

The Risks of Low Quality Refrigerants





Introduction

In the current landscape of continually evolving regulations to meet global environmental goals, there is no lack in diversity when it comes to the portfolio of available refrigerants. Due to the abundance of refrigerant options and associated confusion with respect to their differences, cost is often given a significant weight when deciding which refrigerant to select. Cost, however, is a small piece of the larger picture.

Refrigerant design and selection by application is based on the optimum combination of properties,

including latent heat of vaporization, thermal conductivity, density, viscosity, oil solubility, toxicity, flammability, cost, safety, environmental impact, and others. Poor refrigerant quality (also referred to as purity) can have adverse effects on these critical properties. Without the adherence to a recognized and well-defined quality standard, the end-user has no assurance that a refrigerant will perform as advertised. Moreover, there is no guarantee that one charge of refrigerant will perform the same as the next.

Chemours brings over 85 years of history and proven leadership in refrigerant science and pioneered much of the technology that makes air conditioning and refrigeration possible today. This rich history is a direct result of a commitment to product quality.

Purity Standards

The ASHRAE Refrigeration handbook states that “the primary resource for refrigerant purity specification and composition information is the Air Conditioning, Heating, and Refrigeration Institute’s (AHRI) Standard 700.”¹ This standard establishes purity specifications, verifies refrigerant composition, and specifies the associated methods of testing for acceptability of listed refrigerants. Purity is quantified in AHRI Standard 700 by assigning limits to contaminants, including moisture, non-condensables, volatile impurities, high boiling residue, particulates and solids, acidity, and chloride.²

Chemours Freon™ and Opteon™ refrigerant lines are manufactured, packaged, and tested to meet AHRI Standard 700. While adherence to this standard is voluntary, it provides more than just peace of mind to end-users. Significant impacts to system operation, total cost of ownership, and user safety could occur due to poor refrigerant purity.

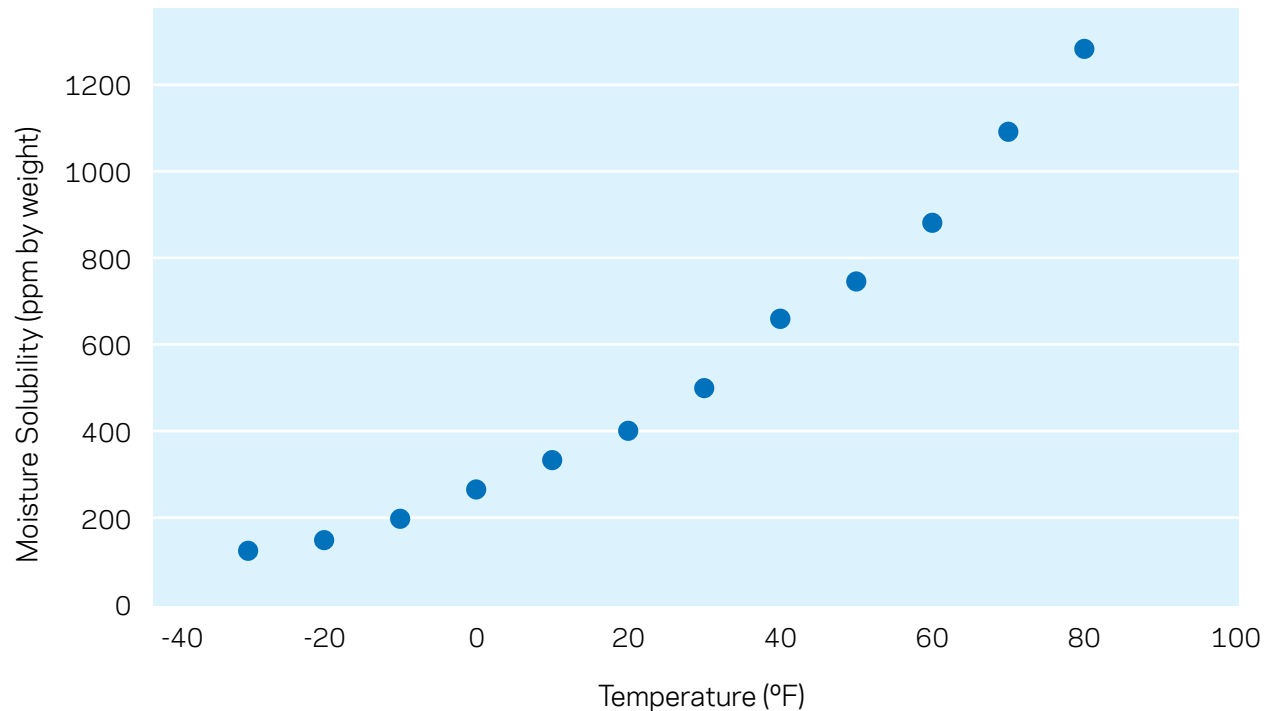
Deviations from Standard

Moisture in a Refrigeration System

The maximum amount of moisture allowed before issues present themselves is a function of the refrigerant being used and the low side

temperature. As an example, the moisture solubility of R-134a over a range of temperatures is shown in **Figure 1**.

Figure 1: R-134a Moisture Solubility vs. Temperature

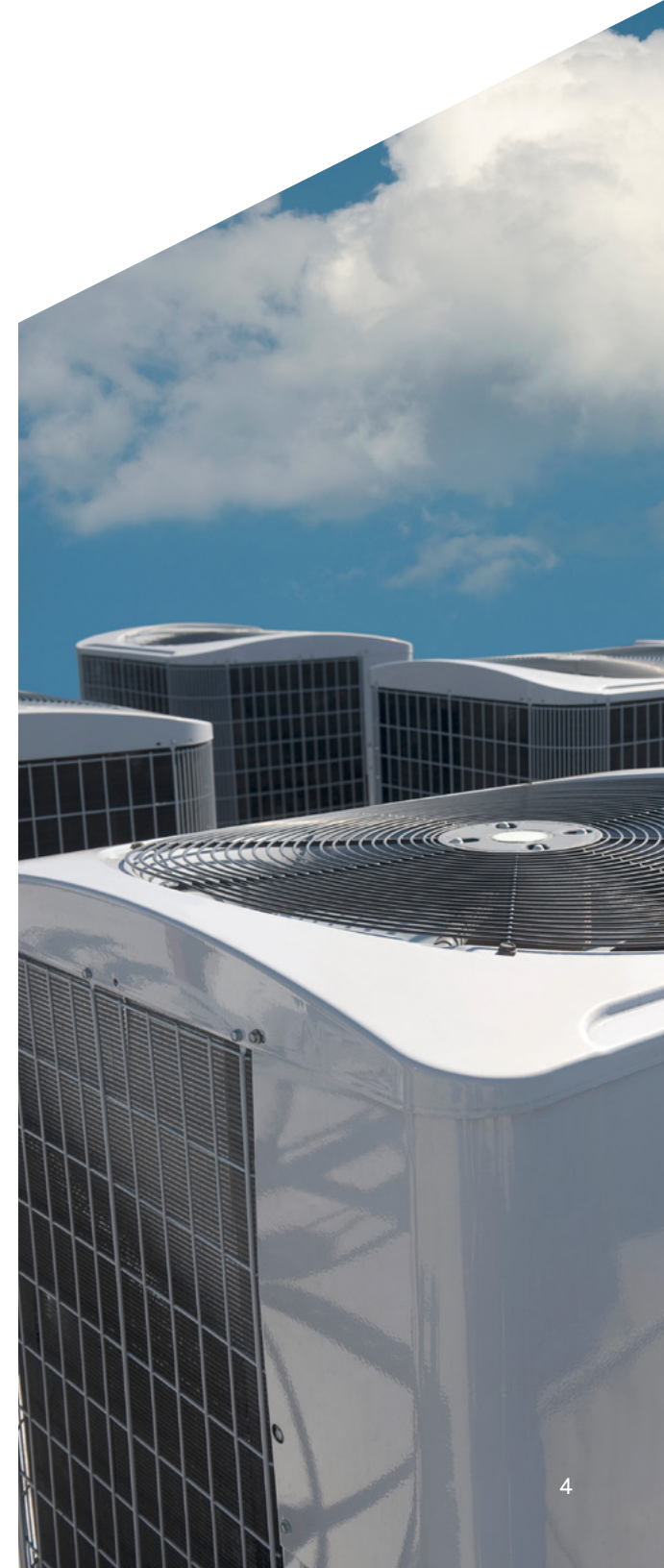
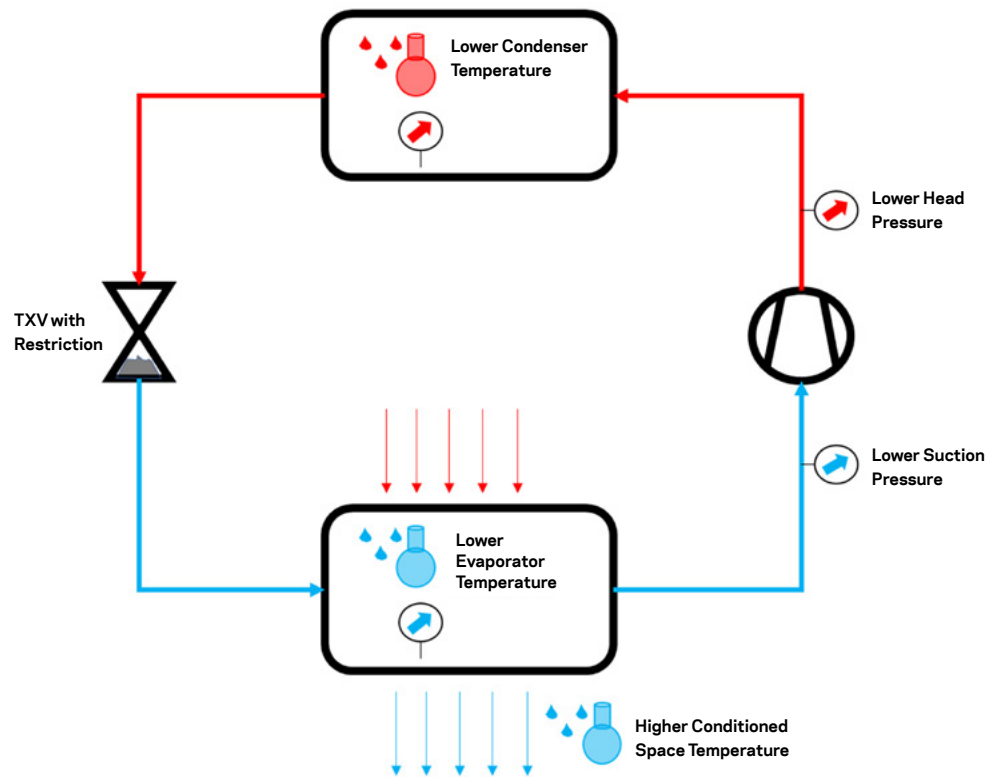


Note: Data on R-134a was obtained from Althouse, Andrew D., et al. Modern Refrigeration and Air Conditioning

Because the moisture solubility of a refrigerant decreases with decreasing temperature, equipment like expansion valves and capillary tubes are especially vulnerable. If temperatures are low enough, moisture will separate from the

refrigerant and freeze. The result is restricted or clogged flow paths.³ Signs of a restricted flow path caused by moisture freezing in an expansion valve can be seen in **Figure 2**.

Figure 2: Signs of a Restricted Flow Path





A restricted thermostatic expansion valve (TXV) or orifice allows less refrigerant to pass into the evaporator. While the resulting lower pressures and temperatures may seem beneficial, less refrigerant passing through the evaporator means less latent heat is absorbed. This will cause the conditioned space or fluid temperature to rise. Conversely, moisture frozen in a TXV can prevent the valve from closing during an Off cycle. This causes the evaporator to flood during the Off cycle, which can lead to liquid carryover to the compressor or short cycling when the system is On.³

In addition to restricted flow paths, moisture in the presence of refrigerants and oils has the potential to create an acidic environment. The effects of acidity are discussed later.

Non-Condensables

Inerts, non-absorbable gas (NAG), non-condensable gas (NCG), or simply non-condensables are all terms used to reference gases such as air, nitrogen, argon, carbon dioxide, and oxygen. When present within a refrigeration system, non-condensables migrate to and are trapped in the condenser. The volume which these gases

occupy reduces the surface area available for the refrigerant to transfer heat, thereby decreasing system performance.

The amount of heat exchanged (q) in a condenser can be expressed using the following equation:

$$q = U_o A_o \Delta t$$

Where U_o is the overall heat transfer coefficient, A_o is the heat transfer surface area, and Δt is the temperature difference that applies to the specific heat exchanger.⁴

With a fixed condenser load (q) required to reject heat (from both the evaporator and the work of compression) and a relatively constant heat transfer coefficient (U_o), the equation above can be used to visualize that a reduction in heat transfer area (A_o) equates to an increase in the condenser Δt . An increase in Δt means an increase in the average condenser refrigerant temperature and pressure. Higher than expected condensing pressures are typically the telltale sign of non-condensables present in a system.

Safety Classifications and Flammability Parameters

Opteon™ XP40 (R-449A) was used to depict the relative trends resulting from increased condenser temperature as seen in **Figure 3**.

As the percentage of non-condensables increase, the average condenser temperature increases. With increases in average condenser temperature, note that coefficient of performance

(COP) and cooling capacity decrease while mass flow requirements increase. Decreases in COP and capacity would manifest in the form of higher electric bills. Additionally, system compressors may not be able to maintain the increasing mass flow rate requirements associated with higher condensing temperatures. The result is

increased evaporator temperatures (i.e., uncomfortable building occupants in the case of an air handling unit or warm dairy products in the case of a supermarket reach-in cooler).

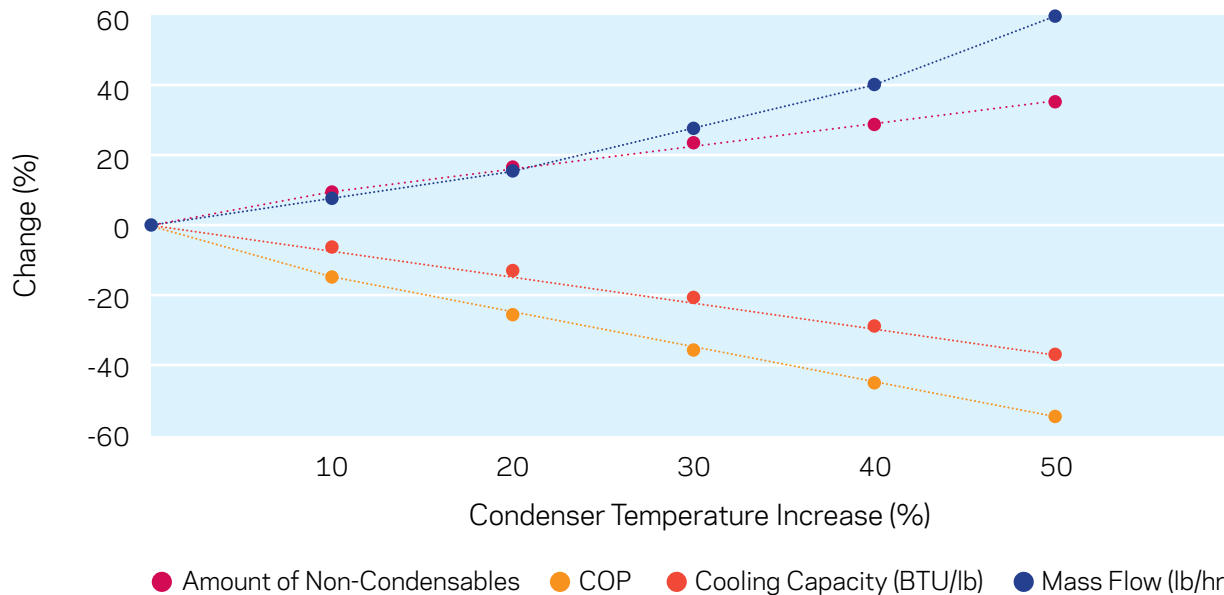
Volatile Impurities

This section of AHRI Standard 700 defines the permissible amount of volatile impurities. Included in the definition of impurities is the presence of other refrigerants. Often referred to as contamination, these impurities could cause a host of issues, including increased energy usage, decreased cooling capacity, premature equipment wear, and even equipment failure. When the composition of a refrigerant is altered with impurities, the ability to troubleshoot the system with the use of published refrigerant properties is lost entirely.

High Boiling Residue, Particulates, and Solids

An abundance of high boiling residues, particulates, or solids can plug equipment like capillary tubes, orifices, and even mist eliminators. Expansion valves can stick, causing too much or too little refrigerant to enter the evaporator. Residue

Figure 3: Opteon™ XP40 (R-449A) Relative Performance vs. Condensing Temperature



Performance trends were generated using Opteon™ XP40 (R-449A) with a 0°F evaporator set point and a 1 tonne cooling load.

can also cover heat transfer surfaces, thereby reducing cooling capacity. Solids present in the refrigerant can cause premature wear and eventual failure of compressor components.⁵

Acidity and Chlorides

Synthetic lubricants such as polyol esters (POEs) used in the majority of refrigeration systems today absorb considerably more moisture than previously used mineral oils. These synthetic lubricants have the potential to decompose in the presence of moisture to form acids. Heat (i.e., high temperatures from the compression process) accelerates the acid

formation.¹ Acid within a system can attack copper and steel causing thinning of piping or even pinhole leaks. Free copper within a system resulting from acid attack has been known to plate on steel bearing surfaces, reducing clearances and increasing wear. Free copper can also be transported to the expansion devices causing them to malfunction.⁶ Acid can also attack some types of motor insulation in hermetic compressors, resulting in motor failure. Finally, lubricants can mix with acid present within the refrigerant, creating a sludge that reduces the ability to lubricate key system components.¹





Final Remarks

Within a refrigeration system, poor refrigerant purity will adversely affect energy performance, system capacity, equipment life, and the over-all safety of operators and users. The purity of refrigerants can only be guaranteed through the strict adherence to purity standards.

At Chemours, customer centricity, unshakable integrity, and an obsession with safety are

the core of everything we do. To align with these values, we manufacture, package, and test all Chemours refrigerants to meet the AHRI 700 purity standard. The result is a safe and effective product that customers can trust for high-performing, reliable operation.

References

¹2018 ASHRAE Handbook Refrigeration. American Society of Heating, Refrigerating, and Air Conditioning Engineers, 2018.

²Air-Conditioning, Heating, and Refrigeration Institute. (2017). AHRI Standard 700 Standard 700: Specifications for Refrigerants.

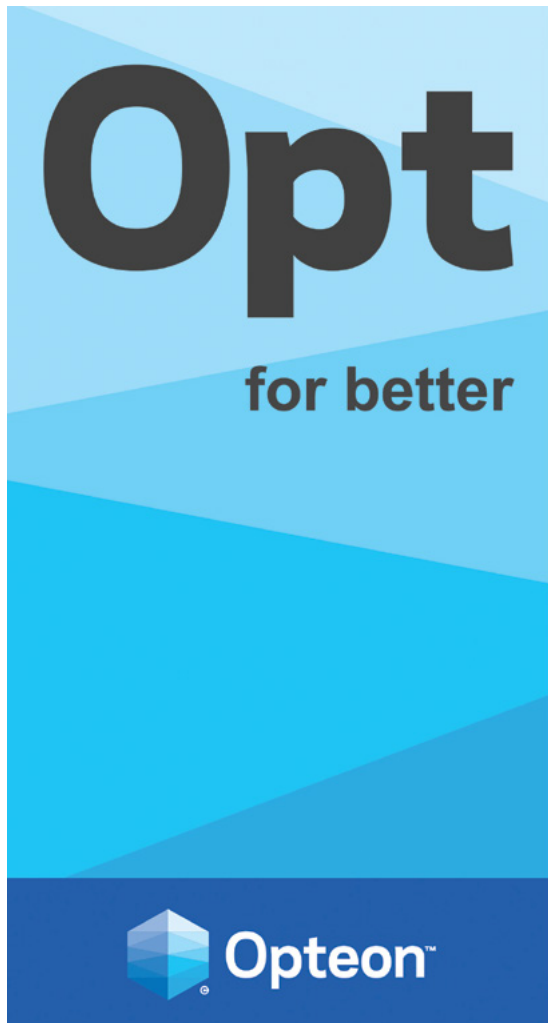
³Althouse, Andrew D., et al. *Modern Refrigeration and Air Conditioning*. The Goodheart-Willcox Company, Inc., 2014.

⁴2018 ASHRAE Handbook HVAC Systems and Equipment Chapter 48. American Society of Heating, Refrigerating, and Air Conditioning Engineers, 2018.

⁵Sporlan Valve Company. (2004). BULLETIN 240-10-3. CONTAMINANT REMOVAL FROM CENTRIFUGAL SYSTEMS.

⁶Sanvordenker, K.S. "Chemical Aspects of Refrigerant Systems." (1972). International Compressor Engineering Conference. Paper 75. <http://docs.lib.purdue.edu/icec/75>

About Opteon™ Refrigerants



The Opteon™ refrigerants portfolio offers the optimal balance of environmental sustainability, performance, safety, and cost to help meet both regulations and business goals.

Specifically, in Europe, the very low GWP Opteon™ XL refrigerant portfolio supports the market transitions required by the F-Gas Regulation and enables customers to select their optimal solution – considering performance, safety, sustainability, and total cost of ownership.

Businesses trust Opteon™ refrigerants because they offer:

Low GWP

Up to a 99% reduction compared to previous refrigerant generations.

Zero ODP

The HFO-based refrigerant family is non-ozone depleting.

Ease-of-Conversion

Minimizing conversion costs and downtime.

Excellent Capacity

A near match to many HCFC- and HFC-based technologies.

Energy Efficiency

Reduced energy use creates long-term savings over the system's life.

Long-Term Regulatory Compliance

HFO-based refrigerants can meet or exceed global and local regulatory standards.

Knowledgeable Experts

With more than 85 years of industry experience, Chemours refrigerant experts can help customers achieve both compliance and peak performance.

Visit [Opteon.com/regulations](https://www.opteon.com/regulations) for more information on HFC replacements or to contact our experts.



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