ENGINEERING WHITE PAPER

Internal use only

June 5, 2021

Thermodynamics

Before we can advocate for our customers on HVAC equipment & system design we must know the basics of Mechanical Engineering. Key to the understanding of this disclipline is Thermodynamics & Heat Transfer. This EWP is dedicated to Thermodynamics.

Key Points

- The first law, also known as Law of Conservation of Energy, states that energy cannot be created or destroyed in an isolated system.
- The second law of thermodynamics states that the entropy of any isolated system always increases.
- The third law of thermodynamics states that the entropy of a system approaches a constant value as the temperature approaches absolute zero.

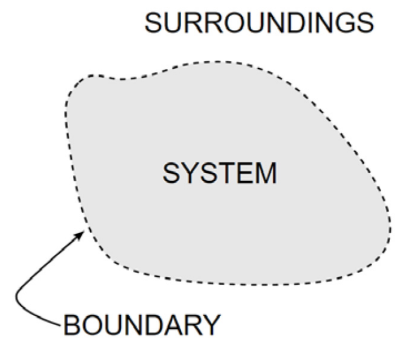
Terms

- **Absolute Zero:** The lowest temperature that is theoretically possible.
- **Entropy:** A thermodynamic property that is the measure of a system's thermal energy per unit of temperature that is unavailable for doing useful work.

System or Surroundings

To avoid confusion, scientists discuss thermodynamic values in reference to a system and its surroundings. Everything that is not a part of the system constitutes its surroundings. The system and surroundings are separated by a boundary. For example, if the system is one mole of a gas in a container, then the boundary is simply the inner wall of the container itself. Everything outside of the boundary is considered the surroundings, which would include the container itself.

The boundary must be clearly defined, so one can clearly say whether a given part of the world is in the system or in the surroundings. If matter is not able to pass across the boundary, then the system is said to be closed; otherwise, it is *open.* A closed system may still exchange energy with the surroundings unless the system is an isolated one, in which case neither matter nor energy can pass across the boundary.



A Thermodynamic System *diagram of a thermodynamic system*

The First Law of Thermodynamics

The first law of thermodynamics, also known as Law of Conservation of Energy, states that energy can neither be created nor destroyed; energy can only be transferred or changed from one form to another. For example, turning on a light would seem to produce energy; however, it is electrical energy that is converted.

A way of expressing the first law of thermodynamics is that any change in the internal energy (ΔE) of a system is given by the sum of the heat (q) that flows across its boundaries and the work (w) done on the system by the surroundings:

Delta E = q + w

This law says that there are two kinds of processes, heat and work, that can lead to a change in the internal energy of a system. Since both heat and work can be measured and quantified, this is the same as saying that any change in the energy of a system must result in a corresponding change in the energy of the surroundings outside the system. In other words, energy cannot be created or destroyed. If heat flows into a system or the surroundings do work on it, the internal energy increases and the sign of q and w are positive. Conversely, heat flow out of the system or work done by the system (on the surroundings) will be at the expense of the internal energy, and q and w will therefore be negative.

3290 146th Place SE, Suite F, Bellevue, WA 98007 | P 425.562.1150 | F 425.562.5123

The Second Law of Thermodynamics

The second law of thermodynamics says that the entropy of any isolated system always increases. Isolated systems spontaneously evolve towards thermal equilibrium—the state of maximum entropy of the system. More simply put: the entropy of the universe (the ultimate isolated system) only increases and never decreases.

A simple way to think of the second law of thermodynamics is that a room, if not cleaned and tidied, will invariably becomes more messy and disorderly with time—regardless if someone may try to clean a bit as they go. Another example is a campfire- the solid wood burns and becomes ash, smoke and gases, all of which spread energy outwards more easily than the solid fuel.

The Third Law of Thermodynamics

The third law of thermodynamics states that the entropy of a system approaches a constant value as the temperature approaches absolute zero. The entropy of a system at absolute zero is typically zero, and in all cases is determined only by the number of different ground states it has. Specifically, the entropy of a pure crystalline substance (perfect order) at absolute zero temperature is zero. This statement holds true if the perfect crystal has only one state with minimum energy.

3290 146th Place SE, Suite F, Bellevue, WA 98007 | **P** 425.562.1150 | **F** 425.562.5123