Commack Fire Department

CFD Probationary Firefighter Basic Lesson Plan Outline

Topic:

Class #2 Introduction to fire Dynamics

- **Level of Instruction**
  - Probationary Firefighter
- **Equipment Needed**
  - USB thumb drive with power point presentation
- **Resources Needed**
  - Computer/smartboard
- **Terminal Objective**
  - Students are talked through a power point presentation and will learn the basics of fire dynamics
- **Enabling Objectives**
  - Students will gain a clear understanding of the science of fire
  - Students will learn how air/ventilation effects fire
  - Students will learn key terms and definitions needed for FF1
- **Lesson Outline:**
  - Introduction
  - NFPA definition of fire
  - Scientific explanation video of what actually burns
  - Pyrolysis
  - The Fire Tetrahedron
  - Heat Release rate
  - Heat Flux
  - Entrainment
  - The neutral plane
  - Rollover
  - Flashover
  - Backdraft
  - Flowpath
  - Methods of Heat transfer
  - Radiation
  - Conduction
  - Convection
  - heat transfer to your gear
  - Fuel rich vent limited fires/The fire growth curve
  - Ventilation as it relates to Fire Dynamics

- Summary/Review

- **Summary**
  - Many people make more of fire dynamics than what it actually is. It is The Science of Fire. It's about fire behavior, what it wants and needs to live and grow and also what we can do to mitigate its growth and to kill it as well. If you understand what it needs, that it wants to pull fresh air in down low and exhaust its by products, smoke and heat, out high, then you understand fire dynamics. Study the key terms and definitions, watch YouTube videos on it and keep up with your training and you will never forget what it's about

COMMACK FIRE DEPARTMENT TRAINING DIVISION

Intro to Fire Dynamics

Introduction

- Fire Dynamics can be a complicated subject if you let it. But really its just a complicated term for a simple subject. Fire Dynamics is basically fire behavior. In this lesson you will learn exactly what fire is both in its scientific form and in its simplest form. You will also be given some key terms and definitions that you will need to know for your Firefighter 1 tests. We will talk about air and how it relates to fire and subsequently how it relates to ventilation of a fire. Fire Dynamics is easy stuff, so don't get your head all bunched up with "how am I going to remember all this stuff?". In next week's class, you will see everything that is explained in this lesson with your own eyes as we will be going into the flashover container. That means what you learn in this lesson will literally be burned into your brains. So don't sweat it. Fire needs 3 things to survive and or thrive. It needs air (oxygen), heat (energy) and fuel (something combustible).

Fire

- NFPA, The National Fire Protection Agency, defines fire as a "Rapid oxidation process, which is a chemical reaction resulting in the evolution of light and heat in varying intensities" So here we go, a wordy term for something pretty simple. In layman's terms it just means when heat is applied to an object, it begins to break down and deteriorate, gasses begin to come off of the object and if the heat is hot enough, the gasses will ignite and you have a fire. It is that simple**.** So the question now is, what actually burns? The answer you would think would be the object, but its not. It is the combustible gasses and or flammable vapors coming off of the object that actually burn. To give you an example of this if you took a heat gun and pointed it at close range to a piece of paper the paper will eventually catch fire, but the heat gun isn't actually on fire, its just hot or heat energy, its heat energy is breaking down the piece of paper causing it to off gas and eventually it gets hot enough to ignite those gasses. In the video you watched, this was shown with a candle. You saw that you have a lit match and a lit candle. When you blow out the candle it still smokes for a bit, when you bring the match over to the candle, the smoke ignites before the match gets near the wick. So that means that a solid doesn't burn, a liquid doesn't burn, the gasses coming off of them do.

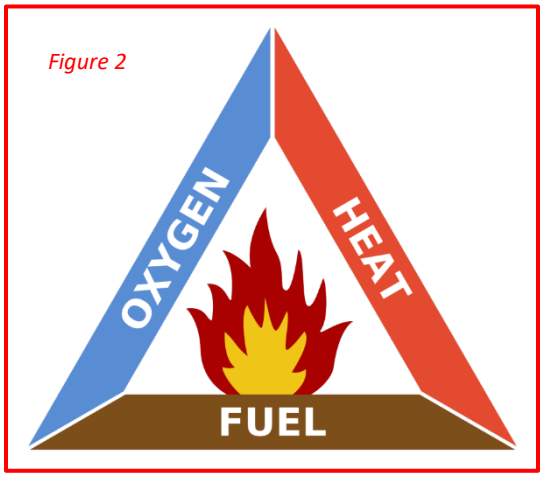
Pyrolysis

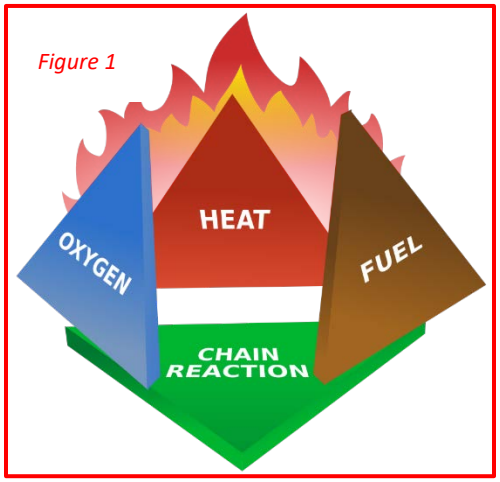
- The NFPA definition of pyrolysis is "A process in which material is decomposed or broken down into simpler molecular compounds by the effects of heat alone; pyrolysis often precedes combustion". What does that mean? Going back to the candle, when heat,

the flame from the lighter, is applied to the candle, the wick and wax undergo a chemical change and begin to pyrolyze or off gas and smoke. The smoke, which contains flammable by-products of combustion ignites and begins to burn. This also known as "The Pyrolysis Process". In the video you watched, they showed a fire that started in the corner of a room. As the fire grew it spread out along the walls and across the ceiling. As it did, the heat radiated down onto the couches. The material began to degrade, break down and off gas. Those gasses went up into the hot gas layer above giving the fire more fuel. Eventually the fire gave off enough heat to ignite the gasses coming off the couch and everything started to burn. That video showed the process of fire. The application of a flame (Heat) to a combustible Object (Fuel) which makes the object decompose. The Pyrolysis Process begins as the object starts to off-gas or smoke. If the ambient air (Oxygen) concentration in the room is enough to support combustion, and the heat source is hot enough, the smoke will ignite. As long as those three things are present, the process will continue.

The Fire Tetrahedron

- Years ago we used to have the fire triangle (Fig 1). It consisted of oxygen, heat and fuel. At some point we were all taught this in school. NFPA has decided that we needed to add a side to the triangle and make it a tetrahedron. It now contains oxygen, heat, fuel and chain reaction. (Fig 2) So basically what they did was add the chain reaction to show that if all three of these things exist together, fire will never stop, the chain reaction will continue unless one of the three needs (sides) are removed from the equation.





Heat Release Rate

- NFPA defines Heat Release Rate (HRR) as "The rate at which heat energy is generated by burning". This simply put means how fast an object that's burning gives off heat energy. HRR should not be confused with temperature. Just because the HRR of a burning chair is extremely high, it doesn't necessarily mean it's extremely hot or hotter than some other object that's burning, it is a measure of how *fast* it gets hot, not *how hot* it gets. When we talk about HRR vs. temperature an easy way to describe it would be to use a candle again. Let's say that one candles heat release rate is 80 Watts and its temperature measures 1500 degrees. If I have 10 candles, does that mean the temperature goes up to 150,000 degrees? No, the temperature is still the same. However, the heat

release rate does go up to 800 Watts because now I have 10 candles giving off 80 Watts each of heat energy being released. So, HRR is the speed at which an object gives off its heat energy. A gallon of gasoline in a pan lit on fire will burn off much faster than say a 2x4 because its heat release rate is much higher.

Heat Flux

- The NFPA definition for Heat Flux is "The measure of the rate of heat transfer to a surface or an area". In a nutshell, its how quickly an object absorbs heat energy from a heat source. For instance, if a chair is on fire, how quickly will a chair next to it heat up and ignite.

Entrainment

- Entrainment as defined by NFPA is "The process of air or gasses being drawn into a fire plume or jet". Going back to the fire tetrahedron, we know that one of the things that fire needs to survive is air. The process of fire dictates that it draws fresh air into itself down low and it exhausts its by-products of combustion at high. It is in essence, a pump. It does this on its own. With its heat energy, it has the ability to move air on its own. If you stop this process of fresh air being drawn in, you can stop the fire by taking away the oxygen side of the tetrahedron.

The Neutral Plane

- NFPA's Definition is "The neutral plane marks the level in a structure fire where, below it, air will be drawn into the structure and above it, combustion gasses will be exhausted." The neutral plane is a dynamic line that you can physically see in the video that is played. It moves up and down as the fire grows or dies in intensity. The entrainment of cooler air is drawn in down low and the heated gasses are exhausted out high. This too will be seen in the flashover container in your next class. You will see how the neutral plane exists for a long time until the fire gets the ratio it needs and the neutral plane drops to the floor as the fire transitions to rollover and eventually, flashover.

Rollover

- The definition of rollover is "The condition where unburned fuel (pyrolysate) from the originating fire has accumulated in the ceiling to a sufficient concentration (i.e. at or above the lower flammable limit) that it ignites and burns; can occur without ignition of or prior to, the ignition of other fuels separate from the origin". This complicated definition can be explained simply by saying, it is the point at which the smoke begins to burn because the gases and oxygen have begun to mix and are at right levels. The heat too must be sufficient. Once rollover begins, flashover is eminent & can only be stopped by suppression and or asphyxiation. Again, back to the candle, smoke is fuel…smoke can, does and will burn. You have seen multiple videos of this and will see more as we go through the program.

Flashover

- Flashover is defined as “A transition phase in the development of a compartment fire in which surfaces exposed to thermal radiation reach ignition temperature more or less simultaneously and fire spreads rapidly throughout the space, resulting in full room involvement or total involvement of the compartment or enclosed space” What we’re talking about here is the moment in a fire in a room gets hot enough to ignite everything in the room, including the smoke. There are signs of flashover that are pre-cursors if you will. Rollover is one of them. When you start to see rollover, flashover is eminent. Often times the smoke is so dense in the rooms adjacent to the fire room, you cant see the rollover completely, you may just see whisps of fire occasionally going by or it may just get real hot real fast. These are watch out situations and need to be addressed immediately as flashover is coming rapidly. You must do one of three things, you must either apply water, close the door to the fire room (if there is one) or you must exit the area immediately. You may even have to do all three in some situations. Flashover is a killer, you need to read its signs and be aware of its possibility at all times.

Backdraft

- Backdraft is defined as “A transition phase in the development of a compartment fire in which surfaces exposed to thermal radiation reach ignition temperature more or less simultaneously and fire spreads rapidly throughout the space, resulting in full room involvement or total involvement of the compartment or enclosed space” It is essentially a fire that is running out of oxygen but is still very hot, and receives a blast of fresh air rapidly, the smoke basically explodes. In the Queens video, you see that a hand line was operated on the roof over a ventilation hole that was cut by the members on the roof. It is thought that this line caused a covering over the ventilation opening briefly and as it did, a door was forced and opened, it created a flow path by which the fire was given oxygen, rapidly causing the smoke and products of combustion to ignite and explode. Whether or not these were the exact circumstances that caused this backdraft is still up for debate but how it got ventilation limited, then got a blast of fresh air doesn’t really matter, the results were the same, a backdraft occurred. Backdrafts are a rare occurrence and happen most often in commercial fires however, it can happen anywhere at any time. It’s all about the right mixture of air heat and gasses occurring at the right time.

Flowpath

- Flow path is a term the meaning of which has been around for a long time, it was just called something different. Edwin Croker was the Chief of The Fire Department of the City of New York from 1899 to 1911 and he called it the “Fire Flow”. Flow path is not a new concept, its just a new term. It is defined as “The volume between an inlet and an outlet that allows movement of heat and smoke from a higher pressure within the fire area towards the lower pressure areas accessible via doors and window openings. Based on varying building configurations, there may be several flow paths within a structure.” So what the hell does all that mean? For starters it can easily be defined as the space between where the fire is and where the fire is going. If you have a fire in a back bedroom, the bedroom door is open and you open the front door, you have created a flow path from the bedroom, where the fire is, to the front door, where the fire wants to go.

From what we learned about fire so far it needs to entrain air in low and expel the bad stuff out high. The door to a house is a perfect place for this to happen. It's a called a bi-directional flow or bi-directional vent. We usually have to operate in the flow path at some point to reach the seat of the fire. This area is where you earn your bones. The hot gasses flowing over your gear can be as high as 15-20 mph when there is no external wind which cause it to feel much hotter. If you can avoid being in the flow path and still get your job done, by all means do so. But sometimes it is just unavoidable. If fire is energy and it is a pump, it is going to create pressure inside that fire compartment. The compartment can be as small as a room or can be as large as the entire house. As the fire grows, it is creating pressure inside that house. If there are no vents, the fire will go out but if there is sufficient oxygen this can take some time. If there is enough vents, the fire will do what it wants. It will pump out that pressure through the exhalation vents and entrain that fresh air through its intake vents. The world, and fire as a part of the world wants everything to be balanced, that being said, high pressure will always move to low pressure to try to equalize the pressure in order to maintain balance. So that means that the fire area, the house, is under high pressure as compared to the outside, the low pressure and when you make an opening in the house, the pressure is pumped out, or relieved by that opening to the outside. If you ever watch the weather on the news and they show a "Low Pressure System" moving across the country on the weather map, that system is always being pushed by a "High-Pressure System" behind it. It is the same concept. High pressure will always move to low pressure to create balance. So you may be asking yourself, if the fire in the back bedroom is venting its bad stuff out its uni-directional exhalation vent (one way) and I open an exterior door, wouldn't that make a flow path of fresh air moving towards the fire and therefore be a cooler place to operate? The answer is yes…but only initially. Wats happening to the fire as it is now entraining all that fresh air from the front door? It's growing and it will eventually outgrow and overwhelm its uni-directional exhalation vent and now start to look for more exhalation vents to use. The door you opened that was initially a uni-directional intake vent, will now become bi-directional (two way) vent in which it still entrains fresh air in low but now above the neutral plane its expelling hot gasses, smoke and bad stuff out high. When you open that exterior door to the house you will see and feel a lift of smoke and heat, but again unless something is done to control the fire it is only temporary. When it comes to flow path, just try to remember that you must recognize when you are in it and understand what the dangers are of operating in such an environment. It is the space between where the fire is and where the fire wants to go.

Methods of Heat Transfer

- Heat energy from a fire comes from three different methods, Radiation, Conduction and Convection. A fire in a building will use all three of these methods to transfer its heat energy around the structure. The following is an in-depth discussion of each of the three methods of heat transfer
    - ## Radiation

      Radiation is defined as "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". An example of this would be, the heat energy from the sun that is radiated to earth through the vacuum of space. Radiant energy

can be transferred by intervening material as well. Intervening materials do not necessarily block all radiant heat. So if the sun is radiating down on the hood of your car and you open the hood and feel the underside, its hot. Radiators and targets are not limited to solids but can be liquids and gases as well. An example of this is the smoke and hot gases that collect at ceiling level in a compartment fire, they can be a source of radiant heat that may lead to ignition of materials below them. Radiant heat travels outward from the fire in a straight line in all directions. A handline will only minimally stop radiant heat from effecting what you're protecting. Water will absorb some, but only a little radiant heat which means if you're trying to protect the house next door from fire and heat, the only way to do so is to put water on the actual house you are protecting. A fog stream in between will not get it done. Two radiating materials will feed off of each other and radiate back and forth thereby growing the fire much faster. This means that a fire that starts in the corner of a room grows much quicker than one that starts in the center of a room. The same goes for two houses, if something is not done to intervene, two houses on fire next to each other will radiate back and forth growing the fire at a much quicker rate than normal. Really the only way to stop radiant heat from effecting something is to put something else in front of whatever it is you're trying to protect, a shield. But, shielding *and* distance may be necessary, because the shield could absorb so much heat that it too can become a radiator. This of course depends on the material of the shield.

- ## Conduction

  Is the form of heat transfer that takes place within solids when one portion of an object is heated. The energy is transferred from the heated area to the unheated area at a rate dependent on the difference in temperature and thermal conductivity of the material being heated. Picture a 20' horizontal steel I-beam in a building fire. When the fire impinges on one end of the beam, it begins to heat up and as it gets hotter, the heat works its way down the I-beam making the entire beam eventually get hot. On June 18th, 2007 the Charleston SC Fire Department responded to The Sofa Super Store for a reported building fire. The fire started in a trash pile outside up against a sheet metal wall. The heat conducted through the steel wall and lit a couch on fire which eventually spread through the entire store killing 9 firefighters, better know as The Charleston 9, when the roof collapsed down on top of all of them

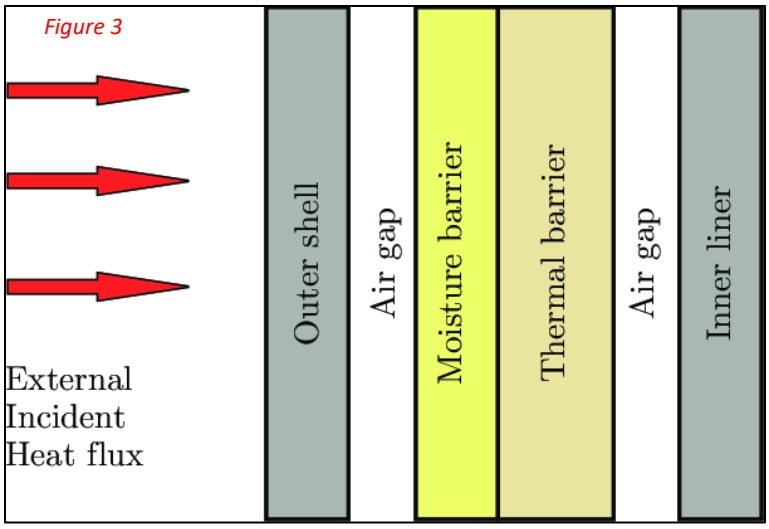
- ## Convection

  Convection is defined as "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". In most cases convection will be present in any environment where there are temperature differences, although in a few cases a stabile stratified condition may be found that does not cause fluid movement. In a nutshell, convection causes everything in its path to get much hotter much faster than if it were just radiating heat. It's like wind chill in reverse.

The same way the wind chill factor makes it much colder, convection makes it much hotter. Some things in the flow path will off-gas adding unburned fuel to the atmosphere. If you get caught in a convective "Flow Path" your gear and *everything* else in the path will become saturated with heat thereby lowering its ignition temperature. As previously discussed, if you're in the convective flow path, you're not in a good place.

Heat Transfer to Your Gear

- Loose fitting gear takes advantage of the insulating properties of air. Your gear consists of the following in order. You have an outer shell, moisture barrier and an inner liner. In-between these layers are layers of air and then your shirt. (Fig 3) Each layer including the air layers absorb and reflect some heat. When your gear is compressed, the air barrier is gone and along with it are its insulating properties. You should keep your gear as puffed up as possible and understand that when a firefighter comes out of a hot environment, the last thing you want to do is touch him anywhere on his gear as this may cause a severe burn injury. Let the gear release the heat it has absorbed first before removing it or touching it. You should understand too that your gear is very much like a sponge. Once a sponge gets filled to its capacity, it will only hold as much as it is designed for. Like the sponge, your gear will only absorb so much heat before it gets full as well. Realizing that you've been in a hot environment too long can keep this from happening. Once your gear, compressed or uncompressed, has absorbed as much heat as it can, the next layer is your skin and that's when burn injuries will occur. Remember that a convective flow over your gear will cause it to absorb heat at a much faster rate thereby cutting your time in that area significantly.



Fuel Rich – Ventilation Limited Fires/Fire Growth Curve

- Fuel rich vent limited fires are fires in which the heat flux is such that there is too much fuel in the form of smoke and gasses and not enough oxygen to sustain flaming combustion. Imagine when you go start a lawnmower or a saw and the it becomes flooded with gas, this is the same principle. There is too much fuel and not enough air to

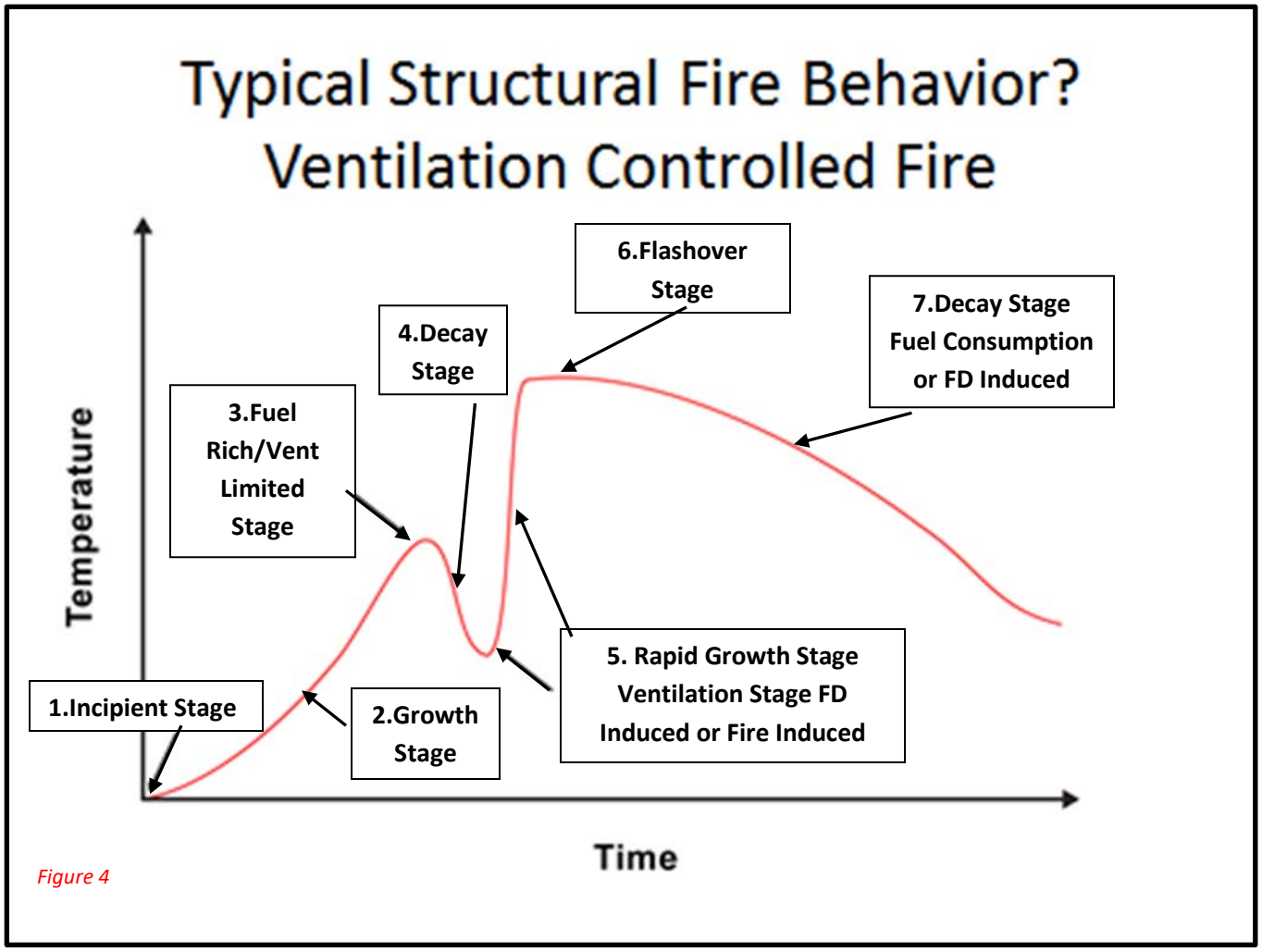


Figure 4

start it. The Fire Growth Curve shows us the various stages of a fire and the order in which they occur and or reoccur. (Fig 4)

- The 7 stages are:
  - Incipient stage
  - Growth Stage
  - Ventilation limited/Fuel Rich Stage
  - Decay Stage
  - Rapid Growth stage (venting occurs from the fire making a vent or FD making entry)
  - Flashover Stage
  - Decay Stage (either from FD suppression or the fire running out of fuel)

Ventilation as it Relates to Fire Dynamics

- The definition of Ventilation is "Circulation of air in any space by natural wind or convection or by fans blowing air into or exhausting air out of a building; a firefighting operation of removing smoke and heat from the structure by opening windows and doors or making holes in the roof." It basically means the movement of air in one direction or another, the changing of the atmosphere by the movement of air. They key words in that definition are "in or out". In the fire service we tend to think of ventilation as removing the heat and smoke. Knowing what we know now about air entrainment and what fire needs to sustain itself, it's time we change that train of though and understand that it works both ways, in and out. Understanding that fire needs

air to grow, when *should* we vent? Does it seem wise to vent before water has been applied to extinguish the fire? Before answering that question, think about what you have learned in this text. The answer is no, giving a fire more air, whether through and exhaust vent or an intake vent, or worse through both, will cause the fire to grow and intensify sometimes quite rapidly depending on the circumstances. The words "Never" and "Always" aren't usually used in the fire service and in the case of ventilation this holds true as well. We can only use best practices as every fire is dynamic and different in its own way. Best practice would be to limit ventilation until water is applied to the fire. The practice of ventilation at a fire is an entire subject in and of itself. The where to, how too, when too are things that you will learn as time goes by with training and experience. For now, it is important for you to understand that there is a method to the madness of ventilation. It's not just firefighters randomly going around breaking windows popping doors and cutting holes in the roof. There are reasons why certain windows are broken first etc. The other thing you need to know is, window breaking is contagious. Just because someone takes a window, that does not mean you should start breaking them too. Hopefully that firefighter understands what's happening inside with the fire and is breaking it in a coordinated effort to ventilate the structure. One firefighter breaking the wrong window at the wrong time can literally destroy a house in seconds along with everyone and everything in it. So…don't be that guy/gal. Ventilation is an advanced topic and an advanced skill however there is something you can do to mitigate this problem at your level. It's called door control. You can control the flow of air entering the building by keeping the entry door slightly ajar instead of all the way open. You can/must use door control on the fire room as well. By closing the fire room door, you limit the amount of air that's being entrained into the fire. This tactic can cause the fire to stop growing and could possibly even go into the decay stage. If you think about it, we've been told since we were little to sleep with our doors closed in case of fire. The fact of the matter is, any time you can put a closed door between you and a fire, you should. Again, as your experience grows in the fire service so too will your knowledge of ventilation. For now, only take orders on ventilation and use door control to your advantage at a structure fire.

Summary/Review

- A solid doesn't burn and a liquid doesn't burn, it's the off gassing of materials when heated is what burns, smoke is fuel. This is known as the Pyrolysis Process. Fire needs air to live, one of the sides of the fire tetrahedron. Remove one side and you kill the chain reaction.
  Pay close attention in the flashover container class. Listen for some of the terms in this text as we describe the evolution of the fire in the container. Study your key terms and definitions so you not only can get them correct when you take the FF1 class, but so you actually know what they mean. Go on YouTube and search for Fire Dynamics videos. Watch the stuff that NIST and UL put out. They are the most comprehensive ones on this topic out there. Fire Dynamics is an important subject to know. Understanding how fire grows and why it behaves the way it does is crucial in not only extinguishing it, but keeping you safe from it by recognizing signs of imminent rapid fire growth as well. Study this topic on your own as much as you can. This text only scratched the surface of it and gave you the basics. So realize that the more you know about it, the better firefighter you will be.

Definitions

Fire - "A rapid oxidation process, which is a chemical reaction resulting in the evolution of light and heat in varying intensities."

Pyrolysis – "A process in which material is decomposed, or broken down, into simpler molecular compounds by the effects of heat alone; pyrolysis often precedes combustion"

Heat Release Rate (HRR) – "The rate at which heat energy is generated by burning"

Entrainment – "The process of air or gases being drawn into a fire, plume or jet"

The Neutral Plane - "The neutral plane marks the level in a structure fire where, below it, air will be drawn into the structure and above it, combustion gasses will be exhausted."

Rollover (Flameover) - The condition where unburned fuel (pyrolysate) from the originating fire has accumulated in the ceiling to a sufficient concentration (i.e. at or above the lower flammable limit) that it ignites and burns; can occur without ignition of or prior to, the ignition of other fuels separate from the origin

Flashover - A transition phase in the development of a compartment fire in which surfaces exposed to thermal radiation reach ignition temperature more or less simultaneously and fire spreads rapidly throughout the space, resulting in full room involvement or total involvement of the compartment or enclosed space

Backdraft - A phenomenon in which a fire that has consumed all available oxygen suddenly explodes when more oxygen is made available, typically because a door or window has been opened

Flow Path - "The volume between an inlet and an outlet that allows movement of heat and smoke from a higher pressure within the fire area towards the lower pressure areas accessible via doors and window openings. Based on varying building configurations, there may be several flow paths within a structure."

Radiation - 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

Conduction - The form of heat transfer that takes place within solids when one portion of an object is heated. The energy is transferred from the heated area to the unheated area at a rate dependent on the difference in temperature and thermal conductivity of the material being heated

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

Definitions (ctnd.)

Fuel Rich/Ventilation Limited Fires - fires in which the heat flux is such that there is too much fuel in the form of smoke and gasses and not enough oxygen to sustain flaming combustion

Ventilation - Circulation of air in any space by natural wind or convection or by fans blowing air into or exhausting air out of a building; a firefighting operation of removing smoke and heat from the structure by opening windows and doors or making holes in the roof.


COMMACK
TRAINING
DIVISION
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"GET INVOLVED"

Introduction To Fire Dynamics

Using The Knowledge When You Are Called Upon To Vent

Program Written For:
The Commack Fire Department
Program Written By:
Joseph Digiose, CFI
Fire Marshal

INTRODUCTION TO FIRE DYNAMICS

Scope

- Fire Dynamics
- The Scientific Explanation Of Fire, What Is Actually Burning?
- Key Terms And Definitions
- Fire Spread
- Ventilation
- VES vs. VEIS
- When, Where, Why We Vent
- Do’s, Don'ts And The Consequences Of Both
- Flow Path
- Door Control

A *Scientific* Explanation

FIRE

FIRE

Fire:

- “NFPA 921 The Guide for Fire and Explosion Investigations” defines fire as follows:
- "*A rapid oxidation process, which is a chemical reaction resulting in the evolution of light and heat in varying intensities.*“

A Scientific Explanation

FIRE

- So what actually burned in that video?
- The wick?....
- No…
- The wax?
- No…
- The Smoke and gasses?
- YES!

FIRE

Pyrolysis

- A process in which material is decomposed, or broken down, into simpler molecular compounds by the effects of heat alone; pyrolysis often precedes combustion
- When heat (the flame from the lighter) is applied to the candle, the wick & wax undergo a chemical change and begin to “Pyrolyze”, (off gas - smoke)

FIRE

Pyrolysis

- The smoke which contains flammable by-products ignites and begins to burn.
- As long as the flame stays lit (the heat) and the wax & wick are there (the fuel), and the air in the room does not get burned up or displaced by the smoke (the oxygen) the Chain Reaction Will Not Stop!
- This is also known as the "Pyrolysis Process"

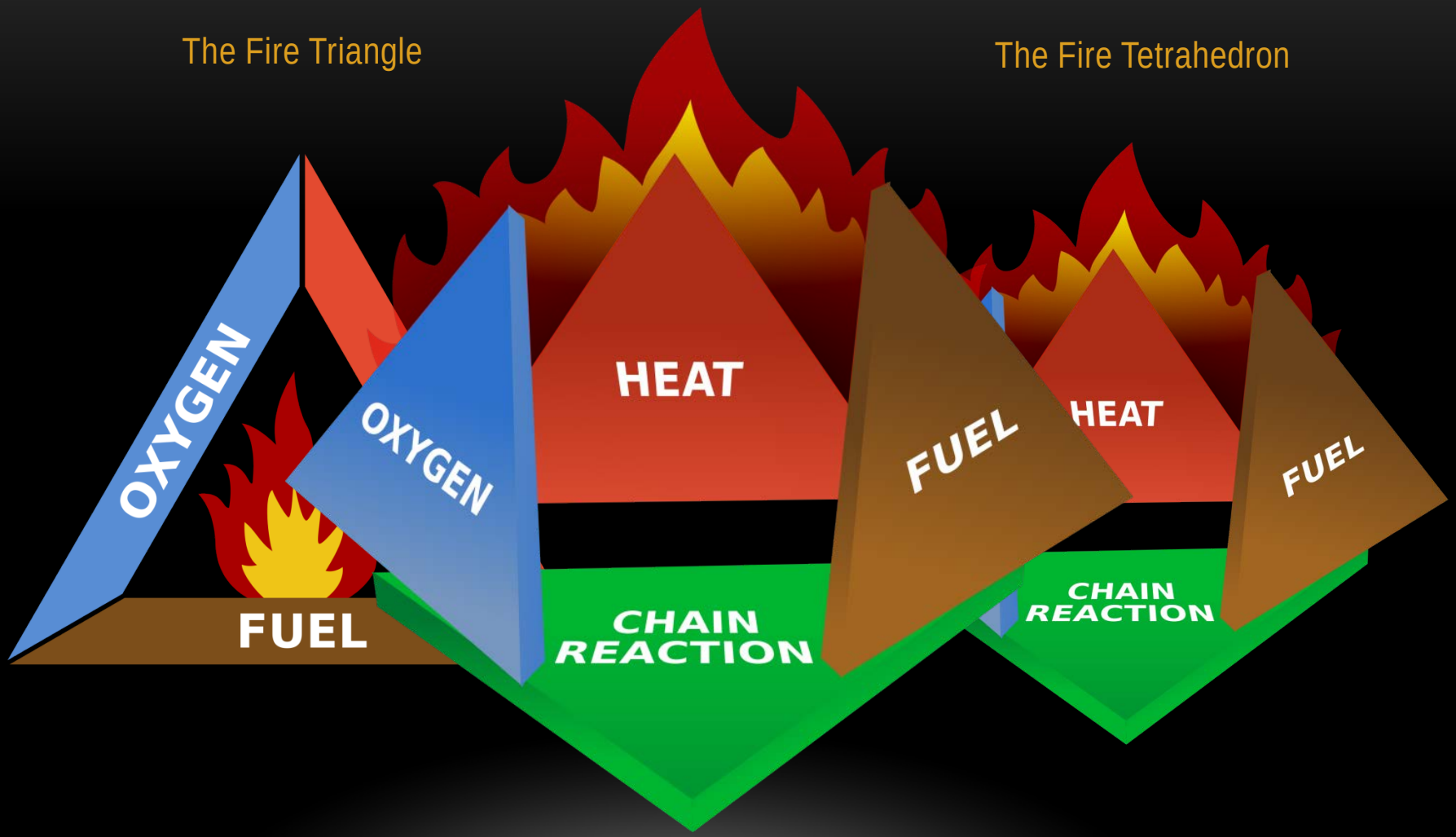
FIRE

FIRE

The Process of Fire

FIRE

The Fire Tetrahedron

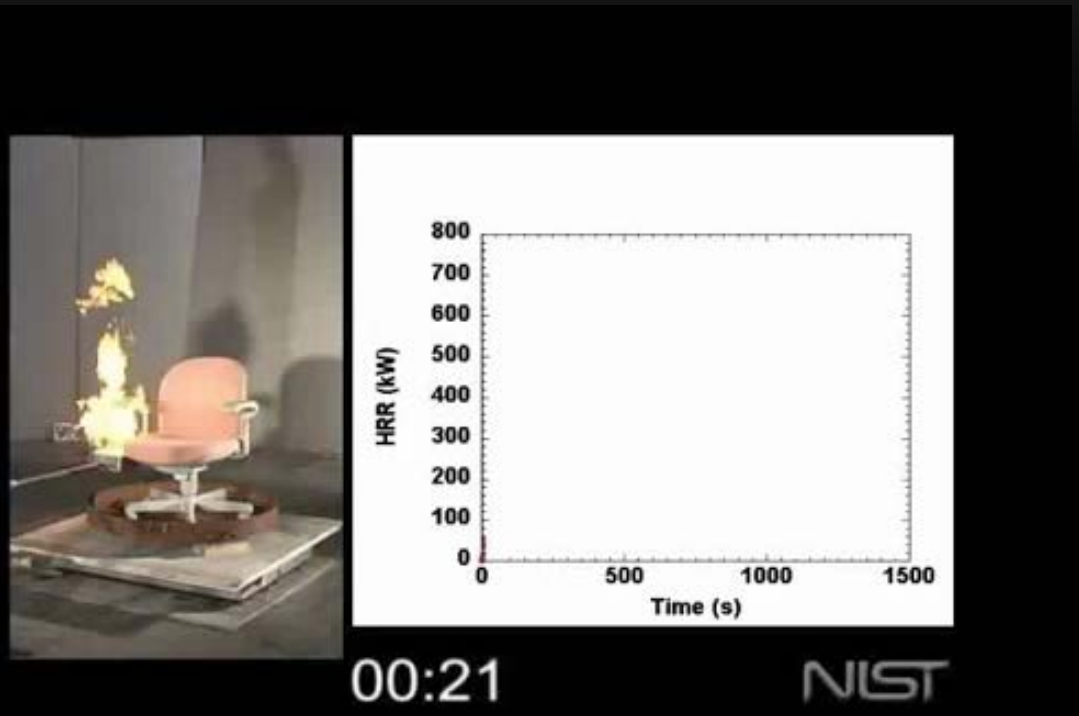


FIRE

FIRE

➢Heat Release Rate (HRR)

- The rate at which heat energy is generated by burning
- How fast an object that's burning gives off heat energy



HRR	Temp
80 W	1500°F

FIRE

Entrainment

- The process of air or gases being drawn into a fire, plume or jet
- Fire pulls fresh air in low and exhausts its heat and by-products of Combustion (smoke) out up high. It does this on its own, it has the ability to create the movement of air with its heat energy

FIRE

➢Entrainment

- Fire is, in essence a pump
- It entrains fresh air in low and hot smoke out high
- If you stop this process in any way, you stop the fire

FIRE

The Neutral Plane

FIRE

ROLLOVER (FLAMEOVER)

FIRE

FIRE

FIRE

FIRE

FIRE

FIRE

FIRE

FIRE

What It Is

And

How It Can Kill You

THE FLOW PATH

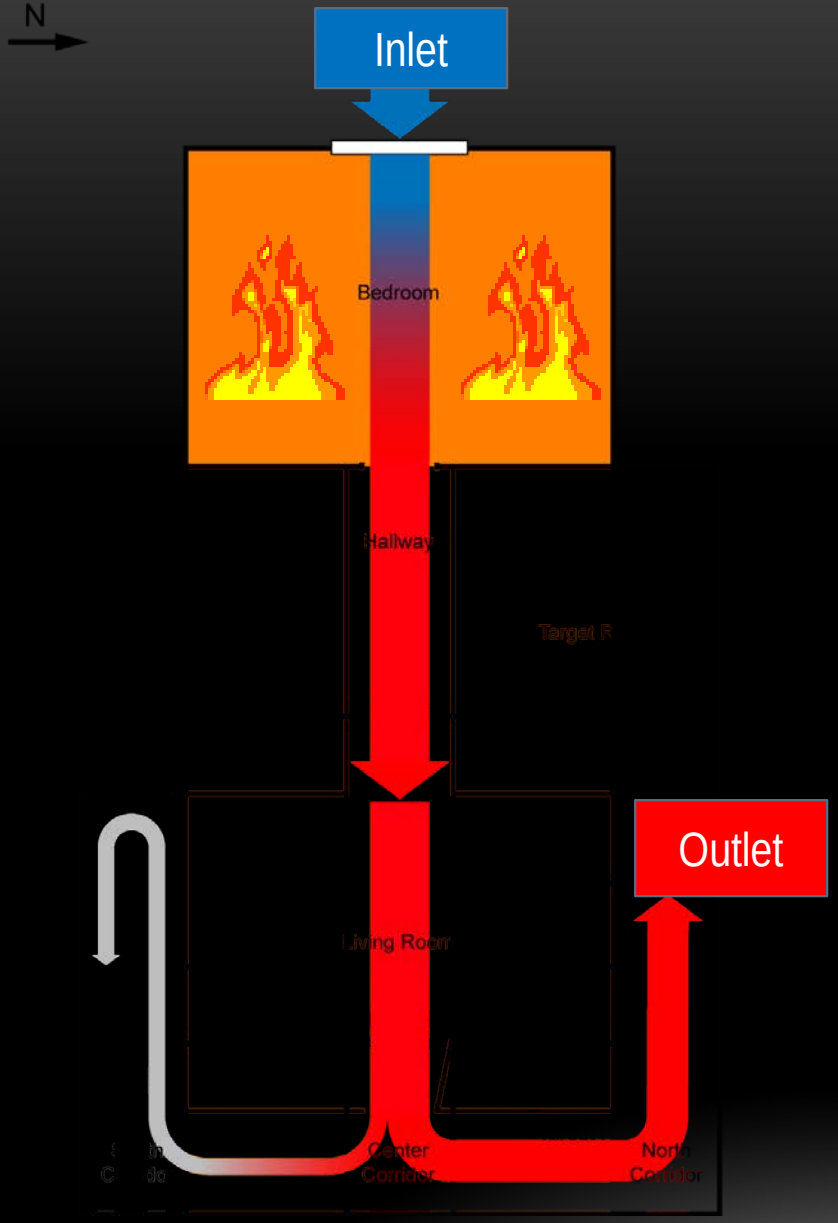
Flow Path

- The flow path is the volume between an inlet and an outlet that allows the movement of heat and smoke from the higher pressure within the fire area towards the lower pressure areas accessible via doors and window openings. Based on varying building configurations, there may be several flow paths within a structure. Operations conducted in the flow path , between the fire and the where the fire wants to go, will place members at significant risk due to the increased flow of fire, heat and smoke toward their position.

FLOW PATH

- Flow Path

FLOW PATH



Flow Path

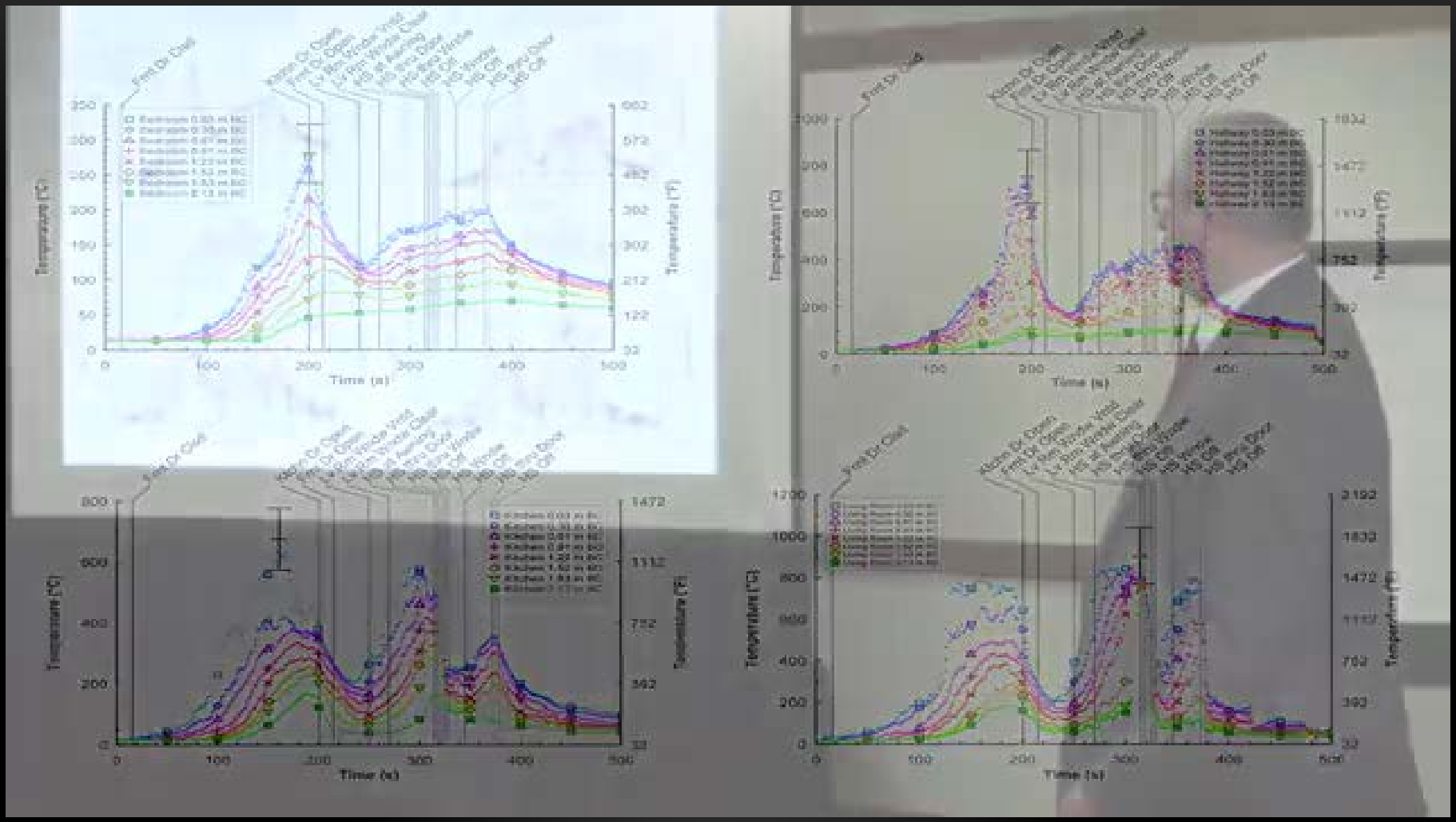
Fire is in essence a pump. It takes in fresh air and pumps out energy in the form of flames heat and super heated smoke which is unburned fuel. Like a pump the more fresh air it gets the more energy it puts out. As it receives this entrained fresh air it HAS to exhaust its by products

YOU DO NOT WANT TO BE IN THE FLOW PATH! Temperatures in the flow path may be tenable on the floor 200*F-400*F however, at the ceiling they can be 800*F – 1600*F. The problem is the CONVECTION. The superheated unburned fuel in the flow path can be moving as quickly as 15MPH. This flow moving over your gear heats your gear up much faster than if you were in a room with no wind. That being said, you wont feel it until its too late.

FLOW PATH

FLOW PATH

How it can kill you



FLOW PATH

FLOW PATH

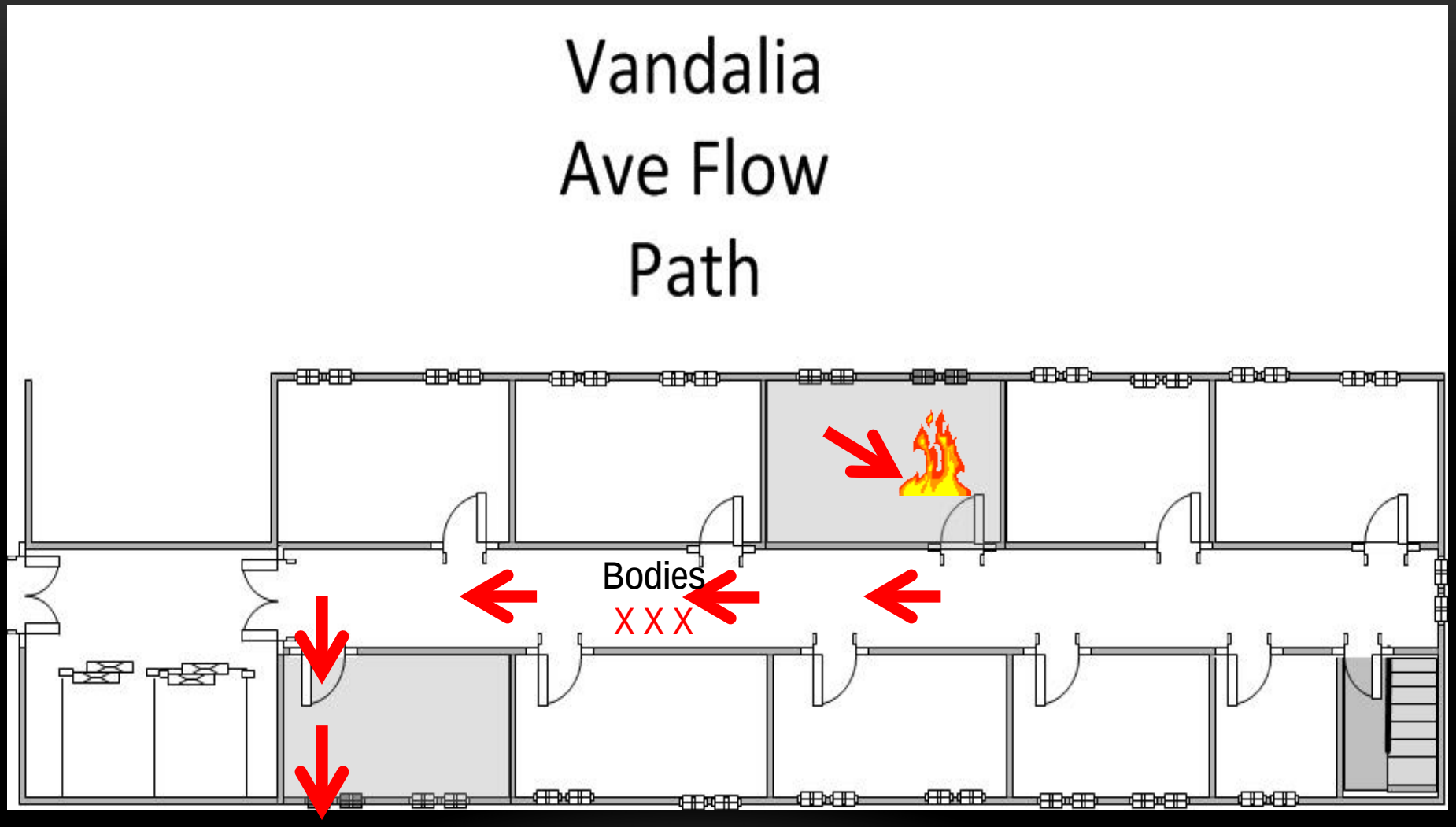
➢What It Is And How It Can Kill You

Vandalia Ave, NYC - December 18, 1998

Downwind side

Upwind side

FLOW PATH



FLOW PATH

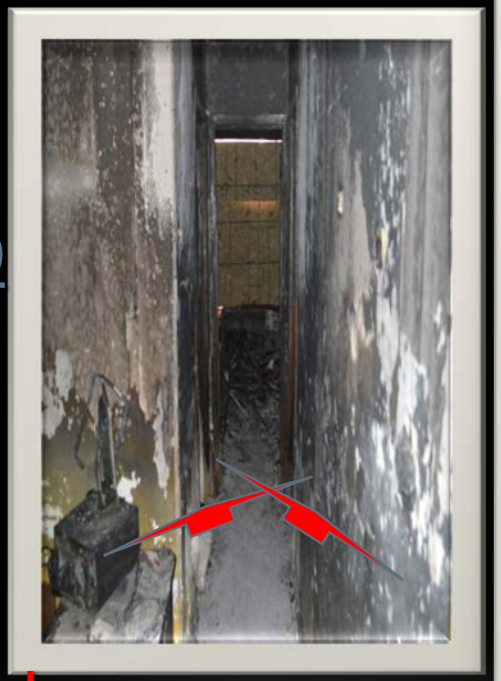
FLOW PATH

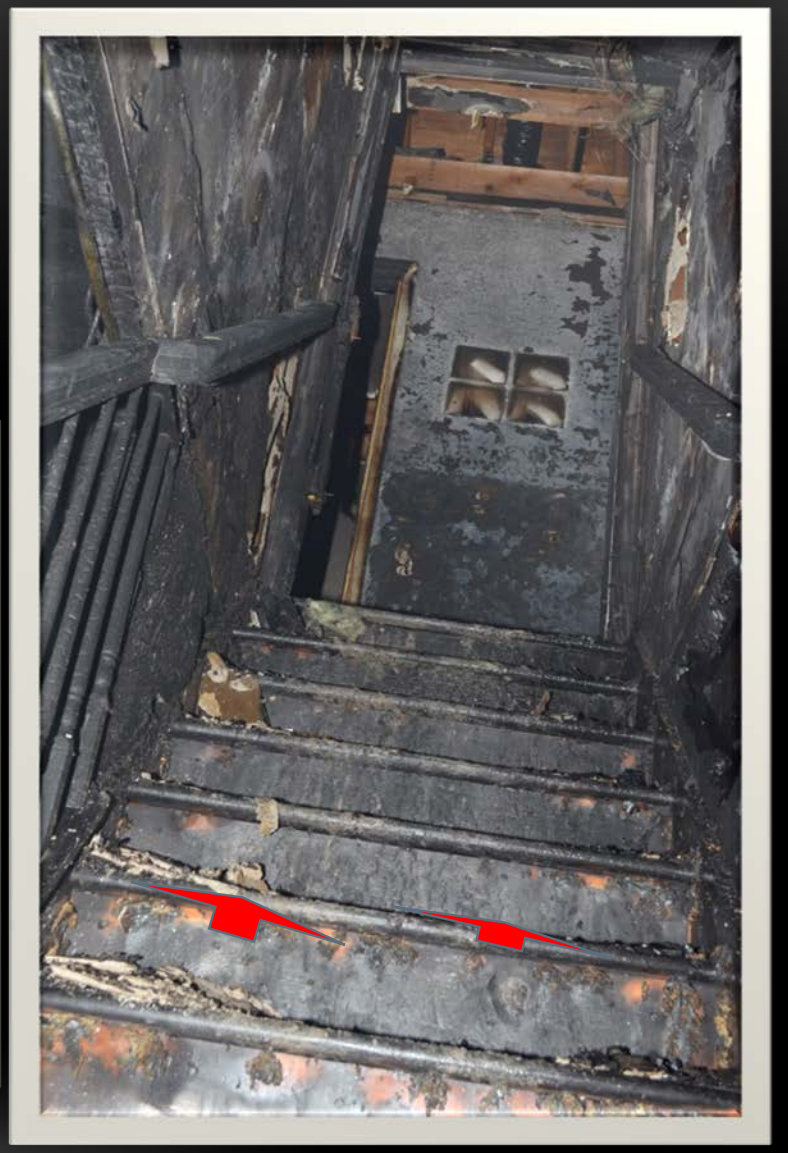
FLOW PATH

FLOW PATH

Flow Path

- The area between where the fire is…and where the fire wants to go.
- The "Flow Path" is *NOT* a good place to be in!!!!
- 1100*F heat blasting over your gear at 15mph saturating it with heat very quickly!





FIRE

The Methods of Heat Transfer

RADIATION

CONDUCTION

CONVECTION

Radiation:

- 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
- For example, the heat energy from the sun is radiated to earth through the vacuum of space. Radiant energy can be transferred by intervening material.
- Intervening materials do not necessarily block all radiant heat.

RADIATION, CONDUCTION, CONVECTION

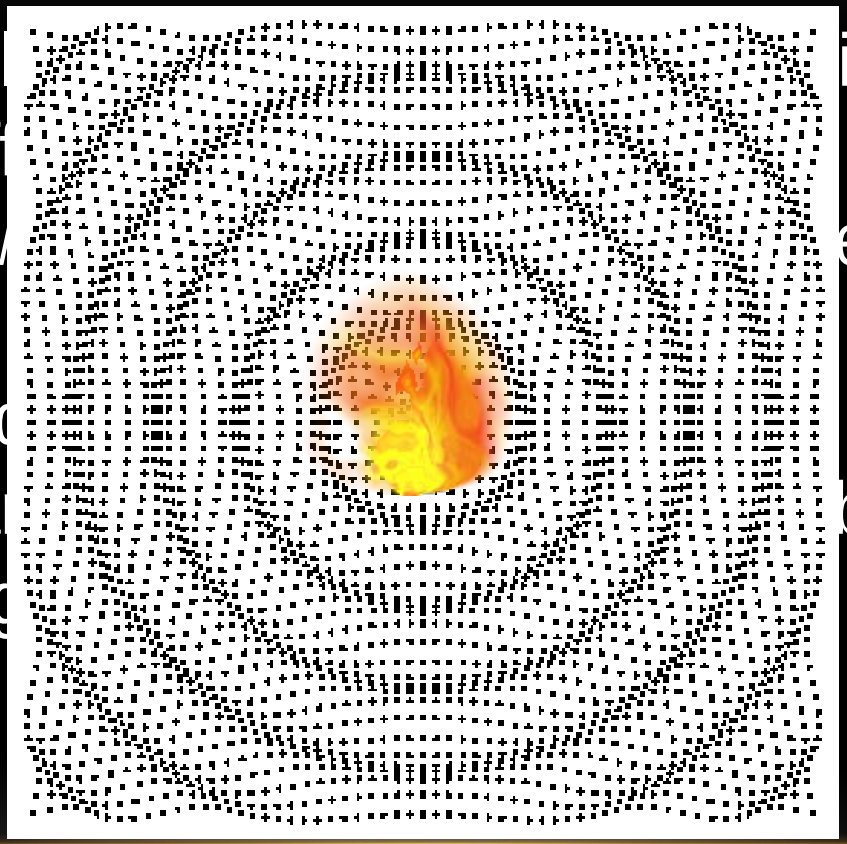
Radiation:

- Radiators and targets are not limited to solids but can be liquids and gases as well
- An example of this is the smoke and hot gases that collect at ceiling level in a compartment fire, they can be a source of radiant heat that may lead to ignition of materials

RADIATION, CONDUCTION, CONVECTION

Radiation:

- Radiant heat travels outward from the fire in a straight line in all directions
- A handl iant heat from eff
- Water v e radiant heat
- Two rad each other a by growing



RADIATION, CONDUCTION, CONVECTION

- Radiation:

RADIATION, CONDUCTION, CONVECTION

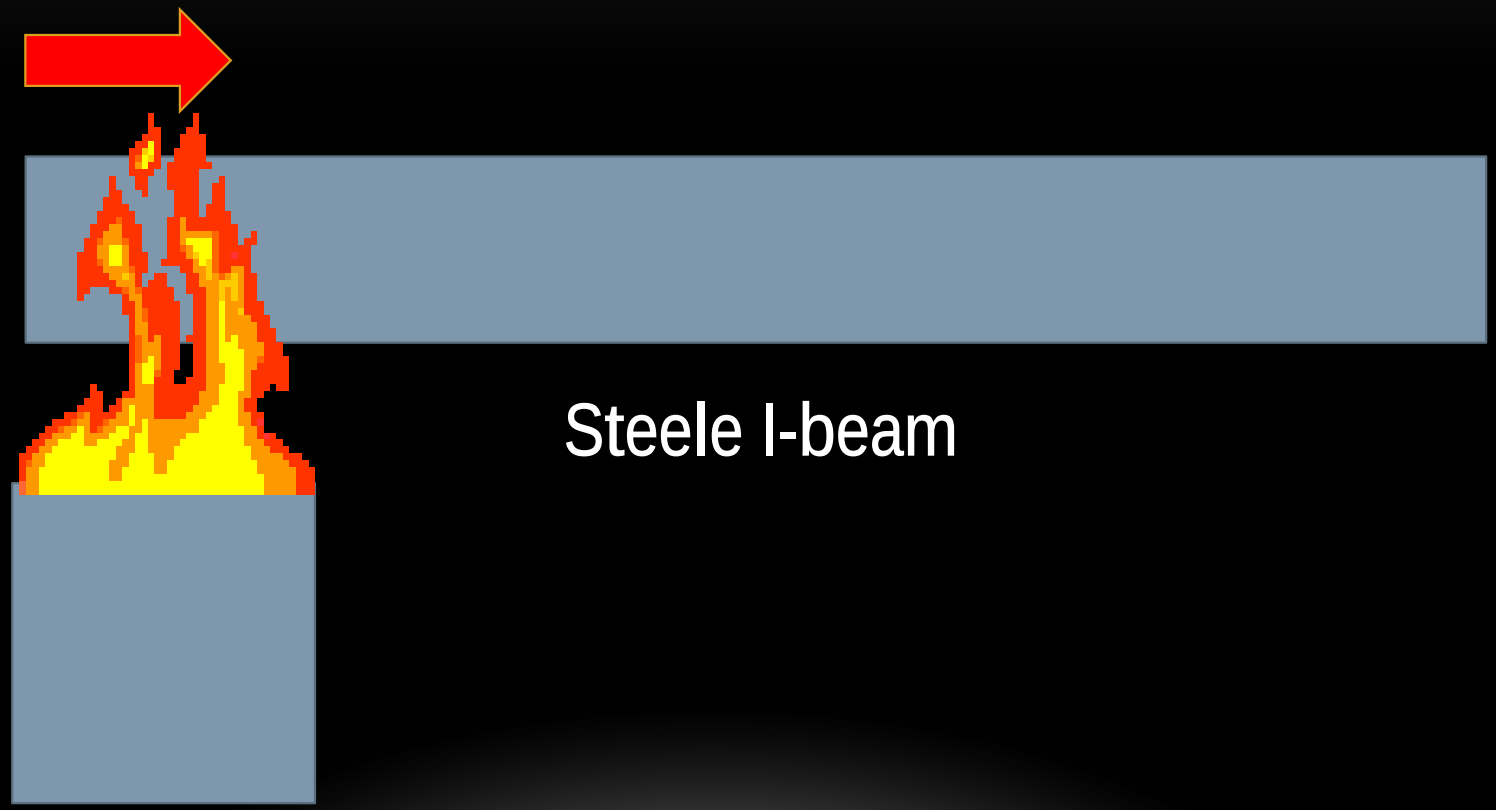
- Radiation:

RADIATION, CONDUCTION, CONVECTION

- Conduction:
  - Is the form of heat transfer that takes place within solids when one portion of an object is heated. The energy is transferred from the heated area to the unheated area at a rate dependent on the difference in temperature and thermal conductivity of the material being heated

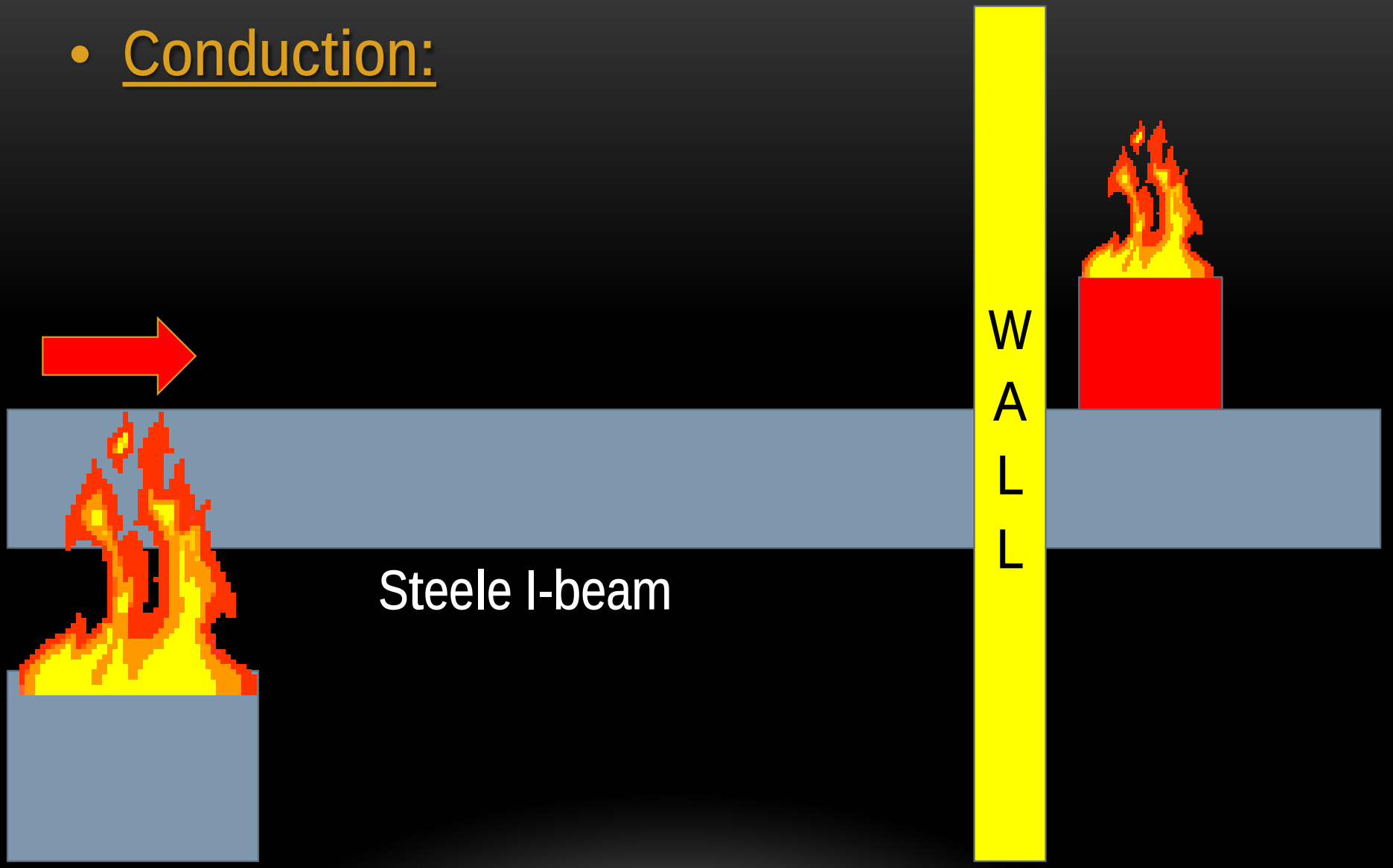
RADIATION, CONDUCTION, CONVECTION

➢ Conduction:



RADIATION, CONDUCTION, CONVECTION

- Conduction:



RADIATION, CONDUCTION, CONVECTION

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
- In most cases convection will be present in any environment where there are temperature differences, although in a few cases a stabile stratified condition may be found that does not cause fluid movement

➢ Convection:

- In a nutshell, convection causes EVERYTHING in its path to GET MUCH HOTTER MUCH FASTER than if it were just radiating heat.
- It's like wind chill in reverse.
- The same way the wind chill factor makes it much colder, convection makes it much hotter.
- Some things in the flow path will off-gas adding unburned fuel to the atmosphere
- If you get caught in a convective "Flow Path" your gear and EVERYTHING else in the path will become saturated with heat thereby lowering its ignition temperature.

RADIATION, CONDUCTION, CONVECTION

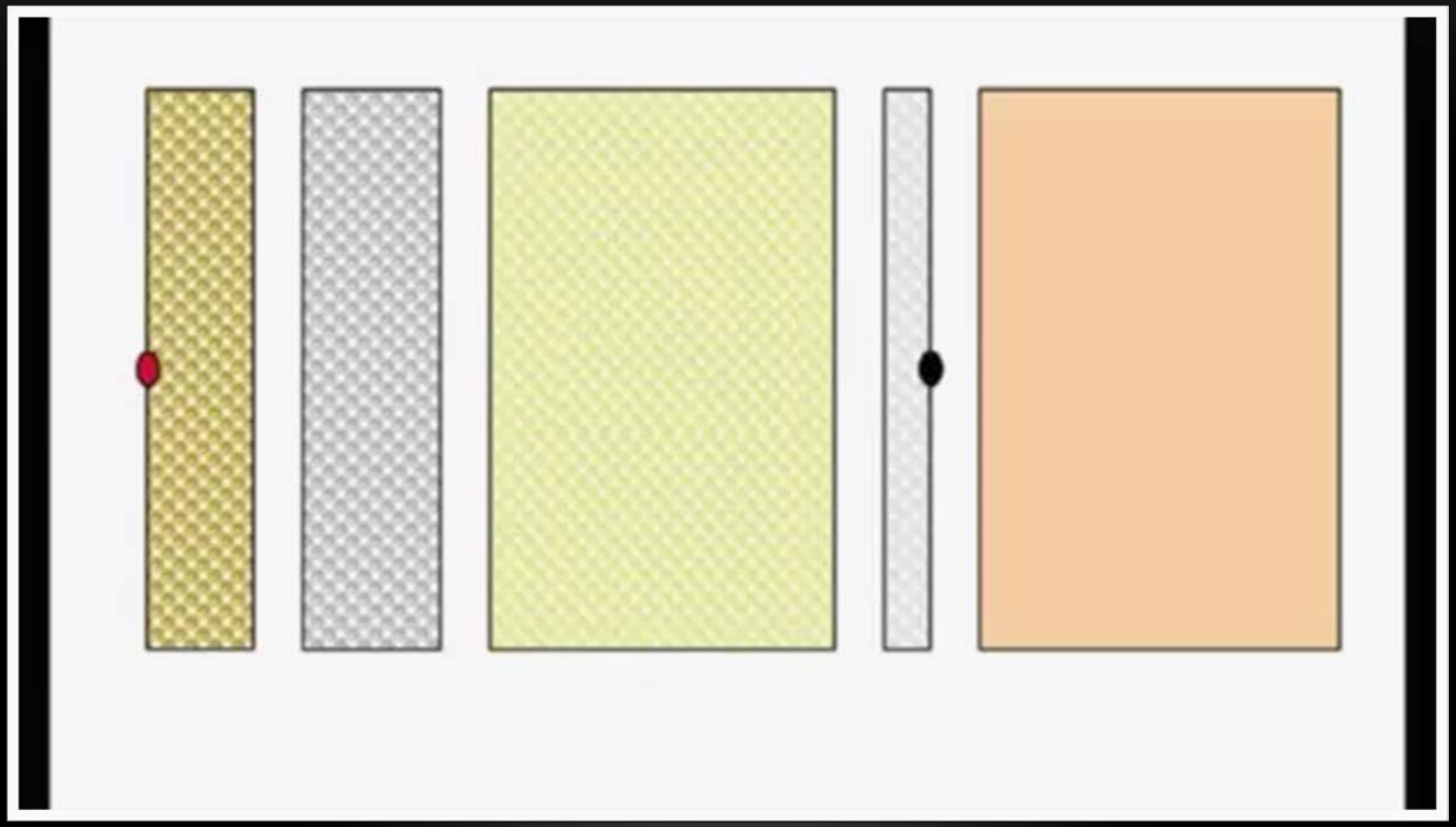
- Convection:

If you're in the convective flow path, you're NOT in a good place

METHODS OF HEAT TRANSFER

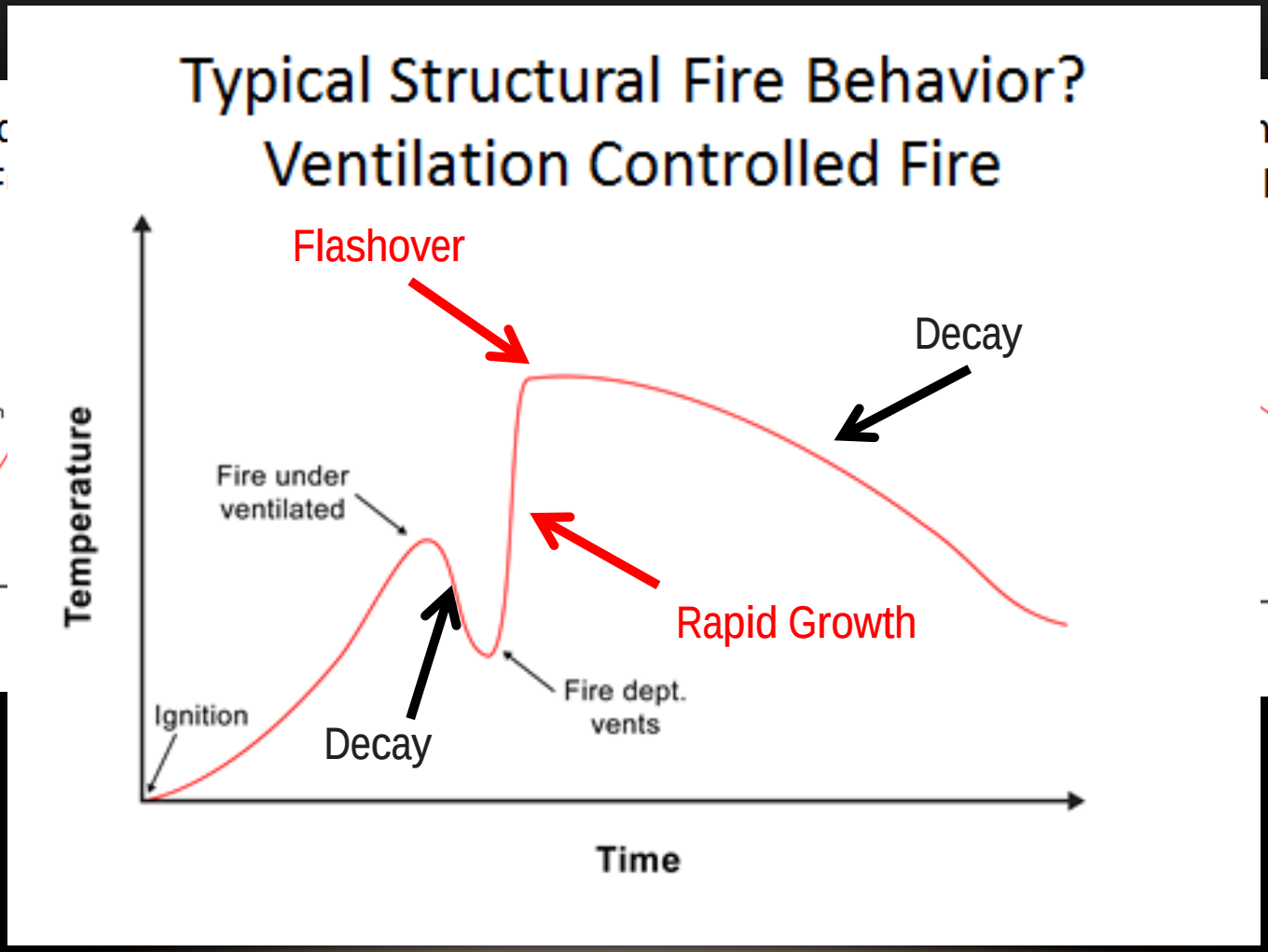
RADIATION, CONDUCTION, CONVECTION

- What is the effect of these forms of Heat Transfer on you?



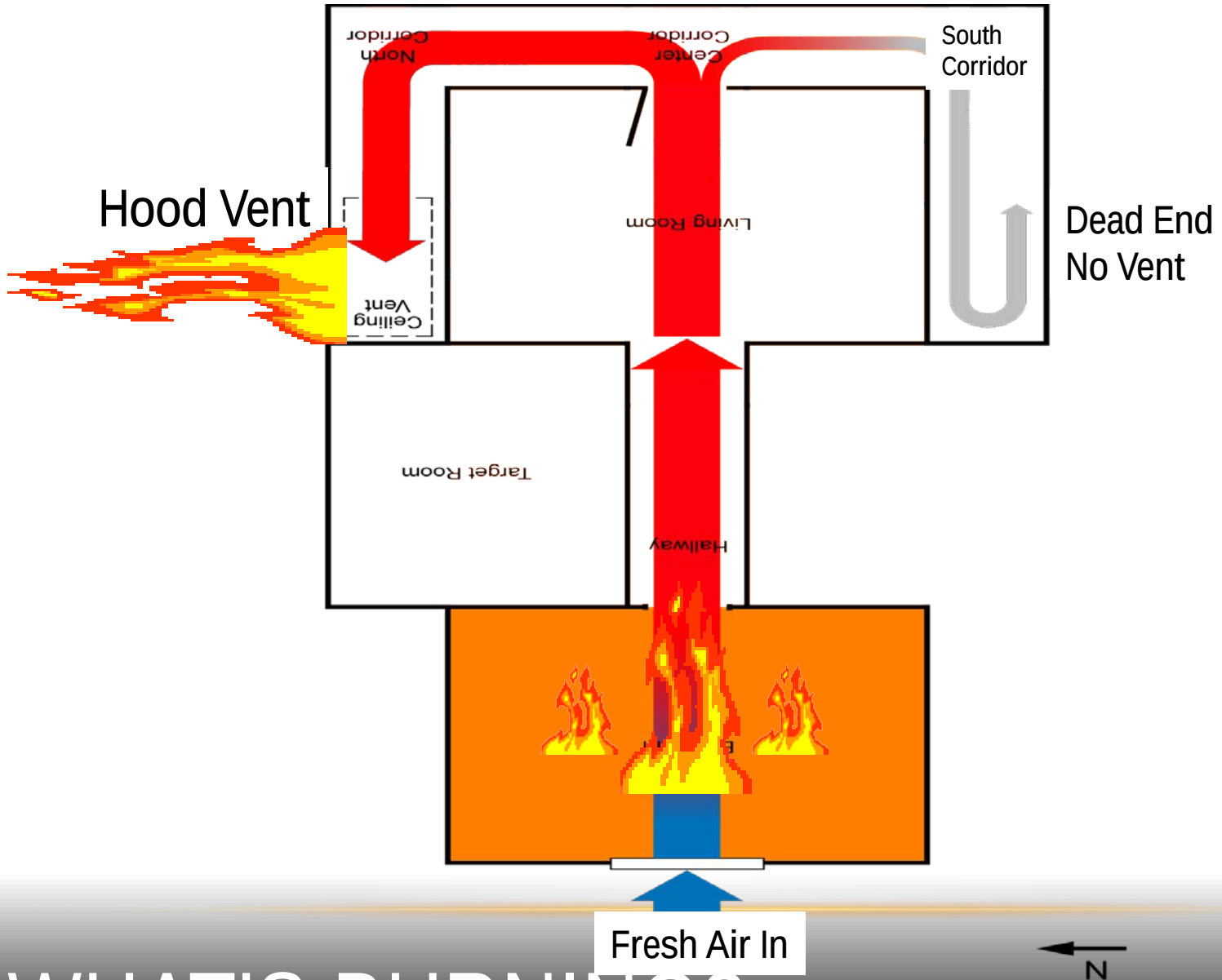
Radiation, Conduction, Convection

THE FIRE GROWTH CURVE



WHAT'S BURNING?

BURNING SMOKE NOWHERE NEAR THE SEAT OF THE FIRE



WHAT'S BURNING?

REVIEW – FIRE DYNAMICS

REVIEW – FIRE DYNAMICS

END

Fire Dynamics


COMMACK
TRAINING
DIVISION
CFD
F
D
"GET INVOLVED"

Fire Dynamics

Written: 9/2022
Version #1

Revision #: _____
Date: _____

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