

## **FIRE DYNAMICS TERMINOLOGY:**

**BACKDRAFT:** A deflagration resulting from the sudden introduction of air into a confined space containing oxygen deficient products of incomplete combustion

**BI-DIRECTIONAL FLOW / NEUTRAL PLANE:** Where smoke/hot gases (HIGHER PRESSURE) are exhausting out of the top of the vent opening and it is drawing a current of cooler/fresh air (LOWER PRESSURE) in through the bottom of the opening which creates a neutral plane.

**CONDUCTION:** The transfer of heat from the direct contact of a solid of higher temperature to a solid of lower temperature

**CONVECTION:** The transfer of heat through the movement of hot smoke and gases to solid surfaces of lower temperature

**COMBUSTIBLE:** Capable of burning, generally in air under normal conditions of ambient temperature and pressure, unless otherwise specified. Combustion can occur in cases where an oxidizer other than oxygen in air is present (e.g., chlorine, fluorine, or chemicals containing oxygen in their structure).

**DOOR CONTROL:** The process of ensuring the entrance door providing access to the fire area is controlled and closed as much as possible after teams enter the structure. Steps must be taken to prevent the door from locking behind the entering members. By controlling the door, we are controlling the flow path of the fire conditions from the high pressure of the fire area towards the low pressure area on the other side of the door. Door control also limits fire development by controlling the flow path of fresh air at the lower level of the open door towards the seat of the fire.

**DICERS-VO:** a fire extinguishment model utilizing interior tactics to extinguish fires

- D**etect the location of the fire
- I**solate the fire area
- C**onfine the fire
- E**xtinguish the fire
- R**escue occupants
- S**earch of the fire area and adjoining spaces
  
- V**entilation coordinated with fire attack
- O**verhaul of the fire area for extension

**FIRE DYNAMICS:** The detailed study of how: chemistry, fire science, material science, and the engineering disciplines of fluid mechanics and heat transfer, interact to influence fire behavior.

## **FIRE STAGES**

**INCIPIENT:** The early stage of fire development where the fire's progression is limited to a fuel source and the thermal hazard is localized to the area of burning material.

**GROWTH:** The stage of fire development when the heat release rate from an incipient fire has increased to the point where heat transferred from the fire and the combustion products are pyrolyzing adjacent fuel sources. The fire begins to spread across the ceiling of the fire compartment (rollover).

**FULLY DEVELOPED STAGE:** Fire development, within a compartment, has reached its peak heat release rate. This usually occurs after flashover, resulting in floor to ceiling burning within the compartment, creating heat conditions untenable for members.

**DECAY STAGE:** The stage of fire development within a structure characterized by either a decrease in the fuel load or available oxygen to support combustion, resulting in lower temperatures and lower pressure in the fire area.

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

**FLASHOVER:** A transition in the development of a compartment fire when surfaces exposed to thermal radiation from fire gases reach ignition temperature simultaneously. This causes the fire to spread rapidly throughout the space, resulting in fire involvement of the entire compartment

**FLOW PATH:** The movement of heat and smoke from the fire area (*HIGHER PRESSURE*) to 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 CONTROL:** The tactic of controlling or closing ventilation points which will:

- Limit additional oxygen into the space, thereby: limiting fire development, heat release rate and smoke production.

- Control the movement of the heat and smoke conditions out of the fire area to the exterior and to the other areas within the building

**FUEL LIMITED FIRE:** A fire in which the heat release rate and fire growth are controlled by the quantity and characteristics of the fuel

**FUEL LOAD:** The total quantity of combustible contents of a building, space, or fire area, including interior finish and trim, expressed in terms of heat release rate. Fires that involve hydrocarbon and synthetic based contents such as foam plastics, polyesters, polypropylenes, and nylons have a relatively high heat release rate when compared to the natural fiber products. Structure fires fueled with common household furnishings composed of synthetic materials have been shown to increase in size and heat release rate due to increased ventilation and the in-flow of additional oxygen.

**FUEL RICH:** An environment with high heat, smoke and products of combustion but not enough oxygen to sustain combustion

**HEAT RELEASE RATE:** The rate at which energy is generated by the burning of a fuel and oxygen mixture. As the heat release rate increases, the heat, smoke production and pressure within the area will increase and spread along available flow paths toward low pressure areas (open doors, windows and roof openings).

**NUETRAL PLANE:** The interface at a Bi-Directional Flow where the hot smoke and gases are moving out of the compartment over the top of cooler air, flowing moving into the compartment

**PATH OF LEAST RESISTENCE:** The path that smoke and heat travel as they move from *HIGHER PRESSURE* to *LOWER PRESSURE*

**PYROLYSIS:** The breakdown of fuels such as, wood and foam plastics, into their basic compound when subjected to heat. Fuels will continue to off-gas (produce pyrolysate) and add to the flammable fuel load within the compartment as long as the material is subjected to elevated temperatures.

**RADIATION:** The transmission of heat energy by electromagnetic waves through the space between a body at a higher temperature to a body at a lower temperature

### **TRANSITIONAL ATTACK / HITTING IT HARD FROM THE YARD /**

**SOFTEN THE TARGET:** The tactic of applying water on the fire, from the exterior, as quickly as possible – regardless of where it is emitting from - to cool the fire and improve conditions in the interior and then transitioning to an interior fire attack

**SITUATIONAL AWARENESS:** The on-going activity of assessing what is going on around you during the complex and dynamic environment of a fire incident. Operations will be more effective and safer by continually observing your surroundings, communicating conditions to other members and monitoring radio transmissions.

**SIZE-UP:** The process of gathering and analyzing information that will influence decisions fire officers make regarding the deployment of resources and the implementation of tactics.

**SMOKE:** The combination of airborne solid particulates, liquid particulates and gases emitted when a material undergoes pyrolysis or combustion. Smoke is a heated fuel source. Smoke is a toxic mixture that contains numerous poisonous gases such as carbon monoxide, hydrogen cyanide and phosgene.

**SLICERS:** Structural Fire Tactical Goals reduce temperatures inside a building prior to entry by fire personnel for extinguishment or rescue

- S**ize Up
- L**ocate the Fire
- I**dentify and Control the Flow Path
- C**ool the Space from the Safest Location
- E**xtinguish the Fire
- R**escue
- S**alvage

**UNI-DIRECTIONAL FLOW:** A vent opening with only one way of smoke and hot gases venting outward or fresh air being drawn into the vent opening

**VENTILATION:** The controlled and coordinated removal of heat and smoke from a structure, replacing the escaping gases with fresh air. This exchange is bi-directional with heat and smoke exhausting at the top and air flowing in towards the fire at the bottom of horizontal vents. The fire will pull the additional air flow into the building towards the fire which can increase the fire size and heat release rate. This exchange can occur by opening doors, windows or roof structures. Coordinated and controlled ventilation will facilitate quicker extinguishment and limit fire spread.

**VENT-ENTER-ISOLATE-SEARCH (VEIS):** A search tactic where you enter a window or door to search for the location of fire or to locate victims where the priority upon entering via a window is to close the door to that room or area to isolate that area being searched from the fire area (Flow Path Control). When entering a fire area through a door, the door needs to be closed (Door Control) until the fire area is further isolated or a charged hoseline is advancing on the fire. By isolating the area, we are

controlling the flow path of the fire, heat and smoke towards the ventilation point as well as controlling the air flow from the ventilation point towards the fire.

**VENTILATION-CONTROLLED/LIMITED FIRE:** A fire with limited ventilation in which the heat release rate or growth is controlled by the amount of oxygen available to the fire.

**VENTILATION INDUCED FLASHOVER (VIF):** A flashover initiated by the introduction of oxygen into a pre-heated, fuel rich (smoke filled), oxygen deficient area. This phenomenon has become more prevalent with well insulated homes. Synthetic fuel loads rapidly consume more of the available oxygen within the fire area and produce fuel rich combustion products creating conditions favorable to a possible ventilation induced flashover.

**VENTILATION PROFILE:** The appearance of the fire building's ventilation points showing the flow paths of heat and smoke out of the structure as well as any air movement into the structure.

**VENTILATION TACTICS:** The coordinated and controlled opening of ventilation points in a structure to facilitate fire operations.



## Fire Behavior Based Upon Changing Fire Dynamics In Structures

### Incident Priorities: Life Safety/Incident Stabilization/Property Conservation



**SMOKE SHOWING**

#### **COMPARTMENT FIRE (UNVENTED)**

Incipient phase changing over to Ventilation-limited fire if self-venting does not occur. A Ventilation-limited fire will proceed from Growth Stage to Decay stage with the risk of Backdraft and Smoke Explosion when Fire Dept. makes entry.

Door Control and Coordinated Fire Attack with systematic ventilation of structure with concentration on utilizing proper Flow Paths.

Compartmental Transitional Fire Attack: short, penciling bursts of straight stream pattern are implemented to cool gaseous layer during door entry and advancement to seat of fire. Nozzle man should wait 10 seconds before advancing further into the structure for safety.

This is an Offensive-interior Operation to protect life and property. Initial RIT of 2 in: 2out should be followed during initial operations.

NFA Flow Formula: (length x width ÷ 3=GPM required).



**SMOKE & INTERIOR FIRE SHOWING**



**SMOKE & EXTERIOR COMPT FIRE SHOWING**

<50% INVOLVED

#### **WORKING STRUCTURE FIRE (VENTED)**

A Fuel-Controlled fire which transitions from Growth Stage to Fully Developed Stage due to self venting of the fire. Uncontrolled Flow Paths will spread heat and smoke throughout the structure resulting in Fire Spread. Remember Smoke is Fuel and Flashover is near if it has not already occurred.

Structural Transitional Fire Attack: cooling from exterior with a hand line or Blitz to "RESET" the fire to an earlier heat level before entry.

This is an Offensive-Defensive Operation usually requiring a 2nd Alarm. After the fire has been darkened down from the exterior, Interior crews attempt to make entry to perform search and rescue.

A Risk-Benefit Analysis must be made prior to crews making entry.

If conditions are untenable, crews pull out and prepare for a Defensive posture. A designated RIT is dispatched.

NFA Flow Formula: (length x width ÷ 3 + 25% per floor involved=GPM required.)



**EXTERIOR FIRE 1 FLOOR FUEL-LADEN SMOKE FLOOR ABOVE**

>50% INVOLVED

#### **FULLY INVOLVED STRUCTURE FIRE**

A WELL Vented, Fuel-Controlled fire in the Fully Developed Stage. Flashover has occurred on multiple floors leading to pyrolysis of Structural Components posing the danger of Collapse and Fire Spread to Exposures due to radiant heating. Wind will also intensify fire spread.

This is a Defensive Operation with establishment of sufficient water supply for elevated Master Stream devices, Wagon pipes, and portable Deluge guns. There should also be Collapse Zones ( 1 1/2 times the height of the building) established with fire attack from corners of the structure.

All units should remain outside the Collapse Zone and RIT should be on alert for signs of potential collapse. Beware of Hydraulic Overload!

NFA Flow Formula: (length x width ÷ 3 + 25% per floor involved + 25% per exposure = GPM required).



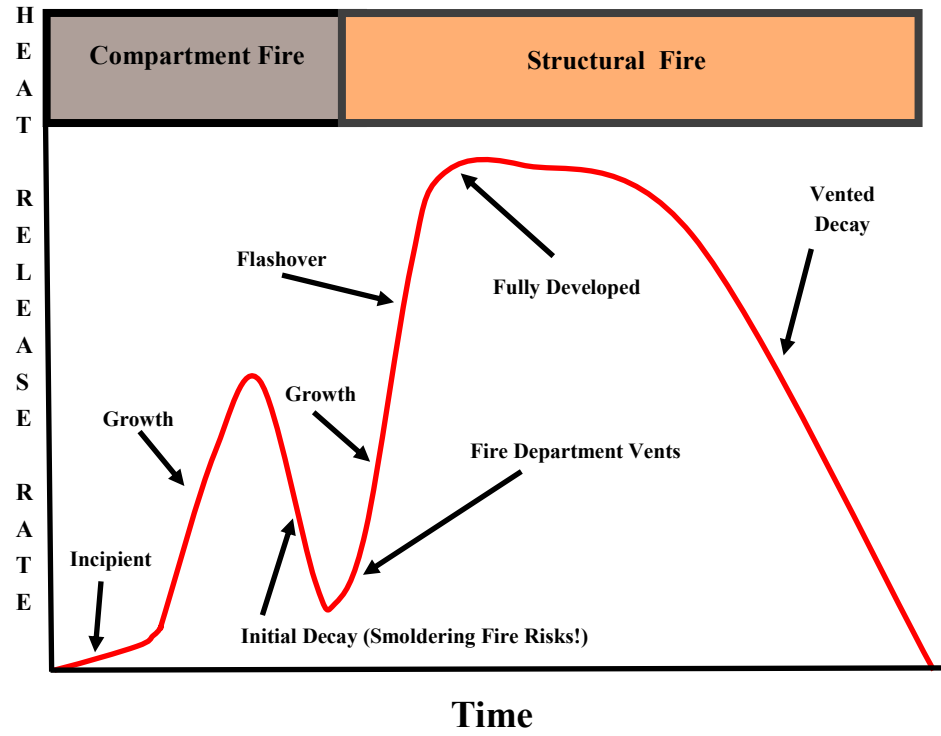
**EXTERIOR FIRE SHOWING MULTIPLE FLOORS AND EXPOSURES**



# Pennsylvania State Fire Academy



## New Fire Growth Chart



## Water Supply

Establish a sustainable Water Supply that exceeds recommended NFA Flow Formula for fire attack.

<b>BLUE</b>	Class AA	1500 gpm or Better
<b>GREEN</b>	Class A	1000 gpm to 1499 gpm
<b>ORANGE</b>	Class B	500 gpm to 999 gpm
<b>RED</b>	Class C	Below 500 gpm

## Fire Flows: Combination and Smoothbore Nozzles

Hose Diameter	Capacity	Smooth Bore Tip Sizes
1 3/4" handline	150-180 gpm	15/16" @ 50psi
2" handline	200 gpm	1" @ 50psi
2 1/2" handline	240-250 gpm	1 1/8" @ 40psi
Step Gun	350 gpm	1 1/4" @ 50 psi
Deluge Gun	500 gpm to 1000 gpm	1 3/8", 1 3/4", 2" @ 80 psi
Wagon Pipe	1000 gpm to 2400 gpm	2", 2 1/2", 3" @ 80 psi
Elevated Master Stream	1000 gpm to 2400 gpm	2", 2 1/2", 3" @ 80 psi

## Strategy And Tactics For Changing Fire Dynamics

### WRECEO - VS

- W**ATER - Soften the target from exterior
- R**ESCUE
- E**XPOSURES
- C**ONFINE
- E**XTINGUISH
- O**VERHAUL

### Actions of Opportunity

- V**ENTILATION-Control Flow Paths
- S**ALVAGE

### SLICERS:COMMAND STRATEGIC GUIDELINES

- S**IZE-UP
- L**OCATE FIRE
- I**DNENTIFY & CONTROL FLOW PATH
- C**OOl THE SPACE FROM SAFE LOCATION
- E**XTINGUISH THE FIRE
- R**ESCUE
- S**ALVAGE

### Actions of Opportunity

- R**ESCUE
- S**ALVAGE

### DICERS-VO: INTERIOR TACTICAL GUIDELINES

- D**ETECT THE LOCATION OF THE FIRE
- I**SOLATE THE FIRE AREA (DOOR CONTROL)
- C**ONFINE THE FIRE
- E**XTINGUISH THE FIRE
- R**ESCUE OCCUPANTS
- S**EARCH OF THE FIRE AREA & ADJOINING SPACES
- V**ENTILATION COORDINATED W/ FIRE ATTACK
- O**VERHAUL OF THE FIRE AREA FOR EXTENSION