

REFRIGERATION

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Laurel and Hardy consider the complexities of the refrigeration cycle and temperature lift while moving a piano up the hill.



From "The Music Box" by Hal Roach Studios

The Temperature Lift

By **Andy Pearson, Ph.D., C.Eng.**, Member ASHRAE

This column is the first in a series that explores some of the concepts associated with refrigeration and heat pump systems. It is aimed at people who are not immersed in refrigeration technology, and who perhaps don't fully understand the jargon. I hope seasoned hands will find the series useful, too, even if only to help explain a point to their less experienced colleagues.

In the natural world heat flows, as a rule, between adjacent objects if one is warmer than the other. The flow of heat is always from the warmer object to the cooler one, because heat is a form of energy, and the energy is being more evenly distributed.

It is a bit like a bathtub full of water; if you push the water up one end of the tub and then release it, the water will redistribute itself so that the level is equal across the whole tub. Left to its own devices, heat, like the bathwater, always finds a level. People who want to sound

smart call this entropy, but the name is not important; it is just smoothing out the bumps.

Refrigerators and heat pumps are mysterious because they seem to break this rule. They keep a temperature difference between the cold end of the system (inside the fridge) and the hot end (down the back), which is like being able to keep all the bathwater down at one end of the tub. On closer inspection, it becomes apparent that the fridge is not, in fact, breaking the rules at all. To understand this,

we need to appreciate the concept of temperature lift.

To make stuff colder or to keep it cold, we need to draw heat energy out of it. This is done by placing the stuff in surroundings that are colder than the stuff. The heat energy flows from the warmer stuff to the colder surroundings. To get rid of that heat energy, we need to make the energy warmer than the outside of the refrigerator. This is done by working on the heat—putting more energy into it—so that it can flow to the outside.

How we turn the cold energy into warmer energy will be covered later in the series, so don't worry about that right now. Just consider the four temperature levels described. The stuff in the fridge is one temperature and the surroundings are colder. The heat is then lifted to a high temperature and the outside of the fridge is colder. To get the heat from the temperature of the stuff in the fridge up to the temperature outside the fridge, it is necessary first to drop the heat down to the temperature of the

cold end of the fridge, and then raise it (by doing work on it) to the temperature of the hot end of the fridge.

If you don't believe that your fridge has a hot end, then feel round the back of it while it is running. The difference between the cold end and the hot end is the temperature lift for the refrigerator circuit. However, the difference between the stuff in the fridge and the outside is the temperature lift for the total system. The refrigerator works because its temperature lift is larger than the required temperature lift for the total system.

Imagine my house, which is halfway up the side of a steep hill between two terraces. There is a path sloping downhill from my basement door to the street below and another path further up the hill that slopes down from the upper street to my front door.

I have a piano in the basement that I want to place upstairs. I can roll the piano out the basement door and down to the street. I then need to do work on the piano to lift it up to the top of the hill, where I can roll it down to my front door.

Wheeling the piano down each of the paths is like heat transfer inside the fridge and from the fridge to the outside.

Lifting the piano up the hill from the lower street to the upper street is like the work done on the heat within the refrigeration system.

While the total removal only lifts the piano from the basement to the front door, the work done in lifting it takes it from the foot of the lower path to the top of the upper path. If that height is more than necessary, for example if I take the piano farther up the hill than I have to, then I need to do more work to lift the piano and the removal is less efficient than necessary.

In a refrigerator the total system lift is usually set by the system specification: from the desired temperature to the ambient. The temperature lift within the refrigeration system is a function of the performance of the heat exchangers. The key to refrigeration system efficiency is ensuring that the temperature lift within the refrigeration system is as small as possible. If the total system temperature lift also can be reduced, that's even better.

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