Managing condensation in medical-grade refrigerators

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Condensation is a naturally-occurring part of the refrigeration process "by which water vapor in the air is changed into liquid water." You probably see condensation every day. If you wear glasses and go from a cold, air-conditioned room to outside on a humid day, the lenses fog up as small water droplets coat the surface via condensation. (1)

"Condensate" is the technical term for the liquid that forms when the temperature of the air becomes colder than the saturation temperature (the dew point) of the air-humidity mixture. Managing condensate is important to maintaining the integrity of refrigerated products. This paper highlights some of the considerations for condensate management in the different types of refrigerators used in the storage of medicines, vaccines, mother's milk, and other medical products.

Condensation forms in all refrigerators

In a refrigerator, condensation is the conversion of water vapor in the air to liquid water drops and occurs when humid air from the ambient environment contacts the colder surfaces inside a refrigerator. This is the same effect as dew forming on the grass or on a car's windshield on a cold morning. According to the laws of physics, all refrigerators will form condensate inside the storage compartment at the humidity levels found in a typical hospital (40-50% relative humidity). This is because the temperature inside the cabinet is lower than the saturation temperature (dew point) of the surrounding hospital (or other healthcare facility) air that enters the unit when a door is opened. Consequently, the water vapor in the air that rushes into the refrigerator condenses as that air cools down to the set temperature of the refrigerator. Such condensation will be greater in humid areas and less in very dry climates or during winter months when humidity in the ambient hospital air is lower.

Why condensation removal is important

The management of condensation inside a refrigerator is important for several reasons. First, molds and other biofilms can grow in wet environments. Small microscopic water droplets forming on the walls or shelving inside a refrigerator can be an ideal site for the growth of molds, yeasts and bacteria that are in the ambient air. The drier the environment, the less likely this is to occur.

In addition, packaging inside the units can be moist and soggy if the condensate is not adequately removed from the storage cabinet.

Effectiveness of condensation management approaches in different refrigerator technologies

Different technologies have different approaches to managing condensation. To manage the condensate that will inevitably form inside a refrigerator storage compartment, it is best to accumulate it and let it drain outside the refrigerator where it can evaporate into the air as opposed to having it form inside the refrigerated compartment and potentially compromise any stored products.

The technology that is best for minimizing condensation inside a refrigerator is one with forced air circulation inside the refrigerator. Forced-air refrigeration coupled with a fin and tube type evaporator, provides the maximum protection against condensation inside the cabinet because the fan forces air through the evaporator where it condenses on the evaporator coils and fins and drains outside the cabinet where it can evaporate. The additional surface area provided by fin and tube evaporators provides increased cooling capacity and condenses excess water vapor more quickly than comparable cold plate or cold wall type evaporators. Depending on how cold the evaporator is operating, a defrost routine can then also be added to clear the evaporator of any frost or ice that might form as water is removed from the air.

Refrigerators with a cold plate, cold wall evaporator, or a thermoelectric-cooled wall technology will be less effective at removing the condensate from the cabinet because there is no forced air circulation pattern. This lack of forced air circulation introduces the risk of the condensate undesirably accumulating on any internal cold surfaces and inviting the growth of unwanted contaminants inside the storage cabinet. Mild air circulation, as adopted in some plate evaporator designs, is somewhat better but has less air flow than forced air systems and, consequently, has a lower rate of moisture removal and can still leave condensation behind.

Some manufacturers advise that desiccants be placed inside the cabinet to absorb moisture; however, the desiccants themselves could also become a source of contamination. Others recommend wiping down the inside of the cabinets every day to prevent the adverse effects of condensation. Not only is this a time-consuming process that requires daily discipline, it is difficult to effectively clean hard-to-reach areas where condensation would be likely to collect.

Summary

In summary, it is important to note that all refrigerators will generate condensation. The key is to select the right equipment and implement the appropriate maintenance practices for your specific application to assure the safety of medicines, vaccines, mother's milk, and other valuable medical products that are stored inside.

References

(1) Condensation – The Water Cycle; USGS

https://water.usgs.gov/edu/watercyclecondensation