ABSTRACT
Removing water, oil and particulates from a vehicle's air brake system is the most basic function of all Haldex air dryers. Regeneration of the air dryer is accomplished via the pressure swing cycle and isothermal purge theory. This paper describes how Haldex applies the Pressure Swing and Purge Theory to the new DRYest and PURest Air Dryers.

Introduction
Air brake systems are susceptible to problems of corrosion and damage of air actuated components by the passage of water, oil and other contaminants. Severe damage may even occur in cold weather when moisture in the compressed air brake system condenses and freezes. The benefits of using an air dryer are to: 1) Decrease downtime losses due to air brake component failures; 2) Reduce routine maintenance; and 3) Minimize the frequency of repair.

Source of the Problem
As the temperature for the exhaust of the air compressor increases, it can subsequently contain more water and oil vapor before it becomes saturated. The opposite is true for increasing pressures. Most air brake systems operate between 120 and 160 psi. The compressed air is delivered to a primary reservoir that is exposed to ambient conditions. The compressed air may only approach ambient temperature to within 20°F-50°F before entering the reservoir. The hot compressed air could carry over oil and water vapor and as the air continues to cool, liquid water and oil will accumulate in the primary reservoir and possibly other air brake components. By adding the pressure swing dryer ahead of the primary reservoir, these problems are avoided.

Pressure Swing Desiccant Dryers
Since air brake systems are exposed to the environment, the compressed air will have a significant temperature change imposed by normal daily temperature cycles. The dryness requirement in typical air brake systems is 20°F-60°F dew point depression. To attain this degree of dryness, it is necessary to remove water and oil vapor in addition to entrained and condensed liquid water and oil. A desiccant dryer can take full advantage of the normal intermittent service of air compressors by regenerating the desiccant immediately after the completion of the duty cycle.

Pressure Swing Theory
A pressure swing adsorption process adsorbs water at high total pressures and desorbs water at low total pressures (i.e., compression and purge cycles). Water is carried out of the cartridge by using a fraction of the dried higher pressure air in the air dryer purge reservoir or the brake system secondary reservoir. Since air has a higher saturated water content at the lower pressures, only a fraction of the dried compressed air needs to be used to remove an equivalent amount of water from the adsorbent.

Figure 1 shows a functional diagram of the internals of a typical desiccant dryer. When the pressure in the primary reservoir falls below its minimum allowable level, the
Pressure Swing Theory

... compressor engages and begins to pump up the reservoir. Air from the compressor enters the internal desiccant chamber. The air swirls around and down along the cool surface of the external housing, condensing water and coalescing oil droplets in the process.

While the water and oil droplets are collected in the sump, the air changes direction 180° and begins to flow up through the bed of desiccant. The air passes through the bed and is dried on the way. Dried air exits the top of the dryer and flows to the primary reservoir.

While the primary reservoir is being pumped up with dry air, a fraction of this air is saved for the purge volume. When system pressure is reached in the primary reservoir, the compressor disengages and activates the purge valve in the air dryer. The pressure within the desiccant chamber is quickly reduced to atmospheric pressure. The purge air path is the opposite direction from the adsorption (loaded) path. The dry purge air flows over the desiccant and picks up water and oil until it exits the air dryer.

Effects of Oil in the Desiccant Bed

Figure 2 is data obtained from UOP®. It indicates that “oil-soaked” molecular sieve (desiccant) will increase outlet air dew point by approximately 50%. The loss is largely attributable to an increase in mass transfer resistance due to layer of oil which impedes the rate at which water vapor is transferred from the gas phase to the desiccant surface.

Therefore, it is critical that in order to maintain optimum water drying efficiency, the desiccant must be free of liquid and oil vapor.

Adoption of Theory to DRYEst and PUREst

The Haldex Multi-Treatment Cartridge (MTC) uses basic pressure swing theory. However, Haldex engineers have also applied the theory in a way that protects the core desiccant from getting excessive oil contamination. In doing so, the Haldex MTC has proven itself as the industry leader in real world drying efficiency.

In other words, Haldex Air Dryers are the best at preventing ALL contaminants (water, oil and solid particles) from entering into the air brake system.

The patented idea of the MTC is to direct the contaminated air through a path of five unique filters. Each filter is designed to remove a specific contaminant with the underlying objective being to protect the inner desiccant from oil and other contaminants. See the Multi-Treatment Cartridge Data Sheet (L25046) for further details.