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Fire Patterns

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Knowledge Objectives

- Identify fire effects and understand their causes.
- Recognize fire patterns.
- Identify the cause of fire patterns.
- Analyze fire patterns to produce a hypothesis.

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Skills Objectives

- Interpret fire patterns to determine the point of origin.

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Introduction

- Recognition, identification, and analysis of fire effects and fire patterns
- Knowledge of fire dynamics is important to understand fire patterns.

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Fire Effects and Fire Patterns (1 of 2)

- Fire effects = observable or measurable changes in material resulting from fire
- Fire pattern = visible or measurable changes or shapes formed by fire effects
- Fire investigator attempts to recreate fire development history and origin

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Fire Effects and Fire Patterns (2 of 2)

- Primary physical evidence of a fire:
  - Burned materials
  - By-products of burning
- Pattern interpretation changes over time.

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Fire Effects

- Knowledge of fire effects is necessary to identify and interpret fire patterns.
- Melting can help determine temperature in a given area.
- Temperatures at a location do not indicate a particular fuel source.

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Mass Loss

- Can sometimes determine duration and intensity of a fire
  - There are many additional factors.
- Postfire analysis can use exemplars and undamaged portions of an object.
- As fire intensifies, mass loss increases.

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Char (1 of 2)

- Carbonaceous material that has been burned
  - Wood char is most common.
  - There is no standard rate of char.

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Char (2 of 2)

- Factors affecting rate of char:
  - Rate and duration of heating
  - Ventilation effects
  - Surface-to-mass ratio
  - Direction, orientation, and size of wood grain
  - Species of wood
  - Moisture content of the wood product
  - Any surface coating

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Spalling (1 of 2)

- Chipping or pitting of concrete or masonry
  - Founds on floors, walls, ceilings
  - May show different coloration
  - May have existed prior to the fire
  - May be caused by heat or mechanical stress

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Spalling (2 of 2)

- Spalling on the floor of a garage.

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Oxidation (1 of 2)

- Basic chemical process associated with combustion
- Oxidation of noncombustible materials can produce:
  - Color and texture changes
  - Fire patterns

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Oxidation (2 of 2)

- More pronounced oxidation can be caused by:
  - Higher temperature
  - Longer exposure

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Melting

- Physical change of material from solid to liquid caused by heat
- Demarcation lines between melted and unmelted portions of a material can be useful.
- Each solid material has its own melting temperature.
- Can be difficult to distinguish from oxidation

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Alloying of Metals

- Two metals, one in liquid state, come into contact and form a new material.
- Can look like melting

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Thermal Expansion and Deformation

- Heat causes most materials to expand and change shape.
  - Temporarily or permanently
- Structural failures can occur as a result.
- Distortion indicates that melting temperature was never reached.

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Smoke Deposits (1 of 2)

- May collect on cooler surfaces such as walls and windows
  - Especially during smoldering fires
- Color and texture do not indicate burning or heat release rate
- As fire grows, it consumes smoke deposits from earlier in fire
  - Referred to as a *clean burn*

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Smoke Deposits (2 of 2)

- Clean burn
  - Created when fire oxidizes smoke deposits and consumes carbon

Courtesy of Jamie Novak, Novak Investigation Inc. and St. Paul Fire Department

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Calcination

- Occurs in plaster or gypsum wall surfaces
- Chemically bound water is driven out by heat.
- Gypsum wallboard reacts to fire in predictable manner
  - First paper burns off, then color changes
- Rate and depth do not indicate burn times.

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Glass Effects (1 of 3)

- Glass deposits free of soot usually indicate early failure of the glass before accumulation of smoke.
- May result from:
  - Rapid heating
  - Damage prior to fire
  - Direct flame impingement

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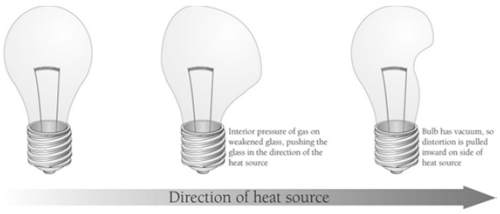
Glass Effects (2 of 3)

- Light bulb damage can indicate direction of heat source.



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Glass Effects (3 of 3)

- Fractured glass is found in most structure fires.
- Window panes may pop out of frames.
- Crazing results from rapid cooling of glass.
  - Not from heating, as previously believed

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Furniture Springs

- Damage can provide clues to:
  - Fire intensity
  - Duration
  - Direction of travel
- Does not indicate type of fire

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Heat Shadowing

- Caused by object blocking travel of heat to a surface:
  - Radiated heat
  - Convected heat
  - Direct flame
- Creates discontinuous pattern

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Protected Areas

- Object is shielded from:
  - Heat transfer
  - Combustion
  - Deposition
- Useful in reconstructing fire scene

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Rainbow Effect

- Hydrocarbons do not mix with water.
  - Float on the surface
  - Interference pattern produces rainbow effect
- Produced by many materials

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Fire Patterns (1 of 2)

- Visible or measurable physical changes, or identifiable shapes, formed by a fire effect or group of fire effects
- Three basic causes:
  - Heat
  - Decomposition
  - Consumption

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Fire Patterns (2 of 2)

- Analyze fire patterns within the context of all the patterns.
- Used to determine the sequence of events that occurred during the fire
- When fires increase in size or burn for an extended period, fire patterns at the origin may be more difficult to identify.

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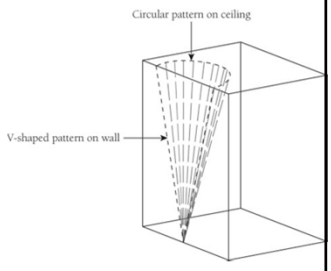
Plume-Generated Patterns (1 of 3)

Fire patterns are two dimensional, but the fire plume creating the pattern was three dimensional.



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Plume-Generated Patterns (2 of 3)

- When a fuel package is ignited, a plume of gas, smoke, and flame rises upward until it is contained or cooled.
- The heat release rate greatly affects the fire pattern.

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Plume-Generated Patterns (3 of 3)

- Pattern shapes include:
  - V-shaped
  - Inverted cone
  - Hourglass
  - U-shaped
  - Circular
  - Pointer and arrow
- As plume develops, size and shape of pattern changes

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Ventilation-Generated Patterns

- As pressure builds during combustion, hot gases and fire escape through openings with increased velocity.
- Well-ventilated fires increase the rate of material damage.
- Heavy damage is often found at ventilation areas, even if they are not the point of origin.

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Hot Gas Layer-Generated Patterns (1 of 2)

- Prior to flashover, hot gas layer begins to descend
- Level of descent can be determined by examining the line of demarcation
- Sometimes referred to as containment patterns

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Hot Gas Layer-Generated Patterns (2 of 2)

An example of a hot gas layer-generated pattern.

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Patterns Generated by Full-Room Involvement

- Usually found on all exposed surfaces in the room
- Makes traditional patterns more difficult to document and analyze
- Material damage is more extensive

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Suppression-Generated Patterns

- Fire suppression actions may create or change fire patterns.
  - Water streams may change direction of fire spread
  - Ventilation actions affect fire patterns.

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Lines of Demarcation

- Produce a border between affected and less affected areas
- Numerous factors dictate where these lines form.

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Patterns Detected in Fire Victims' Injuries (1 of 2)

- Body should not be moved until it has been documented and analyzed
- Heat effects on the body:
  - Skin will redden, darken, blister, split, and char.
  - Muscle will dehydrate, contract, and shrink.
  - Pugilistic pose
  - Exposed bone will change in color and mass.

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Patterns Detected in Fire Victims' Injuries (2 of 2)

- Bodies found at fire scenes should be treated as evidence and interpreted for fire patterns.
- Investigators should also document injuries to those who have survived a fire.

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Pattern Location (1 of 2)

- Fire effects can be three dimensional.
- Look for large-scale patterns such as aerial views of the roof.
- Look for small-scale patterns such as heat effects on wiring insulation.
- Examine all areas in a building for patterns.

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Pattern Location (2 of 2)

- Wall patterns usually V-shaped or U-shaped
- Ceiling patterns above fire are usually circular
- Floor patterns depend on many conditions.
- Flashover and full-room involvement can produce relatively uniform burning.

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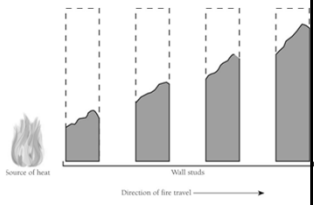
Beveling (1 of 3)

- Beveling is an indicator of fire direction on wood wall studs.
- Bevel leans in direction of fire travel



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Beveling (2 of 3)

- Fire penetration of a horizontal surface
  - Potential causes include radiant heat, isolated smoldering objects, and ventilation.
  - Downward movement is not necessarily from an ignitible liquid.
  - Gas may have been forced through small holes in the flooring.

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Beveling (3 of 3)

- Direction of fire travel is determined by examining the sides of the hole and the slope created by the fire.
  - Wide hole and downward slope indicates fire travel from above.
  - Wider on the bottom and sloped upward indicates fire travel from below.

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Irregular Patterns

- Irregular patterns can be misinterpreted.
- Investigator should work to identify fuel that caused pattern
- If an ignitable liquid is suspected, samples should be submitted for laboratory analysis.

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Pattern Geometry (1 of 2)

- Fire and smoke produce variety of distinctive patterns
- Multiple interpretations possible

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Pattern Geometry (2 of 2)

- Examples:
  - V-shaped patterns from fire plume
  - Inverted cone patterns created by vertical flame plume not reaching ceiling level
  - Hourglass patterns from fuel package at the base, near a vertical surface
  - Truncated cone patterns from intersection of a cone pattern on vertical and horizontal surfaces

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Fire Pattern Analysis

- Process of identifying and interpreting fire patterns to determine how they were created
- Two basic types
  - Heat (intensity) patterns
  - Fire spread (movement) patterns

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Heat (Intensity) Patterns

- As a fuel item is exposed to heat and flames, patterns are created.
- Lines of demarcation indicate:
  - Direction of fire travel
  - Characteristics and amounts of fuel present

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Fire Spread (Movement) Patterns

- Produced by growth, spread, and flow of combustion products
- Helpful in determining the original heat source

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Summary (1 of 5)

- The examination of fire patterns allows the investigator to determine the direction of fire travel as well as the point of origin.
- Fire patterns may be created by flame impingement, hot gases, smoke, and other products of combustion.

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Summary (2 of 5)

- The area of most damage may not indicate the point of origin.
- Factors such as ventilation, fire suppression activities, and types of materials that are burning will influence the severity of damage as well as the direction of fire travel during a fire.

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Summary (3 of 5)

- Glass that displays crazing indicates rapid cooling.
- Spalled concrete, brick, and mortar may indicate rapid heating of the surface.

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Summary (4 of 5)

- Incandescent light bulbs that are equal to or greater than 25 watts will tend to push outward toward the heat source, whereas those less than 25 watts will collapse inward.

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Summary (5 of 5)

- Penetrations in floors may be the result of ignitable liquids; however, they can also be caused by smoldering items, the effects of ventilation, and areas exposed to flashover conditions.