WARREN

THE WARREN GROUP, INC. FORENSIC ENGINEERS & CONSULTANTS
7805 ST. ANDREWS ROAD | PO BOX 1608 | IRMO, SOUTH CAROLINA 29063
TEL 803.732.6600 FAX 803.732.7576 WARRENFORENSICS.COM

Modes of Heat Transfer

By S. Dyer Harris, Ph.D., P.E.

One of the basic concepts taught in both basic firefighter training and fire investigation training is the theory of heat transfer. This article will address the three basic modes of heat transfer.

Why is heat transfer so important to understand? It helps us to understand how a fire may have spread from one area of a structure to another through no readily visible path. It also indicates how a fire may start in one building and spread to another, again with no direct contact being made by flame.

Heat transfer is defined by NFPA 921 Guide to Fire and Explosion Investigation as "the transport of heat energy from one point to another caused by a temperature difference between those points."[1]

There are three basic modes of heat transfer: Conduction, Convection, and Radiation.

CONDUCTION

"Conduction is the form of heat transfer that takes place within solids when one portion of an object is heated. Energy is transferred from the heated area to the unheated area at a rate dependent on the difference in temperature and the thermal conductivity (k) of the material."[2]

An example would be a metal I-Beam or truss located in a room and passing through a wall to another room that is being impinged upon by a fire. As the beam or truss heats, the temperature increases along the I-Beam or truss to the cooler end. The end opposite the fire heats up, and if it reaches the auto ignition temperature of combustible materials close to it, a second fire will start. The subsequent second fire may lead one to identify two separate points of origin.

CONVECTION

"Convection is the transfer of heat energy by the movement of heated liquids or gases from the source of heat to a cooler part of the environment.[3]

An example of convection is air contacting heating elements, as in a furnace, and being heated to comfort temperature.

Convection plays a significant role in fire investigation because it is one of the initial means for fire to spread by the hot or super heated gases and products of combustion spreading out into the upper portions of the room or area of origin. This is why we see soot and other products of combustion spread throughout a structure and even in rooms that are a significant distance away and have no direct flame impingement.

RADIATION

"Radiation is the transfer of heat energy from a hot surface or gas, the radiator, to a cooler material, the target, by electromagnetic waves without the need of an intervening medium. Radiant energy can be transferred only by line of sight and will be reduced or blocked by intervening materials."[4]

A good example of radiation heat transfer is the "heat from the sun being radiated to the earth through a vacuum." Another example of radiant heating is the heat that you feel that is being radiated from a fireplace when you stand in front of it.

CONCLUSION

In conclusion, imagine a fire originating on a stove. The burner heats a frying pan through conductive heating, which is also heating the oil, located in the frying pan. As the oil reaches its ignition temperature and begins flaming combustion, it produces gases, which start to spread throughout the area through convective currents. As the oil ignites and produces flaming combustion, the fire will radiate heat to other combustible materials in the area, which subsequently reach their ignition temperature and in turn burst into flames. Therefore, more than one of the basic heat transfer modes can be involved in a fire situation.

REFERENCES

1. National Fire Protection Association, NFPA 921 Guide to Fire and Explosion Investigations, NFPA, Quincy, MA, 2011 edition, Page 22, Section 5.5.1
2. National Fire Protection Association, NFPA 921 Guide to Fire and Explosion Investigations, NFPA, Quincy, MA, 2011, Page 23, Section 5.5.2
3. National Fire Protection Association, NFPA 921 Guide to Fire and Explosion Investigations, NFPA, Quincy, MA. 2011, Page 23, Section 5.5.3
4. National Fire Protection Association, NFPA 921 Guide to Fire and Explosion Investigations, NFPA, Quincy, MA 2011, Page 24, Section 5.5.4