! If you could continue this process for another 15 folds (a total of 25 (2^{25})) the result would be a stack a little over two miles high! And, if you could complete 50 folds (2^{50}) a 70 million mile high monster would appear before you!

Now, do not be concerned if you attempted to complete this exercise. When confronted with such an apparently simple task, most of us will do the same thing. Let it be a lesson though - - numbers can fool us, and especially when they are presented in a way that is not intuitively obvious. An important component of exponential change is something called doubling (or halving) time. Doubling time is the time it takes for something, growing at a steady rate, to double in size. The reason it is so important is because doubling (or halving) is a much easier concept for us to comprehend where as the exponent itself may not be. The following simple equation allows us to calculate doubling time based upon some steady rate of growth.

Doubling Time = 70 / %Growth Rate

Here is an example all of us can appreciate. The doubling time equation predicts that an investment returning 10% annually will double in value every seven years. This, of course, is known as compound interest and represents interest earned on both the principle and interest.

In our example, the town of Groin was experiencing an increase in demand of less than 2% per year and its system was operating around 50% capacity. If this continued the existing system would be good for about 35 years. But, the city council forecasts a population growth rate of 5% each year. Upon first glance this doesn't seem to be an unusually large increase (just 3%) but, based upon the exponential function and the doubling time equation above, the population (and water usage) will double in just 14 years. An increase of just 3% reduces the system life by 60%. Suppose our estimate was wrong and the actual increase in usage is 7% per year. This would reduce the remaining life of the existing system to just 10 years!

It becomes easy to see the importance of doubling time. It takes some pretty "fuzzy" numbers and puts them in a perspective we can readily comprehend. Planning and building for growth is an ongoing process. In the case of Groin, ten years is not a long time especially when one considers the services that must be scaled up to meet the needs of a growing population. Doubling time is a tool that can help portray exponential change in a more understandable format.

Joe Evans is responsible for customer and employee education at PumpTech Inc, a pumps & packaged systems manufacturer & distributor with branches throughout the Pacific Northwest. He can be reached via his website www.PumpEd101.com. If there are topics that you would like to see discussed in future columns, drop him an email.