Air Conditioning and Lubrication

Prepared By: Hamoudi Dakik BASc, Chemical Engineer • ZEC Lubrication • April 18, 2013

Oil build-up (or coking) in large-scale air-conditioning or refrigerant systems (AC/R) of any kind can cause significant performance degradation, leading to higher energy costs, more system maintenance and a shorter lifespan of the unit. There are numerous mitigation strategies available to HVAC/R specialists to increase system performance and Energy Efficiency Rating (EER), but one of the most cost-effective is the use of an oil additive strategy.

This paper explains how ZEC Lubrication's AC-XL product can dramatically reduce oil coking in AC/R systems leading to large increases in efficiency, including a more than 20% increase in cooling output.

I. OVERVIEW

The ASHRAE Handbook 1998, "Effects on Heat Transfer" states: "Oil fouling of the heat transfer surfaces of air conditioning and refrigeration systems will cause a loss of about 7% efficiency the first year and 2% per year the following years."

Over a 6 year period that results in the following dramatic degradation of performance:

Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
100%	93%	91.1%	89.3%	87.5%	85.8%	84.1%

This loss of performance, combined with the fact that cooling is one of the highest sources of energy consumption in a typical US office building (see Figure 1), provides a significant opportunity for improved energy consumption. Given today's high cost of energy, the payback for improved efficiency of an AC/R unit can be compelling.

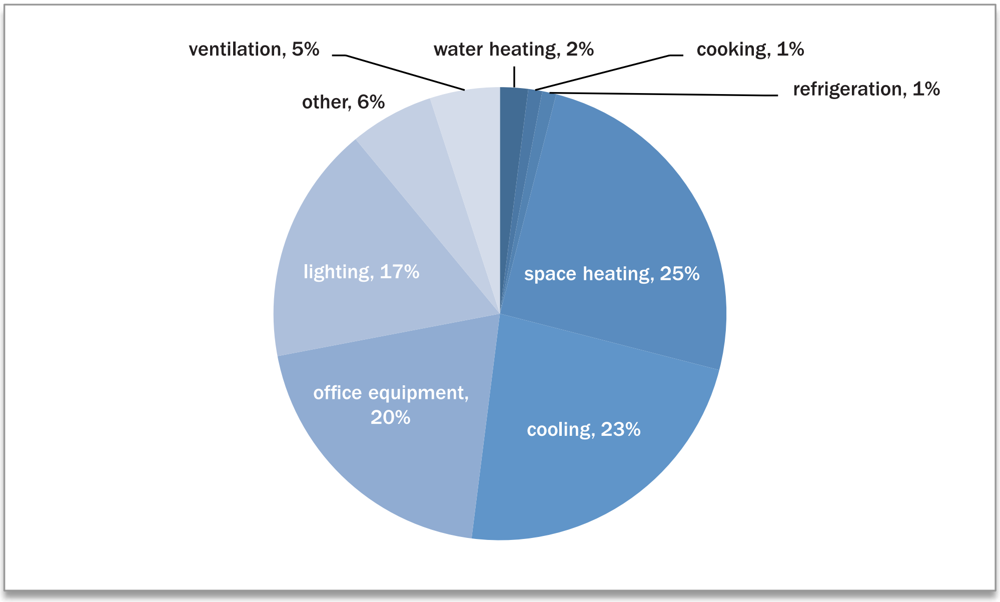


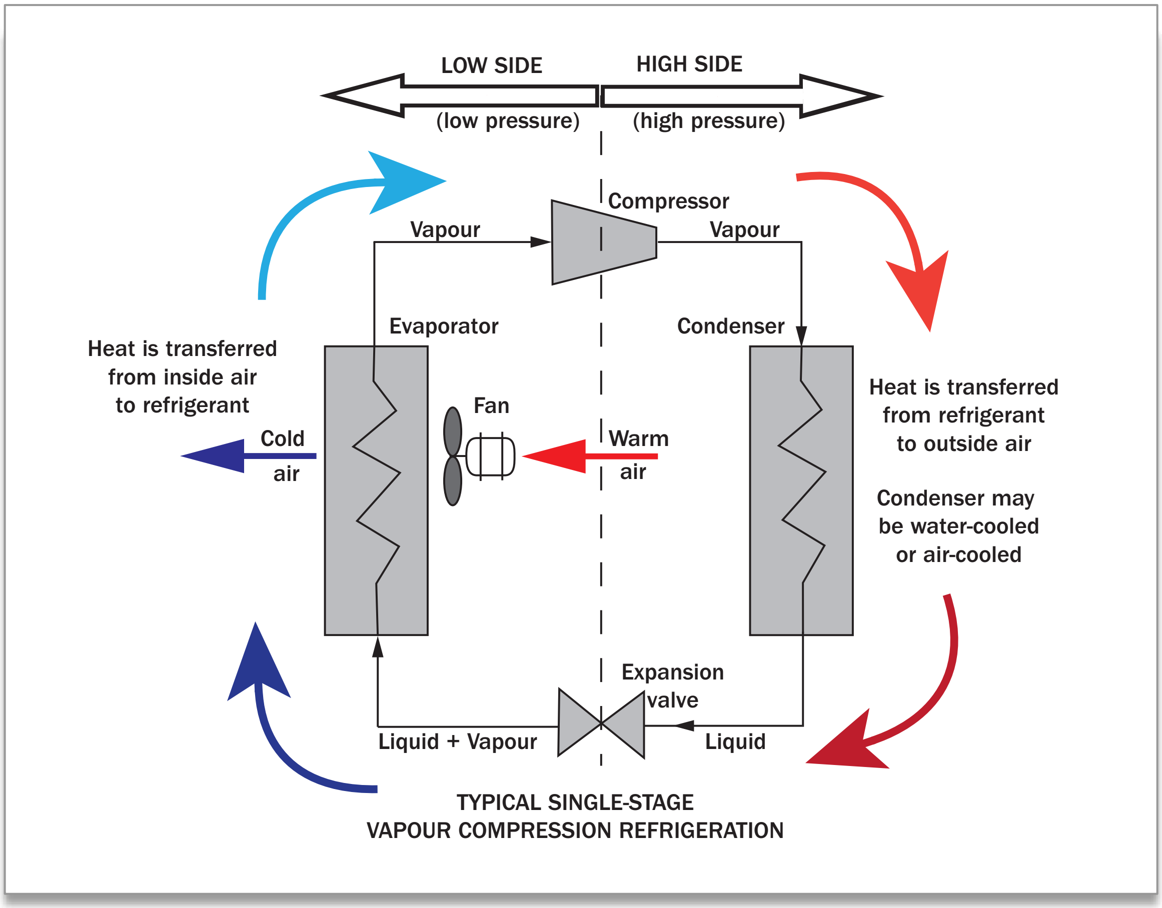
Figure 1: End Use Energy Consumption Data
(Source: Esource.com, Managing Energy Costs in Office Buildings)

II. PROBLEM AREAS IN A TYPICAL AIR CONDITIONING UNIT

Air Conditioners (AC) are designed to modify the air temperature and humidity within a closed area. The primary components of an AC unit are: condenser, expansion valve, evaporator, and compressor (see Figure 2). These are also the four areas where oil coking can cause a loss of efficiency.

Any solution that attempts to improve energy efficiency through reduced oil coking needs to target all four of these components, provide compatibility with common refrigerant gases and lubricants, all while reducing negative side effects such as pipe corrosion.

Figure 2: Refrigeration Cycle



Primary Components Description and Problem Areas

AC compressors, condensers, evaporators and expansion valves all suffer adverse effects as a result of oil coking, which contributes to the performance degradation that impacts all AC units. When the refrigerant fluid passes through the system and a small amount of compressor oil is carried with it, the oil leaves coke deposits on the surface of the metal.

The table below outlines the performance issues for each of these components as a result of oil coking.

AC Component	Description	Performance Issues as a Result of Oil Coking
Compressor	The compressor uses an electrical motor to provide the necessary work to pressurize a gas; in an automobile this is accomplished by the drive belt. The function of the compressor is to keep the fluid in the system moving forward as well as to pressurize the hot refrigerant gas prior to it being sent to the condenser.	• High friction between piston and cylinder wall • Lower compression ratios • Use more KW and have less BTU, reduces EER • Continuously running • Potential for ice build-up
Condenser	The high pressure vapour that enters the condenser will liquefy by releasing heat to the outside air as a result of the change in enthalpy. The hot liquid then travels through the expansion valve to be changed back into a vapour.	• Lower heat transfer due to coke deposits • Narrows pathways and creates an insulation barrier not allowing heat to escape • Higher pressure drops due to reduced gas flow
Expansion Valve	The expansion valve is a flow restricting medium that will cause a pressure drop in the fluid passing through it. Because the pressure at the inlet of the valve is greater than the outlet, the fluid will naturally flow through the orifice. The change of pressure will create a low pressure fluid to be sent to the evaporator.	• Coking changes orifice size creating unwanted pressure changes • Coking will cause the orifice to stick, unable to adjust positions
Evaporator	The fluid that enters the evaporator will vaporize into a gas by absorbing heat in the process as a result of the change in enthalpy. A fan moves air through the coils of the evaporator to provide cold air to the air conditioned space as shown in Figure 2. The hot gas then travels back to the compressor for the cycle to be repeated.	• Lower heat transfer due to coke deposits • Narrows pathways and creates an insulation barrier not allowing heat to absorb and release cold air • Higher pressure drops due to reduced gas flow

COMMONLY USED REFRIGERANTS AND LUBRICANTS

Different AC units use different types of refrigerant fluids and lubricants, depending on the category of refrigerant being used. Any solution that attempts to address the oil coking problem must ensure compatibility with these different types of refrigerants.

Refrigerant Category	Types of Refrigerant Fluid	Types of Lubricant
Chlorofluorocarbons or CFCs	R-11, R-12, R-114	Mineral oil, Polyalphaolefin (PAO), AlkylBenzene (AB)
Hydrochlorofluorocarbons or HCFCs	R-22, R-123, R-401A	Mineral oil, Polyalphaolefin (PAO), AlkylBenzene (AB)
Hydrofluorocarbons or HFCs	R-134, R-410A, R-404A, R-507	Polyol Ester (POE), PAO
Ammonia	R-717	Mineral oil, Polyalphaolefin (PAO), AlkylBenzene (AB)
Carbon-Dioxide	R-744	PAO, Esters, Polyalkylene Glycol (PAG)

III. AC-XL: OIL ADDITIVE DESIGNED FOR AC AND REFRIGERANTS

The AC-XL lubrication additive is non-halogenated and does not contain any sulfur, phosphorus, corrosive compounds or toxic heavy metals making it compatible and appropriate for AC units. It is an extreme pressure lubricant that uses polar technology to adhere itself to metal surfaces under high friction and temperature. Traditional compressor lubricants are unable to handle high temperature and pressure conditions; the result being a decrease in the functional lifetime of the equipment.

When AC-XL is first added to the system, the active polar components remove the coke from the tube walls. As the coke is removed from the metal surface, a one molecule thick layer of additive will bond to the surface of the metal and will deter the formation of further coking where AC-XL is bonded. This layer allows closer and more frequent contact of the additive molecules and the metal surface, allowing for a better heat transfer coefficient and reduced pressure drop.

Creating this one molecule thick boundary in the compressor allows for much lower friction factors at higher pressures, in turn allowing it to run more smoothly. AC-XL therefore has the capacity to restore efficiency to more worn units; this will allow for shorter run-times, better heat transfer in the evaporator and condenser, reduced friction and wear in the compressor, and reduced energy costs by simultaneously increasing your BTU output using less Kilowatts of energy, therefore increasing the EER.

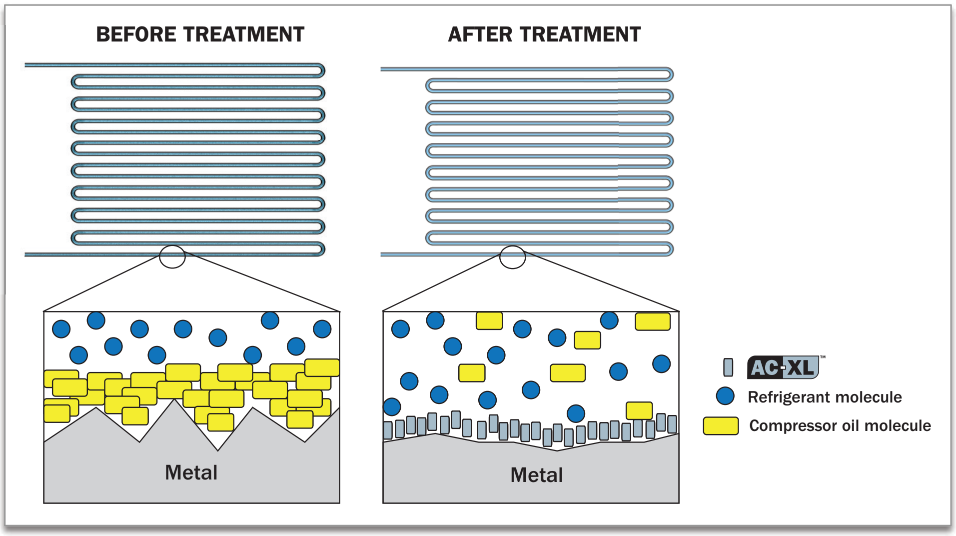


Figure 3: Before and After Effects of AC-XL on Pipes with Coking

The table below explains how AC-XL addresses the performance issues related to oil coking.

AC Component	Performance Issues as a Result of Oil Coking	AC-XL Solutions
Compressor	• High friction between piston and cylinder wall • Lower compression ratios • Use more KW and have less BTU • Continuously running • Potential for ice build-up	• Extreme pressure component cleans coke and creates one molecule thick barrier to protect metal surface • Increases compression ratios and increases BTUs while decreasing KW consumption, increasing Energy Efficiency Rating (EER) • Decreases run times • AC-XL is non-hygroscopic, resists moisture absorption and therefore no ice forms on the metal surface
Condenser	• Lower heat transfer due to coke deposits • Narrows pathways and creates an insulation barrier not allowing heat to escape • Higher pressure drops due to reduced gas flow	• Cleans coke and creates one molecule thick barrier to protect metal surface from future coke deposits • The thin layer allows more refrigerant to pass through and closer to metal surface increasing heat transfer coefficient and reducing pressure drop resulting in lower energy consumption and better heat transfer
Expansion Valve	• Coking changes orifice size creating unwanted pressure changes • Coking will cause the orifice to stick, unable to adjust positions	• Cleans orifice allowing it to function properly with proper pressure changes • Brings it back to original ratings
Evaporator	• Lower heat transfer due to coke deposits • Narrows pathways and creates an insulation barrier not allowing heat to absorb and release cold air • Higher pressure drops due to reduced gas flow	• Cleans coke and creates one molecule thick barrier to protect metal surface from future coke deposits • The thin layer allows more refrigerant to pass through and closer to metal surface increasing heat transfer coefficient and reducing pressure drop resulting in lower energy consumption and better heat transfer

AC-XL is compatible with any CFCs, HCFCs, HFCs, Ammonia and CO2 systems.

Third party tests have shown the AC-XL formula to be an effective measure to immediately reduce coking on an AC/R unit, resulting in an increase of cooling power by more than 20%. The resulting increase in energy efficiency will lead to significant reduction in maintenance costs on the system.

IV. SUMMARY

AC/R units have become a required part of modern life in places with warm climates, however they require a high amount of energy use and associated cost. There are many strategies available to reduce these energy costs, but most of them require high upfront investment and/or the purchase of new equipment. Reducing a common performance degradation issue such as oil coking through an oil additive strategy is a cost effective way to see improved energy efficiency, while extending the life of your AC unit.

V. ABOUT

ZEC Lubrication provides a family of industrial-grade oil additives that significantly improve mechanical performance. The ZEC Lubrication oil additives were first formulated over 15 years ago for use on heavy machinery in Northern Ontario's mining region. Since that time, the formula has been proven in a wide range of industry applications, including engines of all sizes, gears, hydraulics and large-scale cooling systems.

The AC-XL oil additive product has been specifically designed for use in cooling systems and can improve cooling capacity by more than 20%. The AC-XL formula uses active polar molecule (APM) technology to target the built-up oil layer in a cooling system, resulting in increased heat transfer and dramatically improved energy efficiency. For more information visit www.zeclubrication.com.