Hydraulic
Accumulator
Division

Application News

2003

Volume 3
Issue 4

Effects of Precharge Properties on Accumulators:

When applying an accumulator in a hydraulic system, it is very important to understand the property of nitrogen. Since nitrogen will pretty much follow the ideal gas laws at low pressure (under 300 psi and temperatures between 30ºF up to 100 ºF) once these parameters are exceeded the gas will deviate from the ideal gas laws and follow the real gas laws.

Since the precharge in the accumulator is effected by the change in a gases behavior, it is very important to understand a little about the properties of nitrogen.

We know the output of an accumulator, or the useable volume of an accumulator between two distinct pressures is determined by the accumulator having the proper precharge at the operating temperature. If the precharge is too high, we know the accumulator will not take in the correct amount of fluid, resulting in less fluid being discharged from the accumulator to do work between the minimum and maximum pressure. If the precharge is too low, we know the accumulator will take in more fluid, but there will be less fluid. available to do the work between the minimum and maximum pressure.

Parker Hydraulics

Accumulator Gases

By Walt Flippo

Properties of Nitrogen

Nitrogen is the recommended gas to be used to charge an accumulator. Gases whose compressibility factors are not unity are referred to as actual gases. What causes these gases to deviate from the ideal gases? It is assumed that the molecules of an ideal gas behaves as perfect elastic spheres, that intermolecular attraction has very little effect and molecular size is insignificant when compared to the total volume. Any changes or deviations from the above assumption cause a real gas or actual gas to deviate from the ideal gas laws.

Since we recommend that dry nitrogen be used in gas charged accumulators to prevent corrosion and oxidation, the thermodynamic properties of nitrogen should be understood. Since nitrogen does not fit the ideal gas laws, the compressibility factor deviates from unity at higher pressures and temperatures. In most accumulator applications, we are compressing the gas to high pressures and high temperatures. Since nitrogen can act like an ideal gas under certain conditions and like a real gas under other types of conditions, we can divide the operation of an accumulator into two types of operations: one being isothermal and the other being adiabatic.

Isothermal Operation

"Isothermal" describes the operation of an accumulator in such a manner as to maintain a constant temperature. Isothermal operations require the rate of expansion or compression of the gas in the accumulator is at such a rate that the gas temperature inside the accumulator remains relatively constant throughout the entire cycle. This isothermal process is accomplished by slowly letting the gas inside the accumulator expand and/or compress. The heat that is generated from the compression of the gas is dissipated through the walls of the accumulator or, in the case of expansion, heat is drawn in through the wall of the accumulator thus maintaining a relatively stable gas temperature. The equation below represents an isothermal process.

$$P_1V_1^n = P_2V_2^n$$

$n = 1$ Polytropic Exponent

Adiabatic Operation

"Adiabatic" describes the operation of an accumulator in such a manner that the gas temperature inside the accumulator does not remain constant. The gas temperature inside the accumulator increases/decreases at a high rate due to the rapid compression or expansion of the gas - as a result, the gas temperature changes. In the case of compression, the heat being generated by the compression of the gas cannot be dissipated through the walls of the accumulator fast enough, so the gas retains some of the heat resulting in an increase in pressure. In the case of expansion, the gas temperature drops rapidly and enough heat cannot be drawn in through the wall of the accumulator to maintain a constant gas temperature, therefore the gas temperature drops. When the gas temperature drops, so does the pressure. The equation below represents an adiabatic process.

$$P_1V_1^n = P_2V_2^n$$

n = Polytropic Exponent varies depending on the gas in use, gas pressure and temperature