

Fire Investigation: Essentials

FI: E-Student Manual

1st Edition, 9th Printing-May 2025



FEMA

FEMA/USFA/NFA

FI: E-SM

May 2025

1st Edition, 9th Printing

Fire Investigation: Essentials



FEMA

Fire Investigation: Essentials

FI: E-Student Manual

1st Edition, 9th Printing-May 2025



FEMA

This Student Manual may contain material that is copyright protected. USFA has been granted a license to use that material only for NFA-sponsored course deliveries as part of the course materials, and it shall not be duplicated without consent of the copyright holder. States wishing to use these materials as part of state-sponsorship and/or third parties wishing to use these materials must obtain permission to use the copyright material(s) from the copyright holder prior to teaching the course.

This page intentionally left blank.

TABLE OF CONTENTS

	PAGE
Table of Contents	iii
Acknowledgments	v
Audience, Scope and Course Purpose	vii
Firefighter Code of Ethics	ix
A Student Guide to End-of-course Evaluations.....	xi
UNIT 1: SAFETY	SM 1-1
UNIT 2: OVERVIEW OF FIRE INVESTIGATION AND NFPA 921/1033	SM 2-1
UNIT 3: SCIENTIFIC METHOD.....	SM 3-1
UNIT 4: COMPARTMENT FIRE DYNAMICS, PART 1	SM PART 1: 4-1
COMPARTMENT FIRE DYNAMICS, PART 2	SM PART 2: 4-1
UNIT 5: ELECTRICAL SYSTEMS AND ARC MAPPING	SM 5-1
UNIT 6: FAILURE ANALYSIS – SYSTEMS & SMALL APPLIANCES.....	SM 6-1
UNIT 7: FIRE EFFECTS AND PATTERNS.....	SM 7-1
UNIT 8: EVIDENCE COLLECTION AND PRESERVATION (GUEST LECTURER).....	SM 8-1
UNIT 9: FIRE DYNAMICS PRACTICUM.....	SM 9-1
UNIT 10: FIRE SCENE INVESTIGATION AND DOCUMENTATION.....	SM 10-1
UNIT 11: INJURIES, FATAL FIRES AND LINE-OF-DUTY DEATHS	SM 11-1
UNIT 12: FIRE PROTECTION SYSTEMS	SM 12-1
UNIT 13: FIRE SCENE EXAMINATION AND PROCESSING	SM 13-1
UNIT 14: REPORT WRITING	SM 14-1
UNIT 15: TIMELINE DEVELOPMENT, ANALYSIS AND SYNTHESIS.....	SM 15-1
UNIT 16: LEGAL CONSIDERATIONS.....	SM 16-1
UNIT 17: SUMMATIVE STUDENT EVALUATION AND COURSE SUMMARY	SM 17-1

This page intentionally left blank.

ACKNOWLEDGMENTS

The development of any National Fire Academy (NFA) course is a complex process aimed at providing students with the best possible learning opportunity we can deliver. There are many players in course development, each of whom plays an equally important part in its success. We want to extend our heartfelt thanks to everyone who participated in making this quality product.

Sincerely,

Kevin Oliver, IAAI-CFI
Training Specialist
U.S. Fire Administration, National Fire Academy
Emmitsburg, Maryland

Martin Monahan, IAAI-CFI
Program Manager
ATF, Fire Programs Training Branch
Emmitsburg, Maryland

This page intentionally left blank.

AUDIENCE, SCOPE AND COURSE PURPOSE

The target audience for “Fire Investigation: Essentials” (R2110) is personnel tasked with fire investigative duties. Priority will be given to full-time public service personnel with fire or arson investigative responsibilities. Each offering will accommodate, at least, 24 students, with a maximum of 32 students.

The course will introduce the student to fundamental content found in National Fire Protection Association (NFPA) 921, *Guide for Fire and Explosion Investigations*, and NFPA 1033, *Standard for Professional Qualifications for Fire Investigators*, and other professional publications. Through analysis, application, and evaluation of these documents, the course provides the student an opportunity to obtain the knowledge and skills needed to conduct successful, science-based fire/arson investigations with legal merit. Successful completion of this course satisfies the training and education requirement for International Association of Arson Investigators (IAAI) for Fire Investigation Technician (FIT) certification.

This page intentionally left blank.

FIREFIGHTER CODE OF ETHICS

Background

The Fire Service is a noble calling, one which is founded on mutual respect and trust between firefighters and the citizens they serve. To ensure the continuing integrity of the Fire Service, the highest standards of ethical conduct must be maintained at all times.

Developed in response to the publication of the Fire Service Reputation Management White Paper, the purpose of this National Firefighter Code of Ethics is to establish criteria that encourages fire service personnel to promote a culture of ethical integrity and high standards of professionalism in our field. The broad scope of this recommended Code of Ethics is intended to mitigate and negate situations that may result in embarrassment and waning of public support for what has historically been a highly respected profession.

Ethics comes from the Greek word *ethos*, meaning character. Character is not necessarily defined by how a person behaves when conditions are optimal and life is good. It is easy to take the high road when the path is paved and obstacles are few or non-existent. Character is also defined by decisions made under pressure, when no one is looking, when the road contains land mines, and the way is obscured. As members of the Fire Service, we share a responsibility to project an ethical character of professionalism, integrity, compassion, loyalty and honesty in all that we do, all of the time.

We need to accept this ethics challenge and be truly willing to maintain a culture that is consistent with the expectations outlined in this document. By doing so, we can create a legacy that validates and sustains the distinguished Fire Service institution, and at the same time ensure that we leave the Fire Service in better condition than when we arrived.



FIREFIGHTER CODE OF ETHICS

I understand that I have the responsibility to conduct myself in a manner that reflects proper ethical behavior and integrity. In so doing, I will help foster a continuing positive public perception of the fire service. Therefore, I pledge the following...

- Always conduct myself, on and off duty, in a manner that reflects positively on myself, my department and the fire service in general.
- Accept responsibility for my actions and for the consequences of my actions.
- Support the concept of fairness and the value of diverse thoughts and opinions.
- Avoid situations that would adversely affect the credibility or public perception of the fire service profession.
- Be truthful and honest at all times and report instances of cheating or other dishonest acts that compromise the integrity of the fire service.
- Conduct my personal affairs in a manner that does not improperly influence the performance of my duties, or bring discredit to my organization.
- Be respectful and conscious of each member's safety and welfare.
- Recognize that I serve in a position of public trust that requires stewardship in the honest and efficient use of publicly owned resources, including uniforms, facilities, vehicles and equipment and that these are protected from misuse and theft.
- Exercise professionalism, competence, respect and loyalty in the performance of my duties and use information, confidential or otherwise, gained by virtue of my position, only to benefit those I am entrusted to serve.
- Avoid financial investments, outside employment, outside business interests or activities that conflict with or are enhanced by my official position or have the potential to create the perception of impropriety.
- Never propose or accept personal rewards, special privileges, benefits, advancement, honors or gifts that may create a conflict of interest, or the appearance thereof.
- Never engage in activities involving alcohol or other substance use or abuse that can impair my mental state or the performance of my duties and compromise safety.
- Never discriminate on the basis of race, religion, color, creed, age, marital status, national origin, ancestry, gender, sexual preference, medical condition or handicap.
- Never harass, intimidate or threaten fellow members of the service or the public and stop or report the actions of other firefighters who engage in such behaviors.
- Responsibly use social networking, electronic communications, or other media technology opportunities in a manner that does not discredit, dishonor or embarrass my organization, the fire service and the public. I also understand that failure to resolve or report inappropriate use of this media equates to condoning this behavior.

Developed by the National Society of Executive Fire Officers

A Student Guide to End-of-course Evaluations

Say What You Mean ...

Ten Things You Can Do to Improve the National Fire Academy

The National Fire Academy takes its course evaluations very seriously. Your comments and suggestions enable us to improve your learning experience.

Unfortunately, we often get end-of-course comments like these that are vague and, therefore, not actionable. We know you are trying to keep your answers short, but the more specific you can be, the better we can respond.

Actual quotes from student evaluations:	Examples of specific, actionable comments that would help us improve the course:
1 "Update the materials."	- The (ABC) fire video is out-of-date because of the dangerous tactics it demonstrates. The available (XYZ) video shows current practices. - The student manual references building codes that are 12 years old.
2 "We want an advanced class in (fill in the blank)."	- We would like a class that enables us to calculate energy transfer rates resulting from exposure fires. - We would like a class that provides one-on-one workplace harassment counseling practice exercises.
3 "More activities."	- An activity where students can physically measure the area of sprinkler coverage would improve understanding of the concept. - Not all students were able to fill all ICS positions in the exercises. Add more exercises so all students can participate.
4 "A longer course."	- The class should be increased by one hour per day to enable all students to participate in exercises. - The class should be increased by two days so that all group presentations can be peer evaluated and have written abstracts.
5 "Readable plans."	- The plans should be enlarged to 11 by 17 and provided with an accurate scale. - My plan set was blurry, which caused the dotted lines to be interpreted as solid lines.
6 "Better student guide organization," "manual did not coincide with slides."	- The slide sequence in Unit 4 did not align with the content in the student manual from slides 4-16 through 4-21. - The instructor added slides in Unit 4 that were not in my student manual.
7 "Dry in spots."	- The instructor/activity should have used student group activities rather than lecture to explain Maslow's Hierarchy. - Create a pre-course reading on symbiotic personal relationships rather than trying to lecture on them in class.
8 "More visual aids."	- The text description of V-patterns did not provide three-dimensional views. More photographs or drawings would help me imagine the pattern. - There was a video clip on NBC News (date) that summarized the topic very well.
9 "Re-evaluate pre-course assignments."	- The pre-course assignments were not discussed or referenced in class. Either connect them to the course content or delete them. - The pre-course assignments on ICS could be reduced to a one-page job aid rather than a 25-page reading.
10 "A better understanding of NIMS."	- The instructor did not explain the connection between NIMS and ICS. - The student manual needs an illustrated guide to NIMS.

This page intentionally left blank.

UNIT 1: SAFETY

TERMINAL OBJECTIVE

The students will be able to:

- 1.1 *Simulate safe behavior on a fire scene.*

ENABLING OBJECTIVES

The students will be able to:

- 1.1 *Identify and describe primary safety and health hazards.*
 - 1.2 *Identify the relevant National Fire Protection Association (NFPA) standards and Occupational Safety and Health Administration (OSHA) regulations as they apply to fire investigations.*
 - 1.3 *Model training in the use of the R/N95 disposable respirator.*
-

This page intentionally left blank.



TERMINAL OBJECTIVE

Simulate safe behavior on a fire scene.



Slide 1-2

ENABLING OBJECTIVES

- 1.1 Identify and describe primary safety and health hazards.
- 1.2 Identify the relevant National Fire Protection Association (NFPA) standards and Occupational Safety and Health Administration (OSHA) regulations as they apply to fire investigations.
- 1.3 Model training in the use of the R/N95 disposable respirator.

Slide 1-3

I. SAFETY

SAFETY

- Safety information is embedded in each unit.
- Safety is your responsibility.
- Complacency kills.
- Don't wash fire clothes at home!
- OSHA.
 - Not exempt.
- Hazard and risk assessment.
- Tyvek = best practice.
 - Dust, barrier, cross contamination.



Slide 1-4

- A. Safety information is embedded in each unit.
- B. Safety is your responsibility.
- C. Complacency kills.
- D. Don't wash fire clothes at home!
- E. Occupational Safety and Health Administration (OSHA): not exempt.
- F. Hazard and risk assessment.
- G. Tyvek = best practice: dust, barrier, cross contamination.

SAFETY RECOMMENDATIONS

<https://www.firearson.com/media/exnp1434/fire-investigator-health-and-safety-best-practices-3rd-edition.pdf>

2023 Fire Investigator Health and Safety Best Practices (Third Edition)

Health and Safety Top Tips



Slide 1-5

EQUIPMENT

- Needed:
 - Work boots (students provide).
 - Respirator – N95 particulate.
 - Helmet.
 - Safety glasses.
 - Gloves.
 - Tyvek.
- Equipment is located at Burn Laboratory, and its use is required.

Slide 1-6

H. For this class you will need:

1. Work boots (students provide).
2. Respirator – N95 particulate.
3. Helmet.
4. Safety glasses.
5. Gloves.
6. Tyvek.

I. Equipment is located at Burn Laboratory, and its use is required.

GLASSES

Students are required to wear provided safety glasses at the Burn Laboratory:

- Ignition Sources Demonstration.
- Electrical Demonstration.
- Scene Processing.



Slide 1-7

J. Students are required to wear provided safety glasses at the Burn Laboratory during:

1. Ignition Sources Demonstration.

2. Electrical Demonstration.
3. Scene Processing.

II. RESPIRATOR TRAINING

RESPIRATORY

- Employer may determine if voluntary respirator is permitted when it does not create a hazard.
- Employer may elect to prohibit using respirators if unnecessary.
- If voluntary use is permissible, the employer must provide users with appropriate training.

Slide 1-8

- A. Employer may determine if voluntary respirator is permitted when it does not create a hazard.
- B. Employer may elect to prohibit using respirators if unnecessary.
- C. If voluntary use is permissible, the employer must provide users with appropriate training.

RESPIRATOR TRAINING

Exception: Employers are not required to include in a written program employees whose only use of respirators involves voluntary use of filtering face pieces (dust masks).

Employees must be provided with one-page 29 CFR 1910.134 Appendix D, *Information for Employees Using Respirators When Not Required Under the Standard*. The form is signed by the employee and kept in training records.

Slide 1-9

- D. Exception: Employers are **not required** to include in a written program employees whose only use of respirators involves voluntary use of filtering face pieces (dust masks).

- E. Employees must be provided with one-page 29 Code of Federal Regulations (CFR) 1910.134 Appendix D, *Information for Employees Using Respirators When Not Required Under the Standard*. The form is signed by the employee and kept in training records.

RESPIRATOR TRAINING

Filtering facepiece (dust mask): A negative pressure particulate respirator with a filter as an integral part of the facepiece or with the entire facepiece composed of the filtering medium.

- Place over nose and mouth.
- Tighten straps around head.
- Place mask on before assisting others.



Slide 1-10

- F. “Filtering facepiece (dust mask): A negative pressure particulate respirator with a filter as an integral part of the facepiece or with the entire facepiece composed of the filtering medium” (Respiratory Protection, 2019).
1. Place over nose and mouth.
 2. Tighten straps around head.
 3. Place mask on before assisting others.

RESPIRATOR TRAINING

- Congratulations!
- Please sign and date the one-page 29 CFR 1910.134 Appendix D, *Information for Employees Using Respirators When Not Required Under the Standard*.
- Pass forward to instructor.

Slide 1-11

- G. Congratulations!

Please sign and date the one-page 29 CFR 1910.134 Appendix D, *Information for Employees Using Respirators When Not Required Under the Standard*.

III. BURN LAB SAFETY

BURN LAB SAFETY

- Automated external defibrillator (AED) in new garage (door is marked).
- Emergency shower and eye wash in new garage (door is marked).
- First aid kit (policy).
- Fire extinguishers.
- Handwashing sink, face wipes.
- Boot decontamination.

Slide 1-12

- A. Automated external defibrillator (AED) in new garage (door is marked).
- B. Emergency shower and eye wash in new garage (door is marked).
- C. First aid kit (policy).
- D. Fire extinguishers.
- E. Handwashing sink, face wipes.
- F. Boot decontamination.

IV. SUMMARY



SUMMARY



- Be safe at the Burn Laboratory.
- Practice safety suggestions incorporated into other units.
- Don't wash your PPE at home.
- Perform some level of scene assessment for each fire scene inspection.

Slide 1-13

REFERENCE

Respiratory Protection, 1910 C.F.R. § 134 (2019).

This page intentionally left blank.

UNIT 2: OVERVIEW OF FIRE INVESTIGATION AND NFPA 921/1033

TERMINAL OBJECTIVE

The students will be able to:

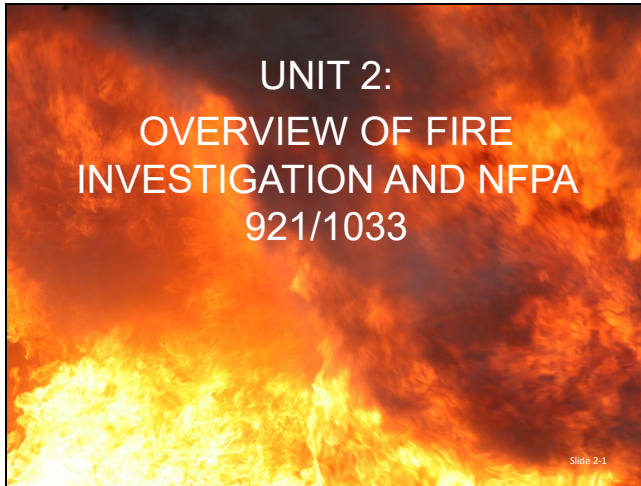
- 2.1 *Consider concepts associated with the nature of fire investigation and professional guiding documents.*

ENABLING OBJECTIVES

The students will be able to:

- 2.1 *Recognize the responsibilities associated with fire investigation and testifying as an expert witness.*
 - 2.2 *Review the pertinent national guides and standards associated with the profession of fire investigation.*
 - 2.3 *Differentiate among the potential uses and applications of publications by counter experts, attorneys, and judges.*
 - 2.4 *Utilize knowledge of nationally recognized fire investigation publications to support their approach to fire analysis process and investigation.*
-

This page intentionally left blank.



TERMINAL OBJECTIVE

Consider concepts associated with the nature of fire investigation and professional guiding documents.

Slide 2-2

ENABLING OBJECTIVES

- 2.1 Recognize the responsibilities associated with fire investigation and testifying as an expert witness.
- 2.2 Review the pertinent national guides and standards associated with the profession of fire investigation.
- 2.3 Differentiate among the potential uses and applications of publications by counter experts, attorneys, and judges.
- 2.4 Utilize knowledge of nationally recognized fire investigation publications to support their approach to fire analysis process and investigation.

Slide 2-3

I. WHAT IS A FIRE INVESTIGATION?

WHAT IS A FIRE INVESTIGATION?

An attempt to discover, through investigating the facts, the scene, and any evidence, what happened at a given location to result in a fire.

“The process of determining the origin, cause, and development of a fire or explosion.”

-NFPA 921, Section 3.3.79

Slide 2-4

- A. An attempt to discover, through investigating the facts, the scene, and any evidence, what happened at a given location to result in a fire.
- B. “The process of determining the origin, cause, and development of a fire or explosion” (NFPA 921, Section 3.3.79, 2024 ed.).

WHY INVESTIGATE?

- Save lives.
- Prevent future fires.
- Identify product failures.
- Prosecute crimes.
- Identify responsibility.
- Others.



Slide 2-5

- C. Save lives.
- D. Prevent future fires.
- E. Identify product failures.
- F. Prosecute crimes.
- G. Identify responsibility.
- H. Others.

RESPONSIBILITY

It is the nature of this profession that new investigators are learning to be an expert

AND

provide expert testimony in a court of law, to potentially have someone deprived of their life or liberty.



Slide 2-6

SELF AWARENESS

- Ego/identity.
- Personal limitations.
- Training.



Slide 2-7

- I. Ego/identity.
- J. Personal limitations.
- K. Training.

HISTORY OF PROFESSION

1600-1900s

Apprentice-like approach.

1960s

Recognition of legal impact, training to include science and testing.

1970s-80s

Loss of ventilation science AND transition of home furnishings (fuel) from natural to synthetic result in a significant loss of the understanding, application, and testing in regard to the relationship between fuels, heat, and air.

Slide 2-8

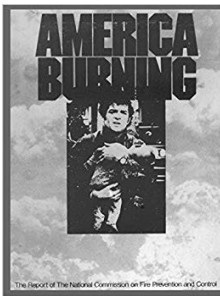
L. History of profession.

1. **1600-1900s:** Apprentice-like approach.
2. **1960s:** Recognition of legal impact, training to include science and testing.
3. **1970s-80s:** Loss of ventilation science **and** transition of home furnishings (fuel) from natural to synthetic result in a significant loss of the understanding, application, and testing in regard to the relationship between fuels, heat, and air.

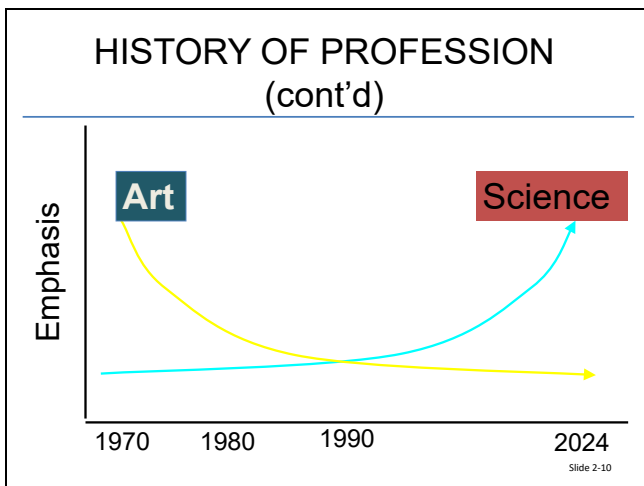
HISTORY OF PROFESSION (cont'd)

Historical View:

- America Burning – Presidential Committee (1973).
- Insurance Fraud Cases Increase.
- Identification & Prosecution of Arson Suspects Decrease.
- Federal Fire Protection & Control Act 1974.
- Anti-Arson Act Of 1982 Passed by Congress.



Slide 2-9

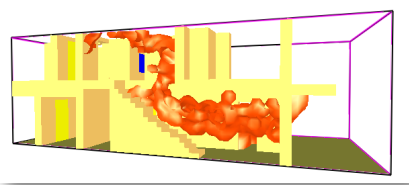


In 1973, a Presidential Committee produced a report called “*America’s Burning*” and concluded that there were deficits in the fire service and in fire investigation that needed to be addressed. Suggestions were made to include improving training of fire investigators to include more fire science and methodology. The era of the *apprentice-like approach* in training fire investigators was changing to an era of more *fire science-based* training for fire investigation.

4. “An appropriate education in fire investigation must teach the investigator the importance of the scientific approach and how to perform each of these steps properly and effectively.” (Kennedy, P.M. (1989). The crisis in fire investigation education. Fire Journal, 83(6). (November/December 1989), 13-14.)

TODAY'S CULTURE

- Development and acceptance of standards and guidebooks.
- Technological advancements in fire testing.
- Advancement of fire engineering disciplines.
- Integration of science and the investigative approach.



Slide 2-11

M. Today's culture.

1. Development and acceptance of standards and guidebooks.
2. Technological advancements in fire testing.
3. Advancement of fire engineering disciplines.
4. Integration of science and the investigative approach.

II. RESPONSIBILITY AND HISTORICAL

CONVICTION BASED ON FAULTY SCIENCE

This video introduces the story of Todd Willingham and illustrates the legal pitfalls and responsibility associated with bad science.

<https://youtu.be/W5gTVdQ0rIE>

Slide 2-12

A. Conviction based on faulty science.

THE BATTLE OF THE EXPERTS

In 1995, William Amor confessed to arson after a 15 hour interrogation. He was tried and convicted in 1995, for arson murder.

In May 2017, Judge Liam Brennan ruled it was scientifically impossible for the fire to have started in the way Amor described.

Retrieved from:
<https://www.chicagotribune.com/suburbs/naperville-sun/ct-naperville-arson-defendant-posts-bond-0531-20170530-story.html>

Slide 2-13

B. The battle of the experts.

William Amor was convicted in 1995 for arson murder. In May 2017, Judge Liam Brennan ruled it was scientifically impossible for the fire to have started in the way Amor described. He confessed after being interrogated for 15 or more hours. Retrieved from: <https://www.chicagotribune.com/suburbs/naperville-sun/ct-naperville-arson-defendant-posts-bond-0531-20170530-story.html>.

PREVENT MISTAKES

An understanding of the science and principles contained within texts, publications, journals, guides, and standards empowers fire investigators to avoid mistakes at the scene.

Slide 2-14

C. Prevent mistakes: An understanding of the science and principles contained within texts, publications, journals, guides, and standards empowers fire investigators to avoid mistakes at the scene.

[illegible]

- Many of these convictions were overturned on the basis of “Junk Science.”

Slide 2-15

1. Browse the National Registry of Exonerations (umich.edu).
2. As of March 28, 2024, there have been 153 reported arson-related convictions overturned nationwide.
3. Many of these convictions were overturned on the basis of “Junk Science.”

[illegible]

- Ignition Handbooks.
- Kirk's Fire Investigation.
- Government Technical Reports.



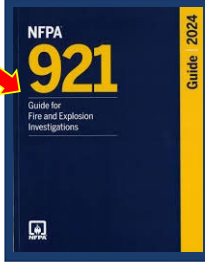
1. Ignition Handbooks.
2. Kirk's Fire Investigation.

3. Government Technical Reports.

GUIDES

A document, advisory or informative, that contains only non-mandatory provisions.



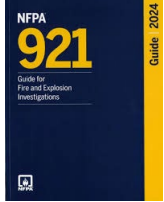


Slide 2-17

- B. Guide: a document that is advisory or informative in nature and that contains only non-mandatory provisions.

GUIDE EXAMPLE

“Guide for Fire and Explosion Investigations” published by the National Fire Protection Association (NFPA).



Slide 2-18

- C. “Guide for Fire and Explosion Investigations,” published by the National Fire Protection Association (NFPA).

NFPA – GUIDES SUCH AS 921

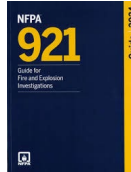
- Guides are revised every 3 years.
- Revision guided by technical committee using NFPA consensus process.
- Process is open to the public.

Slide 2-19

- D. Guides such as NFPA 921, *Guide for Fire and Explosion Investigations*, are revised every 3 years.
- E. Revision guided by technical committee using NFPA consensus process.
- F. Process is open to the public.

CHANGES TO THE 2024 EDITION

- Additional guidance on an investigator's potential confirmation bias, opinions, and expressions of certainty.
- The impact of suppression activities on fire ventilation and flow path remote from the area of origin.
- Relocation of all fire effects on electrical systems and components to Chapter 6.
- Four general classifications of fire causes added for investigators and authorities having jurisdiction.
- Additional guidance on fire investigator safety, health, and wellness.
- Expanded text on investigating fire involving hybrid electric vehicles (HEVs) and electric vehicles (EVs).
- Revised chapter on wildfire investigations.



Slide 2-20

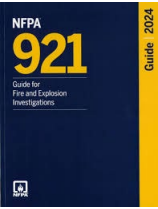
- G. The NFPA committee made the following changes in the 2024 edition:
1. Additional guidance on an investigator's potential confirmation bias, opinions, and expressions of certainty.
 2. The impact of suppression activities on fire ventilation and flow path remote from the area of origin.
 3. Relocation of all fire effects on electrical systems and components to Chapter 6.

4. Four general classifications of fire causes added for investigators and authorities having jurisdiction (AHJs).
5. Additional guidance on fire investigator safety, health, and wellness.
6. Expanded text on investigating fire involving hybrid electric vehicles (HEVs) and electric vehicles (EVs).
7. Revised chapter on wildfire investigations, including new terminology and unique indicators associated with these investigations.

IV. PUBLICATIONS AND THE EFFECTS ON AN INVESTIGATOR

POTENTIAL USES FOR NFPA 921

- Fire investigator conclusions.
- Attorneys support or contest opinions.
- Judges to qualify witnesses.
- Agencies for training and education programs.



Slide 2-21

- A. Potential uses for NFPA 921.
1. Fire investigator conclusions.
 2. Attorneys support or contest opinions.
 3. Judges to qualify witnesses.
 4. Agencies for training and education programs.

USING NFPA 921

- The guidebook of the profession.
- Courts use to evaluate the quality of the investigation and/or investigator.
- Investigators may be asked to read from the text. Can you read the formulas?
- The NFPA committee prominently displayed “*Guide 2024*” on the 2024 edition to reinforce the concept of being a *guide*.



Slide 2-22

B. Using NFPA 921.

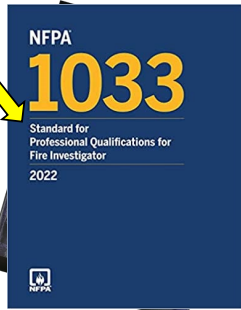
1. The guidebook of the profession.
2. Courts use to evaluate the quality of the investigation and/or investigator.
3. Investigators may be asked to read from the text. Can you read the formulas?
4. The NFPA committee prominently displayed “*Guide 2024*” on the 2024 edition to reinforce the concept of being a *guide*.

C. “Peer review is a formal procedure generally employed in prepublication review of scientific or technical documents and screening of grant applications by research-sponsoring agencies. Peer review carries with it connotations of both independence and objectivity. Peer reviewers should not have any interest in the outcome of the review....As such, the term ‘peer review’ should not be applied to reviews of an investigator’s work by coworkers, supervisors, or investigators from agencies conducting investigations of the same incident” (NFPA 921, Section 4.6.3, 2024 ed.).

STANDARDS

A document, containing mandatory provisions, using the word “shall” to indicate requirements.

Generally suitable for mandatory reference by another code or for adoption into law.



Slide 2-23

STANDARDS EXAMPLE

The “Standard for Professional Qualifications for Fire Investigator,” published by the National Fire Protection Association (NFPA).



Slide 2-24

- D. The “Standard for Professional Qualifications for Fire Investigator,” published by the NFPA.

NFPA-STANDARDS SUCH AS 1033

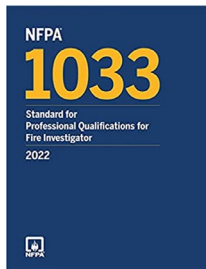
- Standards are revised every 5 years.
- Revision guided by technical committee using NFPA consensus process.
- Process is open to the public.

Slide 2-25

- E. NFPA standards such as NFPA 1033, *Standard for Professional Qualifications for Fire Investigator*, are revised every five years.
- F. Revision guided by technical committee using NFPA consensus process.
- G. Process is open to the public.

USING NFPA 1033

- Defines the minimum standards necessary to be a fire investigator.
- The educational knowledge base and Job Performance Resources (JPRs).



Slide 2-26

NFPA 1033

Requires investigators to remain current in the subjects listed as "requisite knowledge" as they relate to fire investigations, which include the following:

1. Fire Science
 - a. Fire Chemistry
 - b. Thermodynamics
 - c. Fire Dynamics
 - d. Explosion Dynamics
2. Fire Investigation
 - a. Fire Analysis
 - b. Fire Investigation Methodology
 - c. Fire Investigation Technology
 - d. Evidence Documentation, Collection, and Preservation
 - e. Failure Analysis and Analytical Tools

-NFPA 1033, Section 4.1.7

Slide 2-27

NFPA 1033 (cont'd)

Requires investigators to remain current in the subjects listed as “requisite knowledge” as they relate to fire investigations, which include the following:

- | | |
|---|---|
| <p>3. Fire Scene Safety</p> <ul style="list-style-type: none"> a. Hazard Recognition, Evaluation, and Basic Mitigation Procedures b. Hazardous Materials c. Safety Regulations | <p>4. Building Systems</p> <ul style="list-style-type: none"> a. Types of Construction b. Fire Protection Systems c. Electricity and Electrical Systems d. Fuel Gas Systems |
|---|---|

-NFPA 1033, Section 4.1.7

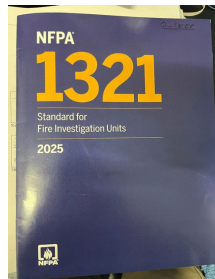
Slide 2-28

- H. Requires investigators to remain current in the subjects listed as “requisite knowledge” for the JPRs in Section 4.1.7.

The fire investigator shall complete and document a minimum of 40 hours of continuing education training every five years by attending formal education courses, workshops and seminars.

NFPA 1321

- In 2025, NFPA 1321, *Standard for Fire Investigation Units*, was first issued.
- This standard shall specify the minimum requirements relating to the establishment, structure, operation and management of fire investigation units (FIUs).



Slide 2-29

- I. In 2025, NFPA 1321, *Standard for Fire Investigation Units*, was first issued.

This standard shall specify the minimum requirements relating to the establishment, structure, operation and management of fire investigation units (FIUs).

HOW NFPA WORKS

- **Public input** is encouraged and accepted during revision cycles.
- **Proposals** are reviewed, considered, adopted or rejected by the appropriate technical committees.
- **Final change via a proposal** with two-thirds vote of the technical committee members.
- **Committee** members are made up of interested parties:
 - Public sector.
 - Private sector.
 - Manufacturers.
 - Attorneys.



Slide 2-30

J. How NFPA works.

1. **Public input** is encouraged and accepted during revision cycles.
2. **Proposals** are reviewed, considered, adopted or rejected by the appropriate technical committees.
3. **Final change via a proposal** with two-thirds vote of the technical committee members.
4. **Committee** members are made up of interested parties:
 - a. Public sector.
 - b. Private sector.
 - c. Manufacturers.
 - d. Attorneys.

EFFECT OF 1033 ON INVESTIGATOR

- The fire investigator must present the origin and cause to the judge and/or jury.
- Consider this as *teaching* the judge/jury.
- NFPA 1033 is likely to be used to challenge an investigator.



Slide 2-31

- K. The fire investigator must present the origin & cause investigation to the judge and/or jury so that they understand it. It may be helpful to consider this as *teaching* the judge and jury.
- L. NFPA 1033 is likely to be used to challenge a fire investigator's qualifications as an expert in origin & a fire investigator's methodology of determining an origin & cause.

A FIRE INVESTIGATOR WILL BE AN EXPERT WITNESS

A judge will determine if an investigator qualifies as an expert witness by considering:

- Relevancy – impact of specialized testimony on a jury.
- Qualifications – CV, education, and training.
- Methodology – science, repeatability, accepted.

And will determine if the investigator meets the threshold to provide testimony.

Slide 2-32

- M. A fire investigator will be an expert witness.
1. A judge will determine if an investigator qualifies as an expert witness by considering:
 - a. Relevancy – impact of specialized testimony on a jury.
 - b. Qualifications – curriculum vitae (CV), education and training.
 - c. Methodology – science, repeatability, accepted.

2. And will determine if the investigator meets the threshold to provide testimony.

CURRICULA VITAE

A curriculum vitae (CV) is an extensive resume style, listing your experience, training and education.

A CV includes items such as:

- Formal education, degrees, certifications.
- Seminars, training attended.
- Test and training burns.
- Publications.
- Presentations.
- (May include) case citation information on past testimony.

Slide 2-33

- N. A CV is an extensive resume style, listing your experience, training and education.

A CV includes items such as:

1. Formal education, degrees, certifications.
2. Seminars, training attended.
3. Test and training burns.
4. Publications.
5. Presentations.
6. (May include) case citation information on past testimony.

V. SUMMARY



SUMMARY

- Make accurate origin and cause determinations by using the systematic approach that is based upon the facts (data) of the fire scene.
- Always use the systematic methodology for origin and cause determinations that are based upon the systematic approach of the scientific method, per NFPA 1033 and 921.



Slide 2-34



SUMMARY

- Your opinion, determination, investigation, and report **will be heavily scrutinized** many times, possibly over many years, after the incident.
- Science is the pillar on which this profession is based.
- Be as thorough as possible; it will be vital to your work in the future.
- No fire is worth compromising your integrity.
- The fire investigator must base all origin and cause determinations upon fire science and the systematic approach of the scientific method.

Slide 2-35

REFERENCES

- Kennedy, P. M. (1989). The crisis in fire investigation education. *Fire Journal*, 83(6). (November/December 1989), 13-14.
- Kirk, P. (1969). *Fire investigation*. New York, NY: John Wiley & Sons. p.vii.
- NFPA 1033, Chapter 4.1.7, 2022 edition.
- NFPA 1033, Chapter 4.2 – 4.7, 2022 edition.
- NFPA 921, Section 3.3.79, 2024 edition.
- NFPA 921, Section 3.3.84, 2024 edition.
- NFPA 921, Section 4.2, 2024 edition.

This page intentionally left blank.

UNIT 3: SCIENTIFIC METHOD

TERMINAL OBJECTIVE

The students will be able to:

- 3.1 *Evaluate and apply the Scientific Method to fire investigation.*

ENABLING OBJECTIVES

The students will be able to:

- 3.1 *List and define the seven steps of the Scientific Method.*
- 3.2 *Outline the Scientific Method and apply it to the origin and cause of the fire.*
- 3.3 *Evaluate the use of the Scientific Method to collect and analyze the data points of the fire scene, and then to develop and test hypotheses.*
- 3.4 *Apply the Scientific Method to prevent various types of bias.*
-

This page intentionally left blank.



TERMINAL OBJECTIVE

Evaluate and apply the Scientific Method to fire investigation.

Slide 3-2

ENABLING OBJECTIVES

- 3.1 List and define the seven steps of the Scientific Method.
- 3.2 Outline the Scientific Method and apply it to the origin and cause of the fire.
- 3.3 Evaluate the use of the Scientific Method to collect and analyze the data points of the fire scene, and then to develop and test hypotheses.
- 3.4 Apply the Scientific Method to prevent various types of bias.

Slide 3-3

I. SCIENTIFIC METHOD OVERVIEW

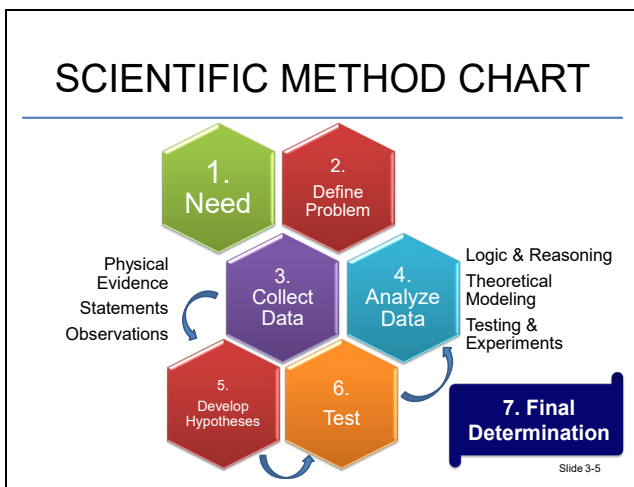
SCIENTIFIC METHOD

“The systematic pursuit of knowledge involving the recognition and definition of a problem; the collection of data through observation and experimentation; analysis of the data; the formulation, evaluation and testing of hypotheses; and, where possible, the selection of a final hypothesis.”

-NFPA 921, Section 3.3.171

Slide 3-4

- A. The Scientific Method is: “The systematic pursuit of knowledge involving the recognition and definition of a problem; the collection of data through observation and experimentation; analysis of the data; the formulation, evaluation and testing of hypotheses; and, where possible, the selection of a final hypothesis” (NFPA 921, Section 3.3.171, 2024 edition).



- B. Scientific Method chart.

FIRE INVESTIGATION AND THE SCIENTIFIC METHOD

Essential for all fire investigations:

- Universally recognized — no debate over its relevance or use.
- Recognized in court via Daubert and Rule 702.



Slide 3-6

C. Fire investigation and the Scientific Method.

Essential for all fire investigations:

1. Universally recognized — no debate over its relevance or use.
2. Recognized in court via Daubert and Rule 702.

II. SEVEN STEPS OF SCIENTIFIC METHOD

A. Fire investigation steps.

STEP 1: RECOGNIZE THE NEED

- First, one should determine the problem statements(s) or the question(s) that needs to be addressed.
- Investigate to identify conditions or people responsible, prevent future losses.
- See NFPA 921, 4.3.1



Slide 3-7

1. Step 1: Recognize the need.
 - a. First, one should determine the problem statements(s) or the question(s) that needs to be addressed.

- b. Investigate to identify conditions or people responsible, prevent future losses.
- c. See National Fire Protection Association (NFPA) 921, *Guide for Fire and Explosion Investigations*, 4.3.1.

**STEP 2:
DEFINE THE PROBLEM**

- How can the problem be solved?
- Should a proper origin and cause investigation be conducted?
- Where did the fire or explosion originate, and what caused it?



Slide 3-8

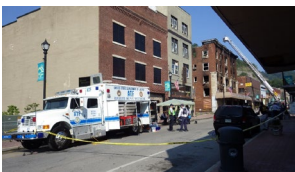
2. Step 2: Define the problem.

Having determined the problem statement(s), the following are questions that need to be addressed:

- a. How can the problem be solved?
- b. Should a proper origin and cause investigation be conducted?
- c. Where did the fire or explosion originate, and what caused it?

**STEP 2:
DEFINE THE PROBLEM (cont'd)**

- Additional resources.
- Legal authority.
- Scene security.
- Scene safety/hazmat.



Slide 3-9

- d. What additional resources will be needed to conduct an origin and cause investigation? More investigators? More logistics support?
- e. What is the legal authority of being on the fire scene?
- f. Any safety/HAZMAT concerns?
- g. Is the scene secured to protect the integrity of the scene?

STEP 3: COLLECT DATA

“Information about the fire or explosion incident is now collected by observation, experiment, or other direct data-gathering means. The data collected is called empirical data because it is based on observation or experience and is capable of being verified or known to be true.”

-NFPA 921, Section 4.3.3

Slide 3-10

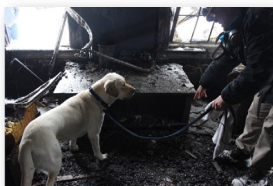
3. Step 3: Collect data.

- a. “Information about the fire or explosion incident is now collected by observation, experiment, or other direct data-gathering means. The data collected is called empirical data because it is based on observation or experience and is capable of being verified or known to be true” (NFPA 921, Section 4.3.3, 2024 edition).

STEP 3: COLLECT DATA

Data collection may occur during any stage of the investigation and is derived from:

- Witness statements.
- Fire patterns, to include arc mapping.
- Fire effects.
- Other data points.



Slide 3-11

- b. Data collection may occur during any stage of the investigation and is derived from:
- Witness statements.
 - Fire patterns, to include arc mapping.
 - Fire effects.
 - Other data points.

STEP 4: ANALYZE DATA

- A detailed examination and analysis of the data must occur before a hypothesis can be developed.
- Requires the use of knowledge, training, and experience.
- If the data cannot be understood after analysis, seek assistance.



Slide 3-12

4. Step 4: Analyze data.

- a. A detailed examination and analysis of the data must occur before a hypothesis can be developed.
- b. Requires the use of knowledge, training, and experience.
- c. If the data cannot be understood after analysis, seek assistance.

STEP 5: DEVELOP A HYPOTHESIS

Develop a hypothesis (or explanation of the event) based on the analysis of empirical data, collected through observations, which are developed into explanations (hypotheses) for the event. Base hypotheses on information available (inductive reasoning).



Slide 3-13

5. Step 5: Develop a hypothesis.
- Develop a hypothesis (or explanation of the event) based on the analysis of empirical data, collected through observations, which are developed into explanations (hypotheses) for the event. Base hypotheses on information available (inductive reasoning).
 - Remember that multiple alternate hypotheses can developed during this step.

**STEP 6:
TEST EACH HYPOTHESIS**

- The purpose of testing all alternate hypotheses is to disprove each hypothesis (deductive reasoning).
- Means of testing a hypothesis:
 - Cognitive.
 - Thought experiments.
 - Physical testing.
 - Reference literature.
 - Fire models.
 - Appliance examinations.



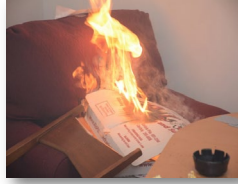
Slide 3-14

6. Step 6: Test each hypothesis.
- The purpose of testing all alternate hypotheses is to disprove each hypothesis (deductive reasoning).
 - Means of testing a hypothesis:
 - Cognition.
 - Thought experiments.
 - Physical testing.
 - Reference literature.
 - Fire models.
 - Appliance examinations.

STEP 7: SELECT FINAL HYPOTHESIS

- After the collection and analysis of data, and the development and testing of hypotheses, the one remaining hypothesis is selected as the final hypothesis.
- "When using the scientific method, the failure to consider alternate hypotheses is a serious error."

-NFPA 921, Section 4.3.7



Slide 3-15

7. Step 7: Select final hypothesis.

- After the collection and analysis of data, and the development and testing of hypotheses, the one remaining hypothesis is selected as the final hypothesis.
- "When using the scientific method, the failure to consider alternate hypotheses is a serious error" (NFPA 921, Section 4.3.7, 2024 edition).

SCIENTIFIC METHOD

How the Scientific Method works:

- The Scientific Method applies to both the origin and cause, and the process does not stop at the scene. More data can be collected and then analyzed as the investigation continues.
- The recommended systematic approach is the Scientific Method.

Slide 3-16

B. Applying the Scientific Method.

1. How the Scientific Method works:

- The Scientific Method applies to both the origin and cause, and the process does not stop at the scene. More data can be collected and then analyzed as the investigation continues.
- The recommended systematic approach is the Scientific Method.

EXAMPLES OF SYSTEMATIC APPROACH

- Exterior to interior.
- Working from lesser to greater areas of damage to determine an origin, keeping in mind that areas of greater damage may be caused by ventilation-induced fire patterns/effects.
- Consistent documentation of every fire scene, regardless of the size.



Slide 3-17

2. Systematic approach (examples).

- a. Exterior to interior.
- b. Working from lesser to greater areas of damage to determine an origin, keeping in mind that areas of greater damage may be caused by ventilation-induced fire patterns/effects.
- c. Consistent documentation of every fire scene, regardless of the size.

III. GROCERY STORE ARSON CASE STUDY

ARSON FIRE SET IN A GROCERY STORE VIDEO



Slide 3-18

RACK BELOW STEAKS



Slide 3-19

COOLER



Slide 3-20

WIRING HARNESS



Slide 3-21

WIRING HARNESS



Slide 3-22

NO ELECTRICAL FAILURE

- Mid-range of previous photo with rubber wiring tape removed.
- Indicating no fault between wiring harness and chiller tubing.



Slide 3-23

CLOSE-UP: NO ELECTRICAL ACTIVITY TO COPPER



Slide 3-24

NEXT STEPS

1. Arrest suspect in video.
2. Have press conference.
3. It's IPA time.

Check one more time?

Slide 3-25

HEY BOBBY, WHAT DO YOU THINK THIS IS?



Slide 3-26

LOOKING UP ABOVE FIRE



Slide 3-27

PRIOR TO REMOVAL



Slide 3-28

ACTUAL CAUSE - PIN FAILURE

- Oops.
- HRC at pin.



Slide 3-29

VIDEO REPLAY



Slide 3-30

This page intentionally left blank.

ACTIVITY 3.1

Hypothesis Testing

Purpose

Test hypotheses by analyzing the scenarios below with NFPA 921, using the Scientific Method, and conclude whether the given hypotheses are correct.

Directions

1. You will read the scenarios below and use NFPA 921 to determine whether or not the hypotheses provided are correct.
2. You will provide the correct NFPA 921 numeric section reference and reasoning to support your answer.

Scenario 1

Fire Investigator Robin conducts a fire origin and cause investigation at a commercial warehouse. Robin has identified an area measuring approximately 20 feet by 30 feet that has sustained heavy fire damage. It is Robin's opinion that the fire originated in the heavily damaged area. During excavation of the floor in the suspected fire origin area, Robin identifies the remains of a ceiling-mounted fluorescent light fixture. A closer examination of the fluorescent light ballast and area surrounding the ballast reveals the liquefied remains of potting compound. Robin recalls that his on-the-job training (OJT) instructor told him the discovery of liquefied potting compound is conclusive evidence that the fluorescent light ballast sustained pre-fire failure and overheating. Robin subsequently identifies the fluorescent light as causing the fire and classifies the fire as accidental. Do you agree with Robin's findings?

Scenario 2

Fire Investigator Stapleton conducts a fire origin and cause investigation at a residential structure. The fire origin investigation is focused on the basement based on witness statements, fire dynamics and fire patterns. Stapleton continues to collect fire scene data, evaluates the electrical system, and conducts arc mapping. Stapleton notes that the electrical system is single phase 120/240 volt (V). Stapleton identifies an 18 American Wire Gauge (AWG) extension cord rated for 10 amps plugged into a wall directly in the area where he believes the fire originated (beside a trash can filled with combustible materials). Stapleton identifies that two 1,200 watt (W) space heaters are plugged into the extension cord. The owner stated the heaters ran all the time because of moisture in the basement. Stapleton examines the breaker panel and identifies that the circuit is protected by a 20-ampere breaker. With this information, Stapleton believes that the fire was caused by an overloaded extension cord which ignited available, common combustible materials. Stapleton classifies the fire as accidental. Do you agree with Stapleton's findings?

Scenario 3

Fire Investigator Patel conducts an origin and cause determination at a large single-family residential fire. The fire occurred at 3:00 AM, the structure was unoccupied, the alarm system was not armed/active, and the fire department response time was 17:00 minutes. The initial information from the fire companies is that the fire was hard to "knock down," and the flames kept reigniting in the living room and kitchen area. There was significant damage to the living room, kitchen and garage sections of the house; the entire west side of the house was heavily damaged, with fire venting the windows, doors, and breaching the roof above the living room. During the walk through of the remaining house, Patel discovers a heavy amount of black, oily soot on the surfaces of the high-end, tile, suite-style master bathroom. Patel understands that hydrocarbon-based fuels burn with a heavy black sooty smoke. Based on the irregular burn patterns on the floor in the kitchen, and the interpretation of the heavy soot and oily residue, Patel determines ignitable liquids were used to accelerate the fire. Do you agree with Patel's findings?

ACTIVITY 3.2

Scientific Method — Fire Cause Analysis

Purpose

Demonstrate various steps of the Scientific Method. The students will collect and analyze data regarding potential fire cause, develop a fire cause hypothesis, and discuss applicable testing methods to disprove their fire cause hypothesis.

Example: The student is provided with an incandescent light bulb and bath towel. An initial hypothesis can be developed that the incandescent light bulb ignited the bath towel. The student should then consider what conditions would be necessary for the ignition scenario to be possible, i.e., test their hypothesis. Additional data collection and analysis to test the hypothesis may include: Was the structure energized? Was the branch circuit energized? What position is the switch in? Did the bulb work? What is the bulb wattage? What was the orientation of the bulb? What temperature is the bulb capable of reaching? What was the distance between the bulb and the bath towel? If the bulb was on, for how long?

Safety Precautions

None.

Directions

1. You will be separated into groups of four. Each group will identify the contents within their assigned container to include the potential ignition source and first fuel. The group will develop a fire cause hypothesis and identify what additional data would need to be collected to test their hypothesis.
2. Each group will verbally present their findings to the class.

This page intentionally left blank.

ACTIVITY 3.3

Large Burn Cell Walkthrough

Purpose

Evaluate a fire scene on the first day of training, employ a systematic evaluation of evidence, and render an opinion as to the fire origin area(s). This activity will allow the students to demonstrate their baseline knowledge, training, and experience of the Scientific Method, fire dynamics, and the analysis of fire patterns/effects.

The students will reevaluate the fire scene during the second week of training, and it is expected that students will synthesize the concepts learned up to, and then after, Unit 3 when identifying the fire origin area(s). The students will have the opportunity to change their original opinion of the first fire origin if needed.

Safety Precautions

- Safety glasses and hard hat are required.
- Follow all direction of instructors and range personnel.

Directions

1. You will conduct a 15-minute walkthrough of the large burn cell with an emphasis on identifying the fire origin area(s). You should conduct both an exterior and interior scene evaluation. You will develop a theory of fire origin area by interpreting fire patterns and assessing compartment fire dynamics. You will render an independent opinion as to the fire origin area(s), which will be documented by placing a mark(s) on the provided scene diagram. You will turn your diagram in to the instructors when you complete the exercise.
2. The fire cause and classification is not to be considered during this exercise. The fire(s) was intentionally set and therefore classified as incendiary.

This page intentionally left blank.

IV. SUMMARY


FEMA


U.S. Fire
Administration

SUMMARY

In this lesson you should have learned:

- To list and define the seven steps of the Scientific Method.
- How to outline the Scientific Method and to apply it to the origin and cause of the fire.
- How to evaluate the use of the Scientific Method to collect and analyze the data points of the fire scene, and then to develop and test hypotheses.
- How to apply the Scientific Method to prevent various types of bias.

Slide 3-31

This page intentionally left blank.

REFERENCES

NFPA 921, Section 3.3.171, 2024 edition.

NFPA 921, Section 4.2, 2024 edition.

NFPA 921, Section 4.3.1, 2024 edition.

NFPA 921, Section 4.3.3, 2024 edition.

NFPA 921, Section 4.3.7, 2024 edition.

NFPA 921, Section 4.3.9, 2024 edition.

NFPA 921, Section 4.3.10, 2024 edition.

NFPA 921, Section 6.3.2.4, 2024 edition.

NFPA 921, Section 6.4, 2024 edition.

NFPA 921, Section 6.5.7.4, 2024 edition.

NFPA 921, Section 17.5.4, 2024 edition.

NFPA 921, Section 23.2.2.4, 2024 edition.

NFPA 921, Section 25.5.8.1.5, 2024 edition.

This page intentionally left blank.

UNIT 4: COMPARTMENT FIRE DYNAMICS, PART 1

TERMINAL OBJECTIVE

The students will be able to:

- 4.1 *Integrate the knowledge of fuels, heat transfer, and ventilation to investigate ignition, the stages of fire development, and the resulting fire damage.*

ENABLING OBJECTIVES

The student will be able to:

- 4.1 *Describe the basic concepts of fire dynamics and explosion dynamics.*
 - 4.2 *Examine the characteristics of different types of fuels.*
 - 4.3 *Differentiate the impact of different types of fuels on ignition potential and fire growth.*
 - 4.4 *Analyze flow paths and compartment fire dynamics.*
 - 4.5 *Anticipate and explain the progression of a fire within a compartment employing the variables that impact fire growth, development, and spread.*
 - 4.6 *Construct an explanation of the correlation of fire growth with the expected fire damage patterns.*
 - 4.7 *Conclude the correlation between a competent ignition source and the first fuel ignited.*
-

This page intentionally left blank.



TERMINAL OBJECTIVE

Integrate the knowledge of fuels, heat transfer, and ventilation to investigate ignition, the stages of fire development, and the resulting fire damage.

This unit is presented in two parts.

Slide 4-2

ENABLING OBJECTIVES

- 4.1 Describe the basic concepts of fire dynamics and explosion dynamics.
- 4.2 Examine the characteristics of different types of fuels.
- 4.3 Differentiate the impact of different types of fuels on ignition potential and fire growth.
- 4.4 Analyze flow paths and compartment fire dynamics.
- 4.5 Anticipate and explain the progression of a fire within a compartment employing the variables that impact fire growth, development, and spread.
- 4.6 Construct an explanation of the correlation of fire growth with the expected fire damage patterns.
- 4.7 Conclude the correlation between a competent ignition source and the first fuel ignited.

Slide 4-3

OVERVIEW

- Fire Dynamics.
- Heat Transfer.
- Fire Chemistry/Materials.
- Smoke.
- Fuels.
- Ignition.
- Flames.
- Flame Spread.
- Air Entrainment & Plumes.
- Fuel Limited Fires.
- Ventilation Limited Fires.
- Compartment Fires.
- Flow Paths.
- Patterns and Pattern Development.
- Summary.

Slide 4-4

I. DEFINITIONS

WHAT IS FIRE DYNAMICS?

The scientific study of fire behaviors:

- Ignition.
- Combustion.
- Flame spread.
- Fire growth.
- Extinguishment.



Slide 4-5

A. What is fire dynamics?

1. The scientific study of fire behavior such as:

- Ignition.
- Combustion.
- Flame spread.
- Fire growth.
- Extinguishment.

FIRE DYNAMICS

Fire dynamics incorporates science from many areas of knowledge including:

- Chemistry.
- Mathematics.
- Physics.
- Engineering.



Slide 4-6

2. Fire dynamics incorporates science from many areas of knowledge including:

- Chemistry.
- Mathematics.
- Physics.
- Engineering.

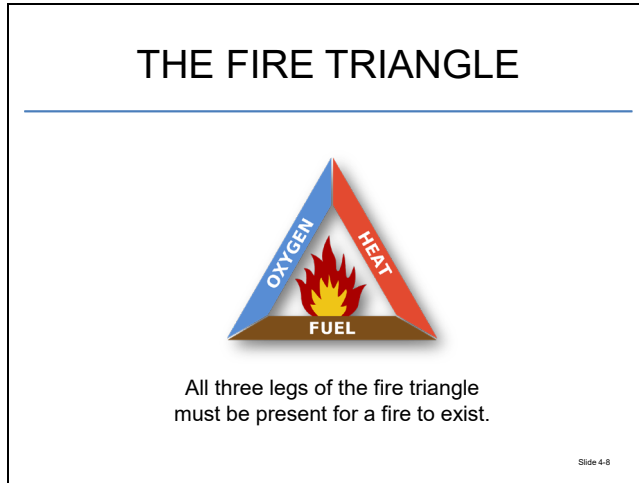
WHAT IS FIRE

A rapid oxidation process, which is an exothermic chemical reaction, resulting in the evolution of light and heat in varying intensities.

— NFPA 921, Section 3.3.71

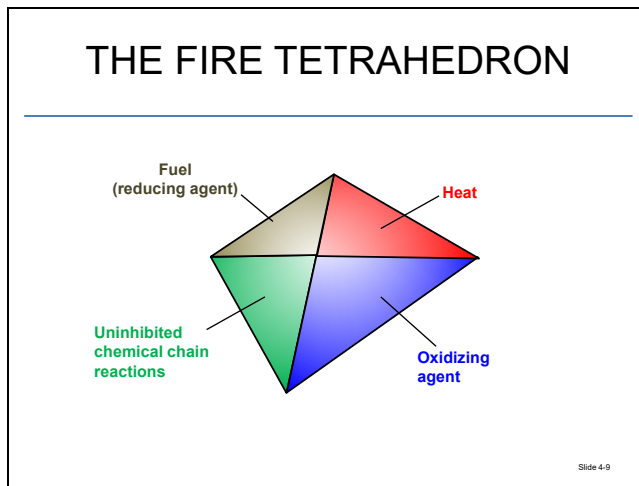


Slide 4-7



B. The Fire Triangle.

The fire triangle provides the key elements for combustion; however, it does not provide the action that generates a sustained flame.



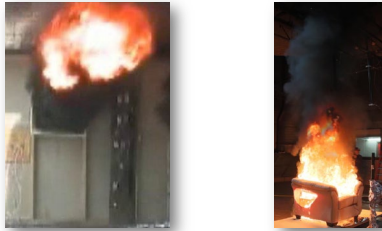
C. The Fire Tetrahedron.

Contains the chemical reaction that is needed to generate flaming combustion.

1. Heat.
2. Fuel (reducing agent).
3. Uninhibited chemical chain reaction.
4. Oxidizing agent.

TRIANGLE VS. TETRAHEDRON

Flash of flame versus sustained flame.



Slide 4-10

D. Fire Triangle versus Fire Tetrahedron.

1. Flash of flame versus sustained flame.
2. When heat, fuel, and oxygen mix in the correct quantities, a flame can exist. However, in order for the flame to continue, the chemical chain reaction must continue to support flaming combustion. In the photo on the left, the flame is generated once the hot, fuel-rich gases (smoke) are mixed with enough air (oxygen) to enable auto-ignition and generate a flame. Once the fuel that ignited burns away, or the mixture of fuel and air becomes too rich or too lean to burn, the flaming combustion stops. In the photo on the right, the flame continues to heat solid fuels in the chair, causing them to change into a gaseous fuel, which supplies the flaming combustion process. The flames will be sustained until the fuel is consumed, or until someone works to extinguish the fire.

THE GOAL OF A COMPLETE FIRE INVESTIGATION IS...

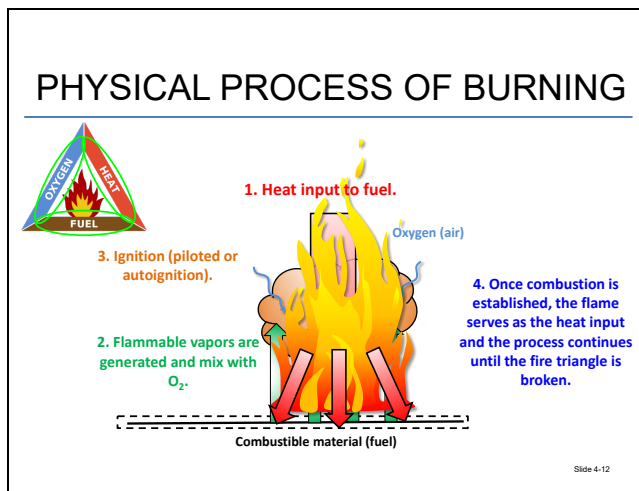
- To identify the Ignition Sequence of the Fire.
- NFPA 921 defines the ignition sequence of a fire event as "the succession of events and conditions that allow the source of ignition, the fuel, and the oxidant to interact in the appropriate quantities and circumstance for combustion to begin." (19.4.4.1)
 - Heat.
 - Fuel.
 - Oxygen.
 - Circumstances that brought the other three factors together.

Slide 4-11

E. Ignition sequence.

1. The goal of a complete fire investigation is to identify the ignition sequence of the fire event.
2. Ignition sequence is defined as “the succession of events and conditions that allow the source of ignition, the fuel, and the oxidant to interact in the appropriate quantities and circumstance for combustion to begin.” (NFPA 921, Section 19.4.4.1, 2024 ed.)
3. The investigator must be able to identify:
 - a. Heat.
 - b. Fuel.
 - c. Oxygen.
 - d. Circumstances that brought the other three factors together.

II. THE BURNING PROCESS



- A. Physical process of burning.

OXYGEN REQUIRED FOR COMBUSTION

- Flaming fires (gas phase combustion) require at least 14% to 16% oxygen.



- Smoldering (solid phase combustion) requires as little as 8% oxygen.

Slide 4-13

B. Oxygen required for combustion.

1. Flaming fires (gas phase combustion) require at least 14% to 16% oxygen.
2. Smoldering (solid phase combustion) requires as little as 8% oxygen.

PRODUCTS OF COMBUSTION

Heat.

Smoke:

- Gases.
- Solid particles.
- Liquid aerosols.



Slide 4-14

C. Products of combustion.

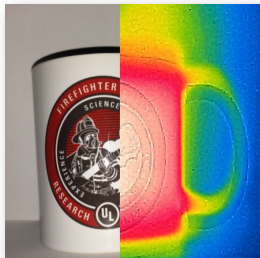
1. Heat.
2. Smoke:
 - a. Gases.
 - b. Solid particles.
 - c. Liquid aerosols.

- d. Smoke is composed of combustion products and unburned pyrolysates. The pyrolysates (unburned fuel gases from solids) are not necessarily considered products of combustion since they can be generated prior to ignition.
- e. Post-ignition, they may be generated at a rate at which they exceed the oxygen available to burn them, so they may be in the smoke unburned.

III. HEAT AND TEMPERATURE

WHAT IS TEMPERATURE?

- The degree of sensible heat of a body as measured by a thermometer or similar instrument.
- Temperature is a measure of the degree of molecular activity relative to some reference point (e.g., freezing point of water).
- “Hotter” objects have molecules that move faster than “colder” objects.



Slide 4-15

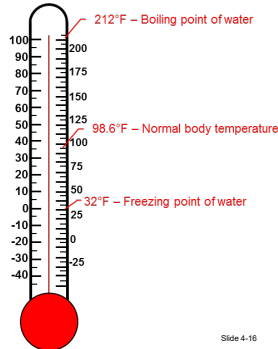
A. What is temperature?

1. The degree of sensible heat of a body as measured by a thermometer or similar instrument (NFPA 921, Section 3.3.195, 2024 ed.).
2. Temperature is a measure of the degree of molecular activity relative to some reference point (e.g., freezing point of water).
3. “Hotter” objects have molecules that move faster than “colder” objects.

RELATIVE TEMPERATURE SCALES

Relative temperature scales are based on the freezing point and boiling point of water:

- Metric (SI).
 - Celsius ($^{\circ}\text{C}$).
 $^{\circ}\text{C} = (^{\circ}\text{F} - 32)/1.8$.
- US (English).
 - Fahrenheit ($^{\circ}\text{F}$).
 $^{\circ}\text{F} = (1.8)(^{\circ}\text{C}) + 32$.



Slide 4-16

4. Relative temperature scales.

Relative temperature scales are based on the freezing point and boiling point of water:

a. Metric (SI).

- Celsius ($^{\circ}\text{C}$).
- $^{\circ}\text{C} = (^{\circ}\text{F} - 32)/1.8$.

b. US (English).

- Fahrenheit ($^{\circ}\text{F}$).
- $^{\circ}\text{F} = (1.8)(^{\circ}\text{C}) + 32$.

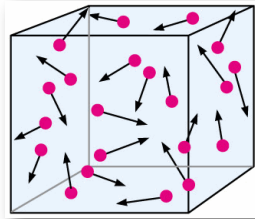
TEMPERATURE EXAMPLES

Temperature $^{\circ}\text{C}$ ($^{\circ}\text{F}$)	Response
37 $^{\circ}\text{C}$ (98.6 $^{\circ}\text{F}$).	Normal human oral/body temperature.
44 $^{\circ}\text{C}$ (111 $^{\circ}\text{F}$).	Human skin begins to feel pain.
48 $^{\circ}\text{C}$ (118 $^{\circ}\text{F}$).	Human skin receives a first degree burn injury.
55 $^{\circ}\text{C}$ (131 $^{\circ}\text{F}$).	Human skin receives a second degree burn injury.
62 $^{\circ}\text{C}$ (140 $^{\circ}\text{F}$).	A phase where burned human tissue becomes numb.
72 $^{\circ}\text{C}$ (162 $^{\circ}\text{F}$).	Human skin is instantly destroyed.
100 $^{\circ}\text{C}$ (212 $^{\circ}\text{F}$).	Water boils and produces steam.
140 $^{\circ}\text{C}$ (284 $^{\circ}\text{F}$).	Glass transition temperature of polycarbonate.
230 $^{\circ}\text{C}$ (446 $^{\circ}\text{F}$).	Melting temperature of polycarbonate.
250 $^{\circ}\text{C}$ (482 $^{\circ}\text{F}$).	Charring of natural cotton begins.
>300 $^{\circ}\text{C}$ (>572 $^{\circ}\text{F}$).	Charring of modern protective clothing fabrics begins.
>600 $^{\circ}\text{C}$ (>1112 $^{\circ}\text{F}$).	Temperatures inside a post-flashover room fire.

Slide 4-17

WHAT IS HEAT?

- **Heat is not the same as temperature.**
- Heat is a form of energy characterized by vibration of molecules and capable of initiating and supporting chemical changes and changes of state
- It is the amount of energy required to maintain or change the temperature of an object.



Slide 4-18

B. What is heat?

1. **Heat is not the same as temperature.**
2. Heat is a form of energy characterized by vibration of molecules and capable of initiating and supporting chemical changes and changes of state (NFPA 921, Section 3.3.109, 2024 ed.).
3. It is the amount of energy required to maintain or change the temperature of an object.

UNITS OF HEAT ENERGY

- Metric (SI):
- Joule (J).
 - Calorie (cal) = 4 J.



Slide 4-19

4. Units of heat energy.

Metric (SI).

- a. Joule (J).
- b. Calorie (cal) = 4 J.

IV. HEAT TRANSFER

HEAT TRANSFER

- Energy that is transferred between objects due to a temperature difference.
- Heat is always transferred from hotter objects to colder objects.

$T_A > T_B$

A and B in contact.

$T_A = T_B$

Slide 4-20

- A. Energy that is transferred between objects due to a temperature difference.
- B. Heat is always transferred from hotter objects to colder objects.
- C. Once A and B are in thermal equilibrium (i.e., the same temperature), the movement of heat stops.

UNITS OF HEAT TRANSFER

Rate of heat transfer = Energy per unit time.

Metric (SI):

- Watt (W) = 1 Joule per second (J/s).
- Kilowatt (kW) = 1,000 W.
- Megawatt (MW) = 1,000,000 W.

Slide 4-21

- D. Units of heat transfer.
 1. Rate of heat transfer = Energy per unit time.
 2. Metric (SI):
 - a. Watt (W) = 1 Joule per second (J/s).
 - b. Kilowatt (kW) = 1,000 W.

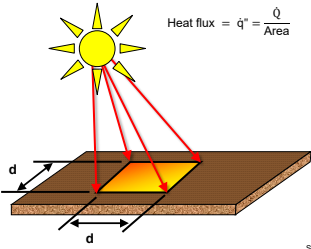
c. MegaWatt (MW) = 1,000,000 W.

HEAT FLUX

Heat flux is the rate of heat transfer to or from a defined area or surface.

Heat flux = energy per unit area.

Metric (SI):
Watts per square meter (W/m^2).
kilowatts per square meter (kW/m^2).



Heat flux = $q'' = \frac{Q}{\text{Area}}$

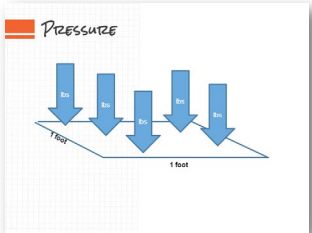
Slide 4-22

E. Heat flux is the rate of heat transfer to or from a defined area or surface.

V. PRESSURE

PRESSURE

- Pressure is the force applied perpendicular to the surface of an object per unit area.



Slide 4-23

- A. Pressure is the force applied perpendicular to the surface of an object per unit area.
- B. Pressure is important because differences in pressure move fire gases and the heat and fuel that goes with them through a structure.
- C. High pressure always flows to low pressure.

IDEAL GAS LAW

The diagram shows the equation $PV=nRT$ in large orange letters. Arrows point to each variable: 'Pressure' points to 'P', 'Volume' points to 'V', 'Number of moles' points to 'n', 'Temperature' points to 'T', and 'Gas constant' points to 'R'.

Slide 4-24

D. Ideal gas law.

1. Pressure is a function of temperature. In a closed space, when the gas temperature increases, the gas pressure increases.

IDEAL GAS LAW KEY POINTS

- If the pressure increases, then temperature increases.
- If the temperature increases the pressure increases.

The diagram consists of a large red arrow pointing upwards, followed by a green equals sign, followed by a large blue arrow pointing upwards.

Slide 4-25

2. Key points:
 - a. If the pressure increases, then temperature increases.
 - b. If the temperature increases, the pressure increases.
 - c. In a room fire, when the gas temperature increases, the pressure of the hot gas will increase as well.

IDEAL GAS LAW

- If the pressure decreases, then temperature decreases.
- If the temperature decreases, then pressure decreases.

Slide 4-26

- d. If the pressure decreases, then temperature decreases.
- e. If the temperature decreases, then pressure decreases.
- f. When the temperature in the fire room cools, the gas pressure in the room will decrease.

VI. MODES OF HEAT TRANSFER - INTRODUCTION

MODES OF HEAT TRANSFER

Conduction:

- Heat transfer between solids in contact with each other or through a solid material.

Convection:

- Heat transfer between fluid(s) or fluid(s) and a solid surface.

Radiation:

- Heat transfer by electromagnetic waves through open space.

Slide 4-27

- A. Conduction:
 - 1. Transfer of heat through a material by direct contact.
 - 2. E.g., flow of heat through a wall.

B. Convection:

1. Transfer of heat by movement of a fluid. Keep in mind that gases and liquids are considered fluids for this purpose.
2. E.g., hot smoke on the surfaces (ceilings/walls) of a room or the oven in your home.

C. Radiation:

1. Transfer of heat by electromagnetic waves.
2. E.g., the warmth you feel from a campfire.

This page intentionally left blank.

ACTIVITY 4.1

Candle Experiment

Purpose

Demonstrate the anatomy of a flame, review methods of heat transfer, reinforce chemistry of fire and combustion reaction zone, and show the differences between a diffusion and premixed flame.

Safety Precautions

- Ensure that all loose clothing is tucked in and all hair is tied back.
- Ensure to remain a safe distance from the candle and lighter flame.

Directions

1. Clear off tables.
2. Place the candle securely inside the pie plate and light the candle.
3. Wait for the instructor to guide you through the following exercises:
 - a. Place hands in a cupped fashion around candle flame. What type of heat transfer is taking place into your hands?
 - b. Place hand over candle flame. What type of heat transfer is taking place into your hand?
 - c. Place paper clip into flame while holding one end. What type of heat transfer is occurring in the paper clip?
 - d. Place a spoon into the blue luminous zone just above the wick. Observe how this produces little soot.
 - e. Hold the spoon at the tip of the candle's flame. Observe how there are large amounts of soot and carbon deposits present.
 - f. Hold the spoon in a vertical position against the side of the candle flame, limiting the fresh air intake into the candle fire plume. Observe the shadow heat patterns left on the spoon. Note that little soot is present.

- g. Hold the mesh screen above the tip of the candle flame and slowly move it downward toward the base of the flame. While moving the mesh screen through the flame, observe the differences in the flame structure, especially toward the midsection of the candle. Note change in smoke production. Why?
- h. Use glass eye dropper to extract unburned paraffin vapors from the side of the candle wick. Vapors may be re-injected into the combustion zone and ignite and burn at the tip of the eye dropper.
- i. Extinguish the candle. Ignite the white vapors trailing off the wick, causing the flame to jump back to the candlewick.

ACTIVITY 4.1 (cont'd)

Worksheet

1. Does the candle have a diffusion or premixed flame?

2. How do you explain the different soot patterns formed by holding the spoon in different positions?

3. How did the flame structure change as you moved the screen from tip to base?

4. Why were you able to reignite the wick by lighting the vapors coming off the candle?

This page intentionally left blank.

COMPARTMENT FIRE DYNAMICS CONTINUES IN PART 2



Slide 4-29

This page intentionally left blank.

UNIT 4: COMPARTMENT FIRE DYNAMICS, PART 2

TERMINAL OBJECTIVE

The students will be able to:

- 4.1 *Integrate the knowledge of fuels, heat transfer, and ventilation to investigate ignition, the stages of fire development, and the resulting fire damage.*

ENABLING OBJECTIVES

The student will be able to:

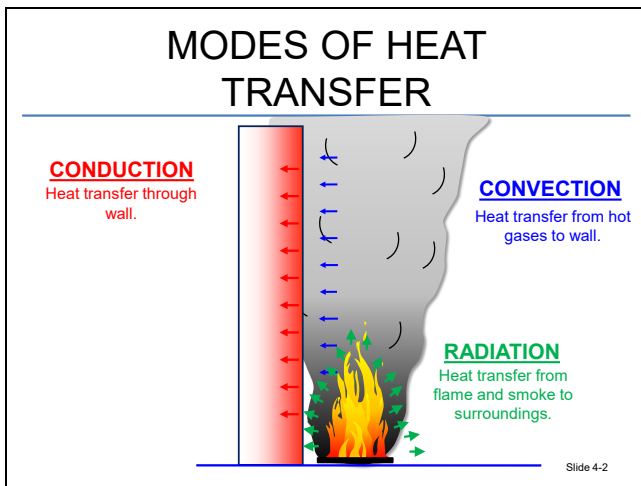
- 4.1 *Describe the basic concepts of fire dynamics and explosion dynamics.*
 - 4.2 *Examine the characteristics of different types of fuels.*
 - 4.3 *Differentiate the impact of different types of fuels on ignition potential and fire growth.*
 - 4.4 *Analyze flow paths and compartment fire dynamics.*
 - 4.5 *Anticipate and explain the progression of a fire within a compartment employing the variables that impact fire growth, development, and spread.*
 - 4.6 *Construct an explanation of the correlation of fire growth with the expected fire damage patterns.*
 - 4.7 *Conclude the correlation between a competent ignition source and the first fuel ignited.*
-

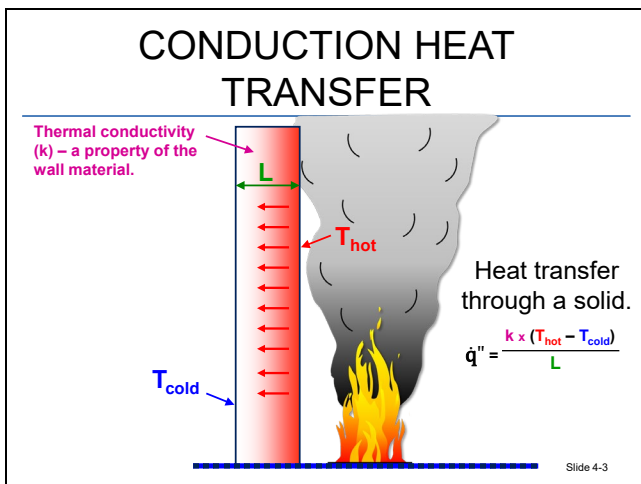
This page intentionally left blank.



I. OVERVIEW AND REVIEW OF PART 1

II. MODES OF HEAT TRANSFER





A. Conduction heat transfer.

1. Thermal conductivity (k) – a property of the wall material.
2. Heat transfer through a solid.

CONDUCTION		
Thermal conductivity (k) (W/m*K)		
– Copper	387.0	$\dot{q} = \frac{kA(T_{Hot} - T_{Cold})}{L}$
– Steel	45.8	
– Glass	0.76	
– Brick	0.69	
– Water	0.60	
– Gypsum	0.48	
– Oak	0.17	
– Pine	0.14	
– PPE	0.034 to 0.136	
– Air	0.026	

Slide 4-4

B. Conduction.

1. The equation shows that for a given geometry (area (A) and thickness (L)), the factors that determine the heat transfer rate ($\dot{q}$), are the thermal conductivity (k) and the temperature difference.
2. Factors that influence conduction through solid:
 - a. Heat flux equals “q dot, double prime” in Watts per square meter.
 - b. Area through which heat is transferred (A) in square meters.
 - c. Material property – thermal conductivity (k) in Watts per meter Kelvin.
 - d. Temperatures on each side (T_{cold} & T_{hot}) in Kelvin. This temperature difference is sometimes referred to as “delta T” (ΔT).
 - e. Thickness of wall (L) in meters.
3. $(\dot{q}) \text{ (W)/A(m}^2\text{)} = (k \text{ (W/(m K))} * (T_{hot(K)} - T_{cold(K)})) / L(m)$. The units are important.

HEAT CONDUCTION AND IGNITION

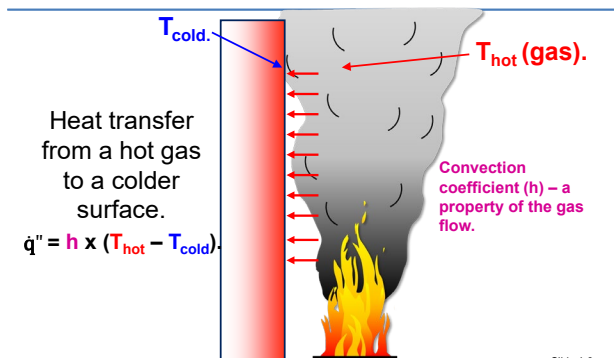
- Conduction of heat into a material is an important aspect of ignition.
- The surface temperature of the fuel must be raised sufficiently to release enough fuel vapors for combustion to occur.
- When a fuel is heated, heat is conducted away from the fuel's surface to its interior.
- A fuel's ability to dissipate the heat away from its surface will affect how easily the fuel is ignited.

Slide 4-5

4. Heat conduction and ignition.

- Conduction of heat into a material is an important aspect of ignition.
- The surface temperature of the fuel must be raised sufficiently to release enough fuel vapors for combustion to occur.
- When a fuel is heated, heat is conducted away from the fuel's surface to its interior.
- A fuel's ability to dissipate the heat away from its surface will affect how easily the fuel is ignited.

CONVECTION HEAT TRANSFER



Slide 4-6

C. Convection heat transfer.

- Buoyant forces in the plume result in rise of hot gas.

2. Buoyancy results from temperature differences. Keep in mind that as the gases are heated, they also expand and become less dense than the surrounding ambient air.

TYPES OF CONVECTION

Natural (free) convection

- Flow induced by density difference in gases (buoyancy).
- Example: radiator.

Forced convection

- Flow is induced by an external source.
- Example: heater with mechanical fan.

Slide 4-7

3. Types of convection.

These types of convection affect the rate of heat transfer.

- a. Natural (free) convection.

- Flow induced by density difference in gases (buoyancy).
- Example: radiator.

- b. Forced convection.

- Flow is induced by an external source.
- Example: heater with mechanical fan.

CONVECTIVE HEAT TRANSFER COEFFICIENT

- h has units of $(W/m^2 K)$.
 - h is dependent on thermal conductivity of the fluid, the properties of the area being heated, and the velocity of the fluid.
 - The higher the velocity of the gas, the higher the rate of convective heat transfer.
- | | |
|--------------------------------------|---------|
| • Buoyant turbulent flows in air. | 5 to 10 |
| • Fire plume impinging on a ceiling. | 5 to 50 |
| • 2 m/s wind speed in air. | ~10 |
| • Units for h ($W/m^2 K$). | |

Quintiere, J.G., *Principles of Fire Behavior*, 2nd ed., 2017, p. 83.

Slide 4-8

4. Convective heat transfer coefficient.
 - a. h has units of (W/m² K).
 - b. h is dependent on thermal conductivity of the fluid, the properties of the area being heated, and the velocity of the fluid.
 - c. The higher the velocity of the gas, the higher the rate of convective heat transfer.
 - d. Buoyant turbulent flows in air — 5 to 10.
 - e. Fire plume impinging on a ceiling — 5 to 50.
 - f. 2 m/s wind speed in air — ~10.
 - g. Units for h (W/m² K).

**CONDUCTION VS
CONVECTION**

$$\dot{q}'' = \frac{k \times (T_{\text{hot}} - T_{\text{cold}})}{L}$$

$$\dot{q}'' = h \times (T_{\text{hot}} - T_{\text{cold}})$$

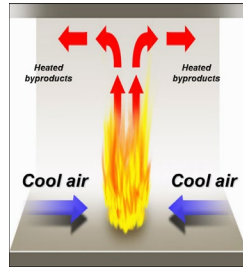
Slide 4-9

- D. Conduction versus convection.
 1. Note the similarities between equations. Both modes of heat transfer are dependent on the difference in temperature and multiplying the difference in temperature by a coefficient. In the case of conduction, the difference in temperature is multiplied by the thermal conductivity of the material. In the case of conductivity, the difference in temperature is multiplied by the conductive heat transfer coefficient.
 2. The higher the coefficient, the faster the rate of heat transfer.

CONVECTION AND FIRE SPREAD

Early in a fire, convection is important in:

- moving hot gases from the fire to the upper portion of the room of fire origin.
- transporting hot gases to other areas outside of the room of fire origin.
- providing convective cooling low in the room.



Slide 4-10

E. Convection and fire spread.

Early in a fire, convection is important in:

1. Moving hot gases from the fire to the upper portion of the room of fire origin.
2. Transporting hot gases to other areas outside of the room of fire origin.
3. Providing convective cooling low in the room.

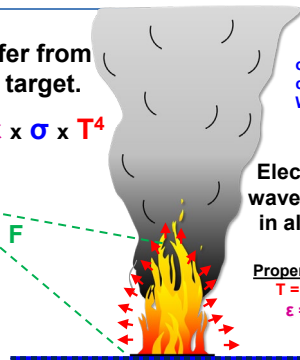
RADIATION HEAT TRANSFER

Heat transfer from flame to a target.

$$\dot{Q}'' = F \times \epsilon \times \sigma \times T^4$$

Target

F = view factor – how much of the fire the target “sees.”



σ = Stefan-Boltzmann constant ($5.67 \times 10^{-8} \text{ W/m}^2\text{K}^4$).

Electromagnetic waves are emitted in all directions.

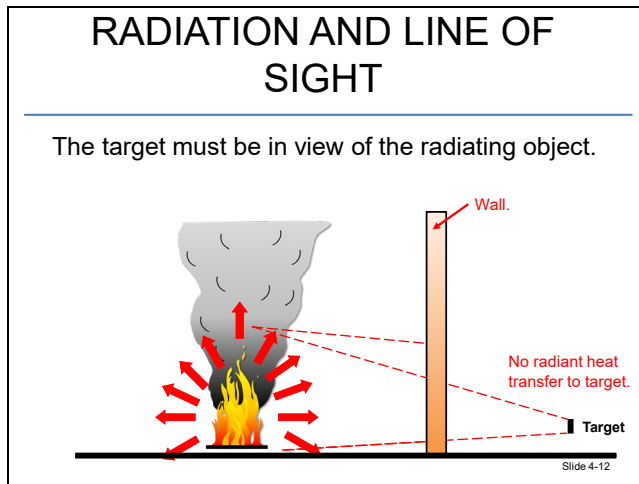
Properties of the flame

T = Temperature.

ϵ = Emissivity.

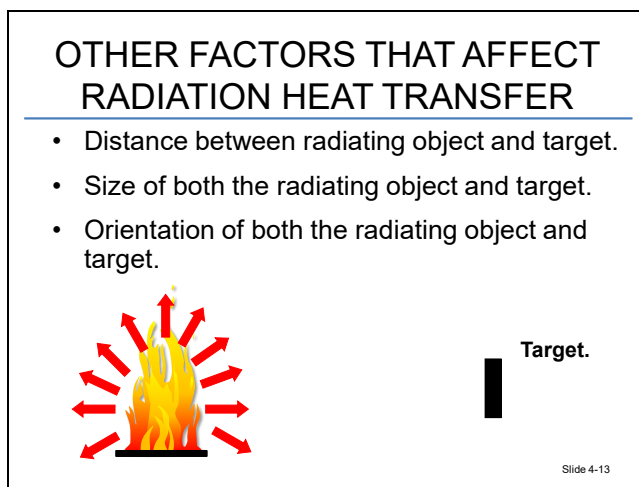
Slide 4-11

F. Radiation heat transfer.



G. Radiation and line of sight.

The target must be in view of the radiating object.

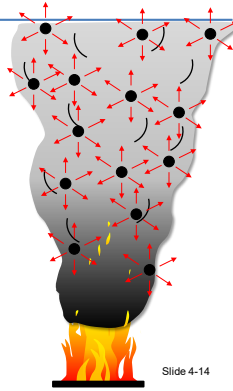


H. Other factors that affect radiation heat transfer.

1. Distance between radiating object and target.
2. Size of both the radiating object and target.
3. Orientation of both the radiating object and target.
4. In general, the radiant heat flux will decrease as the distance between the radiating object and target increases.
5. Keep in mind that the target will begin to heat up and start to radiate (emit energy) as well.

RADIATION AND SMOKE

- Smoke consists of millions of tiny, dark, solid carbon particles, each radiating heat.
- The dirtier or darker the smoke, the more radiation it will emit (higher emissivity).
- Keep in mind that if the soot-filled smoke is between a target and a flaming source, the soot will absorb and scatter radiation.



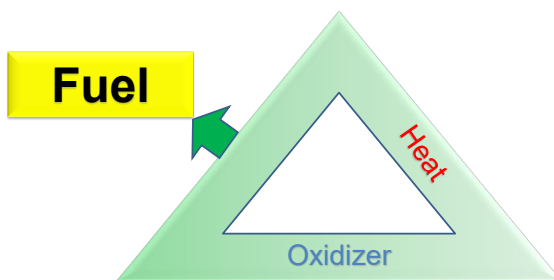
Slide 4-14

I. Radiation and smoke.

1. Smoke consists of millions of tiny, dark, solid carbon particles, each radiating heat.
2. The dirtier or darker the smoke, the more radiation it will emit (higher emissivity).
3. Keep in mind that if the soot-filled smoke is between a target and a flaming source, the soot will absorb and scatter radiation.

III. FUELS

FUELS



Slide 4-15

GAS PHASE COMBUSTION

Solids and liquids do not burn (and result in flaming combustion).

Liquids evaporate into a vapor that burns when mixed with the proper amount of air.

Most solids chemically decompose due to heat (pyrolyze) into gases that burn when mixed with the proper amount of air.

Slide 4-16

A. Gas phase combustion.

1. Solids and liquids do not burn (and result in flaming combustion).
2. Liquids evaporate into a vapor that burns when mixed with the proper amount of air.
3. Most solids chemically decompose due to heat (pyrolyze) into gases that burn when mixed with the proper amount of air.
4. Type of wording for your reports: “Radiant heat created pyrolysis products, and these products burned.”

PYROLYSIS

Chemical decomposition of a compound into one or more substances due to heat alone.



Slide 4-17

B. Pyrolysis.

Chemical decomposition of a compound into one or more other substances by heat alone (NFPA 921, 3.3.162, 2024 ed.).



C. Fire development and pyrolysis.

1. Fire experiment conducted to examine the Seton Hall Fire (Jan. 19, 2000), where 3 students were killed, and more than 50 students were badly injured. The fire was started with an intentional ignition of paper pulled down from the bulletin board onto a sofa in a day room that was open to two corridors and an elevator/stair lobby.
2. The data for the experiment can be found in “Impact of Sprinklers on the Fire Hazard in Dormitories: Day Room Fire Experiments (NIST IR 7120)” by Madrzykowski, Stroup, and Walton.

FUEL VAPOR GENERATION

Phase changes (reversible events)

- melting:
 - no change in chemical structure, liquids change back to a solid when cooled (candle wax).
- evaporation:
 - no change in chemical structure, gases change back to a liquid when cooled.

Thermal decomposition (irreversible changes)

- changes the chemical structure of material due to effect of heat (pyrolysis).
- sublimation:
 - when heated, solid material changes directly into a vapor (naphthalene, methenamine).

Slide 4-19

D. Fuel vapor generation.

1. Phase changes (reversible events).
 - a. Melting: No change in chemical structure, liquids change back to a solid when cooled (candle wax).

- b. Evaporation: No change in chemical structure, gases change back to a liquid when cooled.
2. Thermal decomposition (irreversible events).
 - a. Changes to the chemical structure of the material due to the effects of heat (pyrolysis).
 - b. Sublimation: When heated, solid material changes directly into a vapor (naphthalene, methenamine).
3. The candle represents a change in phase or state. Pyrolysis is an irreversible change, like the thermal decomposition of wood resulting in char and vapors. Flexible polyurethane, when heated, may decompose into a liquid and flammable gases.

FUELS ARE DIFFERENT VIDEO

Wood



Polystyrene



Slide 4-20

- E. Fuels are different.

FUEL – HEAT OF COMBUSTION (ΔH_c)

Heat of Combustion = the amount of heat released when a known amount of a substance burns completely.

Examples of ranges:

- Wood ~ 12-20 MJ/kg.
- Plastics ~ 15-40 MJ/kg.
- Liquid hydrocarbons ~ 43 - 50 MJ/kg.

Slide 4-21

F. Fuel – heat of combustion (HoC) (ΔH_c).

1. HoC = the amount of heat released when a known amount of a substance burns completely.
2. Examples of ranges:
 - a. Wood ~ 12-20 MJ/kg.
 - b. Plastics ~ 15-40 MJ/kg.
 - c. Liquid hydrocarbons ~ 43-50 MJ/kg.
3. Typically measured by burning in pure oxygen at atmospheric pressure and 298 K.
4. HoCs vary due to chemical composition differences in the fuels. The HoC of gasoline is typically given as 43.7 MJ/kg in handbooks.

FUEL LOAD VS HEAT RELEASE RATE

- Fuel Load - mass per unit area (kg/m^2)
 - Used to estimate total heat release based on HoC (assuming all fuel burns).
 - An indicator of “potential severity.”
 - If the ventilation limit is known, burning time and peak heat release rate may be estimated.
- Heat Release Rate (kW or MW)
 - Rate of growth of fire.
 - an indicator of “potential severity.”

Slide 4-22

G. Fuel load versus heat release rate (HRR).

1. Fuel Load – mass per unit area (kg/m^2).
 - a. Used to estimate total heat release based on HoC (assuming all fuel burns).
 - b. An indicator of “potential severity.”
 - c. If the ventilation limit is known, burning time and peak HRR may be estimated.
2. HRR (kW or MW).

- a. Rate of growth of fire.
 - b. An indicator of “potential severity.”
3. Understanding the fuel load is a way of estimating the potential size of a fire. However, more fuel load does not always mean a bigger fire. If the fuel cannot get enough oxygen, it will not burn to its potential. HRR on the other hand can provide a more realistic measure of fire size or fire hazard.

MASS LOSS RATE ($\dot{m}$)

The mass loss rate of a material is determined from weighing a material while it is undergoing chemical decomposition through combustion.

The rate of loss is expressed as mass of fuel being consumed per unit of time (kg/s).

Slide 4-23

H. Mass loss rate ($\dot{m}$).

1. The mass loss rate of a material is determined from weighing a material while it is undergoing chemical decomposition through combustion.
2. The rate of loss is expressed as mass of fuel being consumed per unit of time (kg/s).

HEAT RELEASE RATE (HRR)

Heat Release Rate (HRR) is the amount of heat energy released by the fire per unit time. Often used to describe the “size” of a fire, which is specified by the heat release rate.



Remember: It is single most important factor in characterizing fire behavior.

Slide 4-24

I. HRR.

1. HRR is the amount of heat energy released by the fire per unit time. Often used to describe the “size” of a fire, which is specified by the HRR.
2. Remember: It is the single most important factor in characterizing fire behavior.
3. The HRR of an object or a room is important to understanding how the energy released from that item would change the thermal conditions in a room or how it might ignite other nearby fuels via heat transfer.

**HEAT RELEASE RATE ($\dot{q}$)
(OBJECT)**

Heat release rate from an object is controlled by:

- The chemical and physical properties of the fuel.
- Geometry of fuel and containment.
- Ventilation.
- Surrounding fuels.

Slide 4-25

4. HRR ($\dot{q}$ (object)).

HRR from an object is controlled by:

- a. The chemical and physical properties of the fuel.
- b. Geometry of fuel and containment.
- c. Ventilation.
- d. Surrounding fuels.

HEAT RELEASE RATE (IMPACT ON A ROOM)

The heat release rate of an object or a room is important to understanding how the energy released from that item would change the thermal conditions in a room or how it might ignite other nearby fuels via heat transfer.

Slide 4-26

5. HRR impact on a room.

The HRR of an object or a room is important to understanding how the energy released from that item would change the thermal conditions in a room or how it might ignite other nearby fuels via heat transfer.

UNITS OF HEAT RELEASE RATE

Measured in heat energy per unit time.

Metric (SI):

- Watts (W) = J/s.
- Kilowatts (kW) = 1000 W.
- Megawatts (MW) = 1000 kW.

Slide 4-27

6. Units of HRR.

- a. Measured in heat energy per unit time.
- b. Metric (SI):
 - Watts (W) = J/s.
 - Kilowatts (kW) = 1000 W.
 - Megawatts (MW) = 1000 kW.

MEASURING HRR

- Mass loss rate.
 - Mass loss rate times Heat of Combustion equals the Theoretical HRR.
- Oxygen Consumption Calorimetry.
 - 13.1 MJ of energy generated per gram of oxygen consumed.
- Heat Release Rate = (theoretical heat of combustion X mass loss rate).
 - wood and cellulose 12 to 20 MJ/kg
 - plastics 15 to 40 MJ/kg
 - liquid hydrocarbons 40 to 50 MJ/kg

Slide 4-28

7. Measuring HRR.

- a. Mass loss rate.
 - Mass loss rate times the HoC equals the Theoretical HRR.
- b. Oxygen Consumption Calorimetry.
 - 13.1 MJ of energy generated per gram of oxygen consumed.
- c. $HRR = (\text{theoretical HoC} \times \text{mass loss rate})$.
 - Wood and cellulose – 12 to 20 MJ/kg.
 - Plastics – 15 to 40 MJ/kg.
 - Liquid hydrocarbons – 40 to 50 MJ/kg.

HEAT RELEASE RATE MEASUREMENTS

Oxygen bomb calorimetry (total theoretical heat release per unit mass or theoretical heat of combustion).

Heat Release Rate = (theoretical heat of combustion X mass loss rate).

wood and cellulose	12 to 20 MJ/kg
plastics	15 to 40 MJ/kg
liquid hydrocarbons	40 to 50 MJ/kg



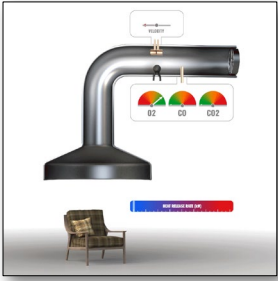
Slide 4-29

- d. Oxygen bomb calorimetry (total theoretical heat release per unit mass or theoretical heat of combustion).

HRR MEASUREMENT BY OXYGEN CONSUMPTION

Oxygen consumption calorimetry - most materials generate 13.1 MJ/kg of oxygen consumed.

Oxygen consumption heat release rate -divided by mass loss rate yields an *effective heat of combustion*.



Slide 4-30

8. HRR measurement by oxygen consumption.

- a. Oxygen consumption calorimetry – most materials generate 13.1 MJ/kg of oxygen consumed.
- b. Oxygen consumption HRR divided by mass loss rate yields an effective HoC.

LARGE SCALE HRR CALORIMETERS



- Controlled environment
- No room effects
- No hot layer
- No other fuels
- Free burn, no restrictions

Slide 4-31

9. Large scale HRR calorimeters.

- a. Controlled environment.
- b. No room effects.

- c. No hot layer.
- d. No other fuels.
- e. Free burn, no restrictions.

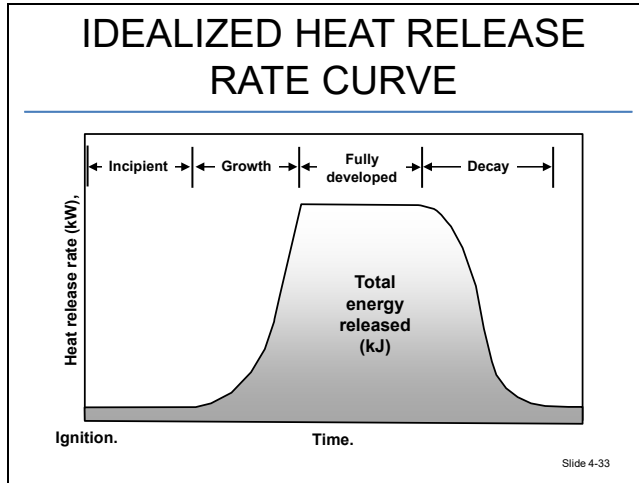
APPROXIMATE PEAK HEAT RELEASE RATES

• Cigarette	5 W
• Match	80 W
• Coffeemaker	40 kW
• Small plastic trash can	50 kW
• Trash bag fires	50 to 300 kW
• Upholstered chair	80 kW to 2.5 MW
• Upholstered sofa	3 MW to 5 MW
• Dry holiday tree (6 to 8 ft)	1.6 MW to 5.2 MW

Slide 4-32

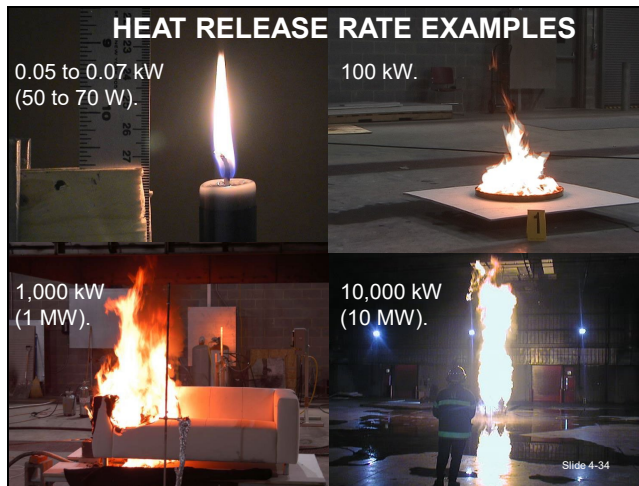
10. Approximate peak HRRs.

- a. Cigarette: 5 W.
- b. Match: 80 W.
- c. Coffeemaker: 40 kW.
- d. Small plastic trash can: 50 kW.
- e. Trash bag fires: 50 to 300 kW.
- f. Upholstered chair: 80 kW to 2.5 MW.
- g. Upholstered sofa: 3 MW to 5 MW.
- h. Dry holiday tree (6 to 8 ft): 1.6 MW to 5.2 MW.



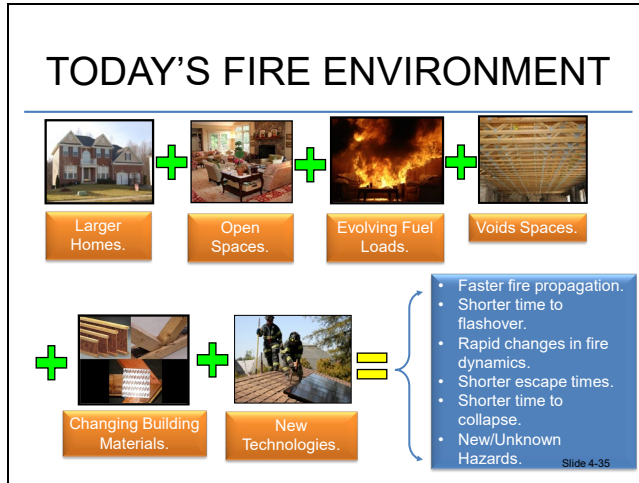
11. Idealized HRR curve.

This is the idealized HRR curve for a fuel-controlled fire: actual curves fluctuate significantly.



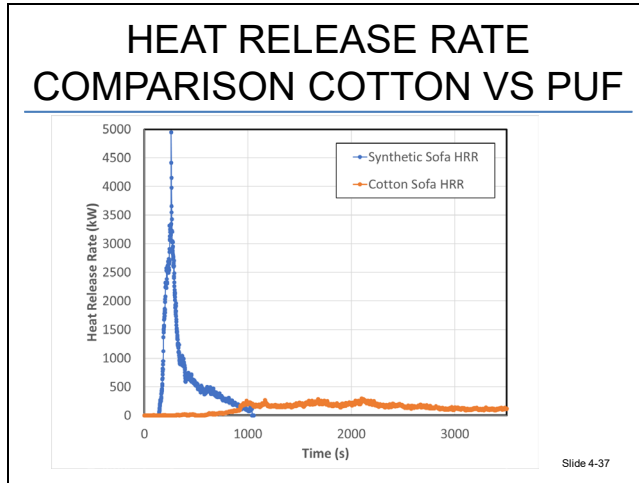
12. HRR examples.

- a. Candle (50 W to 70 W).
- b. Heptane pool fire (2-foot diameter) with a ~2-foot tall flame. Over 100 times bigger than a single candle flame.
- c. Upholstered couch: This fire is 10 times bigger than the heptane pool fire.
- d. Heptane spray burner with a ~20-25-foot tall flame. This fire is 10 times bigger than the previous couch fire.



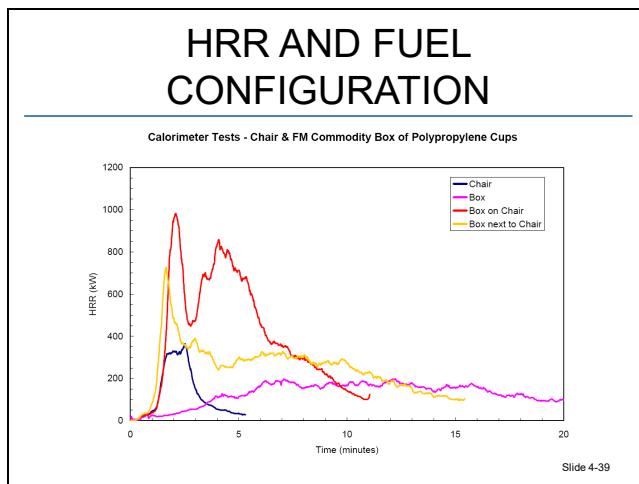
13. Today's fire environment.
- Faster fire propagation.
 - Shorter time to flashover.
 - Rapid changes in fire dynamics.
 - Shorter escape times.
 - Shorter time to collapse.
 - New/unknown hazards.





14. HRR comparison: Cotton versus polyurethane/polyester.

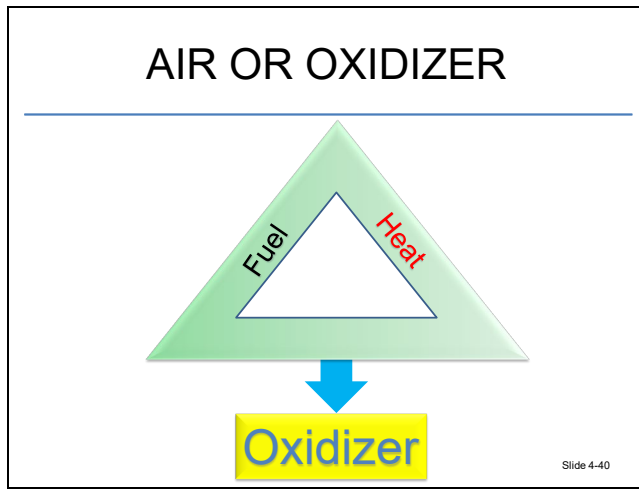
Note how the different sofas burn. So a sofa is not a sofa is not a sofa. What it is made of and how it is constructed is very important.



15. HRR and fuel configuration.

- a. Note how the box on the chair peaks very high, but the burning duration is very short.
- b. The packages that peak at lower values have a much longer burning duration.
- c. Note the differences between the HRR of curves of the box on the chair vs. the box next to the chair. The concurrent flame spread up from the chair to the box causes the peak HRR to be relatively high and overall has a short duration. The lateral flame spread when the box is placed next to the chair is slower, and therefore the peak HRR is less and the duration is longer.

IV. OXIDIZERS



- A. Air or oxidizer.

OXYGEN (OXIDIZERS)

Air:

- 21% oxygen.
- 79% nitrogen and other constituents.

Enriched oxygen:

- Medical environments.
- Industrial/scientific.

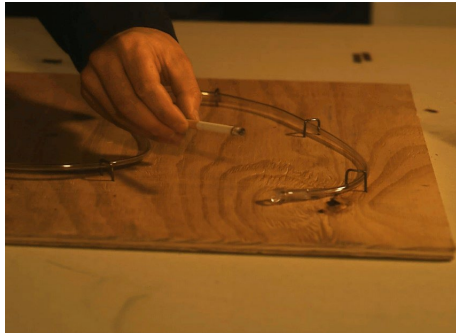
Solid oxidizers:

- materials that contain oxygen.
- chemicals: nitrates, chlorates, sulfates, phosphates, etc.

Slide 4-41

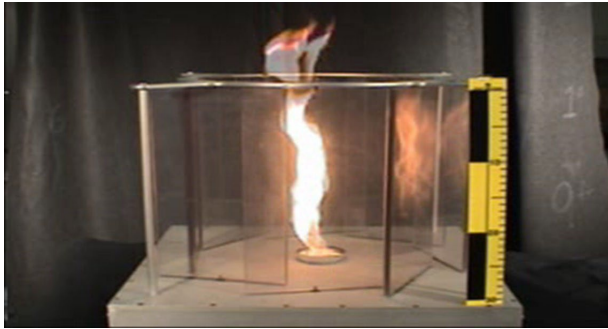
- B. Oxygen (oxidizers).
1. Air:
 - a. 21% oxygen.
 - b. 79% nitrogen and other constituents.
 2. Enriched oxygen:
 - a. Medical environments.
 - b. Industrial/scientific.
 3. Solid oxidizers:
 - a. Materials that contain oxygen.
 - b. Chemicals: nitrates, chlorates, sulfates, phosphates, etc.
 4. What does 21% oxygen mean?
 - a. In fire, the fuel & air need to be heated up.
 - b. 4/5 of air is dead weight (nitrogen); it doesn't burn.

ENRICHED OXYGEN FIRE-
VIDEO



Slide 4-42

VENTILATION-VIDEO



Slide 4-43

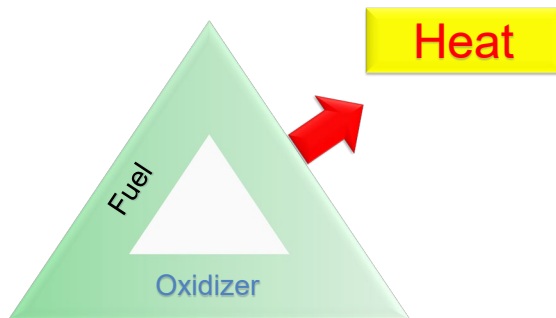
WIND IMPACT ON A FIRE-VIDEO



Slide 4-44

V. HEAT

HEAT OR IGNITION



Slide 4-45

A. Heat or ignition.

IGNITION

The process of initiating self-sustained combustion.

Ignition temperature:

- Minimum temperature required to cause combustion.

Types of ignition:

- Piloted ignition
- Autoignition



-NFPA 921, Section 3.3.120

Slide 4-46

1. Ignition.

“The process of initiating self-sustained combustion” (NFPA 921, Section 3.3.120, 2024 ed.).

a. Ignition temperature:

- Minimum temperature required to cause combustion.

b. Types of ignition:

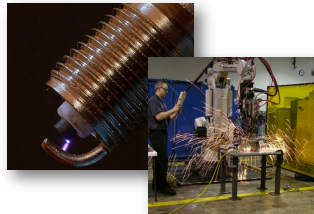
- Piloted ignition.
- Autoignition.

PILOTED IGNITION

External ignition source ignites flammable vapors.

Types:

- Small flames.
- Sparks (electric and mechanical).
- Hot surfaces.



Slide 4-47

2. Piloted ignition.

a. External ignition source ignites flammable vapors.

b. Types:

- Small flames.
- Sparks (electric and mechanical).
- Hot surfaces.

AUTOIGNITION

- Initiation by heat, without direct contact from a flame, spark, or hot surface.
- Occurs once the fuel reaches its autoignition temperature (AIT).



Slide 4-48

3. Autoignition.

- a. Initiation by heat, without direct contact from a flame, spark, or hot surface.
- b. Occurs once the fuel reaches its autoignition temperature (AIT).
- c. Autoignition temperatures for a given material are typically higher than the piloted ignition temperature.

SOLID FUELS

Wood
Plastics
Cloth
Synthetics
Metals



Slide 4-49

B. Solid fuels.

1. Wood.
2. Plastics.
3. Cloth.
4. Synthetics.
5. Metals.
6. Most of the fuels contain carbon and hydrogen in some combination. From a fire suppression perspective, these are Class A fuels.

**COMPETENT IGNITION
SOURCE**

A competent ignition source will have:

- **enough energy.**
- **will be in contact with the fuel long enough to raise it to the fuel's ignition temperature**

During origin and cause, need to be able to articulate each of these bullets.

-NFPA 921, Section 3.3.39

Slide 4-50

C. Competent ignition source.

1. A competent ignition source will have:
 - a. **Enough energy.**
 - b. **Will be in contact with the fuel long enough to raise it to the fuel's ignition temperature.**
2. During origin and cause, need to be able to articulate each of these bullets (NFPA 921, Section 3.3.39, 2024 ed.).
3. The temperature of the source is not sufficient to determine if a source could ignite a material.

EXAMPLE: A MATCH AS AN IGNITION SOURCE

A single match can ignite a toothpick, but not a 2 x 4 piece of wood, even though:

- Both objects have the same material properties.
- The flame temperature is above the ignition temperature of the wood.

Slide 4-51

4. Example: A match as an ignition source.

- A single match can ignite a toothpick, but not a 2 x 4 piece of wood, even though:
 - Both objects have the same material properties.
 - The flame temperature is above the ignition temperature of the wood.
- This is an example of assessing the heat transfer and the energy available from the source to determine if the match is a competent ignition source.

IGNITION OF SOLIDS

- Heat must be supplied to decompose solid fuel into fuel vapors.
- Fuel vapor/air mixture must be within flammability limits.



Slide 4-52

D. Ignition of solids.

- Heat must be supplied to decompose solid fuel into fuel vapors.

2. Fuel vapor/air mixture must be within flammability limits.

FACTORS THAT AFFECT IGNITION OF SOLIDS

- Shape (surface to mass ratio).
- Density (how tightly the fuel is packed).
- Thickness (thick versus thin materials).



Slide 4-53

- E. Factors that affect ignition of solids.

1. Shape (surface to mass ratio).
2. Density (how tightly the fuel is packed).
3. Thickness (thick versus thin materials).

VI. THERMAL INERTIA AND IGNITION

THERMAL INERTIA

Thermal inertia ($k\rho c$) is a measure of how fast the surface temperature of a material will rise.

It is a product of the material's thermal conductivity (k), density (ρ), and specific heat (c).

k = material's ability to conduct heat.

ρ = material's density.

c = material's capacity to store heat.

Slide 4-54

- A. Thermal inertia.

1. Thermal inertia ($k\rho c$) is a measure of how fast the surface temperature of a material will rise.

2. It is a product of the material's thermal conductivity (k), density (ρ), and specific heat (c).
 - a. k = material's ability to conduct heat.
 - b. ρ = material's density.
 - c. c = material's capacity to store heat.

SIMPLIFIED EFFECTS OF $k\rho c$

Low $k\rho c$	High $k\rho c$
Surface heats rapidly Fast Ignition (example: foam)	Surface heats slowly Slow Ignition (example: wood, metals)

Materials with high thermal inertia ($k\rho c$) require more energy to raise their surface temperature.

Slide 4-55

3. Simplified effects of $k\rho c$.

THERMALLY THIN MATERIALS

The entire thickness of the material is at approximately the same temperature during heating.

Physical thickness of 1 to 2 mm (<1/16 inch).



Example: Sheer window treatments.

Slide 4-56

4. Thermally thin materials.
 - a. The entire thickness of the material is at approximately the same temperature during heating.
 - b. Physical thickness of 1 to 2 mm (<1/16 inch).

- c. Thermally thin materials will ignite with less energy than thermally thick materials.
- d. Examples of “thin” materials: single sheet of paper, drapes, garments (Quintiere, Principles of Fire Behavior – Second Edition, Page 116, 2016).

THERMALLY THICK MATERIALS

- The temperature varies throughout as the item is being heated.
- Physical thickness greater than 2 mm (>1/16 inch).



Example: wood desk, and stack of papers.

Slide 4-57

- 5. Thermally thick materials.
 - a. The temperature varies throughout as the item is being heated.
 - b. Physical thickness greater than 2 mm (>1/16 inch).
 - c. Requires more energy for ignition than thermally thin materials.
 - d. Example of a thick material: wallpaper on plasterboard (composite assembly).

DUST IGNITION

- Very small solid particles.
- Typically occurs in unoccupied spaces due to the high concentration of particles required.
- Fuel (dust)/air mixture must be within flammability limits.
- Mechanical sparks, static, hot bearings, and arcing are all competent ignition sources.

Slide 4-58

- 6. Dust ignition.

- a. Very small solid particles.
- b. Typically occurs in unoccupied spaces due to the high concentration of particles required.
- c. Fuel (dust)/air mixture must be within flammability limits.
- d. Mechanical sparks, static, hot bearings, and arcing are all competent ignition sources.

LIQUID FUELS

- Gasoline.
- Kerosene.
- Diesel.
- Cooking oil.
- Solvents.
- Thinners.

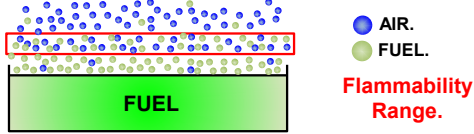


Slide 4-59

- B. Liquid fuels.
- 1. Gasoline.
 - 2. Kerosene.
 - 3. Diesel.
 - 4. Cooking oil.
 - 5. Solvents.
 - 6. Thinners.

IGNITION OF LIQUIDS

The liquid must be at or above its flashpoint temperature. If it isn't, heat must be applied to vaporize enough fuel.



Vapor/air mixture must be within flammability limits.

Slide 4-60

C. Ignition of liquids.

1. The liquid must be at or above its flashpoint temperature. If it isn't, heat must be applied to vaporize enough fuel.
2. Vapor/air mixture must be within flammability limits.

FLASHPOINT AND FIRE POINT

Flashpoint:

- Lowest temperature of a liquid at which the liquid gives off vapors at a sufficient rate to support a momentary flame across its surface.
- **Flashpoint < 100°F: Flammable liquid.**
- **Flashpoint ≥ 100°F: Combustible liquid.**

Fire point:

- Temperature at which burning of the vaporizing liquid can be sustained.

Slide 4-61

3. Flashpoint and fire point.

a. Flashpoint:

- Lowest temperature of a liquid at which the liquid gives off vapors at a sufficient rate to support a momentary flame across its surface.
- Flashpoint < 100°F: Flammable liquid.
- Flashpoint ≥ 100°F: Combustible liquid.

b. Fire point.

- Temperature at which burning of the vaporizing liquid can be sustained.



GASEOUS FUELS

- Propane.
- Methane.
- Carbon monoxide.
- Hydrogen.
- Acetylene.
- Vapors: produced by solid or liquid fuels.



Slide 4-63

D. Gaseous fuels.

1. Propane.
2. Methane.
3. Carbon monoxide.
4. Hydrogen.
5. Acetylene.
6. Vapors: produced by solid or liquid fuels.
7. Gaseous hydrocarbons such as carbon monoxide, do burn.

IGNITION OF GASES

Gases require the least amount of energy to ignite.

Fuel gases and air mixture must be within the flammability limits of the fuel.



Slide 4-64

E. Ignition of gases.

1. Gases require the least amount of energy to ignite.
2. Fuel gases and air mixture must be within the flammability limits of the fuel.

EXPLOSIVE LIMITS

Lower Explosive Limit (LEL). Minimum concentration of fuel vapors in air that will burn.

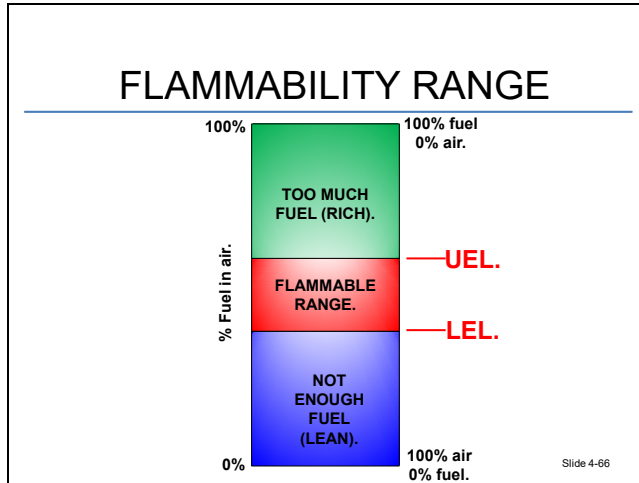
Upper Explosive Limit (UEL). Maximum concentration of fuel vapors in air that will burn.

Also referred to as the Flammability Limits (LFL and UFL).

Slide 4-65

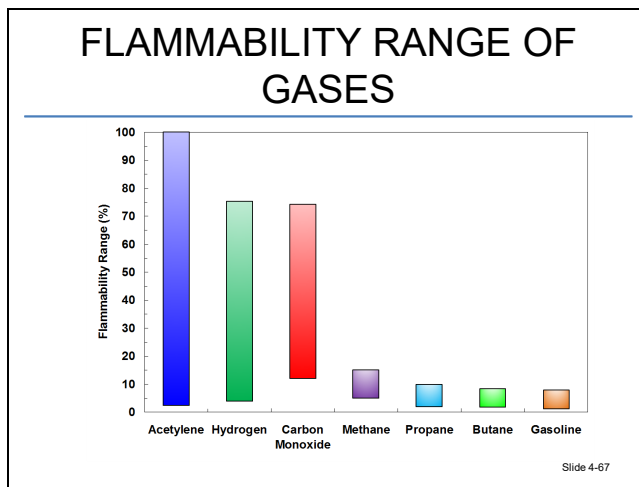
F. Explosive limits.

1. Lower Explosive Limit (LEL). Minimum concentration of fuel vapors in air that will burn.
2. Upper Explosive Limit (UEL). Maximum concentration of fuel vapors in air that will burn.
3. Also referred to as the Flammability Limits (LFL and UFL).



G. Flammability range.

Gases can only be ignited in a specific gas-air mixture range.



H. Flammability range of gases.

1. Acetylene UFL = 100%.
2. In these cases, the gas does not require oxygen to react, since the fuel molecule itself can explosively decompose.

IGNITION ENERGY FOR GASES

Gases require less than 1 mJ of energy to ignite.

A strong static shock is on the order of 1 J or 1,000 mJ.

Ignition energy must be applied in a region of the vapors within the flammable range to start the reaction.

Slide 4-68

I. Ignition energy for gases.

1. Gases require less than 1 mJ of energy to ignite.
2. A strong static shock is on the order of 1 J or 1,000 mJ.
3. Ignition energy must be applied in a region of the vapors within the flammable range to start the reaction.

"MINNESOTA IAAI NATURAL GAS IGNITION"



Slide 4-69

VII. FLAMES

FLAMING COMBUSTION

- Flaming fires only occur in the gas phase.
- All solid and liquid fuels must first pyrolyze and/or vaporize to burn.
- Fuel vapor and oxygen must be in correct proportion to burn.



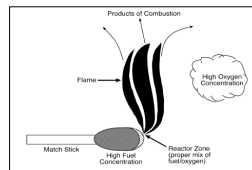
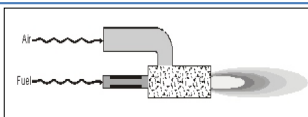
Slide 4-70

A. Flaming combustion.

1. Flaming fires only occur in the gas phase.
2. All solid and liquid fuels must first pyrolyze and/or vaporize to burn.
3. Fuel vapor and oxygen must be in correct proportion to burn.

TYPES OF FLAMES

- Premixed flames:
 - Fuel and oxidizer are mixed prior to combustion.
- Diffusion flames:
 - Fuel and air mix or diffuse together at the combustion region.



Slide 4-71

B. Types of flames.

1. Premixed flames: Fuel and oxidizer are mixed prior to combustion.
2. Diffusion flames: Fuel and air mix or diffuse together at the combustion region.

DIFFUSION VS PREMIXED FLAMES



Slide 4-72

C. Diffusion versus premixed flames.

PREMIXED FLAMES

Premixed flames can only burn if the fuel-air mixture is between the LEL and UEL.

When the gas-air mixture is ignited, it quickly propagates through the volume of fuel-air mixture.

- Deflagration
 - *Flame velocity < speed of sound.*
- Detonation
 - *Flame velocity > speed of sound.*

Slide 4-73

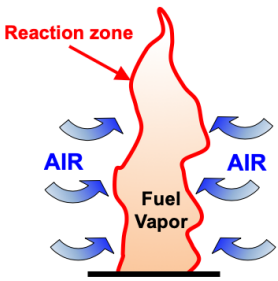
D. Premixed flames.

1. Premixed flames can only burn if the fuel-air mixture is between the LEL and UEL.
2. When the gas-air mixture is ignited, it quickly propagates through the volume of fuel-air mixture.
 - a. Deflagration: Flame velocity < speed of sound.
 - b. Detonation: Flame velocity > speed of sound.

- c. **Deflagration** is defined as the “propagation of a combustion zone at a velocity that is less than the speed of sound in the unreacted medium” (NFPA 921, Section 3.3.46, 2024 ed.). Damage is walls pushed out, but not concentrated with bricks shattered like you would see in detonation.
- d. **Detonation** is defined as the “propagation of a combustion zone at a velocity greater than the speed of sound in the unreacted medium” (NFPA 921, Section 3.3.49, 2024 ed.).
- e. Explosion may occur if the mixture is located in a confined space.
- f. **Explosion** is defined as the “sudden conversion of potential energy (chemical or mechanical) into kinetic energy with the production and release of gases under pressure, or the release of gas under pressure. These high-pressure gases then do mechanical work such as moving, changing, or shattering nearby materials” (NFPA 921, Section 3.3.60, 2024 ed.).

DIFFUSION FLAMES

- Combustion occurs in a thin reaction zone where the unmixed fuel vapors and air come together.
- Diffusion flame burning is the ordinary sustained burning mode in most fires.



The diagram illustrates a diffusion flame. A central column of orange 'Fuel Vapor' rises from a black base. On either side, blue arrows labeled 'AIR' point towards the center. A red arrow points to the thin layer where the fuel and air meet, labeled 'Reaction zone'.

Slide 4-74

- E. Diffusion flames.
1. Combustion occurs in a thin reaction zone where the unmixed fuel vapors and air come together.
 2. Diffusion flame burning is the ordinary sustained burning mode in most fires.

TYPES OF DIFFUSION FLAMES

Laminar:

- Orderly, unfluctuating fluid motion.
- Only small flames (candles).

Turbulent:

- Randomly fluctuating fluid motion.
- Flames in most real fires are turbulent.



Turbulent.



Laminar.

Slide 4-75

3. Types of diffusion flames.

a. Laminar:

- Orderly, unfluctuating fluid motion.
- Only small flames (candles).

b. Turbulent:

- Randomly fluctuating fluid motion.
- Flames in most real fires are turbulent.

FLAME TEMPERATURE

For most common fuels, flame temperature is essentially the same regardless of fuel type.

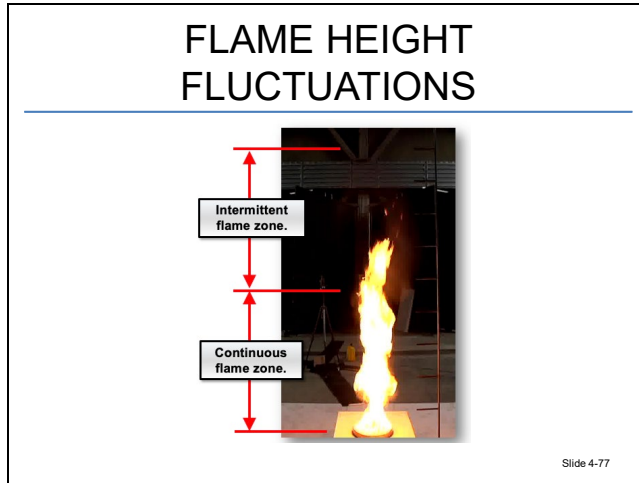
Fuel	Flame Temperature (F)
Gasoline	1,879
Kerosene	1,814
Methanol	2,192
Wood	1,881



Slide 4-76

F. Flame temperature.

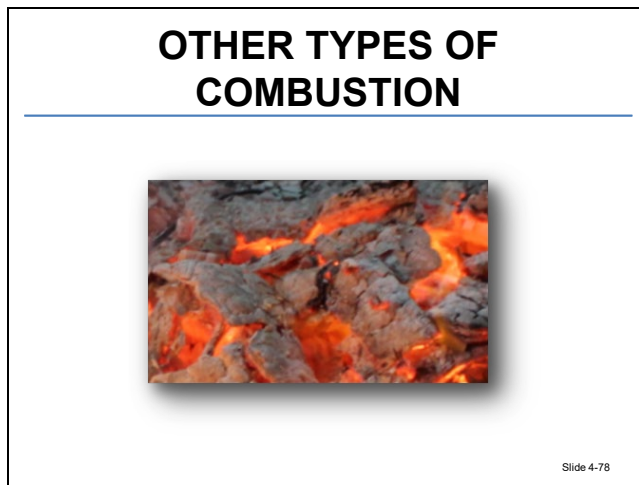
For most common fuels, flame temperature is essentially the same regardless of fuel type.



G. Flame height fluctuations.

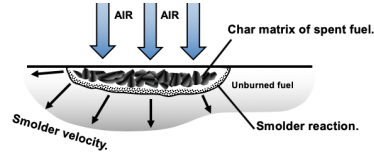
These flames are observed like frames from a movie — they fluctuate and are turbulent.

VIII. OTHER TYPES OF COMBUSTION



SMOLDERING COMBUSTION

- Reaction occurs on the solid surface, and oxygen diffuses to the surface.
- Thermal decomposition step to create char followed by solid phase burning of the char produced.



Slide 4-79

A. Smoldering combustion.

1. Reaction occurs on the solid surface, and oxygen diffuses to the surface.
2. Thermal decomposition step to create char followed by solid phase burning of the char produced.
3. Smoldering occurs on the surface of the solid, and flaming occurs on the gas stage.
4. Smoldering combustion is slow, low-temperature and flameless (Quintiere, "Principles of Fire Behavior," 1998).

WHY IS SMOLDERING COMBUSTION IMPORTANT?

- Yields substantially more toxic compounds than flaming combustion (but more slowly).
- Can be initiated by heat sources that are too weak to directly produce a flame.
- Smoldering combustion may transition into flaming combustion.

Slide 4-80

5. Why is smoldering combustion important?

- a. Yields substantially more toxic compounds than flaming combustion (but more slowly).

- b. It can be initiated by heat sources that are too weak to directly produce a flame.
- c. Smoldering combustion may transition into flaming combustion.
- d. Smoldering may go unobserved for long periods of time before the transition to flaming combustion.
- e. Smoldering or solid phase combustion occurs at oxygen concentrations below those needed to support flaming combustion.

SPONTANEOUS COMBUSTION

- Self-heating occurs when the fuel is unable to dissipate heat generated by a chemical reaction within the bulk of the fuel.
- As the temperature of the fuel increases, it causes a faster chemical reaction, eventually leading to thermal runaway.
- Ignition occurs when the temperature reaches the ignition temperature of the material.

Slide 4-81

B. Spontaneous combustion.

1. Self-heating occurs when the fuel is unable to dissipate heat generated by a chemical reaction within the bulk of the fuel.
2. As the temperature of the fuel increases, it causes a faster chemical reaction, eventually leading to thermal runaway.
3. Ignition occurs when the temperature reaches the ignition temperature of the material.

THERMAL RUNAWAY LITHIUM-ION BATTERIES



Slide 4-82

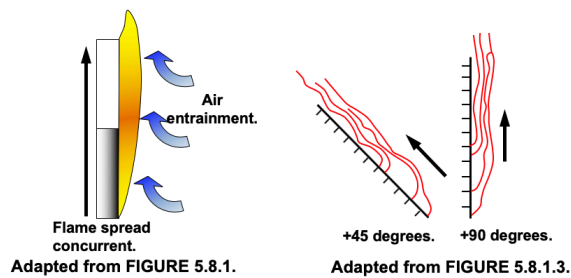
IX. FLAME SPREAD

FLAME SPREAD



Slide 4-83

CONCURRENT FLAME SPREAD



-NFPA 921, Chapter 5, Section 5.8.1.2

Slide 4-84

A. Concurrent flame spread.

1. Flame spread is simply a series of ignitions. We have a pilot flame that preheats and pyrolyzes the next section of fuel, then ignition occurs. Easier to spread flames with the air flow than it is to spread the flame against the air flow.

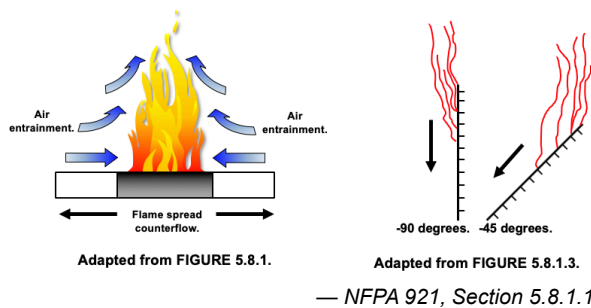
CONCURRENT FLAME SPREAD

- Also known as wind-aided flame spread. Flame spread direction is the same as the gas flow or wind direction.
- Generally quite rapid as a result of the direct contact of the flame with the fuel ahead of the flame front.

Slide 4-85

2. Also known as wind-aided flame spread. Flame spread direction is the same as the gas flow or wind direction.
3. “Generally quite rapid as a result of the direct contact of the flame with the fuel ahead of the flame front” (NFPA 921, Section 5.8.1.2, 2024 ed.).

COUNTERFLOW FLAME SPREAD



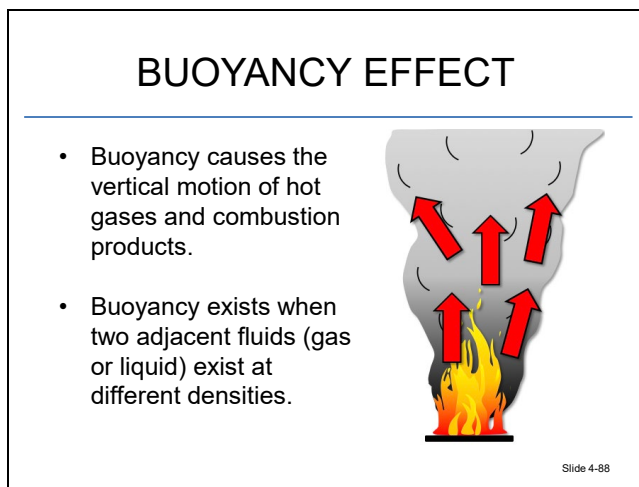
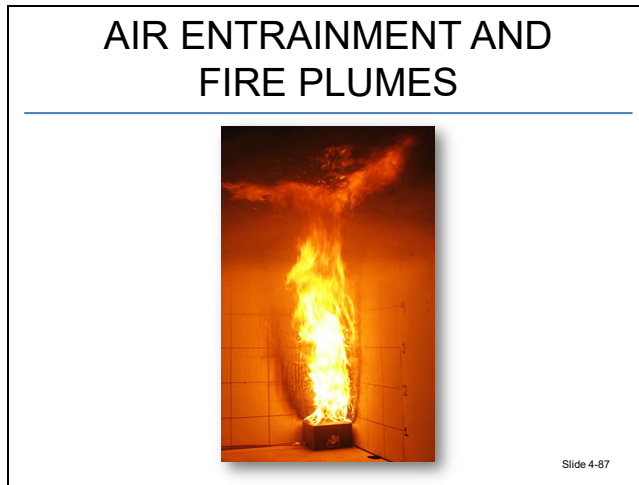
Slide 4-86

B. Counterflow flame spread.

1. Also called opposed flow flame spread. Flame spread direction is counter to or opposed to the gas flow.

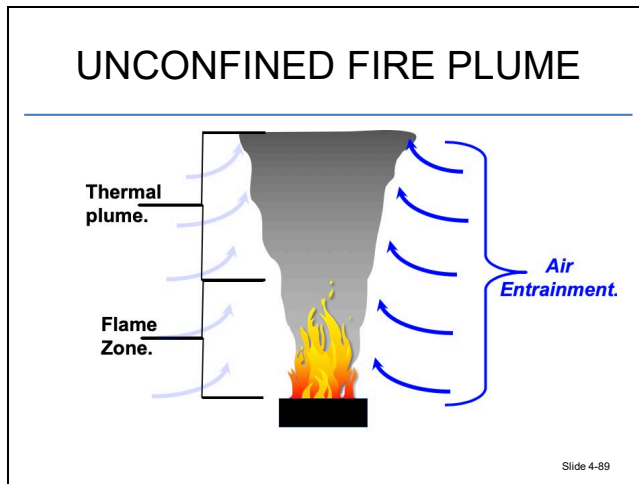
2. “Generally slow as a result of the limited ability of the flame to heat the fuel ahead of the flame front” (NFPA 921, Section 5.8.1.1, 2024 ed.).

X. AIR ENTRAINMENT AND FIRE PLUMES



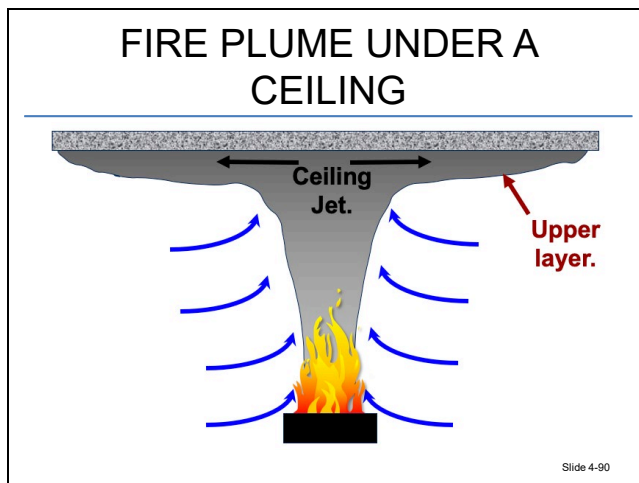
A. Buoyancy effect.

1. Hottest part of the plume just above the flame.
2. Cooler air entrained as you move away.
3. No ceiling in open fire means plume disperses into atmosphere (hot gases cool down quickly).
4. Ceiling traps hot fire gases (gases do not cool down as fast.)



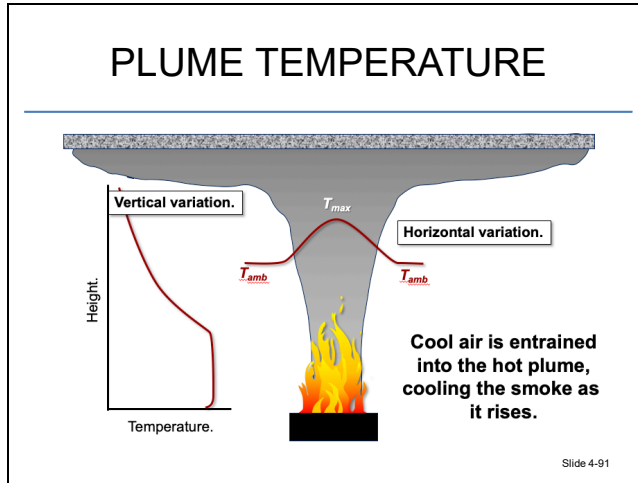
B. Unconfined fire plume.

1. Plume gets wider due to entrainment. Eddies facilitate air entrainment.
2. Entrainment occurs throughout the height of the plume, not just down at the base of the fire.
3. Higher velocity gases result in a local decrease in pressure resulting in air entrainment, just like the Bernoulli Bag.



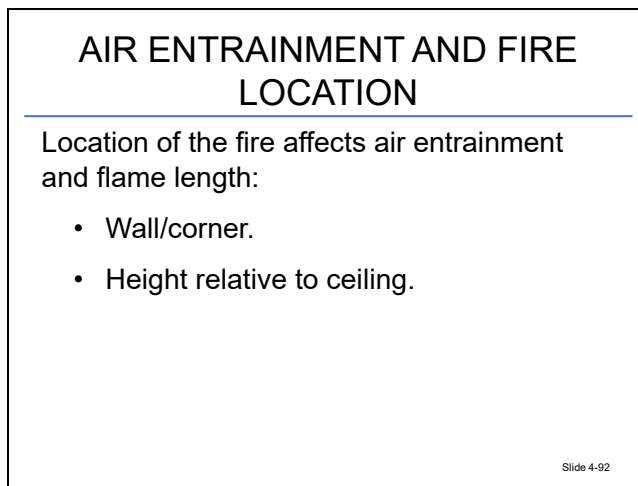
C. Fire plume under a ceiling.

Note symmetry: Plumes and the jet created when the plume hits the ceiling are symmetric.



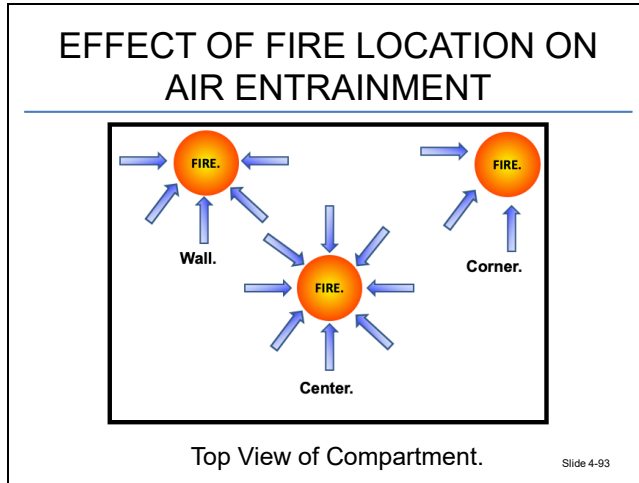
D. Plume temperature.

1. Cool air is entrained into the hot plume, cooling the smoke as it rises.
2. Same principle applies in ceiling as in open air.
3. Entrainment continues until plume reaches ambient temperature.
4. Gases in the plume are less dense than the surroundings.



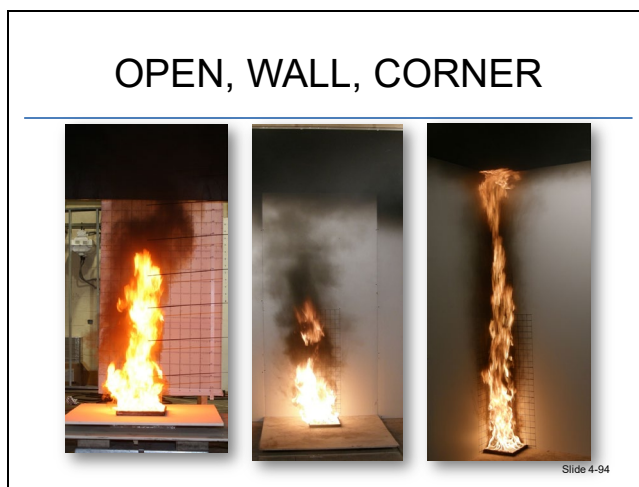
E. Air entrainment and fire location.

1. Location of the fire affects air entrainment and flame length:
 - a. Wall/corner.
 - b. Height relative to ceiling.



2. Effect of fire location on air entrainment.

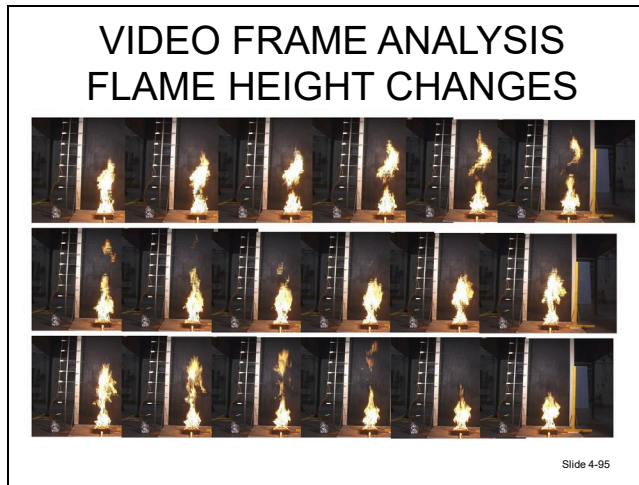
- a. A fire in the center of a room can entrain air from 360° around the base of fire, the combustion zone and the plume.
- b. A fire against a wall can no longer entrain air from the full 360° . Now it would be reduced to 270° or less.
- c. A fire in a corner could have the air entrainment limited to as little as 90° of its perimeters.



3. Open, wall, corner.

- a. Each fire is a 1 square foot gasoline pan fire.
- b. The photo on the left shows the fire in the open with a flame height of about 2.5 ft.

- c. The center photo shows a similar fire against a wall in an 8-ft. tall room with the tip of flame almost 4 ft.
- d. The last photo (right) shows a similar fire in a corner, with the flames impinging on the 8-ft. high ceiling.



- F. Frame analysis of flame height changes.

This slide depicts 18 frames from a video and represents a little more than half of a second. Note the range of flame movement. From the lowest position, it more than doubles as it cycles. This is considered a steady state fire. The eye tends to average out some of the movement, so it does not appear to move up and down as much.

XI. COMPARTMENT FIRES

COMPARTMENT FIRES

Fire growth in a compartment is a function of:

- Fuel properties (chemistry, kpc, etc.).
- Fuel quantity.
- Ventilation (natural or mechanical).
- Compartment geometry - volume and ceiling height.
- Location of fire with compartment.
- Ambient conditions (wind, temperature and RH).
- Time.

Slide 4-96

- A. Fire growth in a compartment is a function of:

1. Fuel properties (chemistry, kpc, etc.).
2. Fuel quantity.
3. Ventilation (natural or mechanical).
4. Compartment geometry – volume and ceiling height.
5. Location of fire with compartment.
6. Ambient conditions (wind, temperature and relative humidity).
7. Time.

FUEL LIMITED FIRES

Also known as over-ventilated fires.

More oxygen supplied to the fire than required to react with all of the fuel.



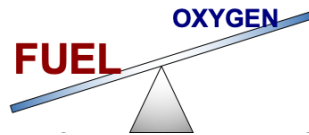
In general, all fires start out as fuel limited fires.

Slide 4-97

- B. Fuel limited fires.
1. Also known as over-ventilated fires.
 2. More oxygen supplied to the fire than required to react with all the fuel.
 3. In general, all fires start out as fuel limited fires.

VENTILATION LIMITED FIRES (A)

Also known as under-ventilated or fuel rich fires. Insufficient oxygen to react with all of the fuel (more fuel than air), which results in the incomplete combustion of the fuel.



Compartment fires can transition from fuel limited to ventilation limited and back again.

Slide 4-98

C. Ventilation limited fires.

1. Also known as under-ventilated or fuel rich fires.
2. Insufficient oxygen to react with all of the fuel (more fuel than air), which results in the incomplete combustion of the fuel.
3. Compartment fires can transition from fuel limited to ventilation limited and back again.

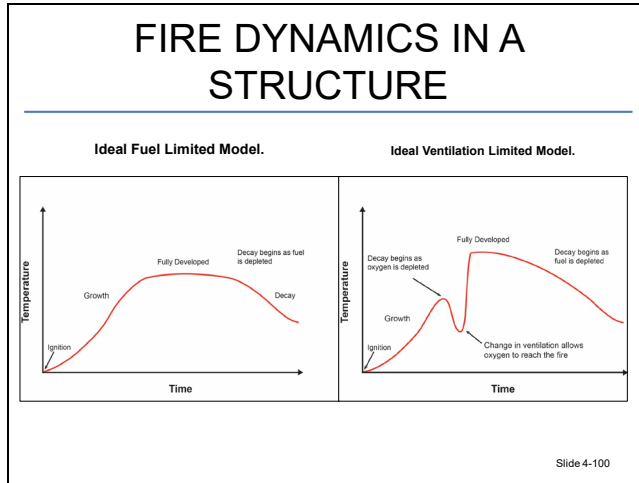
VENTILATION LIMITED FIRES

Most enclosure fires that you will investigate are ventilation limited. The size and location of fire is determined by ventilation.



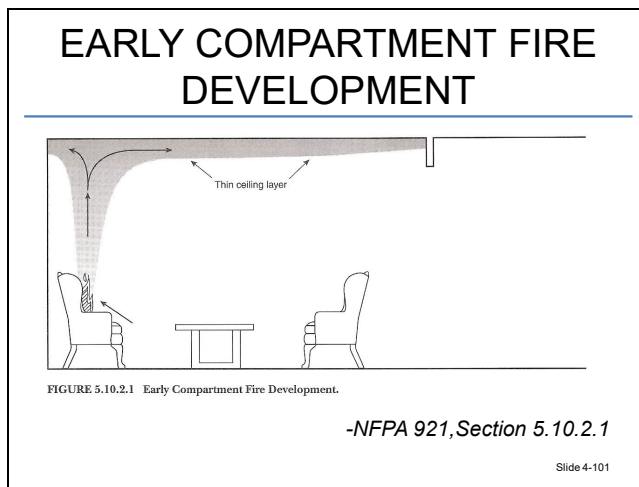
Slide 4-99

4. Most enclosure fires under investigation are ventilation limited. The size and location of fire is determined by ventilation.



D. Fire dynamics in a structure.

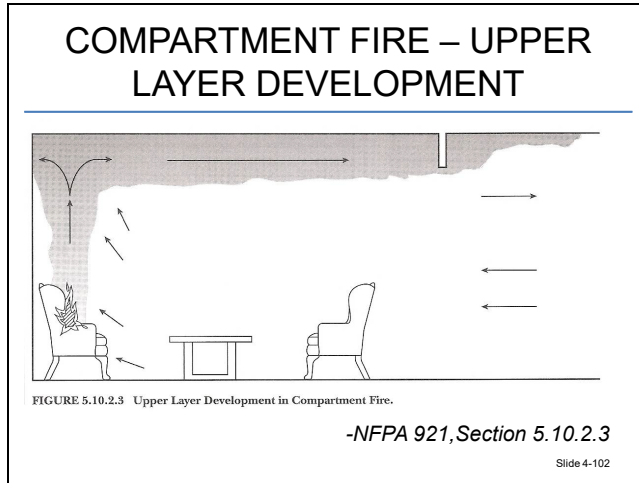
1. Ideal fuel limited model.
2. Ideal ventilation limited model.
3. Both curves start off as fuel limited, then the impacts of compartment size, ventilation, fuel types, etc., generate a ventilation limited fire condition.



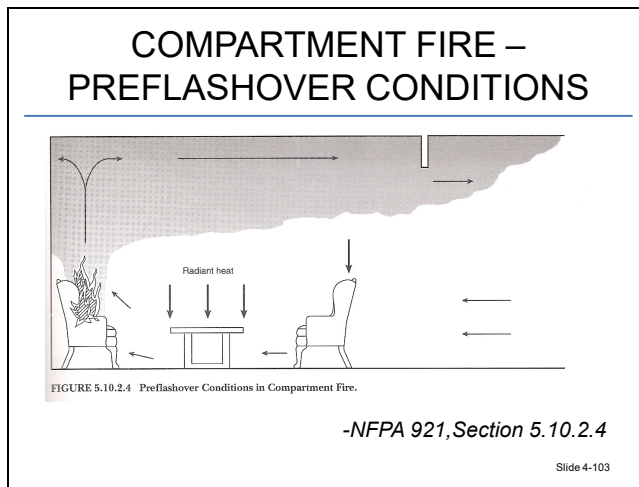
E. Compartment fire development.

1. Early compartment fire development.

Slide shows a flashover cell – not necessarily applicable for all compartment fires.

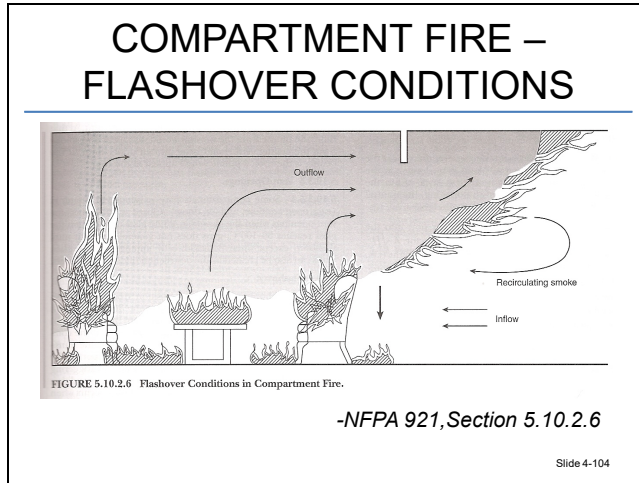


2. Upper layer development.



3. Preflashover conditions.

- a. Radiant heat from the hot gas layer rises and preheats all fuels within the line of sight of the layer.
- b. As the temperature of the hot gas layer increases, the radiant heat causes the horizontal surfaces to pyrolyze.
- c. Provided enough fuel, heat and makeup air, the fire will continue to grow in HRR and size.



4. Flashover conditions.

The hot gas layer ignites, and flames spread toward the room opening (low pressure vent). As the HRR increases, everything in the room that can burn will burn if the oxygen can reach it.

FLASHOVER

Transition from “a fire in a room” to “a room on fire”.

Several flashover transition characteristics:

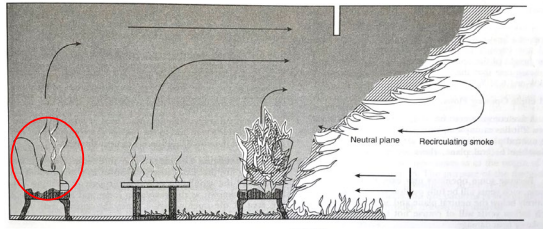
- 610°C (1130°F) upper layer gas temperature.
- 20 kW/m² incident heat flux to the compartment floor.
- “Everything that can burn is burning”
- “Flames out the door”.

Slide 4-105

5. Flashover.

- a. Transition from “a fire in a room” to “a room on fire.”
- b. Several flashover transition characteristics:
 - 610°C (1130°F) upper layer gas temperature.
 - 20 kW/m² incident heat flux to the compartment floor.
 - “Everything that can burn is burning.”
 - “Flames out the door.”

COMPARTMENT FIRE – POST-FLASHOVER CONDITIONS



-NFPA 921, Section 5.10.2.7

Slide 4-106

6. Post-flashover conditions.

Examine this image carefully. It is likely that the area of origin would no longer be burning due to a lack of oxygen at that location in the room.

UL VIDEO



In November 2009, Underwriters Laboratories conducted a side by side comparison of two simulated living room fires. The purpose was to gain knowledge on the difference between modern and legacy furnishings. The rooms measured 12 ft by 12 ft with an 8 ft ceiling and had an 8 ft wide by 7 ft tall opening on the front wall. Both rooms contained similar amounts of like furnishings.

Both rooms were ignited by placing a lit stick candle on the right side of the sofa. The fires were allowed to grow until flashover.

Copyright© 1993-2008 Underwriters Laboratories Inc. All rights reserved. No portion of this material may be reprinted in any form without the express written permission of Underwriters Laboratories Inc. or as otherwise provided in writing.

Slide 4-107

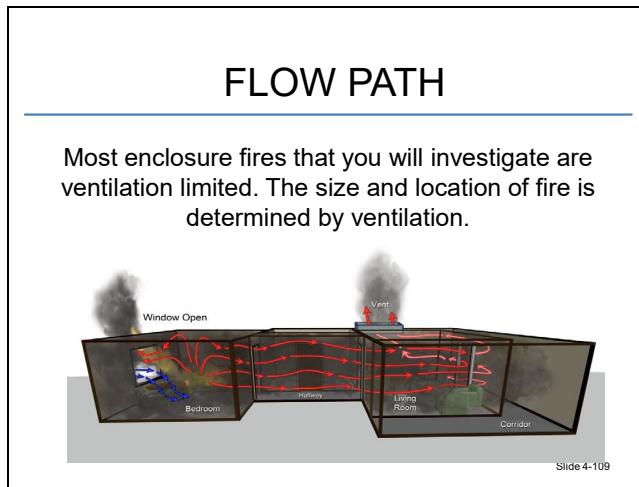
NEUTRAL PLANE

- The interface at a vent, such as a doorway or a window opening, between the hot gas flowing out of a fire compartment and the cool air flowing into the compartment.
- It is at this location that the pressure difference between the fire room and the exterior is neutral or zero.

Slide 4-108

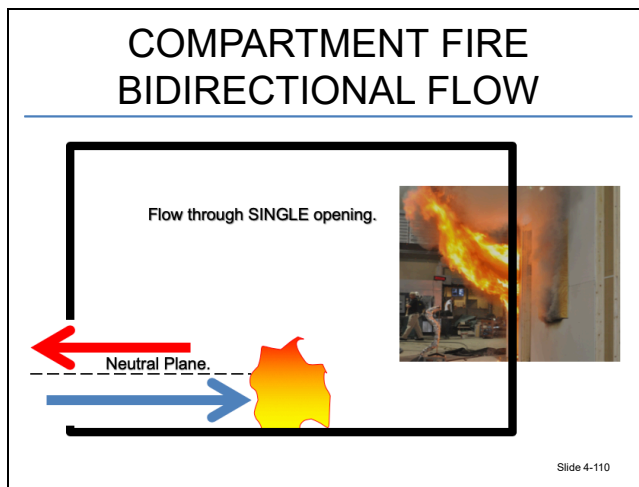
F. Neutral plane.

1. The interface at a vent, such as a doorway or a window opening, between the hot gas flowing out of a fire compartment and the cool air flowing into the compartment.
2. It is at this location that the pressure difference between the fire room and the exterior is neutral or zero.



G. Flow path.

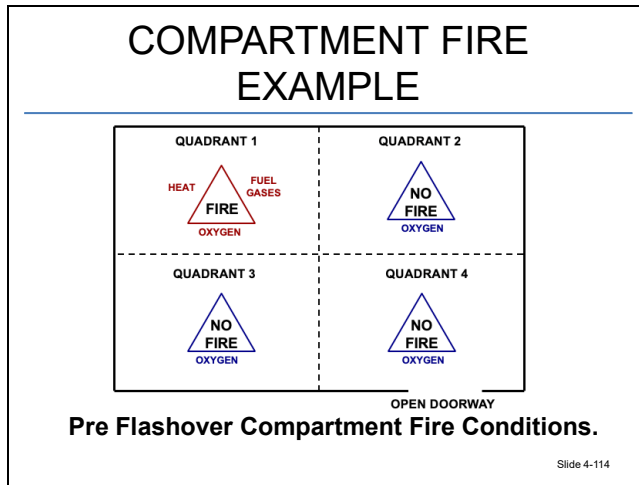
1. Most enclosure fires that you will investigate are ventilation limited. The size and location of fire is determined by ventilation.



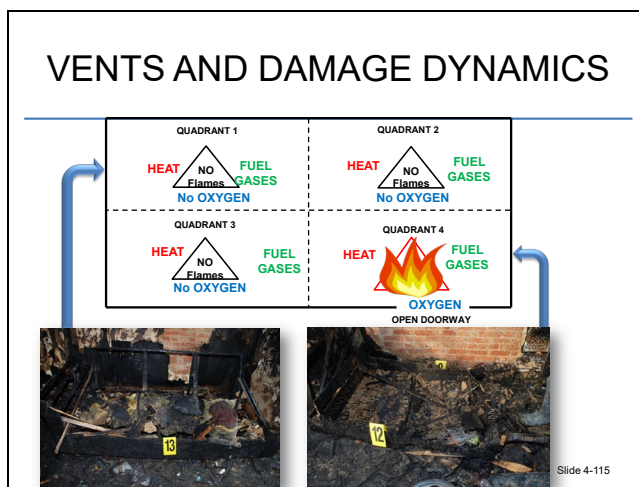
2. Compartment fire bidirectional flow.

[illegible][illegible][illegible]

1. How can a fire investigator use the information on HRR, heat transfer, ventilation, and flow paths to analyze the fire effects and patterns in a compartment fire?
2. In this example, the fire starts in Quadrant 1, remote from the open doorway.



3. Analyze the compartment in terms of the Fire Triangle. What were the conditions like preflashover?
4. Assume that solid fuel is available throughout the compartment. However, there would only be fuel gases near the source of the fire.
5. Oxygen is available throughout the compartment, but heat is only near and above the area of origin.
6. The only place that we have all three of the components needed for flaming combustion is in Quadrant 1.



- I. Vents and damage dynamics.
 1. Structural members and contents near ventilation points may have sustained greater degrees of damage depending on the fire's duration.
 2. Remember that the fire origin is not always the area of greatest damage.

VENT FLOW-VIDEO



Slide 4-116

This page intentionally left blank.

ACTIVITY 4.2

Heat Transfer, Ignition and Flame Spread

Purpose

Demonstrate and enhance the understanding of the fundamental concepts of fire dynamics: three mechanisms of heat transfer, flame spread and fuel orientation. Illustrate how heat transfer and material properties affect the determination of a competent ignition source.

Being able to understand and describe the basic concepts of fire dynamics with the aid of demonstrations.

Safety Precautions

- Safety glasses are required.
- Take appropriate safety measures to prevent person or clothing from coming in contact with open flames or hot surfaces.
- Report any injury to an instructor immediately.

Directions

1. This is an instructor-led activity conducted in the downrange classroom.
2. Use your activity sheets to record your observations.
 - a. Observe how the heat transfer modes of conduction, convection, and radiation differ.
 - b. Observe how some materials are conductors and some are insulators.
 - c. Examine the concept of surface to mass ratio.
 - d. Observe different forms of energy.
 - e. Explain how heat transfer impacts ignition.
 - f. What needs to be determined for a credible ignition source?
3. Be able to explain how or why something occurred.

This page intentionally left blank.

ACTIVITY 4.2 (cont'd)

Worksheet

Conduction heat transfer

1. With the copper wire, the steel rod, and the wood dowel on the table, touch them. Does one of the materials feel colder or warmer than the others? Why?

2. Light the candle. Place the copper wire, the steel rod, and the wood dowel next to each other on the protective surface. Carefully drip wax from the candle across the three materials so that there is a drop of wax about one to two inches from the end of each rod. Three people take one of the materials and place the tip closest to the drop of wax near or above the flame.

Observe which material's wax drop melts first. Explain why. What else did you observe?

- Conduction
 - Copper, Steel, Wood



Convection and radiation heat transfer

Convection and radiation can transfer heat to objects remote from the seat of the fire. In the case of convection, the object has to be exposed to the thermal plume or hot combustion products generated by the fire in order to absorb energy. For radiation, heat is transferred by light, so a line of sight with the hot object is necessary to heat a cooler object.

Light the candle. Carefully place your hand, palm toward the flame, about 3 inches away from the side of the candle flame. What did you feel?

Next, position your hand above the candle flame. Please keep your hand at least 3 inches above the candle flame. What did you feel? Which position felt hotter?

Explain why. Repeat with index cards. Keep cards in place for approximately 30 seconds.

- Convection

- Radiation



Heat transfer experiment

Ignition temperature of a wax-coated paper cup is approximately 240 °C (465 °F). The flame temperature is at least 600 °C (1110 °F). Therefore, the candle should be able to ignite the waxed paper cup.

Pour water into a cup until it is about 1/2 full. Light the candle. Pick up the cup with the tongs and hold over the candle for about 30 seconds. What happened?

Next, pick up the empty cup with the tongs and hold over the candle. What happened?

Explain your observations in terms of heat transfer.

What do you need to consider when determining a competent ignition source?



Heat transfer and ease of ignition experiment

The piloted ignition temperature of wood has been measured over a range of 220 to 460 °C (430 to 860 °F). The flame temperature is at least 600 °C (1110 °F). Therefore, the candle should be able to ignite the wood.

Light the candle. Using tongs, hold the larger block of wood, with the center of the wide portion over the candle flame for approximately 30 seconds. What did you observe?

Next, using the tongs, hold the end edge of the thin piece of wood in the flame. The wide section of the thin board should be vertical to the flame. What did you observe?

Next, sprinkle the sawdust into the flame. What did you observe?

Explain your observations in terms of heat transfer.

What do you need to consider when determining a competent ignition source?



Types of energy experiment

We know that energy can have many forms and that heat is one form of energy.

Take a piece of steel wool and gently spread it apart so that it is a loose mesh.

Place the steel wool on a piece of napkin or tissue paper on the protective surface.

Touch the terminals of the 9V battery to the steel wool to create a circuit for electricity to flow.

What did you observe? Explain why.



Impact of fuel orientation on heat transfer and flame spread

Observe how flame spread is different on vertical surfaces as compared to horizontal.

Light the candle. Hold an index card flat with the wide area parallel to the table top. Using tongs, place the corner of the index card into the flame. Extinguish the card. What did you observe?

Next, hold another index card with the wide area on the vertical. Using tongs, place the edge of the card into the flame. Extinguish the card. What did you observe? In terms of heat transfer, explain your observations.

- Horizontal fuel



-
- Vertical fuel



ACTIVITY 4.3

Pressure Laboratory

Purpose

Examine how pressure inside a closed fire compartment can change, how higher pressure always flows to areas of lower pressure, and the power of air entrainment.

Observe and record observations for each demonstration and explain why.

Knowing how fire affects pressure in a structure will assist the students in determining how and why fire can move through a structure.

Safety Precautions

- Safety glasses are required.
- Take appropriate safety measures to prevent person or clothing from coming in contact with open flames or hot surfaces.
- Report any injury to an instructor immediately.
- **Warning:** Keep the large plastic bags away from heat and flames. The bags are not a toy. Please dispose of them properly. To avoid danger of suffocation, keep bag away from babies and children.

Directions

1. This is an instructor-led activity conducted in the classroom or at the Burn Lab.
2. Use your activity sheets to record your observations.
3. Be able to explain how or why something occurred.

This page intentionally left blank.

ACTIVITY 4.3 (cont'd)

Pressure Laboratory

Fire in a closed compartment (glass over candle in pan of water)

Description: Place a candle in the center of the cake pan. Add about ¼ inch of water to the pan. Light the candle. Once the flame is established, place the glass over the candle and set the rim of the glass down in the pan of water. Observe and explain what happened.

Fire in a Closed Compartment (Glass over Candle in pan of water)



Flow paths – plastic bottle

Description: Take a small piece of paper and roll it into a ball. Place an empty water bottle on its side and place the paper ball in the neck of the bottle. With a sharp exhale, blow into the bottle. Observe, record, and explain what happened. Did the paper ball go into the bottle? If not, why?

Next, open a hole in the side of the bottle near the bottom. Now try to blow the paper ball into the bottle. Observe, record, and explain what happened.



ACTIVITY 4.4

Materials Laboratory

Purpose

Familiarize students with a range of materials that are used in the construction, exterior and interior finish, and furnishings of buildings.

Knowing how these materials react to a small open flame will assist the students in determining a competent ignition relative to the ignitability of the first fuel.

Safety Precautions

- Safety glasses are required.
- Take appropriate safety measures to prevent person or clothing from coming in contact with open flames or hot surfaces.
- Report any injury to an instructor immediately.

Directions

1. This is an instructor-led activity conducted in the downrange classroom.
2. Use your activity sheets to record your observations.
3. Be able to explain how or why something occurred.

This page intentionally left blank.

ACTIVITY 4.4 (cont'd)

Worksheet

Description: Using a candle flame, you will expose one material at a time to the flame and observe. Use tongs to hold the samples. If the sample ignites, allow it to burn to observe flame spread, smoke properties and changes to the material.

2) Materials Burn Differently

1st Burn - Compare

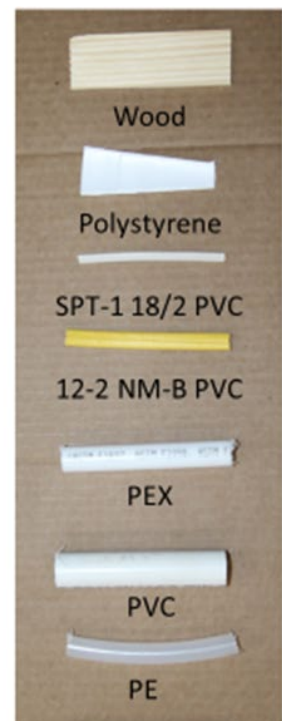
Wood vs Expanded Polystyrene (insulation)

Wiring and Plumbing

Cross Linked Polyethylene (PEX) (Burn last)

Poly Vinyl Chloride (PVC)

Polyethylene (PE)



Material	Ignition	Flame spread	Smoke	Physical change
Wood				
Expanded polystyrene foam				
SPT-1 18/2 PVC lamp cord				
12-2 NM-B PVC				
PEX tubing				
PVC pipe				
PE tubing				

3) Structural/Interior Finish Materials

Vinyl Siding (Poly Vinyl Chloride (PVC))
 Pine Board
 Plywood
 Oriented Strand Board (OSB)
 Vinyl Tile (PVC)
 Polyurethane Foam (PUF) Carpet Padding
 Nylon Carpeting
 Olefin Carpeting
 Laminated MDF Flooring
 Ceramic Tile
 Gypsum Board
 PVC Tile
 Vinyl covered MDF Paneling
 Ceiling Tile

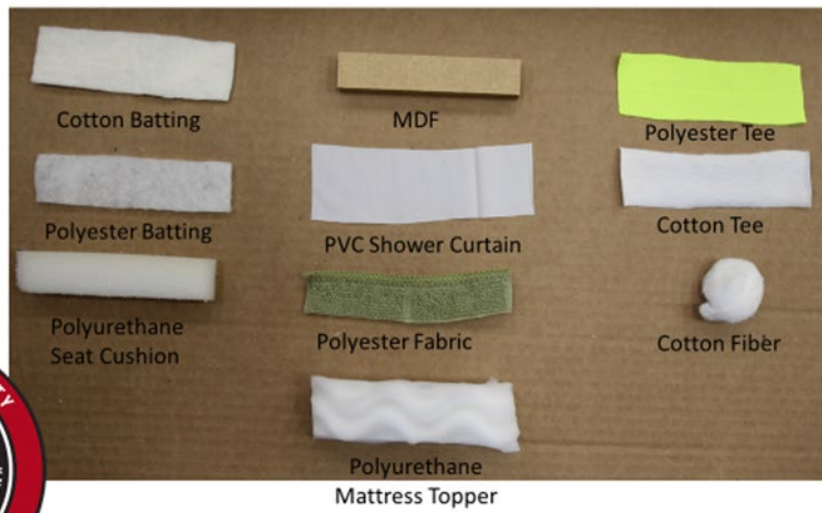


Material	Ignition	Flame spread	Smoke	Physical change
Vinyl siding (PVC)				
Pine board				
Plywood				
OSB				
Vinyl floor tile (PVC)				
PUF carpet (Re-bond) padding				
Nylon carpeting				

Material	Ignition	Flame spread	Smoke	Physical change
Olefin carpeting				
Laminated Medium Density Fiberboard (MDF) flooring				
Ceramic tile				
Gypsum board				
PVC tile/trim				
Vinyl-covered MDF paneling				
Mineral fiber ceiling tile				

4) Home Furnishing & Clothing

Cotton Batting (older furniture)
 Polyester Batting (new furniture)
 Polyurethane Foam (new furniture)
 MDF (furniture)
 PVC Shower Curtain
 Polyester fabric
 Polyurethane Mattress Topper
 Polyester Tee Shirt
 Cotton Tee Shirt
 Cotton Fiber



Material	Ignition	Flame spread	Smoke	Physical change
Cotton batting				
Polyester batting				
PUF seat cushion				
MDF				
Shower curtain (PVC)				
Polyester fabric from towel				
PUF mattress topper				

Material	Ignition	Flame spread	Smoke	Physical change
Polyester t-shirt				
Cotton t-shirt				
Cotton fiber				

DEMONSTRATION

Live Burns and Ventilation

Purpose

Demonstrate the various stages of a compartment fire, growth and development, from ignition (incipient stage) to decay (smoldering stage). This demonstration allows the students to experience radiant heat transfer and observe other forms of heat transfer. Additionally, students are provided demonstrative reinforcement of the objectives that illustrates the differences in ventilation controlled fires and the fire patterns they produce.

Safety Precautions

- Safety glasses are required.
- Follow all direction of instructors and range personnel.

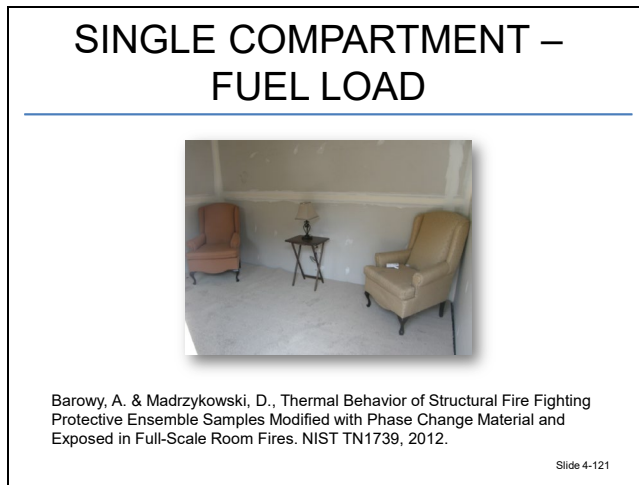
Directions

You will go down range to observe two compartment fires: Both compartments will be furnished the same, and the area of origin will be in the same location. The only difference will be the location of the door (vent path). Ignition for both cells is an open flame.

This page intentionally left blank.

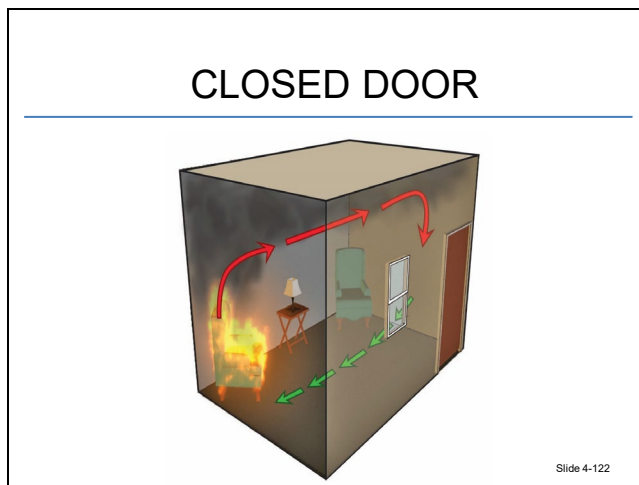
A. Fire test examples – open and closed openings.

In the following fire scenarios, a 42-lb. upholstered chair stuffed with PUF and polyester batting will serve as the first item ignited in the corner of the room that is farthest away from the doorway. A similar chair is located in corner closest to the door.



B. Single compartment fuel load.

Fuel load: two upholstered chairs, small table and lamp, carpet and padding. Paper on the gypsum board will also contribute.



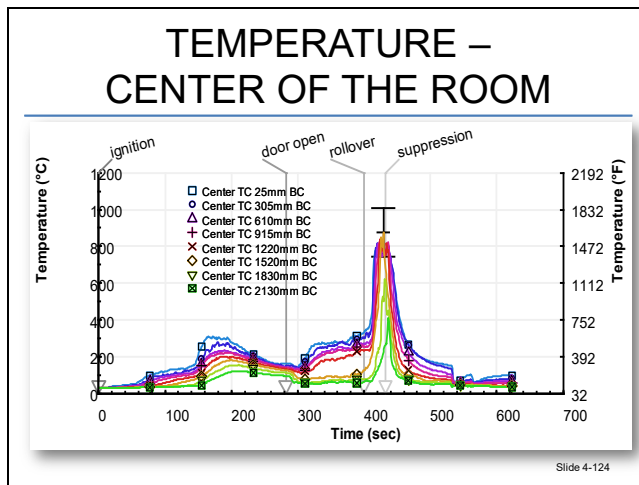
C. Closed room.

Drawing of gas flow or circulation in the room when the door and window are closed. This circulation will continue until the fire has consumed the oxygen to the point where the fire decreases and the smoke layer descends to the floor. Red arrows represent hot gas, and the green arrows represent fresh air.



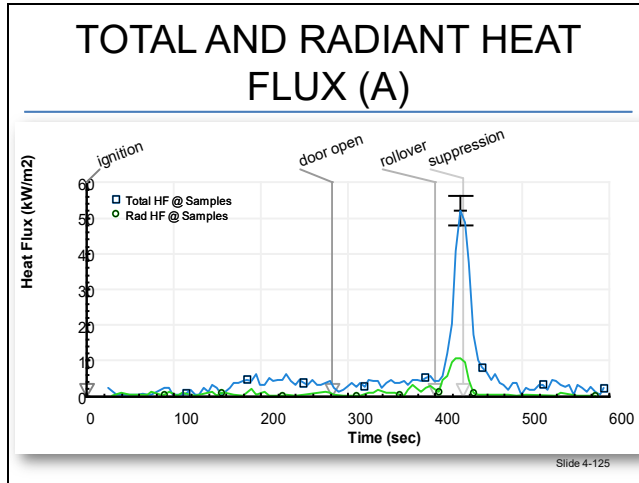
D. Open door compartment fire suppressed – flashover onset.

1. Area of origin.
2. Target chair.
3. Fire effects.



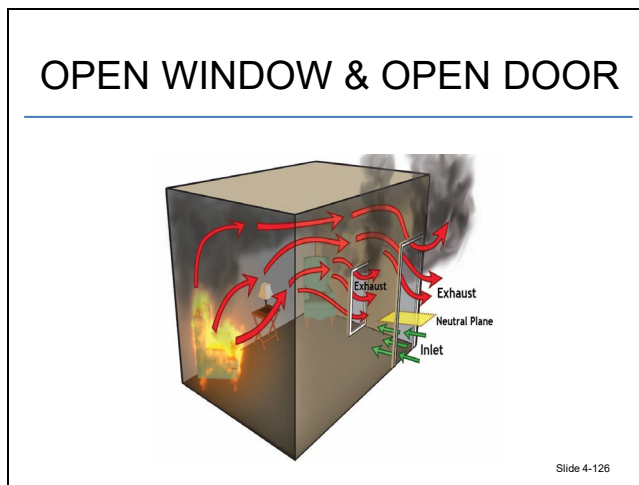
E. Temperature – center of the room.

Slide shows the temperature time history from the previous video. Note how the temperatures peaked and then decreased as the oxygen in the room was depleted and the smoke filled the room. After the door was opened, the hot gas layer and cool air layer separated, and visibility returned inside the room. Then the fire grew and was on the way to flashover at the time of suppression.



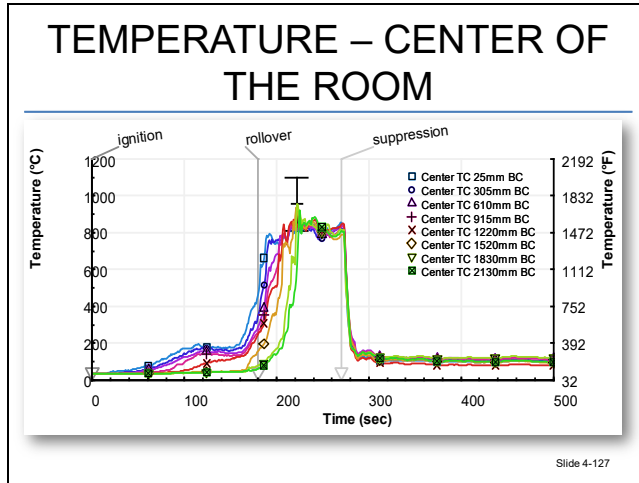
F. Total and radiant heat flux.

The heat flux measured in the room on the wall just below the window — about 3 ft. above the floor. The total heat flux represents a combination of convection and radiation heat transfer. The lower line is radiation heat flux only. Note how rapidly the heat flux increased after the flames started to move across the ceiling.



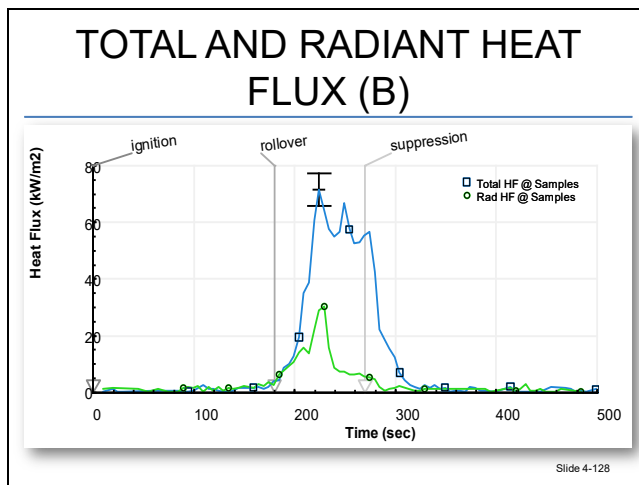
G. Open window and door.

This graphic shows how the flows would change with the window providing another exhaust vent.



H. Temperature – center of the room.

Slide shows the temperature time history from the previous video. With the door open, a continuous supply of air entered the room and enabled the fire to grow and transition through flashover. Based on the data, the temperatures were in excess of 1100 °F and nearly uniform from the ceiling down to the floor.



I. Total and radiant heat flux.

The heat flux measured in the room on the wall just below the window — about 3 ft. above the floor. The total heat flux represents a combination of convection and radiation heat transfer. The lower line is radiation heat flux only. The heat fluxes were higher in experiment due to the added ventilation. Note the convected heat transferred was higher than the radiant heat transferred from the fire, just like the candle demonstration that was conducted earlier.

OPEN DOOR & WINDOW COMPARTMENT
FIRE SUPPRESSED POST-FLASHOVER

Area of Origin.



Target Chair.



Slide 4-129

J. Open door and window compartment.

Fire suppressed post-flashover.

1. Area of origin.
2. Target chair.
3. Fire effects.

UL Xplorlabs



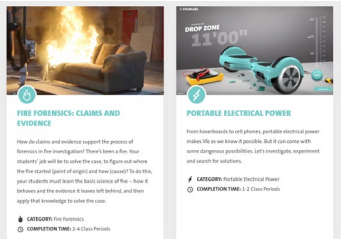
Slide 4-130

Introducing UL Xplorlabs

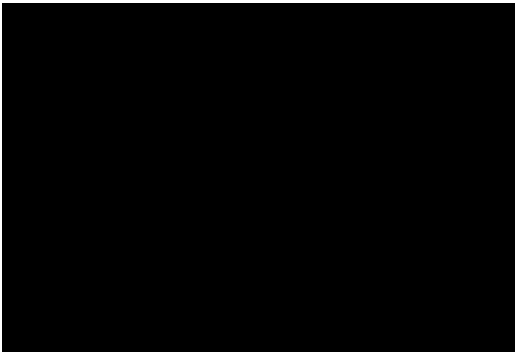


Slide 4-131

Xplorlabs
ulxplorlabs.org



Slide 4-132



Slide 4-133

This page intentionally left blank.

REFERENCES

- Quintiere, J.G. *Principles of Fire Behavior*, 2nd ed., 2017, p. 83.
- Quintiere, J.G. *Principles of Fire Behavior*, 1998, p. 70.
- NFPA 921, Chapter 21, Section 21.2.1.2, 2024 ed.
- NFPA 921, Chapter 3, Section 3.3.37, 2024 ed.
- NFPA 921, Chapter 3, Section 3.3.46, 2024 ed.
- NFPA 921, Chapter 3, Section 3.3.49, 2024 ed.
- NFPA 921, Chapter 3, Section 3.3.60, 2024 ed.
- NFPA 921, Chapter 3, Section 3.3.71, 2024 ed.
- NFPA 921, Chapter 3, Section 3.3.81, 2024 ed.
- NFPA 921, Chapter 3, Section 3.3.120, 2024 ed.
- NFPA 921, Chapter 5, Section 5.5.4.2, 2024 ed.
- NFPA 921, Chapter 5, Section 5.8.1.2, 2024 ed.
- NFPA 921, Chapter 5, Section 5.10.2.1, 2024 ed.
- NFPA 921, Chapter 5, Section 5.10.2.3, 2024 ed.
- NFPA 921, Chapter 5, Section 5.10.2.4, 2024 ed.
- NFPA 921, Chapter 5, Section 5.10.2.6, 2024 ed.
- NFPA 921, Chapter 5, Section 5.10.2.7, 2024 ed.
- Origin Matrix Analysis: A Systematic Methodology for the Assessment and Interpretation of Compartment Fire Damage.
- NFPA 921, Chapter 6, Section 6.2.10.2, 2024 ed.
- NFPA 921, Chapter 6, Section 6.2.10.4, 2024 ed.
- NFPA 921, Chapter 6, Section 6.2.15.3, 2024 ed.

This page intentionally left blank.

UNIT 5: ELECTRICAL SYSTEMS AND ARC MAPPING

TERMINAL OBJECTIVE

The students will be able to:

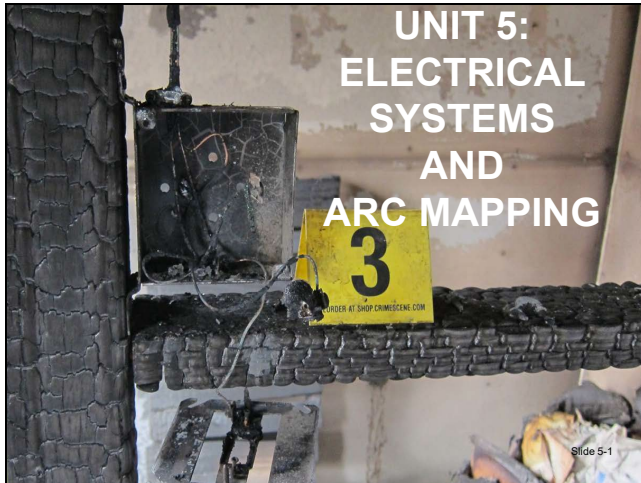
- 5.1 *Evaluate electrical systems, electrical failures, and arc mapping through the lens of basic electrical theory.*

ENABLING OBJECTIVES

The students will be able to:

- 5.1 *Describe basic electrical theory.*
- 5.2 *Recognize the components of a building's electrical system from generation to distribution.*
- 5.3 *Model basic safety practices when evaluating an electrical system.*
- 5.4 *Evaluate electrical circuits using Ohm's law/Joule's law.*
- 5.5 *Differentiate between electrical and thermal damage on energized and non-energized conductors.*
- 5.6 *Evaluate common modes of electrical failure to systems, components, and appliances.*
- 5.7 *Collect data and create an arc map, illustrating the application of arc mapping to origin determination.*
-

This page intentionally left blank.



TERMINAL OBJECTIVE

Evaluate electrical systems, electrical failures, and arc mapping through the lens of basic electrical theory.

Slide 5-2

ENABLING OBJECTIVES

- 5.1 Describe basic electrical theory.
- 5.2 Recognize the components of a building's electrical system from generation to distribution.
- 5.3 Model basic safety practices when evaluating an electrical system.
- 5.4 Evaluate electrical circuits using Ohm's law/ Joule's law.

Slide 5-3

ENABLING OBJECTIVES

- 5.5 Differentiate between electrical and thermal damage on energized and non-energized conductors.
- 5.6 Evaluate common modes of electrical failure to systems, components, and appliances.
- 5.7 Collect data and create an arc map, illustrating the application of arc mapping to origin determination.

Slide 5-4

I. INTRODUCTION

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) 921 – 2024

“Ignition by electrical energy involves transferring sufficient heat to a fuel (i.e., competent ignition source) by passage of electrical current to ignite material that is close.”

Reference: NFPA 921, Guide for Fire and Explosion Investigations, Chapter 9, Section 9.9.1.1.

Slide 5-5

- A. National Fire Protection Association (NFPA) 921, *Guide for Fire and Explosion Investigations* – 2024.

“Ignition by electrical energy involves transferring sufficient heat to a fuel (i.e., competent ignition source) by passage of electrical current to ignite material that is close” (NFPA 921, Section 9.9.1.1, 2024 ed.).

NFPA 921 – SUFFICIENT HEAT

Enough heat may be generated by a wide variety of means, such as:

- Short-circuit and ground-fault parting arcs.
- Excessive current through wiring or equipment.
- Resistance heating.
- By ordinary sources such as:
 - Lightbulbs.
 - Heaters.
 - Cooking equipment.

Slide 5-6

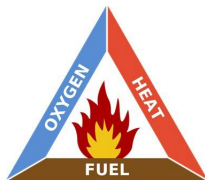
B. NFPA 921 – Sufficient heat.

Sufficient heat may be generated by a wide variety of means, such as:

1. Short-circuit and ground-fault parting arcs.
2. Excessive current through wiring or equipment.
3. Resistance heating.
4. By ordinary sources such as:
 - a. Lightbulbs.
 - b. Heaters.
 - c. Cooking equipment.

NFPA 921 – TIME DEPENDENT

The requirement for ignition is that the temperature of the electric source be maintained long enough to bring the adjacent fuel up to its ignition temperature.



Slide 5-7

- C. NFPA 921 – Time dependent.
1. The requirement for ignition is that the temperature of the electric source be maintained long enough to bring the adjacent fuel up to its ignition temperature.
 2. Note: There must be an oxidizer present to allow combustion.

II. SAFETY

SAFETY – ARC FLASH

Equipment Labeling



WARNING	
Arc Flash & Shock Hazard Appropriate PPE Required	
FLASH PROTECTION Flash Hazard Category: 1 Min. Arc Rating (cal/cm²): 8 Flash Protection Boundary: 3 ft PPE: [X] Cotton Underwear [X] FR Shirt and Pants (or FR coveralls) [X] Full Flash Suit and Hood [X] Hard Hat [X] Safety Glasses or Goggles [X] Hearing Protection [X] Leather Gloves and Shoes	SHOCK PROTECTION 250 VAC Shock Hazard When: Cover Is Removed Limited Approach Boundary: 4 ft Restricted Approach Boundary: 3 ft Prohibited Approach Boundary: 1 ft PPE: [X] Class 4 [X] V-Rating [X]
Equipment ID: AB19485	

Slide 5-8

- A. Safety – Arc Flash.
1. Equipment Labeling.
 2. An Arc Flash occurs during a fault, or short circuit condition, which passes through this arc gap.
 3. The Arc Flash can be initiated through:
 - a. Accidental contact.
 - b. Equipment which is underrated for the available short circuit current.
 - c. Contamination.
 - d. Tracking over insulated surfaces.
 - e. Deterioration or corrosion of equipment or parts, as well as other causes.

4. An Arc Flash event can expel large amounts of deadly energy.
5. The arc causes an ionization of the air, and Arc Flash temperatures can reach as high as 35,000 F.

This is hotter than the surface of the sun.

SAFETY – 480V ARC FLASH VIDEO

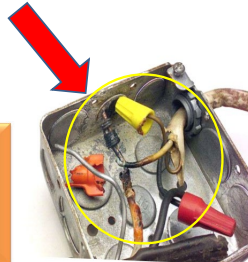


Slide 5-9

SAFETY – ONSITE HAZARDS

Electrical hazards may be present on a fire scene long after fire ends.

Never assume that just because the structure suffered heavy damage, all sources of electrical energy have been eliminated.



Slide 5-10

B. Safety – onsite hazards.

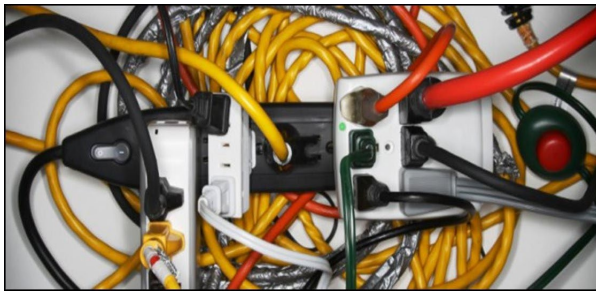
1. Electrical hazards may be present on a fire scene long after fire ends.
2. Never assume that just because the structure suffered heavy damage, all sources of electrical energy have been eliminated.

SAFETY – ONSITE HAZARDS

- Electrical energy can be present in the form of energized circuits or stored energy.
- Never attempt to disconnect electrical utility service from the structure.
 - Only the utility representative should do so.
- Multiple sources may bring electrical service to a structure, from overhead or underground.

Slide 5-11

SAFETY – MULTIPLE SOURCES



Slide 5-12

3. Electrical energy can be present in the form of energized circuits or stored energy.
4. Never attempt to disconnect electrical utility service from the structure.
Only the utility representative should do so.
5. Multiple sources may bring electrical service to a structure from overhead or underground.

SAFETY – DISCONNECT

Use observations and testing equipment to verify that electricity is disconnected.

Never assume that power has been disconnected.

- 1) Observe
- 2) Separate
- 3) Test



Slide 5-13

C. Safety – disconnect.

1. Use observations and testing equipment to verify that electricity is disconnected.
2. Never assume that power has been disconnected.
 - a. Observations are made to ensure that there is a disconnect from the utility system to the involved structure.
 - b. There must be some type of separation. Either the wires are separated from utility to structure, the breaker is in an “off” position, or the disconnect is in an open position.
 - c. Test the equipment to ensure it is de-energized.

SAFETY – EFFECTS

Effects of 60 Hertz electricity

1 milliamp.	Threshold of perception.
5 milliamps.	Maximum “harmless” current.
10-20 milliamps.	Maximum “let go” current.
50 milliamps.	Pain, possible fainting, mechanical injury. Heart and respiratory functions continue.
100-300 milliamps.	Ventricular fibrillation will start, respiratory center remains intact.
>300 milliamps.	Sustained myocardial contraction. Temporary respiratory paralysis. Burns if current density is high.



Slide 5-14

D. Safety – effects.

Effects of 60 Hertz (Hz) electricity:

1 milliamp.	Threshold of perception.
5 milliamps.	Maximum “harmless” current.
10-20 milliamps.	Maximum “let go” current.
50 milliamps.	Pain, possible fainting, mechanical injury. Heart and respiratory functions continue.
100-300 milliamps.	Ventricular fibrillation will start, respiratory center remains intact.
>300 milliamps.	Sustained myocardial contraction. Temporary respiratory paralysis. Burns if current density is high.

SAFETY – TESTER

Proximity noncontact tester (tic tracer):

- Detect the electrostatic field generated around an alternating current (AC) conductor.
- Provide an audible signal as voltage is detected.
- Check against a known source.
- Check batteries.
- User needs to have physical contact with the ground.



Slide 5-15

E. Safety – tester.

Proximity noncontact tester (tic tracer):

1. Detect the electrostatic field generated around an alternating current (AC) conductor.
2. Provide an audible signal as voltage is detected.
3. Check against a known source.

4. Check batteries.
5. User needs to have physical contact with the ground.

SAFETY – MULTIMETER

Digital multimeter:

- A contact measurement device.
- Device probes must come into physical contact with the conductors or surfaces to be measured.



Slide 5-16

F. Safety – multimeter.

1. Digital multimeter: a contact measurement device. Device probes must come into physical contact with the conductors or surfaces to be measured.
2. Note that there have been instances where cheap meters used beyond their rating have exploded and caused severe **injury and death**.

SAFETY – WIGGY

Wiggy:

- A direct contact measurement device.
- Does not require batteries.
- The readings are not as accurate as digital multimedia.
- Vibrates when an electric field is detected to provide tactile feedback.



Slide 5-17

G. Safety – Wiggy.

1. A direct contact measurement device.
2. Does not require batteries.

3. The readings are not as accurate as digital multimedia.
4. Vibrates when an electric field is detected to provide tactile feedback.

SAFETY – DIGITAL TESTER

Digital voltage and continuity tester:

- Contact measurement device.
- Automatically determines range and function.
- Measures AC/DC voltage from 12 to 600 volts and detects voltage when the battery dies.



Slide 5-18

H. Safety – digital tester.

1. Digital voltage and continuity tester:
 - a. Contact measurement device.
 - b. Automatically determines range and function.
 - c. Measures AC/direct current (DC) voltage from 12 to 600 volts and detects voltage when the battery dies.

SAFETY – DIGITAL TESTER

Three notifications for voltage detected:

- Light.
- Sound.
- Vibration.



Continuity is reported by light and sound.

Slide 5-19

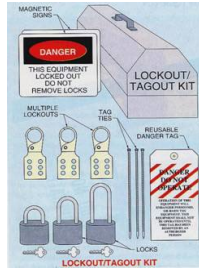
2. Three notifications for voltage detected:
 - a. Light.

- b. Sound.
 - c. Vibration.
3. Continuity is reported by light and sound.

SAFETY – LOCK OUT

Before preventative maintenance can be performed, equipment **must be:**

- **Locked out and tagged out** before examination.



Slide 5-20

I. Safety – lock out.

Before preventative maintenance can be performed, equipment **must be locked out and tagged out** before examination.

SAFETY – TAG OUT

Lock outs and tag outs are attached only after the equipment is turned **off** and tested to ensure that power is **off**.

Students will use tag out procedures at Burn Laboratory



Slide 5-21

J. Safety – tag out.

Lock outs and tag outs are attached only after the equipment is turned **off** and tested to ensure that power is **off**. **Students will use tag out procedures at Burn Laboratory.**

III. BASIC ELECTRICAL THEORY

BASIC THEORY

Electricity:

“The physical phenomena arising from the behavior of electrons and protons that is caused by the attraction of particles with opposite charges and the repulsion of particles with the same charge.”

The American Heritage Dictionary of the English Language

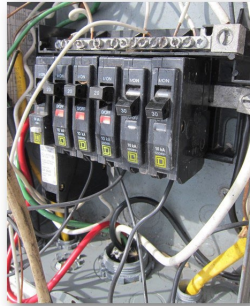
Slide 5-22

A. Basic theory.

Electricity: “The physical phenomena arising from the behavior of electrons and protons that is caused by the attraction of particles with opposite charges and the repulsion of particles with the same charge.” *The American Heritage Dictionary of the English Language.*

ELECTRICITY

- The flow of electrons due to a difference in energy potential between two points on a conductor.
- Only the effects of electrons can be seen; some are wanted, others are not.



Slide 5-23

B. Electricity.

1. The flow of electrons due to a difference in energy potential between two points on a conductor.
2. Only the effects of electrons can be seen; some are wanted, others are not.

TERMS

- Voltage (V) or electromotive force (E).
- Current (I) or amperes or amps (A).
- Power (P) or watts (W).
- Resistance (R).
- Inductance (L).

Slide 5-24

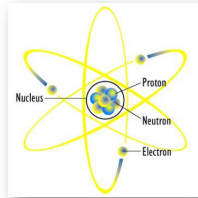
C. Terms.

1. Voltage (V) or electromotive force (E): the pressure behind the electrons, measured in volts. You may see the electrical symbol “V” or, scientifically, “E.”
2. Current (I): the rate at which electrons are going to pass a given rate in one second. It is measured in amperes or amps (A). Electrical symbol is “I,” which stands for intensity of electrons in conductors.
3. Power (P) or watts (W).
 - a. Power: a product of how much voltage and current is in the circuit. It is measured in watts.
 - b. Watts: the heating component that must be identified.
4. Resistance (R): the opposition to current flow. Measured in ohms or the Greek symbol omega.
5. Inductance (L): the influx of a magnetic field on a conductor, which causes electrons to begin to flow. This is the basic principle of a generator as well as a transformer.

MATTER

Matter:

- Has weight and takes up space.
- Atoms.
- Nucleus = + charged protons and neutrons.



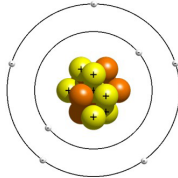
Slide 5-25

D. Matter.

1. Has weight and takes up space.
2. Atoms.
3. Nucleus = + charged protons and neutrons.

ATOMIC THEORY

- All matter is made of atoms.
- Protons + neutrons = nucleus.
- Electrons form valance rings.
- Number of electrons = number of protons.
 - Outer ring has one to eight electrons.
- One to two electrons in outer ring = unstable ring (conductor).
- Examples: silver, copper, gold, aluminum.



Slide 5-26

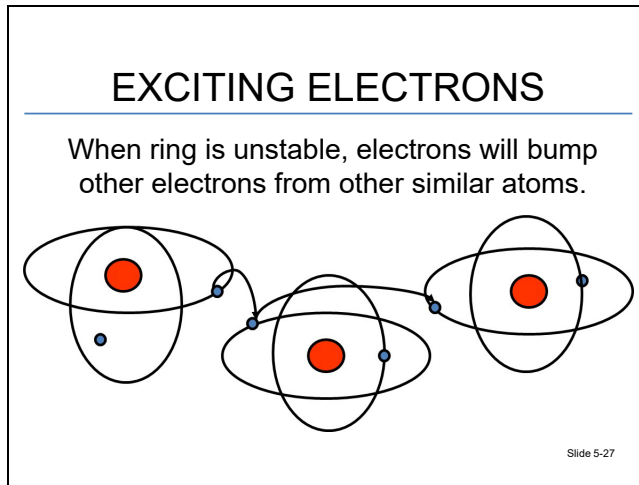
E. Atomic theory.

1. All matter is made of atoms.
2. Protons + neutrons = nucleus.
3. Electrons form valance rings.
4. Number of electrons = number of protons.

Outer ring has one to eight electrons.

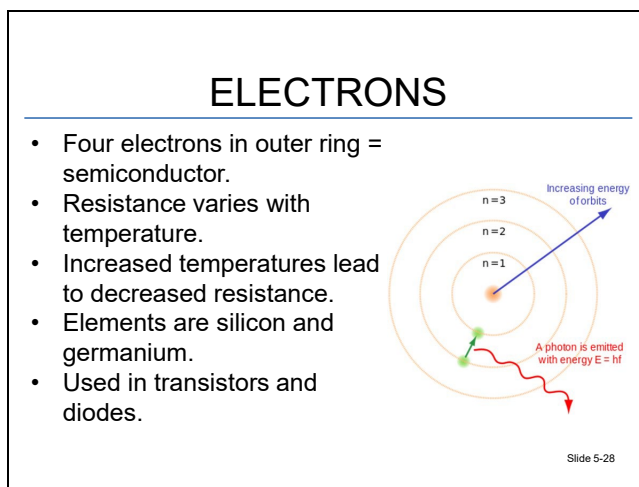
5. One to two electrons in outer ring = unstable ring (conductor).

6. Examples: silver, copper, gold, aluminum.



F. Exciting electrons.

When ring is unstable, electrons will bump other electrons from other similar atoms.



G. Electrons.

1. Four electrons in outer ring = semiconductor.

2. Resistance varies with temperature.

3. Increased temperatures lead to decreased resistance.

4. Elements are silicon and germanium.
5. Used in transistors and diodes.

ELECTRONS STRUCTURE

- Seven to eight electrons in the outer ring = stable ring (insulator).
- Examples include various carbon molecules such as rubber, plastics, and wood.
- Movement of electrons from one atom to another is known as electricity.
- Energy is required to initiate and continue this movement.



Slide 5-29

H. Electrons structure.

1. Seven to eight electrons in the outer ring = stable ring (insulator).
2. Examples include various carbon molecules such as rubber, plastics, and wood.
3. Movement of electrons from one atom to another is known as electricity.
4. Energy is required to initiate and continue this movement.

ELECTRON FLOW

- Energy is transformed during this movement to heat and magnetism.
- Heat and magnetism always accompany electron flow in some amount.



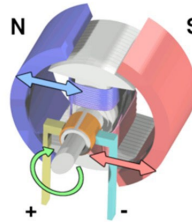
Slide 5-30

I. Electron flow.

Energy is transformed during this movement to heat and magnetism. Heat and magnetism always accompany electron flow in some amount.

MAGNETIC FIELD

- When current flows, a magnetic field is generated.
- Conversely, when a conductor is put into a magnetic field, current will flow; this is the principle of a generator.



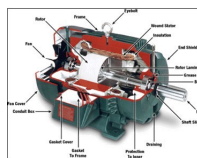
Slide 5-31

J. Magnetic field.

1. When current flows, a magnetic field is generated.
2. Conversely, when a conductor is put into a magnetic field, current will flow; this is the principle of a generator.

CONDUCTORS

- Materials that allow current to flow freely with minimal resistance.
- Copper and aluminum – two of the most recognized; both are used in electrical systems.
- Gold and silver also used, usually at point of contact.



Slide 5-32

K. Conductors.

1. Materials that allow current to flow freely with minimal resistance.
2. Copper and aluminum – two of the most recognized; both are used in electrical systems.
3. Gold and silver also used, usually at point of contact.

INSULATORS

- Insulators work the opposite of conductors; they oppose or stop the flow of current.
- Some insulators are glass, porcelain, air and pure water.
- However, a high enough voltage may defeat the insulator.



Vintage power pole glass insulator.

Slide 5-33

L. Insulators.

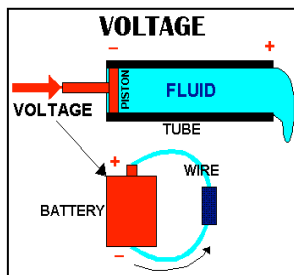
1. Insulators work the opposite of conductors; they oppose or stop the flow of current.
2. Some insulators are glass, porcelain, air and pure water.
3. However, a high enough voltage may defeat the insulator.

IV. VOLTAGE, AMPERES AND POWER

VOLTAGE

Volts:

- Electrical pressure that moves electrons through the conductor, known as **electromotive force**.
- Shown in formulas as "E."



Slide 5-34

A. Voltage.

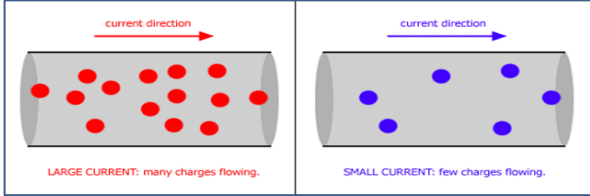
Volts:

1. Electrical pressure that moves electrons through the conductor, known as **electromotive force**.

2. Shown in formulas as “E.”
3. Measured in volts.

CURRENT: AMPERES

The rate at which electrons flow through a conductor.
Shown in formulas as “I” (intensity). Measured in amperes (amps).



The diagram consists of two side-by-side rectangular boxes representing a conductor. The left box is labeled 'LARGE CURRENT: many charges flowing.' and contains many red dots representing charges. A red arrow above it points to the right, labeled 'current direction'. The right box is labeled 'SMALL CURRENT: few charges flowing.' and contains a few blue dots representing charges. A blue arrow above it points to the right, labeled 'current direction'.

Image of large and small currents. The large current has many charges flowing. The small current has few changes flowing. Slide 5-35

B. Current: amperes.

1. The rate at which electrons flow through a conductor. It is determined by measuring the amount of electrons flowing past a single point in one second.
2. Shown in formulas as “I” (intensity).
3. Measured in amperes (amps).

RESISTANCE

- Opposition to current flow.
- Shown in formulas as “R”.
- Measured in ohms.
- Greek Omega Ω .



The illustration shows a person in a blue uniform pushing a large, black, spherical object. The sphere has a white circle in the center with the number '8' inside. The person is bent over, pushing the sphere from behind. The sphere is casting a shadow on the ground.

Slide 5-36

C. Resistance.

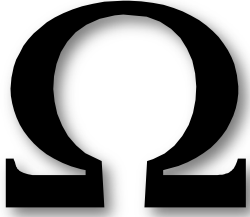
1. Opposition to current flow.
2. Shown in formulas as “R.”

3. Measured in ohms.

Greek Omega Ω .

OHMS

- When current flows through resistance, heat is generated.
- Every conductor offers resistance.
- Excess resistance can create high temperatures.



Slide 5-37

D. Ohms.

1. When current flows through resistance, heat is generated.
2. Every conductor offers resistance.
3. Excess resistance can create high temperatures.

POWER

Watts or kilowatts (kW):

- Quantitative measurement of work done consumed in an electrical circuit.
- Power is a larger issue over a period of time.



Slide 5-38

E. Power.

1. Quantitative measurement of work done consumed in an electrical circuit.
2. Power is a larger issue over a period of time.

WATTS

- Turn on a 100-W light bulb for one second, touch it, no problem.
- Leave it on for an hour, touch it, burned.



Slide 5-39

F. Watts.

1. Turn on a 100-W light bulb for one second, touch it, no problem.
2. Leave it on for an hour, touch it – burned.

ELECTRICAL

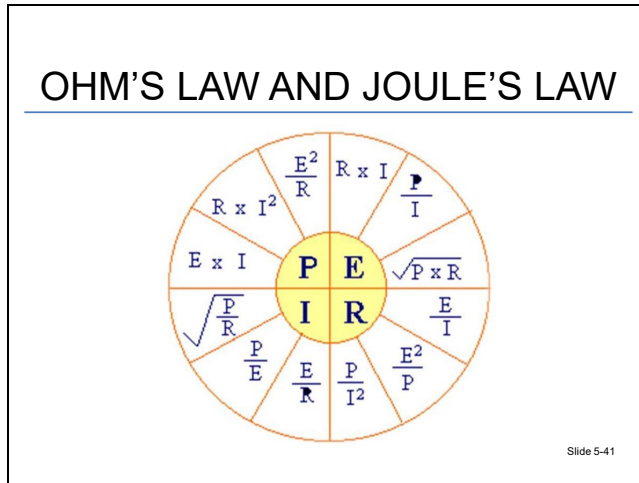
A chart representing Hydraulic versus Electrical.

Hydraulic	Electrical
Water/Fluid.	Electrons.
Pump.	Generator.
Pressure.	Voltage.
Pounds per square inch (psi).	Volts.
Flow.	Current.
Gallons per minute (gpm).	Amperes.
Friction loss.	Resistance.

Slide 5-40

G. Electrical.

V. OHM'S AND JOULE'S LAWS



GEORG OHM

Ohm's law was named after Georg Simon Ohm (1787-1854). Ohm's law is stated as:

The voltage in a circuit is equal to the current multiplied by the resistance or $E = I \times R$.

Where: E = Voltage.
I = Amperage.
R = Resistance.



Slide 5-42

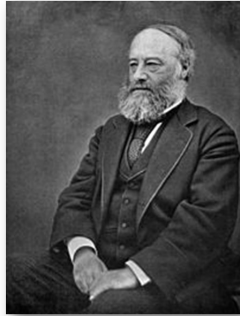
-NFPA 921, Section 9.2.5

A. Georg Ohm.

1. The voltage in a circuit is equal to the current multiplied by the resistance or $E = I \times R$.
2. Where: E = Voltage.
I = Amperage.
R = Resistance.

JAMES JOULE

James Prescott Joule (1818-1889) formulated a relationship between the heat generated in an electric wire and the voltage across and current through that wire.



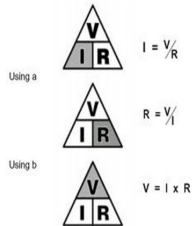
Slide 5-43

B. James Joule.

James Prescott Joule (1818-1889) formulated a relationship between the heat generated in an electric wire and the voltage across and current through that wire.

OHM'S LAW

- I (current, amperes) = $\frac{E \text{ (voltage)}}{R \text{ (resistance, ohms)}}$
- R (resistance) = $\frac{E \text{ (volts)}}{I \text{ (current)}}$
- $E \text{ (volts)} = I \text{ (current)} \times R \text{ (resistance)}$



$$I = \frac{V}{R}$$

$$R = \frac{V}{I}$$

$$V = I \times R$$

Slide 5-44

C. Ohm's law.

1. I (current, amperes) = $\frac{E \text{ (voltage)}}{R \text{ (resistance, ohms)}}$
2. R (resistance) = $\frac{E \text{ (volts)}}{I \text{ (current)}}$
3. $E \text{ (volts)} = I \text{ (current)} \times R \text{ (resistance)}$

JOULE'S LAW

- P (power, watts) = I (current, amps) x E (voltage).
- I (current) = $\frac{P \text{ (power)}}{E \text{ (voltage)}}$
- E (voltage) = $\frac{P \text{ (power)}}{I \text{ (current)}}$
- By substituting Ohm's law for voltage:
 - P (power) = I^2 (current squared) x R (resistance).

Slide 5-45

D. Joule's law.

1. P (power, watts) = I (current, amps) x E (voltage).
2. I (current) = $\frac{P \text{ (power)}}{E \text{ (voltage)}}$
3. E (voltage) = $\frac{P \text{ (power)}}{I \text{ (current)}}$
4. By substituting Ohm's law for voltage:

$$P \text{ (power)} = I^2 \text{ (current squared)} \times R \text{ (resistance)}.$$

PRACTICAL DEMONSTRATION OF OHM'S AND JOULE'S LAWS

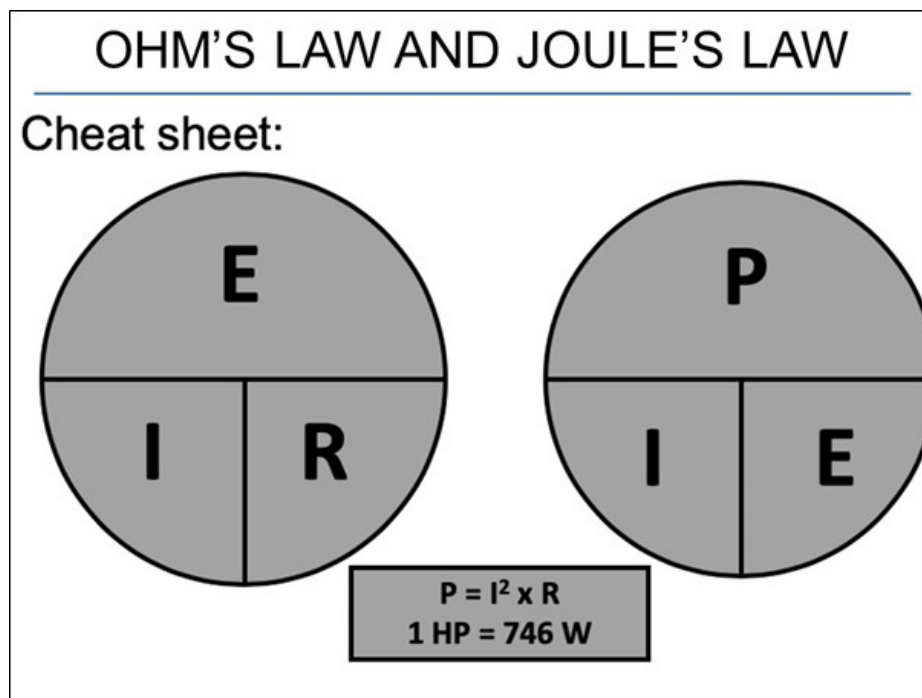
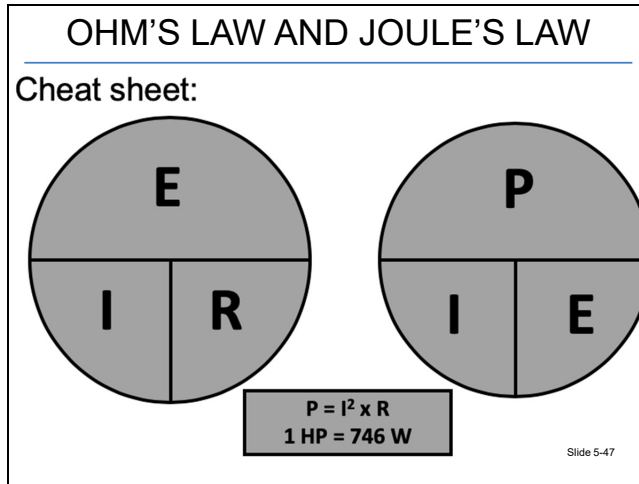
- Used to determine load on the circuit.
- Can prove if overload condition existed on circuit or circuit components.
- "Model" what was occurring in the circuit provided you have proper input data (e.g., resistance, voltage, wattage).

Slide 5-46

E. Practical demonstration of Ohm's and Joule's law.

1. Used to determine load on the circuit.

2. Can prove if overload condition existed on circuit or circuit components.
3. “Model” what was occurring in the circuit provided you have proper input data (e.g., resistance, voltage, wattage).



VI. AC/DC AND BASIC CIRCUITS**DIRECT CURRENT THEORY**

Types of electrical currents are AC/DC:

- DC
 - Mechanically or chemically generated.
 - Chemical = batteries or photovoltaic.
 - Mechanical = generator.
 - Electrons flow in one direction only.
 - Positive and negative terminals on equipment.

Slide 5-48

A. DC theory.

1. Types of electrical currents:
 - a. DC.
 - b. AC.
2. DC:
 - a. Mechanically or chemically generated.
 - b. Chemical = batteries, solar, or photovoltaic.
 - c. Mechanical = generator.
 - d. Electrons flow in one direction only.
 - e. Positive and negative terminals on equipment.

ALTERNATING CURRENT

AC

- Mechanically generated.
- Electrons reverse flow many times per second (frequency).
- Ungrounded (hot) and grounded (neutral) terminals on equipment.
- Voltages can be changed with transformers.

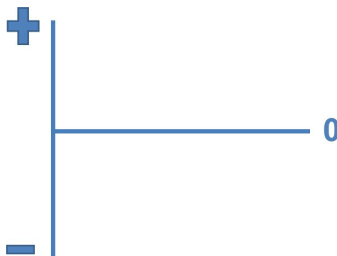
Slide 5-49

B. AC.

1. Refer to example of copper conductor moving through magnetic field.
2. Electrons will reverse flow 60 times per second.
3. With AC circuits, we have two key components; we have either ungrounded (hot) or grounded (neutral) – not positive or negative.
4. Advantage of AC is that you can change voltages through transformers – you can't do that with DC.

ALTERNATING CURRENT SINE WAVE

- Found predominantly in structures.
- 120, 240, 208, 277, 480 volts.
- Vehicle inverter.



Slide 5-50

5. Found predominantly in structures.
6. 120, 240, 208, 277, 480 volts.
7. Vehicle inverter.

ALTERNATING CURRENT – FREQUENCY

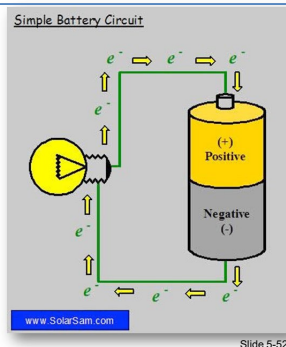
- Frequency is the number of times the flow of electricity reverses itself in the span of one second and is measured in Hz.
- United States frequency most often used is 60 Hz. Foreign countries typically use 50 Hz systems.

Slide 5-51

8. Frequency is the number of times the flow of electricity reverses itself in the span of one second and is measured in Hz.
9. U.S. frequency most often used is 60 Hz. Foreign countries typically use 50 Hz systems.

DIRECT CURRENT

- Most recognized as a battery; found in power supplies and DC generators; has some industrial applications.
- DC is used for numerous operations.

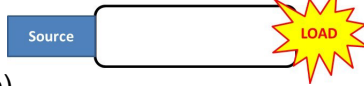


C. DC.

1. Most recognized as a battery; found in power supplies, DC generators; has some industrial applications.
2. DC is used for numerous operations.

ELECTRICAL CIRCUITS

- A source (power supply),
 - A path (conductors),
 - and
 - A load (lightbulb).
- Without a source, path, and load, there is no electrical circuit.

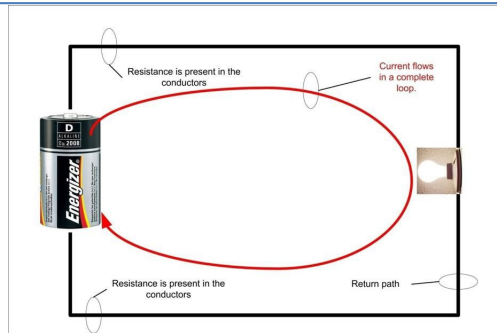


Slide 5-53

D. Electrical circuits.

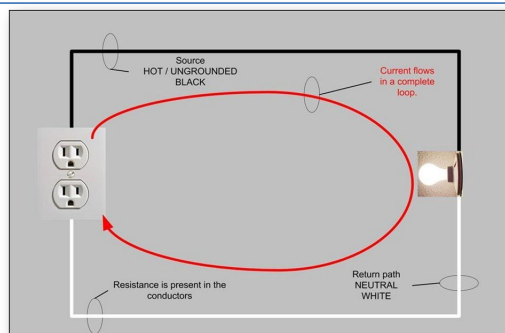
1. There must be a complete path from the power source through the load and back to the power source in order for electrons to flow.

ELECTRICAL CIRCUITS – DC



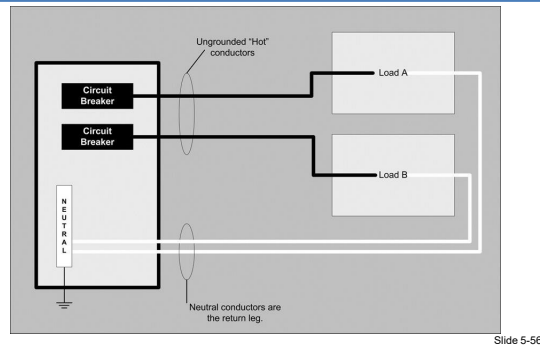
Slide 5-54

ELECTRICAL CIRCUITS – AC



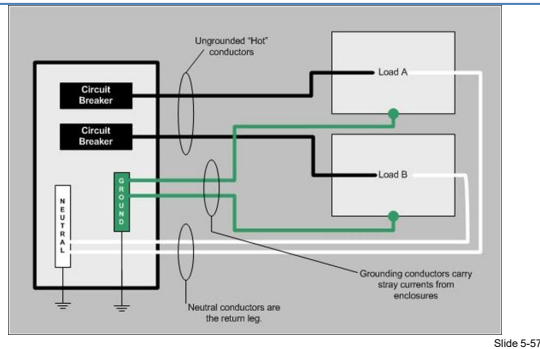
Slide 5-55

ELECTRICAL CIRCUITS



2. This shows circuit breaker, load, and return pathway.

ELECTRICAL CIRCUITS – WITH GROUND



3. Grounding conductor.
4. The green or bare wire is not needed for operation; it is utilized as a life safety line to take lightning and fault currents to earth ground.

ELECTRICAL CIRCUITS – NOMENCLATURE

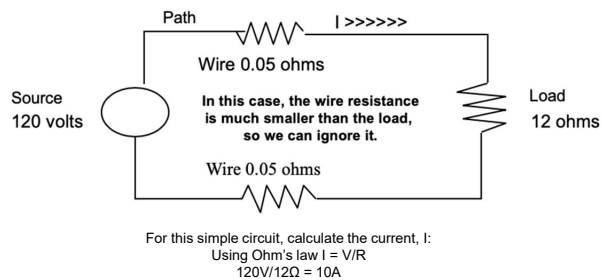
All circuits have:

- (E) Voltage, Electromotive Force (EF), (V).
- (R) Resistance (ohms), (Ω).
- (I) Current, Intensity, Amperes (amps), (A).
- (P) Power, Work, (watts), (W).



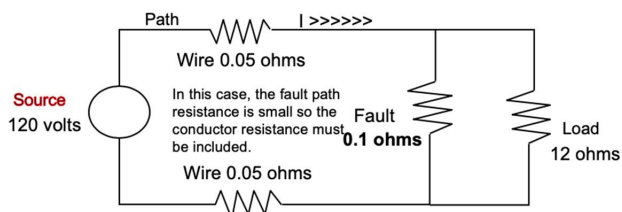
Slide 5-58

ELECTRICAL CIRCUITS – OHM'S LAW



Slide 5-59

ELECTRICAL CIRCUITS – FAULTS

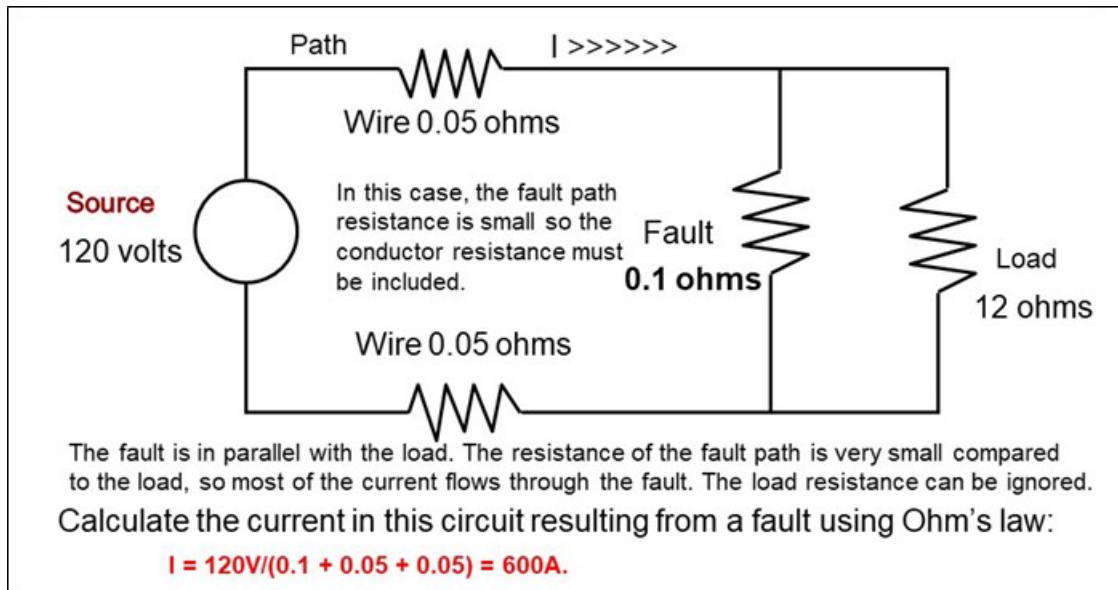


The fault is in parallel with the load. The resistance of the fault path is very small compared to the load, so most of the current flows through the fault. The load resistance can be ignored.

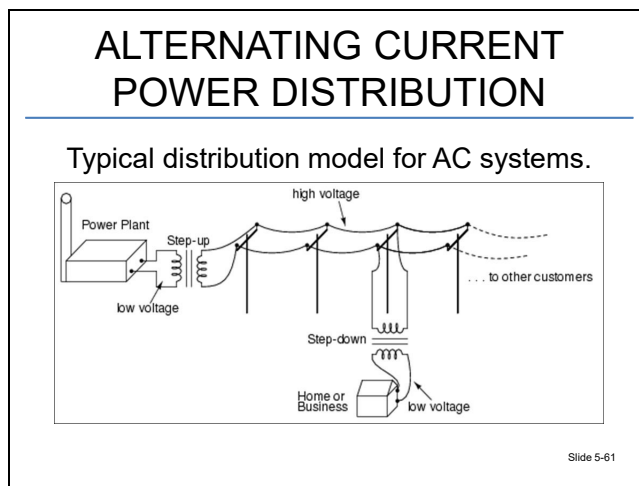
Calculate the current in this circuit resulting from a fault using Ohm's law:

$$I = 120V / (0.1 + 0.05 + 0.05) = 600A.$$

Slide 5-60



VII. DISTRIBUTION AND SERVICE EQUIPMENT



A. AC power distribution.

1. Typical distribution model for AC systems.

ALTERNATING CURRENT POWER DISTRIBUTION

- Typically, transmission voltages between power generators and substations are 69,000; 138,000; 345,000; 500,000; and 1,100,000.
- Transmission wires are not insulated.



Slide 5-62

2. **Danger:** The wires are not insulated.

SUBSTATION



Slide 5-63

- B. Substation.

TRANSFORMER EXPLAINED

- A transformer is used to increase or decrease voltage.
- Consists of two isolated coils of wire around an iron core.
- Primary coil is the input voltage coil.
- Secondary coil is the output voltage coil.

Slide 5-64

C. Transformer explained.

1. A transformer is used to increase or decrease voltage.
2. Consists of two isolated coils of wire around an iron core.
3. Primary coil is the input voltage coil.
4. Secondary coil is the output voltage coil.

AC TRANSMISSION

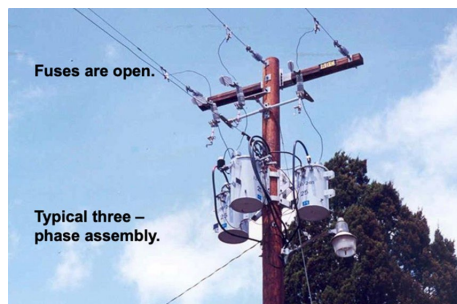
- In the United States, three-phase power is typically generated.
- Used in larger occupancies where lighting and motor loads are greater than a residential occupancy.
- Motors are less costly and run more efficiently.

Slide 5-65

D. AC transmission.

1. In the U.S., three-phase power is typically generated.
2. Used in larger occupancies where lighting and motor loads are greater than a residential occupancy.
3. Motors are less costly and run more efficiently.

AC TRANSMISSION OVERHEAD



Fuses are open.

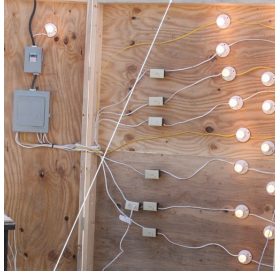
Typical three –
phase assembly.

Slide 5-66

AC TRANSMISSION VOLTAGE

Common voltages are:

- 120/240 with a 208 “high leg.”
- **Orange in color - Phase B.**
- 120/208.
- 277/480.

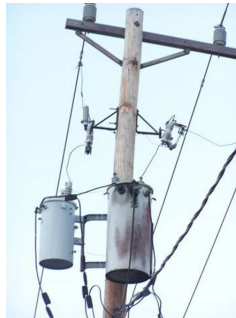


Slide 5-67

4. Common voltages are:
 - a. 120/240 with a 208 “high leg.”
 - b. Orange in color – Phase B.
 - c. 120/208.
 - d. 277/480.

AC TRANSMISSION 3 PHASE

- Three-phase 120/240-volt system with 208 volts to ground “high leg.”
- Two transformers are indicative of this “open delta” transformer configuration.



Slide 5-68

5. Three-phase 120/240-volt system with 208 volts to ground “high leg.”
6. Two transformers are indicative of this “open delta” transformer configuration.

PAD MOUNTED TRANSFORMER

Pad-mounted transformer:

- Can be single or three-phase.
- Accompanied by underground lateral.



Slide 5-69

E. Pad-mounted transformer:

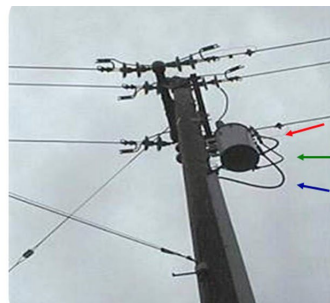
1. Can be single or three-phase.
2. Accompanied by underground lateral.

DISTRIBUTION EQUIPMENT



Slide 5-70

OVERHEAD DISTRIBUTION

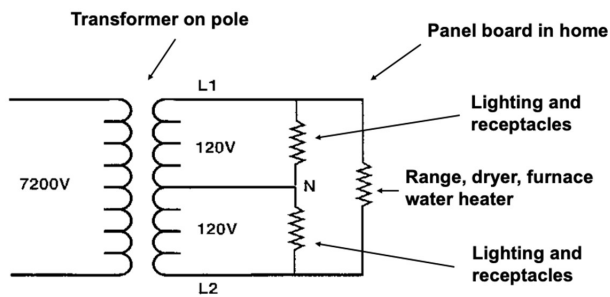


Line 1
Neutral
Line 2

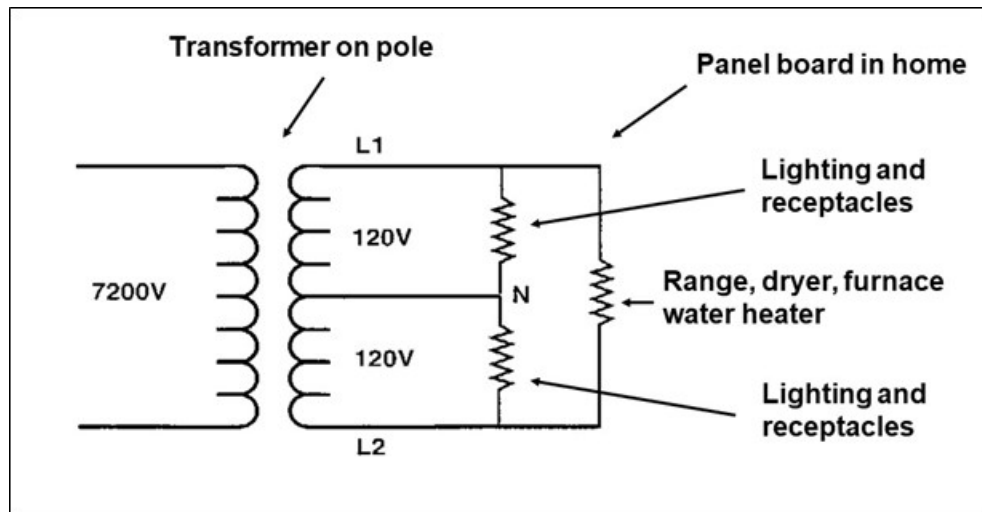
120 volts
240 volts
120 volts

Slide 5-71

DISTRIBUTION LOADS



Slide 5-72



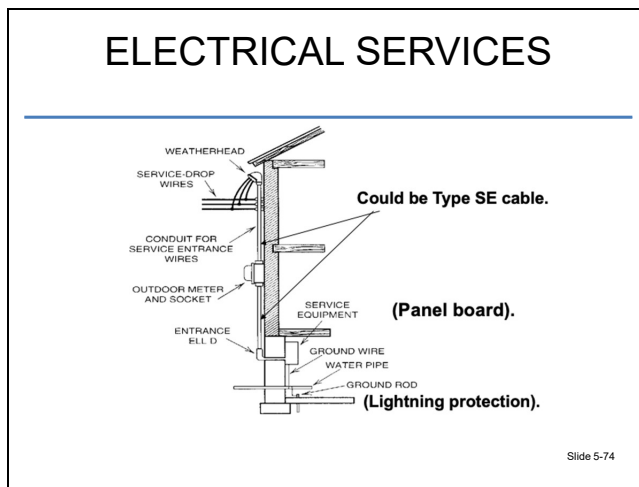
ELECTRICAL SERVICES

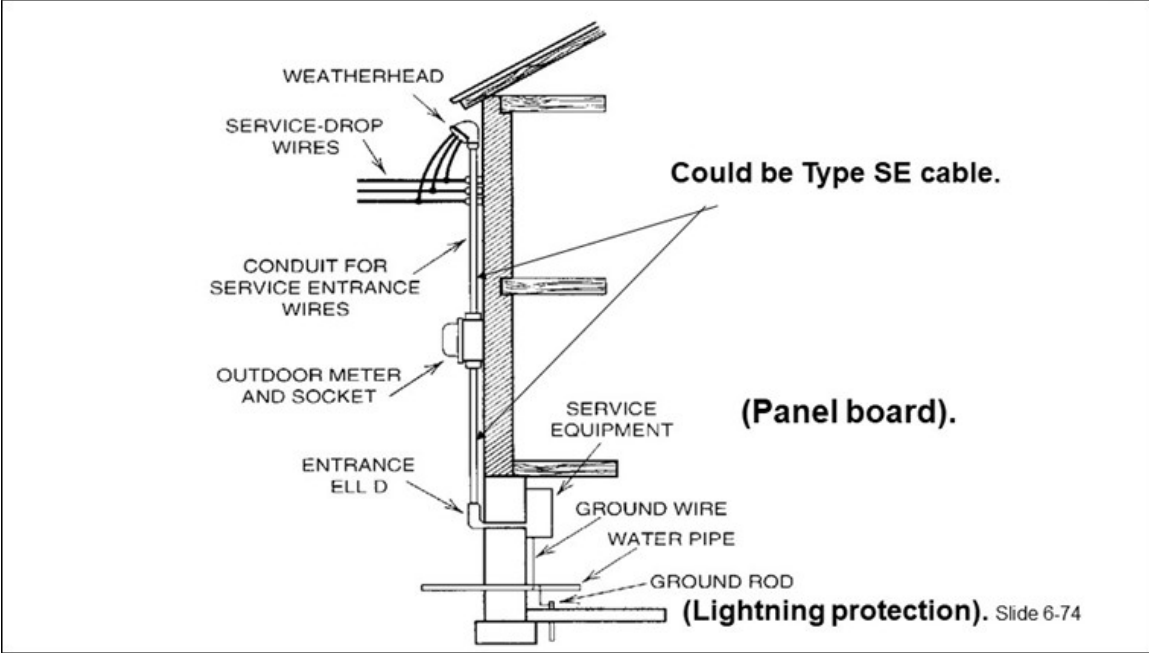
- Starts at utilities demarcation point.
- Includes metering equipment.
- Includes a main disconnect and overcurrent protection for the premises.
- May include a load center with individual branch circuit protection.
- Includes premises grounding systems.
- Two classifications or types:
 - Overhead.
 - Underground.

Slide 5-73

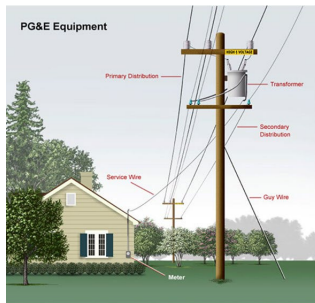
F. Electrical services.

1. Starts at utilities demarcation point.
2. Includes metering equipment.
3. Includes a main disconnect and overcurrent protection for the premises.
4. May include a load center with individual branch circuit protection.
5. Includes premises grounding systems.
6. Two classifications or types:
 - a. Overhead.
 - b. Underground.



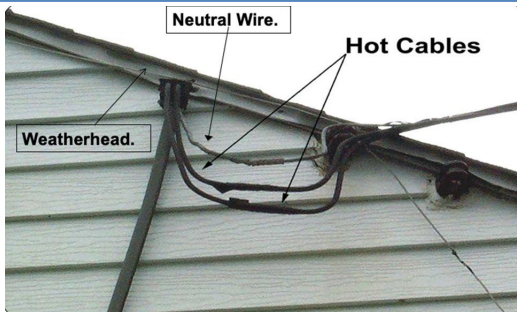


ELECTRICAL SERVICES – UTILITY



Slide 5-75

ELECTRICAL SERVICES – OVERHEAD



Slide 5-76

ELECTRICAL SERVICES – PAD MOUNTED



Slide 5-77

ELECTRICAL SERVICES – LOAD CENTER



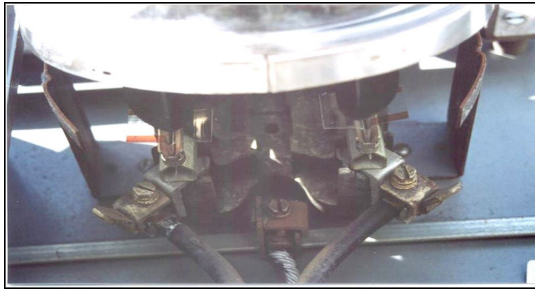
Slide 5-78

ELECTRICAL SERVICES – METER



Slide 5-79

ELECTRICAL SERVICES – BOOT

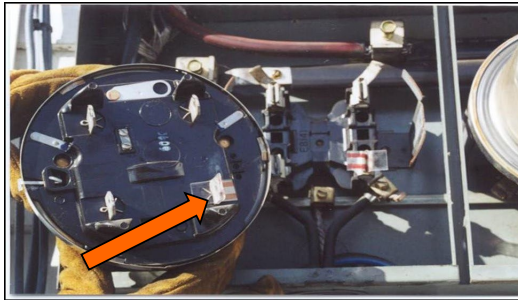


"Booted" meters.

Slide 5-80

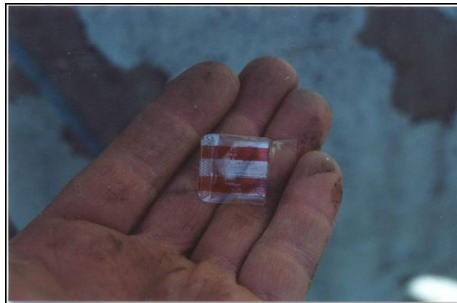
7. "Booted" meters.

ELECTRICAL SERVICES



Slide 5-81

ELECTRICAL SERVICES – CLOSE-UP BOOT



Slide 5-82

CURRENT TRANSFORMER (CT) METERING

Exposed current transformer (CT) metering.
Can also be found in an enclosure.
Used when service is greater than 400 amps.

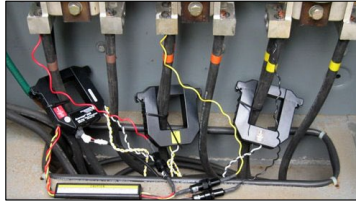


Photo by United States Coast Guard (USCG).

Slide 5-83

8. Exposed current transformer (CT) metering.
9. Can also be found in an enclosure.
10. Used when service is greater than 400 amps.

CT METERING

CT meter – no disconnect.

Two functional types:

- CT.
- Socket mount watt-hour transformer.



Slide 5-84

- G. CT metering.
1. CT meter – no disconnect.
 2. Two functional types:
 - a. CT.
 - b. Socket mount watt-hour transformer.

CT METERING

- Meter is found in this style of enclosure.
- Removing meter **does not** disconnect power.
- CT can also be in an enclosure, which can be found indoors or out.

Slide 5-85

3. Meter is found in this style of enclosure.
4. Removing meter **does not** disconnect power.
5. CT can also be in an enclosure, which can be found indoors or out.

DISCONNECTS

Main disconnects:

- Used when service panel is distant from location where service conductors enter the building.
- Used to supply multiple panels.



Slide 5-86

H. Disconnects.

1. Main disconnects:
 - a. Used when service panel is distant from location where service conductors enter the building.
 - b. Used to supply multiple panels.

ELECTRICAL SYSTEMS – BREAKERS

- Fuses, circuit breakers, or a combination of both.
- Provide overcurrent protection for building and branch circuits.



2. Fuses, circuit breakers, or a combination of both.
3. Provide overcurrent protection for building and branch circuits.

VIII. OVERCURRENT PROTECTION

OVERCURRENT PROTECTION DEVICES

Edison fuses and pull out cartridge fuses.



- A. Overcurrent protection devices.

OVERCURRENT PROTECTION DEVICES



Slide 5-89

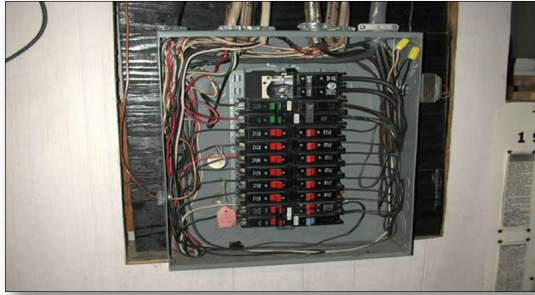
OVERCURRENT PROTECTION DEVICES



Slide 5-90

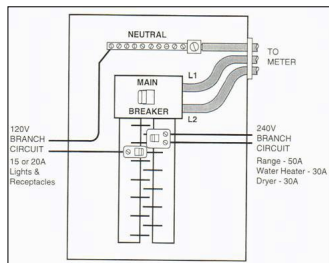
1. Contains a fusible link that opens when an electrical fault occurs.
 - a. Size and rating is marked on the fuse itself.
 - b. Usually over 30 amps.
2. Inside the cartridge fuse is an arc-suppressing compound.
 - a. It mechanically creates a barrier between the fusible link as it is separating under fault.
 - b. It takes a minimum of 350 volts to cross an air gap to create an arc.
 - c. Often times, cartridge fuses are found in applications greater than 350 volts.

OVERCURRENT PROTECTION DEVICES

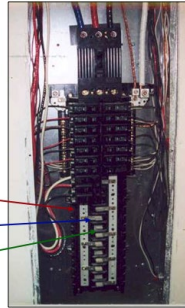


Slide 5-91

OVERCURRENT PROTECTION DEVICES

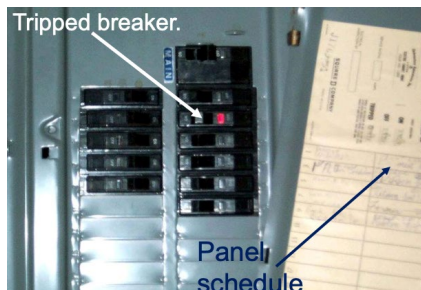


Identified as: L1, L2, Neutral, Ground.



Slide 5-92

OVERCURRENT PROTECTION DEVICES



Slide 5-93

3. The breaker shown in this photo is a Square D QO-style breaker.
4. This is the only breaker in the industry that has a trip indicator window.

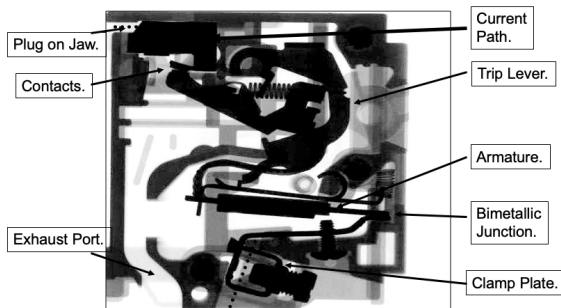
OVERCURRENT PROTECTION DEVICES



Slide 5-94

5. Breakers should have their ampacity identified on the handle.
6. Breakers that are designed to be used as switches need to be rated as SWD.
7. Breakers are rated also to operate in a thermal environment and need to be rated as such.
8. Breakers with black handles without trip indicator will trip to a midline position.
9. Tan-colored breaker handle “cutler-hammer, Crouse-Hines” will trip to an “off” position.
10. Breakers operate on both a thermal and magnetic concept.

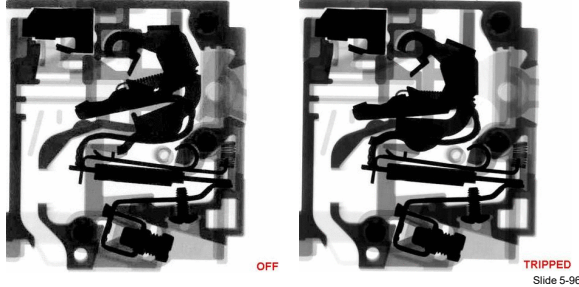
OVERCURRENT PROTECTION DEVICES



Slide 5-95

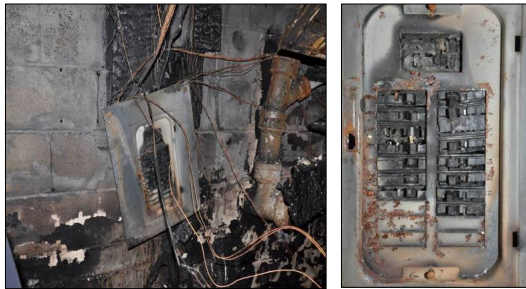
OVERCURRENT PROTECTION DEVICES

Observe the contacts and the trip lever.



11. Observe the contacts and the trip lever.
 - a. Breakers will trip from an on position.
 - b. Breakers can also trip from an off position.
 - c. A breaker will trip thermally in an environment.

OVERCURRENT PROTECTION DEVICES



B. Effects of fire:

1. The panel on the right – all of the breakers are in the tripped position.
2. The investigator must still arc map those conductors; however, the trips identified in the panel may be associated to the thermal environment that the panel box was in.
3. In other words, many of those breakers may have tripped due to the temperature of the compartment in which the panel box was located.

OVERCURRENT PROTECTION DEVICES

A panel board that has been impinged by flames will generally have all of the circuit breakers tripped.



Slide 5-98

4. A panel board that has been impinged by flames will generally have all of the circuit breakers tripped.

OVERCURRENT PROTECTION DEVICES

A small coil observes the difference between currents in the neutral and ungrounded legs.

If more than 5 milliamps are observed, the outlet or circuit breaker is tripped.



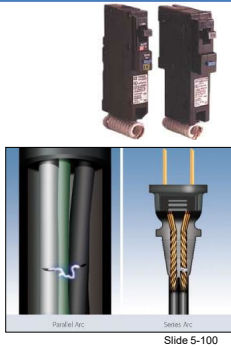
Slide 5-99

5. A small coil observes the difference between currents in the neutral and ungrounded legs.
6. If more than 5 milliamps are observed, the outlet or circuit breaker is tripped.
7. Note: The pigtail attached to the breaker needs to be connected to the neutral busbar in order for circuit breaker to function.

OVERCURRENT PROTECTION DEVICES

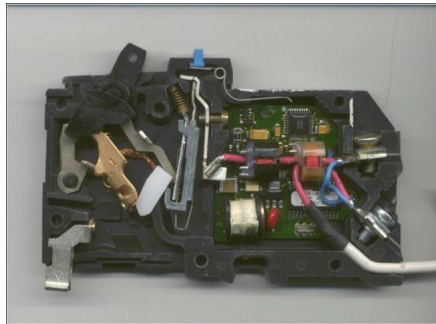
Combination Arc Fault Circuit Interrupter (AFCI) circuit breakers sense and respond to both parallel and series arcing incidents.

It is a thermal magnetic circuit breaker with a computer to sense arc activity.



8. Combination Arc Fault Circuit Interrupter (AFCI) circuit breakers sense and respond to both parallel and series arcing incidents.
9. It is a thermal magnetic circuit breaker with a computer to sense arc activity.

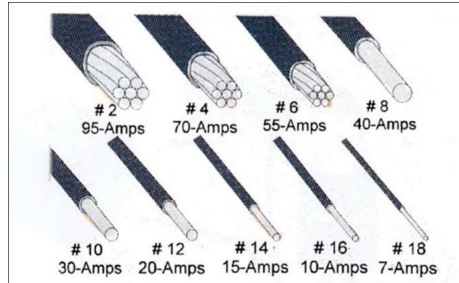
OVERCURRENT PROTECTION DEVICES



10. An AFCI has a micro-processor inside of it.
 - a. The micro-processor monitors the AC current sine wave.
 - b. Once it sees an erratic sine wave caused by arcing, the circuit breaker opens.
11. Additionally, the arc fault circuit breaker gives you additional breaker protection as well – thermal and magnetic.

IX. WIRE

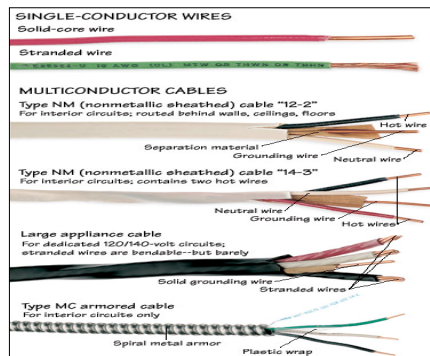
WIRING METHODS AND MATERIALS



Slide 5-102

Wiring methods and materials.

WIRING METHODS AND MATERIALS (NONMETALLIC)



Slide 5-103

A. Nonmetallic.

1. Even though many of the conductors show three and four wires in them, the actual cable count is only associated to the wires that would be insulated.
2. 12-2 actually shows three conductors; however, the two insulated conductors are the ones that count. "12-2 W G."
3. The bottom conductor with the metal jacket is called "metal-clad armored cable." This is not BX brand cable.
4. BX brand cable had a steel metal jacket and did not have a separate insulated, isolated grounding conductor.

WIRING METHODS AND MATERIALS (CONDUIT)



Slide 5-104

B. Conduit.

1. Comes in various sizes and materials.
2. Used to serve as protection and as a raceway for the conductors.
3. National Electric Code® (NEC) dictates what type of conduit can be installed in various environments.
4. Additionally, there are maximum calculations fill associated to conduit.

WIRING METHODS AND MATERIALS (KNOB & TUBE)

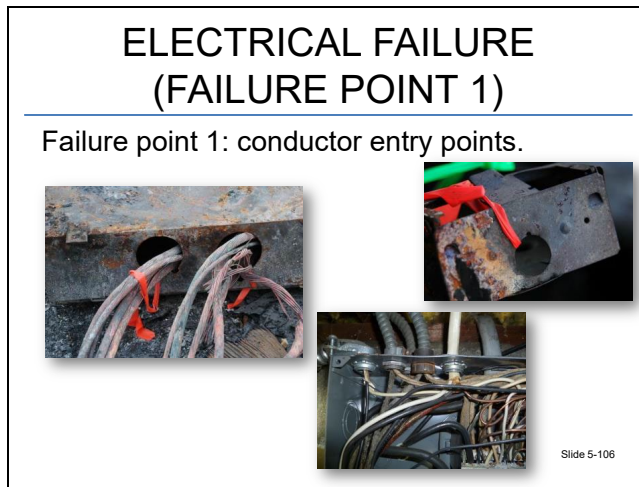


Slide 5-105

- C. Knob and tube wiring consisted of single-strand conductors run throughout the home.
- D. Porcelain knobs and tubes were used where conductors either went through a combustible framing member or were attached to the combustible framing member.
- E. The biggest problem with knob and tube wiring systems is the splices.

1. There was no requirement to have these splices within an enclosure; often times they were made interstitial spaces.
2. The splice was simply a matter of wrapping a wire around another, applying solder, and covering with tape.

X. ELECTRICAL FAILURES, ARCS AND SPARKS



- A. Electrical failure.
 1. Failure point 1: conductor entry points.
 2. Investigators should examine the conductors and the enclosure where they enter.
 - a. Over-tightening of clamps, or not using the appropriate connector, can cause failure at these points.
 - b. Many of these connectors have melting temps less than copper, and have a tendency to melt out, exposing the energized conductors.
 - c. Arc damage is often found at this location.

ELECTRICAL FAILURE (FAILURE POINT 2)

Failure point 2: connection points.



3. Failure point 2: connection points.
 - a. This failure is typically known as a high-resistive connection (HRC).
 - b. The cause is associated to a loose or improperly made connection at a point of termination.

ELECTRICAL FAILURE (FAILURE POINT 3)

Failure point 3: transition points.



4. Failure point 3: transition points.
 - a. Failures in a straight run of conductor are **extremely** rare.
 - However, at times, larger conductors, such as service entrance cables, can become damaged at points of transition.
 - b. Branch circuits may also become damaged at points of transition.

- c. The investigator needs to show that the conductor was grossly bent or we have an area where there was physical impact; you may have a failure at that point.

TRANSITION POINT – SERVICE ENTRANCE AREA

Transition point: service entrance area.



Slide 5-109

- B. Electrical failure (service entrance area).

1. Transition point: service entrance area.

TRANSITION POINT – BRANCH CIRCUIT

Transition point: branch circuit.



Slide 5-110

2. Transition point: branch circuit.

ELECTRICAL FAILURE

Wiring in conduit or behind walls normally will not fail in the middle of a run without some sort of mechanical event.



Focus on points of entry, connection and transition.



Slide 5-111

3. Wiring in conduit or behind walls normally will not fail in the middle of a run without some sort of physical impact event.
4. Focus on points of entry, connection and transition.

COMMON FORMS OF ELECTRICAL HEATING

Electricity is one of four sources of heat energy.

Five forms of electrical heating:

- Resistance.
- Arcing.
- Sparking.
- Static electric charge.
- Lightning.

Slide 5-112

- C. Common forms of electrical heating.
1. Electricity is one of four sources of heat energy.
 2. Five forms of electrical heating:
 - a. Resistance.
 - b. Arcing.
 - c. Sparking.
 - d. Static electric charge.
 - e. Lightning.

ARCING

Caused by:

- Electricity traveling through an air space from one conducting point to another.
- Temperatures are between 5,000 and 15,000 °F, expel small particles.
- Often of short duration.
- Can be continual or intermittent.



Slide 5-113

D. Arcing.

Caused by:

1. Electricity traveling through an air space from one conducting point to another.
2. Temperatures are between 5,000 and 15,000 °F, expel small particles.
3. Often of short duration.
4. Can be continual or intermittent.

SPARKING

- Produced by conversion of metals to vapors and liquids from exposure to intense heat.
- Metal is displaced from origin.
- Substantial heating effect.
- Extremely dangerous in flammable atmospheres.

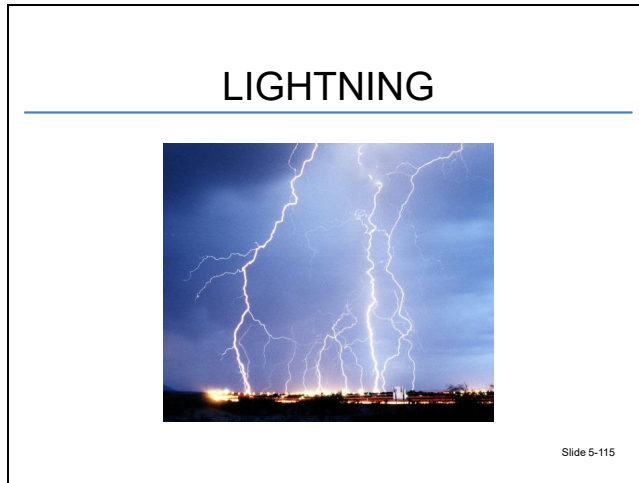


Slide 5-114

E. Sparking.

1. Produced by conversion of metals to vapors and liquids from exposure to intense heat.

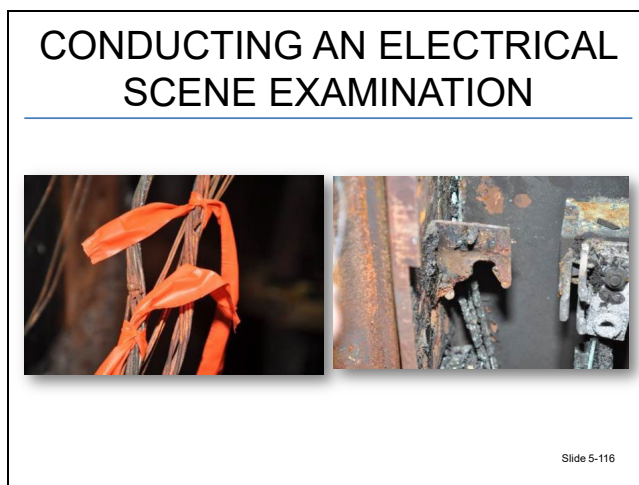
2. Can occur only once.
3. Metal is displaced from origin.
4. Substantial heating effect.
5. Extremely dangerous in flammable atmospheres.



F. Lightning.

1. Lightning is an “arc” (electrical discharge) that temporarily neutralizes the positive and negative charges between objects.
2. The lightning strike should be verified through some meteorological source or service, such as National Oceanic and Atmospheric Administration (NOAA), Visalia, or STRIKENet.

XI. ELECTRICAL SCENE EXAMINATION



- A. Conducting an electrical scene examination.

**CONDUCTING AN ELECTRICAL SCENE
DATA COLLECTION**

- Forensic examination alone will not indicate if the thermal damage is a cause or result of the fire.
- Practice identifying thermal damage to be able to identify thermal damage.

Slide 5-117

- B. Conducting an electrical scene data collection.

1. Forensic examination alone will not tell you if the thermal damage is a cause or result of the fire.
2. Practice identifying thermal damage to be able to identify thermal damage.

**METHODOLOGY
(CONDUCT INTERVIEWS)**

Conduct interviews:

- Obtain information about:
 - Facility status.
 - Wiring.
 - Maintenance.
- Obtain information about what was/should have been energized.

Slide 5-118

- C. Methodology.

1. Conduct interviews:
 - a. Obtain information about:
 - Facility status.
 - Wiring.
 - Maintenance.

- b. Obtain information about what was/should have been energized.

METHODOLOGY (START OUTSIDE)

Start outside:

- Document the primary distribution transformer.
- Get information about the service from the utility provider.
- Determine when the scene was de-energized.
- Examine and document the service entrance.

Slide 5-119

2. Start outside:
- a. Document the primary distribution transformer.
- b. Get information about the service from the utility provider.
- c. Determine when the scene was de-energized.
- d. Examine and document the service entrance.

METHODOLOGY (MOVE INSIDE)

Move inside:

- Trace the system throughout the facility, starting at the service entrance.
- Emphasis is placed on feeders and branch circuits that are tripped or open.
- Identify all instances of arc melting.
- Obtain information from the alarm system.

Slide 5-120

3. Move inside:
- a. Trace the system throughout the facility, starting at the service entrance.
- b. Emphasis is placed on feeders and branch circuits that are tripped or open.

- c. Identify all instances of arc melting.
- d. Obtain information from the alarm system.

PANEL BOARD DOCUMENTATION

- Tripped circuit breakers in a panel board that has not been impinged may provide a basis for tracing circuits.
- Watch for potential thermal trip patterns that may be misleading.
- Use the interview process to determine what should have been on/what was observed to be on.

Slide 5-121

D. Panel board documentation.

1. Tripped circuit breakers in a panel board that has not been impinged may provide a basis for tracing circuits.
2. Watch for potential thermal trip patterns that may be misleading.
3. Use the interview process to determine what should have been on/what was observed to be on.

PANEL BOARD DOCUMENTATION

Identify fuses or breakers:

- Note any blown fuses or “tripped breakers.”
- Breakers can be removed to check bus bars for evidence of pitting or signs of arcing.

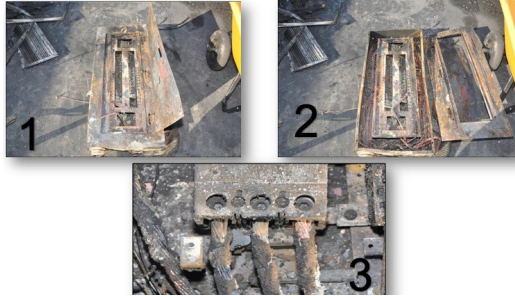
Warning: This may damage or destroy breaker.

Slide 5-122

4. Identify fuses or breakers:
 - a. Note any blown fuses or “tripped breakers.”
 - b. Breakers can be removed to check bus bars for evidence of pitting or signs of arcing.

Warning: This may damage or destroy breaker.

PANEL BOARD DOCUMENTATION



Slide 5-123

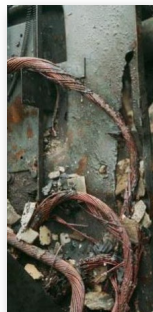
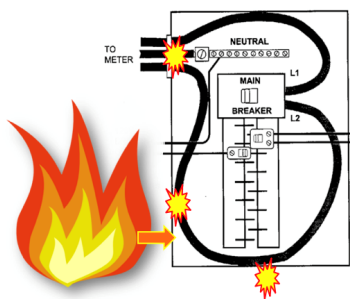
PANEL BOARD DOCUMENTATION



Slide 5-124

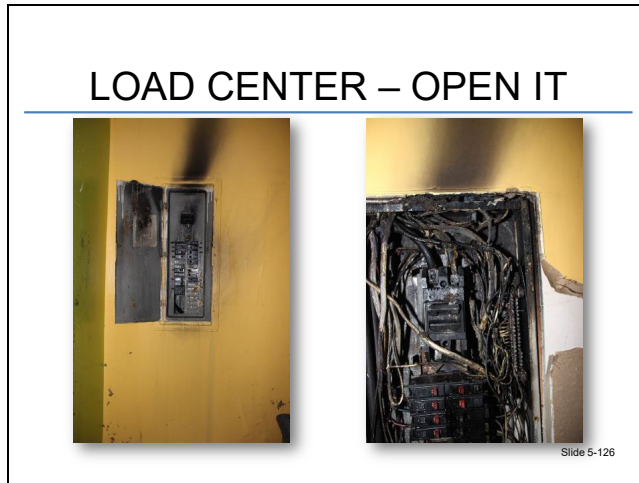
5. Points of entry – look for any evidence of arcing or failure at the points where conductors enter the enclosure.

ENERGIZED FLAME IMPINGEMENT

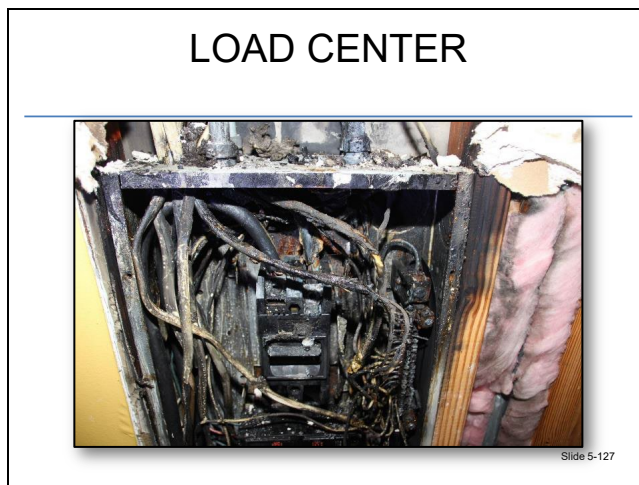


Slide 5-125

- E. Energized flame impingement.



- F. Load center – open it.



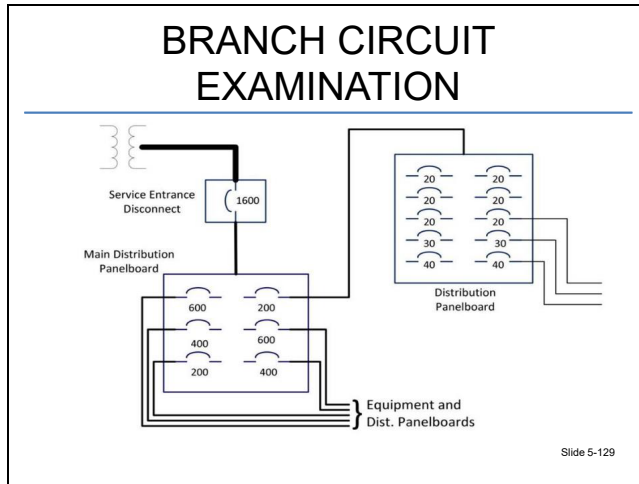
LOAD CENTER

- Pre-existing loose connection overheated and ignited due to current flow of arcing activity downstream during fire.
- This ignition was contained within the metal enclosure, as designed.

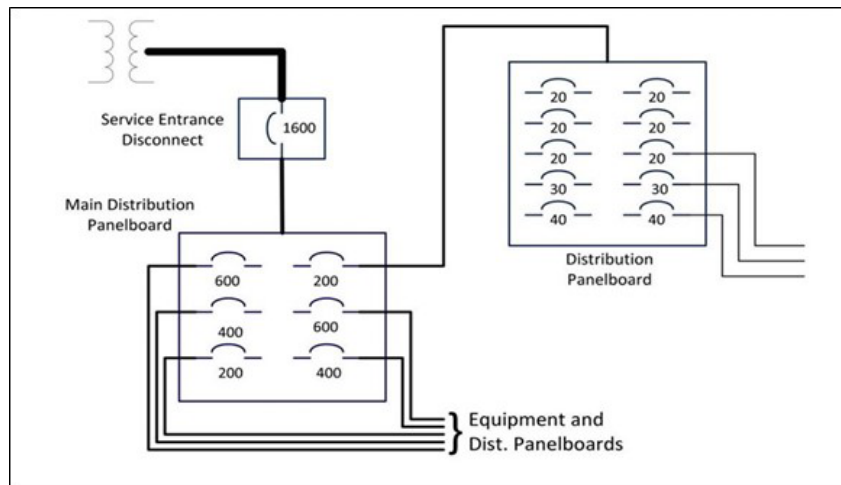


Slide 5-128

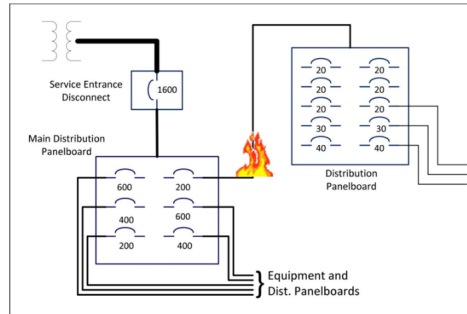
1. Pre-existing loose connection overheated and ignited due to current flow of arcing activity downstream during fire.
2. This ignition was contained within the metal enclosure, as designed.



G. Branch circuit examination.

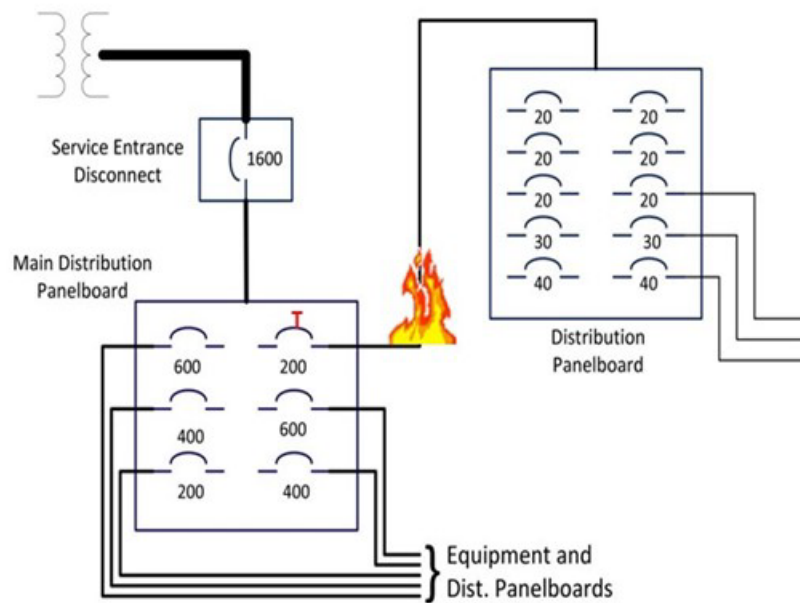


BRANCH CIRCUIT EXAMINATION (EFFECT 1)

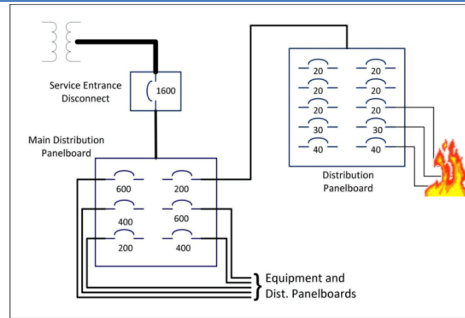


Slide 5-130

1. Effect 1.



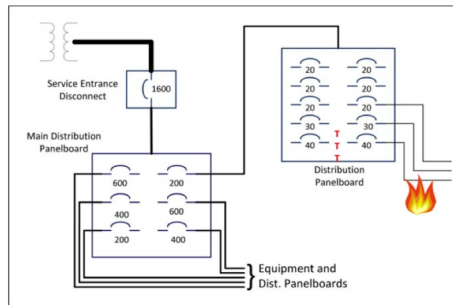
BRANCH CIRCUIT EXAMINATION (EFFECT 2)



Slide 5-131

2. Effect 2.

BRANCH CIRCUIT EXAMINATION (SCENARIO 1)

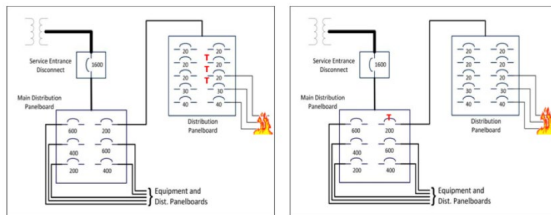


Cascading Breakers

Slide 5-132

3. Scenario 1.

BRANCH CIRCUIT EXAMINATION (SCENARIO 1A)



Cascading Breakers Scenario

Slide 5-133

BRANCH CIRCUIT EXAMINATION (CONDUCTORS)

- When conductors are removed from conduit, they need to be visually examined for arc damage.



Slide 5-134

- Smaller conductors should be felt and visually examined.

4. Conductors.

- a. When conductors are removed from conduit, they need to be visually examined for arc damage.
- b. Smaller conductors should be felt and visually examined.

SYSTEM DOCUMENTATION

Using the same methodology, follow the distribution system from the Main Distribution Panel (MDP) to the individual distribution panel boards, and then decide what is important.



Slide 5-135

H. System documentation.

Using the same methodology, follow the distribution system from the Main Distribution Panel (MDP) to the individual distribution panel boards, and then decide what is important.

ORIGIN DETERMINATION (ARC SURVEY)

Arc fault mapping:

- Locating and mapping all faults that occurred in the electrical wiring.
- Using arc fault mapping techniques, the area of origin can sometimes be narrowed to a very specific area that may not have been possible using conventional means.

Slide 5-136

I. Origin determination (arc survey).

1. Arc fault mapping:

Locating and mapping all faults that occurred in the electrical wiring.

- #### 2. Using arc fault mapping techniques, the area of origin can sometimes be narrowed to a very specific area that may not have been possible using conventional means.

CIRCUIT EVALUATION

Branch circuit feeders are circuits that run the length of a building and may yield helpful results.



Slide 5-137

J. Circuit evaluation.

- #### 1. Branch circuit feeders are circuits that run the length of a building and may yield helpful results.

CIRCUIT EVALUATION (EMERGENCY EXIT)

Emergency exit lights will normally always be energized.



Slide 5-138

2. Emergency exit lights will normally always be energized.
3. Emergency lights exit signs once power is interrupted.
4. A good circuit to trace.
5. Works well if you have corresponding video.

CIRCUIT EVALUATION (CONDUCTORS)

- Conductors tend to be in contact with conduit at and near bends and near fittings.
- They can present easier access to the conduit and a good location for evidence of arc melting.

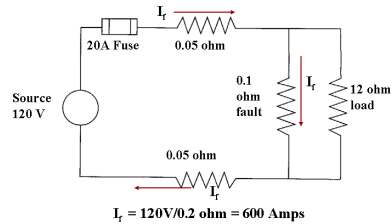


Slide 5-139

6. Conductors tend to be in contact with conduit at and near bends and near fittings.
7. They can present easier access to the conduit and a good location for evidence of arc melting.

CIRCUIT EVALUATION (ELECTRICAL SYSTEMS)

In a properly installed and operating electrical system, short circuits (faults) cause tripped breakers and blown fuses.



Slide 5-140

8. Electrical systems.

- a. In a properly installed and operating electrical system, short circuits (faults) cause tripped breakers and blown fuses.

CIRCUIT EVALUATION (ELECTRICAL SYSTEMS)

Cherry red conductors are more about oxidation and impurities than failure.



Slide 5-141

- b. Cherry red conductors are more about oxidation and impurities than failure.

XII. ARC FAULT SURVEYS AND ARC MAPPING

ARC MELTING



Slide 5-142

A. Arc melting.

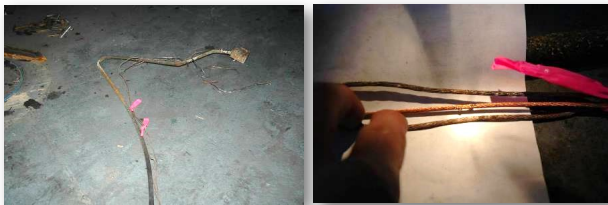
ARC MELTING



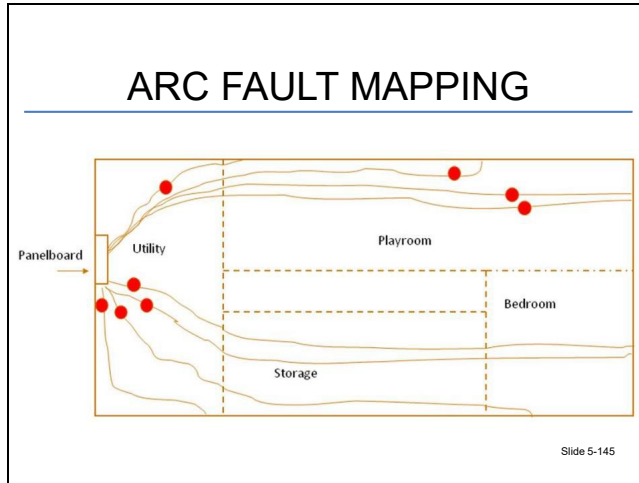
Note the bead on the end of the conductor

Slide 5-143

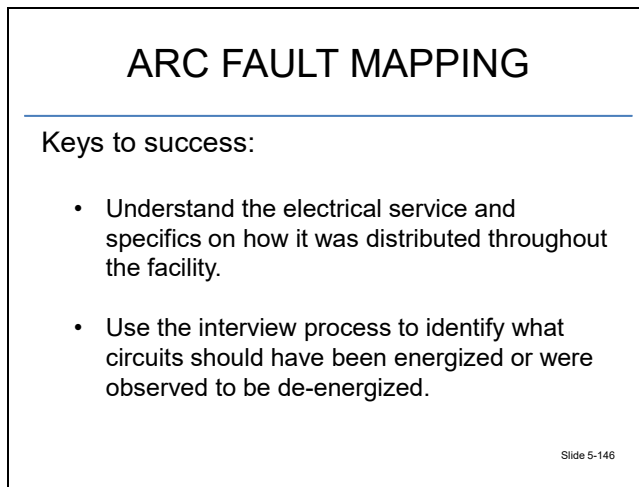
ARC MELTING



Slide 5-144



B. Arc fault mapping.



1. Keys to success:

Understand the electrical service and specifics on how it was distributed throughout the facility.

2. Use the interview process to identify what circuits should have been energized or were observed to be de-energized.

ARC FAULT MAPPING

- Start the evaluation at the primary distribution system and follow it to the end, regardless of the fire dynamics.
- Compare all observations with the remaining investigative tools before making a final conclusion.
- Arc mapping needs to support the entire investigation.

Slide 5-147

3. Start the evaluation at the primary distribution system and follow it to the end, regardless of the fire dynamics.
4. Compare all observations with the remaining investigative tools before making a final conclusion.
5. Arc mapping needs to support the entire investigation.

ARC FAULT MAPPING

Limitations:

- Failure to identify the key components of the distribution system.
- Failure to identify arc damage on conductors.
- Complete destruction of the branch circuits (can be impacted by collapse or extreme heat).

Slide 5-148

6. Limitations:
 - a. Failure to identify the key components of the distribution system.
 - b. Failure to identify arc damage on conductors.
 - c. Complete destruction of the branch circuits (can be impacted by collapse or extreme heat).

ARC FAULT MAPPING

- Inability to trace circuits back to the source (multistory building with collapse makes this very difficult).
- Melting of conductors from fire exposure.
- Post-fire re-energizing of the electrical system.

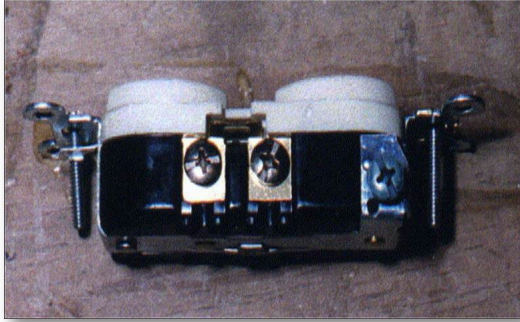
Slide 5-149

7. Inability to trace circuits back to the source (multistory building with collapse makes this very difficult).
8. Melting of conductors from fire exposure.
9. Post-fire re-energizing of the electrical system.

ARC FAULT MAPPING



Slide 5-150

XIII. ELECTRICAL FIRE CAUSES AND FAILURES**ELECTRICAL FAULTS AND FAILURES****A. Electrical faults and failures.**

Loose or failed connections:

1. A standard receptacle can be screw terminal or push terminal (back stabbed) connected. Back stabbing of connections caused fires in the past.
2. Not because this is a bad way to connect wires. Instead, the terminals allowed the use of 12 American Wire Gauge (AWG) wire.
3. When the receptacles were pushed back into the outlet box, the heavy gauge wire placed pressure on the plastic body.
4. Many bodies fractured, resulting in loose and failed connections.
5. These terminals will now only accept 14 AWG or smaller wire. In fact, more fires result from loose or improperly made screw terminal connections.

ELECTRICAL FAULTS AND FAILURES

A splice requires electrical continuity and mechanical security. (Requires the use of proper terminals or connectors.)



ELECTRICAL FAULTS AND FAILURES



Slide 5-153

6. Evidence of a loose and failed connection, a more common failure.

ELECTRICAL FIRE CAUSE



Evidence of loose and failed connection at a plug-in fusible disconnect.

Slide 5-154

- B. Electrical fire cause.

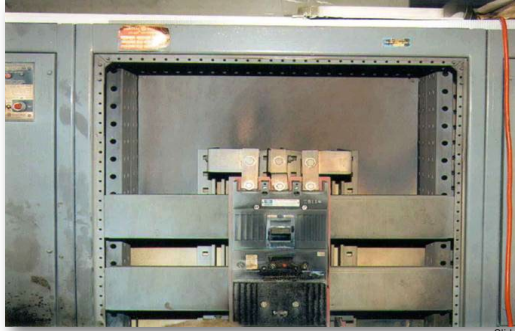
ELECTRICAL FIRE CAUSE (EXAMINATION)



Slide 5-155

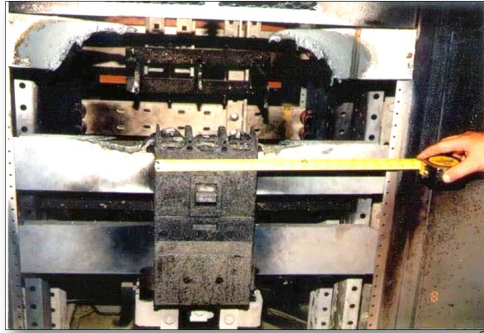
1. Examination: The slight to the right depicts the failure of federal pacific breaker that occurred at STAB-LOK, and the panel box on the right shows evidence of moisture intrusion.

ELECTRICAL FIRE CAUSE
(BEFORE)



2. Before: Many times you have to step back and look for an exemplar of what you're looking at or need to find.

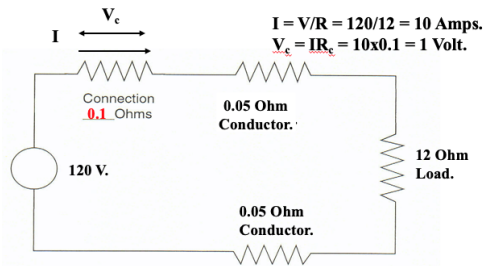
ELECTRICAL FIRE CAUSE
(AFTER)



3. After.

ELECTRICAL FIRE CAUSE (LOOSE CONNECTIONS)

Why loose connections cause fires:



Slide 5-158

4. Loose connections.

Why loose connections cause fires.

DYNAMICS OF A LOOSE CONNECTION

- The temperature at the screw is raised by 10 W of heat being dissipated at the screw head.
- As the temperature increases, the resistance increases.
- As the resistance increases, the power being lost at the screw head increases.

Slide 5-159

C. Dynamics of a loose connection.

1. The temperature at the screw is raised by 10 W of heat being dissipated at the screw head.
2. As the temperature increases, the resistance increases.
3. As the resistance increases, the power being lost at the screw head increases.

DYNAMICS OF A LOOSE CONNECTION CONT.

- The temperature increases until stabilization occurs (when all the heat generated on the screw can be radiated or conducted away).
- Studies have shown that the temperature can stabilize when the screw head is red hot.
- The screw head can reach temperatures over 1,000 °F.

Slide 5-160

4. The temperature increases until stabilization occurs (when all the heat generated on the screw can be radiated or conducted away).
5. Studies have shown that the temperature can stabilize when the screw head is red hot.
6. The screw head can reach temperatures over 1,000 °F.

DYNAMICS OF A LOOSE CONNECTION CONT.

- The result of long-term heating breaks down the plastic receptacle body. As the plastic breaks down into carbon, a current-limited fault path can occur.
- This results in excessive heating that can ignite nearby combustible materials.

Slide 5-161

7. The result of long-term heating breaks down the plastic receptacle body. As the plastic breaks down into carbon, a current limited fault path can occur.
8. This results in excessive heating that can ignite nearby combustible materials.

XIV. DEMONSTRATION

DEMONSTRATION

- Burn Lab Demonstration

Slide 5-162

XV. SUMMARY



SUMMARY

In this lesson students should be able to:

- Describe basic electrical theory.
- Recognize the components of a building's electrical system from generation to distribution.
- Model basic safety practices when evaluating an electrical system.
- Evaluate electrical circuits using Ohm's law and Joule's law.

Slide 5-163



SUMMARY

- Differentiate between electrical and thermal damage on energized and non-energized conductors.
- Evaluate common modes of electrical failure to systems, components and appliances.
- Collect data and create an arc map, illustrating the application of arc mapping to origin determination.

Slide 5-164

REFERENCES

National Fire Protection Association (NFPA) 921, Chapter 9, Section 9.9.1.1, 2024 ed.

NFPA 921, Chapter 9, Section 9.2.5, 2024 ed.

This page intentionally left blank.

UNIT 6: FAILURE ANALYSIS – SYSTEMS & SMALL APPLIANCES

TERMINAL OBJECTIVE

The students will be able to:

- 6.1 *Test hypotheses using knowledge of appliance controls and failure analysis.*

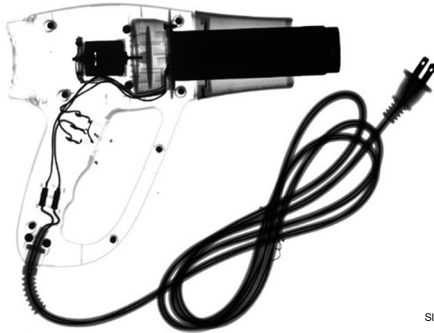
ENABLING OBJECTIVES

The students will be able to:

- 6.1 *Compare failure analysis methods.*
 - 6.2 *Demonstrate how failure analysis is applied to fire causation.*
 - 6.3 *Characterize and explain functions of small appliance controls.*
 - 6.4 *Evaluate a given appliance for competency as ignition source.*
 - 6.5 *Prepare a fault tree analysis or Failure Mode and Effects Analysis (FMEA) for a given appliance.*
-

This page intentionally left blank.

UNIT 6: FAILURE ANALYSIS – SYSTEMS & SMALL APPLIANCES



Slide 6-1

TERMINAL OBJECTIVE

Test hypotheses using knowledge of appliance controls and failure analysis.

Slide 6-2

ENABLING OBJECTIVES

- 6.1 Compare failure analysis methods.
- 6.2 Demonstrate how failure analysis is applied to fire causation.
- 6.3 Characterize and explain functions of small appliance controls.
- 6.4 Evaluate a given appliance for competency as ignition source.
- 6.5 Prepare a fault tree analysis or Failure Mode and Effects Analysis (FMEA) for a given appliance.

Slide 6-3

SYSTEMS ANALYSIS

Systems analysis tools are used to provide a systematic method for analyzing systems to determine hazards or faults. This process may also identify areas of deficiency within a data set.

Common system analysis tools include:

- Fault tree analysis
- Failure Mode and Effects Analysis (FMEA)

-NFPA 921, Section 21.3

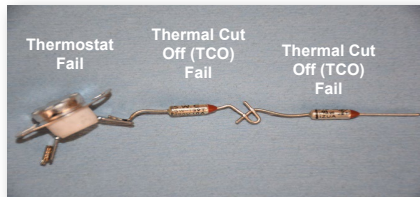
**Students are encouraged to follow lecture in NFPA 921, Chapter 21.3.
Timelines were covered in Essentials, Unit 12.*

Slide 6-4

I. FAULT TREE ANALYSIS

FAULT TREE ANALYSIS

- Logic diagram that can be used to analyze a fire or explosion.
- Diagram places, in logical sequence and position, the conditions and chains of events that are necessary for a given fire to occur.

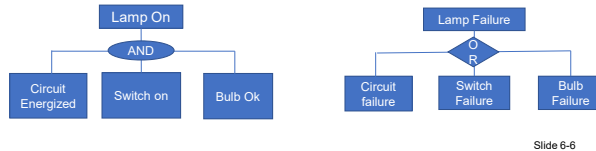


Slide 6-5

- A. Fault tree analysis uses a logic diagram to analyze, evaluate or explain a fire or explosion, by developing a diagram that places in logical sequence and position the conditions (events or actions) that are necessary for a fire to occur (NFPA 921, Section 21.3.1, 2024 ed.).

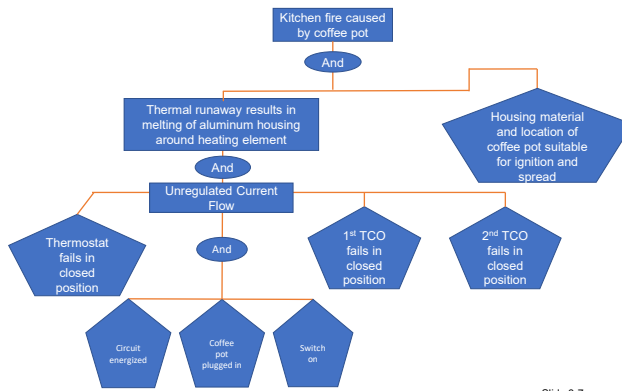
FAULT TREE ANALYSIS

- Fault tree analysis use “AND” and “OR” decisions referred to as gates.
- AND decisions are events that all conditions must be present for the subject event.
- OR decisions are events that one of several conditions may result in the subject event.



- B. Fault tree analysis uses “and” and “or” decisions referred to as gates. **And** decisions are events that **all conditions** must be present for the subject event. **Or** decisions are events **that one** of several conditions may result in the subject event.

FAULT TREE – COFFEE POT



FAILURE MODE AND EFFECTS ANALYSIS (FMEA)

- Identify basic sources of failure within a system, and follow the consequences of the failures in a systematic fashion.
- Column headings and format can vary.

Component	Failure Mode	Cause of Failure	Effects of Failure	Hazard Created	Necessary Conditions	Indication of Failure
Hair Dryer	Heating element current flows without shutoff	Switch on and controls fail	Thermal runaway of heating elements	Ignition of plastic housing	Power on, Switch on, thermostat fails in ON position, fuse (TCO) fails to open	Thermostat closed circuit, TCO closed circuit

-NFPA 921, Section 21.3.2

Slide 6-8

C. Failure Mode and Effects Analysis (FMEA).

1. Identify basic sources of failure within a system, and follow the consequences of the failures in a systematic fashion.
2. Column headings and format can vary.

II. SMALL APPLIANCE OPERATION AND ANALYSIS

ORIGIN ANALYSIS APPLIANCE

- Is the appliance located in the fire origin area or in close proximity?
- What fuels are in proximity to the appliance?
- Are fire patterns on appliance consistent with it being the point of origin?



Commercial fryer
exemplar and fire damaged unit

Slide 6-9

Consider the following:

- A. Is the appliance located in the fire origin area or in close proximity?
- B. What fuels are in proximity to the appliance?
- C. Are fire patterns on appliance consistent with it being the point of origin? Consider that fire patterns can occur on a variety of surfaces within the fire compartment.

APPLIANCE ANALYSIS

- What type of damage did the appliance sustain? Is it consistent with damage to other appliances and contents in the proposed origin area?
- Did an appliance outside of your fire origin area contribute to the fire cause (i.e., extension cord or series wiring)?



Slide 6-10

- D. What type of damage did the appliance sustain? Is it consistent with damage to other appliances and contents in the proposed origin area?
- E. Did an appliance outside of the fire origin area contribute to the fire cause (i.e., extension cord or series wiring)?

CAUSE ANALYSIS – SMALL APPLIANCE

- Did the appliance create enough heat to cause the fire?
- Normal operating temperatures?
- Electrical failures?
- Appliance malfunction?
- Known manufacturing defects?
- Product recalls?
- When was the appliance manufactured?
- Appliance housing materials?



Benchtop test of curling iron wrapped in lightweight combustibles.
Time vs. Temperature

Slide 6-11

- F. Questions to be considered by the investigator include:
1. Did the appliance create enough heat to cause the fire?
 2. Normal operating temperatures?
 3. Electrical failures?
 4. Appliance malfunction?
 5. Known manufacturing defects?

6. Product recalls?
7. When was the appliance manufactured?
8. Appliance housing materials?

EXEMPLAR APPLIANCES

- Obtain exemplar appliances when possible.
- Check with manufacturer of any design changes.
- Test for normal operating temperatures and/or malfunctions of component(s).



Slide 6-12

G. Exemplar appliances.

1. Obtain exemplar appliances when possible.
2. Check with manufacturer of any design changes.
3. Test for normal operating temperatures and/or malfunctions of component(s).

AGE OF APPLIANCE

Consider the age of the appliance. Vintage appliances may lack common safety features found in many of today's appliances.



Vintage Iron



Modern Iron



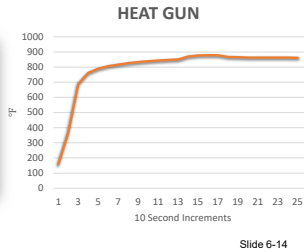
Modern Space Heater and Vintage Space Heater

Slide 6-13

- H. The investigator must consider the age of the appliance. Vintage appliances may lack common safety features found in many of today's appliances.

NORMAL OPERATION = COMPETENT IGNITION SOURCE?

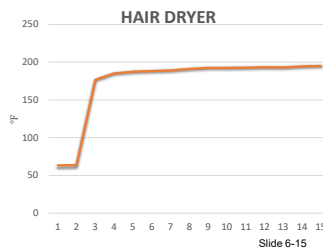
Collect data regarding heat energy generated by the appliance during normal operation. Is the appliance capable of igniting the hypothesized first fuel?



- I. Collect data regarding heat energy generated by the appliance during normal operation. Is the appliance capable of igniting the hypothesized first fuel?

ANOTHER OPERATION EXAMPLE

Collect data regarding heat energy generated by the appliance during normal operation. Is the appliance capable of igniting the hypothesized first fuel?



- J. Is this appliance capable of igniting the hypothesized first fuel?

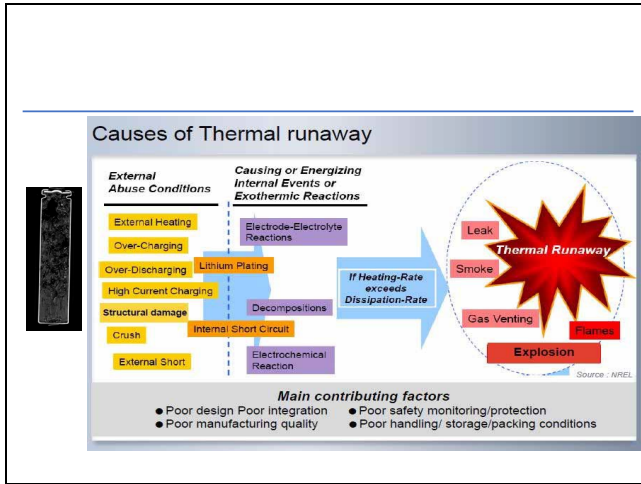
ELECTRICAL FAULTS AS AN IGNITION SOURCE

Electricity is a common denominator in most appliances; therefore, loose connections, mechanical damage, chemical damage and overloads can result in electrical faults.



Slide 6-16

- K. Electricity is a common denominator in most appliances; therefore, loose connections, mechanical damage, chemical damage and overloads can result in electrical faults.



- L. The chart illustrates the potential failure process with lithium batteries.

APPLIANCE HOUSING

- Is the appliance housing constructed of steel, aluminum, plastic, wood, ceramic or glass?
- Thermal properties of housing, will it sustain combustion?
- UL 94 - V rated plastics vs HB Rated Plastics.
- Separation between energized parts and housing. UL 48.

Slide 6-18

- M. The photos depict the plastic cover of an appliance. Is the appliance housing constructed of steel, aluminum, plastic, wood, ceramic or glass?
- N. What are the ignition qualities of housing and will it sustain combustion? What spacing exists between the energized parts and housing?
- O. Classifications.

From lowest (least flame-retardant) to highest (most flame-retardant):

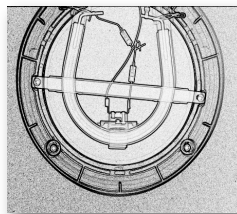
1. **“HB:** slow burning on a horizontal specimen; burning rate < 76 mm/min for thickness < 3 mm or burning stops before 100 mm.

2. **V-2:** burning stops within 30 seconds on a vertical specimen; drips of flaming particles are allowed.
3. **V-1:** burning stops within 30 seconds on a vertical specimen; drips of particles allowed as long as they are not inflamed.
4. **V-0:** burning stops within 10 seconds on a vertical specimen; drips of particles allowed as long as they are not inflamed.
5. **5VB:** burning stops within 60 seconds on a vertical specimen; no drips allowed; plaque specimens may develop a hole.
6. **5VA:** burning stops within 60 seconds on a vertical specimen; no drips allowed; plaque specimens may not develop a hole” (“UL 94,” n.d.).

APPLIANCE COMPONENTS

What heat regulating components have been engineered into the appliance design?

- Manual switches – toggle, push button, turning knobs or sliding knobs.
- Fuses.
- Circuit breakers.
- Circuit boards.
- Thermostats.
- Thermal cutoffs.
- Limit switches.



X-ray of coffee maker heating element.

Slide 6-19

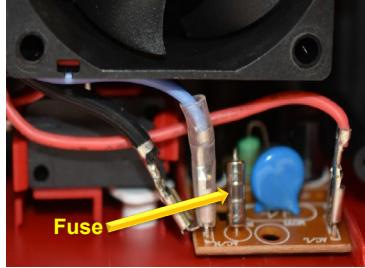
P. Appliance components.

1. What heat regulating components have been engineered into the appliance design?

OVERCURRENT PROTECTION

Fuses and breakers protect against excessive current.

- Present.
- Function as designed.
- Bypassed.



Slide 6-20

2. This slide illustrates controls, such as fuses and breakers, which protect against excessive current. The investigator should determine if they were present in the appliance. Did they function as designed? Were any safety or controls bypassed?

CIRCUIT BOARDS

A printed board that contain numerous electronic components.

Common failures:

- Environmental exposures such as moisture and contaminants can cause arc tracking.
- Overloads from power surges or lightning strikes.
- Manufacturing issues such as poor soldering, inadequate insulation on traces, traces placed too close to each other, etc.
- Mechanical damages.



Slide 6-21

3. Circuit boards: a printed board that contains numerous electronic components.

Common failures:

- a. Environmental exposures such as moisture and contaminants can cause arc tracking.
- b. Overloads from power surges or lightning strikes.
- c. Manufacturing issues such as poor soldering, inadequate insulation on traces, traces placed too close to each other, etc.
- d. Mechanical damages.

CIRCUIT BOARD ARCING VIDEO



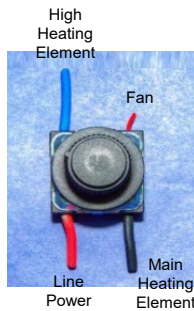
Slide 6-22

MANUAL SWITCHES

- Type of switch – slide, rocker, toggle, push button, knob, etc.



Rocker Switch
High Setting

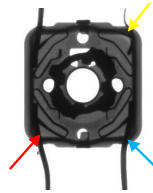


Slide 6-23

4. This slide illustrates an assortment of switch controls. The investigator should identify position of switches. Were the contacts in an opened or closed position? What is the type of switch – slide, rocker, toggle, push button, knob, etc.

MANUAL SWITCHES

- Identify position of switches.
- Contacts opened vs. closed position.
- Visual inspection.
- Check for continuity.
- X-ray.



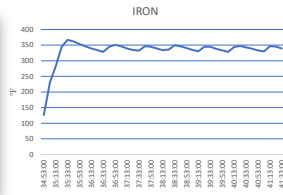
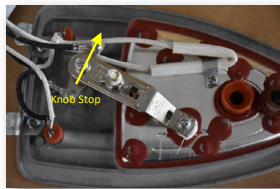
Electric Heater Switch in Low Setting

Slide 6-24

5. The investigator should conduct a visual inspection and check for continuity of the switch. An X-ray provides another level of non-destructive inspection.

THERMOSTAT – ADJUSTABLE

Thermostats operate by temperature and are designed to keep the appliance operating within designed temperature limits. Thermostats may be adjustable or nonadjustable.



Slide 6-25

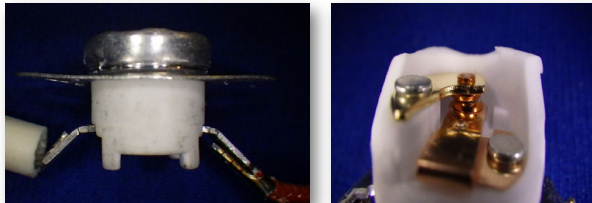
6. Thermostats operate by temperature and are designed to keep the appliance operating within designed temperature limits. Thermostats may be adjustable or nonadjustable.

THERMOSTAT – VIDEO



Slide 6-26

THERMOSTAT – FIXED HIGH LIMIT



High limit thermostat from coffee pot. Switch designed to operate at 155 °C. Switch designs vary (bi-metal switches, snap disc, etc.).

Slide 6-27

7. High limit thermostat from coffee pot. Switch designed to operate at 155 °C. Switch designs vary (bi-metal switches, snap disc, etc.).

TEMPERATURE SWITCHES THERMAL CUT OFF (TCO)

Non-Reset (240 °C)



Redundant TCO's (216 °C)



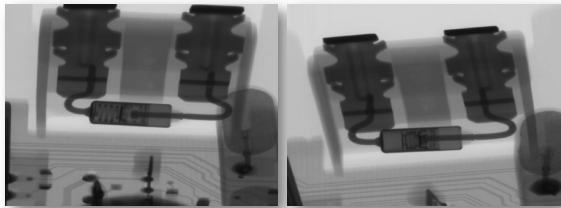
Slide 6-28

- [illegible]

Slide 6-29

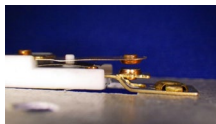
OPENED

CLOSED



Slide 6-30

CLOSED



OPEN



Slide 6-31

RELOCATABLE POWER TAP SWITCH-VIDEO



Slide 6-32

TIP-OVER SWITCHES-VIDEO



Slide 6-33

COLLECT FOR EVIDENCE

- Was appliance intentionally manipulated into incendiary device?
- Did DIY repairs of appliance go wrong?
- Is “victim” attempting to sell you an “accidental” fire?
- Does your agency have the ability to conduct forensic examination of suspect appliance?
- Identifying and leaving for insurance company?
- Attending insurance company joint inspection?

Slide 6-34

9. The investigator should consider:

a. Was appliance intentionally manipulated into incendiary device?

- b. Did DIY repairs of appliance go wrong?
- c. Is “victim” attempting to sell you an “accidental” fire?
- d. Does your agency have the ability to conduct forensic examination of suspect appliance?
- e. Identifying and leaving for insurance company?
- f. Attending insurance company joint inspection?

AVOID SPOILIATION

- Destructive examination.
- Grossly negligent.
- Intentionally damaging or removing potential evidence.
- Discarding (throwing out window or losing after collection).



Slide 6-35

Q. Spoliation refresher.

- 1. Destructive examination.
- 2. Grossly negligent.
- 3. Intentionally damaging or removing potential evidence.
- 4. Discarding (throwing out window or losing after collection).

III. SUMMARY



FEMA

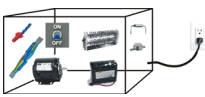
SUMMARY...



U.S. Fire
Administration

- Housing.
 - Burning from interior outward.
- Switch and connector.
 - Damage at the switch and connectors.
- Heat generating components.
 - Damage or high heat indications at the motor or heater.
- Safety devices.
 - Does the product contain safety devices? Look for tampering.

- Fuel Loads.
 - Types of fuel near or in the product. Spontaneous combustion.
- Supply cord and plug.
 - A pinched or damaged cord, damage at strain relief, loose or failed connections.
- Energy storage.
 - Type of battery. Lithium and lithium-ion store enormous energy. Internal and external shorts can cause overheating.



Slide 6-36

This page intentionally left blank.

ACTIVITY 6.1

Failure Analysis Exercise

Purpose

Examine and demonstrate an understanding of how an appliance is wired, and identify all controls and safety components that are present. Disassemble an appliance and bypass or defeat the factory installed safety controls. Prepare a fault tree analysis or an FMEA for the appliance.

DO NOT PLUG APPLIANCE INTO ANY RECEPTACLES UNTIL INSTRUCTED TO DO SO AT BURN RANGE!

Directions

1. **DO NOT energize any appliance in the classroom. DO NOT leave your modified appliance unattended or remove it from the classroom (except to take to the Burn Laboratory). Failure to abide by this instruction will result in a 25-point deduction from your final exam score.**
2. Examine and document the type of appliance and information available from the appliance container or labeling.
3. Determine the Voltage, Watts, and Amps the appliance will draw under normal operation. You may use Ohm's Law or Joule's Law to calculate unknown values.
4. Disassemble the appliance carefully so as to be able to reassemble the appliance.
5. Create a wiring diagram of the appliance circuitry.
6. Identify and note on diagram the location of (if equipped):
 - a. Thermostat.
 - b. High limit switches.
 - c. TCOs.
 - d. Operating controls.
 - e. Operating switch.
 - f. Any other controls or safety features identified.

7. Rewire the appliance so as to defeat the safety controls, and allow the appliance, when energized (see item #1 above), to go into thermal runaway, leading to ignition.
8. Create a fault tree analysis or FMEA for the appliance.

ACTIVITY 6.1 (cont'd)

Student Submission

Name: _____

Record your answers to each numbered item and turn in to an instructor.

2 _____

3 _____

5 & # 6

8

This page intentionally left blank.

REFERENCES

NFPA 1033, *Standard for professional qualifications for fire investigator*, 2022 edition. Quincy, MA: Author.

NFPA 921, *Guide for fire and explosion investigations*, 2024 edition. Quincy, MA: Author.

Wikipedia contributors. (2019, June 24). UL 94. In *Wikipedia, The Free Encyclopedia*. Retrieved from https://en.wikipedia.org/w/index.php?title=UL_94&oldid=903194028

This page intentionally left blank.

UNIT 7:

FIRE EFFECTS AND PATTERNS

TERMINAL OBJECTIVE

The students will be able to:

- 7.1 *Recognize, identify and evaluate fire patterns and effects, while demonstrating an understanding of the fire dynamics that created the same.*

ENABLING OBJECTIVES

The students will be able to:

- 7.1 *Recognize, identify and evaluate various fire patterns and effects.*
 - 7.2 *Explain the fire dynamics that produce various fire patterns and effects.*
 - 7.3 *Analyze fire patterns and effects that demonstrate an understanding of the burning characteristics of the fuel packages and the development of heat that contributed to fire spread.*
 - 7.4 *Explain how a proper understanding of fire dynamics can debunk myths surrounding various fire patterns and effects.*
-

This page intentionally left blank.



TERMINAL OBJECTIVE

Recognize, identify and evaluate fire patterns and effects, while demonstrating an understanding of the fire dynamics that created the same.

Slide 7-2

ENABLING OBJECTIVES

- 7.1 Recognize, identify and evaluate various fire patterns and effects.
- 7.2 Explain the fire dynamics that produce various fire patterns and effects.
- 7.3 Analyze fire patterns and effects that demonstrate an understanding of the burning characteristics of the fuel packages and the development of heat that contributed to fire spread.
- 7.4 Explain how a proper understanding of fire dynamics can debunk myths surrounding various fire patterns and effects.

Slide 7-3

OVERVIEW

Fire Effects = changes in material properties from fire.

Fire Patterns = observable physical artifacts or shapes formed by fire effects.

Interpretation = the use of patterns and artifacts to trace fire movement and behavior.

-NFPA 921, Section 3.3.77, 2024

Slide 7-4

VENTILATION CONTROLLED FIRE VIDEO



Slide 7-5

I. FIRE EFFECTS

FIRE EFFECTS

- Fire effects are “the observable or measurable changes in or on material as a result of a fire.”
-NFPA 921, Section 3.3.77

- Fire pattern is a visible or measurable physical change, or identifiable shape, formed by a fire effect or group of fire effects.



Slide 7-6

- A. Fire effects are “the observable or measurable changes in or on material as a result of a fire” (National Fire Protection Association (NFPA) 921, Section 3.3.77, 2024 ed.).
- B. Fire pattern is a visible or measurable physical change, or identifiable shape, formed by a fire effect or group of fire effects.

FIRE EFFECTS LIST

• Temperature. • Mass loss of materials. • Char. • Spalling. • Oxidation. • Color changes. • Melting. • Thermal expansion and deformation of materials.	• Deposition of smoke on surfaces. • Clean burn. • Gypsum wall board. • Window glass. • Collapsed furniture springs. • Distorted lightbulbs. • Rainbow effect. • Victim injuries. • Smoke alarms.
---	---

-NFPA 921, Chapter 6
Slide 7-7

- C. These are the fire effects that are presented and discussed in detail in NFPA 921, *Guide for Fire and Explosion Investigations*, Chapter 6, 2024 ed. Students are encouraged to review Chapter 6 in its entirety.

1. Temperature.
2. Mass loss of materials.
3. Char.
4. Spalling.
5. Oxidation.
6. Color changes.
7. Melting.
8. Thermal expansion and deformation of materials.
9. Deposition of smoke on surfaces.
10. Clean burn.
11. Gypsum wall board.

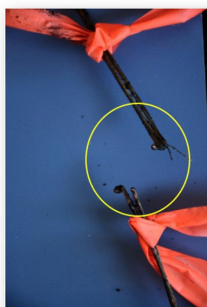
12. Window glass.
13. Collapsed furniture springs.
14. Distorted lightbulbs.
15. Rainbow effect.
16. Victim injuries.
17. Smoke alarms.

FIRE EFFECT: TEMPERATURE ESTIMATION

Melting, color changes, and deformation of material may be used to evaluate intensity and duration of heating.

Temperature estimation can be applied to materials that are:

- Clearly identified.
- Well characterized in the scientific or engineering literature.



Slide 7-8

MYTH - TEMPERATURE EFFECT

Myth: Temperatures in accelerated fires are higher than temperatures in non-accelerated fires.

Reality: The temperature of the fire is relatively the same based on geometry and ventilation conditions (wood and gasoline both burn at approximately 1,880 F).



Slide 7-9

D. Temperature estimation (Section 6.3.1.5).

1. Investigators can make temperature estimations based on material behaviors, e.g., melting temperatures of copper, 1981 F; aluminum, 1220 F; steel, 2600 F; plastics, 190 – 750 F; etc.
2. Temperature estimations can be applied to materials that are:
 - a. Clearly identified.

- b. Well characterized in the scientific or engineering literature.
3. If the known material has melted, changed color, charred or deformed, the investigator may estimate the minimum temperature that the material reached based on the thermal exposure (heat flux).

FIRE EFFECT: MASS LOSS OF MATERIALS



The surviving material often produces fire patterns with distinct lines of demarcation.

Slide 7-10

E. Mass loss of materials (Section 6.2.9).

1. The surviving material often produces fire patterns with distinct lines of demarcation.
2. When a material burns, it loses mass. Adjacent materials that are not burning can lose mass due to pyrolysis.
3. The rate of mass loss will change during the duration of a fire. Mass loss may be used as indicator of duration and intensity of fire. Of course, this is dependent upon heat flux exposure, fire growth rate, heat transfer to the material, heat release rate (HRR) of the material once ignited (e.g., wood vs. polyurethane foam). Mass loss can give indicator of direction of heat exposure.

FIRE EFFECT: CHAR

- Multiple variables affect char depth and appearance.
- Wood age generally has no relation to rate of char.
- Char depth is more related to heat flux rather than time.



Slide 7-11

F. Char (Section 6.3.2).

1. When wood is exposed to an elevated heat flux, it undergoes pyrolysis. As the heating continues, fuel gases and water vapor are emitted from the wood and the wood chars. Char variables include rate/duration of heating, ventilation, surface area-to-mass, wood species, wood grain orientation, wood density, moisture, surface coating, gaps, cracks, crevices, and velocity of impinging gases.
2. Other materials such as polyvinyl chloride (PVC) and other fire-retardant plastics can also char.

MYTH – SHINY BLISTERING

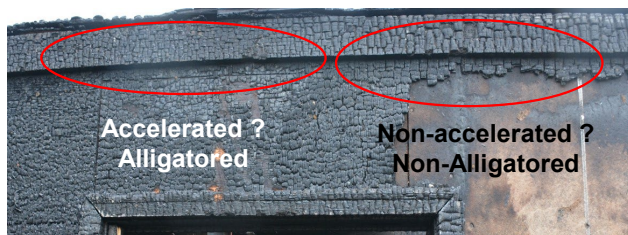
Myth: Shiny blistering indicates a fast-moving, rapidly burning fire, while dull checkering indicates a slow-moving fire.

Reality: Many factors affect surface appearance as well as char depth.



Slide 7-12

MYTH – ALLIGATORING



Slide 7-13

3. Myth: The appearance of “alligatoring” means an accelerant was used. Several factors must be considered when comparing degrees of char. The photo shows a piece of structural wood in a burn cell that has different degrees of charring noted. There was no ignitable liquid used in this training burn! The variance is due to intensity and exposure time.

2016 – EXPERT WITNESS TESTIMONY

Q. **What if anything did you notice about these points of origin?**

A. *There was what we like to call crocodiling of the wood.*

Q. **What does that mean?**

A. *The wood, whenever it burns, it leaves char, deep charring like it was, like a crocodile skin, basically, and if it burns slow and hot, it'll burn deep big crocodile tiles, like little tiles. And then if it burns hot and fast, they won't be as deep. They'll be smaller and won't be as deep. And as we noticed, at these points, that the crocodiling was small, which led us to believe it was a hot fast burning fire.*

Q. **Once you were led to believe that this fire burned hot and fast, what did that tell you about its origin?**

A. *That's typically a sign that accelerants were used to accelerate this fire.*



Slide 7-14

FIRE EFFECT: SPALLING

- It is not "spalding."
- Many factors can contribute to spalling.
- Spalling can be fire or non-fire related.
- Involves the expansion or contraction of surface areas at different rates.



Slide 7-15

G. Spalling (Section 6.2.14).

1. It is not "spalding."
2. Many factors can contribute to spalling.
3. Spalling can be fire or non-fire related.
4. Involves the expansion or contraction of surface areas at different rates.
5. Breakdown in surface tensile strength caused by temperature change. Factors involved include moisture present in concrete, expansion of reinforcing rods or steel mesh, differential expansion between concrete mix and aggregates, or differential expansion between fire exposed surface area and underlying concrete.

MYTH – SPALLING

Myth: Spalling is a positive indicator of an ignitable liquid pour.

Reality: Spalling is the fracturing of concrete or brick surfaces as a result of exposure to thermal or mechanical stress.



Slide 7-16

FIRE EFFECT: OXIDATION

Degrees of oxidation are dependent upon temperature and exposure time.



Slide 7-17

H. Oxidation (Section 6.2.11).

Color and texture changes to surfaces as a result of heat exposure. Color changes vary on different materials (e.g., stainless steel will have dull gray color vs. copper will have dark red or black oxide). Other metals like aluminum also oxidize which results in a dull white color. Oxidation (rust) can occur to materials containing iron, including rock and dirt. Oxidation lines of demarcation can be valuable to the fire investigator.

FIRE EFFECT: COLOR CHANGE

Color changes to materials as a result of exposure to heat could be due to pyrolysis, char, oxidation, or smoke deposition.

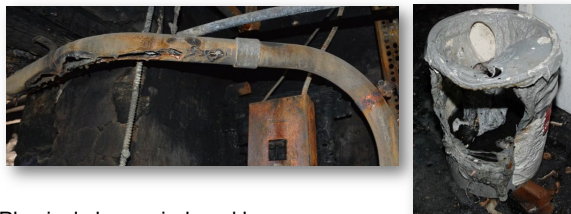


Slide 7-18

I. Color change (Section 6.2.4).

Color change is typically the result of heat and light exposure. However, color change could have occurred as a result of non-fire related exposures, previous to the fire. Color changes can give information regarding direction of heat exposure.

FIRE EFFECT: MELTING



Physical change induced by heat exposure.

-NFPA 921, Section 6.2.10.2

Materials	°F	°C
Aluminum	1,220	660
Copper	1,981	1,082
Steel	2,760	1,516

Slide 7-19

J. Melting (Section 6.2.10).

1. NFPA 921, Section 6.2.10.1: General. "The melting of a material is a physical change caused by exposure to heat. The border between the melted and non-melted portions of a fusible material can produce lines of heat and temperature demarcation that the investigator can use to define fire patterns."
2. NFPA 921, Section 6.2.10.2: "Many solid materials soften or melt at elevated temperatures ranging from a little over room temperature to thousands of degrees. A specific melting temperature or range is characteristic for each material. (See Table 6.2.10.2.)"

3. NFPA 921, Section 6.2.10.3: “Melting temperatures of common metals range from as low as 170 C (338 F) for solder to as high as 1460 C (2660 F) for steel. When the metals or their residues are found in fire debris, some inferences concerning the temperatures in the fire can be drawn.”
4. NFPA 921, Section 6.2.10.5: “Glass softens over a range of temperatures. Nevertheless, glass can give useful information on temperatures during a fire.”
5. Average turbulent flame = 1,500-1,800 F.

MELTING PLASTICS

Thermoplastics: soften, melt and flow under exposure to heat and continue to burn.





Thermosetting polymer (plastic): hardened into a permanent shape; not subject to softening. Typically will char, not melt.

Slide 7-20

K. Melting plastics.

1. **Thermoplastics:** soften, melt and flow under exposure to heat and continue to burn (Section 3.3.201).
2. **Thermosetting polymer (plastic):** hardened into a permanent shape; not subject to softening. Typically will char, not melt (Section 3.3.202).

THERMOPLASTICS VERSUS THERMOSET

Thermoplastics



Thermoset



Slide 7-21

- 3 NFPA 921, Section 6.2.10.4: “Thermoplastics soften and melt over a range of relatively low temperatures, from around 75°C (167°F) to near 400°C (750°F). Thus, the melting of plastics can give information on temperatures, but mainly where there have been hot gases and little or no flame in that immediate area. (See Figure 6.2.10.4(a) & (b).)”
4. If the thermoset plastic is composed of fire-retardant chemicals, they will typically not support flaming combustion.

MYTH – MELTING

Myth: Melted aluminum thresholds or melted at floor level means an ignitable liquid was used.

Reality: Melted aluminum thresholds are commonly caused by the effects of flashover, not the use of ignitable liquid pours. (Aluminum melts at approximately 1,220 F.)



Slide 7-22

FIRE EFFECT: THERMAL EXPANSION AND DEFORMATION

- 100-foot steel beam lengthens 9 inches at 1,000 °F.
- Expansion may displace restraining masonry components, leading to possible collapse.
- Loses half its strength around 1,000 °F.
- Temperature, load and exposure time affect deformation.



Slide 7-23

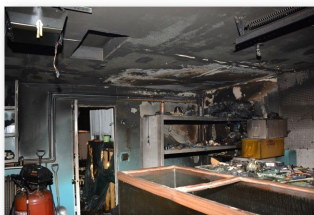
L. Thermal expansion and deformation (Section 6.2.15).

1. NFPA 921, Section 6.2.15.3: “Bending and buckling (deformation) of steel beams and columns occurs when the steel temperature exceeds approximately 500°C (approximately 900°F). At elevated temperatures, steel exhibits a progressive loss of strength. When there is a greater fire exposure, the load required to cause deformation is reduced.”

2. “Deformation is not the result of melting. A deformed element is not one that has melted during the fire, and therefore the occurrence of such deformation does not indicate that the material was heated above its melting temperature. On the contrary, a deformed as opposed to melted item indicates that the material’s temperature did not exceed its melting point. Thermal expansion can also be a factor in the bending of the beam, if the ends of the beam are restrained.”
3. Studs, beams, columns, and the construction components that are made of high-melting-point metals, such as steel, can be distorted by heating.
4. The amount and location of distortion in a particular metal construction can indicate which areas were heated to higher temperatures or for longer times.

FIRE EFFECT: DEPOSITION SMOKE

- Smoke particulates collect on cooler surfaces: walls, windows and content surfaces.
- Smoke deposition lines of demarcation can aid in fire spread hypothesis development.



Slide 7-24

M. Deposition of smoke (Section 6.2.5).

Smoke is unburned fuel resulting from incomplete combustion. Smoke adheres to cooler surfaces. Lines of demarcation will assist the investigator in determining how the smoke moved throughout the compartment(s).

FIRE EFFECT: CLEAN BURN

Burning of fuels such as paper, paint and soot from noncombustible surfaces can be indicative of high heat flux exposure.



Slide 7-25

N. Clean burn (Section 6.2.3).

1. A visible fire effect, typically on non-combustible surfaces, where the surface covering has burned away, and no soot was deposited or soot was deposited early in the fire, but pyrolyzed and burned away as the incident progressed.
2. A clean burn indicates that the area was exposed to a very high heat flux; however, clean burns alone do not indicate an area of origin.
3. Clean burn lines of demarcation can assist investigators in determining fire spread.

FIRE EFFECT: GYPSUM WALL BOARD

- Removal of free and chemically bound water from gypsum.
- Chemical change of gypsum to the mineral anhydrite.



Slide 7-26

O. Gypsum wall board (Section 6.2.8).

1. Heat drives chemically bound moisture out of the gypsum, which results in anhydrite. This is called calcination. Anhydrite is softer and less dense than gypsum.
2. Note that the paper covering on gypsum wall board acts as a fuel, as does any paint that has been applied to it. Areas of clean burn are often found on the remains of gypsum board.

FIRE EFFECT: WINDOW GLASS

Variables affecting glass:

- Type / thickness of glass.
- Rate of heating.
- Degree of insulation to the edges of the glass provided by the glazing method.



Slide 7-27

P. Window glass (Section 6.2.17).

1. Window glass may have many responses for fire exposure. It may collect smoke condensates, it may fracture due to differences in heat exposures (Section 6.2.17.1).
2. Types of fractures.
 - a. Smooth undulating lines that spread and join together are a result of thermal impact.
 - b. Conchoidal fractures with cobweb appearance from mechanical impact.
 - c. Crazing (complicated short cracks) occurs with rapid cooling.
3. Smoke condensing or not condensing on the inside of the glass may provide information whether the glass or a portion of the glass was hot during the fire.

MYTH – CRAZING

Myth: Crazing or spidering of glass means the fire was accelerated.

Reality: Crazing or spidering of glass is the internal shattering into small, irregular areas caused by the sudden cooling of hot glass.



Slide 7-28

MYTH– SMOKE STAINS ON GLASS

Myth: Amount or color of deposited soot/smoke reveals if the fire was fast and hot **or** slow and normal.

- No soot, black/heavy soot = accelerated.
- Yellowish brown or heavy soot = non accelerated.

Reality: Ventilation, HHR, fuel packages and the cooler surfaces within the structure determine soot deposits.



Slide 7-29

4. Smoke stains on glass should not be used as a conclusive indicator of the burning time for any fire event.

FIRE EFFECT: FURNITURE SPRINGS

Springs may lose tensile strength due to intensity or duration of heat exposure.



Slide 7-30

Q. Furniture springs (Section 6.2.7).

1. Annealing of furniture springs may occur for several reasons: short-term intense heat exposure; long-term, moderate-level heat exposure; load on springs during heating; wear and tear over time.

MYTH - ANNEALING

Myth: Annealing of springs is always the result of use of an accelerant.

Reality: Annealing of springs is dependent on temperature and can be caused by accidental means.

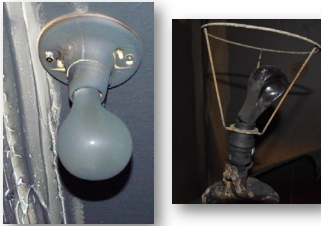


Slide 7-31

2. Annealing should not be associated to a specific fire cause. Annealing of springs is a common effect that occurs to furniture springs when exposed to heat.

FIRE EFFECT: DISTORTED LIGHTBULBS

- Distortion on lightbulbs may indicate direction of highest thermal exposure.
- Effect may be observed on incandescent, light emitting diode (LED) and halogen bulbs.



Slide 7-32

R. Distorted lightbulbs (Section 6.2.6).

1. Bulbs react differently if the bulb is under pressure (push towards heat) or under vacuum (pull inward). The side which displays distortion is typically the side which sustained the greatest degree of heat flux exposure.

2. Different types of lightbulbs: compact fluorescent light (CFL), halogen, LED. The bulbs are not constructed in the same manner as an incandescent lightbulb and may respond differently.

FIRE EFFECT: RAINBOW EFFECT

Substances which do not mix with water such as plastics, asphalt, oils from woods and ignitable liquids can create rainbow effect.



Slide 7-33

- S. Rainbow effect (Section 6.2.12).

1. Substances which do not mix with water such as plastics, asphalt, oils from woods and ignitable liquids can create rainbow effect.
2. Ignitable liquid should not be inferred from the rainbow effect without laboratory confirmation.

FIRE EFFECT: VICTIM INJURIES

- Color changes.
- Skin splits.
- Posture.
- Muscle dehydration, shortening and contraction.
- Body fat melt and burn as fuel.
- Bone char and fragmentation.



Slide 7-34

- T. Victim injuries (Section 6.2.16).

1. Color changes.
2. Skin splits.
3. Posture.

4. Muscle dehydration, shortening and contraction.
5. Body fat melt and burn as fuel.
6. Bone char and fragmentation.

FIRE EFFECT: SMOKE ALARMS — ENHANCED SOOT DEPOSITION

- The presence (or absence) of smoke alarms, along with soot deposits, should be documented.
- Enhanced soot deposition is also known as acoustic agglomeration.
- The presence (or absence) of soot deposition **may** assist in determining if the smoke alarm sounded at the time of the fire.

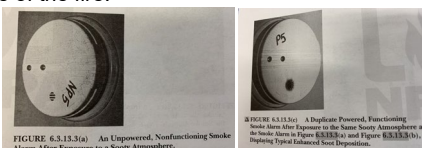


FIGURE 6.2.13.3(a) An Unpowered, Nonfunctioning Smoke Alarm After Exposure to a Sooty Atmosphere.

Photos courtesy of NFPA 921

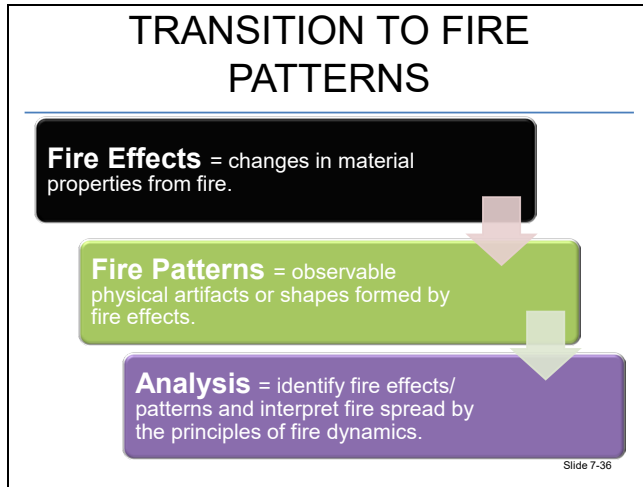
FIGURE 6.2.13.3(b) A Duplicate Powered, Functioning Smoke Alarm After Exposure to the Same Sooty Atmosphere as the Smoke Alarm in Figure 6.2.13.3(a) and Figure 6.2.13.3(c), Depicting Typical Enhanced Soot Deposition.

Slide 7-35

U. Smoke alarms — enhanced soot deposition (Section 6.2.13).

1. The presence of smoke alarms, as well as smoke deposits on a smoke alarm, should be documented. If the smoke alarm has fallen down, its former location may be visible in the form of a protected area or mounting equipment.
2. Enhanced soot deposition is also known as acoustic soot agglomeration.
3. In many cases, the nature of the soot deposition on certain surfaces of typical single- and multistation smoke alarms can show that the smoke alarm sounded or did not sound during the fire.
4. The presence (or absence) of soot deposition may assist in determining if the smoke alarm sounded at the time of the fire.

II. FIRE PATTERNS AND INTERPRETATION



FIRE EFFECTS TO FIRE PATTERNS

“The visible or measurable physical changes, or identifiable shapes, formed by a fire effect or group of fire effects.”

-NFPA 921, Section 3.3.77,
Section 3.3.81

Slide 7-37

A. Fire effects to fire patterns.

1. “The visible or measurable physical changes, or identifiable shapes, formed by a fire effect or group of fire effects” (NFPA 921, Section 3.3.77, Section 3.3.81, 2024 ed.).

FIRE PATTERNS

Fire effect/pattern analysis is an integral function of origin determination and can be subjective. It is imperative to consider the fire dynamics that created the fire pattern.



Slide 7-38

2. Fire effect/pattern analysis is an integral function of origin determination and can be subjective. It is imperative to consider the fire dynamics that created the fire pattern.

FIRE PATTERNS: FIRE DYNAMICS

- Flame, heat and smoke intensity and movement throughout a structure are recorded by fire patterns.
- Modes of heat transfer.
- Fuel package location and geometry.
- Stage of fire growth.
- Ventilation.



Slide 7-39

B. Fire dynamics.

1. Flame, heat and smoke intensity and movement throughout a structure are recorded by fire patterns.
2. Modes of heat transfer.
3. Fuel package location and geometry.
4. Stage of fire growth.
5. Ventilation.

FIRE PATTERNS: LOCATIONS

Interior and exterior walls,
floors, ceilings, structural
members and contents.

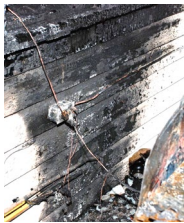


Slide 7-40

C. Locations.

Interior and exterior walls, floors, ceilings, structural members and contents.

FIRE PATTERNS: PLUME CREATED



V Pattern



Inverted Cone



Hourglass

Slide 7-41

D. Plume created.

1. V pattern (see NFPA 921, Section 6.5.1).
2. Inverted cone pattern (see NFPA 921, Section 6.5.2).
3. Hourglass pattern (see NFPA 921, Section 6.5.3).

MYTH– INVERTED CONE

Myth: Inverted cone pattern indicates an ignitable liquid was used.

Reality: Inverted cone patterns may be caused by fires of short duration or fires involving fuels that have low heat release rates (HRRs).

They do not evolve into floor to ceiling flame plumes or plumes that are vertically restricted.



Slide 7-42

FIRE PATTERNS: PLUME GENERATED



Circular



U Shaped

Slide 7-43

4. U pattern (see NFPA 921, Section 6.5.4).
5. Circular pattern (see NFPA 921, Section 6.5.5).

FIRE PATTERNS: PLUME CREATED



Truncated Cone



Pointer or Arrow

Slide 7-44

6. Truncated cone pattern (see NFPA 921, Section 6.5.6).
7. Irregular patterns (see NFPA 921, Section 6.5.7).
8. Doughnut patterns (see NFPA 921, Section 6.5.8).
9. Linear patterns (see NFPA 921, Section 6.5.9).
10. Pointer/arrow pattern (see NFPA 921, Section 6.7).

FIRE PATTERNS: VENTILATION GENERATED

Location, shape, and magnitude of patterns can be affected by vent openings.



Slide 7-45

- E. Ventilation generated (Section 6.4.2).

It is essential that investigators consider how ventilation contributed to fire pattern development. Ventilation patterns can be observed at the exterior and interior sides of vent openings. Greater degrees of fire damage may be observed around ventilation openings. Remember that the area of greatest damage is not always indicative of fire origin.

FIRE PATTERNS: HOT GAS LAYER GENERATED

- Lines of demarcation define the hot gas layer.
- Radiant heat flux damage to floor and content surface areas.



Slide 7-46

F. Hot gas layer generated (Section 6.4.3).

Hot gas layer generated patterns can be used to identify fire movement in a structure.

FIRE PATTERNS: FULL ROOM INVOLVEMENT

- Room transitioned to flashover conditions.
- Severe fire damage throughout compartment.
- Burning of carpet, under furniture, baseboards.



Slide 7-47

G. Full room involvement (Section 6.4.4).

Post flashover burn times must be considered when conducting fire pattern analysis. Lengthy post flashover burn times may cover or destroy fire patterns.

FIRE PATTERNS: SUPPRESSION GENERATED

- Hose stream generated patterns.
- Ventilation operations.



Slide 7-48

H. Suppression generated (Section 6.4.5).

1. Hose stream generated patterns.
2. Ventilation operations.

MYTH - HOSE STREAM VIDEO

Myth: Hose streams push or move fire throughout the structure.

Reality: Application of water cools the fire and aids with suppression.

Uncoordinated ventilation operations may result in fire spread throughout the structure.



Slide 7-49

FIRE PATTERNS: HEAT SHADOWING

Shadowed area may be used to assist with scene reconstruction.

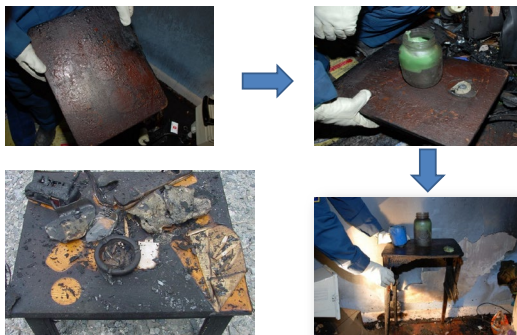


Slide 7-50

I. Heat shadowing (Section 6.3.3.1).

Object blocking line of sight heat flux. Shadowed area may be used to assist with scene reconstruction. Were the contents claimed in the proof of loss actually at the scene?

FIRE PATTERNS: PROTECTED AREAS



Slide 7-51

J. Protected areas (Section 6.3.3.3).

The investigator should understand the importance of identifying protected areas and how they assist with the fire investigation, the importance of protected areas when conducting scene reconstruction, and that inaccurate reconstruction may lead to misinterpretation of fire patterns. Protected areas may shed light on sequence of events.

FIRE PATTERNS: IRREGULAR PATTERNS

- Irregular, curved or pool-shaped.
- Numerous causes.
- Lab analysis needed for determination of presence of ignitable liquid.



Slide 7-52

K. Irregular patterns (Section 6.5.7).

Irregular pattern causes include floor/carpet adhesives, dripping thermoplastics, ventilation, localized heating, fallen fire debris and ignitable liquids. Avoid the term “Pour Pattern.” **Never** infer that an ignitable liquid is present because of an irregular pattern! Lab confirmation is always needed.

FIRE PATTERNS: DOUGHNUT SHAPED

- Liquid cooling effect.
- Lab confirmation needed for presence of ignitable liquid.



Slide 7-53

L. Doughnut shaped (Section 6.5.8).

Doughnut-shaped pattern may be caused by the presence of an ignitable liquid. The unburned area is protected by the liquid with burning confined to the perimeter of the pool.

FIRE PATTERNS: TRAILERS

- Trail or spread fire from area to another.
- Solid or liquid fuels may be utilized.



Slide 7-54

M. Trailers (Section 6.5.9.1).

1. Trail or spread fire from one area to another.
2. Solid or liquid fuels may be utilized.

FIRE PATTERNS: SADDLE BURNS



Slide 7-55

N. Saddle burns.

Distinctive U- or saddle-shaped patterns (see NFPA 921, Section 6.5.10.2.3).

FIRE PATTERN: OUTLIERS

Electrical fault resulting in MC cable sheathing being energized.
Event started to cause saddle burning in wood joists.



Slide 7-56

O. Outliers.

FIRE PATTERN: DROP DOWN OUTLIER

- Hot, burning, or smoldering debris that falls or drops down during the fire event and produces observable patterns.
- May be misinterpreted as origin or multiple points of origin.



Slide 7-57

P. Drop down outlier.

1. Hot, burning or smoldering debris that falls or drops down during the fire event and produces observable patterns (see Section 6.3.2.6).
2. May be misinterpreted as origin or multiple points of origin.

FIRE PATTERN: ANALYSIS

Each fire pattern requires an analysis that leads to hypothesis about what generated it and a test of that hypothesis.



-NFPA 921, Section 6.3.1.1

Slide 7-58

Q. Analysis.

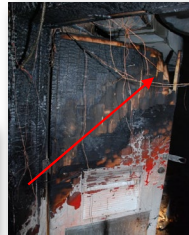
ANALYZING FIRE PATTERNS

Some patterns may display aspects defining both movement and intensity.

-NFPA 921, Section 6.3.1.1



HEAT (INTENSITY)
PATTERNS



FIRE SPREAD
(MOVEMENT)

Slide 7-59

R. Analyzing fire patterns.

1. Each fire pattern requires an analysis that leads to hypothesis about what generated it and a test of that hypothesis. (NFPA 921, Section 6.3.1.1, 2024 ed.).
2. Dynamics of Pattern Production: The recognition, identification, and proper analysis of fire patterns depend on the understanding of the fire dynamics of fire development and heat and fire spread. (NFPA 921, Section 6.3.1.2, 2024 ed.).

III. SUMMARY



SUMMARY

In this lesson you learned to:

- 7.1 Recognize, identify, and evaluate various fire patterns and effects.
- 7.2 Explain the fire dynamics that produce various fire patterns and effects.
- 7.3 Analyze fire patterns and effects that demonstrate an understanding of the burning characteristics of the fuel packages and the development of heat that contributed to fire spread.
- 7.4 Explain how a proper understanding of fire dynamics can debunk myths surrounding various fire patterns and effects.

Slide 7-60

REFERENCES

NFPA 921, Chapter 3, Section 3.3.77, 2024 ed.

NFPA 921, Chapter 3, Section 3.3.81, 2024 ed.

NFPA 921, Chapter 3, Section 3.3.201, 2024 ed.

NFPA 921, Chapter 3, Section 3.3.202, 2024 ed.

NFPA 921, Chapter 6, Section 6.2.3, 2024 ed.

NFPA 921, Chapter 6, Section 6.2.4, 2024 ed.

NFPA 921, Chapter 6, Section 6.2.5, 2024 ed.

NFPA 921, Chapter 6, Section 6.2.6, 2024 ed.

NFPA 921, Chapter 6, Section 6.2.7, 2024 ed.

NFPA 921, Chapter 6, Section 6.2.8, 2024 ed.

NFPA 921, Chapter 6, Section 6.2.9, 2024 ed.

NFPA 921, Chapter 6, Section 6.2.10, 2024 ed.

NFPA 921, Chapter 6, Section 6.2.10.1, 2024 ed.

NFPA 921, Chapter 6, Section 6.2.10.2, 2024 ed.

NFPA 921, Chapter 6, Section 6.2.10.3, 2024 ed.

NFPA 921, Chapter 6, Section 6.2.10.4, 2024 ed.

NFPA 921, Chapter 6, Section 6.2.10.5, 2024 ed.

NFPA 921, Chapter 6, Section 6.2.11, 2024 ed.

NFPA 921, Chapter 6, Section 6.2.12, 2024 ed.

NFPA 921, Chapter 6, Section 6.2.13, 2024 ed.

NFPA 921, Chapter 6, Section 6.2.14, 2024 ed.

NFPA 921, Chapter 6, Section 6.2.15.3, 2024 ed.

NFPA 921, Chapter 6, Section 6.2.16, 2024 ed.

NFPA 921, Chapter 6, Section 6.2.17, 2024 ed.

NFPA 921, Chapter 6, Section 6.3.1.1, 2024 ed.

NFPA 921, Chapter 6, Section 6.3.1.2, 2024 ed.

NFPA 921, Chapter 6, Section 6.3.2.6, 2024 ed.

NFPA 921, Chapter 6, Section 6.3.3.1, 2024 ed.

NFPA 921, Chapter 6, Section 6.3.3.3, 2024 ed.

NFPA 921, Chapter 6, Section 6.4.2, 2024 ed.

NFPA 921, Chapter 6, Section 6.4.3, 2024 ed.

NFPA 921, Chapter 6, Section 6.4.4, 2024 ed.

NFPA 921, Chapter 6, Section 6.4.5, 2024 ed.

NFPA 921, Chapter 6, Section 6.5.1, 2024 ed.

NFPA 921, Chapter 6, Section 6.5.2, 2024 ed.

NFPA 921, Chapter 6, Section 6.5.3, 2024 ed.

NFPA 921, Chapter 6, Section 6.5.4, 2024 ed.

NFPA 921, Chapter 6, Section 6.5.5, 2024 ed.

NFPA 921, Chapter 6, Section 6.5.6, 2024 ed.

NFPA 921, Chapter 6, Section 6.5.7, 2024 ed.

NFPA 921, Chapter 6, Section 6.5.8, 2024 ed.

NFPA 921, Chapter 6, Section 6.5.9, 2024 ed.

NFPA 921, Chapter 6, Section 6.5.9.1, 2024 ed.

NFPA 921, Chapter 6, Section 6.5.10.2.3, 2024 ed.

NFPA 921, Chapter 6, Section 6.7, 2024 ed.

UNIT 8: EVIDENCE COLLECTION AND PRESERVATION (GUEST LECTURER)

TERMINAL OBJECTIVE

The students will be able to:

- 8.1 *Construct field level identification and collection techniques, with an understanding of laboratory process, to demonstrate the evidence collection process.*

ENABLING OBJECTIVES

The students will be able to:

- 8.1 *Define terminology relevant to evidence collection and preservation.*
 - 8.2 *Discuss the most common sources of evidence contamination and how to avoid them.*
 - 8.3 *Explain proper collection and packaging techniques.*
 - 8.4 *Articulate the process for laboratory analysis, and reporting, for ignitable liquids, and relate the significance of sample analysis.*
-

This page intentionally left blank.



TERMINAL OBJECTIVE

Construct field level identification and collection techniques, with an understanding of laboratory process, to demonstrate the evidence collection process.

Slide 8-2

ENABLING OBJECTIVES

- 8.1 Define terminology relevant to evidence collection and preservation.
- 8.2 Discuss the most common sources of evidence contamination and how to avoid them.
- 8.3 Explain proper collection and packaging techniques.
- 8.4 Articulate the process for lab analysis, and reporting, for ignitable liquids, and relate the significance of sample analysis.

Slide 8-3

I. EVIDENCE TERMINOLOGY

FIRE DEBRIS EVIDENCE - TOPICS

- Terminology.
- Fire Scene Investigation.
- Contamination Prevention.
- Sample Selection.
- Sample Collection and Preservation.
- Laboratory Examination.

Slide 8-4

TERMINOLOGY

- Fire debris.
 - No longer “arson” or “accelerant” analysis.
 - Includes anything related to fire investigation (debris from origin, clothes, liquid, bottles, etc.)
 - Analyzed for presence of ignitable liquids.
- Ignitable liquid.
 - No longer “accelerant.”
 - Use of ignitable liquid in scene determined by investigator, not laboratory.

Slide 8-5

A. Fire debris.

1. No longer “arson” or “accelerant” analysis.
2. Includes anything related to fire investigation (debris from origin, clothes, liquid, bottles, etc.)
3. Analyzed for presence of ignitable liquids.

B. Ignitable liquid.

1. No longer “accelerant.”
2. The reason for the presence of ignitable liquid in scene determined by investigator, not laboratory.

TERMINOLOGY (cont'd)

- **Ignitable liquid** includes both flammable and combustible liquids.
 - Flammable: $FP < 37.8^{\circ}C$ ($100^{\circ}F$)
 - Combustible: $FP \geq 37.8^{\circ}C$ ($100^{\circ}F$)
- **Flash Point (FP).**
 - Lowest temperature of a liquid at which the liquid gives off vapors at a sufficient rate to support a momentary flame across its surface.



Slide 8-6

3. **Ignitable liquid** includes both flammable and combustible liquids.
 - a. Flammable: $FP < 37.8^{\circ}C$ ($100^{\circ}F$).
 - b. Combustible: $FP \geq 37.8^{\circ}C$ ($100^{\circ}F$).

4. **Flash Point (FP).**

Lowest temperature of a liquid at which the liquid gives off vapors at a sufficient rate to support a momentary flame across its surface.

FIRE DEBRIS ANALYSIS

- Ignitable liquids.*
- Alternative fuels.*
- Vegetable oils/animal fats.
- Lubricating oils.
- Incendiary devices.

**most forensic labs*



Slide 8-7

5. Fire debris analysis.
 - a. Ignitable liquids.*
 - b. Alternative fuels.*
 - c. Vegetable oils/animal fats.

- d. Lubricating oils.
- e. Incendiary devices.

II. FIRE SCENE INVESTIGATION

FIRE SCENE INVESTIGATION

Fire scene evidence is unique:

- In some cases, not immediately identifiable.
- Usually discovered near completion of fire scene investigation.
- Until scene is completed it should be viewed as "large" piece of evidence.



Slide 8-8

- A. Fire scene evidence is unique.
- 1. In some cases, it is not immediately identifiable.
 - 2. Usually discovered near completion of the fire scene investigation.
 - 3. Until the scene is completed, it should be viewed as one "large" piece of evidence.

FIRE SCENE EVIDENCE

- Used to corroborate an incendiary cause.
 - Is an ignitable liquid present? What is it?
- Associate a suspect with a fire scene...



Slide 8-9

- B. Fire scene evidence.

1. Used to corroborate an incendiary cause.

Is an ignitable liquid present? What is it?

2. Associate a suspect with a fire scene.

ASSOCIATIVE EVIDENCE

- Physical evidence:
 - Cigarette butts.
 - Torn matches.
 - Cloth.
 - Tape.
- DNA samples.
- Latent fingerprints.
- Tool marks.



Slide 8-10

- C. Associative evidence.

1. Physical evidence.
2. DNA samples.
3. Latent fingerprints.
4. Tool marks.

ASSOCIATIVE EVIDENCE (cont'd)

- Tire impressions:
 - Vehicles at scene.
- Shoe impressions:
 - May provide leads regarding individual(s) at fire scene.



Slide 8-11

5. Tire impressions.

Vehicles at scene.

6. Shoe impressions.

May provide leads regarding individual(s) at fire scene.

III. CONTAMINATION PREVENTION

WHAT IS CONTAMINATION?

The unintended transfer of a material onto the scene and/or onto evidence collected.

Slide 8-12

A. What is contamination?

The unintended transfer of a material onto the scene and/or onto evidence collected.

HOW CAN CONTAMINATION OCCUR?

- Locard Exchange Principle:
 - When two materials come into contact with one another, there will be a transfer of each material to the other.
 - Demonstrated through laboratory tests.

Slide 8-13

B. How can contamination occur?

Locard Exchange Principle:

1. When two materials come into contact with one another, there will be a transfer of each material to the other.
2. Demonstrated through laboratory tests.

IGNITABLE LIQUID CONSIDERATIONS

- Contamination may occur through:
 - Transfer of liquids or residual material.
 - Transfer of vapors.
- If you can smell it, the vapors are contaminating you.



Slide 8-14

C. Ignitable liquid considerations.

1. Contamination may occur through:
 - a. Transfer of liquids or residual material.
 - b. Transfer of vapors (if you can smell it, the vapors are contaminating you).

IGNITABLE LIQUID CONSIDERATIONS (cont'd)

- Contamination examples.
 - Filling up car at gas station.
 - Excavating a basement where a fuel tank was breached.
 - Standing/kneeling in puddles of spilled fuels.
 - Leaving evidence packaging open next to scene gear.



Slide 8-15

2. Contamination examples.

- a. Filling up car at gas station.
- b. Excavating a basement where a fuel tank was breached.
- c. Standing/kneeling in puddles of spilled fuels.
- d. Leaving evidence packaging open next to scene gear.

IGNITABLE LIQUID CONSIDERATIONS (cont'd)

- Trace contamination.
 - Contact with ignitable liquid residue at some fire scenes and at scenes of search warrants.
 - Typically for short periods of time and in small quantities.
- Gross contamination.
 - Exposure to bulk ignitable liquids.
 - Either vapor or liquid.
 - Typically for extended periods of time and in large quantities.

Slide 8-16

3. Trace contamination.
 - a. Contact with ignitable liquid residue at some fire scenes and at scenes of search warrants.
 - b. Typically for short periods of time and in small quantities.
4. Gross contamination.
 - a. Exposure to bulk ignitable liquids, either vapor or liquid.
 - b. Typically for extended periods of time and in large quantities.

SCENE CONSIDERATIONS

- Avoid use of gas-powered tools to collect evidence.
- Check with fire chief or Incident Commander and find out if gas-powered tools were used during suppression.
 - Location used.
 - Location filled.
- Check heavy equipment for leaks prior to using in scene.

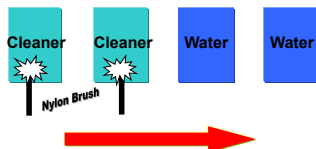
Slide 8-17

D. Scene considerations.

1. Avoid use of gas-powered tools to collect evidence.
2. Check with fire chief or Incident Commander and find out if gas-powered tools were used during suppression.
 - a. Location used.
 - b. Location filled.
3. Check heavy equipment for leaks prior to using in scene.

MINIMIZING ON-SCENE CONTAMINATION

- Do not bring ignitable liquid residues into scene.
 - Consider decontamination line.



Slide 8-18

E. Minimizing on-scene contamination.

1. Do not bring ignitable liquid residues into the scene.
2. Consider setting up a decontamination line.

CONTAMINATION PREVENTION

- Store new cans with lid on.
- Use separate, clean (disposable) tools for each sample.
- Use new packaging for every item.



Slide 8-19

F. Contamination prevention.

1. Store cans with lid on.
2. Use separate, clean (or disposable) tools for each sample.
3. Use new packaging for every item.

CONTAMINATION PREVENTION (cont'd)

- Change gloves between samples.
- Use clean or disposable tools for:
 - Evidence collection.
 - Scene processing.
- Tools should be cleaned after each use.
 - Avoid wood and wood-handled tools.



Slide 8-20

4. Change gloves between samples.
5. Use clean or disposable tools for:
 - a. Evidence collection.
 - b. Scene processing.
6. Tools should be cleaned after each use.

Avoid wood and wood-handled tools.

CONTAMINATION PREVENTION (cont'd)

- If possible, have separate gear for training and scene work.
- Wear Tyvek and Tychem appropriately.
 - Tyvek — particulates.
 - Tychem — vapors/chemicals.



Slide 8-21

7. If possible, have separate gear for training and scene work.
8. Wear Tyvek or Tychem appropriately.
 - a. Tyvek — particulates.
 - b. Tychem — vapors/chemicals.

CONTAMINATION PREVENTION (cont'd)

- Do not store or ship/transport together:
 - Bulk ignitable liquids.
 - Fire scene evidence.
 - Search warrant evidence.
 - Suspects or their clothing.



Slide 8-22

9. Do not store or ship/transport together:
 - a. Bulk ignitable liquids.
 - b. Fire scene evidence.
 - c. Search warrant evidence.
 - d. Suspect or their clothing.

CLEANING PROCEDURES

- Items exposed to fire scene:

- Boots.
- Clothing.
- Jackets.
- Tools.
- Vehicles.



Slide 8-23

G. Cleaning procedures.

1. Items exposed to the fire scene:

- Boots.
- Clothing.
- Jackets.
- Tools.
- Vehicles.

CLEANING PROCEDURES (cont'd)

- Boots and metal tools.*

- Cleaning solution with brush.

- Clothing.

- Normal laundering (machine wash).
- Dry-cleaning also effective.



**NOTE: The only effective way to destroy DNA is through bleaching (10% for at least 5 min).*

Slide 8-24

2. Boots and metal tools.

Cleaning solution with brush.

3. Clothing.
 - a. Normal laundering (machine wash).
 - b. Dry-cleaning is also effective.

SUGGESTED PROCEDURE

- Rinse tool with strong stream of water.
- Scrub entire tool vigorously for 30 sec. in a 1-to-3 part solution of Simple Green®-to-water.
- Rinse tool completely with water.
- Let dry.



**Verify cleaning procedure is effective prior to implementing new products*

Slide 8-25

H. Suggested procedure.

1. Rinse tool with strong stream of water.
2. Scrub entire tool vigorously for 30 seconds in a 1-to-3 parts solution of Simple Green®-to-water.
3. Rinse tool completely with water.
4. Let dry.



Slide 8-26

5. Do **not** use Simple Green® on K-9s! Continue to use Dawn or other dog-approved products.

IV. SELECTING SAMPLES FOR IGNITABLE LIQUID ANALYSIS

SELECTING SAMPLES FOR IGNITABLE LIQUID ANALYSIS

Slide 8-27

IGNITABLE LIQUID DETECTION CANINES

- Canines are a tool which allow you to select the best samples.
- Just because the canine alerts, it does not mean that it was a set fire.



Slide 8-28

- A. Ignitable liquid detection canines.
 1. Canines are a tool which allow you to select the best samples.
 2. Just because the canine alerts, it does not mean that it was a set fire.

IGNITABLE LIQUID DETECTION CANINES (cont'd)

- Selective.
- Sensitive.
- But they can't testify!



Slide 8-29

3. Selective.
4. Sensitive.
5. But they can't testify!

LARGE FIRE SCENES



Slide 8-30

6. Large fire scenes.
 - a. Canines can search much larger areas in shorter amounts of time than it takes humans to search the same area.
 - b. Canines help reduce the number of samples that need to be taken from the fire scene to be sent to the laboratory for analysis.

DISCRIMINATION LINE



Slide 8-31

7. Discrimination line.

One way of ensuring that the sample collected represents what the dog alerted to is to run a discrimination line after collecting the samples.

IAAI AND NFPA 921 POSITION ON CANINES

- Both endorse the use of ignitable liquid detection canines for the purposes of locating and selecting samples.
- **A canine alert must be confirmed by the laboratory.**
- See NFPA 921, Section 17.7, 2024 edition, for more discussion.



Slide 8-32

8. International Association of Arson Investigators and NFPA 921, *Guide for Fire and Explosion Investigations*, positions on canines.

- Both endorse the use of ignitable liquid detection canines for the purposes of locating and selecting samples.
- A canine alert must be confirmed by the laboratory.**
- See NFPA 921, Section 17.7, 2024 edition, for more discussion on the use of canines in fire investigations.

SAMPLE SELECTION

- Use burn patterns and protected areas to locate best sample.
- Location:
 - From area of suspected pour.
 - Not from an area of extreme charring.



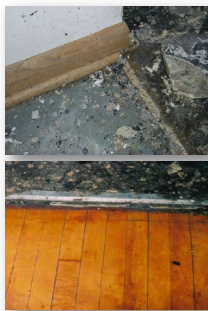
Slide 8-33

B. Sample selection.

1. Use burn patterns and protected areas to locate best sample.
2. Location.
 - a. From area of suspected pour.
 - b. Not from an area of extreme charring.

SAMPLE SELECTION (cont'd)

- Flooring and porous materials are best areas for retaining ignitable liquids.
 - Carpet and padding.
 - Soil.
 - Cloth or rags.



Slide 8-34

3. Flooring and porous materials are best areas for retaining ignitable liquids.
 - a. Carpet and padding.
 - b. Soil.
 - c. Cloth or rags.

SOIL SAMPLES

- Hydrocarbon-eating microbes.
- Degradation within 24 hours.
- Freeze samples and deliver to lab quickly.
- **ALWAYS** collect comparison sample.



Slide 8-35

4. Soil samples.
 - a. Hydrocarbon-eating microbes.
 - b. Degradation with 24 hours.
 - c. Refrigerate samples quickly.
 - d. **Always** collect comparison samples.

COMPARISON SAMPLES

- What are they?
 - Comparison samples identify and may minimize or eliminate sources of interference in the analysis process.
- When are they needed?
 - Almost always...

Slide 8-36

5. Comparison samples.
 - a. What are they?
 - Comparison samples identify and may minimize or eliminate sources of interference in the analysis process.

COMPARISON SAMPLES (cont'd)



- b. When are they needed?
 - Almost always.

COMPARISON SAMPLES (cont'd)

They should be collected at the time of the initial investigation, because it is usually impossible for an investigator to return to a scene to collect a comparison sample.

- c. They should be collected at the time of the initial investigation because it is usually impossible for an investigator to return to a scene to collect a comparison sample.

COMPARISON SAMPLES (cont'd)

Comparison samples are not always available:

- Extensively damaged scenes.
- Amount of ignitable liquid overwhelms scene.



Slide 8-39

d. Comparison samples are not always available.

- Extensively damaged scenes.
- Amount of ignitable liquid overwhelms scene.

COMPARISON SAMPLES (cont'd)

• Should be collected especially when submitting:

- Carpet and padding.
- Vinyl flooring.
- Soil.
- Wood.



• Submit with instructions:

- "Comparison samples — test if needed."

Slide 8-40

e. Should be collected especially when submitting:

- Carpet and padding.
- Vinyl flooring.
- Soil.
- Wood.

f. Submit with instructions:

- “Comparison samples — test if needed.”

PETROLEUM PRODUCTS IN OUR ENVIRONMENT

- Shoes.
- Flooring products.
- Printing inks.
- Copier toners.
- Waterless hand cleaners.
- Clothing.
- Newspapers.
- Carbonless forms.
- Adhesives.
- Insecticide sprays.
- Polishes.
- Linoleum/vinyl flooring.
- Lubricants.

Slide 8-41

g. Petroleum products in our environment.

Remember: Document door and window conditions!

- Shoes.
- Flooring products.
- Printing inks.
- Copier toners.
- Waterless hand cleaners.
- Clothing.
- Newspapers.
- Carbonless forms.
- Adhesives.
- Insecticide sprays.
- Polishes.
- Linoleum/vinyl flooring.
- Lubricants.

V. EVIDENCE PACKAGING

EVIDENCE PACKAGING

Debris and Liquid Samples

Slide 8-42

A. Debris and liquid samples.

FIRE DEBRIS EVIDENCE

- May need the following exams:
 - Fingerprints.
 - DNA.
 - Firearms.
 - Tool marks.
 - Trace (hair, fibers, paint, glass, etc.).
 - Explosives.
- May be wet, bloody — do not dry out!
- May require an X-ray.
- Limit sample handling until after ignitable liquid analysis.
- Prior processing from prints/DNA/trace will affect (prohibit) ignitable liquid testing.

Slide 8-43

B. Fire debris evidence.

1. May need the following exams:

- Fingerprints.
- DNA.
- Firearms.
- Tool marks.
- Trace (hair, fibers, paint, glass, etc.).
- Explosives.

2. May be wet, bloody — do not dry out!
3. May require an X-ray.
4. Limit sample handling until after ignitable liquid analysis.
5. Prior processing from prints/DNA/trace will affect (prohibit) ignitable liquid testing.

FIRE DEBRIS PACKAGING

- Container requirements:
 - Vapor tight!
 - Clean and unused.
 - Never fill to top of container.
- Acceptable containers:
 - Metal cans.
 - Special evidence bags.
 - Glass jars and vials.



Slide 8-44

- C. Container requirements:
1. Vapor tight!
 2. Clean and unused.
 3. Never fill to top of container.
- D. Acceptable containers:
1. Metal cans.
 2. Special evidence bags.
 3. Glass jars and vials.

PACKAGING: METAL CANS

- Cans:
 - Metal.
 - Lined preferred.
 - Clean and unused.
- Pros:
 - Durable.
 - Readily available.
- Cons:
 - Rapid deterioration (rust) in unlined cans.
 - Leakage of vapors (if NOT sealed properly).
 - Bulky.



Slide 8-45

E. Metal cans.

1. Cans:
 - a. Metal.
 - b. Lined preferred.
 - c. Clean and unused.
2. Pros:
 - a. Durable.
 - b. Readily available.
3. Cons:
 - a. Rapid deterioration (rust) in unlined cans.
 - b. Leakage of vapors (if not sealed properly).
 - c. Bulky.

PACKAGING: SPECIAL EVIDENCE BAGS

- Bags:
 - Nylon or polyester (“Kapak”).
 - Require heat sealer.
 - NO COMMON PLASTIC BAGS (polyethylene, polystyrene, polypropylene).
- Pros:
 - Ability to see evidence.
 - Good for large, bulky items.
 - No deterioration.
- Cons:
 - Not puncture resistant.
 - Bad for heavy, wet items.
 - Leakage of vapors (if NOT sealed properly).



Slide 8-46

F. Special evidence bags.

1. Bags.

- a. Ampac Fire Debris, nylon or other “arson” bags.
- b. Require heat sealer.
- c. **No common plastic bags.**

2. Pros:

- a. Ability to see evidence.
- b. Good for large, bulky items.
- c. No deterioration.

3. Cons:

- a. Not puncture resistant.
- b. Bad for heavy, wet items.
- c. Leakage of vapors (if **not** sealed properly).

PACKAGING: GLASS JARS

- Jars and vials:
 - PTFE*-lined caps.
 - Best for liquids.
- Pros:
 - Ability to see evidence.
 - Readily available.
- Cons:
 - Breakable.
 - Ignitable liquids can destroy rubber seals and glued cap liners.



**PTFE → polytetrafluoroethylene (Teflon is brand name)*

Slide 8-47

G. Glass jars.

1. Jars and vials.
 - a. Polytetrafluoroethylene (PTFE)-lined cap (Teflon).
 - b. Best for liquids.
2. Pros:
 - a. Ability to see evidence.
 - b. Readily available.
3. Cons:
 - a. Breakable.
 - b. Ignitable liquids can destroy rubber seals and glue lined cap liners.

PACKAGING RESOURCES

- Cans, bottles, vials:
 - Southpak Container Corp (<https://south-pak.com/>).
 - US Container Corp (www.berlinpackaging.com).
 - Uline (www.uline.com).
 - House of Cans (www.houseofcans.com).
 - MegaChem (www.megacheminc.com).

Slide 8-48

H. Resources.

1. Cans, bottles, vials:

- a. Southpak Container Corp (<https://south-pak.com/>).
- b. US Container Corp (www.berlinpackaging.com).
- c. Uline (www.uline.com).
- d. House of Cans (www.houseofcans.com).
- e. MegaChem (www.megacheminc.com).

PACKAGING RESOURCES (cont'd)

- Bags (nylon or polyester):
 - Grand River Products (313-881-7861).
 - Lynn Peavey Company (www.lynnpeavey.com).
 - Sirchie (www.sirchie.com).
- Heat sealers:
 - Action Bags (<https://www.actionbags.com/>).
 - Uline (www.uline.com).

Slide 8-49

2. Bags:

- a. Ampac Fire Debris (<http://www.ampaconline.com/>).

- b. Grand River Products (313-881-7861).
 - c. Lynn Peavey Company (www.lynnpeavey.com).
3. Heat sealers:
- a. Action Bags (<https://www.actionbags.com/>).
 - b. Uline (<http://www.uline.com/>).

PACKAGING RESOURCES (cont'd)

- Vials (PTFE-lined caps):
 - Fisher Scientific (www.fishersci.com).
 - Sigma Aldrich (www.sigmaaldrich.com).
 - Government Scientific Source (GSS) (www.govsci.com).
- Evidence collection:
 - Evident Crime Scene Products (<https://www.shopevident.com/>).
 - Lynn Peavey Company (www.lynnpeavey.com).
 - Sirchie (www.sirchie.com).

Slide 8-50

4. Vials (PTFE-lined caps):
- a. Fisher Scientific (<http://www.fishersci.com/>).
 - b. Sigma Aldrich (<http://www.sigmaaldrich.com/>).
 - c. Government Scientific Source (GSS) (<http://www.govsci.com/>).
5. Evidence collection.
- a. Evident Crime Scene Products (<https://www.shopevident.com/>).
 - b. Lynn Peavey Company (<http://www.lynnpeavey.com/>).
 - c. Sirchie (www.sirchie.com).

COLLECTION OF SOLID SAMPLES

- Scoop samples into vapor-tight containers (lined cans preferred).
- Do not exceed $\frac{2}{3}$ full (loosely packed).
- Use multiple or larger containers rather than over packing.



Slide 8-51

I. Collection of solid samples.

1. Scoop samples into vapor-tight containers (lined cans preferred).
2. Do not exceed $\frac{2}{3}$ full (loosely packed).
3. Use multiple or larger containers rather than overpacking.

COLLECTION OF LIQUID SAMPLES

Sources:

- Cans, bottles, containers.
- Porous objects wrung out.
- Pooled liquids.
- Sheen on puddles.



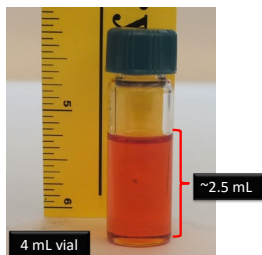
Slide 8-52

J. Collection of liquid samples.

1. Sources:
 - a. Cans, bottles, containers.
 - b. Porous objects wrung out.
 - c. Pooled liquids.
 - d. Sheen on puddles.

COLLECTION OF LIQUID SAMPLES (cont'd)

- Pipette 2-4 mL into clean glass vials.
- Package vial in metal can with packing material to prevent breakage.
- Swabs of liquids should only be collected if liquid cannot be recovered.
 - Submit comparison sample of absorbent.



Slide 8-53

2. Pipette 2-4 mL into clean glass vials.
3. Package vial in metal can with packing material to prevent breakage.
4. Swabs of liquids should only be collected if liquid cannot be recovered.

Submit comparison sample of absorbent.

COLLECTION OF LIQUID SAMPLES (cont'd)

- Gauze pads:
 - **NOT** non-stick.
- Cotton balls.
- Absorbents:
 - Non-self-rising flour.
 - Activated charcoal.
 - Diatomaceous earth.
 - Calcium carbonate.
- Pipettes.
- Eye droppers.



Slide 8-54

K. Collection devices.

1. Gauze pads.
 - Not** non-stick.
2. Cotton balls.

3. Absorbents:
 - a. Non-self-rising flour.
 - b. Activated charcoal.
 - c. Diatomaceous earth.
 - d. Calcium carbonate.
4. Pipettes.
5. Eye droppers.

PRESERVATION OF LIQUID CONTAINERS

- Photograph container.
- Note all manufacturer's markings:
 - Brand.
 - Lot.
 - Production location.
- Provide information with submission documentation.
- Only submit container if it is nearly empty.



Slide 8-55

L. Preservation of liquid containers.

1. Photograph container.
2. Note all manufacturer's markings:
 - a. Brand.
 - b. Lot.
 - c. Production location.
3. Provide information with submission documentation.
4. Only submit container if it is nearly empty.

EVIDENCE FROM VICTIMS AND SUSPECTS

- Clothing — package each item separately.
- Be cognizant of other forensic evidence:
 - DNA.
 - Trace.
- Biological tissues — collect at autopsy:
 - Lung.
 - Skin sections.
- Label as biohazard; observe precautions.



Slide 8-56

M. Evidence from victims and suspects.

1. Clothing.

- a. Package each item separately.
- b. Be cognizant of other forensic evidence:
 - DNA.
 - Trace.
- c. Biological tissues — collect at autopsy:
 - Lung.
 - Skin sections.
- d. Label as biohazard; observe precautions.

EVIDENCE FROM VICTIMS AND SUSPECTS (cont'd)

- Skin is absorbent; however, clothing is much better.
- If absolutely necessary, swab skin.
 - Submit unused swab as a comparison sample.



Slide 8-57

2. Residues.
 - a. Skin is absorbent; however, clothing is much better.
 - b. If absolutely necessary, swab skin.
 - Submit unused swab as a comparison sample.

EVIDENCE FROM VICTIMS AND SUSPECTS (cont'd)

- Package each garment individually — even shoes.
- Package in container that allows for sufficient headspace.



Slide 8-58

3. Clothing.
 - a. Package each garment individually, even shoes.
 - b. Package in container that allows for sufficient headspace.

EVIDENCE FROM VICTIMS AND SUSPECTS (cont'd)

- Large, airtight, volatile-free evidence bags or 5-gallon metal cans are recommended.
- Cut clothing if necessary.
- Use canine to locate best sample area to cut.
- **NOTE: 5-gallon cans are EXCEPTION, not rule.**

Slide 8-59

- c. Large, airtight, volatile-free evidence bags.
- d. Cut clothing if necessary.
- e. Use canine to locate best sample area to cut.
- f. Note: 5-gallon cans are exception, not rule.

EVIDENCE FROM DEVICES

- Remember, the entire device is important!
- Submit device for:
 - Prints.
 - DNA.
 - Trace (hairs, fibers, etc.)
 - Tool marks.
 - Ignitable liquids.



Slide 8-60

N. Evidence from devices.

1. Remember, the entire device is important!
2. Submit device for:
 - a. Prints.
 - b. DNA.

- c. Trace (hairs, fibers, etc.).
- d. Tool marks.
- e. Ignitable liquids.

IMPROPER PACKAGING OF EVIDENCE



Not airtight containers.

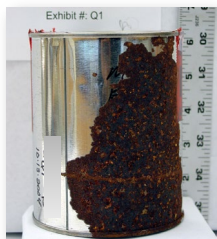


Rubber stoppers,
plastic test tubes.

Slide 8-61

- O. Improper packaging of evidence.
 - 1. Not airtight containers.
 - 2. Rubber stoppers.

IMPROPER PACKAGING OF EVIDENCE (cont'd)



Can is corroded —
not airtight.



Friction lid seal
damaged from
stepping on lid to
close it — not airtight.

Slide 8-62

- 3. Can is corroded — not airtight.
- 4. Friction lid seal damaged from stepping on lid to close it — not airtight.

IMPROPER PACKAGING OF EVIDENCE (cont'd)



Liquid in plastic container, which dissolved.

Slide 8-63

5. Dissolved liquid in plastic container.

IMPROPER PACKAGING OF EVIDENCE (cont'd)



Used container.

Slide 8-64

6. Used container.

IMPROPER PACKAGING OF EVIDENCE (cont'd)



Used container?

Slide 8-65



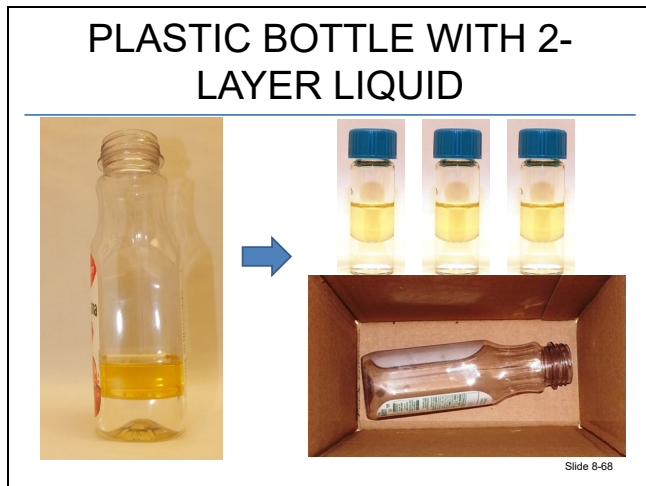
P. Intact Molotov cocktail.

1. Liquid for fire debris.
2. Wick for fire debris, trace and DNA.
3. Bottle for prints and DNA.

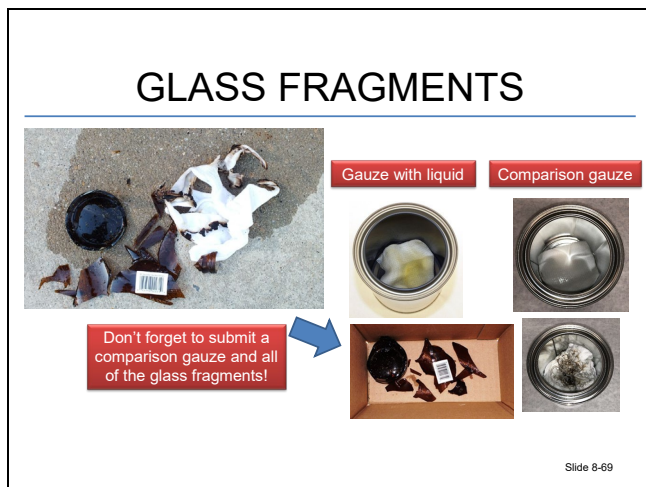


Q. Broken Molotov cocktail.

1. Wick for fire debris and DNA.
2. Bottle for fire debris, prints and DNA.



R. Plastic bottle with 2-layer liquid.



S. Glass fragments.

Don't forget pieces with parts of the label and the bottle mouth!



T. Gasoline can.

Cork the mouth of the can so that the inside of the container can be rinsed for ignitable liquid analysis. Corking prevents evaporation.

PACKAGING OPTIONS

Package	Pro	Con
Cardboard box	Breathable	Not vapor tight
Glass vial/jar (PTFE-lined cap)	Vapor tight	Not breathable, breakable
Metal can	Vapor tight	Not breathable, may rust
Paper bag	Breathable	Not vapor tight, easily punctured
Plastic bag (special fire debris type)	Vapor tight	Not breathable, easily punctured
Plastic bag (zip-lock)	Breathable (somewhat)	Not vapor tight, not breathable, easily punctured

*There is no "one-size-fits-all" packaging option.
Always consult with lab personnel when in doubt.

Slide 8-71

U. Packaging options.

1. There is no "one-size-fits-all" packaging option.
2. Always consult with lab personnel when in doubt.

IMPROPER PACKAGING CONTAINERS

- Avoid the following for fire debris evidence:
 - Paper bags.
 - Plastic or zip-lock bags.
 - Plastic bottles/containers (e.g., Nalgene)
 - Used containers.
- Improper packaging results in loss of evidence!

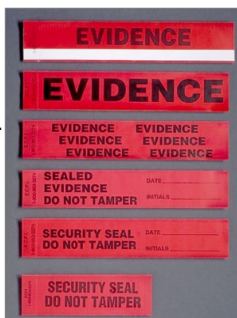
Slide 8-72

V. Improper packaging containers.

1. Avoid the following for fire debris:
 - a. Paper bags.
 - b. Plastic or zip-lock bags.
 - c. Plastic bottles/containers (e.g., Nalgene).
 - d. Used containers.
2. Improper packaging results in loss of evidence!

EVIDENCE SEAL AND LABEL

- Sealing of evidence:
 - Prevents tampering of the sample or evidence (legal).
 - Tamper-proof seal required.
 - Evidence tape or heat seal.
 - Must seal across entire opening.



Slide 8-73

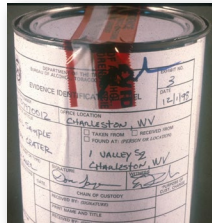
W. Evidence seal and label.

1. Sealing of evidence:
 - a. Prevents tampering of the sample or evidence (legal).
 - b. Tamper-proof seal required.
 - Evidence tape or heat seal.
 - c. Must seal across entire opening.

EVIDENCE SEAL AND LABEL (cont'd)

Labeling:

- Initials and date on seal.
- Case number.
- Description of evidence.
- Inventory # and Item #.
- Custom-made inventory labels.



Slide 8-74

2. Labeling:
 - a. Initials and date on seal.
 - b. Case number.
 - c. Description of evidence.
 - d. Inventory number and Item number.
 - e. Custom-made inventory labels.

EVIDENCE TRANSMITTAL

17. Interagency Routing - Forward evidence to:

☒ Explosives Technology Branch: ☐ Firearms Technology Branch: ☐ IBIS (NIBDV): ☐ Return to Contributor: Other:

18. *Per ATF O 3320.4B Chapter E, Section 54.k - I have retained a representative sample of the explosives evidence. ☐

19. Exam Request Table: Check the box for each exam you are requesting for each exhibit (not evidence type).

Exhibit Number	Special Requests/Priority Justification /Other Comments										
	Explosives	Trace Evidence	Fire Debris	DNA	Document Handwriting	Finger Print	Firearms	Toolmarks	Alcohol/Tobacco	FBI Electrical	FBI Fire Protection
1	☐	☐	☒	☐	☐	☒	☐	☐	☐	☐	☐
2	☐	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐
3	☐	☒	☒	☐	☐	☐	☐	☐	☐	☐	☐
4	☐	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐
5	☐	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐

Description of Exhibit (Attach a Copy of the NForce Inventory Report)

Suspected Molotov Cocktail bottle

Liquid removed from Exhibit 1

Suspected cloth wick removed from Exhibit 1

Soil sample from under Exhibit 1

Comparison soil sample

Slide 8-75

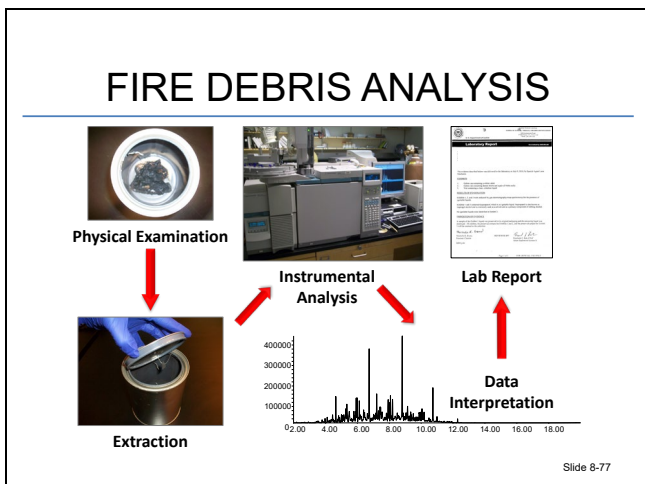
X. Evidence transmittal.

VI. LABORATORY EXAMINATION

LABORATORY EXAMINATION

Chemical Analysis and Data Interpretation

Slide 8-76



- A. Chemical analysis and data interpretation.
- B. Overview of laboratory processing.

The laboratory analysis of fire debris can be considered as a five-step process. Physical Examination, Extraction, Instrumental Analysis, Data Interpretation and Writing the report. Each of these will be discussed in turn.

FIRE DEBRIS ANALYSIS (cont'd)

- Why it works...
 - Vapors above the liquid burn.
 - Some liquid may remain after the fire.
- Isolate residue using an extraction method.



Slide 8-78

- C. Sample analysis — debris.
 1. What is burning at the scene is the evaporated liquid; some liquid may remain after the fire.
 2. Isolate residue using passive headspace extraction.

FIRE DEBRIS ANALYSIS (cont'd)

- Place charcoal strip in can.
- Heat at 60-80°C for 16 hours.
- Rinse strip with solvent.
- Inject into GC-MS.
- Identify ignitable liquid based on pattern recognition and comparison.



Slide 8-79

- D. Passive adsorption-elution.

1. Also known as:
 - a. Passive Headspace Concentration (PHC).
 - b. Passive Charcoal Adsorption (PCA).
 - ASTM E 1412.
2. Samples extracted via PHC:
 - a. Activated Charcoal Strip (ACS) is suspended in container.
 - b. Kept in oven or ambient (overnight).
 - c. ACS eluted with carbon disulfide.

FIRE DEBRIS ANALYSIS

Gas Chromatograph - Mass Spectrometer (GC-MS):

- Separation of components (GC).
- Detection and identification of compounds (MS).



Slide 8-80

E. Instrumentation.

Gas Chromatograph – Mass Spectrometer (GC-MS):

1. Separation of components (GC).
2. Detection and identification of compounds (MS).

IGNITABLE LIQUID CLASSIFICATION

- Petroleum products are classified, not identified.
- Marketing practices.
 - Same product may be marketed under a variety of end uses or brand names.
- Classified by comparing patterns to reference ignitable liquids.



Slide 8-81

F. Ignitable liquid classification.

1. Petroleum products are classified, not identified.
2. Marketing practices.

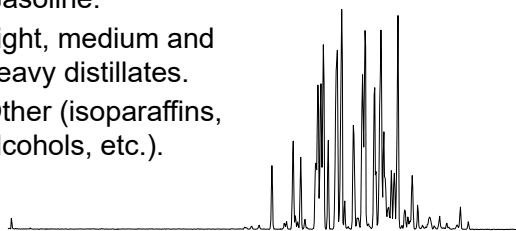
Same product may be marketed under a variety of end uses or brand names.

3. Classified by comparing patterns to reference ignitable liquids.

IGNITABLE LIQUID CLASSIFICATION (cont'd)

Based on boiling point range or "cut" and on chemical composition:

- Gasoline.
- Light, medium and heavy distillates.
- Other (isoparaffins, alcohols, etc.).

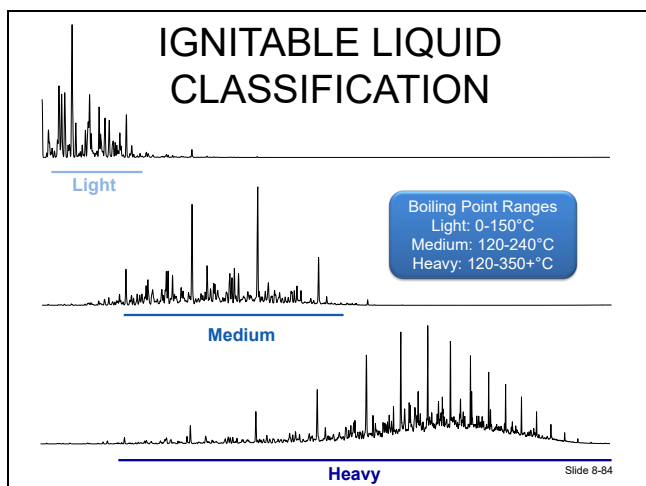


Slide 8-82

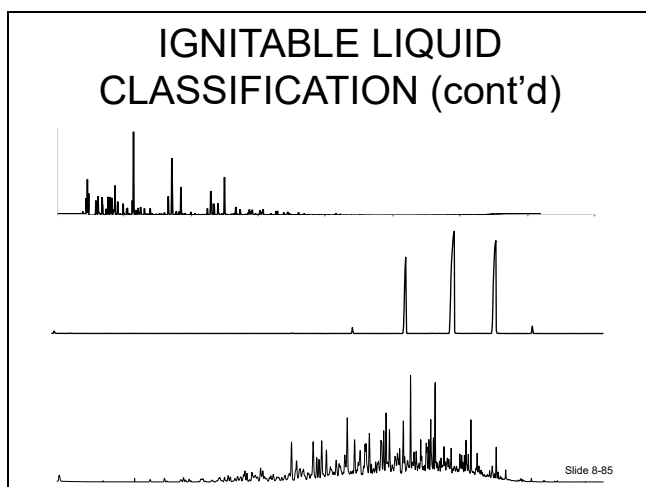
4. Based on boiling point range or "cut" and on chemical composition:
 - a. Gasoline.
 - b. Light, medium and heavy distillates.
 - c. Other (isoparaffins, alcohols, etc.).

Class	Light (C ₄ -C ₁₂)	Medium (C ₁₂ -C ₂₀)	Heavy (C ₂₀ -C ₃₀ *)
Gasoline	Fresh gasoline is typically in the range C ₄ -C ₁₂		
Petroleum Distillates	Petroleum Ether Cigarette Lighter Fluids Camping Fuels Naphtha	Charcoal Starters, Paint Thinners, Dry Cleaning Solvents, Mineral Spirits Automotive Parts Cleaners, Spray Lubricants, Lamp Oils, Desk Sealers, Varnishes, Kerosene, Insecticides	Kerosene, Diesel Fuel Charcoal Starters, Aviation Fuels Insecticides, Fuel Additives, Lamp Oils Automotive Parts Cleaners
Isoparaffinic Products	Aviation Gasolines Lighter Fluids Charcoal Starters	Charcoal Starters, Paint Thinners, Copier Toners, Mineral Spirits, Solvent Cleaners Kerosene, Lamp Oils, Gun Oils	Spot Cleaners Penetrating Oils Insecticides
Aromatic Products	Automotive Parts Cleaners Solvent Cleaners, Xylenes Toluene-based Products Lacquer Thinners	Automotive Parts Cleaners Specialty Cleaning Solvents Insecticides Brush Cleaners	Insecticides Adhesives
Naphthenic/Paraffinic Products	Cyclohexane-based Solvents/Products	Charcoal Starters, Insecticides Lamp Oils, Mineral Spirits Automotive Parts Cleaners	Insecticides Lamp Oils
Normal Alkane Products		Candle Oils Copier Toners Lamp Oils Wax Cleaners	Candle Oils Lamp Oils Carbonless Forms Copier Toners
Oxygenated Solvents	Alcohols, Ketones Lacquer Thinners, Fuel Additives Surface Preparation Solvents Automotive Parts Cleaners Spray Adhesives, Brush Cleaners	Metal Cleaners Gloss Removers Degreasers Furniture Strippers Cleaning Solvents, Insecticides	Biodiesels Fuel Additives Floor Finishes Insecticides
Others-Miscellaneous	Single Component Products Enamel Reducers, Lacquer Thinners Aviation Gasolines Racing Gasolines	Turpentine Products Mineral Spirits, Fuel Additives Spray Lubricants, Brush Cleaners Paint Thinners, Citrus Cleaners Charcoal Starters	Lamp Oils, Insecticides Citrus Cleaners Automotive Parts Cleaners Kerosene, Fuel Additives

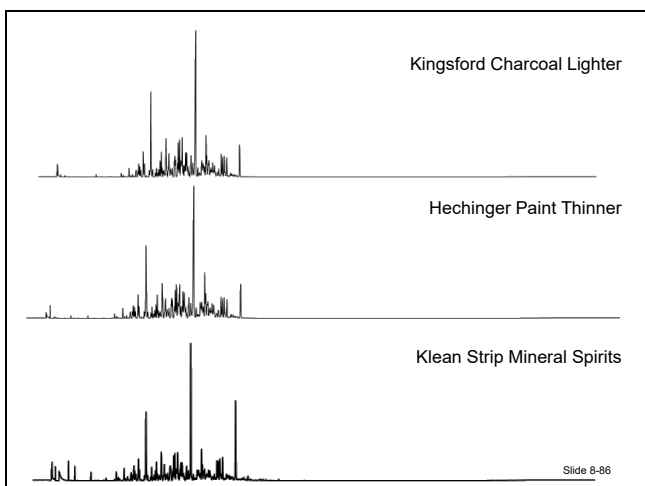
Slide 8-83

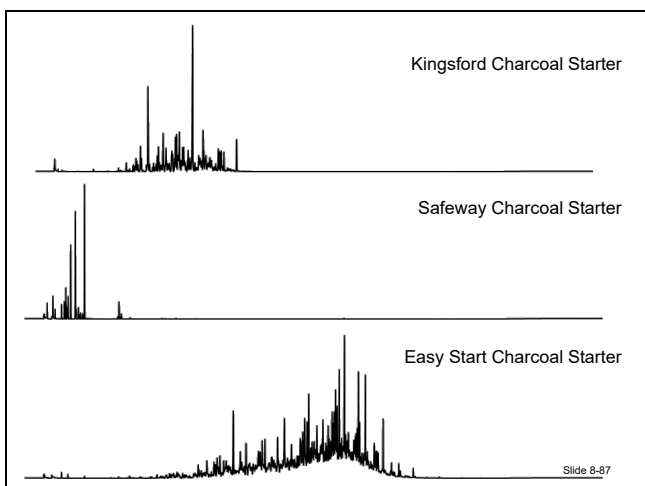


Slide 8-84



Slide 8-85





COMMONLY ASKED QUESTIONS

- Can you compare Liquid A to Liquid B?
 - Not at ATF labs.
 - Testing for markers done at private labs at investigator's and prosecutor's expense.
- Can you compare Liquid A to Debris B?
 - No...



Slide 8-88

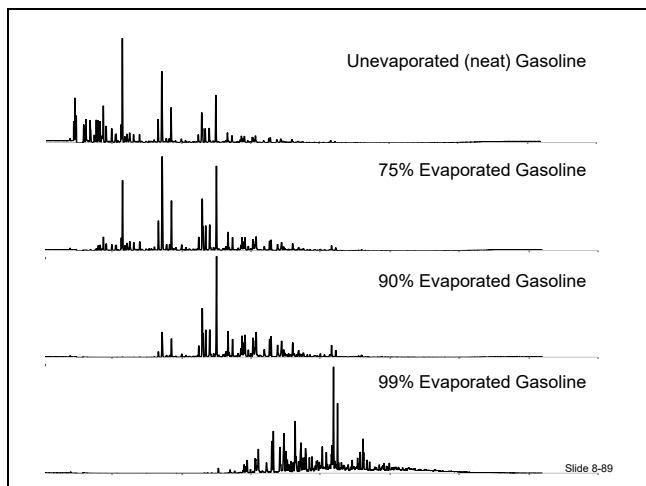
G. Commonly asked questions.

1. Can you compare Liquid A to Liquid B?

- a. Not at the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) labs.
- b. Testing for markers done at private labs at investigator's and prosecutor's expense.

2. Can you compare Liquid A to Debris B?

No.



COMMONLY ASKED QUESTIONS (cont'd)

- When can I expect results?
 - Best scenario: three days from submission to result, depending on:
 - Current backlog.
 - Number of items submitted.
 - Number of items in 5-gallon cans.
 - **REMINDER: 5-gallon cans are the EXCEPTION not the rule.**

Slide 8-90

3. When can I expect results?

Best scenario: three days from submission to result, depending on:

- a. Current backlog.
- b. Number of items submitted.

c. Number of items in 5-gallon cans.

4. **Reminder: 5-gallon cans are the exception, not the rule.**

COMMONLY ASKED QUESTIONS (cont'd)

- Why three or more days?
 - Most evidence requires overnight extraction.
 - Oven space is limited.
 - One GC-MS run takes 45 min.
- Allow at least a week to receive final written report.
 - Consider time needed for other exams.

Slide 8-91

5. Why three or more days?

- a. Most evidence requires overnight extraction.
- b. Oven space is limited.
- c. One GC-MS run takes 45 minutes.

6. Allow at least one week to receive final written report.

Consider time needed for other exams.

COMMON FIRE DEBRIS ISSUES

- Reexamining evidence:
 - Analyzing preserved C-strip.
 - Usually saved for defense.
 - Complete re-extraction (PHC) of evidence
 - Potential degradation over time (packaging, ignitable liquid).
- Most labs will not reexamine evidence from another laboratory:
 - Unless examination not possible, e.g.:
 - Lab does not have DNA capabilities.
 - Lab cannot analyze for vegetable oils.

Slide 8-92

H. Common fire debris issues.

1. Reexamining evidence.
2. Most labs will not reexamine evidence from another laboratory.

Unless examination not possible.

- a. E.g., lab does not have DNA capabilities.
- b. E.g., lab cannot analyze for vegetable oils.

REPORTING GUIDELINES

What should you expect in a fire debris analysis report?

Slide 8-93

I. Reporting guidelines.

What should you expect in a fire debris analysis report?

LABORATORY REPORT WORDING

Results of examination.

- Exhibit 3 contained a medium petroleum distillate (MPD), which is an ignitable liquid. Examples of MPDs include some charcoal starters, some brands of paint thinners and mineral spirits.
- Gasoline, an ignitable liquid, was identified in Exhibit 4.
- No ignitable liquids were identified in Exhibits 1 and 2.

Slide 8-94

J. Laboratory report wording.

Results of examination.

1. Exhibit 3 contained a medium petroleum distillate (MPD), which is an ignitable liquid. Examples of MPDs include some charcoal starters, some brands of paint thinners and mineral spirits.
2. Gasoline, an ignitable liquid, was identified in Exhibit 4.
3. No ignitable liquids were identified in Exhibits 1 and 2.

NEGATIVE REPORTS

- No ignitable liquid in sample:
 - None used.
 - Not in sample collected.
- Below limits of detection due to:
 - Consumption by fire.
 - Evaporation prior to collection.
 - Evaporation after collection.
- Matrix interferences:
 - Native to substrate.
 - Right compounds, not the right pattern.

Slide 8-95

K. Negative reports.

1. No ignitable liquid in sample:
 - a. None used.
 - b. Not in sample collected.
2. Below limits of detection due to:
 - a. Consumption by fire.
 - b. Evaporation prior to collection.
 - c. Evaporation after collection.
3. Matrix interferences:
 - a. Native to substrate.
 - b. Right compounds, not the right pattern.

NEGATIVE REPORTS (cont'd)

- Degradation:
 - Started out as an ignitable liquid, but changed while in the can.
- Lack of appropriate reference.
- Low signal.
- Examiner discretion/examiner error.
- Lab protocol.

Slide 8-96

4. Degradation.

Started out as an ignitable liquid, but changed while in the can.

5. Lack of appropriate reference.

6. Low signal.

7. Examiner discretion/examiner error.

8. Lab protocol.

OTHER RELATED ANALYSES

Incendiary devices, lubricating oils,
vegetable/animal oils and alternative fuels

Slide 8-97

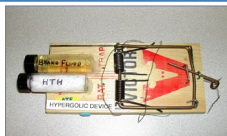
L. Other related analysis.

1. Incendiary devices, lubricating oils.

2. Vegetable/animal oils, and alternative fuels.

CHEMICAL INCENDIARIES

- Homemade napalm.
- Hypergolic devices (self-igniting):
 - Pool chlorine/brake fluid.
 - Potassium chlorate, sugar, sulfuric acid.
 - Sodium/potassium metal and water.
 - Potassium permanganate and glycerin.
 - Commercial thermite.
- Delay — chemical or burn rate.



Slide 8-98

M. Chemical incendiaries.

1. Homemade napalm.
2. Hypergolic devices (self-igniting):
 - a. Pool chlorine/brake fluid.
 - b. Potassium chlorate, sugar, sulfuric acid.
 - c. Sodium/potassium metal and water.
 - d. Potassium permanganate and glycerin.
 - e. Commercial thermite.
3. Delay — chemical or burn rate.

PACKAGING OF CHEMICAL INCENDIARIES

- Polyethylene or nylon bag.
- No direct contact with metal.
- Plastic bag may be placed in metal paint can.



Slide 8-99

N. Packaging of chemical incendiaries.

1. Polyethylene or nylon bags.
2. No direct contact with metal.
3. Plastic bag may be placed in metal paint can.

LUBRICATING OILS

- Examples include:
 - Motor oil.
 - Baby oil.
 - Mineral oil
 - Power steering fluid.
 - Oils in explosives (Composition C-4).
- Q and K comparisons possible on a variety of evidence (scene, clothes, car, ground, etc.)



Slide 8-100

O. Lubricating oils.

1. Examples include:
 - a. Motor oil.
 - b. Baby oil.
 - c. Mineral oil.
 - d. Power steering oil.
 - e. Oils in explosives (Composition C-4).
2. Q and K comparisons possible on a variety of evidence (scene, clothes, car, ground, etc.).

VEGETABLE AND ANIMAL FATS/OILS

- Some are prone to spontaneous ignition:
 - Linseed oil.
 - Tung oil.
- Although not flammable and therefore not good accelerants, they are **ignitable**.
- Extract debris to look for specific compounds indicative of vegetable oils.
- **Must refrigerate immediately.**



Slide 8-101

P. Vegetable and animal fats/oils.

1. Some are prone to spontaneous ignition.
 - a. Linseed oil.
 - b. Tung oil.
2. Although not flammable, they are **ignitable**.
3. Extract debris to look for specific compounds indicative of vegetable oils.
4. **Must refrigerate immediately.**

BIODIESEL

- Manufactured from vegetable oils, animal fats or recycled restaurant greases.
- Grades:
 - B100 — 100% biodiesel.
 - B20 — 20% biodiesel blended with petroleum diesel.

Slide 8-102

Q. Biodiesel.

1. Manufactured from vegetable oils, animal fats or recycled restaurant greases.

2. Grades.

- a. B100 — 100% biodiesel.
- b. B20 — 20% biodiesel blended with petroleum diesel.

BIODIESEL (cont'd)

Production:

- Base catalyzed transesterification of vegetable oil with methanol.
- Raw vegetable oils will not work!



Slide 8-103

3. Production:

- a. Base catalyzed transesterification of vegetable oil with methanol.
- b. Raw vegetable oils will not work!

E85

- 85% ethanol, 15% gasoline.
 - Regular gasoline contains up to 10% ethanol.
- Need special fuel lines for E85.
- Produced from starch-based crops (corn).



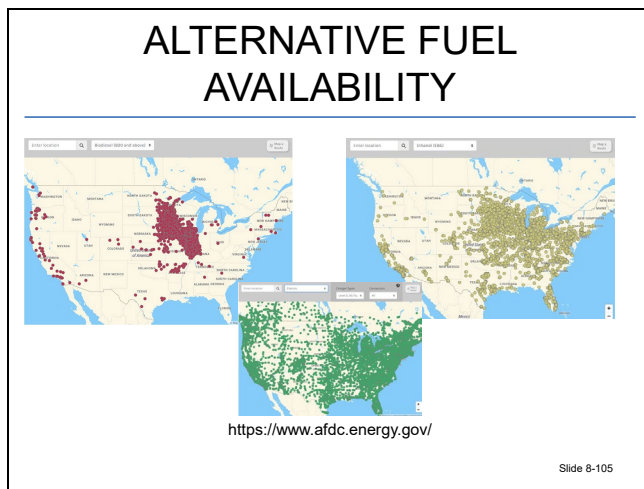
Slide 8-104

R. E85.

1. 85% ethanol, 15% gasoline.

Regular gasoline contains up to 10% ethanol.

2. Need special fuel lines for E85.
3. Produced from starch-based crops (corn).



S. Alternative fuel availability.

ALTERNATIVE FUEL LAB ANALYSIS

- Biodiesel and E85 can be analyzed in fire debris laboratories.
- Ethanol in E85 can be detected with appropriate instrumental conditions.
- Studies show means of suppression may reduce or eliminate presence of ethanol.
- Ethanol is water soluble!

Slide 8-106

T. Alternative fuel lab analysis.

1. Biodiesel and E85 can be analyzed in fire debris laboratories.
2. Ethanol in E85 can be detected with appropriate instrumental conditions.
3. Studies show means of suppression may reduce or eliminate presence of ethanol.
4. Ethanol is water soluble!

VII. SUMMARY



SUMMARY

- Beware of contamination.
- Proper evidence packaging is crucial for fire debris.
- Contact laboratory personnel for packaging and submission questions.

Slide 8-107

UNIT 9: FIRE DYNAMICS PRACTICUM

TERMINAL OBJECTIVE

The students will be able to:

- 9.1 *Conduct a fire loss investigation; document and communicate the findings.*

ENABLING OBJECTIVES

The students will be able to:

- 9.1 *Conduct a safe and systematic fire scene investigation to determine the area (or point) of origin.*
- 9.2 *Identify fire dynamics, fire patterns, electrical system, or evidence, and explain the application to the fire scene.*
- 9.3 *Create an accurate and referenced document explaining the findings.*
-

This page intentionally left blank.



TERMINAL OBJECTIVE

Conduct a fire loss investigation;
document and communicate the
findings.

Slide 9-2

ENABLING OBJECTIVES

- 9.1 Conduct a safe and systematic fire scene investigation to determine the area (or point) of origin.
- 9.2 Identify fire dynamics, fire patterns, electrical system, or evidence, and explain the application to the fire scene.
- 9.3 Create an accurate and referenced document explaining the findings.

Slide 9-3

I. OVERVIEW OF SCENE PROCESSING INSTRUCTIONS

BURN LABORATORY ACTIVITIES

1. On Tuesday of this week, students watched the flashover cell demonstration.
2. On Thursday, instructors demonstrated how they would process a fire scene and showed various aspects, such as fire patterns, effects and dynamics.
3. For this exercise, students will use their observations and notes to answer five essay questions.

Slide 9-4

SCENE INVESTIGATION
ACTIVITY 9.1

Part 1: Scene examination

- Process and document the scene.
- Evaluate the fire dynamics.
- Evaluate ventilation.
- Evaluate the electrical system, including an arc fault survey analysis.
- Evaluate fire patterns significant to the origin determination.
- Determine area of origin.

Slide 9-5

A. Part 1: Scene examination.

1. Process and document the scene.
2. Evaluate the fire dynamics.
3. Evaluate ventilation.
4. Evaluate the electrical system, including an arc fault survey analysis.
5. Evaluate fire patterns significant to the origin determination.
6. Determine area of origin.

SCENE INSPECTION ACTIVITY 9.1

Part 2: Essay questions

- Answers will be uploaded to Blackboard under Assignment 9.1.
- Do not attempt to attach photographs to your essay answers.
- Individually prepared sketches, notes, photographs or evidence may be used for reference during the essay assignment.

Slide 9-6

B. Part 2: Essay questions.

1. Answers will be uploaded to Blackboard under Assignment 9.1.
2. Do not attempt to attach photographs to your essay answers.
3. Individually prepared sketches, notes, photographs or evidence may be used for reference during the essay assignment.
4. Complete essay assignment by 8:00 a.m. Monday morning.

This page intentionally left blank.

ACTIVITY 9.1

Fire Dynamics Practicum

Purpose

Complete a practical exercise that culminates in response to five essay questions. Each question directly aligns to learning objectives that are captured in the grading rubric.

Directions

1. On Tuesday of this week, you watched the flashover cell demonstration.
2. On Thursday, instructors demonstrated how they would process a fire scene and showed various aspects, such as fire patterns, effects and dynamics.
3. For this exercise, you will use your observations and notes to answer five essay questions.
4. The essay assignment is due by 8:00 a.m. Monday morning and is to include:
 - a. Format:
 - Grammatically and technically correct.
 - Responses should be of sufficient length to cover the questions, ranging from 250- to 500-word responses, as needed, based on the fire scene.
 - b. Essay questions:
 - Describe the fire dynamics of Flashover Cell 1 (for example, heat transfer, heat release rate (HRR) and burning characteristics of significant fuel packages).
 - Identify and describe ventilation impacts and effects on fire development and scene investigation. Compare why the ventilation affected the development and patterns observed between Cell 1 and Cell 2.
 - Explain the use or application of the data collected from the electrical system (including arc fault survey analysis) as applied to the origin determination of the fire in Cell 1.
 - Identify and describe fire patterns in Cell 1 that were significant to the origin determination.

- Identify the area of origin of the fire in Cell 1.
- 5. You should reference responses with National Fire Protection Association (NFPA) 921, *Guide for Fire and Explosion Investigations*.
- 6. This assignment is worth 30% of the final grade.

UNIT 10: FIRE SCENE INVESTIGATION AND DOCUMENTATION

TERMINAL OBJECTIVE

The students will be able to:

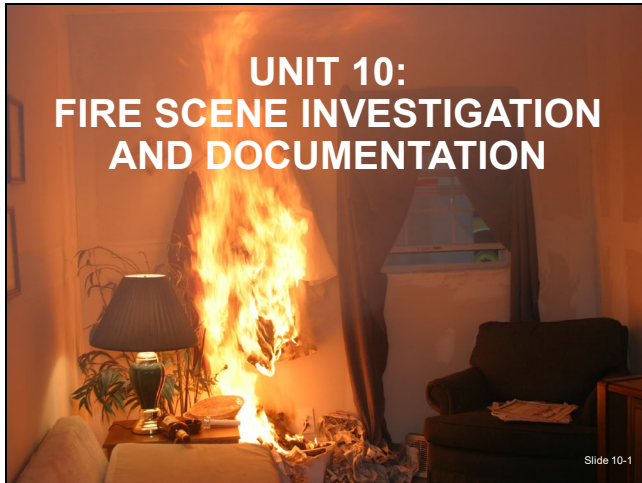
- 10.1 *Formulate a plan, using the systematic approach of the scientific method, to determine the origin and cause of the fire.*

ENABLING OBJECTIVES

The students will be able to:

- 10.1 *Apply the seven steps of the scientific method to systematically determine the origin and cause of a fire, as recommended by National Fire Protection Association (NFPA) 921, Guide for Fire and Explosion Investigations.*
 - 10.2 *Evaluate and create documentation for a fire scene investigation to include notes, sketches, photos, etc., as required by NFPA 1033, Standard for Professional Qualifications for Fire Investigator.*
 - 10.3 *Collect, analyze and differentiate the various types of information: witness statements, fire patterns, and fire dynamics, used to determine an area of origin, as outlined in NFPA 921.*
 - 10.4 *Conduct a comprehensive fire scene examination, including the documentation and evaluation of various related systems.*
 - 10.5 *Summarize the process and evaluate the systematic methods employed to determine the cause of a fire, as outlined by NFPA 921.*
-

This page intentionally left blank.



TERMINAL OBJECTIVE

Formulate a plan, using the systematic approach of the scientific method, to determine the origin and cause of the fire.

Slide 10-2

ENABLING OBJECTIVES

- 10.1 Apply the seven steps of the scientific method to systematically determine the origin and cause of a fire, as recommended by National Fire Protection Association (NFPA) 921, *Guide for Fire and Explosion Investigations*.
- 10.2 Evaluate and create documentation for a fire scene investigation to include notes, sketches, photos, etc., as required by NFPA 1033, *Standard for Professional Qualifications for Fire Investigator*.
- 10.3 Collect, analyze and differentiate the various types of information: witness statements, fire patterns, and fire dynamics, used to determine an area of origin, as outlined in NFPA 921.

Slide 10-3

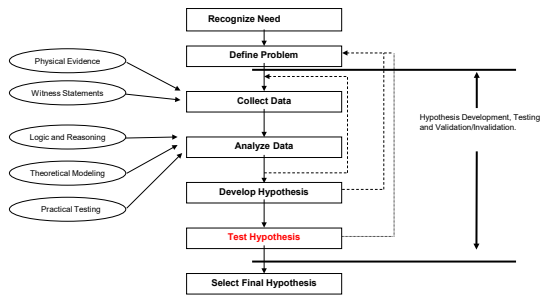
ENABLING OBJECTIVES (cont'd)

- 10.4 Conduct a comprehensive fire scene examination, including the documentation and evaluation of various related systems.
- 10.5 Summarize the process and evaluate the systematic methods employed to determine the cause of a fire, as outlined by NFPA 921.

Slide 10-4

I. APPLY SCIENTIFIC METHOD AND SYSTEMATIC METHODOLOGY

METHODOLOGY APPLIED TO FIRE INVESTIGATION



Slide 10-5

- A. Identify the Scientific Method as the overall methodology to be used for conducting fire origin and cause investigations. Give an example of how the Scientific Method is applied to fire investigation. **Test hypothesis** is highlighted in red because this is a step that is commonly overlooked or misapplied. Example: The investigator examines an exterior wall at a fire scene which is absent of fire effects and patterns.
1. The data collected shows no fire damage to the wall.
 2. The analysis of the data (lack of fire patterns/effects) is indicative of a fire not originating on or along the wall.
 3. The investigator develops the hypothesis that the fire did not originate on or along the wall.

4. The investigator conducts a cognitive test based on their training, knowledge and experience that the fire did not start on or along the wall.
5. The investigator cannot disprove their hypothesis, therefore validating that the fire did not originate on or along the wall.

SCIENTIFIC METHOD – AVOID BIAS

- **Presumption** — hypothesis developed before data collection.
- **Expectation** — a premature conclusion without consideration of all data; typically based on previously formed assumption(s).
- **Confirmation** — only collecting data to support the investigator's hypothesis.



Slide 10-6

- a. **Presumption** — hypothesis developed before data collection.
- b. **Expectation** — a premature conclusion without consideration of all data; typically based on previously formed assumption(s).
- c. **Confirmation** — only collecting data to support the investigator's hypothesis.

SYSTEMATIC PROCEDURE

- Establish a systematic procedure for each type of incident.
- Repetition = Consistency.
- Example:
 - Start at exterior working to the interior.
 - Least to most damage.



What is your systematic procedure?

Slide 10-7

- B. Establish a systematic procedure for each type of incident.
 1. Repetition = Consistency.

a. Example:

- Start at exterior working to the interior.
- Least to most damage, keeping in mind the effects that fire dynamics, such as ventilation, may have on fire patterns/effects when analyzing areas of fire damage.

THE SYSTEMATIC PROCEDURE
REMAINS THE SAME



Small countertop fire Large warehouse fire

Slide 10-8

b. Repetition of the same methodology helps to prevent errors. Not all investigations are the same, but the physics and chemistry of all fires are the same.

SYSTEMATIC PROCEDURE

- Use your systematic procedure.
- Scene circumstances may cause the investigator to deviate from their systematic procedure.
- Document deviations in the O&C report.



Slide 10-9

2. The size, type, and complexity of scene will change, but the methodology should remain the same. Developing the process and the method and practicing it on small fires reinforces the habit and methodology.

SCIENTIFIC METHOD

- Recognize the need.
- Define the problem.
- Collect data.
- Analyze data.
- Develop hypotheses.
- Test the hypotheses.
- Select final hypothesis.

-NFPA 921, Section 4.3

Slide 10-10

C. Scientific Method (National Fire Protection Association (NFPA) 921, Section 4.3).

1. Recognize the need (Section 4.3.1).
2. Define the problem (Section 4.3.2).
3. Collect data (Section 4.3.3).
4. Analyze data (Section 4.3.4).
5. Develop hypotheses (Section 4.3.5).
6. Test the hypotheses (Section 4.3.6).
7. Select final hypothesis (Section 4.3.7).

RECOMMENDED FIRE SCENE EXAMINATION METHODOLOGY

- 1) Initial scene assessment.
- 2) Preliminary origin and fire spread hypothesis.
- 3) In-depth scene examination and reconstruction.
- 4) Development of final fire spread hypothesis.
- 5) Fire origin identification.



-NFPA 921, Section 18.2.5

Slide 10-11

D. Recommended methodology for conducting fire scene investigations.

1. Initial scene assessment.

2. Preliminary origin and fire spread hypothesis.
3. In-depth scene examination and reconstruction.
4. Development of final fire spread hypothesis.
5. Fire origin identification (NFPA 921, Section 18.2.5, 2024 ed.)
6. This slide shows the recommended fire scene examination methodology per NFPA 921, *Guide for Fire and Explosion Investigations*. The initial scene assessment should include an exterior and interior assessment. Data collected and analyzed during the initial scene assessment may provide the investigator with a preliminary fire spread hypothesis. The investigator will then conduct an in-depth examination and reconstruction to validate or invalidate the initial spread hypothesis. A final fire origin determination will be made based upon the scene data, analysis, hypothesis development and testing outcomes.

SEQUENCE OF ACTIVITIES

- Recommended methodology for conducting fire scene investigations.
- All investigative activities may be performed independently or simultaneously at various stages of the investigation.



Slide 10-12

- E. Fire scene investigations are not linear.

All investigative activities may be performed independently or simultaneously at various stages of the investigation.

II. OVERVIEW OF DOCUMENTATION

DOCUMENTATION OVERVIEW

- Begin the documentation when you are notified of the assignment of the origin and cause investigation.
- The duties of documenting the fire scene should include diagramming and photographing the scene, and taking field notes to be used to document scene findings, or to prepare a written report.
- Documentation should continue throughout the origin and cause investigation and reflect a systematic approach.

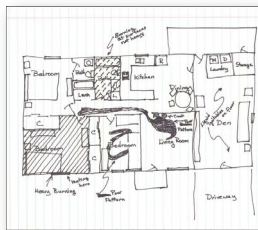


Slide 10-13

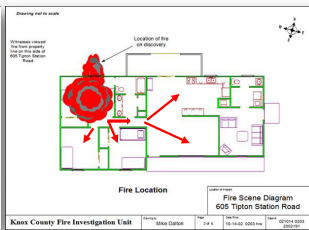
A. Documentation.

1. Begin the documentation when you are notified of the assignment of the origin and cause investigation.
2. The duties of documenting the fire scene should include diagramming and photographing the scene, and taking field notes to be used to document scene findings, or to prepare a written report.
3. Documentation should continue throughout the origin and cause investigation and reflect a systematic approach.

TYPES OF DIAGRAMS



Rough Sketch



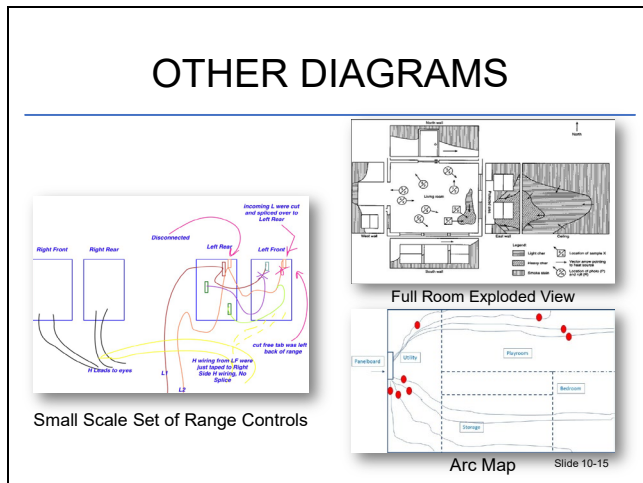
Detailed Floor Plan With Heat/Flame Vector Analysis

Slide 10-14

B. Diagrams.

1. Paper and pencil - no necessity for straight lines or mistake-free work.

2. A legend and notes off to the side.
3. Made after the preliminary scene examination has been conducted and before moving or removing any evidence.
4. When it is necessary to move or remove items prior to completing a sketch, photographs must be taken.
5. Objects are not drawn with infinite detail.
6. Choose and utilize symbols when drawing sketches.
7. When the investigator uses letters or numbers in the sketch or diagram, they may place them in a circular or rectangular box.
8. Use common fire service or diagramming symbols for notations and show a legend.



9. Examples.

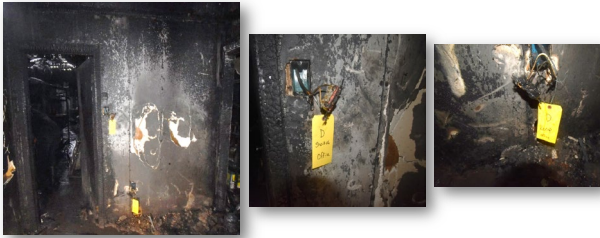


C. Photographs.

1. Essential in revealing smaller pieces of evidence within a large area.
2. The item of evidence or subject to be photographed is first photographed from a distance.
3. Additional photographs are then taken as the investigator narrows the gap between themselves and the subject being photographed.
4. The final photograph is then taken, with the subject area encompassing the entire frame.

FIRE SCENE: PHOTOGRAPHIC TECHNIQUES

Use a methodical order and orient the viewer. Use identifying markers when needed.



Slide 10-17

5. Use a methodical order and orient the viewer. Use identifying markers when needed.

FIRE SCENE: 360 VIDEO SLIDE

- Consider 360° camera to document the fire scene during various stages of processing.
- Several affordable models available from various manufacturers.
- Demonstrative evidence for courtroom.



Slide 10-18

6. Consider 360° camera to document the fire scene during various stages of processing.

- a. Several affordable models available from various manufacturers.
- b. Demonstrative evidence for courtroom.

FIRE SCENE: AERIAL PHOTOGRAPHS

Aerial examination and documentation. May help depict origin area and fire spread.



Slide 10-19

7. Aerial examination and documentation. May help depict origin area and fire spread.

FIRE SCENE: VIDEO DOCUMENTATION

- There may be times when you want to video the scene.
- Disable audio function.
- It helps avoid "mosaic" photography.



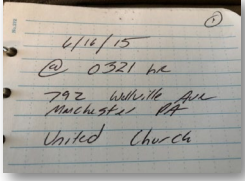
Slide 10-20

D. Video.

1. There may be times when you want to video the scene.
2. Disable audio function.
3. It helps avoid "mosaic" photography.

NOTE TAKING

- Data collection and planning begins at the time the investigator is notified of an incident.
- Should encompass all aspects of investigative activity.
- Notes may be discoverable.



Slide 10-21

E. Note taking.

1. Data collection and planning begins at the time the investigator is notified of an incident.
2. Identify general data that should be collected and documented. Almost all of the notes from this point forward are likely discoverable.

III. OBJECTIVE ONE: DETERMINING THE ORIGIN OF THE FIRE

OBJECTIVE ONE: DETERMINING THE ORIGIN OF THE FIRE

- The origin investigation and determination establishes the area where the fire started.
- An investigator should always be able to determine an origin. It may be a small area or an entire building.



Slide 10-22

- A. The origin investigation and determination establishes the area where the fire started. An investigator should always be able to determine an origin. It may be a small area or an entire building.

FIRE ORIGIN DETERMINATION

- Area of origin (in red) – “a structure, part of a structure, or general geographic location within a fire scene, in which the ‘point of origin’...is reasonably believed to be located.”
- Point of origin (in yellow) – “the exact physical location within the area of origin where a heat source and the fuel interact, resulting in a fire or explosion.”



-NFPA 921, Section 3.3.153

Slide 10-23

1. Area of origin – “a structure, part of a structure, or general geographic location within a fire scene, in which the ‘point of Origin’...is reasonably believed to be located” (NFPA 921, Section 3.3.14, 2024 ed.).
2. Point of origin – “the exact physical location within the area of origin where a heat source and the fuel interact, resulting in a fire or explosion” (NFPA 921, Section 3.3.153, 2024 ed.).

ORIGIN DETERMINATION NFPA 921

Determination of the origin of the fire involves the coordination of information derived from one or more of the following:

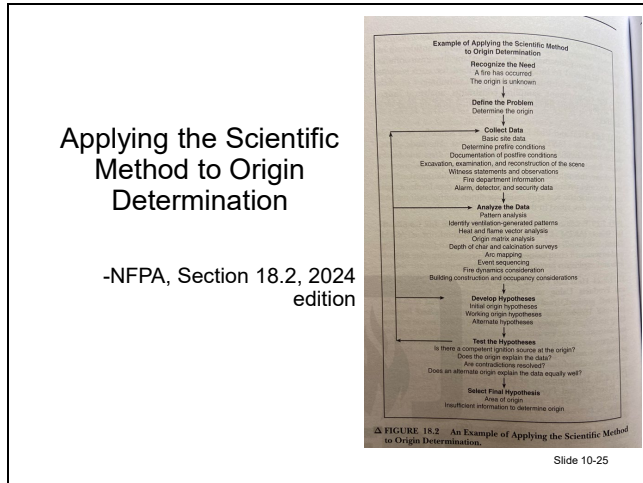
- **Witness Information and/or Electronic Data**
- **Fire Effect/Patterns**
- **Fire Dynamics**

- NFPA 921, Section 18.1.2



Slide 10-24

3. Determination of the origin of the fire involves the collection and analysis of data points of information derived from one or more of the following:
 - a. Witness Information and/or Electronic Data.
 - b. Fire Effects/Patterns.
 - c. Fire Dynamics (NFPA 921, Section 18.1.2, 2024 ed.).



4. Overall methodology of origin determination as recommended by NFPA 921, Section 18.2, 2024 ed.
 - a. Recognizing and defining the problem to be solved.
 - b. Collecting data.
 - c. Analyzing the data.
 - d. Developing hypotheses.
 - e. And most importantly, testing the hypothesis or hypotheses.

FIRE SCENE: LAWFUL ENTRY

Establish lawful entry to the scene:

- Exigent circumstances.
- Consent.
- Search warrant.
- Administrative warrant.

Slide 10-26

- B. Establish lawful entry to the scene.
 1. Exigent circumstances.
 2. Consent.

3. Search warrant.
4. Administrative warrant.

FIRE SCENE: SECURITY

- Maintain the integrity of the scene.
- Treat the scene as a potential crime scene.
- Establish secure perimeter.
- Limit access to the scene.
- Escort witnesses into scene as needed.
- Arrange overnight security.



Slide 10-27

- C. Maintain the integrity of the scene.
 1. Treat the scene as a potential crime scene.
 2. Establish secure perimeter.
 3. Limit access to the scene.
 4. Escort witnesses into scene as needed.
 5. Arrange overnight security.

FIRE SCENE: SAFETY

Common hazards:

- Investigating scene alone.
- Investigator fatigue.
- Working around heavy equipment.
- Physical hazards.
- Structural stability hazards.
- Electrical hazards.
- Mechanical hazards.
- Utilities.



Slide 10-28

- D. Hazards that affect scene safety.

1. Common hazards:
 - a. Investigating scene alone.
 - b. Investigator fatigue.
 - c. Working around heavy equipment.
 - d. Physical hazards.
 - e. Structural stability hazards.
 - f. Electrical hazards.
 - g. Mechanical hazards.
 - h. Utilities.

VIDEO: COLLAPSE HAZARDS VIDEO



Slide 10-29

FIRE SCENE PROCESSING PPE

Wear appropriate type
and level of PPE:

- Chemical hazards.
- Biological hazards.
- Radiological hazards.
- Explosive atmospheres.
- Low oxygen atmospheres.
- Drug labs.



Slide 10-30

2. Wear appropriate type and level of personal protective equipment (PPE):
 - a. Chemical hazards.
 - b. Biological hazards.
 - c. Radiological hazards.
 - d. Explosive atmospheres.
 - e. Low oxygen atmospheres.
 - f. Drug labs.

FIRE SCENE: WEATHER CONDITIONS

Do any of the following weather factors affect the safety of the personnel on the fire scene?

- Wind direction.
- Storms.
- Humidity.
- Temperature.



Slide 10-31

E. Weather.

Do any of the following weather factors affect the safety of the personnel on the fire scene?

1. Wind direction.
2. Storms.
3. Humidity.
4. Temperature.

SCENE PROCESSING: CROSS-CONTAMINATION

Cross-contamination is the unintentional contamination of scene or evidence during examination, collection, storage or transport.

Preventing cross-contamination at the fire scene.

- Use only clean tools.
- Use a clean pair of gloves for every evidence sample.
- Avoid the use of any gasoline-powered equipment upon the fire scene.
- Use only clean evidence containers.
- Consider establishing a decontamination line to clean tools and the footwear of any persons entering the scene.



Slide 10-32

- F. Cross-contamination is the unintentional contamination of scene or evidence during examination, collection, storage or transport.

Preventing cross-contamination at the fire scene.

1. Use only clean tools.
2. Use a clean pair of gloves for every evidence sample.
3. Avoid the use of any gasoline-powered equipment upon the fire scene.
4. Use only clean evidence containers.
5. Consider establishing a decontamination line to clean tools and the footwear of any persons entering the scene.

IV. COLLECT AND ANALYZE DATA: WITNESS INFORMATION/ELECTRONIC DATA

FIRE SCENE PROCESSING: WITNESSES

- Witness statements are one of the three considerations for determining origin.
- Witness information alone may solve the fire origin.
- With no witness information, the fire scene processing can be more time consuming or involved.
- Witness information must be validated or tested through the scene inspection or hypothesis testing.



Witnesses can be transient or lost.

Slide 10-33

- A. The scientific method requires the collection and analysis of data. Witnesses are a primary source of nonscene data in almost every incident. The investigator should identify and interview any witness who may have data that is relevant to the incident (NFPA 921, Section 14.1.1, Section 14.5.1.1, 2024 edition).
1. Witness statements are one of the three considerations for determining the origin of the fire. (NFPA 921, Section 18.1.2, 2024 edition).
 2. Witness information, especially eyewitness, may provide data that identifies the origin of the fire.
 3. With no witness information, the fire scene processing can be more time consuming or involved.
 4. Witness information must be validated, analyzed and tested through the scene inspection and hypothesis testing.

OBTAINING INFORMATION FROM WITNESSES

- Document information via notes, audio/video recordings, photographs and diagrams.
- Ongoing process that occurs prior to, during, and post fire scene examination.
- Includes occupants, first responders, witnesses, others.



Slide 10-34

5. Witness information should be documented via notes, audio/video recordings, photographs and diagrams. Interviews are an ongoing process that occurs prior to, during and post fire scene examination. Persons interviewed can include occupants, first responders, witnesses and others.
6. All electronic data, such as video surveillance and other electronically stored information (ESI), should be collected and analyzed, and considered as sources of information (NFPA 921, Section 14.5.3, 2024 edition).

FIREFIGHTERS AND FIRST RESPONDERS

- Meet with Incident Commander, obtain general incident information.
- Dispatch/arrival data.
- Involved fire/police departments.
- Observations during “360 Size Up.”
- Known hazards present .
- Injuries/fatalities.
- Identify firefighters, apparatus on scene and their locations.
- Offensive or defensive attack.



Slide 10-35

B. Firefighters and first responders.

1. The officer in charge (OIC) should be one of the first individuals to be located and interviewed. The OIC will be able to provide various details regarding the incident to include dispatch times, initial observations, involved personnel, tactics, known hazards, condition of utilities, etc.
2. Meet with Incident Commander (IC), obtain general incident information.
3. Dispatch/arrival data.
4. Involved fire/police departments.
5. Observations during “360 Size Up.”
6. Known hazards present.
7. Injuries/fatalities.
8. Identify firefighters, apparatus on scene and their locations.
9. Offensive or defensive attack.

FIRE SCENE: FIREFIGHTERS/1st RESPONDERS

- Condition of utilities.
- Condition of doors and windows.
- Bystanders present.
- Who made entry and where.
- Fire conditions, location and spread.
- What areas of the structure were accessed.
- Fire or burglar alarms noises.
- Suppression systems operating.
- Sections of structure energized.



Accountability board used to identify persons on scene.

Slide 10-36

10. Fire scene.

- Condition of utilities.
- Condition of doors and windows.
- Bystanders present.
- Who made entry and where.
- Fire conditions, location and spread.
- What areas of the structure were accessed.
- Fire or burglar alarms noises.
- Suppression systems operating.
- Sections of structure energized.

FIREFIGHTER ACTIONS AND OBSERVATIONS

Firefighter observations and actions during suppression:

- Fire spread.
- Alarms operating.
- Suppression systems operating.
- Sections of structure energized.
- Mechanical ventilation of windows, doors, roof.
- Delays in arrival or suppression.
- Any "write-off" areas.



Slide 10-37

11. Firefighters can provide valuable information regarding the operation of building alarm and suppression systems. Investigators should ask about the condition of the electrical system upon arrival and during suppression. This information is important for determining where fire may or may not have impacted the electrical system.
- a. Fire spread.
 - b. Alarms operating.
 - c. Suppression systems operating.
 - d. Sections of structure energized.
 - e. Mechanical ventilation of windows, doors, roof.
 - f. Delays in arrival or suppression.
 - g. Any “write-off” areas.

FIREFIGHTERS: SUPPRESSION

- Gasoline powered tools.
- Heavy equipment used.
- Aqueous Foams Used.
- Evidence noted/preserved.



Slide 10-38

- h. Gasoline-powered tools.
- i. Heavy equipment used.
- j. Aqueous foams used.
- k. Evidence noted/preserved.

FIREFIGHTER ACTIONS POST SUPPRESSION

- Overhaul procedures.
- Post-fire alterations.

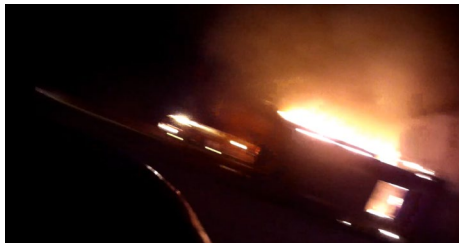


Slide 10-39

12. Excessive overhaul will make the scene examination more difficult to conduct. Contents and structural members may need to be reconstructed in order to accurately interpret fire patterns. In relation to fire department operations, the investigation occurs between suppression and overhaul. Data needs to be collected regarding post-fire alteration of valves, switches, windows, etc.

FIREFIGHTERS VIDEO COLLECTION

- Fire ground photos.
- Helmet cameras.
- Dash cams.
- Department posts to social media.



Fire Fighter Helmet Camera Video

Slide 10-40

13. Potential sources of information a firefighter could provide or the investigator could develop.
- a. Fire ground photos.
 - b. Helmet cameras.
 - c. Dash cams.
 - d. Department posts to social media.

UTILITY WORKER WITNESS INTERVIEWS

Utility or maintenance workers:

- System familiarization.
- System issues or work in area prior to or during fire.
- Utilities disconnected.
- System components removed.
- Post-fire alterations.



Slide 10-41

14. Examples of information which may be obtained:

- a. System familiarization.
- b. System issues in area prior to or during fire.
- c. Utilities disconnected.
- d. System components removed.
- e. Post-fire alterations.
- f. Was any work taking place at the time of the fire?

ANY OTHER WITNESSES

Collecting and analyzing witness information is critical aspect of the fire investigation that may occur before, during, and subsequent to the fire scene investigation.

Examples of interviewees are:

- Owner.
- Occupant.
- Employees.
- Passersby.
- Neighborhood canvas.
- Contractors.



Slide 10-42

15. Collecting and analyzing witness information is a critical aspect of the fire investigation. This may occur before, during and subsequent to the fire scene investigation.

a. Examples of persons who may be interviewed are:

- Owner.
- Occupant.
- Employees.
- Passersby.
- Neighborhood canvas.
- Contractors.

WORKING WITH WITNESSES

Walk the witness through the scene. Ask about their observations, perspective, get their story of the event. Let them talk.

- Actions taken.
- Injuries sustained.
- What was their perspective?
- Measurements.
- Establish timeline, pre, during, and post fire.
- Ask about pre-fire activities.
- Unusual smells, electrical issues.
- Known potential ignition sources.
- Recent contract/DIY work.



Slide 10-43

b. Walk the witness through the scene. Ask about their observations and perspective, and get their story of the event. Let them talk.

- Actions taken.
- Injuries sustained.
- What was their perspective?
- Measurements.
- Establish timeline, pre, during, and post fire.
- Ask about pre-fire activities.
- Unusual smells, electrical issues.
- Known potential ignition sources.
- Recent contract/Do It Yourself (DIY) work.

GET SPECIFIC WITH WITNESS

- Pre-fire conditions/photos.
- Contents present.
- Energized equipment.
- Housekeeping.
- Fire detection/suppression systems.
- Specific processes or routines.



Slide 10-44

c. List of additional information that should or could be obtained from witnesses:

- Pre-fire conditions/photos.
- Contents present.
- Energized equipment.
- Housekeeping.
- Fire detection/suppression systems.
- Specific processes or routines.

EVALUATING WITNESS STATEMENTS

- Are witness observations accurate?
- How does the ignition scenario fit with witness observations?
- Did they fight the fire?
- Statements consistent with fire dynamics and timelines?
- Is the right person asking the right questions?



Slide 10-45

- d. The investigator must evaluate the quality, type and relevancy of the information they are provided. Topics the investigator may consider:
- Are witness observations accurate?
 - How does the ignition scenario fit with witness observations?
 - Did they fight the fire?
 - Statements consistent with fire dynamics and timelines?
 - Is the right person asking the right questions?

OTHER FACTORS AFFECTING WITNESS INFORMATION

Factors affect witness reliability:

- Perception of time.
- Drugs.
- Alcohol.
- Fear.
- Stress.
- Waking.



Slide 10-46

- e. Investigators should identify the condition of the individual being interviewed and note any factors that should be considered or that may affect the reliability of the person being interviewed. Examples are:
- Perception of time.
 - Drugs.
 - Alcohol.
 - Fear.
 - Stress.
 - Waking unexpectedly.

ELECTRONIC DATA

- Witness photographs.
- Witness video.
- Surveillance systems.
- Other sources.



Witness Cell Phone



Surveillance Camera

Slide 10-47

f. Electronic data.

- Witness photographs.
- Witness video.
- Surveillance systems.
- Other sources.

ELECTRONIC DATA: VIDEO SURVEILLANCE

Locate video surveillance:

- Involved structure/property.
- Traffic cameras.
- Verify dates/times are accurate on recordings.
- Get to it early!



Slide 10-48

16. The investigator should consider the availability of other sources of witness information, such as electronic data.

a. Locate video surveillance:

- Involved structure/property.
- Traffic cameras.

- Verify dates/times are accurate on recordings.
- Get to it early!

b. Examples of these “other than people” witnesses include:

- Photographs/video surveillance systems.
- Nest or other in-home surveillance systems.
- Neighbor’s doorbell camera footage.

SPECIFIC VIDEO DATA CONSIDERATIONS

Video surveillance systems:

- Document camera location/perspective.
- Take steps to preserve and recover data.
- Where is the data stored?
- Are date and time stamps accurate?



Slide 10-49

c. Specific video data considerations.

- Document camera location/perspective.
- Take steps to preserve and recover data.
- Where is the data stored?
- Are date and time stamps accurate?

SEARCH FOR ELECTRONIC DATA

The internet as a data source – pre-fire photos, satellite photos, social media, maps, websites, realtor sites, weather.




Business website photo.

Post-fire photo.

Slide 10-50

17. Consider the internet as a data source. Pre-fire photos, mobile phone photos, satellite photos, social media, maps, websites, and realtor sites are all examples. Also, consider asking users of the building if they have any photos from parties, weddings, selfies, etc., inside the building of interest, as the backgrounds of those photos can be very helpful. For example, parishioners at some church fires provided photos from weddings, funerals, and baptisms, all of which provided background details useful during reconstruction of the fire scene.

BUILDING CONSTRUCTION CONSIDERATIONS

- Document building construction type.
- Finish materials (exterior/interior).
- Occupancy type or change of.
- Building construction has significant impact on fire growth and spread.
- Data critical for future testing and fire modeling.




Slide 10-51

18. Understand the importance of documenting building construction types. The investigator should also understand the effect of building construction on fire spread. Information such as:
- a. Document building construction type.
 - b. Finish materials (exterior/interior).
 - c. Occupancy type or change of.

- d. Building construction has significant impact on fire growth and spread.
- e. Data critical for future testing and fire modeling.

V. EXTERIOR EXAMINATION

FIRE SCENE: PROCESSING THE EXTERIOR

Conduct an exterior scene survey prior to a detailed exterior scene examination and documentation:

- General fire damage assessment.
- Identify hazards present.
- Preserve potential evidence for subsequent collection.
- Develop investigative strategy.
- Other resources or equipment needed.

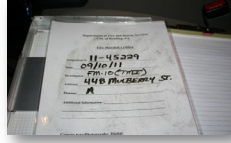


Slide 10-52

- A. The investigator will conduct an initial exterior scene survey. This is similar to the Size-up 360 conducted by the initial responders. It is to orient and familiarize the investigator with the location. This occurs prior to a **detailed exterior scene examination and documentation**, which will occur later in the process.
 - 1. Things to look for include:
 - a. General fire damage assessment.
 - b. Identify hazards present.
 - c. Preserve potential evidence for subsequent collection.
 - d. Develop investigative strategy.
 - e. Other resources or equipment needed.

FIRST THING DOCUMENT LOCATION

- Identify location of fire.
- Should be one of the first photographs taken.



Slide 10-53

2. The investigator should identify, by way of a photograph, the location of the incident. A photo of the address, street signs, or of a white board, sheet of paper, or anything that will identify the fire incident information.

EXTERIOR AREA EXAMINATION

Examine security surrounding the fire scene:

- Physical security measures and condition.
- Scene access points.
- Barricaded areas?
- Damage pre-existing, from first responders, or others?



Slide 10-54

3. Look outward; examine areas surrounding the fire scene. Look for things like:
 - a. Perimeter physical security measures.
 - b. Scene access or egress points.
 - c. The condition of physical security measures.
 - d. Damage: Is it pre-existing, or was it from first responders or others?

FIRE SCENE: EXTERIOR EXAMINATION 360°

- Examine and document all sides of the structure.
- Analyze fire effects and patterns.
- Identify areas which warrant further examination.



Slide 10-55

- B. The investigator should conduct a detailed exterior scene examination. This is an additional inspection, after the previously discussed initial survey. This examination is more detailed, methodical and slower. The investigator would take notes, photographs, measurements, and develop an initial sketch during this activity.

EXTERIOR EXAMINATION MEASUREMENTS

- Document structure dimensions.
- Forensic mapping.
- Diagram.

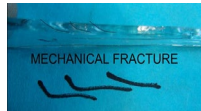


Slide 10-56

1. Structure.
 - a. Document structure dimensions.
 - b. Forensic mapping.
 - c. Diagram.

OTHER EXTERIOR DATA SOURCES - WINDOWS

- Window locations and positions at time of fire?
- Size and type of glass?
- Position and condition of locks?
- Thermal or mechanical glass failure?
 - Smooth edges.
 - Conchoidal fractures.



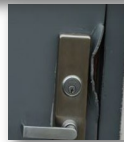
Slide 10-57

2. Windows.

- a. Window locations and positions at time of fire?
- b. Size and type of glass?
- c. Position and condition of locks?
- d. Thermal or mechanical glass failure?
 - Smooth edges.
 - Conchoidal fractures.

OTHER EXTERIOR DATA SOURCES - DOORS

- Door locations and positions at time of fire.
- Size and material type.
- Were the doors locked and secured?
- Mechanical damage to frames/jambs.
- Damage existing prior to fire?
- Damaged during/post suppression?
- Automatic door openers?



Slide 10-58

3. Doors.

- a. Door locations and positions at time of fire.
- b. Size and material type.

- c. Were the doors locked and secured?
- d. Mechanical damage to frames/jambs.
- e. Damage existing prior to fire or caused during/post suppression?
- f. Automatic door openers?

EXTERIOR EXAMINATION: EXPOSURES

Exposure damage:

- Document exposure physical address.
- Proximity/orientation to primary fire scene.
- Degrees of damage.



Slide 10-59

4. The investigator should document any damage to exposure buildings, including the physical address and amount of damage.

FIRE SCENE: EXTERIOR EXAMINATION

Examine areas surrounding the fire scene:

- Outbuildings.
- Evidentiary items.
- Other areas of fire origin.



Separate and distinct area of fire origin located away from primary fire.

Slide 10-60

TRACE EVIDENCE: EXTERIOR

Identify, preserve and collect trace evidence:

- Lighter, matches, devices.
- Ignitable liquids, containers.
- Clothing.
- Footprints, tire tracks.
- Documents.
- DNA/blood, fingerprints.
- Tool marks.



Slide 10-61

5. Investigators may encounter trace or other evidence, for example:

- a. Lighter, matches.
- b. Devices.
- c. Ignitable liquids.
- d. Containers.
- e. Clothing.
- f. Footprints, tire tracks.
- g. Documents.
- h. DNA/blood.
- i. Fingerprints.
- j. Tool marks.

EXTERIOR EXAMINATION: OTHER CONSIDERATIONS

Exterior Ignition
Sources:

- Receptacles and extension cords.
- Appliances.
- Lights and lighted signs.
- Grills and gas appliances.
- Cigarettes.
- Garbage bins and fire pits.



Slide 10-62

6. There is an assortment of other factors that may be found on the exterior examination that the investigator should consider:
 - a. Receptacles and extension cords.
 - b. Appliances.
 - c. Lights and lighted signs.
 - d. Grills and gas appliances.
 - e. Cigarettes.
 - f. Garbage bins and fire pits.

VI. SYSTEM EXAMINATIONS

SYSTEM EXAMINATIONS

- The following sections will address various building systems encountered during the scene inspection.
- They should be documented as they are encountered.
- Detailed inspections may follow.



Slide 10-63

- A. The following sections will address various building systems encountered during the scene inspection.
1. They should be documented as they are encountered.
 2. Detailed inspections may follow.

ELECTRICAL SYSTEMS

Electric service:

- De-energize!
- Locate and examine transformer.
- Pole mount/pad mount.
- Identify utility company pole number/pad number.
- Single or three phase.
- Voltages.



Slide 10-64

- B. As discussed in Unit 7: Fire Effects and Patterns, the investigator must inspect the electrical systems. Items to consider include:
1. De-energize!
 2. Locate and examine transformer.
 3. Pole mount/pad mount.
 4. Identify utility company pole number/pad number.
 5. Single or three phase.
 6. Voltages.

ELECTRICAL SERVICE

Document electric service:

- Underground service lateral.
- Overhead service drop.
- Condition of service raceway and weather head.
- Arc mapping data.



Slide 10-65

C. Additional items to consider on the exterior inspection. Items include:

1. Determine if the service arrives by an underground service lateral or overhead service drop.
2. What is the condition of service raceway and weather head?
3. Is there arc mapping data?

SERVICE ENTRANCE

- Examine meter base and meter.
- Meter removed by utility company?
- Smart meter data.
- Verify building earth-ground.
- Service disconnects.



Slide 10-66

D. Other items to consider include:

1. Identify and examine meter base and meter.
2. Meter removed by utility company?
3. Smart meter data.
4. Verify building earth-ground.

5. Circuit transformer (CT) enclosures.
6. Service disconnects.

CAUTION

Document and examine other sources of electricity:

- Photovoltaic.
- Generators.
- Wind.
- Have they been disconnected?



Slide 10-67

LOAD CENTERS

Electrical Systems:

- Document load center/sub-panel conditions and locations.
- Make/model.
- OCPD positions.
- Single phase vs. three phase.
- Voltages.
- Disconnect switch positions.
- Transformers present.
- Document quality of electrical system workmanship.



Slide 10-68

- E. Load centers: electrical systems.
1. Document load center/sub-panel conditions and locations.
 2. Make/model.
 3. Overcurrent protective device (OCPD) positions.
 4. Single phase vs. three phase.
 5. Voltages.
 6. Disconnect switch positions.

7. Transformers present.
8. Document quality of electrical system workmanship.

BUILDING GAS SYSTEMS

Location and condition of LPG tanks or NG regulators:

- Tank capacity and volumes.
- Valve control positions.
- Condition of regulators.
- Connection conditions.
- Last filled.
- Appliances serviced.
- Distribution line type.

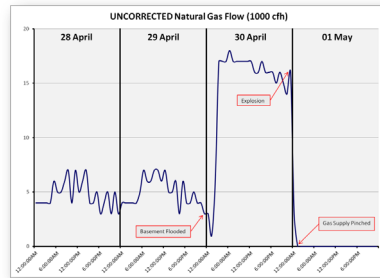


Slide 10-69

- F. Location and condition of liquid petroleum gas (LPG) tanks or natural gas (NG) regulators:
1. Tank capacity and volumes.
 2. Valve control positions.
 3. Condition of regulators.
 4. Connection conditions.
 5. Last filled.
 6. Appliances serviced.
 7. Distribution line type.

GAS SYSTEMS: UTILITY COMPANY RECORDS

- Smart meter data.
- Utility flow charts.
- Installation records.
- Service history.



Slide 10-70

G. Gas systems: utility company records.

1. Smart meter data.
2. Utility flow charts.
3. Installation records.
4. Service history.

GAS APPLIANCES

- Make, model, and fuel type.
- Valve/control knob positions.
- Thermostat settings.
- Ignition mechanism.
- Proximity to combustibles.
- Contribute to fire cause.
- Add to fuel load.
- Appliance conversions
LPG vs. NG.
- Timeline.



H. Gas appliances.

1. Make, model, and fuel type.
2. Valve/control knob positions.
3. Thermostat settings.

4. Ignition mechanism.
5. Proximity to combustibles.
6. Contribute to fire cause.
7. Add to fuel load.
8. Appliance conversions LPG vs. NG.
9. Timeline.

HEATING, VENTILATING, and AIR CONDITIONING (HVAC) SYSTEMS

- Supply and return vent locations.
- Thermostat position, system in operation?
- Fire/smoke spread?
- Automatic or manual dampers.
- Fire detection.



I. Heating, ventilating, and air conditioning (HVAC) systems:

1. Supply and return vent locations.
2. Thermostat position, system in operation?
3. Fire/smoke spread?
4. Automatic or manual dampers.
5. Fire detection.

LIQUID FUEL HEATING

- Examine and document liquid fuel systems.
- Type of fuel.
- Storage tank location and volume.
- Associated appliances and conditions.



Slide 10-73

J. Liquid fuel systems may be present in the structure: If so:

1. Examine and document liquid fuel systems.
2. Type of fuel.
3. Storage tank location and volume.
4. Associated appliances and conditions.

HVAC EXAMINATION

Document and examine HVAC units and related components as encountered.



Slide 10-74

K. The investigator should document and examine HVAC units and related components.

DOCUMENT BUILDING FIRE PROTECTION SYSTEMS

Water-based fire protection systems:

- System type.
- Occupancy design.
- Pump location and condition.
- Valve positions.
- Tamper switches.
- Inspection and service records.
- Post-fire alterations.



Slide 10-75

L. Water-based fire protection systems.

1. System type.
2. Occupancy design.
3. Pump location and condition.
4. Valve positions.
5. Tamper switches.
6. Inspection and service records.
7. Post-fire alterations.

BUILDING ALARMS-FIRE

Active fire protection systems:

- Monitored vs. unmonitored.
- Sensor types – smoke detector/alarm, heat detector, gas detector, etc.
- Sensor locations.
- Activation history.
- Inspection/maintenance records.
- Where is the data stored?
- SME needed for alarm panel data recovery?



Slide 10-76

M. Active fire protection systems.

1. Monitored vs. unmonitored.
2. Sensor types - smoke detector/alarm, heat detector, gas detector, etc.
3. Sensor locations.
4. Activation history.
5. Inspection/maintenance records.
6. Where is the data stored?
7. Subject-matter expert (SME) needed for alarm panel data recovery?

BUILDING ALARMS-INTRUSION

Security systems:

- Monitored vs. unmonitored systems.
- Sensor types – motion, door, glass-break sensors.
- Sensor locations.
- Backup power sources.
- Who is familiar with system.
- Where is data stored.



Slide 10-77

N. Initially the investigator should consider some basic information about security systems:

1. Monitored vs. unmonitored systems.
2. Sensor types - motion, door/window sensors, glass-break sensors.
3. Sensor locations.
4. Backup power sources.
5. Who is familiar with system and has panel access and codes.
6. Where is data stored.
7. Monitoring company or installer may have to assist with data interpretation.

FIRE SCENE WITH SPECIALIZED PROCESS

- Document processes/activities that occur in the origin area.
- Fuels involved.
- Potential ignition sources with the process/activities.
- Seek SME assistance when needed.
- Investigator may need to learn about the process.



Paint booth

Slide 10-78

O. Occasionally the fire scene will involve specific processes or activities that are specific to a particular location. In addition to interviewing the users of the process, the investigator may consider:

1. Document processes/activities that occur in the origin area.
2. Fuels involved.
3. Potential ignition sources with the process/activities.
4. Seek SME assistance when needed.
5. Investigator may need to learn about the process.

VII. INTERIOR EXAMINATION

MOVING TO AN INTERIOR EXAMINATION

The process of conducting an initial interior survey.



Slide 10-79

- A. The initial survey identifies safety hazards and areas that warrant comprehensive examination. Preliminary hypothesis of fire origin and spread may be developed during the survey.

DISCUSSION PHOTO



Slide 10-80

OBSERVATION WHILE INSIDE

Examine all areas:

- Examine and document all rooms/areas.
- Identify areas that warrant further examination.
- Avoid tunnel vision.
- Separate and distinct areas of fire origin?



Slide 10-81

- B. Once inside the structure, the investigator should attempt to examine all areas related to the fire:
1. Examine and document all rooms/areas.
 2. Identify areas that warrant further examination.
 3. Avoid tunnel vision.
 4. Separate and distinct areas of fire origin?

OTHER EVIDENCE ON INTERIOR

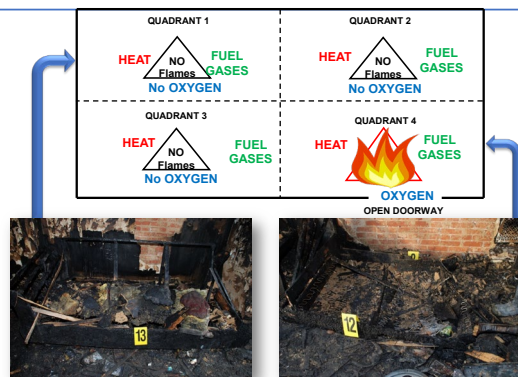
Identify, preserve, and document potential evidentiary items identified early in the investigation.



Slide 10-82

- C. Identify, preserve and document potential evidentiary items identified early in the investigation.

VENTS AND DAMAGE DYNAMICS

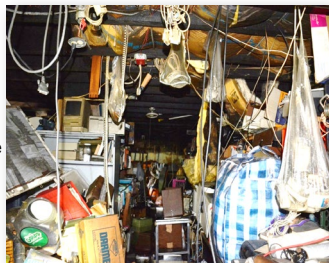


Slide 10-83

- D. Vents and damage dynamics.

OTHER CONSIDERATIONS INSIDE

- Document occupancy type.
- Commercial/residential.
- Note conditions and housekeeping.
- Did the conditions contribute to fire ignition, growth and spread?



Slide 10-84

- E. Inspect the occupancy and conditions. Items of interest include:
1. Document occupancy type.
 2. Commercial/residential.
 3. Note conditions and housekeeping.
 4. Did the conditions contribute to fire ignition, growth and spread?

OBSERVATIONS OF CONTENTS

- Document contents or lack of contents.
- Contents consistent with witness statements.
- Crime concealment.
- Contents consistent with insurance proof of loss.



Lights destroyed
approximate value \$200



Lights listed on
insurance claim value
= \$2,000

Slide 10-85

- F. During the interior inspection, the investigator may encounter items in the structure that require documentation.
1. Document contents or lack of contents.
 2. Contents consistent with witness statements.
 3. Crime concealment.
 4. Contents consistent with insurance Proof of Loss (POL).

VIII. PROCESSING THE AREA OF ORIGIN

INTERIOR ACTIVITY ARC SURVEY

- The arc survey is the process of examining and locating arc damage.
- Arc mapping the process of creating the map which shows where the arcs occurred in relation to fire origin.
- Both occur during the scene examination. Usually during the processing of the interior.
- Arc residue or signs of electrical activity may only be found on appliance cords (lamps, alarm clocks, coffee pots, etc.) if the fire did not penetrate into the building's fixed wiring.

Slide 10-86

AN ARC SURVEY IS PART OF DATA COLLECTION

Identify circuits present in arc survey area.

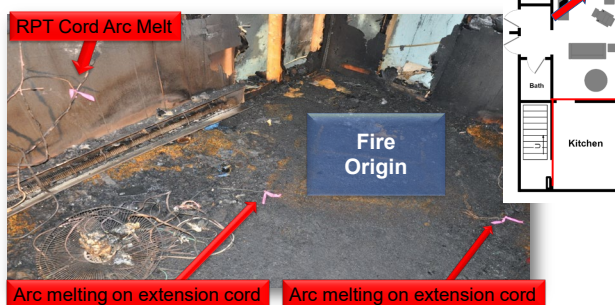


Slide 10-87

A. Identify circuits present in arc survey area.

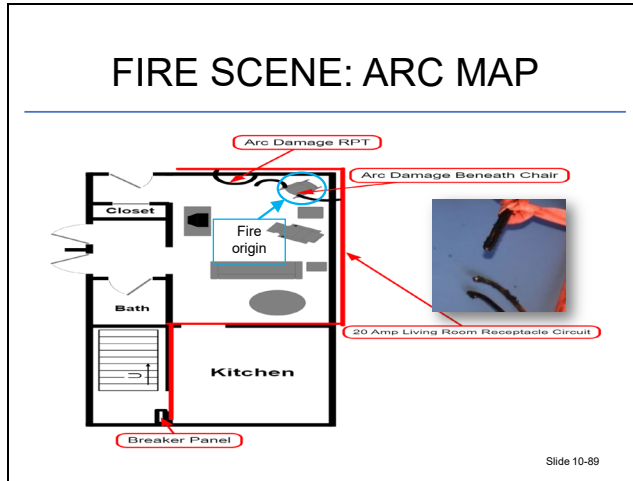
DATA COLLECTION: ARC SURVEY

Examine and mark arc sites found on circuits.



Slide 10-88

B. Examine and mark arc sites found on circuits.



C. Arc map.

AREA OF ORIGIN HAS BEEN ESTABLISHED

- The fire origin should never be undetermined.
- The fire origin should be specific, but may be broad and encompass the entire structure.
- Once defined, the origin is processed, examined and excavated.

Slide 10-90

D. Once defined, the origin is processed, examined and excavated.

PROCESSING THE ORIGIN

- The origin area requires careful documentation, excavation, and reconstruction.
- Excavation is conducted to reveal fire effects, fire patterns, ignition sources, and locate evidence.

Slide 10-91

- E. The origin area requires careful documentation, excavation and reconstruction.

Excavation is conducted to reveal fire effects, fire patterns, ignition sources and locate evidence.

DOCUMENT ORIGIN PROCESSING

Photography:

- Take 360° photographs of the origin area before disturbing contents and fire debris.
- Continue photographs in stages while documenting your excavation process.



Slide 10-92

- F. The investigator will take photographs of the fire scene. With the use of digital cameras, there is practically no limit on the number of photos an investigator can use to document the scene.

1. Take 360° photographs of the origin area before disturbing contents and fire debris.
2. Continue photographs in stages while documenting your excavation process.

ORIGIN PROCESSING – IGNITABLE LIQUIDS DETECTION CANINE

Ignitable Liquids Detection Canine (ILDC):

- Formerly referred to as an Accelerant Detection Canine (ADC).
- Consider ILDC use prior to and during excavation.
- Safety concerns for canine and handler.
- Lab confirmation is required.



Slide 10-93

- G. If the investigator has access to an Ignitable Liquids Detection Canine (ILDC), they should consider the following:

1. Formerly referred to as an Accelerant Detection Canine (ADC) (NFPA 921, Section 17.7, 2024 edition).
2. Consider ILDC use prior to and during excavation.
3. Specific areas vs. broad search.
4. Safety concerns for canine and handler.
5. Lab confirmation is required.

HEAVY EQUIPMENT

- Document scene prior to use.
- Avoid adding debris to scene.
- When possible collect fire debris samples prior to use.
- Fuel in designated areas.
- Collect comparison fuel sample if cross-contamination is a concern.
- Be systematic with equipment use.
- Just because you can, does not mean you should.



Slide 10-94

H. Heavy equipment.

1. Document scene prior to use.
2. Avoid adding debris to scene.
3. When possible collect fire debris samples prior to use.
4. Fuel in designated areas.
5. Collect comparison fuel sample if cross-contamination is a concern.
6. Be systematic with equipment use.
7. Just because you can, does not mean you should.

ORIGIN PROCESSING- EXCAVATION

Overall:

- Excavate fire debris in layers.
- Document excavation process.
- Examine fire patterns and effects on contents and structural surfaces.
- Preserve fire debris for other interested parties.



Slide 10-95

I. Fire scene excavation.

1. During fire scene excavation, remember to:
 - a. Excavate fire debris in layers.
 - b. Document excavation process, including during the process. Avoid having only two photos, one of the room filled with debris and the other a completely clean excavation, Take photos during the process.
 - c. Examine fire patterns and effects on contents and structural surfaces.
 - d. Preserve fire debris for other interested parties.

ORIGIN PROCESSING- SEQUENCING

Excavate the origin area to locate evidence, reveal fire patterns, and establish sequence of events.



Pre
Excavation.



Window glass
beneath debris.



Protected carpet beneath
window glass.

Slide 10-96

2. The process of excavation can reveal evidence, reveal fire patterns and establish the sequence of events in this situation.

ORIGIN PROCESSING - LAYERING

- Layering of debris in stages.
- Document layering process.
- Consider washing floors to reveal patterns.



Slide 10-97

3. The process of a simple fire scene excavation.
 - a. Layering of debris in stages.
 - b. Document layering process.
 - c. Consider washing floors to reveal patterns.

ORIGIN AREA PROCESSING

Look beneath furniture and other contents. Are fire effects/patterns consistent with the scene? Was furniture moved during suppression/overhaul?



Slide 10-98

4. Other features and techniques of fire scene excavation:
 - a. Look beneath furniture and other contents.
 - b. Are fire effects/patterns consistent with the scene?
 - c. Potential ignition sources or other evidence may be located.
 - d. Was furniture moved during suppression/overhaul?

ORIGIN PROCESSING - SIFTING

Sifting is an effective method for locating and preserving evidence that may easily be overlooked, lost or destroyed.



Slide 10-99

5. Sifting debris from a fire scene, or specific section of the scene, is an effective method for locating and preserving evidence that may easily be overlooked, lost or destroyed.

ORIGIN PROCESSING – EVIDENCE COLLECTION

Collecting evidence:

- Document, preserve, and collect.
- Photograph, measure, scale.
- Avoid cross-contamination.
- Comparison samples.
- Use proper collection and comparison techniques.



Slide 10-100

- J. Investigators will discover evidence; need to preserve and collect that evidence. This slide serves as a preview for additional information, which will be covered in Unit 11: Injuries, Fatal Fires and Line-of-Duty Deaths. Some basic topics to consider include:

1. Document, preserve and collect evidence when located.
2. Photograph, measure, scale.
3. Proper collection techniques and packaging.
4. Avoid cross-contamination.
5. Comparison samples.

ORIGIN PROCESSING - RECONSTRUCTION

Fire scene reconstruction is necessary to accurately interpret fire effects and patterns on contents and structural surfaces.



Slide 10-101

- K. Scene reconstruction is necessary to accurately interpret fire effects and patterns on contents and structural surfaces. Investigators should be familiar with the process of fire scene reconstruction.

OTHER EXAMPLES OF RECONSTRUCTION

Reconstruction can be conducted both inside and outside the scene/origin area.



Slide 10-102

- L. Fire scene reconstruction will vary widely in complexity. It may include or occur both inside and outside the confines of the scene/origin area.

ORIGIN PROCESSING – FUEL LOAD ANALYSIS

- Document fuel loads in origin area.
- Type, quantities and location.
- Is the fuel load consistent with fire damage, lack of fuel?
- Fuels proximity to ignition sources.



Slide 10-103

M. The investigator should examine, document and understand the effect of fuel loads:

1. Document fuel loads in origin area.
2. What is the type, quantities and location of the fuel?
3. Is the fuel load consistent with fire damage?
4. What fuels were in proximity to which ignition sources?
5. Other considerations relating to fuel loads include items such as:
 - a. Is there a lack of fuel load?
 - b. Are the discovered fuel loads consistent with witness information?
 - c. Were fuels consumed by the fire or is it possible they were never present?
 - d. Were ignitable liquids or other fuels introduced?

ORIGIN PROCESSING – FUEL LOAD IDENTIFICATION

- Document exemplar fuels/contents when possible.
- May be needed for future testing.



Slide 10-104

- N. The investigator should search for and document any examples of exemplar or similar fuel loads. This can be helpful in hypothesis testing or a fire experiment. The experiment should be conducted with fuel loads that were identical, or as similar as possible, to the items in the fire scene.

ORIGIN - SUMMARY

- Identify, collect and analyze all data to develop hypotheses of the origin of the fire and fire spread.
- Test each hypothesis of the origin of the fire and fire spread.
- Select the final hypothesis of the origin of the fire and fire spread.



Slide 10-105

- O. Identify, collect and analyze all data to develop hypotheses of the origin of the fire and fire spread.
- P. Test each hypothesis of the origin of the fire and fire spread.
- Q. Select the final hypothesis of the origin of the fire and fire spread.

IX. OBJECTIVE TWO: DETERMINING THE CAUSE OF THE FIRE

**THE ORIGIN IS ESTABLISHED-
CONTINUE TO CAUSATION**

Causation, what happened? Here the investigator will identify:

- The **first fuel** ignited.
- The **competent ignition source**.
- The **act or circumstances** that brought them together.

```

graph TD
    1[1 Origin "Where"] --> C((Complete Fire Investigation))
    2[2 Cause "What"] --> C
    3[3 Classification "Why"] --> C
    
```

The diagram consists of three rectangular boxes at the top: '1 Origin "Where"' on the left, '2 Cause "What"' in the center, and '3 Classification "Why"' on the right. Arrows from each of these three boxes point downwards to a central red circle labeled 'Complete Fire Investigation'.

Slide 10-106

A. Causation, what happened?

FIRE CAUSE

- "The determination of the cause of the fire requires the identification of those factors that were necessary for the fire to have occurred."
- "Those factors include the presence of a **competent ignition source**, the type and form of the **first fuel ignited**, and the **circumstances**, such as failures or human actions, that allowed the factors to come together."

-NFPA 921, Section 19.1.1

Slide 10-107

B. A causation determination requires the identification of:

1. Competent ignition source in area of origin.
2. Most probable first fuel ignited.
3. Identification of the oxidant.
4. The circumstances that brought these together to initiate a fire (e.g., failures or human action).

FIRE CAUSE DETERMINATION- IGNITION

What does a competent ignition source require?

- Sufficient energy to ignite the first fuels.
- The capability to transfer the energy to the first fuel.
- A duration sufficient to raise the fuel to its ignition temperature.



Slide 10-108

- C. What is a competent ignition source? How important is the word competent? Investigators should understand the importance of heat flux (energy) and time as related to the ignition process.

FIRE CAUSE DETERMINATION- FUEL

- First fuel ignited is that which sustains combustion beyond the initial ignition source.
- First fuel may be part of or in close proximity to source of heat.



The potential ignition source is the cigarette. What is the first fuel ignited?

Slide 10-109

FIRST FUEL-FIRE SPREAD

Is first fuel capable of ignition and fire spread?

- Geometry and orientation.
- Quantity of fuel.
- Heat release rate.
- Distance to other fuels.
- Thermal inertia.

Explain how the first fuel transferred heat to, and caused ignition of, target fuels.



Disposal of smoking materials in plastic planter.

Slide 10-110

1. It is important to evaluate the first fuel and its ability to facilitate fire spread. How does geometry and orientation affect heat release rate (HRR)? What is the distance to target fuels? What form of heat transfer caused ignition of the target fuels?
2. Would the investigator hypothesize the 1st fuel to be capable of causing the resulting damages?

FIRE CAUSE DETERMINATION- OXIDIZER

Oxidant or oxidizer:

- The ignition source may have enough energy to ignite the first fuel.
- Is an oxidizer present?
- Flaming fires require at least 14% to 16% oxygen.
- Smoldering combustion can occur in as little as 8% oxygen.



Slide 10-111

3. Investigators should understand the importance of the fire triangle. The lack of oxygen (oxidizer) will prevent a combustion reaction.
 - a. The photo depicts a Rival brand electric Panini maker in operation. A thermocouple is inserted in the maker and reads a temperature of 451°F. There is also a paper towel inside the appliance. The Auto Ignition Temperature (AIT) of the paper towel is about 450°F.
 - b. Panini maker reaches temperatures of 451°F but does not ignite paper with an AIT of approximately 450°F.
 - c. What is missing?

CAUSE DETERMINATION

Circumstances, conditions, or agencies that brought the first fuel, ignition source and oxidizer together causing the fire to occur?

DO NOT CONFUSE FIRE CAUSE WITH FIRE (INCIDENT) CLASSIFICATION.



Slide 10-112

4. Circumstances, conditions or agencies that brought the first fuel, ignition source and oxidizer together causing the fire to occur.

Do not confuse fire cause with fire (incident) classification.

X. HYPOTHESIS TESTING

CAUSE DETERMINATION DISCUSSION

Identify in this photo:

- A competent ignition source.
- A first fuel ignited.
- The oxidant.
- The circumstances, conditions, or agencies that brought the above together.

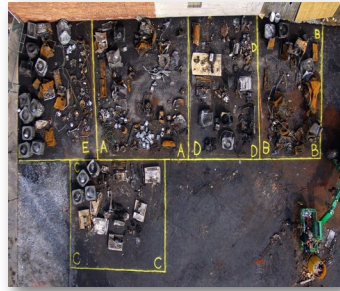


Slide 10-113

- A. Is a toaster oven a competent ignition source for combustible materials? What were the circumstances that brought the ignition source and fuel together?

CAUSE DETERMINATION- HYPOTHESIS

- Separate hypothesis must be considered for each potential ignition source within a reasonable distance from the fire origin area.
- Must also hypothesize about potential ignition sources not present at the scene.



Slide 10-114

- B. Each of the alternate hypotheses of ignition that were developed must then be tested using the scientific method, including those transient, open flame devices like lighters that were not present at the scene (NFPA 921, Section 19.6.1, 2024 edition).

Hypotheses Testing Questions (NFPA 921, Section 19.6.3, 2024 edition).

HYPOTHESIS TEST QUESTIONS REVIEW

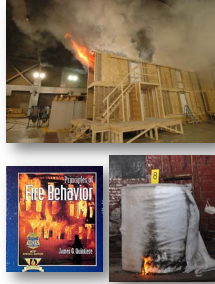
- Is the ignition source competent for the first fuel ignited?
- Is time required for ignition consistent with timeline?
- What circumstances brought the ignition source in contact with the fuel?
- What failure modes were required for ignition to occur?

Slide 10-115

1. Is the ignition source competent for the first fuel ignited?
2. Is time required for ignition consistent with timeline associated with the cause hypothesis and the facts of the incident?
3. What circumstances brought the ignition source in contact with the first fuel ignited?
4. What failure modes were required for ignition to occur?

MEANS OF HYPOTHESIS TESTING

- Scientific literature.
- Fundamental principles of science.
- Physical experiments or testing.
- Cognitive experiments.
- Timelines.



Slide 10-116

C. Means of hypothesis testing.

1. Scientific literature.
2. Fundamental principles of science.
3. Physical experiments or testing.
4. Cognitive experiments.
5. Timelines.

CAUSE DETERMINATION OPINIONS

Opinions are derived from confidence in the analysis of data and testing of hypotheses.

The level of certainty for expert opinions are:

- **Probable** = more likely true than not – greater than 50%.
- **Possible** = feasible but cannot be declared probable.

What to do when two hypotheses are equally possible?
Is one hypothesis more probable?

Slide 10-117

D. Cause determination opinions.

1. The level of certainty for our expert opinions are:
 - a. **Probable** = more likely true than not.

- b. **Possible** = feasible but cannot be declared.
2. For an opinion to be probable, it must be derived from our confidence and analysis data and testing of the hypothesis.

XI. IDENTIFICATION AND TESTING OF IGNITION SOURCES

EXAMPLES OF COMMON IGNITION SOURCES

- The following slides will provide general information and an overview of various types, conditions, and appliances which may contribute to an ignition.
- The list is general and not all inclusive.





Slide 10-118

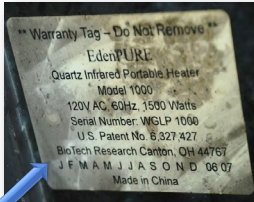
A. Examples of common ignition sources.

1. The following slides will provide general information and an overview of various types, conditions, and appliances which may contribute to an ignition.
2. The list is general and not all inclusive.

APPLIANCES AS IGNITION SOURCES

Identify appliance and relevant information:

- Manufacturer.
- Model.
- Serial number.
- Recalls.
- Exemplars.




Slide 10-119

- ### B. When the investigator encounters an appliance, they should attempt to obtain as much identifying data as possible.

1. Items to look for include:
 - a. Manufacturer.
 - b. Model.
 - c. Serial number.
 - d. Wire gauge.
 - e. Recalls.
 - f. Exemplars.

FIRE SCENE: COMMON IGNITION SOURCES

Appliance identification:

- Become familiar with appliance components.
- Post-fire appliance artifacts may be difficult to identify.

The image contains two photographs. The top photograph, labeled 'Before', shows a yellow and black relocatable power tap (RPT) or power strip in its original condition. The bottom photograph, labeled 'After', shows the same device after a fire, appearing charred, melted, and heavily damaged, making it difficult to identify. The text 'Slide 10-120' is visible in the bottom right corner of the image area.

2. Items appear different after a fire. This photo illustrates an relocatable power tap (RPT) or power strip, pre-fire and post fire.
 - a. Be familiar with appliance components.
 - b. Post-fire appliance artifacts may be difficult to identify.
 - c. Seek technical assistance when needed.

FIRE SCENE: COMMON IGNITION SOURCES

Receptacles:

- Document locations.
- Appliances/cords connected.
- Condition of connection points.
- Enclosure type (e.g. plastic vs. metal).
- Wiring type (e.g. series vs. parallel).



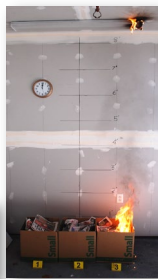
Slide 10-121

C. Another source of potential ignition is connections and components within receptacles:

1. Document locations.
2. Appliances/cords connected.
3. Condition of connection points.
4. Enclosure type (e.g., plastic vs. metal).
5. Wiring type (e.g., series vs. parallel).

COMMON IGNITION SOURCES - LIGHTS

- Bulb type.
- Condition of connection points.
- Enclosure type (e.g. plastic vs. metal).
- Diffusers present.
- In contact (IC) vs. non-IC ratings.
- Electronic vs. magnetic ballast.



Slide 10-122

D. Lights and fixtures should be documented:

1. Document locations.
2. Bulb type.

3. Condition of connection points.
4. Enclosure type (e.g., plastic vs metal).
5. Diffusers present.
6. In contact (IC) vs. non-IC ratings.
7. Electronic vs. magnetic ballast.

COMMON IGNITION SOURCES- BATTERIES

- Associated appliances.
- Type, i.e., lithium, NiCd, lead acid, etc.
- Damage to cells.
- All cells recovered.
- Charging state.
- Compatible transformer.



Slide 10-123

- E. Other potential ignition sources include batteries. The investigator should attempt to locate and examine associated appliances and batteries (lithium, nickel cadmium (NiCd), lead acid). Identify damage to cells, and are all cells accounted for? Battery explosions are energetic and can result in ignition of combustible materials located at distances away from the appliance.

What was the condition of the batteries at the time of the fire? Were they charging?
Was the correct transformer being used?

COMMON IGNITION SOURCES- RANGES

- Type.
- Shaft position.
- First fuels present.
- Witness information.
- Pungent smell.
- Timeline.
- Fragile evidence.



Slide 10-124

1. Document locations.
2. Type.
3. Knob position.
4. Shaft position.
5. First fuel.
6. Witness information.
7. Pungent smell.
8. Timeline.
9. Fragile evidence.

[illegible]

1. Fault tree analysis.

2. Tip over switches.
3. Thermostats.
4. Thermal cut off (TCO).
5. First fuels.
6. Appliance housing.
7. Timelines.

COMMON IGNITION SOURCES-
ELECTRIC HEATERS

- Radiant or convective.
- Heating element: ceramic, quartz, nichrome, other.
- Thermostat position.
- Tip over switches.
- Heat regulating TCOs.
- Distance from combustibles.
- Arc damage.



Slide 10-126

H. The investigator should evaluate any observed electric heaters:

1. Radiant or convective.
2. Heating element: ceramic, quartz, nichrome, other.
3. Thermostat position.
4. Tip over switches.
5. Heat regulating TCOs.
6. Distance from combustibles.
7. Arc damage.

COMMON IGNITION SOURCES- CLOTHES DRYERS

- Type electric or gas.
- Gas conversion.
- Spontaneous combustion.
- Lint accumulation.
- Vents and associated ductwork.
- Witness statements.



Slide 10-127

I. When evaluating or documenting clothes dryers, the investigator should determine the type of dryer (gas or electric) and attempt to identify or document the following:

1. Gas conversion.
2. Spontaneous combustion.
3. Lint accumulation.
4. Vents and associated ductwork.
5. Witness statements.

COMMON IGNITION SOURCES- VENT FANS

- Motor failure can result in ignition of combustible materials.
- Condition of vents and associated ductwork.
- Condition of windings.
- Arc damage.
- Witness statements.



Slide 10-128

J. When investigating a ceiling-mounted vent fan, such as is found in a bathroom, evaluate the following:

1. Motor failure can result in ignition of combustible materials.

2. Condition of vents and associated ductwork.
3. Condition of windings.
4. Arc damage.
5. Witness statements.

COMMON IGNITION SOURCES- SMOKING

- Document presence and type of smoking materials.
- Ashtrays, containers.
- Witness statements.
- Smoking habits.
- Ambient conditions.
- Fuels present.



Slide 10-129

K. When evaluating fire involving smoking materials:

1. Document presence and type of smoking materials.
2. Ashtrays, containers.
3. Witness statements.
4. Smoking habits.
5. Ambient conditions.
6. Fuels present.

COMMON IGNITION SOURCES- OPEN FLAMES

- Lighters, matches, candles, oil lamps.
- Containers plastic, glass, wood.
- Proximity to other fuels.
- Witness statements.
- Timelines.



Slide 10-130

L. When ignition is suspected by the use of an open flame source the investigator should evaluate the following:

1. Lighters, matches, candles, oil lamps, etc.
2. Containers (e.g., plastic, glass, wood, etc.).
3. Proximity to other fuels.
4. Witness statements.
5. Timelines.

IGNITION SOURCE- SPONTANEOUS COMBUSTION

- Types of organic materials.
- Storage/disposal conditions.
- Fuel configurations.
- Ambient conditions.
- Witness statements.
- Timeline.



Cleaning rags contaminated with cooking oils and grease stored in green plastic milk crate.

Slide 10-131

M. Spontaneous combustion fires would necessitate the investigator evaluating the following:

1. Types of organic materials.

2. Storage/disposal conditions.
3. Fuel configurations.
4. Ambient conditions.
5. Witness statements.
6. Timeline.

COMMON IGNITION SOURCES- SOLID FUEL

- Type of fuels (e.g., wood, coal, pellets).
- Type of chimney (e.g., masonry or metal, double or triple walled).
- Chimney/appliance clearances.
- Chimney/connector maintenance.
- Attic insulation shield.
- NFPA 211.



Slide 10-132

N. During the evaluation of solid-fuel-burning appliances consider the following:

1. Type of fuels (e.g., wood, coal, pellets, etc.).
2. Type of chimney (e.g., masonry or metal).
3. Chimney/appliance clearances.
4. Chimney/connector maintenance (e.g., creosote).
5. Air-cooled chimney (e.g., double vs. triple wall).
6. Attic insulation shielding.
7. NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*.

IGNITION SOURCES- MECHANICAL AND FRICTION

Mechanical friction from moving parts may ignite fuels in close proximity and suitable state.



Slide 10-133

- O. Other forms of heat for ignition may be produced through mechanical means. Friction from moving parts may ignite fuels in close proximity and suitable state. The photo on the right is from an accidental fire at recycling facility where the shredding machine jammed.

IGNITION SOURCE- NOT FOUND

- Ignition source altered, destroyed, consumed, moved or removed.
- "There are times when there is no physical evidence of the ignition source found at the origin, but where an ignition sequence can be logically inferred."



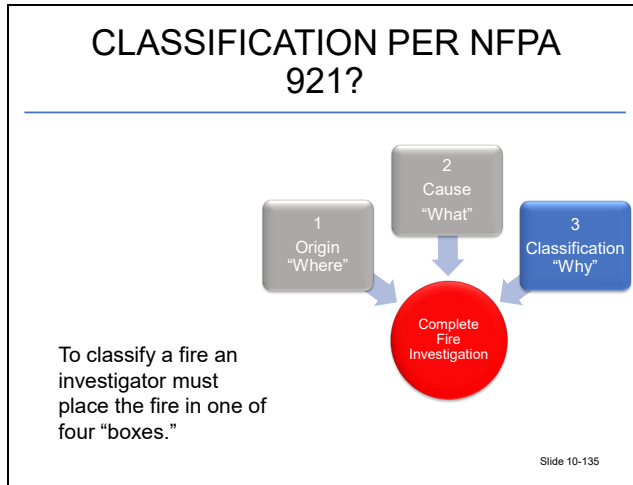
-NFPA 921, Section 19.4.4.3

Slide 10-134

- P. The investigator may encounter a situation where the ignition source was altered, destroyed, consumed, moved or removed.

"There are times when there is no physical evidence of the ignition source found at the origin, but where an ignition sequence can be logically inferred" (NFPA 921, Section 19.4.4.3, 2024 ed.).

XII. OBJECTIVE THREE: FIRE INCIDENT AND CAUSE CLASSIFICATION



INCIDENT CLASSIFICATION

- Beginning in the 2021 edition of NFPA 921, investigators are not "required" to classify the incident.
- However, agency policy may require a classification of the incident.
- If an incident requires classification, the investigator should refer to the appropriate classification system.

Slide 10-136

- A. Beginning in the 2021 edition of NFPA 921, investigators are not "required" to classify the incident.
- B. However, agency policy may require a classification of the incident.
- C. If an incident requires classification, the investigator should refer to the appropriate classification system.

INCIDENT CLASSIFICATION (cont'd)

- Examples of National Classification Systems used for incident reporting of fire and explosions (not all inclusive):
 1. The United States National Fire Incident Reporting System (NFIRS).
 2. NFPA 901.
 3. The Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) Bomb Arson Tracking System (BATS).
 4. The Uniform Crime Reporting (UCR) Program maintained by the FBI.
 5. The Canadian Code Structure on Fire Loss Statistics, developed by the Council of Canadian Fire Marshalls and Fire Commissioners.
 6. National Incident-Based Reporting System (NIBRS) maintained by the FBI.

Slide 10-137

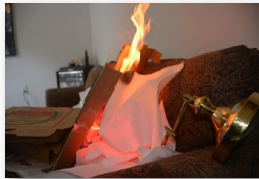
D. Examples of National Classification Systems used for incident reporting of fire and explosions (not all inclusive):

1. The United States National Fire Incident Reporting System (NFIRS).
2. NFPA 901.
3. The Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) Bomb Arson Tracking System (BATS).
4. The Uniform Crime Reporting (UCR) Program maintained by the FBI.
5. The Canadian Code Structure on Fire Loss Statistics, developed by the Council of Canadian Fire Marshalls and Fire Commissioners.
6. National Incident-Based Reporting System (NIBRS) maintained by the FBI (NFPA 921, Section 19.8, 2024 ed.).

CLASSIFICATION OF FIRE INCIDENT

Classification of a fire cause may be used for assignment of responsibility, reporting purposes, or compilation of statistics.

- ☐ Accidental
- ☐ Natural
- ☐ Incendiary
- ☐ Undetermined



Slide 10-138

FIRE CLASSIFICATION- ACCIDENTAL

“An unplanned event that interrupts an activity and sometimes causes injury or damage or a chance occurrence arising from unknown causes; an unexpected happening due to carelessness, ignorance, and the like”

-2024 NFPA, Section 3.3.3



Slide 10-139

- E. “An unplanned event that interrupts an activity and sometimes causes injury or damage or a chance occurrence arising from unknown causes; an unexpected happening due to carelessness, ignorance, and the like” (NFPA 921, Section 3.3.3, 2024 ed.).

FIRE CLASSIFICATION- NATURAL

Natural fire causes involve fires caused without direct human intervention or action, such as fires resulting from lightning, earthquake, wind, and flood.



Slide 10-140

- F. Natural fire causes involve fires caused without direct human intervention or action, such as fires resulting from lightning, earthquake, wind, and flood.

FIRE CLASSIFICATION- INCENDIARY

"A fire that is intentionally ignited in an area or under circumstances where there should not be a fire."

-NFPA 921, Section 3.3.124



Slide 10-141

- G. "A fire that is intentionally ignited in an area or under circumstances where and when there should not be a fire" (NFPA 921, Section 3.3.124, 2024 ed.).

FIRE CLASSIFICATION- UNDETERMINED

"The final opinion is only as good as the quality of the data used in reaching that opinion. If the level of certainty of the opinion is only "possible" or "suspected," the fire cause is undetermined. This decision as to the quality of data and the level of certainty of the opinions rests with the investigator."



Slide 10-142

- H. "The final opinion is only as good as the quality of the data used in reaching that opinion. If the level of certainty of the opinion is only "possible" or "suspected," the fire cause is undetermined. This decision as to the quality of data and the level of certainty of the opinions rests with the investigator." (NFPA 921, Section 19.7.4, 2024 ed.).

ARSON IS NOT A CLASSIFICATION

Arson: "The crime of maliciously and intentionally, or recklessly, starting a fire or causing an explosion."

- NFPA 921, Section 3.3.16



Slide 10-143

- I. Arson and incendiary are **not** the same thing. Arson is "the crime of maliciously and intentionally, or recklessly, starting a fire or causing an explosion" (NFPA 921, Section 3.3.16, 2024 ed.).

FIRE CLASSIFICATION: WITNESS INFORMATION CAN HELP-VIDEO



Slide 10-144

XIII. INCENDIARY INDICATORS AND MISSING IGNITION SOURCES

FIRE SCENE-INCENDIARY FIRE INDICATORS

The following slides represent possible indicators of an incendiary fire.

In and of themselves, they cannot be relied upon to justify an incendiary classification.

Remember: totality of circumstances!



Multiple Fire Origins or Drop Down?

Slide 10-145

POSSIBLE INCENDIARY FIRE INDICATORS

- Multiple origins.
- Trailers.
- Containers.
- Pour patterns, ignitable liquids.
- Disabling fire protection systems.
- Tampering with utilities.



Slide 10-146

- A. Multiple origins.
- B. Trailers.
- C. Containers.
- D. Pour patterns, ignitable liquids.
- E. Disabling fire protection systems.
- F. Tampering with utilities.

POSSIBLE INCENDIARY FIRE INDICATORS

- Unusual fuel loads or fuel configurations.
- Incendiary devices.
- Crime concealment.



Slide 10-147

- G. Unusual fuel loads or fuel configurations.
- H. Incendiary devices.
- I. Crime concealment.

POSSIBLE INCENDIARY FIRE INDICATORS

Contents:

- Contents lacking.
- Contents obviously replaced.
- Contents placed suspiciously.
- Over-inflated claim of loss.
- Condition of contents.



Slide 10-148

- J. Contents.
1. Contents lacking.
 2. Contents obviously replaced.
 3. Contents placed suspiciously.
 4. Over-inflated claim of loss.
 5. Condition of contents.

APPROPRIATE USE: NEGATIVE CORPUS

“Identifying the ignition source for a fire by believing to have eliminated all ignition sources found, known, or suspected to have been present in the area of origin, and for which no supporting evidence exists, is referred to by some investigators as *negative corpus*.”

-NFPA 921, Section 19.6.5

Slide 10-149

K. Appropriate use: negative corpus.

1. “Identifying the ignition source for a fire by believing to have eliminated all ignition sources found, known, or suspected to have been present in the area of origin, and for which no supporting evidence exists, is referred to by some investigators as *negative corpus*” (NFPA 921, Section 19.6.5, 2024 ed.).

NEGATIVE CORPUS EXAMPLE

- All accidental sources eliminated.
- Inference is made that an open flame source was used to ignite the fire and was either destroyed or left the scene with the fire setter.
- **OPINION IS BASED SOLELY ON THE BELIEF THAT ALL ACCIDENTAL IGNITION SOURCES WERE ELIMINATED.**



Slide 10-150

2. The process of elimination is an integral part of the Scientific Method. See NFPA 921, Section 19.6.5, 2024 ed., for a further discussion and research. In this circumstance, the investigator opines all accidental sources were eliminated. Inference is made that an open flame source was used to ignite the fire and was either destroyed or left the scene with the actor. **Your opinion is based solely on the belief that all accidental ignition sources were eliminated.**

THE NEGATIVE CORPUS PITFALL

- Bias.
- Origin area correct.
- All ignition sources considered.
- Ignition source consumed or moved.
- All data collected.



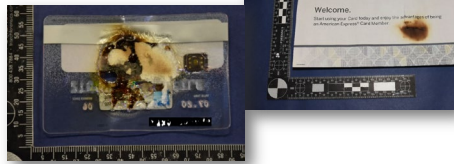
Slide 10-151

3. Pitfalls.

- Bias?
- Origin area correct?
- All ignition sources considered?
- Ignition source consumed or moved?
- Was all data collected?

NEGATIVE CORPUS-CREDIT CARD

- Was all of the data collected?
- Were all potential ignition scenarios considered?



Slide 10-152

4. Credit card.

- Did you collect all of the data?
- Did you consider all potential ignition sources/scenarios?

FIRE SCENE - SPOILIATION

Before the investigator enters the structure and begins to move items, consider:

- The willful destruction of evidence or the failure to preserve potential evidence for another's use in pending or future litigation.
- "Loss, destruction, or material alteration of an object or document that is evidence or potential evidence in a legal proceeding by one who has the responsibility for its preservation."

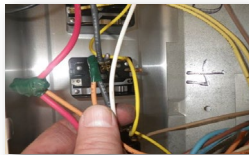
-NFPA 921, Section 3.3.190

Slide 10-153

5. Before the investigator enters the structure and begins to move items, they should consider:
 - a. The willful destruction of evidence or the failure to preserve potential evidence for another's use in pending or future litigation.
 - b. "Loss, destruction, or material alteration of an object or document that is evidence or potential evidence in a legal proceeding by one who has the responsibility for its preservation" (NFPA 921, Section 3.3.190, 2024 ed.).

SPOILIATION IN PRACTICE

- Intentional or malicious destruction of evidence.
- If fire cause appears due to a certain piece of equipment, do not take the item apart.
- Intrusive vs. destructive.
- Document!
- Document!
- Document!



Slide 10-154

6. Be careful how you manipulate evidence or artifacts.
 - a. Intentional or malicious destruction of evidence.
 - b. If you feel that the fire cause was due to a certain piece of equipment, **do not take apart the item.**
 - c. Evaluate intrusive vs. destructive.
 - d. Regardless of your actions, document! Document! Document!

ACTIVITY 10.1

Fire Scene Examination Overview

Purpose

Demonstrate the process used to conduct a systematic, basic examination of a fire scene.

Safety Precautions

You are required to wear safety glasses while participating in this mock investigation. You should take appropriate measures to avoid physical hazards, such as protruding nails, broken glass and falling debris. Report any injury to an instructor immediately.

Directions

This is an instructor-led mock fire scene investigation, conducted at the Burn Lab, utilizing the flashover and ventilation cells as mock fire scenes. With an instructor, you will participate in a guided group discussion of the following topics while evaluating a fire scene. You may take the activity sheet to the Burn Lab for reference or note taking.

Discussion Topics

1. Witness statements: Did anyone see this fire? Discuss use of witness statements as outlined in NFPA 921, Chapter 18.
2. Safety.
 - a. Site observations, structural hazards.
 - b. Electrical safety.
 - Meter base.
 - Three-step system: physical separation, non-contact test, meter test.
 - Demonstrate lock-out/tag-out procedures.
3. Exterior examination.
 - a. Walk-around observations.
 - b. Documentation, exterior scene considerations.

- c. Electrical system examination: meter base, load center exam, OCPDs or circuit breaker position.
 - Test by moving to “on” position; trip to off position.
 - Type of OCPD (breakers) window flags.
 - Considerations in scene documentation, photographing electrical components.
- 4. Interior examination considerations.
 - a. Building construction.
 - b. Identify vent openings, air flow, flow paths.
 - c. Walkthrough, observations.
 - d. Arc mapping.
 - Identify/isolate conductors.
 - Trace conductors.
 - Examine for arc residue.
 - Localized damage.
 - Diagram and draw results.
 - e. Fire pattern observations and assessment.
 - f. Evaluate furnishings, mass loss, and damage.
 - g. Examine and evaluate depth of char.
 - h. Identify and assess movement and intensity of fire patterns on furnishings.
 - i. Inspect for light bulb indicators.
 - j. Understand the process and necessity for fire scene reconstruction.
 - Consider pros and cons of bringing witnesses back into the structure for a walkthrough interview.
 - k. Identify protected areas.

5. Evaluate remaining evidence to determine what constitutes valuable evidence and how that evidence would be collected.
 - a. Identify the items that may be collected.
 - b. Explain the process of fire scene excavation.
 - Removing debris.
 - Layering.
 - What is on the floor?
 - c. Document the contents of the compartment.
 - Photography.
 - Sketching/drawing.
 - Notes.
 - Documentation.
6. Summary of observations and discussion.
 - a. Fire is in corner of room?
 - b. Can you make an origin determination?
 - c. Can you make a cause determination?
 - d. Can you classify this fire?
 - e. Is this a “Negative Corpus” fire?

This page intentionally left blank.

XV. SUMMARY

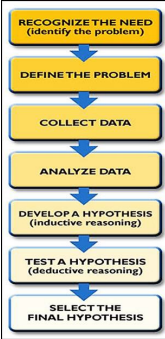


FEMA

SUMMARY



U.S. Fire Administration



Slide 10-155

This page intentionally left blank.

REFERENCES

NFPA. (2022). NFPA 1033, Standard for professional qualifications for fire investigator. Quincy, MA: Author.

NFPA. (2024). NFPA 921, Guide for fire and explosion investigations. Quincy, MA: Author.

This page intentionally left blank.

UNIT 11: INJURIES, FATAL FIRES AND LINE-OF- DUTY DEATHS

TERMINAL OBJECTIVE

The students will be able to:

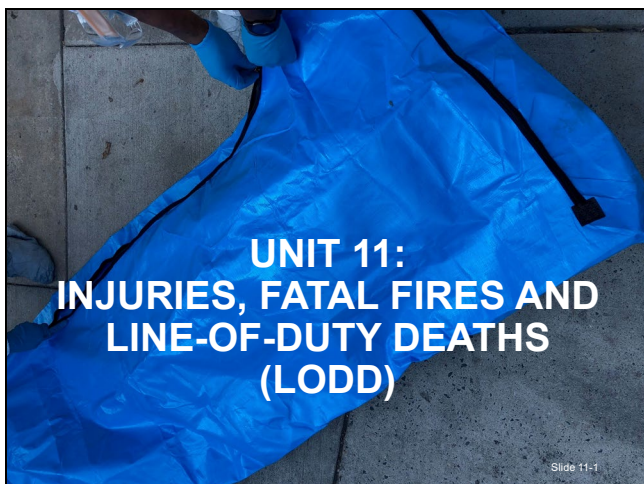
- 11.1 *Integrate personal and professional best practices while investigating a fatal fire.*

ENABLING OBJECTIVES

The students will be able to:

- 11.1 *Analyze the responsibilities of the medical examiner, fire investigator, law enforcement, and other agency roles as they relate to fire death investigation.*
 - 11.2 *Assess fire-related human behavior.*
 - 11.3 *Characterize the relationship between an origin and cause investigation and a death investigation.*
 - 11.4 *Adapt and apply appropriate procedures and techniques in a fatal fire investigation.*
 - 11.5 *Summarize protocols involved with line-of-duty deaths (LODDs).*
 - 11.6 *Consider the need for awareness of post-traumatic stress disorder (PTSD).*
-

This page intentionally left blank.



TERMINAL OBJECTIVE

Integrate personal and professional best practices while investigating a fatal fire.

Slide 11-2

ENABLING OBJECTIVES

- 11.1 Analyze the responsibilities of the medical examiner, fire investigator, law enforcement and other agency roles as they relate to fire death investigation.
- 11.2 Assess fire-related human behavior.
- 11.3 Characterize the relationship between an origin and cause investigation and a death investigation.

Slide 11-3

ENABLING OBJECTIVES (CONTINUED)

- 11.4 Adapt and apply appropriate procedures and techniques in a fatal fire investigation.
- 11.5 Summarize protocols involved with line-of-duty deaths (LODDs).
- 11.6 Consider the need for awareness of post-traumatic stress disorder (PTSD).

Slide 11-4

Advisory

This presentation contains:
GRAPHIC PHOTOGRAPHS.
VIDEOS OF BODIES BURNING.
FRANK DISCUSSION OF FIRE DEATHS, VICTIMS, AND INJURIES.

Students previously exposed to traumatic events, fire deaths, and traumatic situations should be aware of the content of this module.

Slide 11-5

CONSIDER

- Fire deaths are a gruesome responsibility of the fire investigator; students should enter this career with a full understanding.
- Please read entire advisory in the student guide.

Slide 11-6

I. FATAL VS. NON-FATAL FIRE**FIRE VS. FATAL FIRE**

- Fires resulting in significant personal injury or fatalities are the same as other fires, the process is the same.
- However, the potential consequences are likely significant.

Slide 11-7

- A. The student should be aware that fires resulting in significant personal injury or fatalities have the same chemistry and fire dynamics, and the investigative process still follows the Scientific Method. However, the potential consequences may be more significant.
- B. These fires require an understanding of the victim's actions such as whether they were attempting escape, putting out the fire, etc., and may require interactions with the medical community.

**FIRE VS. FATAL FIRE
DIFFERENCES**

Fatal fires may:

- Require an understanding of the victim's actions, e.g., escaping, fighting the fire, etc.
- Require interaction with the medical community.
- Take years between the death and the start of litigation.
- Only provide ONE chance at a scene examination.

Slide 11-8

- C. Fatal fires may:
1. Require an understanding of the victim's actions, e.g., escaping, fighting the fire, etc.
 2. Require interaction with the medical community.

3. Take years between the death and the start of litigation.
4. Only provide **one** chance at a scene examination.

WHO IS INVOLVED?

- Firefighters.
- Emergency Medical Services (EMS) personnel.
- Law enforcement.
- Fire investigator.
- Medical examiner.



Slide 11-9

- D. These slides provide a listing of potential persons involved in a fatal fire investigation. The investigator should be familiar with the role and responsibility of each.

1. Firefighters.
2. Emergency Medical Services (EMS) personnel.
3. Law enforcement.
4. Fire investigator.
5. Medical examiner.

WHO IS INVOLVED?

- Coroner.
- Pathologist .
- Clergy.
- Private investigators.
- Attorneys.



Slide 11-10

6. Coroner.
7. Pathologist.
8. Clergy.
9. Private investigators.
10. Attorneys.

RESPONSIBILITIES IN THE
INVESTIGATION OF FATAL FIRES

- Timely arrival of the investigator.
- Security of incident scene.
- Notification of appropriate agencies.
- Proper scene investigation.

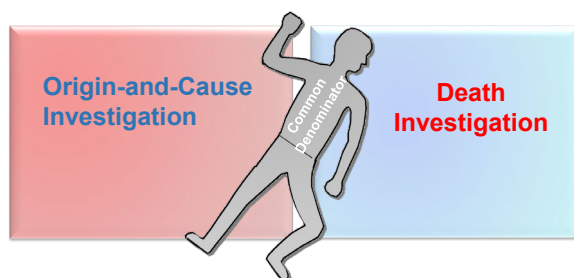


Slide 11-11

E. Responsibilities in the investigation of fatal fires.

1. Timely arrival of the investigator.
2. Security of incident scene.
3. Notification of appropriate agencies.
4. Proper scene investigation.
5. You only get **one** chance to do it right!

FATAL FIRE INVESTIGATION



Slide 11-12

- F. The investigator should understand that the body bridges the origin and cause investigation and the death investigation. The victim ties both investigations together. It essentially becomes two individual investigations.
1. Fire origin and cause.
 2. Fire death investigation.
- G. Any contradiction of facts developed must be reconciled.
- H. May involve other agencies (especially LODDs).
- I. Understand and know your responsibility.
- J. Handle it the same way as you process each and every fire scene.
- K. Only difference is that a body is now involved, and this will require additional investigative steps and documentation.

HUMAN BEHAVIOR

- Fear.
- Panic.
- Forgetfulness.
- Training.
- Mobility issues.



Slide 11-13

L. Human behavior.

1. Human behavior in fire.
 - a. Fear.
 - b. Panic.
 - c. Forgetfulness.
 - d. Training in appropriate fire behavior.
 - e. Lack of training in appropriate fire behavior.
2. Behavior of people may increase the danger.
 - a. Breaking a window for fresh air.
 - b. Re-entering a home to save others.
 - c. Shutting off water supply during building refurbishment.
 - d. Occupants may not do what we want them to do!

II. INJURIES AND CAUSE OF DEATH

**INJURIES AND CAUSE
OF DEATH**

- Asphyxiant/narcotic gases.
- Hyperthermia.
- Skin burns.
- Inhalation of hot gases/smoke.
- Soot and smoke.
- Hypoxia – reduced oxygen.
- Blunt trauma.



Slide 11-14

- A. The information presented indicates there are a variety of ways a person can perish by fire. While the investigator is not a medical professional, an understanding of the effect of fire on a victim is necessary.

1. Asphyxiant/narcotic gases.
2. Hyperthermia.
3. Skin burns.
4. Inhalation of hot gases/smoke.
5. Soot and smoke.
6. Hypoxia – reduced oxygen.
7. Blunt trauma.

ASPHYXIAN/NARCOTIC GASES

- Carbon monoxide (CO).
- Hydrogen cyanide (HCN).
- Carbon dioxide (CO₂).
- Oxygen depleted air.



Slide 11-15

B. Asphyxiant/narcotic gases.

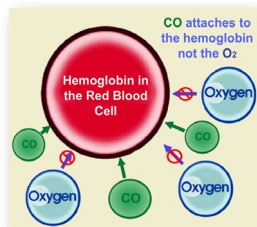
1. Simple asphyxiants are inert gases or vapors that displace oxygen from air when present in high concentrations. In low concentrations, they have no physiological effects. Normally oxygen can be measured in air at 18% by volume.
2. Simple asphyxiants include: H: hydrogen, helium; E: ethane, ethylene; N: nitrogen, neon; C: carbon dioxide (CO₂); A: acetylene, argon; M: methane; and P: propane, propylene.
3. When the O₂ concentration at sea level is below 16%, subjects have decreased mental alertness, visual acuity, and muscular coordination. Loss of consciousness occurs at concentrations below 10%, and death occurs at concentrations below 6%.
4. Narcotic: “A drug that causes insensibility or stupor. A narcotic induces narcosis, from the Greek ‘narke’ for ‘numbness or torpor.’”

CARBON MONOXIDE HEMOGLOBIN

Many fire victims die from carbon monoxide poisoning rather than thermal injuries.

Carboxyhemoglobin (COHb) level is a factor of many variables, including:

- Carbon monoxide (CO) concentration.
- Exposure time.
- Volume and rate of breathing.
- Medical issues (respiratory, cardiac).



Slide 11-16

C. Carboxyhemoglobin (COHb) level is a factor of many variables, including:

1. Carbon monoxide (CO) concentration.
2. Exposure time.
3. Volume and rate of breathing.
4. Medical issues (respiratory, cardiac).
5. COHb is relatively stable and can be measured in the blood long after death.
6. Graphic showing the attraction CO has for hemoglobin over oxygen.

CARBON MONOXIDE

- Evidence of CO poisoning is cherry red skin.
- **COHb** level will be reduced if the victim was administered oxygen prior to measurement.



Slide 11-17

7. Evidence of CO poisoning is cherry red skin.
8. COHb level will be reduced if the victim was administered oxygen prior to measurement.

9. Baseline COHb Levels.
 - a. Nonsmokers: 0.5 to 1.5%.
 - b. Smokers: 4 to 10%.
10. COHb levels in fire victims.
 - a. Ranges from less than 20% to more than 90%.
 - b. Greater than 50% is generally assumed to be fatal, but this value depends on each person.

COHb SYMPTOMS			
COHb (%)	Healthy Adult Symptoms	COHb (%)	Susceptible Subpopulations Symptoms
≈1	Physiologic background concentration	2	During physical exertion reduced time to onset of angina
5-6	Increase in cardiac arrhythmias in subjects with coronary artery disease	3-8	Background concentration in smokers
10	No appreciable effect, except shortness of breath on vigorous exertion, possible tightness across the forehead, dilation of cutaneous blood vessels	15	Myocardial infarction in subjects with coronary artery disease
20	Shortness of breath on moderate exertion, occasional headache with throbbing in temples	25	Stillbirths

Slide 11-18

COHb SYMPTOMS (CONTINUED)			
COHb (%)	Healthy Adult Symptoms	COHb (%)	Susceptible Subpopulations Symptoms
30	Decided headache, irritable, easily fatigued, judgment disturbed, possible dizziness, dimness of vision		
40-50	Headache, confusion, collapse, fainting on exertion	Source: Adapted from WHO 1999a. Retrieved from: https://www.ncbi.nlm.nih.gov/books/NBK220007/table/ttt00024/?report=objectonly	
60-70	Unconsciousness, intermittent convulsion, respiratory failure, death if exposure is long continued		
80	Rapidly fatal		

Slide 11-19

HYDROGEN CYANIDE (HCN)

- HCN is produced during the combustion of nitrogen-based materials such as:
 - Wool.
 - Nylon.
 - Plastics.
- These products are commonly found in household furniture and interior finishes.

Slide 11-20

D. Hydrogen cyanide (HCN).

HCN is produced during the combustion of nitrogen-based materials such as wool, nylon, and plastics, which are commonly found in household furniture and interior finishes.

CARBON DIOXIDE (CO₂)

CO ₂ (%)	Effect
0.04	Normal Air
0.5	Safe Limit, prolonged exposure
1.8 to 2.0	30-50% increase in ventilation rate
2.5 to 3.0	100% increase in ventilation rate
4	300% increase in ventilation rate
5	Dizziness, poisoning symptoms, > 30 minutes
7 to 9	Unconscious, in 15 minutes
10 to 30	Unconscious, in < 10 minutes, followed by death

Table 8-4; Quintiere, *Principles of Fire Behavior*, 1998: pg. 162

Slide 11-21

E. CO₂.

HYPERTHERMIA OR HEAT STROKE

- Acute Hyperthermia.
 - Exposure to high temperature less than 15 minutes.
- Simple Hyperthermia.
 - Prolonged exposure typically beyond 15 minutes.
 - Temperatures ranging from 180 °F to 250 °F.



Slide 11-22

F. Hyperthermia.

1. Acute hyperthermia: exposure to high temperature less than 15 minutes.
2. Simple hyperthermia: prolonged exposure typically beyond 15 minutes. Temperatures ranging from 180 F to 250 F.

BURNS

Burns are the result of thermal impact to soft tissue:

- The exterior of the body.
- Intradermally.
- Internally.



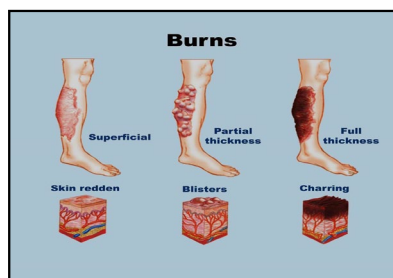
Slide 11-23

G. Burns.

1. Burns are the result of thermal impact to soft tissue. Burns occur on the exterior of the body, intradermally, or internally.

DEGREES OF BURNS

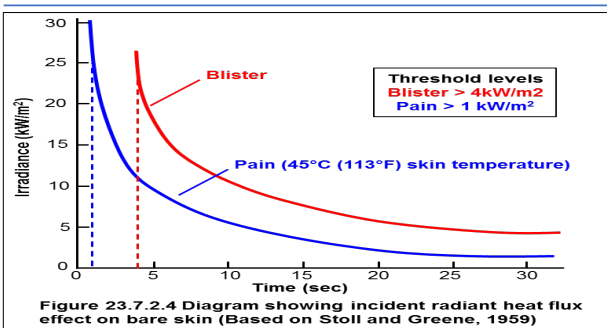
- 1st degree. (sunburn)
- 2nd degree. (blistering)
- 3rd degree. (full thickness of skin damage)
- 4th degree. (charring)



Slide 11-24

2. Degrees of burns.
 - a. 1st degree (sunburn).
 - b. 2nd degree (blistering).
 - c. 3rd degree (full thickness of skin damage).
 - d. 4th degree (charring).

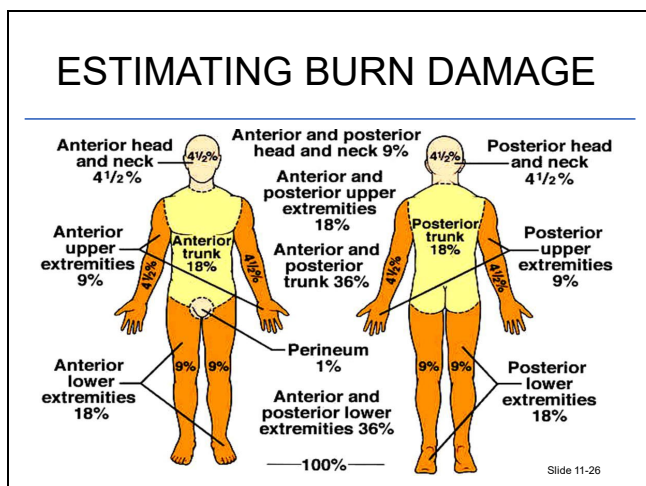
BURNS DUE TO RADIATION



-NFPA 921, Section 25.2.5.1

Slide 11-25

3. Thermal radiation on exposed skin.



4. The rule of nines is a method used to easily calculate the treatment needs for a person who has been burned. It is sometimes referred to as the Wallace rule of nines after Dr. Alexander Wallace, the surgeon who first published the method.

INHALATION OF HOT GASES

- Thermal inhalation burns are accompanied by external facial burns.
- Burns occur at lower temperatures when air is moist.

Slide 11-27

H. Inhalation of hot gases.

1. It may be difficult to distinguish the effects of thermal inhalation burns from edema and inflammation caused by chemical irritants in smoke.
2. Thermal inhalation burns are accompanied by external facial burns.
3. Burns occur at lower temperatures when air is moist.
4. Dry air at around 300 C may cause burns at the larynx after a few minutes.

5. Humid air, steam, or smoke with a high thermal capacity or latent heat may be dangerous at temperatures of around 100 C, causing burns throughout the respiratory tract.

SMOKE AND SOOT

Effects of smoke and soot are:

- Upper and lower respiratory tracts:
 - Irritation.
 - Burns.
 - Edema.
- Absorption of toxic chemicals by the body when inhaled.



Slide 11-28

- I. Effects of smoke and soot.
 1. Upper and lower respiratory tracts.
 - a. Irritation.
 - b. Burns.
 - c. Edema.
 2. Absorption of toxic chemicals by the body when inhaled.

SMOKE AND SOOT

Effects of smoke and soot may prevent escape from the fire by:

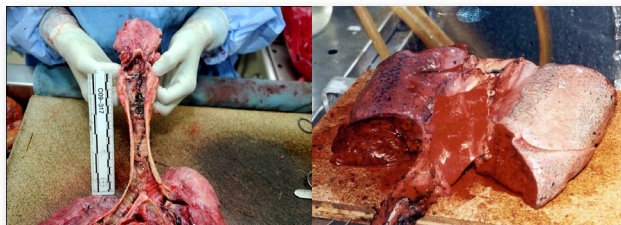
- Impaired vision due to eye irritation.
- Visual obscuration by particulate matter.



Slide 11-29

3. Irritation, burns, or edema of the upper and lower respiratory tracts. Respiratory tract may contain traces of toxic chemicals absorbed by body when inhaled. Additionally, the ability to escape is hindered by impaired vision due to eye irritation as well as visual obscuration by particulate matter.

SMOKE AND SOOT (TRACHEA CROSECTION)



Cross section of trachea and lungs showing soot inhalation.

Slide 11-30

THERMAL EXPOSURE

If thermal exposure continues past the intensity to create thermal burns and killing the victim, the body will then continue to be destroyed by the fire.

Slide 11-31

4. If thermal exposure continues past the intensity to create thermal burns and killing the victim, the body will then continue to be destroyed by the fire.

DESTRUCTION OF BODY BY FIRE

- There are four major combustible components of the body:
 - Skin.
 - Fat.
 - Muscle.
 - Bone.
- The significant difference between these components is moisture content.



-NFPA 921, Section 24.3

Slide 11-32

J. Destruction of body by fire.

1. There are four major combustible components of the body: skin, fat, muscle, and bone. The significant difference between these components is moisture content. Skin, muscle tissue and bone are not good fuels, but will burn, will get consumed and will develop patterns. Fat is a fuel and will contribute to the combustion process.

For additional information, turn to National Fire Protection Association (NFPA) 921, *Guide for Fire and Explosion Investigations*, 2024 edition, Section 24.3 and review Sections 24.3.1, 3.2, 3.3, and 3.4 for detailed information of fire effects on each of the body systems.

DESTRUCTION OF BODY BY FIRE (SKIN)

Heat damage to skin will expose the underlying fat layer and ultimately expose fatty tissue.



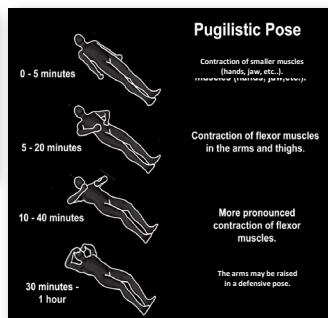
Slide 11-33

2. Heat damage to skin will expose the underlying fat layer and ultimately expose fatty tissue. This can result in splitting of the skin to expose the underlying fat. The photo on the slide depicts color change, blistering and splitting of skin.

CONSUMPTION OF BODY BY FIRE (MUSCLE)



Muscle dehydrates resulting in shrinking and flexion. The pugilistic pose.



Slide 11-34

3. Muscle dehydrates resulting in shrinking and flexion. The pugilistic pose.
 - a. Pugilistic posture (fighter pose) is caused by the retraction of flexor muscle due to heat contraction of the finger, arms and legs.
 - b. Myth was that finding a victim in this position made reference to a fight before the fire.
 - c. If the fire and thermal impacts continue to affect the victim, additional soft tissue loss will result in the exposure and destruction of muscle tissue.

DESTRUCTION OF BODY BY FIRE (MUSCLE- VIDEO)



Slide 11-35

DESTRUCTION OF BODY BY FIRE (MUSCLE- VIDEO RESULT)



Slide 11-36

DESTRUCTION OF BODY

- Bodies **DO NOT** burn well unless fatty tissue is exposed.
- Once fatty tissue and oils are exposed, prolonged burning will occur as a result of a wick effect.
- Without something to act as a wick, an ignitable liquid poured on a body will burn as a pool fire until another combustible is ignited:
 - Example: Fatty tissue and/or clothing.

Slide 11-37

4. Bodies **do not** burn well unless fatty tissue is exposed. Once fatty tissue and oils are exposed, prolonged burning will occur as a result of a wick effect. Without something to act as a wick, an ignitable liquid poured on a body will burn as a pool fire until another combustible is ignited (ex. fatty tissue, clothing).

DESTRUCTION OF BODY BY FIRE (FAT – VIDEO)



Slide 11-38

CONSUMPTION OF BODY BY FIRE (BONE)



- Living bone will shrink, fracture, and change color.
- Bone becomes very fragile depending upon thermal exposure time.
- Supplies fuel in the form of marrow and tissue.



- Small bones are generally not consumed but become dislodged and lost in debris.

Slide 11-39

5. Bones go through color and degradation changes proportional to the exposure to heat and orientation.
 - a. Color changes from buff to carbonized black from charring.
 - b. White to gray calcination.
 - c. Become brittle and fractures easily.
 - d. Long bones may shrink.
6. Myth or fact: Fingers, hands and feet will be consumed in the fire.

POSTMORTEM CHANGES



LIVIDITY



RIGOR MORTIS

Slide 11-40

- K. Postmortem changes.
 1. Rigor mortis.
 - a. Develops first in the hands and feet, then torso and limbs and head.

- b. The onset has to do with the temperature of the body, the environment, and the physical activity of the victim just before death.
 - c. After 12 to 24 hours, rigor mortis dissipates.
 - d. An experienced forensic pathologist can determine the difference between rigor mortis or rigidity caused by exposure to fire and heat.
 - e. Helps establish time of death.
2. Lividity.
- a. Pooling of blood (lividity/liver mortis).
 - b. Can change within the first few hours after death but is fixed in 6 to 9 hours.
 - c. Severe CO discoloration can give similar appearance.
 - d. Loss of body temperature.
 - e. Rigor mortis.
 - f. Postmortem lividity.
 - g. Decomposition.

FIRE DEATH (CAUSES AND TIMES)

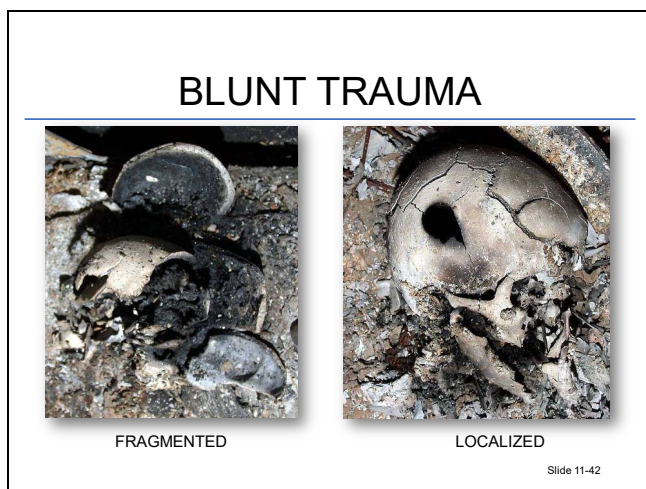
- Immediate:
 - Smoke inhalation/superheated gases.
 - Thermal burns, blunt force trauma.
- Delayed deaths (2 to 3 days):
 - Shock.
 - Fluid loss.
 - Inhalation of toxic gases.
- Delayed deaths (>3 days):
 - Sepsis.
 - Chronic respiratory insufficiency.

Slide 11-41

L. Fire death causes and times.

- 1. Immediate: smoke inhalation/superheated gases, thermal burns, blunt force trauma.

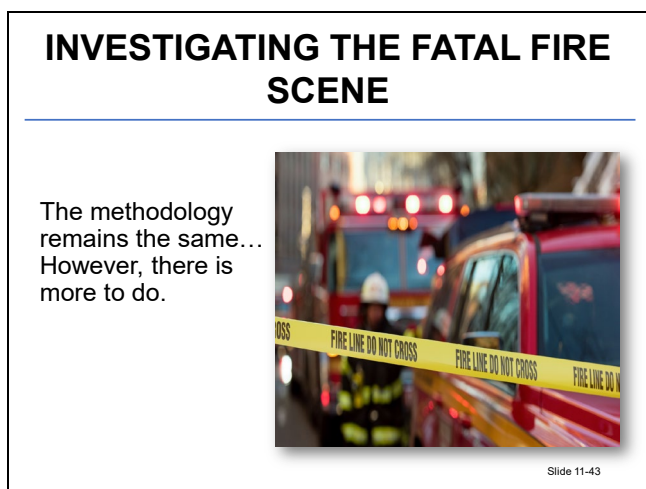
2. Delayed deaths (2 to 3 days): shock, fluid loss, inhalation of toxic gases.
3. Delayed deaths (>3 days): sepsis, chronic respiratory insufficiency.



M. Blunt trauma.

The victim may not have been killed as a result of the fire. The photo on the left shows a skull damaged by the fire. The photo on the right illustrates a skull which was damaged by localized blunt force trauma.

III. INVESTIGATING THE FATAL FIRE



STARTING THE INVESTIGATION

Team Approach:

- Coroner/medical examiner.
- Local PD.
- Local crime scene. Unit/state agencies.
- Ignitable Liquid Detection K-9.
- ATF.
 - (CFI, fire research lab consult, NRT)
- Prosecutor.



Slide 11-44

A. Starting the investigation.

1. A team approach is the recommended process for a fatal fire scene. There will be multiple interested parties, agencies with jurisdictions and requirements, which will create demands on the investigator.
2. Examples include:
 - a. Coroner/medical examiner.
 - b. Local police department.
 - c. Local crime scene unit/state agencies.
 - d. Ignitable Liquid Detection K-9.
 - e. Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) Certified Fire Investigator (CFI), Fire Research Lab (FRL), Fire Protection Engineer (FPE), Electrical Engineer (EE), National Response Team (NRT).
 - f. Prosecutor.

SAFETY

- Disposable gloves.
- Do not use fire work gloves.
- Eye and face protection.
- Disposal of contaminated debris.
- Clean tools after use.



Slide 11-45

B. Safety.

1. Disposable gloves (do not use fire work gloves).
2. Eye and face protection.
3. Disposal of contaminated debris.
4. Clean tools after use.
5. **Potential hazard: Employee exposure to bloodborne pathogens** from blood and Other Potentially Infectious Materials (OPIMs) because employees are not using universal precautions.
 - a. Bloodborne pathogens are pathogenic microorganisms that are present in human blood and can cause disease in humans.
 - b. Some infections that can be transmitted through contact with blood and body fluids include:
 - HIV, Hepatitis A, B, C, Staph and Strep infections, Gastroenteritis-salmonella, and shigella, Pneumonia, Syphilis, TB, Malaria, Measles, Chicken Pox, Herpes, urinary tract infections, and blood infections.
 - The greatest risks are from HIV and Hepatitis B and C.

6. **Possible solutions.**

Use universal precautions. Universal precautions are an approach to infection control to treat all human blood and certain human body fluids as if they were known to be infectious for HIV, HBV and other bloodborne pathogens (Bloodborne Pathogens Standard 29 CFR 1910.1030(b) definitions).

7. Bloodborne Pathogen Standard 29 CFR 1910.1030(d)(1) requires:
 - a. Employees to observe universal precautions to prevent contact with blood or OPIMs.
 - b. “Under circumstances in which differentiation between body fluid types is difficult or impossible, all body fluids shall be considered potentially infectious materials.”
 - c. Treat all blood and other potentially infectious materials with appropriate precautions such as:
 - Use gloves, masks, and gowns if blood or OPIM exposure is anticipated.
 - Use engineering and work practice controls to limit exposure.
8. OPIM is defined in 29 CFR 1910.1030(b) as:
 - a. “The following human body fluids: semen, vaginal secretions, cerebrospinal fluid, synovial fluid, pleural fluid, pericardial fluid, peritoneal fluid, amniotic fluid, saliva in dental procedures, any body fluid that is visibly contaminated with blood, and all body fluids in situations where it is difficult or impossible to differentiate between body fluids.
 - b. Any unfixed tissue or organ (other than intact skin) from a human (living or dead).
 - c. HIV-containing cell or tissue cultures, organ cultures, and HIV- or HBV-containing culture medium or other solutions; and blood, organs, or other tissues from experimental animals infected with HIV or HBV.”
9. The Bloodborne Pathogens Standard allows for hospitals to use acceptable alternatives (OSHA Directive CPL 02-02-069, (2001, November 27)) to universal precautions:
 - a. “Alternative concepts in infection control are called Body Substance Isolation (BSI) and Standard Precautions. These methods define **all** body fluids and substances as infectious. These methods incorporate not only the fluids and materials covered by the Bloodborne Pathogens Standard but expands coverage to include all body fluids and substances.

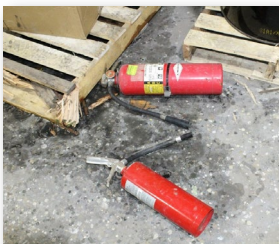
- b. These concepts are acceptable alternatives to universal precautions, provided that facilities utilizing them adhere to all other provisions of this standard.”
- 10. “For compliance with OSHA Standards, the use of either Universal Precautions or Standard Precautions are acceptable. The CDC recommends **Standard Precautions** for the care of all patients, regardless of their diagnosis or presumed infection status.
 - a. **Standard Precautions** apply to 1) blood; 2) all body fluids, secretions, and excretions, **except sweat**, regardless of whether or not they contain visible blood; 3) non-intact skin; and 4) mucous membranes. Standard precautions are designed to reduce the risk of transmission of microorganisms from both recognized and unrecognized sources of infection in hospitals.
 - b. Standard precautions include the use of: hand washing, appropriate personal protective equipment such as gloves, gowns, masks, whenever touching or exposure to patients’ body fluids is anticipated.”
- 11. “**Transmission-Based Precautions** (i.e., Airborne Precautions, Droplet Precautions, and Contact Precautions) are recommended to provide additional precautions beyond Standard Precautions to interrupt transmission of pathogens in hospitals.

Transmission-Based Precautions can be used for patients with known, or suspected to be infected or colonized with, epidemiologically important pathogens that can be transmitted by airborne or droplet transmission or by contact with dry skin or contaminated surfaces. These precautions should be used in addition to standard precautions.
- 12. **Airborne Precautions** used for infections spread in small particles in the air such as chicken pox.
- 13. **Droplet Precautions** used for infections spread in large droplets by coughing, talking, or sneezing such as influenza.
- 14. **Contact Precautions** used for infections spread by skin to skin contact or contact with other surfaces such as herpes simplex virus.
- 15. Airborne Precautions, Droplet Precautions, and Contact Precautions. May be combined for diseases that have multiple routes of transmission. When used either singularly or in combination, they are to be used in addition to Standard Precautions.”

LOCATE AND DOCUMENT VICTIM LOCATION

If victim is located at the point of origin, need to ask why. They may have been:

- Attempting to locate or suppress the fire.
 - Delayed notification?
- Incapacitated.
- Ignition witness.
 - Person responsible for initiating fire.



Slide 11-46

C. Locate and document victim location.

1. If victim is located at the point of origin, need to ask why:
 - a. Attempting to locate or suppress the fire.
 - b. Incapacitated.
 - c. Ignition witness.
 - d. Were they the person responsible for initiating fire?

DOCUMENTING THE VICTIM

- If victim has already been moved from the scene the clothing should be obtained at the hospital for evidence.
- Interview first responders to identify victim location.
- Search and document immediate area around where the victim was found or once located.



Slide 11-47

2. If the victim has already been moved from the scene and transported to the hospital, the clothing should be obtained at the hospital for evidence. Interview first responders to identify victim location. Search and document immediate area around where the victim was found or once located.

VICTIM MEASUREMENTS

- Take measurements prior to and after layering procedures.
- Measure from fixed points.
- Photograph measurements.
- Identify measurements on diagram.



Slide 11-48

3. Victim measurements.

- Take measurements prior to and after layering procedures.
- Measure from fixed points.
- Photograph measurements.
- Identify measurements on diagram.

PHOTOGRAPH THE VICTIM

- Body and surroundings.
- Position of the body.
- All exposed surfaces of body.



Slide 11-49

D. Photographing the victim.

- The investigator will take multiple photographs, many of which may be disturbing, including close-up photos, photos of deceased children, and morbid photos. Take more photos than what you think you need.
 - Body and surroundings.

- b. Position of the body.
- c. All exposed surfaces of body.

PHOTOGRAPH PATTERNS

- Fire patterns on victim body and clothes.
- Manner of dress.
- Physical trauma.



Slide 11-50

2. During the scene examination, the investigator should consider additional photographs, over and above what may be used at other fire scenes. Photos should include:
- a. Fire patterns on victim body and clothes.
 - b. Manner of dress.
 - c. Physical trauma.

PHOTOGRAPH EXCAVATION



Take photographs prior to, during, and at completion of layering procedures.

Slide 11-51

3. The investigator should take photographs prior to, during, and at completion of layering procedures. For example, there should be another 15 to 25 photos in between the two pictured on the slide.

PHOTOGRAPH REMAINS

- Physical evidence around body and overall scene.
- Items that assist in identification.



Slide 11-52

4. Investigators should include any items around the body, as part of the detailed photography. Any physical evidence around body and overall scene or any items that would assist in identification. Photograph everything in and around the body.
 - a. Items that assist in identification.
 - b. Position of the body.
 - c. Extent of burning to the body.
 - d. Removal of the body.
 - e. Body location in relation to the origin of the fire.

PHOTOGRAPH REMOVAL

- Removal of body.
- Placement in body bag.
- Body bag sealed and tagged.
- Location of body post removal.



Slide 11-53

5. Photographing the body removal should be thorough and document all steps. Use mid-range and close-up photographs. Photograph any items discovered under the victim.

- a. Removal of body.
- b. Placement in body bag.
- c. Body bag sealed and tagged.
- d. Location of body post removal.

PHOTOGRAPH MOVEMENTS

- Entry and exit points.
(means of egress)
- Escape attempts by the victim.
- Obstacles preventing escape.



Slide 11-54

E. Photographing movements.

Investigators should evaluate discoveries such as:

1. Entry and exit points (means of egress).
2. Escape attempts by the victim.
3. Obstacles preventing escape.

F. Photographing smoke detectors.

PHOTOGRAPH THE SCENE

- Identify location.
- Were they operational.
 - Soot agglomeration around audible horn.
- Hard-wired or battery.
- Monitored.
- Witness statements to support activation.



Slide 11-55

1. Look for detectors on the ground.
 - a. Did anyone hear the alarm?
 - b. Soot attached to the external audible horn?
2. Sound activation causes vibrations which results in remarkable patterns around the sound cone. Recent research suggests the soot accumulation around the horn is an indication the smoke detector was sounding.

DIAGRAMS AND SKETCHES

Used to supplement photos, and show additional details:

- Measurements and distances:
 - Need to be able to "place" the body back in the diagram.
 - Consider total station system/forensic mapping, specialty cameras.
- Doors, windows, exits and any other unique features.
- Complete documentation for reconstruction purposes.
- Take plenty of photos – you never know what may end up being important.

Slide 11-56

G. Diagrams and sketches.

1. Diagrams and sketches are used to supplement photos and show additional details. Investigators should take accurate measurements and distances, including doors, windows, exits and any other unique features.

DIAGRAMS

- Diagrams — not to scale.
- Information regarding the fire and the victim.



Slide 11-57

2. Take measurements so as to be able to “place” the body back in the diagram. Complexity of scene may require additional mapping technology, 3D imagery, or drone footage. Collect complete documentation in order to re-create the scene if necessary. Take multiple photos – you never know what may end up being important.

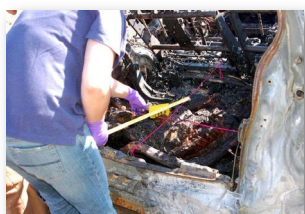
SCENE PROCESSING AND BODY REMOVAL

- Many items of evidence may be around, under, or near the body.
- The entire area requires a thorough search:
 - Sectoring.
 - Gridding.
 - Chalking, taping, stringing.
- Each grid documented and overlapped.
- Careful sifting and layering of debris with periodic photographs during stages.

Slide 11-58

- H. The investigator may find evidence around, under or near the body. The entire area requires a thorough search:
 1. Sectoring.
 2. Gridding.
 3. Chalk, tape, string.
- I. Care should be taken to use appropriate search techniques, each grid documented and overlapped including careful sifting and layering of debris with periodic photographs during stages.

SCENE PROCESSING



GRID SEARCH

BONE FRAGMENTS RECOVERED
DURING GRID SEARCH AND
SIFTING.

Slide 11-59

BODY REMOVAL

- Examine debris around body prior to removal.
- Place body in new sealed body bag.
- Debris adhering to body should be transported in body bag and preserved for examination.



Slide 11-60

- J. Care should be taken to fully document the body removal, including:
1. Examine debris around body prior to removal.
 2. Place body in new sealed body bag.
 3. Debris adhering to body should be transported in body bag and preserved for examination.

VICTIM CLOTHING

- Preserve clothing when self-immolation is suspected or evidence of ignitable liquid exposure.
- Preserve clothes in evidence cans for forensic examination.



Slide 11-61

- K. Preserve clothing when self-immolation is suspected or evidence of ignitable liquid exposure. If preserved for ignitable liquid exam, preserve clothes in evidence cans.

CORONER VERSUS MEDICAL EXAMINER

Coroner

- Elected by the people or appointed by the government authority.
- Specific training or experience in medicine is not required.

Medical Examiner

- Appointed by the Health Department.
- Must be a physician and is usually a pathologist who is trained in forensic medicine.

Slide 11-62

- L. Coroner versus medical examiner.

IV. AUTOPSY PROCEDURES

FORENSIC AUTOPSY AND IDENTIFICATION

- Identification of victim.
- Establish:
 - Time of death.
 - Cause of death.
 - Manner of death.

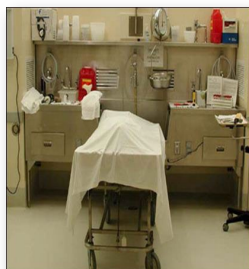


Slide 11-63

- A. Forensic autopsy and identification.
1. Identification of victim.
 2. Establish the time of death.
 3. Establish the cause of death.
 4. Establish the manner of death.

FORENSIC AUTOPSY PROCEDURES

- Supervise the removal of the victim.
- Conduct a postmortem examination of the body.
- Through external, internal and microscopic exams.
- Perform a radiological examination.
- Conduct toxicology tests.



Slide 11-64

B. Procedures for forensic autopsy.

1. Supervise the removal of the victim.
2. Conduct a postmortem examination of the body.
3. Through external, internal and microscopic exams.
4. Perform a radiological examination.
5. Conduct toxicology tests.

INVESTIGATORS ROLE AT THE AUTOPSY

- The investigator should attend the autopsy if possible.
- Collect any clothing that was transported with the body at this time for evidence.
- Document the autopsy with photos.
- May help answer questions from the scene.
- Ask questions.

-NFPA 921, Section 25.9

Slide 11-65

C. The investigator should attend the autopsy. Collect any clothing that was transported with the body at this time for evidence.

1. Document the autopsy with photos.
2. May help answer questions from the scene.

3. Ask questions.

RECOMMENDED TESTS

- COHb in blood.
- Hydrogen cyanide concentration.
- Blood alcohol.
- Drug screen.
- Poisons.
- Stomach contents.



Slide 11-66

D. Recommended tests.

1. COHb in blood.
2. HCN concentration.
3. Blood alcohol.
4. Drug screen.
5. Poisons.
6. Stomach contents.

DETERMINING CAUSE OF DEATH

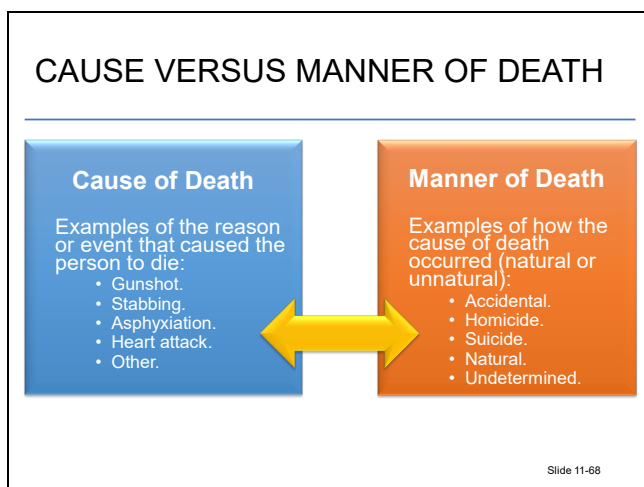
- Cause and manner of death are the responsibility of the medical examiner.
- Fire investigator can make observations:
 - Observation of fire effects on the body.
 - Observation of time effects on the body.



Slide 11-67

E. Determining cause of death.

1. Cause and manner of death are the responsibility of the medical examiner. Fire investigator can make observations, such as:
 - a. Observation of fire effects.
 - b. Observation of time effects on the body.



2. Determination as to the cause of death (what killed the person). A second determination is the manner of death, e.g., an accident, homicide, etc.

VICTIM IDENTIFICATION

- Visual.
- Fingerprints.
- Dental.
- Medication.
- Prosthetics.
- Prosthetic implants.



Slide 11-69

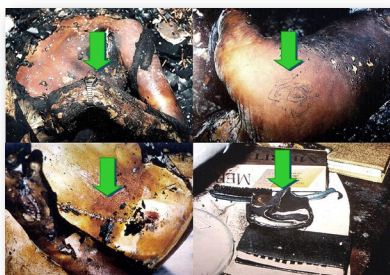
F. Victim identification.

1. While the autopsy will provide a definitive identification of the victim, the investigator may observe other indicators of identification either at autopsy or at the scene.

- a. Fingerprints can be retrieved from fingertips if the skin has peeled away. The underlying tissue would have to be rehydrated, which would cause the print to become more legible.
- b. Medication may help to establish identification and other information regarding the victim.
 - Any prescription bottle should be collected and given to the medical examiner.
 - The type of prescription may help in the identification of past illness, mental health or recent injury.
- c. Prosthetics can also assist in the identification of the victim while on the scene.
- d. Dentures may have identification of the “wearer” engraved in the appliance.
 - If dental appliances are recovered at the scene, they should accompany the body to the morgue. Dental X-rays may assist with identification: molars will normally remain because of their location within the mouth.
 - Dental crowns/caps may explode due to high heat.
- e. Many surgical appliances have serial numbers and can be traced back to the person that received that device. Additionally, the appliance/implant may support the tentative identification of the deceased.

VICTIM IDENTIFICATION (CONTINUED)

- Scars.
- Jewelry.
- Tattoos.
- X-rays.



Slide 11-70

2. Other example of potentially identifying marks.

- a. Scars.
- b. Jewelry.
- c. Tattoos.
- d. X-rays.

IDENTIFICATION DIFFICULTIES

- Human remains can be difficult to identify and may have similar mass to some larger animals.
- Smaller mass, such as children and infants, may suffer severe damage which can hamper identification.
- Forensic anthropologist can be useful (e.g., animal versus human)



Slide 11-71

- 3. Severely damaged human remains of an adult can be difficult to identify and have similar mass to some larger animals.
 - a. Smaller mass, such as children and infants, may suffer severe damage which may hamper identification.
 - b. Forensic anthropologist can be useful (e.g., animal versus human).

ANALYSIS OF INVESTIGATIVE DATA

Analyze all investigative data:

- Incident timeline.
 - Fire events.
- Victim timeline.
 - Victim discovery.
 - Removal.
 - Transport.
 - Arrival at medical exam facility.



Slide 11-72

- G. Analyze all investigative data, including the incident timeline and fire events. Produce a victim timeline which would include:
1. Victim discovery.
 2. Removal.
 3. Transport.
 4. Arrival at medical exam facility.
- H. The relationship between the death and the fire should be investigated. Not all fire-related deaths are directly caused by heat, flame, smoke and gas, e.g., a person smoking in bed dying from a heart attack.
1. Immediate: smoke inhalation, thermal burns, blunt force trauma.
 2. Delayed deaths (2 to 3 days): shock, fluid loss, inhalation of toxic gases.
 3. Delayed deaths (>3 days): sepsis, chronic respiratory insufficiency.

ANALYSIS OF INVESTIGATIVE DATA

Victim activity before, during, and after the fire:

- Victim location.
- Position.
- Clothing type/patterns.
- Body burn patterns/damage.
- Items found with the body.
- Blast damage.



Slide 11-73

- I. Victim activity before, during and after the fire:
1. Victim location.
 2. Position.
 3. Clothing type/patterns.
 4. Body burn patterns/damage.
 5. Items found with the body.

6. Blast damage.

ANALYSIS OF INVESTIGATIVE DATA

Pre-fire victim impairment:

- Was the victim a smoker or drug user?
- What was the mental state of the victim?
- What was the victim's medical history?



Slide 11-74

J. The investigator should attempt to determine if there was any pre-fire impairment of the victim.

1. Was the victim a smoker or drug user?
2. What was the mental state of the victim?
3. What was the victim's medical history?

ANALYSIS OF INVESTIGATIVE DATA (CONTINUED)

Sources:

- Last person to see victim.
- Discoverer of the fire.
- Discoverer of the victim.
- Last person at the point of origin.
- Ask about insurance information.



Slide 11-75

K. Other sources of information for the investigator could include:

1. Last person to see victim.
2. Discoverer of the fire.
3. Discoverer of the victim.

4. Last person at the point of origin.
5. Ask about insurance information.

V. LINE-OF-DUTY DEATHS

FIREFIGHTER LINE-OF-DUTY DEATHS (LODDs)



Slide 11-76

FIREFIGHTER LINE-OF-DUTY DEATHS (LODDs)

- An on-duty fatality includes any injury or illness that was sustained while on duty and proves fatal.
- The term “on duty” refers to:
 - Being involved in operations at the scene of an emergency, whether it is a fire or non-fire incident.
 - Responding to or returning from an incident.
 - Performing other officially assigned duties, such as training, maintenance, public education, inspection, investigations, court testimony or fundraising.
 - Being on call, under orders or on standby duty (except at the individual's home or place of business).

Slide 11-77

- A. The term “on duty” refers to:
1. Being involved in operations at the scene of an emergency, whether it is a fire or non-fire incident.
 2. Responding to or returning from an incident.
 3. Performing other officially assigned duties, such as training, maintenance, public education, inspection, investigations, court testimony or fundraising.
 4. Being on call, under orders or on standby duty (except at the individual’s home or place of business).

FIREFIGHTER LINE-OF-DUTY DEATHS (LODDs)

- On Dec. 15, 2003, President George W. Bush signed the Hometown Heroes Survivors Benefit Act of 2003 into law. The law presumes that a heart attack or stroke is in the line of duty if the firefighter was engaged in nonroutine, stressful or strenuous physical activity while on duty, and the firefighter became ill within 24 hours after engaging in such activity.

Slide 11-78

- B. On Dec. 15, 2003, President George W. Bush signed the Hometown Heroes Survivors Benefit Act of 2003 into law. The law presumes that a heart attack or stroke is in the line of duty if the firefighter was engaged in nonroutine, stressful or strenuous physical activity while on duty, and the firefighter became ill within 24 hours after engaging in such activity (“Firefighter Fatalities in the United States in 2019”, USFA, October 2020).

FIRE FIGHTER LINE-OF-DUTY DEATHS

- Firefighting claims about 100 lives annually in the United States.
- Approximately half are volunteer fire fighters.
- Over half are on-scene or on-duty.
- Over half are attributed to stress and/or overexertion.
- Heart attack has consistently been the leading cause of “on-duty” deaths, accounting for about 45% of the mortality.
- The vast majority of the remaining deaths are traumatic with motor vehicle-related deaths, smoke inhalation/burns, and falls/structure collapse being common causes.
- Approximately one-third are not incident-related.

Slide 11-79

- C. Firefighting claims about 100 lives annually in the United States.
1. Approximately half are volunteer firefighters.
 2. Over half are on-scene or on-duty.
 3. Over half are attributed to stress and/or overexertion.
 4. Heart attack has consistently been the leading cause of “on-duty” deaths, accounting for about 45% of the mortality.

5. The vast majority of the remaining deaths are traumatic with motor vehicle-related deaths, smoke inhalation/burns, and falls/structure collapse being common causes.
6. Approximately one-third are not incident-related.

**NATIONAL INSTITUTE FOR
OCCUPATIONAL SAFETY AND HEALTH
(NIOSH)**

The NIOSH FIRE FIGHTER FATALITY
INVESTIGATION AND PREVENTION PROGRAM
(FFFIPP):

- Implemented by Congress in 1998 to address the problem of occupational firefighter fatalities.
- Team conducts investigations of all line-of-duty firefighter fatalities.
- Issues reports and recommendations to prevent future incidents.
– <http://www.cdc.gov/niosh/fire/>

Slide 11-80

D. National Institute for Occupational Safety and Health (NIOSH).

1. Implemented by Congress in 1998 to address the problem of occupational firefighter fatalities.
2. Team conducts investigations of all line-of-duty firefighter fatalities.
3. Issues reports and recommendations to prevent future incidents.
4. <http://www.cdc.gov/niosh/fire/>

**PUBLIC SAFETY OFFICER
BENEFITS ACT**

- PSOB Law 26, the PSOB Act (42 United States Supreme Court (USSC) 3796, Public Law 94-430), became law on Sept. 29, 1976.
- On Oct. 26, 2001, as part of the Patriot Act of 2001, the benefit was increased to \$250,000 and made retroactive to Jan. 1, 2001.



Slide 11-81

E. Public Safety Office Benefits Act.

1. The Public Safety Officer Benefits (PSOB) Law 26, the PSOB Act (42 United States Supreme Court (USSC) 3796, Public Law 94-430), became law on Sept. 29, 1976.
2. On Oct. 26, 2001, as part of the Patriot Act of 2001, the benefit was increased to \$250,000 and made retroactive to Jan. 1, 2001.
3. As part of the PSOB, an autopsy is recommended on all LODDs, regardless of how they occurred.

U.S. FIRE ADMINISTRATION AUTOPSY PROTOCOL



Slide 11-82

F. U.S. Fire Administration (USFA) autopsy protocol.

1. The “Firefighter Autopsy Protocol” has been extensively revised since its original 1994 edition. In this new protocol, a number of additional areas of information have been provided to take into account emerging issues and new technologies as applied to the conduct of autopsies.
2. As stated in the report, it is recommended that autopsies be performed for all firefighter fatalities where an LODD has occurred. It is further recommended that an autopsy be performed when a non-LODD may be linked to a line-of-duty exposure.
3. Autopsies are now recommended for all firefighter deaths, and the International Association of Fire Fighters (IAFF) and other organizations encourage this practice.
4. NIOSH’s Fire Fighter Fatality Investigation and Prevention Program (FFFIPP) uses autopsy results in the analysis of firefighter fatalities and specifically recommends that an autopsy be performed even if the cause of death is presumed to be natural. Section III.3, Investigation of Line-of-Duty Deaths, provides additional details on this NIOSH program.

5. The protocol is divided into the following sections:
 - a. Preliminary.
 - b. Initial examination.
 - c. External examination.
 - d. Internal examination.
 - e. Toxicological examination.
 - f. Microscopic examination.
 - g. Summary of pathological findings.
 - h. Conclusions.
6. The specific areas of procedures are described, but detailed step-by-step instructions are not provided as autopsy practice varies and changes with the specific circumstances of death.

**UNITED STATES FIRE
ADMINISTRATION (USFA) AUTOPSY
PROTOCOL**

Personal Protective
Equipment (PPE)
description:

- Turnout gear.
- Helmet.
- Gloves.
- Boots.
- Self Contained
Breathing Apparatus.
(SCBA)
- Personal Alert Safety
System. (PASS)



Slide 11-83

7. Securing the personal protective equipment (PPE) is crucial since an examination to determine if it failed in some way needs to be performed by qualified personnel.
 - a. Turnout gear.
 - b. Helmet.
 - c. Gloves.

- d. Boots.
- e. Self-contained breathing apparatus (SCBA).
- f. Personal Alert Safety System (PASS).
- g. Protective hood.

FATAL FIRE EVIDENCE

Anything on the victim should be preserved or collected to include items removed at the scene during medical treatment:

- All clothing worn under turnouts.
- AppleWatch™ or other smart watch.
- Cell phone.
- Helmet camera or body camera.



Slide 11-84

- 8. Everything on the victim is evidence. Preserve it!
 - a. All clothing worn under turnouts.
 - b. AppleWatch™ or other smart watch.
 - c. Cell phone.
 - d. Helmet camera or body camera.

CUSTODY OF EQUIPMENT

- Appropriate storage conditions.
- Chain of custody.
- Limitation of handling if clothing and equipment are fragile.



Slide 11-85

9. Custody of equipment.
 - a. Appropriate storage conditions.
 - b. Chain of custody.
 - c. Limitation of handling if clothing and equipment are fragile.

SUMMARY LODD

- Best first chance at evidence.
- Protect and preserve evidence.
- Stay aware during patient care.



Slide 11-86

- G. Summary of LODD.

VI. SECONDARY TRAUMA

SECONDARY TRAUMA

- Fire investigators can experience “secondary trauma” or “compassion fatigue” from exposure to the trauma of others.
- Secondary trauma can manifest in many forms such as:
 - Depression/helplessness.
 - Sleep disorders.
 - Avoidance behaviors.
- Secondary trauma can be diagnosed as repeated exposure trauma (RET) or post traumatic stress disorder (PTSD).

Slide 11-87

- A. Fire investigators can experience “secondary trauma” or “compassion fatigue” from exposure to the trauma of others.

- B. Secondary trauma can manifest in many forms such as:
1. Depression/helplessness.
 2. Sleep disorders.
 3. Avoidance behaviors.
- C. Secondary trauma can be diagnosed as repeated exposure trauma (RET) or post traumatic stress disorder (PTSD).

FIREFIGHTING AND MENTAL HEALTH

Experiences of repeated exposure to trauma:

- Firefighters are responding to fewer fires, but are increasingly called upon to provide Emergency Medical Services (EMS), perform rescues, and (investigators) are exposed to multiple tragic events.



~Jahnke, S. A., Poston, W. S. C., Haddock, C. K., & Murphy, B. (2016)

Slide 11-88

- D. Firefighting and mental health.

FIRE FIGHTING AND MENTAL HEALTH STUDY

- It's more common for firefighters (investigators) to experience a negative impact from a series of traumatic events rather than from one event.
- Symptoms of RET for most firefighters include desensitization, irritability, cynicism, and intrusive flashbacks.



Jahnke, S. A., Poston, W. S. C., Haddock, C. K., & Murphy, B. (2016). *Firefighting and mental health: Experiences of repeated exposure to trauma*. Emmitsburg, MD: National Emergency Training Center.

Slide 11-89

- E. Firefighting and mental health study.

HISTORICAL STUDY DATA

- Evidence shows that rates of depression among fire and EMS personnel are higher than in the general population.
- Firefighters have higher rates of alcohol use and binge drinking compared to the general population. There is a possible connection between risky drinking behaviors and PTSD.
- Firefighters may not be diagnosed with PTSD, but clearly suffer from symptoms such as sleep disorders, avoidance behaviors, and feelings of helplessness that are associated with PTSD.

Slide 11-90

F. Historical study data.

1. Evidence shows that rates of depression among fire and EMS personnel are higher than in the general population.
2. Firefighters have higher rates of alcohol use and binge drinking compared to the general population. There is a possible connection between risky drinking behaviors and PTSD.
3. Firefighters may not be diagnosed with PTSD, but clearly suffer from symptoms such as sleep disorders, avoidance behaviors, and feelings of helplessness that are associated with PTSD.

SELF AWARENESS

Sometimes, it's easier to recognize PTSD in others rather than ourselves. Warning signs:

1. Intrusive memories or thoughts of a traumatic event.
2. Avoidance of thoughts, feelings or external reminders of the event.
3. Feelings of numbness.
4. Hypervigilance or exaggerated states of fear.
5. Persistent, negative beliefs about yourself and the world.

Ignoring or keeping quiet about these warning signs can be dangerous.



Slide 11-91

G. Self-awareness.

1. Sometimes, it's easier to recognize PTSD in others rather than ourselves.
Warning signs:
 - a. Intrusive memories or thoughts of a traumatic event.
 - b. Avoidance of thoughts, feelings or external reminders of the event.
 - c. Feelings of numbness.
 - d. Hypervigilance or exaggerated states of fear.
 - e. Persistent, negative beliefs about yourself and the world.
2. Ignoring or keeping quiet about these warning signs can be dangerous.

GLASS TEST

- Imagine stress as water and our ability to handle stress as an empty glass.
- People without PTSD start each day with an empty glass, and as the day goes on, that glass slowly fills with stress.
- Someone with PTSD starts out their day with their glass already three-quarters full.



"Emotional survival for law enforcement: A guide for officers and their families" by Kevin M. Gilmartin, PhD.

Slide 11-92

H. Glass test.

1. Imagine stress as water and our ability to handle stress as an empty glass.
2. People without PTSD start each day with an empty glass, and as the day goes on, that glass slowly fills with stress.
3. Someone with PTSD starts out their day with their glass already three-quarters full.

REMEMBER

- The most important rule when seeking treatment for others? Include yourself.
- Don't underestimate the impact of trauma on you, your coworkers, and/or family.
- Don't overestimate the stigma of getting help. It is a treatable injury, not a life sentence.



Resource: "Emotional survival for law enforcement: A guide for officers and their families" by Kevin M. Gilmartin, PhD

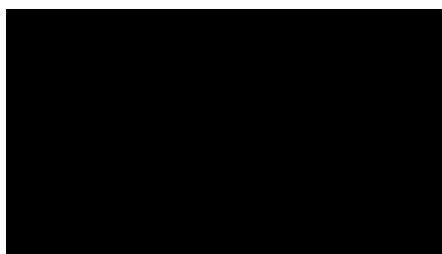
Slide 11-93

I. Remember.

1. The most important rule when seeking treatment for others? Include yourself.
2. Don't underestimate the impact of trauma on you, your coworkers, and/or family.
3. Don't overestimate the stigma of getting help. It is a treatable injury, not a life sentence.

THE FIREFIGHTERS RESCUER

STARBUCKS'
STORIES
& NEWS



Slide 11-94

VII. SUMMARY



SUMMARY

- 11.1 Analyze the responsibilities of the medical examiner, fire investigator, law enforcement, and other agency roles as they relate to fire death investigation.
- 11.2 Assess fire-related human behavior.
- 11.3 Characterize the relationship between an origin and cause investigation and a death investigation.
- 11.4 Adapt and apply appropriate procedures and techniques in a fatal fire investigation.
- 11.5 Summarize protocols involved with LODD.
- 11.6 Recognize the need for awareness of PTSD.

Slide 11-95

REFERENCES

- NFPA. (2022). *NFPA 1033, Standard for professional qualifications for fire investigator*. Quincy, MA: Author.
- NFPA. (2024). *NFPA 921, Guide for fire and explosion investigations*. Quincy, MA: Author.
- Alarie, Y. (2002). Toxicity of fire smoke. *Critical Reviews in Toxicology*, 32(4), 259-289.
doi:10.1080/20024091064246
- Table 8-4; Quintiere, *Principles of Fire Behavior*, 2017: pg. 255.
- NFPA 921, Section 24.2.5.1, 2024 edition.
- NFPA 921, Section 24.3, 2024 edition.
- NFPA 921 Section 24.9, 2024 edition.
- NFPA 921, Section 24.10, 2024 edition.

This page intentionally left blank.

UNIT 12: FIRE PROTECTION SYSTEMS

TERMINAL OBJECTIVE

The students will be able to:

- 12.1 *Evaluate the response and effect of the Fire Protection Systems (FPS) to include compartmentation, detection and suppression, in relation to the fire investigation.*

ENABLING OBJECTIVES

The students will be able to:

- 12.1 *Compile FPS documentation.*
 - 12.2 *Formulate FPS impact as it relates to fire investigation.*
-

This page intentionally left blank.



TERMINAL OBJECTIVE

Evaluate the response and effect of the Fire Protection Systems (FPS) to include compartmentation, detection and suppression, in relation to the fire investigation.

Slide 12-2

ENABLING OBJECTIVES

12.1 Compile FPS documentation.

12.2 Formulate FPS impact as it relates to fire investigation.

Slide 12-3

I. INTRODUCTION

INTRODUCTION TO FIRE PROTECTION AND LIFE SAFETY SYSTEMS

Codes and Standards:

- Codes typically provide sets of rules that describe the where and what.
- Standards typically provide sets of rules on the how.
- Both can be adopted into law at the state or local government level.

Slide 12-4

- A. Two key Standards Development Organizations in the United States are the International Code Council (ICC) (<https://www.iccsafe.org/>) and the National Fire Protection Association (NFPA) (<https://www.nfpa.org/>).
 1. Both organizations have model building codes that can be adopted in full or in part by local governments.
 2. Most codes and standards are typically revised and re-issued on 3 or 5 year cycles.
- B. Keep in mind that even though the most recent version of a standard was issued in 2018, it is likely that the jurisdiction that your fire was in has adopted into law an older version of that code, say from 2009 or 2012.
- C. If you are investigating a fire where the building construction or the building's life safety systems were involved in the incident, you will need to determine what code or standard and what version that they were required to be designed to comply with.
 1. Codes typically provide sets of rules that describe the where and what.
 2. Standards typically provide sets of rules on the how.
 3. Both can be adopted into law at the state or local government level.

WHAT DOES LISTED MEAN?

Definition from NFPA :

"3.2.3* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose."

Slide 12-5

- D. **"3.2.3* Listed.** Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose."
- E. Listings address standards that products and equipment are tested to. Definition from NFPA 13, *Standard for the Installation of Sprinkler Systems*.

II. TYPES OF SYSTEMS

3 TYPES OF FIRE PROTECTION AND LIFE SAFETY SYSTEMS

- Safety Plans – prevent the fire or manage the fire.
- Passive Systems – fire-rated assemblies, walls and floors.
- Active Systems:
 - Alarm.
 - Smoke Control.
 - Fire Suppression.



Slide 12-6

- A. Types of fire protection systems include:
1. Safety Plans (prevent the fire or manage the fire).
 2. Passive Systems (fire-rated assemblies, walls and floors).

3. Active Systems (alarm, smoke control, fire suppression).

SAFETY PLANS

Items that may be included in an administrative control of a hazard plan:

- Prevention activities.
- Egress signage.
- Egress director.
- Manual alarm activation.
- Fire safety system maintenance.

Slide 12-7

B. Items that may be included in an administrative control of a hazard:

1. Prevention activities.
2. Egress signage.
3. Egress director.
4. Manual alarm activation.
5. Fire safety system maintenance.

C. Administrative controls are changes in work procedures with the goal of reducing the potential hazard of a situation and are achieved through:

1. Written safety plans.
2. Rules.
3. Training.

D. Prevention activities could be keeping a hot work area free of combustible debris, or a rule that states no smoking or open flames in certain areas of a building.

1. Egress signage: exit signs, floor plans on the walls of a building showing the egress path, warnings on the use of elevators.

2. Egress director: in a high-rise or large building, a person trained to understand how to stage emergency egress of the building depending on the location and extent of the fire. Or, as the result of the 100 lives lost in the Station Night Club fire in 2003, the requirement for a trained crowd manager and the need to keep egress paths clear and unobstructed.
3. Training for building occupants on the location of exits, what the fire alarm sounds like and where to gather.
 - a. A maintenance program for fixed systems as well as for portable fire extinguishers of critical importance in many occupancies.
 - b. For a commercial structure or an apartment complex, determining if a safety plan exists begins to provide you with information on how the facility was run.
 - c. If a safety plan exists, was it followed leading up to and during the fire incident?
 - d. Asking questions about any informal actions relative to a safety plan (when no safety plan existed) regarding property care or emergency preparation may provide information relative to the fire.
- E. For a fire in a single-family home, there is no requirement for a safety plan, just recommendations from community risk reduction teams.
 1. Were the occupants following good practice?
 2. Were risky fire behaviors the norm?
 3. Example fire safety plan template is found in the file, fire safety plan.doc.

III. COMPARTMENTATION

COMPARTMENTATION

Compartmentation is typically thought of as a passive system:

- Walls, floors, ceilings.
- Doors.
- Interior finish.



Post-fire photograph of non-combustible corridor with self-closing solid core doors.
Slide 12-8

- A. Compartmentation is typically thought of as a passive system:
1. Walls, floors, ceilings.
 2. Doors.
 3. Interior finish.
- B. Compartmentation is basically fire control based on the construction method and materials used.
1. A passive system is one with no moving parts. In many structures the codes require some level of fire-rated assembly.
 2. The fire-rated walls, floors and ceiling are intended to contain the fire in the compartmented area of origin in order to maintain safe egress paths through the building and maintain structural integrity to provide the fire department time to affect rescue and suppress the fire.
 3. In a fire-rated wall, a fire-rated door with a self-closer would be required.
 4. Typically, non-combustible interior finish is required in the egress paths (corridors, stairways) in fire-rated buildings to limit the potential for flame spread or combustion in the hallway.

**COMPARTMENTATION
MULTI-UNIT**

Single-family homes typically have no fire-rated walls, floors, or ceilings, except for:

- Wall or ceiling for attached garage.
- Door to attached garage.
- Rated fire wall between townhouses.



Non-combustible wall between townhouses.

Slide 12-9

- C. Single-family homes typically have no fire-rated walls, floors, or ceilings, except for:
1. Wall or ceiling for attached garage.
 2. Door to attached garage.

3. Rated fire wall between townhouses.
- D. One- and two-family homes typically do not have fire-rated walls, floors or ceiling assemblies.
1. In current residential construction, the compartmentation is provided by lightweight, one-half inch thick gypsum board attached to wood-based framing or joists.
 2. Compartmentation or lack thereof will impact the time and degree of fire spread through a structure.
 3. While a fire wall may be installed between the living spaces, in many cases the living spaces may be under a common attic area that is open from one end of the building to the other.

COMPARTMENTATION FIRE RATED DOORS

Doors have a significant role in maintaining compartmentation.

Self-closing doors:

- Save Lives.
- Contained fire.
- Protected from fire.
- May close automatically based on a smoke or heat detector activation.
- Reduce or stop the flow of smoke and heat.



Fire rated door.



Fire door tag.

Slide 12-10

- E. Doors have a significant role in maintaining compartmentation.

Self-closing doors:

1. Save lives.
2. Contained fire.
3. Protected from fire.
4. May close automatically based on a smoke or heat detector activation.
5. Reduce or stop the flow of smoke and heat.

COMPARTMENTATION NON-RATED DOORS

Non-rated, hollow core doors can slow fire growth and spread.

However:

- Less time to failure than rated door.
- Steel sided doors over wood frame with insulating foam also fail in a short period of time after flame exposure.



Post-fire photographs of hollow core door.

Slide 12-11

F. Non-rated, hollow core doors can slow fire growth and spread.

1. However, less time to failure than rated door.
2. Steel sided doors over wood frame with insulating foam also fail in a short period of time after flame exposure.

COMPARTMENTATION NON-RATED DOORS

Example analysis of a steel sided door with wood frame and insulating foam or cardboard core that failed after direct fire exposure.



Post-fire photographs of non-fire-rated steel door and door frame.



Slide 12-12

G. Example analysis of a steel sided door with wood frame and insulating foam or cardboard core that failed after direct fire exposure.

COMPROMISED COMPARTMENTATION

Compartmentation relies on fire-resistance, solid walls, ceilings, and floors with protected openings. A compartmentation fire protection system can be rendered ineffective by:

- Blocked open fire doors.
- Unsealed penetrations.
- Non-fire-rated HVAC systems.
- Compartmentation may change during the fire.

Slide 12-13

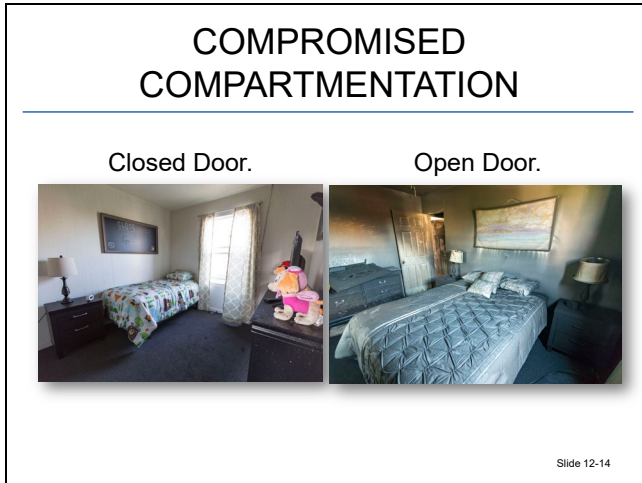
- H. Compartmentation relies on fire-resistance, solid walls, ceilings, and floors with protected openings.

A compartmentation fire protection system can be rendered ineffective by:

1. Blocked open fire doors.
2. Unsealed penetrations.
3. Non-fire-rated heating, ventilating, and air conditioning (HVAC) systems.
4. Compartmentation may change during the fire.

- I. Compartmentation has different requirements between commercial, multi-family, and single-family residential.

1. For example, some commercial occupancies require HVAC systems that incorporate fire dampers or fan controllers that are activated by heat or smoke detectors.
2. Compartmentation may change during the fire (doors open, penetration seal could fail during fire, wall could burn through during fire).



- J. An experiment was conducted by Underwriters Laboratories (UL) Fire Safety Research Institute (FSRI) to examine the value of a closed bedroom door in a ranch house type structure where the living room was allowed to transition through flashover. Retrieved from <https://ulfirefightersafety.org/posts/close-before-you-doze-fullscale-test.html>
- K. In this case, the focus was extending the tenability time available to someone that might be trapped in the structure.
1. From the fire investigator's perspective, notice how the closed door provided enough of a barrier to isolate the bedroom from the exhaust flows from the fire.
 2. The website contains temperature and oxygen concentration data.

**COMPARTMENTATION
SUMMARY**

Compartmentation (or lack of) impacts fire movement through a structure. The fire investigator needs to determine:

- Was a passive FPS in place?
- What type? Did it meet code?
- Did it fail? If so, why?
 - Poor design, poor installation.
 - Lack of maintenance.
 - Intentional act.

Additional information, NFPA 921, Section 7.4, 7.6, 7.9
Slide 12-15

- L. Compartmentation (or lack of) impacts fire movement through a structure.

The fire investigator needs to determine:

1. Was a passive Fire Protection Systems (FPS) in place?
2. What type? Did it meet code?
3. Did it fail? If so, why?
 - a. Poor design, poor installation.
 - b. Lack of maintenance.
 - c. Intentional act.

M. NFPA 921, *Guide for Fire and Explosion Investigations*, Section 7.4, Section 7.6, and Section 7.9, 2024 edition.

IV. ALARM SYSTEMS AND COMPONENTS

ALARM SYSTEMS

Active fire protection and life safety system composed of:

- Initiating device.
- Fire Alarm Control Unit (FACU).
- Power supplies.
- Notification appliances.
- Connecting circuitry.

-NFPA 921, Section 8.3

Slide 12-16

- A. Active fire protection and life safety system composed of:
1. Initiating device, Fire Alarm Control Unit (FACU), power supplies, notification appliances, and connecting circuitry.
 2. Additional information can be found in NFPA 921, Section 8.3, 2024 edition.

INITIATING DEVICES

Switches or detectors that transmit a change of condition.

- Manual fire alarm pull station.
- Smoke detector.
- Heat detector.
- Video-based smoke or fire detection.
- Gas detectors.



Slide 12-17

- B. Switches or detectors that transmit a change of condition.
1. Manual fire alarm pull station.
 2. Smoke detector.
 3. Heat detector.
 4. Video-based smoke or fire detection.
 5. Gas detectors.
- C. There are many types of detectors or sensors that are used as initiating devices in a fire alarm system.
1. Smoke detection may be accomplished using either a spot type ionization detector or photoelectric detector, air sampling systems, or projected beam.
 2. Heat detection could be with spot-type or line-type heat detectors, radiant heat detectors, flame detector or infrared (IR) spark detectors.
 3. Video systems utilize a software package that analyzes the image for visual characteristics of smoke or flame.
- D. Depending on the system requirements and the area protected, other types of detectors may be connected to the FACU.
- E. Examples of other types of detectors include carbon monoxide, fuel gases, or motion detectors.

FIRE ALARM CONTROL UNIT (FACU)

All system components connect to the FACU:

- Receives signals from initiating devices.
- Processes signals.
- Activates appropriate alarm notification.
- Could activate components of HVAC, smoke control system.
- Memory.



Slide 12-18

F. All system components connect to the FACU:

1. Receives signals from initiating devices.
2. Processes signals.
3. Activates appropriate alarm notification.
4. Could activate components of HVAC, or smoke control system.
5. Memory.

G. The FACU is similar to the central processing unit of a computer.

1. It monitors the signals from all of the initiating devices.
2. When a signal from an initiating device changes from the normal operating condition to an alarm condition, the FACU will activate the appropriate alarm.
3. For example, this could be the fire alarm which would notify everyone in the building, or a system trouble alarm which would only notify the appropriate staff or perhaps a remote central station.
4. A FACU and in many cases the central station that it is connected to will record the time history of the alarm system signals.
 - a. In the case of a growing fire, the alarm system history may be able to help a fire investigator track the movement of smoke or heat through a structure.

- b. A FACU could activate the opening or closing of smoke control dampers or release magnetic locks to allow smoke control doors to close.

POWER SUPPLIES

Provides power to system.

- Transformers.
- Batteries.
- Backup generators.



Slide 12-19

- H. Provides power to system.

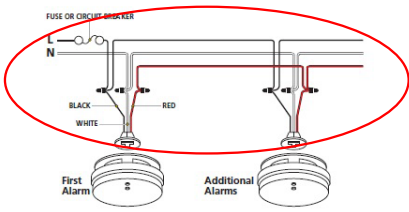
Transformers, batteries, backup generators, commercial power company.

CONNECTING CIRCUITRY

Ties System Together.

Wired.

Wireless.



Slide 12-20

- I. Examples of connecting circuitry.

NOTIFICATION APPLIANCES

Components of a fire alarm system used to alert occupants in the protected area:

- Audible.
 - horn, speaker, bell
- Visual.
 - strobe lights, text
- Tactile.
 - vibration



Slide 12-21

- J. Components of a fire alarm system used to alert occupants in the protected area:
1. Audible – horn, speaker, bell.
 2. Visual – strobe lights, text.
 3. Tactile – vibration.
- K. The notification appliances are intended to alert the appropriate population to the information from the initiating devices as processed by the FACU.
- L. In the case of a fire, the building occupants would be alerted, as well as facility staff, and in some cases the fire department.
- M. In the case of a system malfunction, the trouble signal may only be transmitted to the facility staff.
- N. Utilize a fire alarm professional to download the data. In some cases, turning off the power to the panel could result in a loss of data. Or, allowing the panel to run for an extended time after an event could result in the loss of data due to the data being overwritten.

RESIDENTIAL SMOKE ALARMS

Single Station: all required alarm components in one package:

- Initiating device (spot detector).
- Power supply (or battery backup).
- Notification.
- Connecting circuitry.



Residential smoke alarm.

Slide 12-22

O. Single Station: all required alarm components in one package:

1. Initiating device (spot detector).
2. Power supply (or battery backup).
3. Notification.
4. Connecting circuitry.

ALARM SYSTEM ANALYSIS

Beyond the scope of this course. Potential considerations include:

- Code – what were requirements?
- Design – were requirements met?
- Installation – was the design followed?
- Maintenance – system been tested?
 - Was it fully functional at the time of the fire?
- System performance – did the alarm function?
- *Review: NFPA 921, Section 8.3.4*

Slide 12-23

P. Beyond the scope of this course. Potential considerations include:

1. Code – what were requirements?
2. Design – were requirements met?
3. Installation – was the design followed?

4. Maintenance – system been tested?
Was it fully functional at the time of the fire?
5. System performance – did the alarm function?
6. Review: NFPA 921 (2024 ed.), Section 8.3.4 for details on Fire Alarm System Analysis.

V. FIRE SUPPRESSION SYSTEMS

FIRE SUPPRESSION SYSTEMS

Types of fire suppression systems:

- Water based.
- Non-water based.



Slide 12-24

A. Types of fire suppression systems:

1. Water based.
2. Non-water based.

WATER BASED FIRE SUPPRESSION SYSTEMS

Types of Sprinkler Systems:

- Wet pipe.
- Dry pipe.
- Preaction.
- Deluge.
- Water mist systems.
- Foam water systems.

-NFPA 921, Section 8.4

Slide 12-25

- B. Types of Sprinkler Systems:
 - 1. Wet pipe.
 - 2. Dry pipe.
 - 3. Preaction.
 - 4. Deluge.
 - 5. Water mist systems.
 - 6. Foam water systems.
 - 7. NFPA 921, Section 8.4, 2024 edition.
- C. There are several different types of water-based fire suppression systems; however, the basic concept is the same.
- D. An initiating device, either a thermally sensitive element in the sprinkler and/or a heat or smoke detector in the compartment, will activate the water flow in the system, and water will be charged into the fire area with a flow rate and spray pattern that should control the fire and limit fire spread, assuming that the hazard the sprinkler was designed for is the hazard that is in place in the fire area and that the water supply is as designed.
- E. The commercial and large multiple dwelling unit buildings have sprinkler systems that are designed in accordance with NFPA 13.
- F. NFPA 13 systems are designed for both life safety and property protection.
- G. The water mist systems are designed to NFPA 750, *Standard on Water Mist Fire Protection Systems*.
- H. NFPA 750 systems are also designed for both life safety and property protection.

AUTOMATIC SPRINKLER OPERATION- ANIMATION

- In a system, the sprinkler is the initiating device.
- It contains a thermally sensitive element that will release when it reaches its activation temperature (which opens the sprinkler to allow the flow of water).



Sprinkler Operation Video.

Slide 12-26

- I. In a system, the sprinkler is the initiating device.
- J. It contains a thermally sensitive element that will release when it reaches its activation temperature (which opens the sprinkler to allow the flow of water).
- K. The thermally sensitive element in a sprinkler could be a frangible glass bulb, as shown in the video, or a eutectic solder fusible link.
 1. The elements are designed to operate at specific temperatures with a specific response time index (RTI).
 2. Only sprinklers that are exposed to the required amount of heat will activate.
 3. The exception is the deluge sprinkler system where all of the sprinklers in a given area are designed to flow water at the same time upon system activation.

TYPES OF SYSTEMS- ANIMATION

Wet Pipe

- Water in system to sprinkler head.
- Automatic sprinkler.

Dry Pipe

- Pipes filled with compressed air.
- Water held by valve at dry pipe valve.
- Automatic sprinkler.



Slide 12-27

L. Wet pipe system:

1. Water supply open stem and yoke (OS&Y) valve, water flow alarm valve, piping network with sprinklers appropriately positioned throughout.
2. In a wet pipe system, once a sprinkler has activated, the water will be flowing from the water supply through the system, out of the sprinkler and into the fire area.
3. The OS&Y valve design is used so that it is easy to see if it is in the open or closed position.
4. In some systems, the OS&Y valve may be electronically supervised.
5. In some systems, activation of the water flow alarm may be recorded at a FACU.

M. Dry pipe system: water supply, OS&Y valve, dry pipe valve, piping network with sprinklers appropriately positioned throughout.

1. Dry pipe systems may be used in an unheated area or a refrigerated area.

The piping between the dry pipe valve and the sprinklers is pressurized with dry air or nitrogen.
2. In a dry pipe system, once a sprinkler has activated, the pressure will be released from the piping system, which will allow the dry pipe valve to open and water to fill the piping network.
 - a. Water will then be available to flow from the open sprinkler(s) and into the fire area.
 - b. If care is not taken to provide dry air or nitrogen to the system, condensation could freeze inside the piping and impair the operation of the system.
 - c. If the air pressure leaks down over time and the dry pipe valve opens, the system could be filled with water, which could then freeze and impair the operation of the system.

TYPES OF SYSTEMS

Preaction

- Dry pipes.
- Requires two stages to activation.
- Smoke or thermal detector, followed by automatic sprinkler.



Deluge

- Open heads.
- Dry pipe until detector activation.
- Smoke or thermal detector.

Slide 12-28

N. Preaction sprinkler system:

1. Water supply, OS&Y valve, preaction valve, detectors in the protected area, and a piping network with sprinklers appropriately positioned throughout.
 - a. The preaction system activates in two stages.
 - b. The piping between the preaction valve and the sprinkler is normally dry.
2. Once a detector in the area is activated, a signal is set to open the preaction valve and fill the sprinkler mains and branch lines with water.
3. If a fire is present, and the heat activates a sprinkler, then water will flow out of the sprinkler and into the fire area.
4. So both the detector and the sprinkler must activate in order to have water flow into the fire area.
5. In theory, the preaction system should be able to deliver water to the fire area faster than a dry pipe system.
6. The preaction system may be used in unheated or refrigerated environments. Or it could be used in areas where an accidental sprinkler opening, say due to mechanical damage, would cause significant damage or mission interruption, so a secondary type of activation is needed to confirm the need for water flow.

O. Deluge sprinkler system:

1. Water supply, OS&Y valve, deluge valve, detectors in the protected area, and a piping network with **open** sprinklers appropriately positioned throughout.

2. Similar to a preaction system, detectors are installed in the protected area.

However, in this case, the fire hazard is so high that once the detector activates the system, water flows through all the sprinklers in the fire compartment (or design area) at one time to limit fire growth and spread and save the structure.

NFPA 13 – STANDARD FOR THE
INSTALLATION OF SPRINKLER SYSTEMS

- Commercial and large multiple dwelling unit buildings have sprinkler systems.
- NFPA 13 systems are designed for both life safety and property protection.



Slide 12-29

P. Commercial and large multiple dwelling unit buildings have sprinkler systems.

Q. NFPA 13 systems are designed for both life safety and property protection.

1. There are three NFPA installation standards for sprinkler systems:

NFPA 13, 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*, and 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*. What's the difference?

2. A building with a sprinkler system designed and installed in accordance with NFPA 13 is considered a fully sprinklered building.
3. NFPA 13 sprinklers can be designed to protect a wide range of commercial, industrial, and residential occupancies.

NFPA13R – STANDARD FOR THE INSTALLATION
OF SPRINKLER SYSTEMS IN LOW-RISE
RESIDENTIAL OCCUPANCIES

- Residential occupancies up to and including 4 stories in height (60 ft. above grade).
- NFPA13R is a life safety system.



Slide 12-30

- R. Residential occupancies up to and including 4 stories in height (60 ft. above grade). NFPA 13R is a life safety system.

NFPA 13R systems are limited to certain residential occupancies, such as a garden style apartment building.

- S. The system is considered a life safety system as the intent is to provide time for people to safely egress.
1. In a 13R system, the building is not fully sprinklered. Typically, the attics, small storage spaces and small bathrooms are not required to be sprinklered.
 2. NFPA 13R systems are wet pipe systems, although they may have dry pendent or sidewall sprinklers that extend into unheated areas which are not intended as living areas.
 3. Photos along bottom show examples of signage, fire department connection (FDC) and water flow alarm bell.

NFPA13D – STANDARD FOR THE INSTALLATION OF
SPRINKLER SYSTEMS IN ONE- AND TWO-FAMILY
DWELLINGS AND MANUFACTURED HOMES

- NFPA 13D systems can be used in any size one- and two-family dwelling.
- System designed to protect against a fire originating from a single ignition location.
- NFPA 13D is a life safety system.



Slide 12-31

- T. NFPA 13D systems can be used in any size one- and two-family dwelling.
1. System designed to protect against a fire originating from a single ignition location.
 2. NFPA 13D is a life safety system.
 3. NFPA 13D systems are limited to certain residential occupancies, such as:
 - a. Single-family home.
 - b. Townhome (each unit is a single-family home).
 - c. Manufactured homes.
 4. The system is considered a life safety system as the intent is to provide time for people to safely egress.
 5. In a 13D system, the building is not fully sprinklered.
 6. Typically, attics, garages, small storage spaces and small bathrooms are not required to be sprinklered.
 7. NFPA 13D systems are wet pipe systems, although they may have dry pendent or sidewall sprinklers that extend into unheated areas which are not intended as living areas.

**WATER-BASED SUPPRESSION
SYSTEM ANALYSIS**

Investigator questions:

- Code – what were the code requirements?
- Design – were the code requirements met?
- Did the level of hazard match the design at the time of the fire?
- Installation – was the design (water supply, sprinkler type, spacing, design area, etc.) followed?

Slide 12-32

U. Investigator questions:

1. Code – what were the code requirements?
2. Design – were the code requirements met?

3. Did the level of hazard match the design at the time of the fire?
4. Installation – was the design (water supply, sprinkler type, spacing, design area, etc.) followed?

WATER-BASED SUPPRESSION SYSTEM ANALYSIS

- Maintenance – had the system been tested? Was it fully functional at the time of the fire?
- System performance – did the alarm sound? When? Where? Was the fire contained?

Slide 12-33

5. Maintenance – had the system been tested? Was it fully functional at the time of the fire?
6. System performance – did the alarm sound? When? Where? Was the fire contained?

NON-WATER BASED FIRE SUPPRESSION SYSTEMS

Typically used for:

- Commercial cooking operations.
- Telecommunications or data rooms.
- Engine rooms or compartments.
- Flammable liquid process areas.

Slide 12-34

V. Typically used for:

1. These systems are used where water would have little impact on suppressing a fire or where water on the fire might make the situation worse in terms of increasing the hazard.
2. These systems may be found in structures or mounted on heavy equipment.

3. These systems could be designed for a local application, say a deep fat fryer, or for total room flooding, like a computer operations center.
4. The system for the restaurant kitchen's deep fat fryer may be a "pre-engineered" system designed to control that well-defined hazard.
5. The system for the computer operations center may need to be engineered specifically for that situation.

NON-WATER BASED FIRE SUPPRESSION AGENTS

- Carbon dioxide.
- Dry chemical.
- Wet chemical.
- Condensed & dispersed aerosols.
- Clean agents (Halon and Halon replacements).

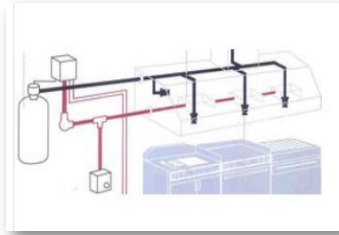


Slide 12-35

6. Examples of non-water-based suppression agents.
 - a. Carbon dioxide.
 - b. Dry chemical.
 - c. Wet chemical.
 - d. Condensed & dispersed aerosols.
 - e. Clean agents (Halon and Halon replacements) (NFPA 921, Section 8.5.1.3, 2024 ed.).

NON-WATER BASED FIRE SUPPRESSION SYSTEM COMPONENTS

- Suppression agent supply.
- Pressure source.
- Distribution network.
- Actuation system.
- Control valves.



Slide 12-36

7. The components of the non-water based similar to the components needed for a water-based system. The suppression agent supply is equivalent to the water supply.
8. The pressure source is needed to move the suppression agent from the supply tank through the distribution piping or hoses and out of the nozzles and on to the fire area, just like pressure is used to move the water through the sprinkler piping.
9. The actuation system has initiating devices that may be thermally sensitive fusible links, smoke alarms, or other detectors that either mechanically or electrically will open the control valve and start the flow of agent.
10. The initiating devices and/or the control valve may be connected to a FACU or a central station.

VI. PORTABLE EXTINGUISHERS

PORTABLE FIRE EXTINGUISHERS

Fire extinguishers:

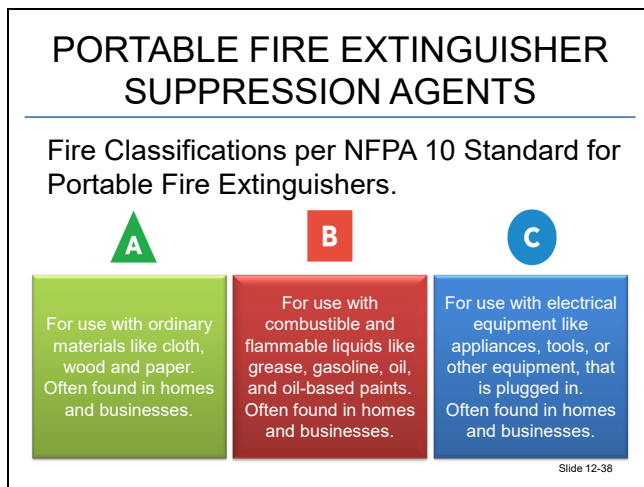
- May be part of the fire safety plan.
- May have been used early in the fire event.
 - Scene documentation.
 - Witness interviews.
 - Firefighter observations.



Slide 12-37

A. Fire extinguishers:

1. May be part of the fire safety plan. May have been used early in the fire event.
 - a. Scene documentation.
 - b. Witness interviews.
 - c. Firefighter observations.
2. While a portable fire extinguisher by itself is not a fixed fire protection or life safety system, it can be part of a fire safety plan.



B. Portable fire extinguishers are labelled based on the agent that they contain and the class and amount of fire that they can extinguish.

Here are a few examples:

1. A 2.5-gallon, pressurized water fire extinguisher filled has a UL rating of 2-A.

The “2” refers to the size of the fire, and the “A” refers to the class of the fire.

2. A 5-lb., dry chemical extinguisher may have a UL rating of 3A-40B-C.

While a 5-lb., carbon dioxide filled extinguisher has a UL rating of 5-B-C.

C. NFPA 10, *Standard for Portable Fire Extinguishers*, is the installation and maintenance standard for portable fire extinguishers, while UL 711, *Rating and Fire Testing of Fire Extinguishers* (ULC S508) is the standard for rating and testing of fire extinguishers.

D. Details of UL 711 can be viewed for free at <https://www.shopulstandards.com>.

**PORTABLE FIRE EXTINGUISHER
SUPPRESSION AGENTS (B)**

Fire Classifications per NFPA 10 Standard for
Portable Fire Extinguishers.



For use with flammable
metals
(found in factories).

K

For use with vegetable oils, animal oils,
and fats in cooking appliances.
Often found in commercial kitchens
(restaurants, cafeterias, catering
businesses).

Slide 12-39

E. Continuation: two additional types of extinguishers.

**PORTABLE FIRE EXTINGUISHER
ANALYSIS**

Items to consider:

- Was it used?
- Was the extinguisher and user training part of the safety plan?
- Correct extinguisher, match the class of fire?
- Did the fire extinguisher function?
- Did use of the extinguisher delay notification?



Slide 12-40

F. Analysis would be similar to the other systems.

1. What documentation can you find regarding the extinguisher?
2. Was it part of a safety plan?
3. Did the user have fire extinguisher training?
4. Was the extinguisher inspected recently? When was the last recharge?

- G. If the user was trained and the extinguisher functioned properly but could not extinguish the fire, based on information from UL 711, the fire investigator may be able to determine information about the size of the fire at the time of extinguisher discharge.
- H. Use of the extinguisher may provide important information for the fire incident timeline.

FPS SUMMARY

The response and effect of FPS including:

- Compartmentation.
- Alarm.
- Suppression.
- Safety plans.

This can be analyzed to assist in the determination of the fire's timeline, fire size, fire spread, and origin and cause.

Slide 12-41

- I. The response and effect of FPS including:
1. Compartmentation.
 2. Alarm.
 3. Suppression.
 4. Safety plans.
 5. This can be analyzed to assist in the determination of the fire's timeline, fire size, fire spread, and origin and cause.

ACTIVITY 12.1

Fire Protection System Component Identification

Purpose

This activity will help students determine proper nomenclature and identification of specific FPS component parts.

Directions

Fire alarm systems can be composed of a variety of devices. Using the abbreviations provided, identify the FPS component parts in the list below by placing the corresponding letter by each device. Match the device to the appropriate category.

I = initiating device

P = power supply

N = notification device

- | | | |
|-----|------------------------------|-------|
| 1. | Strobe Light | _____ |
| 2. | Photoelectric Smoke Detector | _____ |
| 3. | Battery | _____ |
| 4. | Ionization Smoke Detector | _____ |
| 5. | Dedicated electrical circuit | _____ |
| 6. | Line-type Heat Detector | _____ |
| 7. | Engine driven generator | _____ |
| 8. | Horn | _____ |
| 9. | Video | _____ |
| 10. | Air sampling system | _____ |
| 11. | Speaker | _____ |
| 12. | Text Display | _____ |
| 13. | CO Detector | _____ |
| 14. | Printer | _____ |
| 15. | Radiant Energy Sensor | _____ |
| 16. | Flame Detector | _____ |

This page intentionally left blank.

VII. SUMMARY



FEMA SUMMARY – KEY POINTS

Key points to remember:

- Determine the applicable code(s) or standard(s) that applied to the FPS.
- Collect documentation on FPS design, installation, maintenance, and testing.
- Analyze the impact of the FPS as it related to the fire incident.
- Generate a system timeline to incorporate into the fire incident timeline.

Slide 12-43

This page intentionally left blank.

REFERENCES

NFPA 13, Chapter 3, Section 3.2.3, Listed, 2022 edition.

NFPA 921, Chapter 7 and 8, 2024 edition.

NFPA 921, Section 7.4, Construction Assemblies, 2024 edition.

NFPA 921, Section 7.6, Impact of Passive Fire Protection, 2024 edition.

NFPA 921, Section 7.9, Analysis, 2024 edition.

NFPA 921, Section 8.3, Fire Alarm Systems, 2024 edition.

NFPA 921, Section 8.3.4, Fire Alarm System Analysis, 2024 edition.

NFPA 921, Section 8.4, Water-based Fire Suppression Systems, 2024 edition.

NFPA 921, Section 8.4.4, Water-based Suppression System Analysis, 2024 edition.

NFPA 921, Section 8.5, Non-Water-Based Fire Protection Systems, 2024 Edition.

NFPA 921, Section 8.5.4, Non-water-based Suppression System Analysis, 2024 edition.

This page intentionally left blank.

UNIT 13: FIRE SCENE EXAMINATION AND PROCESSING

TERMINAL OBJECTIVE

The students will be able to:

- 13.1 *Conduct a systematic fire scene investigation with the proper documentation, and then communicate the findings of the fire investigation (National Fire Protection Association (NFPA) 921, Section 3.3.79, 2024 edition).*

ENABLING OBJECTIVES

The students will be able to:

- 13.1 *Conduct a safe and systematic fire scene investigation to determine the area of origin, and the cause of the fire.*
 - 13.2 *Identify, collect and package physical evidence and request the appropriate laboratory testing.*
 - 13.3 *Prepare and present all appropriate documentation and evidence to support the final hypothesis of the origin and cause of the fire.*
-

This page intentionally left blank.



TERMINAL OBJECTIVE

Conduct a systematic fire scene investigation with the proper documentation, and then communicate the findings of the fire investigation (National Fire Protection Association (NFPA) 921, Section 3.3.79, 2024 edition).

Slide 13-2

ENABLING OBJECTIVES

- 13.1 Conduct a safe and systematic fire scene investigation to determine the area of origin, and the cause of the fire.
- 13.2 Identify, collect and package physical evidence and request the appropriate laboratory testing.
- 13.3 Prepare and present all appropriate documentation and evidence to support the final hypothesis of the origin and cause of the fire.

Slide 13-3

I. OVERVIEW OF SCENE PROCESSING INSTRUCTIONS

SCENE INVESTIGATION

Student activity scene examination:

- Receive the assignment of investigating a fire and define the way the fire investigation will be conducted.
- Collect and analyze the data of the fire scene.
- Develop hypotheses of the origin of the fire and the cause of the fire.

Slide 13-4

A. Conduct a systematic fire scene investigation that follows the Scientific Method, as recommended by National Fire Protection Association (NFPA) 921, Section 4.1, 2024 edition.

1. Receive the assignment of investigating a fire and define the way the fire investigation will be conducted, NFPA 921, Section 4.3.1 and 4.3.2, 2024 edition.
2. Collect and analyze the data of the fire scene, NFPA 921, Section 4.3.3 and 4.3.4, 2024 edition.
3. Develop hypotheses of the origin of the fire and the cause of the fire, NFPA 921, Section 4.3.5, 2024 edition.

SCENE INVESTIGATION (cont'd)

- Test the hypotheses to arrive at a final hypothesis of the origin and the cause of the fire.
- Classify the fire incident and cause of the fire.
- Prepare and present a presentation that communicates the findings of the origin and cause investigation.

Slide 13-5

4. Test the hypotheses to arrive at a final hypothesis of the origin and the cause of the fire, NFPA 921, Section 4.3.6 and 4.3.7, 2024 edition.

5. Classify the fire incident and cause of the fire, NFPA 921, Section 19.8, 2024 edition.
6. Prepare and present a presentation that communicates the findings of the origin and cause investigation, per the requirements of NFPA 1033, 4.7.2, 2022 edition.

ACTIVITY 13.1

- Group activity: everyone cannot do everything, but everyone must do something.
- Tasks needed likely include:
Notes, photographs, sketching, evidence identification, evidence collection, and completing paperwork (such as lab requests).

Slide 13-6

B. Group activity.

1. Everyone cannot do everything, but everyone must do something.
2. Tasks needed likely include notes, photographs, sketching, evidence identification, evidence collection, completing paperwork (such as lab requests).

GRADE AND PRESENTATION

- Every group member receives the same grade.
- Accounts for 30% of final grade.
- Presentation **MUST** contain all items listed under "satisfactory" in your grading rubric to receive a grade of C or higher.
- The syllabus contains a rubric outlining grading methodology.
- Each group member must present at least one content area.
- 30 minutes for the presentation, including questions from instructors.

Slide 13-7

C. Grade and presentation.

1. Every group member receives the same grade. Accounts for 30% of final grade. Presentation **must** contain all items listed under “satisfactory” in your grading rubric to receive a grade of C or higher.
2. The syllabus contains a rubric outlining grading methodology.
3. Each group member must present at least one content area.
4. 30 minutes for the presentation, including questions from instructors.

BURN LABORATORY

- Take the Data Collections Kits.
- PPE – **Mandatory**
 - Hard Hat.
 - N-95.
 - Tyvek.
 - Gloves.
 - (bring your safety glasses & boots to Lab).
- Scene processing kits are located in garage.
- Students will pick up all other gear at garage.
- Special needs? Ask an instructor.

Slide 13-8

D. Burn Laboratory.

1. Take the Data Collections Kits with you.
2. Personal protective equipment (PPE) is **mandatory**.
 - a. Hard hat.
 - b. N-95.
 - c. Tyvek.
 - d. Gloves.
 - e. Bring your safety glasses and boots to lab.
3. Other equipment: Shovels and brooms are in storage room beside cell 1.
4. Scene processing kits are located in garage.
5. Students will pick up all other gear at garage.
6. Special needs? Ask an instructor.

LEAVING THE BURN LAB

Before departing:

- **Reconstruct the fire scene.** Place **all evidence** back where it was found. Leave Arc flagging tape in place. Do this accurately.
- Decontaminate (wash with soap and water)
 - Tools, shovels, brooms, lights, all used equipment.
 - Boots, reusable gear.
 - Hands, face, use wipes.
- Use the trash cans.
- Clean up area- leave cleaner than found!

Slide 13-9

E. Before departing:

1. **Reconstruct the fire scene.** Place **all evidence** back where it was found. Leave Arc flagging tape in place. Do this accurately.
2. Decontamination will be set up near hydrant; clean off all tools, etc., before putting them away (wash with soap and water):
 - a. Tools, shovels, brooms, lights, all used equipment.
 - When putting the lights away, ensure lights are cool before putting them in scene kits.
 - b. Boots, reusable gear.
 - c. Hands, face, use wipes.
3. Use the trash cans.
4. Clean up area – leave cleaner than found!

Clean up after yourselves. Put trash in cans, pick up cups and bottles; leave the facility cleaner than you found it.

PROCESSING YOUR SCENE

- North is toward the large metal building.
- Panel boxes mounted on exterior of each cell are in play.
- Curtilage around cells is in play for evidence.
- The scene is presumed secure.
- All the data available is contained in the Activity Manual. There are no people to interview; they all died or went on vacation.
- *The case will not be solved based on witness interviews.*

Slide 13-10

F. Processing your scene.

1. North is toward the large metal building.
2. Panel boxes mounted on exterior of each cell are in play.
3. Curtilage around cells is in play for evidence.
4. The scene is presumed secure.
5. All the data available is contained in the Activity Manual. There are no people to interview; they all died or went on vacation.
6. **The case will not be solved based on witness interviews.**

COLLECTING EVIDENCE

- 1) Each team will produce ONE properly labeled and packaged sample.
- 2) Each group will complete an evidence log (in Activity Manual) listing ALL items of evidence that would be collected and what tests would be requested.
- 3) Turn that log in to an instructor for review.

Slide 13-11

G. Collecting evidence.

1. Each team will produce **one** properly labeled and packaged sample.

2. Each group will complete an evidence log (in Activity Manual) listing **all** items of evidence that would be collected and what tests would be requested.
3. Turn that log in to an instructor for review.

NEED SOMETHING

- Need a tool or collection equipment? Just ask.
- Need to do a field test? Ask an instructor.
 - If a field test is conducted, it is discoverable, and should be fully documented without regard to the ultimate results.
 - Properly identify and develop enough information to identify an exemplar if a test is requested.

Slide 13-12

H. Need something?

1. Need a tool or collection equipment? Just ask.
2. Need to do a field test? Ask an instructor.
3. If a field test is conducted, it is discoverable, and should be fully documented without regard to the ultimate results.
4. Properly identify and develop enough information to identify an exemplar if a test is requested.

DEPART FOR BURN LAB

Questions?

Slide 13-13

This page intentionally left blank.

ACTIVITY 13.1

Fire Scene Processing

Purpose

Practical exercise that culminates in a complete fire scene examination and presentation of the results to the class.

Directions

At the burn range, you will investigate a fire scene. You will work the fire scene with your assigned group.

1. Working as a group, collect and share data at the burn range.
2. Determine the area of origin, the fire cause, and if possible, the classification of the fire. Report those findings to the class in a 20-30 minute presentation.
3. Create an independent analysis based on the data collected.
4. See the provided syllabus for presentation topic content areas and grading methodology.

This page intentionally left blank.

REFERENCES

National Fire Protection Association (NFPA) 921, Section 3.3.79, 2024 edition.

NFPA 921, Section 4.1, 2024 edition.

NFPA 921, Section 4.3.1, 2024 edition.

NFPA 921, Section 4.3.2, 2024 edition.

NFPA 921, Section 4.3.3, 2024 edition.

NFPA 921, Section 4.3.4, 2024 edition.

NFPA 921, Section 4.3.5, 2024 edition.

NFPA 921, Section 4.3.6, 2024 edition.

NFPA 921, Section 4.3.7, 2024 edition.

NFPA 921, Section 19.8, 2024 edition.

NFPA 1033, 4.7.2, 2022 edition.

This page intentionally left blank.

UNIT 14: REPORT WRITING

TERMINAL OBJECTIVE

The students will be able to:

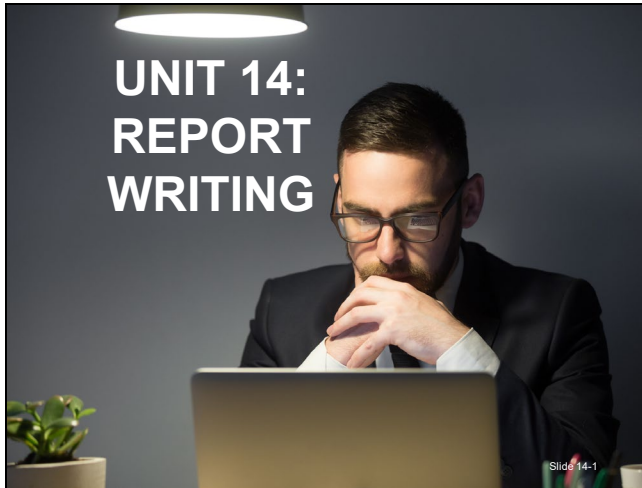
- 14.1 Demonstrate and validate the minimum information required for a basic fire investigation report.*

ENABLING OBJECTIVES

The students will be able to:

- 14.1 Explain the key information contained in the fire investigation report.*
- 14.2 Demonstrate the use of the Scientific Method within the context of a fire investigation report.*
-

This page intentionally left blank.



TERMINAL OBJECTIVE

Demonstrate and validate the minimum information required for a basic fire investigation report.

Slide 14-2

ENABLING OBJECTIVES

- 14.1 Explain the key information contained in the fire investigation report.
- 14.2 Demonstrate the use of the Scientific Method within the context of a fire investigation report.

Slide 14-3

I. PURPOSE

PURPOSE OF INVESTIGATIVE REPORTS

“The purpose of a written report is to document an accurate and concise reflection of the investigator’s findings. The report should contain facts and data that the investigator can rely on to render any opinions and should contain the investigator’s reasoning of how each opinion was reached.”

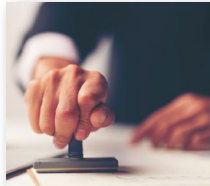
-NFPA 921, Section 16.5.1

Slide 14-4

- A. “The purpose of a written report is to document an accurate and concise reflection of the investigator’s findings. The report should contain facts and data that the investigator can rely on to render any opinions and should contain the investigator’s reasoning of how each opinion was reached” (National Fire Protection Association (NFPA) 921, Section 16.5.1, 2024 ed.).

WHY USE INVESTIGATIVE REPORTS

- General information.
 - Accountability.
 - Assist memory.
 - Authority having jurisdiction (AHJ) requirement.
 - Evidence.
 - Announce and explain.
 - Prove value of services.
 - Improve safety and performance.



Slide 14-5

- B. Why use investigative reports.

General information:

1. Accountability.
2. Assist memory.
3. Authority having jurisdiction (AHJ) requirement.

4. Evidence.
5. Announce and explain.
6. Prove value of services.
7. Improve safety and performance.

DEFENSE EXPERTS: NO WAY TO DEFINITELY SAY WHAT CAUSED FATAL LAFLIN FIRE.

“...Michael Daily was the defense's fire investigator expert...

Daily's testimony stood at odds with the testimony of the prosecution's fire experts, Special Agent Seth Graybill of the Bureau of Alcohol, Tobacco, Firearms and Explosives and Pennsylvania State Police Fire Marshal Karri Dodson.

While Graybill and Dodson both ruled out other potential sources of the fire — including a garbage bag with cigarette butts or the baseboard heater that was the subject of much of Friday's testimony — Daily told jurors these elements could not be ruled out.

However, Daily was **blocked from testifying much about these items under objections from prosecutors, as he did not analyze them in his official report. As an expert witness, Daily was bound to only testify specifically about what was in his report...**

Slide 14-6

- C. Reference: <https://www.timesleader.com/news/746133/defense-experts-no-way-to-definitively-say-what-caused-fatal-laflin-fire>

II. QUALITIES OF A GOOD REPORT

QUALITIES OF A GOOD REPORT

Accurate, clear, and complete

REPORT OF ORIGIN AND CAUSE ANALYSIS

I. SYNOPSIS OF INCIDENT:

1. On March 24, 2014 at approximately 1445 hours a fire and explosion was reported at a residential home at 210 Mooresville Road, Manchester, NH. The Manchester Fire Department (MFD) and the Manchester Police Department (MPD) immediately responded to the scene of the incident. The MFD extinguished the fire, but large portions of the home experienced significant fire and explosion related damages. Two deceased adult victims were found inside the residence.
2. Following the incident, investigative efforts to determine the origin and cause of the fire and explosion were completed by the MPD, the MFD, the New Hampshire State Fire Marshal's Office (NHSMO) and the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF).
3. The cause of the incident is classified as INCENDIARY.

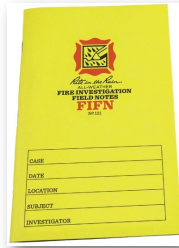
II. PROBLEM STATEMENT AND SCOPE OF WORK:

Slide 14-7

- A. Accurate.
- B. Clear and complete.

QUALITIES OF A GOOD REPORT

- Accurate.
- Clear and complete.
- Concise writing.
- Explain technical terms.
- Reference section.
- Report demonstrates grasp of systematic method.



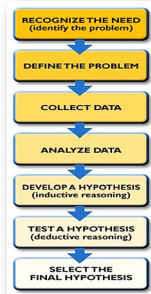
Slide 14-8

- C. Concise writing.
- D. Explain technical terms.
- E. Reference section.
- F. Report demonstrates grasp of systematic method.

III. SCIENTIFIC METHOD APPLIED TO REPORTS

REPORT WRITING – SCIENTIFIC METHOD

- Must demonstrate that the Scientific Method was used to conduct the fire origin and cause investigation.
- Organize so that it reflects the steps of the Scientific Method.



Slide 14-9

- A. Must demonstrate that the Scientific Method was used to conduct the fire origin and cause investigation.
- B. Organize so that it reflects the steps of the Scientific Method.

REPORT WRITING – SCIENTIFIC METHOD

“When the investigator states that the scientific method was used to determine origin and cause, the report should give sufficient detail to show that the methodology was indeed used and not just cited.”



-NFPA 921, Section 16.5.7

Slide 14-10

- C. “When the investigator states that the scientific method was used to determine origin and cause, the report should give sufficient detail to show that the methodology was indeed used and not just cited” (NFPA 921, Section 16.5.7, 2024 ed.).
- D. Steps of the Scientific Method.

RECOGNIZE THE NEED AND DEFINE THE PROBLEM

Examples:

- Summary of event or narrative.
- Participating fire investigators.
- Scope of investigation.
- Legal presence.
- Scene security.



Slide 14-11

1. Recognize the need and define the problem.

Examples:

- a. Summary of event or narrative.
- b. Participating fire investigators.
- c. Scope of investigation.
- d. Legal presence.

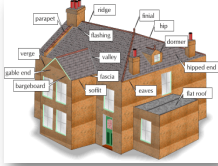
e. Scene security.

COLLECT DATA AND ANALYZE DATA

Examples:

- Building construction description.
- Physical security measures.
- Utilities.
- Fire suppression systems.
- Witness information.

Note: there may be crossover between the steps of collection and analysis.




Slide 14-12

2. Collect data and analyze data.

Note: There may be crossover between the steps of collection and analysis.

a. Examples:

- Building construction description.
- Physical security measures.
- Utilities.
- Fire suppression systems.

COLLECT DATA AND ANALYZE DATA

Additional examples:

- Witness information.
- Video surveillance.
- Burglar/fire alarm systems.
- Other electronic data sources.
- Timeline.

Note: there may be crossover between the steps of collection and analysis.

Time	Event	Data Source	Date
17:30	Janice Gilday last reported person in fire origin room	Janice Gilday	06/13/2018
20:45	Bible Study and AA Meeting depart church	Janice Gilday, Pastor Nauta	06/13/2018
01:50	Kathleen Huss smokes cigarette outside residence and observes fire at church	Kathleen Huss	06/14/2018
01:56:37	Kathleen Huss calls 911 to report fire	County Dispatch	06/14/2018
01:59:33	Fire Department Dispatch	County Dispatch	06/14/2018
02:06	Duncanson Fire Chief Warner 1st to arrive on scene	County Dispatch	06/14/2018

Slide 14-13

- Witness information.
- Video surveillance.

- Burglar/fire alarm systems.
- Other electronic data sources.
- Timeline.

COLLECT AND ANALYZE DATA FROM EXTERIOR

Provide a narrative that describes the exterior examination, process, methodology, and findings.

- Overview of exterior examination.
- Description of doors/windows and conditions.
- Identification and interpretation of fire intensity and movement patterns.
- Identification of areas that required a more comprehensive examination.
- Describe processing/excavation activity.



Slide 14-14

b. Exterior.

Provide a narrative that describes the exterior examination, process, methodology, and findings.

- Overview of exterior examination.
- Description of doors/windows and conditions.
- Identification and interpretation of fire intensity and movement patterns.
- Identification of areas that required a more comprehensive examination.
- Describe processing/excavation activity.

COLLECT AND ANALYZE DATA FROM INTERIOR

Describe data collection and analysis of the interior examination.

- Document sequence of the examination.
- Identify and interpret fire movement and intensity patterns.
- Note areas that warranted a more comprehensive examination.



Slide 14-15

c. Interior.

Describe data collection and analysis of the interior examination.

- Document sequence of the examination.
- Identify and interpret fire movement and intensity patterns.
- Note areas that warranted a more comprehensive examination.

COLLECT AND ANALYZE DATA SPECIFIC TO ORIGIN

- Describe processing/excavation activity in origin area.
- Include the fuel loads in origin area.
- Identify heat sources in origin area.
- Discuss conditions of heat sources.



Slide 14-16

d. Origin.

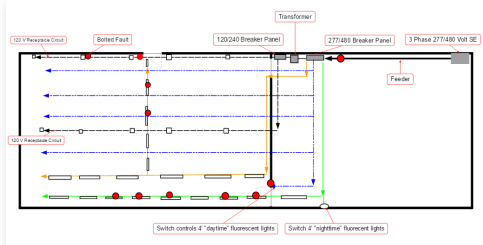
- Describe processing/excavation activity in origin area.
- Include the fuel loads in origin area.
- Identify heat sources in origin area.

- Discuss conditions of heat sources.

COLLECT AND ANALYZE DATA SPECIFIC TO ELECTRICAL

Arc fault survey and mapping:

- Narrative and diagram describing the arc survey and mapping data.



Slide 14-17

e. Electrical.

- Narrative and diagram describing the arc fault survey and mapping data.

COLLECT AND ANALYZE OTHER DATA

- Weather.
- Evidence collected.
- Photographs.
- Insurance information.
- Fire progression to other structures.
- Fatalities and/or other injuries.

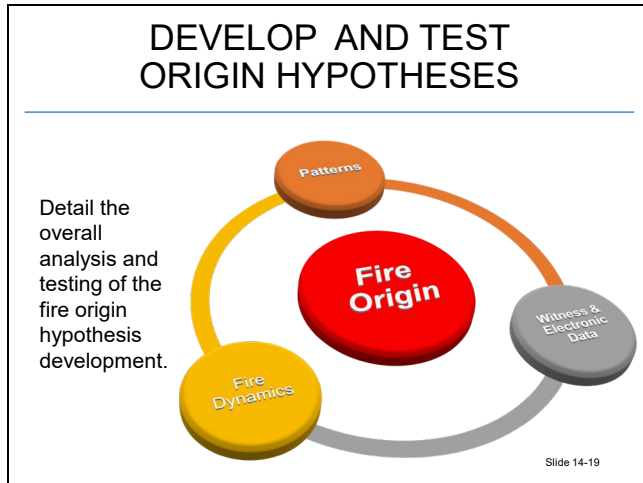


Slide 14-18

f. Other data.

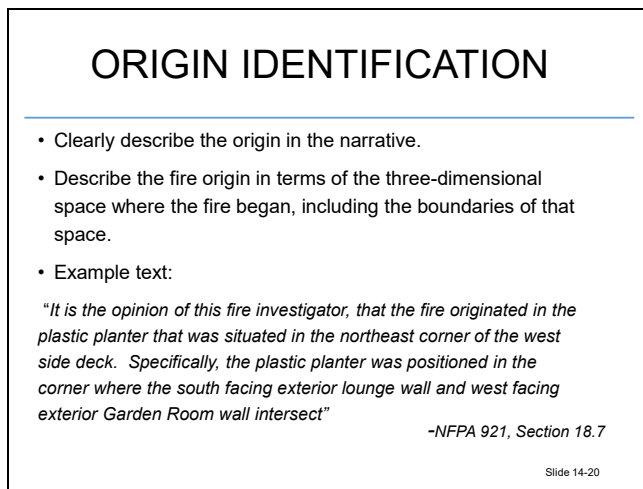
- Weather.
- Evidence collected.
- Photographs.
- Insurance information.
- Fire progression to other structures.

- Fatalities and/or other injuries.



3. Develop and test origin hypotheses.

- a. Detail the overall analysis and testing of the fire origin hypothesis development.



b. Origin identification.

- Clearly describe the origin in the narrative.
- Describe the fire origin in terms of the three-dimensional space where the fire began, including the boundaries of that space.

IV. EXAMPLE TEXTS

**FIRE ORIGIN NARRATIVE
EXAMPLE**

Analysis of witness information, electronic data, fire dynamics, fire effects/patterns and arc mapping is indicative of the fire originating at an unspecified area of the shed.

1. Border Patrol agents were first alerted to the fire by “popping sounds,” which they compared to small explosions. Border Patrol agents opened the back door of the station to investigate and observed the entire shed on fire.

Slide 14-21

- A. Analysis of witness information, electronic data, fire dynamics, fire effects/patterns and arc mapping is indicative of the fire originating at an unspecified area of the shed.

1. Border Patrol agents were first alerted to the fire by “popping sounds,” which they compared to small explosions. Border Patrol agents opened the back door of the station to investigate and observed the entire shed on fire.

**FIRE ORIGIN NARRATIVE
EXAMPLE**

2. The investigation did not lead to the identification of any witnesses or electronic sources that may have observed or recorded the fire during its incipient stage.
3. The general construction of the shed (small compartment) and material properties (thermoplastics panels) would likely support rapid fire growth and spread post ignition. Fire originating at either the interior or exterior would sustain combustion and spread because of the available fuels and ventilation.

Slide 14-22

2. The investigation did not lead to the identification of any witnesses or electronic sources that may have observed or recorded the fire during its incipient stage.
3. The general construction of the shed (small compartment) and material properties (thermoplastics panels) would likely support rapid fire growth and spread post ignition. Fire originating at either the interior or exterior would sustain combustion and spread because of the available fuels and ventilation.

FIRE ORIGIN NARRATIVE EXAMPLE

4. All structural surfaces were consumed during the fire. The contents within the shed sustained uniform fire damage. There were no identifiable movement or intensity patterns due to the extensive structural damage and uniform contents damage.
5. The shed was not supplied by electricity; therefore, arc survey and mapping was not applicable.

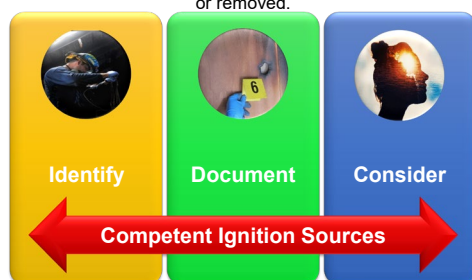


Slide 14-23

4. All structural surfaces were consumed during the fire. The contents within the shed sustained uniform fire damage. There were no identifiable movement or intensity patterns due to the extensive structural damage and uniform contents damage.
5. The shed was not supplied by electricity; therefore, arc survey and mapping was not applicable.

FINAL HYPOTHESIS AND CAUSATION ANALYSIS

Detail the analysis of potential ignition sources in, or around, the fire origin area. Consider sources that may have been destroyed, altered, or removed.



Slide 14-24

B. Final hypothesis and causation analysis.

1. Detail the analysis of potential ignition sources in, or around, the fire origin area. Consider sources that may have been destroyed, altered, or removed.

FIRE CAUSE OPINION DESCRIPTION

The cause should be described in terms of the competent ignition source providing enough heat to ignite the first fuel, and the circumstances of how they came together.



- The first fuel ignited.
- The ignition source.
- The action, event or circumstances that brought the fuel and ignition source together.

-NFPA 921, Section 19.7.1

Slide 14-25

2. The cause should be described in terms of the competent ignition source providing enough heat to ignite the first fuel, and the circumstances of how they came together.
 - a. The first fuel ignited.
 - b. The ignition source.
 - c. The action, event or circumstances that brought the fuel and ignition source together.

FIRE CAUSE EXAMPLE TEXT

Spontaneous combustion:

It is unlikely the fire was caused by spontaneous combustion.

Floor finishing operations, involving sanding and application of polyurethane clear coat via rags and plastic applicator, were not conducted on the day of the fire.

Floor finishing debris including sawdust and polyurethane saturated rags were reportedly placed in plastic trash bags, that were placed in the dumpster located along the building's east exterior wall.

Additionally, outside ambient conditions of 31 °F and 92% humidity are not optimal conditions to support a spontaneous combustion event.

Slide 14-26

3. Spontaneous combustion.

FIRE CAUSE EXAMPLE TEXT

Cooking fire:

The fire was caused by the ignition of cooking oils, by means of the electric range. The electric range was energized and the left front control knob positioned at the high setting.

An aluminum pot containing a small quantity of cooking oils was positioned on the left front heating elements.

The pot containing cooking oils was left in contact with the energized heating elements for a sufficient amount of time to achieve ignition.

Slide 14-27

4. Cooking fire.

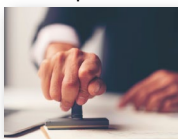
V. CONCLUSIONS

REPORT CONCLUSIONS

Must include identification of the fire origin, fire cause, and if applicable, the classification.

Conclusions are based on the totality of the information available at the time the report is prepared:

- All data should be collected at this point.
- Fire department reports.
- Lab analysis.
- Fire models.
- Witness statements.



Slide 14-28

- A. Must include identification of the fire origin, fire cause, and if applicable, the classification.
- B. Conclusions are based on the totality of the information available at the time the report is prepared:
 1. All data should be collected at this point.
 2. Fire department reports.
 3. Lab analysis.
 4. Fire models.

5. Witness statements.

CONCLUSIONS EXAMPLE TEXT

The conclusions herein are based on the information available at the time of this report to include witness information, electronic data sources, scene analysis and knowledge of fire dynamics, fire patterns and arc fault survey analysis.

Origin - *The fire originated at an unspecified location within the structure.*

Cause - *A precise fire origin area could not be established. Due to the broad fire origin area, investigators were unable to form testable hypotheses as to the first fuels ignited and competent ignition sources. Therefore, the fire cause is listed as undetermined at this time.*

Cause Classification – *Both accidental and intentional fire cause hypotheses remain reasonable possibilities. Therefore, the fire cause is classified as undetermined at this time.*

Slide 14-29

C. Conclusions example.

VI. REPORT REVIEW

ADMINISTRATIVE REVIEW

- An administrative review is typically carried out **within an organization** to ensure that the investigator's work product meets the organization's quality assurance requirements.



-NFPA 921, Section 4.6.1

Slide 14-30

- A. An administrative review is typically carried out **within an organization** to ensure that the investigator's work product meets the organization's quality assurance requirements. (NFPA 921, Section 4.6.1, 2024 ed.)

TECHNICAL REVIEW

- Performed by an individual who is qualified and familiar with all aspects of proper fire investigation and has access to all of the documentation available.
- A technical review can serve as an additional test of the various aspects of the investigator's work product.



-NFPA 921, Section 4.6.2

Slide 14-31

B. Technical review.

1. Performed by an individual who is qualified and familiar with all aspects of proper fire investigation and has access to all of the documentation available.
2. A technical review can serve as an additional test of the various aspects of the investigator's work product. (NFPA 921, Section 4.6.2, 2024 ed.)

PEER REVIEW

- Peer review is a formal procedure generally employed in prepublication review of scientific or technical material. This carries connotations of both independence and objectivity.
- Peer reviewers should not have any interest in the outcome of the review.
- The investigator's report is NOT peer reviewed.
- The investigator relies on peer-reviewed materials in preparation of the report.

-NFPA 921, Section 4.6.3

Slide 14-32

C. Peer review.

1. Peer review is a formal procedure generally employed in prepublication review of scientific or technical material. This carries connotations of both independence and objectivity.
2. Peer reviewers should not have any interest in the outcome of the review.
3. The investigator's report is **not** peer reviewed.

4. The investigator relies on peer-reviewed materials in preparation of the report. (NFPA 921, Section 4.6.3, 2024 ed.)

VII. SUMMARY



SUMMARY

- Prepare a professional report.
- Write accurate, clear, and complete reports.
- Reports are a reflection of the author.
- Use photographs and diagrams to help describe the scene.
- Use the Scientific Method.
- Base findings on a totality of the information available.

Slide 14-33

This page intentionally left blank.

REFERENCE

NFPA 921, *Guide for fire and explosion investigations*, 2024 edition. Quincy, MA: Author.

This page intentionally left blank.

UNIT 15: TIMELINE DEVELOPMENT, ANALYSIS AND SYNTHESIS

TERMINAL OBJECTIVE

The students will be able to:

- 15.1 *Construct a viable, defensible and accurate fire investigation timeline.*

ENABLING OBJECTIVES

The students will be able to:

- 15.1 *List common timeline data sources.*
- 15.2 *Distinguish between hard and soft time data sources.*
- 15.3 *Explain and practice the process of time synchronization.*
- 15.4 *Synthesize timeline data and information to produce an investigative tool for the fire investigator.*
-

This page intentionally left blank.

UNIT 15: TIMELINE DEVELOPMENT, ANALYSIS & SYNTHESIS



Slide 15-1

TERMINAL OBJECTIVE

Construct a viable, defensible and accurate fire investigation timeline.

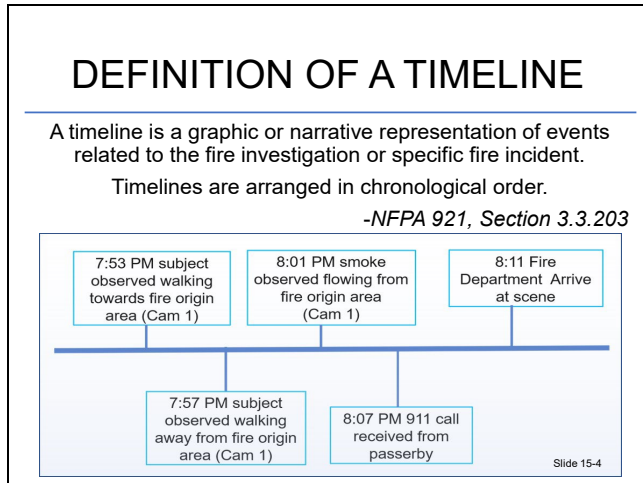
Slide 15-2

ENABLING OBJECTIVES

- 15.1 List common timeline data sources.
- 15.2 Distinguish between hard and soft time data sources.
- 15.3 Explain and practice the process of time synchronization.
- 15.4 Synthesize timeline data and information to produce an investigative tool for the fire investigator.

Slide 15-3

I. DEFINITION OF TIMELINE



- A. A timeline is a graphic or narrative representation of events related to the fire investigation or specific fire incident. Timelines are arranged in chronological order (NFPA 921, Section 3.3.199, 2024 ed.).

BENEFIT OF TIMELINE

- Visual aid, provides clarity to investigation.
- Demonstrative aid during courtroom presentations.
- Organizes witness and other source data to help identify gaps, consistencies, and inconsistencies.
- Identifies trends with investigation.

Slide 15-5

- B. Benefits of a timeline.

1. A timeline is a visual aid that provides clarity to the investigation and will serve as a demonstrative aid during courtroom presentations.
2. A well-developed timeline organizes witness and other source data to help identify gaps, consistencies, inconsistencies and trends with investigation.

APPLICATION OF TIMELINE-VIDEO

Identifies critical data for fire origin and cause hypothesis, i.e., ignition, growth and spread hypothesis





Slide 15-6

3. Identifies critical data for fire origin and cause hypothesis, i.e., ignition, growth and spread hypothesis. The photos in this slide depict a full-scale fire test conducted at the fire scene. Factors such as accelerated versus non-accelerated and ignition location had significant impact on the fire growth and spread. Consider how these factors affect the incident timeline.

TIMELINE VALIDATION

The value of a timeline is dependent upon the information used. Ensure that data included in the timeline is validated for accuracy.



Firefighter Smith stated that his engine company was dispatched to the fire at 3:42 AM (actual dispatch time was 3:32 AM) and arrived on scene of the fire at 3:52 AM (actual arrival time was 3:42 AM)

Slide 15-7

- C. The value of a timeline is dependent upon the information used to create it. Ensure that data included in the timeline is validated for accuracy.

II. TIMES

HARD TIMES (ACTUAL)

Identify a specific point in time that is directly or indirectly linked to a reliable clock or timing device of known accuracy.

Perry County Incident Times - County

LOCATION: 327 NEWPORT RD .21 01
 ConnPlace: OTTERBEIN UNITED METHODIST
 MUNICIPALITY: PENN TWP
 CFS: 1ST ALARM TRANSFER BOX: 2-06 DUNC PEN

Situations	RESOURCE	STATUS	TIME	DA
PF2	C2	RE	02:03:08	06
	C2	DP	02:03:08	06
PF2	C2	AR	02:11:48	06
PF2	C2	AR	03:15:49	06
PF2	C2	AV	05:17:42	06

Situations	RESOURCE	STATUS	TIME	DA
CF20	CCRIT20	DP	02:06:50	06
CF20	CCRIT20	RE	02:14:58	06
CF20	CCRIT20	AR	02:43:50	06

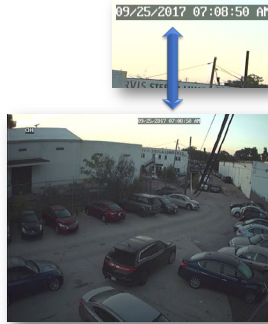
Slide 15-8

A. Hard times.

1. Identify a specific point in time that is directly or indirectly linked to a reliable clock or timing device of known accuracy.

HARD TIME SOURCES

- Dispatch logs.
- EMS reports.
- Alarm system reports.
- Private videos/photos.
- Surveillance systems.
- Timers.
- Weather reports.
- Computers.
- Vehicles.
- Wi-Fi antennas or routers.
- Utility records.



Slide 15-9

2. An investigator could obtain hard times from a variety of sources, to include:
 - a. Dispatch logs.
 - b. Emergency Medical Services (EMS) reports.
 - c. Alarm system reports.
 - d. Private videos/photos.

- e. Surveillance systems.
- f. Timers.
- g. Weather reports.
- h. Computers.
- i. Vehicles.
- j. WiFi antennas or routers.
- k. Utility records.

SYNCHRONIZING TIMES

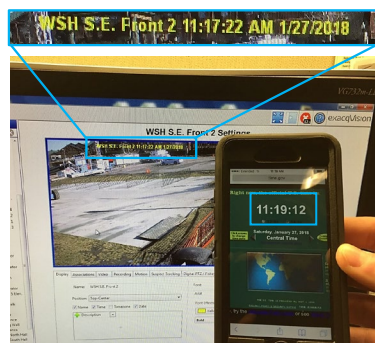
- Time discrepancies may exist between different data sources.
- Times need to be synchronized to a common time source in order to develop an accurate timeline.
- Document common time source used and how the times were synchronized.
- Use the official U.S. time at www.time.gov.
- Synchronize times to the correct time zone.

Slide 15-10

B. Synchronizing times.

1. Time discrepancies may exist between different data sources. The sources should be synchronized to a **common time** source in order to develop an accurate timeline. The investigator should document common time source used and explain how the times were synchronized.
2. Use the official U.S. time at www.time.gov. Synchronize times to the correct time zone!

SYNCHRONIZE TIMES



Surveillance camera
1 minute 50
seconds behind
time.gov official
U.S. time.

Slide 15-11

SOFT TIME (ESTIMATED)

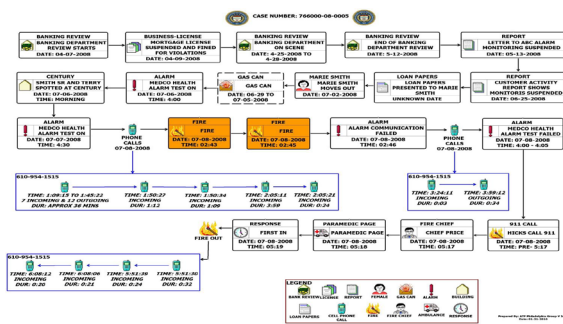
- Soft times are estimated times.
- Generally provided by witnesses.
- May be determined within a known degree of accuracy when compared to hard times or time range.
- Soft times are subjective and may vary based on stress levels and the individual's general perception of time.



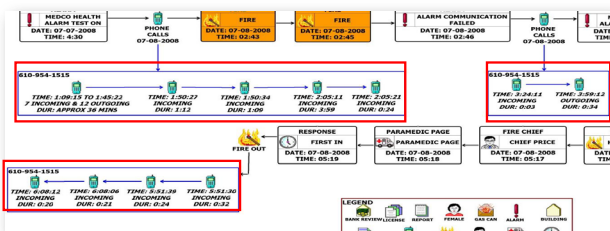
Slide 15-12

C. Soft times.

1. Soft times are estimated or approximated times that are commonly provided by witnesses. Estimated times may be for observations, time for an activity or when an event happened.
2. Soft times are subjective and may vary based on stress levels and the individual's general perception of time. For example, two witnesses that make the same observation may have large variances in time estimates.

EXAMPLE OF MULTIPLE
TIMELINES – MACRO

MULTIPLE TIMELINES – MICRO



D. Multiple timelines (macro/micro).

III. CASE STUDY: CHILDS POINT

CASE STUDY
936 CHILDS POINT ROAD

32 agencies, over 160 people worked the scene investigation. Estimated approximately 150 additional persons supported the investigation.

Slide 15-15

- A. This case required over thirty-two agencies and included both government and non-government agencies providing investigative assistance. During the course of the investigation, over 160 persons were documented as working the scene investigation. There were approximately 150 additional persons who supported the investigation.
- B. The Childs Point case study is a representation of how timelines helped investigators identify and explain the rapid fire growth and spread in a 16,000-square-foot residential structure. The fire resulted with 6 fatalities and complete destruction of the residence. The probable fire cause was determined to be a high-resistance connection in a floor-mounted receptacle. The receptacle failure resulted in ignition of dry pine needles, fabric tree skirt and a 15-foot Fraser fir Christmas tree that had low moisture content. Ignition of the Christmas tree resulted in rapid fire growth and spread, which was confirmed through analysis of fire alarm system data, video surveillance data and witness data. Further, data source times needed to be synchronized for timeline accuracy.

936 CHILDS POINT ROAD

Overview of the fire:

- On Monday, January 19, 2015, a fire occurred at a residence located at 936 Childs Point Road, Annapolis, Anne Arundel County, Maryland 21401. The residence was owned by Mr. Donald Pyle and Mrs. Sandra Pyle.
- The two-story, single family dwelling was approximately 16,386 square feet in size and sustained a complete loss to the structure and contents. The damage was estimated to be approximately \$16 million to \$18 million.

Slide 15-16

- C. Case synopsis.
1. On Monday, January 19, 2015, a fire occurred at a residential dwelling located at 936 Childs Point Road, Annapolis, Anne Arundel County, Maryland 21401. The residence was owned by Mr. Donald Pyle and Mrs. Sandra Pyle. The two-story occupied single-family dwelling was approximately 16,386 square feet in size and sustained a complete loss to the structure and contents. The damage was estimated to be approximately \$16 million to \$18 million.

CONTINUED FIRE OVERVIEW

Overview of the fire - continued:

An automatic fire alarm system provided initial notification to 911. First arriving units received conflicting reports about the status of the occupants: some reports indicating that they were home and others suggesting they were out of town.

It was determined that the homeowners, Donald (age 56) and Sandra (age 63), and their four grandchildren, Charlotte Boone, Wesley Boone, Alexis Boone and Kaitlyn Boone (ranging in ages 6 to 9 years old) were unaccounted for. The investigation ultimately concluded that all six individuals died as a result of the fire.

Slide 15-17

2. There was a monitored automatic fire alarm system which provided the initial notification to emergency 911. The first units arriving on the scene received conflicting reports about the status of the occupants of the dwelling: some reports indicating that they were home and others suggesting they were out of town.
3. It was later determined that the two homeowners, Donald (age 56) and Sandra (age 63), and their four grandchildren, Charlotte Boone, Wesley Boone, Alexis Boone and Kaitlyn Boone (ranging in ages 6 to 9 years old), were unaccounted for. The investigation ultimately concluded that all six individuals died as a result of the fire.

DATA SOURCES FOR TIMELINE

3 sources of time-based information:

- Fire/burglar alarm system (monitored).
- Surveillance video.
- 911 dispatch logs.
- Combining events from these three sources produces a more complete picture of the fire event.



Slide 15-18

D. Timeline data sources.

1. This example has three sources of time-based information. They are:
 - a. Fire/burglar alarm system (monitored).

- b. Surveillance video.
 - c. 911 dispatch logs.
2. By combining the events from these three sources, the investigator will obtain a more complete picture of the fire event.

STRUCTURE OVERVIEW



Slide 15-19

ANALYSIS OF SEQUENTIAL EVENTS: FIRE ALARM

~ 0 min Incident Duration

- 03:28 Automatic alarm received 1st & 2nd floor smoke detector
- 03:28 Automatic alarm received basement smoke detector (detector, actually located at top of basement stairs, first floor level)
- 03:29 Automatic alarm received master bedroom gas detector



Slide 15-20

ANALYSIS OF SEQUENTIAL EVENTS: NOTIFICATIONS

~ 2 min Incident Duration

03:30 Orange glow on neighbor surveillance camera (Synchronized 7 minutes slow) – purple arrow

03:31 Central Station (Alarm Co.) calls AAFD 911.

~4–5 min Incident Duration

03:33 Neighbor calls 911 reporting "the whole house is on fire". – blue arrow



Slide 15-21

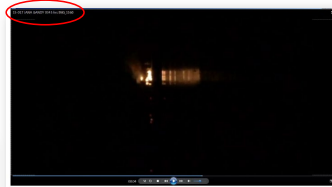
E. Analysis of sequential events/timeline: fire alarm.

1. Various times and sources.

ANALYSIS OF SEQUENTIAL EVENTS: WITNESS VIDEO

~13 min Incident Duration

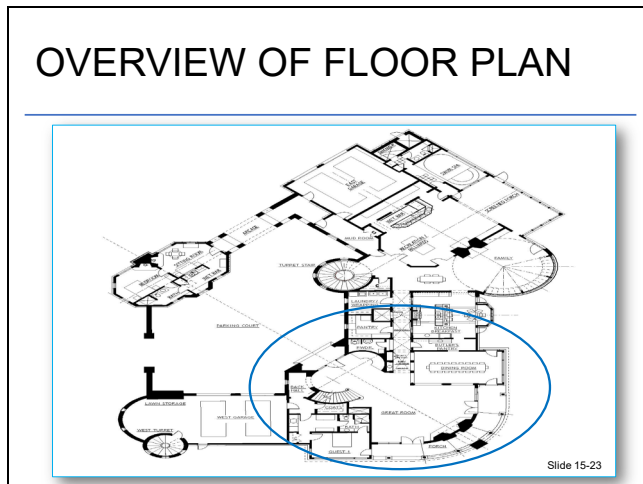
03:41 Witness across river calls 911 reporting "whole house on fire". Provides Surveillance Video



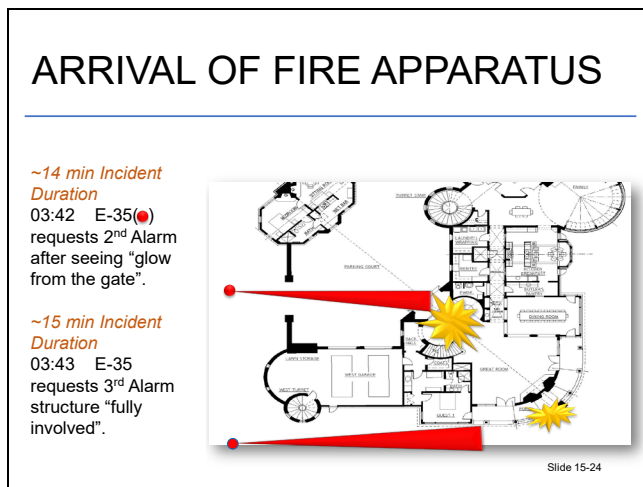
Yellow glow appears on video at 03:23. Surveillance system clock is 7 minutes slow.
Time corrected to 03:30

Slide 15-22

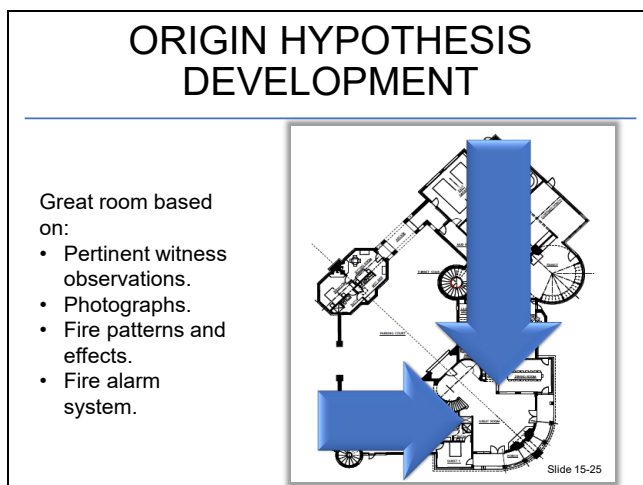
2. Analysis of sequential events: witness video.



3. Overview of floor plan.

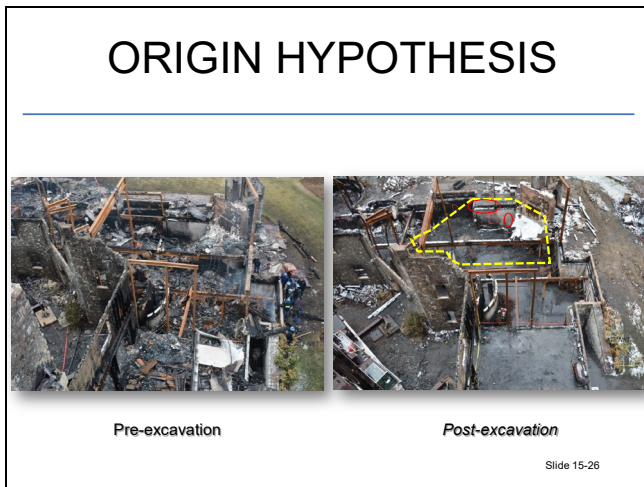


4. Arrival of fire apparatus.

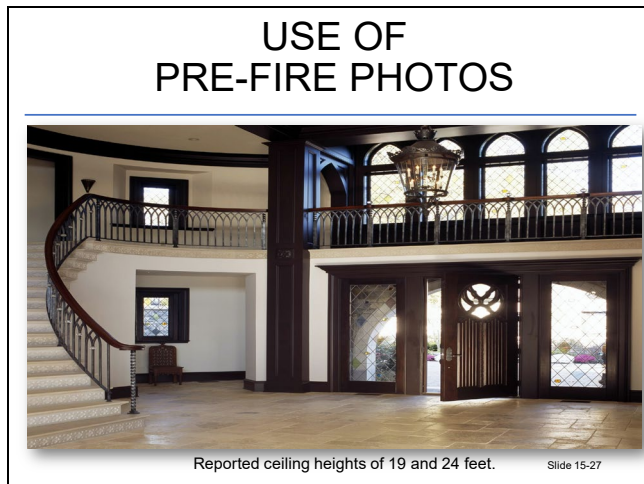


F. Origin hypothesis development.

1. Diagram identifies room of origin as the great room. Data used to identify the great room included witness observations (911 caller and responding firefighters), photographs and video collected from witnesses, fire patterns on a macro level due to the severe destruction of the structure, and fire alarm data.



2. Pre-excavation and post-excavation of the room of origin.
 - a. Description of fire effects and patterns considered to develop the fire origin hypothesis:
 - Rim joist south wall: mass loss.
 - Dining room floor: greater loss/integrity progressing from east to west.
 - Ceiling light can: significant oxidation and mass loss compared to similar in room.
 - b. Investigators were presented with **macro** fire patterns, as **micro** patterns and effects were destroyed by the fire event.
 - c. Comparing like items, such as this ceiling recessed light fixture as compared to others, indicates greater oxidation and mass loss of the can compared to similar in same room.



G. Use of pre-fire photos.

1. Pre-fire photos can assist with identifying building construction, utilities and fuel loads.
2. Slide depicts pre-fire photo of main entrance into home and great room.
 - a. Ceiling height reported at 24 feet.
 - b. Firefighters observed fire venting from 1st and 2nd floor windows.
 - c. Wood solid core front door consumed approximately 5 minutes after fire department arrival (approximately 20 minutes after ignition).



3. Slide depicts pre-fire photos of the initial photographs of contents of room of origin.

- a. Is this fuel item/package capable of creating the fire conditions that were encountered?
- b. What if any fuel sources are present that have heat release rate (HRR) potentials capable of driving this large room to flashover?

FUELS IN AREA OF ORIGIN AT
TIME OF FIRE



15 foot Fraser Fir tree identified pre fire photos and fire debris examination.

Slide 15-29

4. Pre-fire photo showing 15-foot Christmas tree, stuffed chair, decorative garlands and fabric curtains.
 - a. Moisture content greatly affects the ability for a Christmas tree to ignite and burn.
 - b. The history of the Christmas tree is established through hard times/dates and witness information.
 - c. Collecting data regarding the history of the tree allowed investigators to estimate the probable moisture content (15 – 35%).
 - d. Testing showed that Christmas trees with low moisture content are capable of sustaining ignition and rapid fire growth with high HRR.
 - e. Is this fuel load capable of driving the great room to flashover?

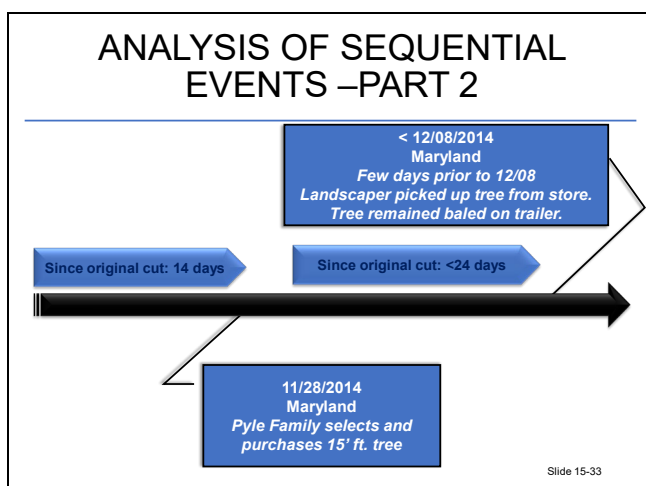
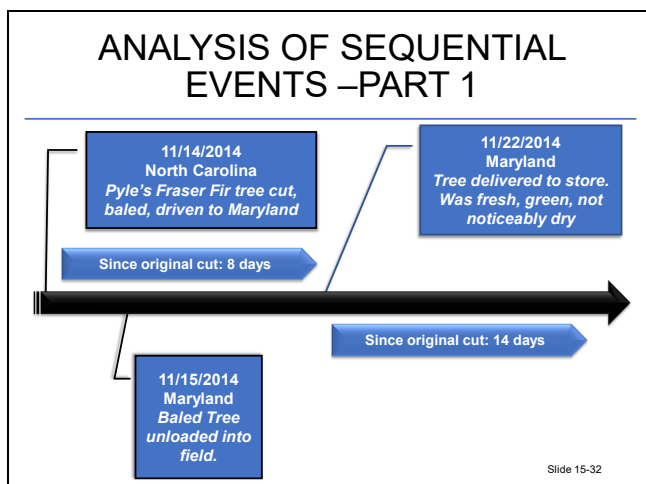


H. Area of origin excavation, sifting, and reconstruction.

1. Slide depicts fire origin area post-excitation and reconstruction.
2. The excavation process assisted with the recovery of a large Christmas tree stand and electrical components (can lights, receptacles, tree lights) recovered on upper layers of fire debris excavated from basement.



3. Location of Christmas tree stand was consistent with witness statements of tree location prior to fire.



I. Building the timeline.

1. Christmas tree timeline (**macro**). Establishing the history of Christmas tree and susceptibility for ignition and sustained combustion was critical for the fire origin and cause hypothesis.
2. Trees with high moisture content are not likely to sustain ignition and fire growth, which would disprove the investigators' hypothesis.
3. Data collected regarding the tree was organized into a timeline which demonstrated that the tree would have a low moisture content based on the time from when it was cut and watering cycle.

ANALYSIS OF SEQUENTIAL EVENTS –PART 3

12/08/2014
Childs Point Road
Landscaper
delivered and set-up
tree

Since original cut: 25 days

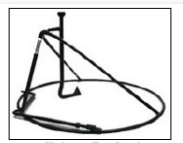
- Unwrapped
- Chain-sawed several inches off base (10" diam)
- Installed tree stand
- Installed water bucket provided
- Placed 6'-8' to left of fireplace, Great Room
- Top was 3'-4' from ceiling (19' Ceiling)

12/09/14
Childs Point
Road
Decorators
decorated tree

- New lights: 1500 lights (100 per string)
- Strung together end-to-end
- Multiple receptacle extension cord/switch (Pyle's)
- RPT plugged into 15 A floor receptacle
- Decorated mostly with plastic ornaments
- Lights are turned on and remain on 24/7

Slide 15-34

PRE-FIRE SETUP



Christmas Tree Stand



Christmas Tree Water Pan

Slide 15-35

ANALYSIS OF SEQUENTIAL EVENTS –PART 4

Recall previous slides:
12/08/2014 –Delivered/Setup
12/09/2014-Decorated

01/20/2015
Scheduled day to
take down tree

Since original cut: 25 days

Since original cut: 66 days

01/2015
Needles are falling from
tree
Branches are sagging

01/19/2015 @ 3:30 AM
FIRE

Lights on continuously: 41 Days (~960 hrs) (612 W, 5.1A)

Slide 15-36

- In 2008, NIST published a research paper in conjunction with the United States Fire Administration titled *"Impact of a Residential Sprinkler on the Heat Release Rate of a Christmas Tree Fire"*, by Daniel Madrzykowski.



Slide 15-37

In that study, NIST test burned four dry Fraser firs in stands.

- The trees ranged in size from 6.75 feet – 8.33 feet high.
- 5.00 feet – 5.35 feet wide.
- 24.13lbs – 36.38lbs.
- Peak HRR varied 3.2 MW – 4.3 MW.
- All trees burned out in less than 60 seconds.



Slide 15-38

TEST TREE VIDEO

Tree B (Weekly watering schedule) Moisture content: 15%



Slide 15-39

PHYSICAL EXPERIMENTS OR TESTING- TREE A

Tree A (Weekly watering schedule)

- Moisture content: 32%
- Observed ignition of tree: **30 seconds**
- Fire growth time to peak burn rate: **44 seconds**
- Peak HRR: **15 MW**
- Peak heat flux (10'): **12.6 kW/m²**



Slide 15-40

PHYSICAL EXPERIMENTS OR TESTING-TREE B

Tree B (Weekly watering schedule)

- Moisture content: 15%
- Observed ignition of tree: **5 seconds**
- Fire growth time to peak burning rate: **35 seconds**
- Peak HRR: **17.6 MW**
- Peak heat flux (10'): **16 kW/m²**



Slide 15-41

PHYSICAL EXPERIMENTS OR TESTING

Tree C (Continuous watering schedule)

- Moisture content: 73%
- Observed ignition of tree: **7:01 minutes**
- Fire growth time to peak burning rate: **46 seconds**
- Peak HRR: **4.3 MW**
- Peak heat flux (10'): **2.7 kW/m²**



Slide 15-42

PROBABLE CAUSE



trolley power rail showing melted blade receptor and plug blade remnant.

Slide 15-43

IV. CASE STUDY: BOGEY HILLS

CASE STUDY BOGEY HILLS COUNTRY CLUB



Slide 15-44

- A. The Bogey Hills Country Club case study is a representation of how timeline data helped investigators identify that the fire originated on a 2nd floor exterior deck. The fire cause was determined to be careless disposal of smoking materials. Cigarettes were discarded into a plastic planter filled with potting soil. Ambient conditions were conducive to support ignition and smoldering combustion of the potting soil.
- B. Data used to identify the fire origin area included 911 caller video and fire alarm systems. The 911 caller observed fire at the exterior of the structure prior to the interior fire alarm system operating. The alarm monitoring company clock was found to be 2 minutes and 49 seconds behind the official U.S. time and was synchronized and necessary adjustments made.

- C. The 911 caller statements and video supported the fire originating at the structure's exterior. Fire originating within the structure would have activated the alarm system prior to venting the building's triple-pane windows.

**BOGEY HILLS COUNTRY CLUB
OVERVIEW**

Case Synopsis:

- On February 16, 2017, at 11:48 PM, a fire was discovered at the Bogey Hills Country Club located at 1120 Country Club Road, Saint Charles, Missouri 63303.
- St. Charles Fire Department and Central County Fire District were the first responding departments with numerous mutual aid companies responding to assist.
- The fire completely destroyed the 36,000 square foot building with an estimated loss of 8 million dollars.

Slide 15-45

- D. Case synopsis.

- On February 16, 2017, at 23:48 hours, a fire was discovered at the Bogey Hills Country Club located at 1120 Country Club Road, Saint Charles, Missouri 63303.
- St. Charles Fire Department and Central County Fire District were the first responding departments with numerous mutual aid companies responding to assist.
- The fire completely destroyed the 36,000 square foot building with an estimated loss of 8 million dollars.

**BOGEY HILLS COUNTRY CLUB
OVERVIEW**

- The ATF National Response Team (NRT) assisted with the fire investigation due to size of the structure, the large dollar loss, and a firefighter injury, as well as the number of personnel necessary to process the scene and investigate the fire.
- The NRT was on scene for four days.
- The fire scene investigation was conducted in partnership with the Central County Fire and Rescue, St. Charles County Police Department, and Missouri State Fire Marshal's Office.

Slide 15-46

4. The Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) National Response Team (NRT) was requested to assist with the fire investigation due to size of the structure, the large dollar loss, and a firefighter injury, as well as the number of personnel necessary to process the scene and investigate the fire.
5. The ATF NRT responded to the fire scene on Monday, February 20, 2017, and commenced the fire scene examination, which lasted through Thursday, February 23. The fire scene investigation was conducted in partnership with the Central County Fire and Rescue, St. Charles County Police Department, and Missouri State Fire Marshal's Office.

UAV SCENE FOOTAGE-VIDEO



Slide 15-47

- E. Aerial view of fire scene.

TIMELINE DATA SOURCES

Three sources of time-based information:

- 911 caller's phone.
- Fire/burglar alarm system.
- 911 dispatch.



Slide 15-48

- F. Timeline data sources.

1. The investigation uncovered 3 sources of time-based information. They were:

911 CALLER

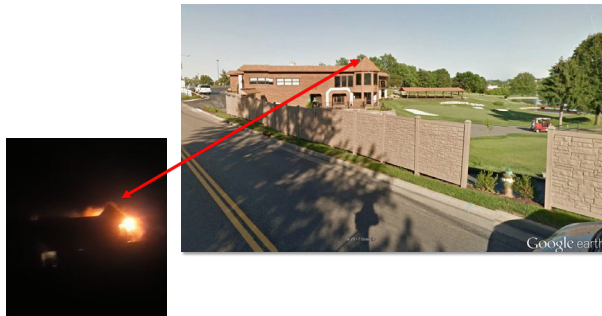
The first indication of fire is a 911 caller at 23:49:20. The 911 caller was taking out his trash and observed fire at the rear of the building.



Slide 15-49

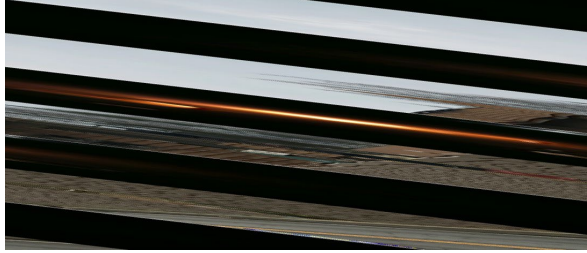
- a. 911 caller's phone.
- The first indication of fire is a 911 caller at 23:49:20. The 911 caller was taking out his trash and observed fire at the rear of the building.

911 CALLER PERSPECTIVE



Slide 15-50

911 CALLER VIDEO



Slide 15-51

FIRE/INTRUSION PROTECTION SYSTEM

- The Country Club building was equipped with a monitored (central station) burglar alarm system.
- Wireless combination photoelectric/heat detector (135°F/57°C) heads were installed in select locations throughout the building.
- Security Systems recorded multiple burglar and fire events on the night of the fire.
- The time stamp associated with Erker Security Systems' network was 2 minutes and 49 seconds slower than the official U.S. time documented by NIST.



Slide 15-52

b. Fire/intrusion protection system.

- The Country Club building was equipped with a monitored (central station) burglar alarm system. Wireless combination photoelectric/ heat detector (135 °F/57 °C) heads were installed in select locations throughout the building.
- Security Systems recorded multiple burglar and fire events on the night of the fire. The time stamp associated with Erker Security Systems' network was 2 minutes and 49 seconds slower than the official U.S. time documented by the National Institute for Standards and Technology (NIST).

911 DISPATCH

- County dispatch was contacted by investigators in order to synchronize times.
- The St. Charles County dispatch times were verified and found to deviate from the official U.S. time by less than one second.



Slide 15-53

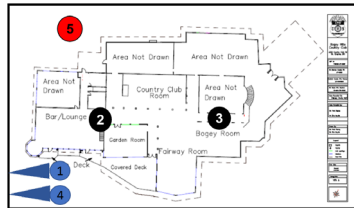
c. 911 dispatch.

- County dispatch was contacted by investigators in order to synchronize times. The St. Charles County dispatch times were verified and found to deviate from the official U.S. time by less than one second.

- By combining the events from these three sources, we obtain a more complete picture of the fire event.

ANALYSIS OF SEQUENTIAL EVENTS / TIMELINE

- 11:49:20 PM – First 911 call observes fire at rear of building
- 11:50:48 PM-Smoke Detector Bar (Synchronized from 11:47:59)
- 11:50:51 PM – Smoke Detector – Lobby hallway (Synchronized from 11:48:02)
- 11:52 PM – 911 caller video

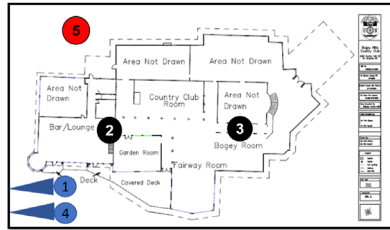


Slide 15-54

G. Analysis of sequential events/timeline.

- This timeline assists investigators in hypothesis development and testing regarding an interior versus exterior fire origin.

ANALYSIS OF SEQUENTIAL EVENTS / TIMELINE



5. 11:55:34 PM – First engine

Slide 15-55

TIMELINE- PAGE 1

Time	Event	Data Source	Date
23:00:47	Security System Armed by "No Dust" Cleaning	Erker Monitoring	02/16/2017
23:49:20	1 st 911 Call from Earl Smith (Flames from Back of Building)	Charles County Dispatch	02/16/2017
23:50:48	Fire Alarm: Main Lounge Smoke Detector (top of stairs near bar)	Erker Monitoring	02/16/2017
23:50:51	Fire Alarm: Lobby Hallway Smoke Detector	Erker Monitoring	02/16/2017
23:52:XX	Video by 911 Caller Immediately After Disconnecting the Call (Facing East) (Previous Slide 50/51)	Earl Smith's Phone	02/16/2017

Slide 15-56

2. Overall Bogey Hills fire incident timeline.

TIMELINE- PAGE 2

Time	Event	Data Source	Date
23:55:34	1 st Engine Company Arrives on Scene	Charles County Dispatch	02/16/2017
23:55:42	Burglar Alarm: Bar Motion Detector (top of stairs near bar)	Erker Monitoring	02/16/2017
23:58:18	Fire Alarm: Second Floor Office Smoke Detector (Top of stairs in Lobby)	Erker Monitoring	02/16/2017
23:58:22	Burglar Alarm: Northwest Bar Door (Fire Department Entry Shortly After)	Erker Monitoring	02/16/2017

Slide 15-57

TIMELINE- PAGE 3

Time	Event	Data Source	Date
23:59:XX	2 nd Video from 911 Caller (Facing East)	Earl Smith's Phone	2/16/17
0:00:13	Fire Alarm: Lower Level Liquor Smoke Detector	Erker Monitoring	2/17/17
0:01:45	Fire Alarm: Second Floor Hall Smoke Detector	Erker Monitoring	2/17/17
0:05:00	Fire Alarm: Pro Shop Storage Smoke Detector	Erker Monitoring	2/17/17



Slide 15-58

TIMELINE- PAGE 4

Time	Event	Data Source	Date
0:06:28	Fire Department Interior Evacuation	Charles County Dispatch	02/17/2017
0:06:33	Fire Alarm: Lower Level Lounge Smoke Detector	Erker Monitoring	02/17/2017
0:10:05	Fire Alarm: Electric Utility Smoke Detector	Erker Monitoring	02/17/2017



Slide 15-59

FIRE ORIGIN HYPOTHESIS



Slide 15-60

H. Fire origin hypothesis.

FIRE ORIGIN HYPOTHESIS



Slide 15-61

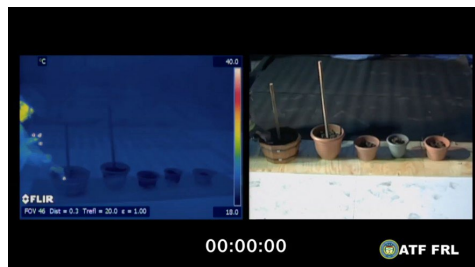


Slide 15-62

- I. The fire origin area was processed in search of competent ignition sources. The origin area processing included excavation, sifting and use of accelerant canine (negative).
- J. Witness statement indicated that individuals smoked on the rear deck at a minimum of 4.5 hours prior to the fire. Witnesses further stated that the cigarettes are sometimes extinguished in planters, but they are routinely cleaned/removed from the planters by club house staff. The statement that cigarettes are routinely cleaned/removed from the planters was disproved through examination and discovery of cigarette butts in planters that were not damaged during the fire.
- K. A melted plastic planter was discovered in the area of origin (2nd floor rear deck at a corner where the bar and dining room intersected). The plastic planter was found to contain potting soil, which is susceptible to ignition and smoldering combustion by cigarettes.

FIRE CAUSE HYPOTHESIS TEST VIDEO

In summary, Schuh found that smoldering ignition occurred when the potting soil had a low moisture content. Smoldering events occurred for periods extending beyond six (6) hours. *Fire Findings*, Spring 2009, Volume 17, NO 2



Slide 15-63

L. Fire cause hypothesis test video.

1. In summary, Schuh found that smoldering ignition occurred when the potting soil had a low moisture content. Smoldering events occurred for periods extending beyond six (6) hours (*Fire Findings*, Spring 2009, Volume 17, No. 2).
2. Investigators tested their hypothesis through cognitive testing and research. Testing and research validated that cigarettes are a competent ignition source for potting soil when ambient conditions are suitable. Further, the testing and literature research validated that potting soil can sustain smoldering combustion for periods extending from 0-6 hours, which was consistent with the Bogey Hills Country Club timeline.

SUMMARY



- Separate into hard/soft times.
- Synchronize clocks.
- Combine and sort events based on times.
- Export for O&C report.

Slide 15-64

ACTIVITY 15.1

Timeline Tool

Purpose

Demonstrate the ability to synthesize and collate information from various sources in order to populate and obtain timeline information from the provided spreadsheet. This activity will reinforce the learning objectives of this unit.

Description

On the following pages, you are provided four different sources which provide time-based information about a structure fire. In this exercise, you will use this information to create a synchronized master timeline.

Directions

1. Review the information for each source.
2. As defined during the lecture portion of this unit, decide whether it's a hard time or an approximate time source.
3. For each source, ensure the times are properly synchronized (if applicable).

Note: The required information for syncing the times has been provided.

4. For each source, add the events to that source's individual timeline.

For the surveillance camera source, add hyperlinks to the four photos. They are located in the folder **(Blackboard-Course Content-Unit 15-Student Activity Materials)** camera images. Start with Image1 for the first event.

5. Click the "Click here to import sources" and select the Excel file "772 demo import video." It will add two additional sources to your timeline.
6. When you have added all sources and events, export the following **two timelines** into a Microsoft Word document:
 - a. Master timeline (formatted as a bulleted list).
 - b. FireGuard Alarm LLC Central Station Log individual timeline (formatted as a table).

This page intentionally left blank.

ACTIVITY 15.1 (cont'd)

Timeline Tool

Source #1:

Prince George's County Public Safety Communications – 911 Call Center

The log below was provided by the Prince George's County Public Safety Department and covers events from the initial 911 call through the arrival of the Battalion Chief on scene. *The fire marshal contacted the dispatch center and confirmed that the county's dispatch clock is 4 seconds slower than the official U.S. Time from www.time.gov.*

	Prince George's County Public Safety Communications	CAD Incident Log – Incident #17-644681
INCIDENT DETAILS		
NATURE OF INCIDENT: STRUCTURE FIRE ADDRESS: 6000 AMMENDEALE ROAD, BELTSVILLE MD 20705 DISPATCH TIME: 07/03/2017 04:33:21 ARRIVE TIME: 07/03/2017 04:36:28		
EVENT LOG		
DATE/TIME	CALL ID	CALL DETAIL
07/03/2017 04:32:26	2068	911 CALL RECEIVED FROM CELL. NATURE OF CALL: FIRE IN BUILDING
07/03/2017 04:32:47	2068	CALLER STATES HEAVY SMOKE AND FLAMES VISIBLE FROM AMMENDEALE ROAD, COMING FROM SECOND FLOOR WINDOWS
07/03/2017 04:33:21	N/A	UNITS ENROUTE: C2, E3, E7, T8, R4, INV8
07/03/2017 04:33:42	2073	CALL FROM FIREGUARD ALARM MONITORING. SMOKE ALARMS ZONES 001, 003, 004. WATERFLOW ALARM ZONE 004
07/03/2017 04:34:21	2079	911 CALL RECEIVED FROM CELL. NATURE OF CALL: FIRE IN BUILDING.
07/03/2017 04:34:37	2079	CALLER STATES HE IS SECURITY GUARD AT BLDG, ENTIRE SECOND FLOOR IS INVOLVED, HE IS TRYING TO LOOK FOR OCCUPANTS
07/03/2017 04:36:28	N/A	C2 ON SCENE, ASSUMING COMMAND. PER C2 BUILDING IS FULLY INVOLVED, POSSIBLE OCCUPANTS TRAPPED

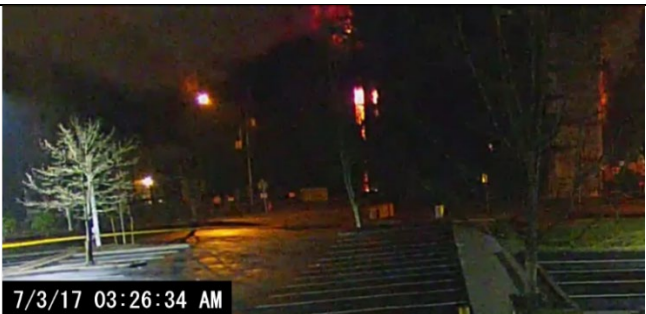
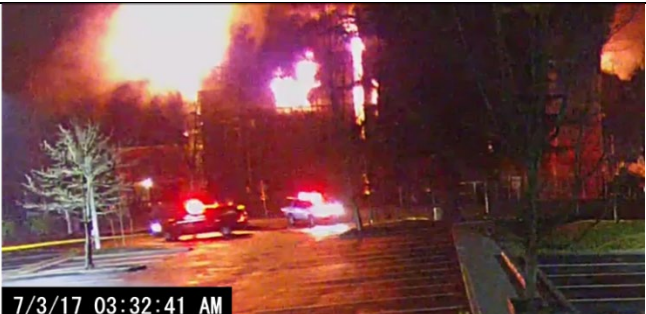
Source #2:**ROI of John Smith, Security Guard**

The building's security guard, John Smith, was interviewed by ATF agents several hours after the fire occurred. An excerpt of the ATF Report of Investigation documenting Mr. Smith's interview is shown below.

U.S. Department of Justice Bureau of Alcohol, Tobacco, Firearms and Explosives		Report of Investigation
Title of Investigation: 6000 Ammendale Rd., Beltsville, MD	Investigation Number: 769001-17-0084	Report Number: 14
SUMMARY OF EVENT: Interview of Building Security Guard: John SMITH		
1. On July 3, 2017, Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF) Special Agent/Certified Fire Investigator Dixon Robin interviewed John SMITH, born 5/19/1982, who was the security guard at 6000 Ammendale Road on the night of the fire. The interview was conducted near the scene, in a mobile command post. 2. SMITH has been employed by the security company, SecurityGuard Inc., since June 2016. He sometimes works at other locations, but usually works the night shift at 6000 Ammendale Rd. On the day of the fire, he was scheduled to work from 11:30 PM (on 7/2/17) to 7:00 AM the next day. 3. SMITH stated that his primary job is to patrol the perimeter of the building to make sure there is no unusual activity. He also checks doors to make sure they are locked. He stated that there is a limited night shift at the building, so he sometimes sees employees during his rounds. 4. SMITH stated that around 3:30 AM on the morning of the fire, he noticed some lights dimming and flickering on the second floor of the NE corner of the building, which is unoccupied at night but is still lit up for security purposes. He did not notice anything else unusual on the night/morning of the fire. 5. SMITH stated that his first indication of a fire was hearing an alarm. He was outside, near the SW corner of the building. He said it sounded like it was coming from the opposite side of the building. He stated that a few moments before, he had looked at his watch and noted that it was 4:32 AM. 6. SMITH ran to where he heard the alarm sound coming from. As he approached the side of the building, he said at least five windows on the second floor were broken out and flames and smoke were coming out. At this point, he called 911 to report the fire. The call log on SMITH's cell phone shows an outgoing call to 911 at 4:34 AM.		

Source #3:**Parking Lot Surveillance Camera**

The images below were collected from a surveillance camera across the street that was pointed at the fire building. Investigators met with the owner of the camera to determine if the camera's clock was correctly set. **At 2:15:00 PM (time.gov time), the timestamp on the camera read 1:11:09 PM.**

Image	Event	Camera time
	Lights go out on second floor	03:03:26 AM
	Fire showing in second floor windows	03:22:27 AM
	Fire breaks through roof	03:26:34 AM
	Battalion chief arrives on scene	03:32:41 AM

Source #4:**FireGuard Alarm LLC – Central Station Log**

The building's fire alarm system was monitored by FireGuard Alarm LLC. The alarm company provided the following alarm event log for the building. **The company confirmed that their system is 32 seconds ahead of the official U.S. time from time.gov.**

FIREGUARD ALARM LLC Alarm Activity Report for Customer ID: 548923 For the Period 7/2/2017 – 7/3/2017				
DATE	TIME	EVENT	DESCRIPTION	ZONE
07/02/2017	22:34:27	Test	Periodic Test Report – Communications OK	N/A
07/03/2017	04:31:08	Fire Alarm	Smoke Detector	001
07/03/2017	04:31:17	Fire Alarm	Smoke Detector	003
07/03/2017	04:32:01	Fire Alarm	Sprinkler water flow	004
07/03/2017	04:34:18	Fire Alarm	Smoke Detector Notes: Call placed to Prince George's County Dispatch (301) 555-2153	004
07/03/2017	04:36:35	Fire Trouble	Protection loop trouble	001
07/03/2017	04:38:02	System Trouble	Loss of communication	N/A

REFERENCE

NFPA 921, Section 3.3.199, 2024 edition.

This page intentionally left blank.

UNIT 16: LEGAL CONSIDERATIONS

TERMINAL OBJECTIVE

The students will be able to:

- 16.1 *Anticipate problems by the application of legal theory, applicable laws, and an understanding of motives as related to the fire investigation.*

ENABLING OBJECTIVES

The students will be able to:

- 16.1 *Describe motives and explain the impact of motives in fire case resolution.*
 - 16.2 *Evaluate constitutional considerations.*
 - 16.3 *Summarize the four types of lawful access by which an investigator may be legally on the premises to conduct a fire scene examination.*
 - 16.4 *Identify applicable rules of evidence.*
 - 16.5 *Explain the importance of effective reports.*
 - 16.6 *Consider court preparation points for the new expert witness.*
-

This page intentionally left blank.



TERMINAL OBJECTIVE

Anticipate problems by the application of legal theory, applicable laws, and an understanding of motives as related to the fire investigation.

Slide 16-2

ENABLING OBJECTIVES

- 16.1 Describe motives and explain the impact of motives in fire case resolution.
- 16.2 Evaluate constitutional considerations.
- 16.3 Summarize the four types of lawful access by which an investigator may be legally on the premises to conduct a fire scene examination.
- 16.4 Identify applicable rules of evidence.
- 16.5 Explain the importance of effective reports.
- 16.6 Consider court preparation points for the new expert witness.

Slide 16-3

I. CRIMINAL LAW

CRIMINAL LAWS

- Common law:
 - Passed down by tradition and interpreted by judges.
- Statutory law:
 - Made by the legislature.



Slide 16-4

A. Criminal law is derived from two sources: common law and statutory law.

1. Common law crimes began as acts people considered inherently wrong such as murder, theft and arson.
 - a. Common law crimes are acts that have been considered criminal as passed down by tradition.
 - b. The legislature defines prohibited acts and assigns a numerical code to them.
 - c. Many crimes that were once common law crimes have now been defined by the legislature in statutes and therefore have been replaced by statutory crimes.
2. Statutory crimes include vehicle fire crimes and insurance fraud fire cases. Arson is a statutory crime in states where common law arson has been replaced with a statutory violation by the legislature.

COMMON LAW ARSON

Common law arson:

- Willful.
- Malicious.
- Burning.
- Dwelling.
- Of another.



Slide 16-5

B. Common law arson.

1. Each word in the definition of “arson” has a specific meaning that must be proven in order to obtain a conviction for arson.
2. “Willful” means intentional and without excuse or justification.
3. “Malicious” means with ill will, hatred, spite or resentment.
4. “Burning” means charring, not just mere discoloration or scorching (must be a change in the composition).
5. “Dwelling” means structure regularly used for sleeping.
6. “Of another” means some person other than or in addition to the defendant.

STATUTORY ARSON

- Statutory law made by legislature.
- Statutory crimes vary by state.
- Federal legislature makes federal crimes.
- Federal arson requires interstate commerce.



Slide 16-6

C. Statutory arson.

1. The elements of statutory arson passed by state legislatures vary by state.
2. Every state, including those that still have common law arson, has one or more statutory fire crimes that prohibit both the burning of buildings other than dwellings and personal property.
3. Fire crimes involve different types of fire damage: to buildings, personal property such as vehicles, and real property (land).
4. The Federal Arson Statutes are codified in Title 18 United States Code (USC) – Crimes and Criminal Procedure.

5. Section 844 includes the interstate commerce clause which makes it a federal crime to use fire or explosive materials and devices to destroy any building, vehicle, or other personal or real property in whole or in part owned or possessed by, or leased to, the United States, or any department or U.S. agency or any institution or organization receiving federal financial assistance or that affects interstate commerce (i.e., across state lines).

JUDICIAL INTERPRETATION

Plain Meaning Rule:

- Generally, judges interpret the words and phrases in a statute by applying the “plain meaning” rule.
- When words or phrases in a statute do not have a clear meaning, judges attempt to determine legislative intent.

Slide 16-7

D. Judicial interpretation.

1. All laws, common and statutory, are subject to judicial interpretation once a case is appealed.
2. Judges generally cannot change a statutory law.

However, they must often interpret the meaning of the words the legislature used in a statute to determine exactly what the legislature prohibited.

ATTEMPT CRIMES

- Specific intent to commit a crime.
- Substantial step toward completion.



Slide 16-8

E. Attempt crimes.

1. An attempt crime means the defendant did not accomplish committing the crime, but wanted and tried to.
2. In order to prove a defendant attempted to commit a particular crime, there must be proof that:
 - a. The defendant specifically intended (wanted to) to commit the crime.
 - b. The defendant did accomplish some substantial part of the crime and would have completed it but was stopped.

CONSPIRACY

- Two or more people.
- Agreement.
- Overt act in furtherance of crime.
- Co-conspirators' statements admissible at trial are exceptions to the hearsay rule.
- Not all states require overt act.

Slide 16-9

F. Conspiracy.

1. There must actually be at least two defendants who agreed to commit a crime (if one of the two individuals is an undercover law enforcement officer, there is no conspiracy).
2. A conspiracy is an agreement between two or more people to commit an act that is a crime and at least one act toward completing the crime.
3. A conspiracy can be charged if the crime was completed or if it was attempted (some states even without an attempt).
4. When there is proof defendants got together to plan a crime ahead of time, the punishment can be increased.
5. When defendants are charged with a conspiracy, each defendant's statement made during the conspiracy can be used against the other defendants (this is an exception to the hearsay rules).

CRIMINAL INTENT

- Arson is a general intent crime in some states.
- Arson for profit is a specific intent crime.
- In most states, intoxication is not a defense to arson.



Slide 16-10

G. Criminal intent.

1. Generally speaking, crimes require some type of intent (mens rea).
2. It is generally the intent that distinguishes crimes from civil torts such as negligence and accidents.
3. Many crimes are general intent crimes, and that simply means the defendant purposely acted.
4. Because arson is a general intent crime, what must be proven is that the defendant intended to start the fire.
5. Because arson is not a specific intent crime, it need not be proven what result was intended, such as whether there was an intent to burn the structure down.

For example: Defendant lights a match and puts the match on a sofa in a residence; whether only the sofa burns, the residence is destroyed and, in some jurisdictions, if a person is injured or killed, the defendant is criminally responsible regardless of whether they only intended to burn the sofa.

6. Specific intent means the defendant acted with a specific purpose intending a particular result.

An example is arson for profit.

7. In order to prove the defendant committed the crime, there must be proof they intended to make a profit.

8. There are defenses to specific intent crimes such as diminished capacity, voluntary intoxication, etc., which basically provides a defense that the defendant was unable to form a specific intent.
9. As long as a fire crime is not classified as a specific intent crime, defenses such as intoxication are not available to a defendant.

JUVENILE/CIVIL INTENT

State statutes set minimum ages for criminal responsibility.

Civil liability applies to foreseeable consequences of voluntary acts.



Slide 16-11

H. Juvenile/Civil intent.

1. Most laws concerning juveniles, and even what the definition of a juvenile is, are determined by the legislature in each state.
2. In some cases, juveniles who would normally be required to handle their cases in juvenile court can be bound over and treated as an adult.
3. The United States Supreme Court (USSC) has set some federal guidelines regarding juveniles.
4. Defendants who were under the age of 18 when they committed murder cannot be sentenced to death or be automatically sentenced to life without the possibility of parole.
5. When juveniles are interrogated, their age is a consideration in determining whether their statement was voluntary.
6. There are often specific state laws requiring strict compliance regarding juveniles in the areas of interviewing, fingerprinting and photographing.
7. There are often limits on the financial recovery for victims of juvenile crime; however, their parents or guardians may be civilly liable.

Slide 16-12

Slide 16-13

VANDALISM

- Mischievously or maliciously cause damage.
- Peer or group pressure may be a factor.
- Common targets:
 - Educational facilities.
 - Grass fires.
 - Abandoned structures.
 - Trash fires.



Slide 16-14

- D. Vandalism is often a motive when the fire is set by a juvenile.
- E. Other motives for juvenile fires include curiosity, revenge, and crime concealment.

EXCITEMENT

- Excited setting fire or suppression efforts.
- Often serial fire setter.
- Thrill seeking excitement and power.
- Attention seeking feel important.
- Recognition hero.
- Sexual gratification or perversion.



Slide 16-15

- F. Excitement.
1. Excitement from the act of setting fire, suppression, or need for attention.
 2. Typically remains at scene to observe fire and suppression-related activities.
 3. Fires may be set to provide the appearance of need or appreciation.
 4. For example, firefighters may be attempting to increase the number of responses to fires in an effort to obtain higher pay or heroic recognition.
 5. Similarly, a security guard may set a fire to demonstrate the need to be hired to protect property from damage.

6. Additional reasons for excitement fires include sexual gratification, which is rare.

EXTREMISM

- Social, political, or religious cause.
- Terrorism targets are typically of political or economic importance.
- Riots/civil disturbance is typically accompanied by looting and vandalism.



Slide 16-16

G. Extremism.

1. Terrorists both international and domestic, such as protestors and other groups, may use explosives to gain media or other attention.
2. Such events should be handled with extreme caution.
3. The danger to first responders and others may be much greater than other fire and explosive situations because the purpose of the event may be to cause as much loss of life or damage to property as possible.
4. Results can be catastrophic and may create the false impression that the group causing the event is much larger than the size of the group actually involved.
5. Riots/civil disturbance may not always be a result of extremism. Fire may be result of opportunity by property owner hoping to have fire blamed/associated with civil disorder.

REVENGE

- Fire as a weapon to inflict harm as punishment.
- Avoids face-to-face conflict.
- Can result in extensive loss of life.
- Responsible for large property losses.



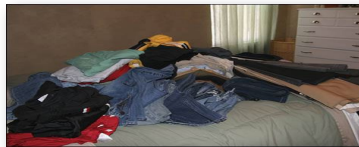
Slide 16-17

H. Revenge.

1. Revenge is often considered the deadliest motive for setting a fire.
2. Jealousy, hatred or uncontrolled emotion arising from relationship issues may be at issue.
3. Such fires often occur at night, using available combustibles and/or liquid accelerants.
4. Writings, markings, or graffiti may indicate clues to the possible underlying cause.

OTHER EXAMPLES OF REVENGE

- Fire location may identify motive.
- Vehicle, tools, jewelry, clothes.
- Items piled onto a bed or in a closet.
- Places of worship or monuments.
- Employment or labor disputes.



Slide 16-18

5. Burning prize possessions, items that carry memories or gifts may indicate a vengeful motive after a personal relationship has endured difficulty.
6. Setting fire to the previously shared bed after a romantic relationship has ended may indicate motive.

7. Just as a scorned lover may set fire to a bed, a disgruntled employee may set fire to a business to exact revenge.

CRIME CONCEALMENT

- Destruction of documents.
- Destruction of physical evidence.
- Distraction.
- Escape.
- Typical types of crimes.
 - Murder.
 - Burglary.
 - Gang-related.
 - Drug-related.



Slide 16-19

I. Crime concealment.

Examples:

1. Paper documents detailing other crimes such as medical fraud or blackmail may be destroyed in a fire.
2. The body of a murder victim may be burned in an attempt to destroy evidence of the wounds inflicted.
3. A residence may be set on fire to destroy evidence such as fingerprints or DNA after a breaking and entering.
4. A fire may be set at one location to direct attention of the victim or law enforcement to an area away from the place where another intended crime is planned to occur, such as an escape from jail or prison.

ARSON FOR PROFIT

- Fraud is deception, a deliberate act to obtain unfair or unlawful gain.
- Direct versus indirect gain.
- Commercial or residential.



Slide 16-20

- J. Arson for profit.
1. Direct versus indirect gain.
 - a. Direct gain occurs when there is no intermediary involved.
 - b. Motives for direct fraud fires include poor economic conditions such as foreclosure or declining business, high vehicle payments and natural disasters.
 - c. In such circumstances, a home or business owner may start a fire to obtain a financial payment by claiming a loss because of the fire.
 - d. Direct gain can be destruction of a structure, vehicle or contents, such as merchandise, due to a desire for a different location, vehicle or new or different items, such as merchandise, to avoid payment on the no longer desired property.
 - e. Indirect gain involves a third party.
 - f. Common examples include contract or business motives.
 2. An example of an indirect gain is where a fire restoration company starts a fire to another person's home or business and obtains payment from an insurance company to complete the fire restoration work.
 3. A tenant may start a fire to avoid remaining in the structure for the duration of a lease, and a landowner may set a fire to force a tenant to leave.
 4. Commercial or residential.
 - a. As just explained, arson for profit may involve either a home or business property.
 - b. Fraudulent fires may also be set to attempt to obtain a financial gain by claiming loss of property valued at more than the actual value, for property that was not actually lost in the fire, or property that never existed prior to the fire.

ARSON FOR PROFIT

Forms of indirect fraud:

Profit Vanity



Hero Vanity

Slide 16-21

5. Vanity is excessive pride in or admiration of one's own appearance or achievements.

CIVIL PROCEEDINGS

- Burden of proof is preponderance of the evidence.
- Plaintiff has the burden of proof.
- Does not have to be a unanimous verdict.



Slide 16-22

K. Civil proceedings.

1. The burden of proof in civil court is preponderance of the evidence, which means more likely than not (greater than 50%).
2. The burden of proof in some civil actions is clear and convincing evidence, which means highly and substantially more probably true than not.
3. The plaintiff, which is the person who brought the suit or action, has the burden of proof.
4. The plaintiff can call the defendant to testify (no 5th Amendment right to silence).

5. The jury may not have to be absolutely unanimous (some states do require unanimity).

CRIMINAL PROCEEDINGS

- Burden of proof is beyond a reasonable doubt.
- Government has burden.
- Guilt must be unanimous.



Slide 16-23

L. Criminal proceedings.

1. The burden of proof in a criminal case is the highest legal standard in our system of justice: it requires proof beyond a reasonable doubt.
2. The government (prosecutor either federal or state) has the burden of proof, and the defendant has nothing to prove.
3. A defendant does not have to present any evidence at all, and they cannot be called to testify (unless they want to testify).
4. A criminal conviction requires each and every juror to agree the government has proven the defendant's guilt beyond a reasonable doubt as to every element of the crime(s) charged.
5. Guilt beyond a reasonable doubt is not proof beyond any doubt or beyond the shadow of a doubt, but it is proof based on reason and common sense that fully satisfies and entirely convinces the jury of the defendant's guilt.

III. CONSTITUTIONAL ISSUES

FOURTH AMENDMENT

"The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated, and no Warrants shall issue, but upon probable cause, supported by Oath or affirmation, and particularly describing the place to be searched and the persons or things to be seized."

Slide 16-24

A. Fourth Amendment.

1. Key provision of the 4th Amendment is the "warrants clause."
2. Purpose of the 4th Amendment is to limit investigatory authority.
3. A search with a warrant is presumed to be constitutional, but when there is no search warrant, the search is presumed unconstitutional until the government can show it was constitutional.
4. Four constitutional means for gaining access to fire scenes include: exigent circumstances, consent, administrative search warrant, and criminal search warrant.
5. The 4th Amendment protects citizens from unreasonable searches and seizures by the government.
6. The 4th Amendment requires that searches and seizures by the government be supported by probable cause and particular descriptions of the evidence to be seized and the place and time of the taking.
7. The warrants clause has four requirements: probable cause, an oath, description of particularity of places and things, and approval by a neutral and detached magistrate.
8. Particularity is important, so investigators should avoid general language in affidavits for search warrants.

9. The exclusionary rule is court created and bars evidence and “fruits” or derivative evidence when the 4th Amendment has been violated by an unconstitutional search and/or seizure.
10. The exclusionary rule was developed by the courts to prevent overzealous investigation that violated constitutional rights.

HOW TO LOOK AT CONSTITUTIONAL ISSUES

Applicability
Compliance
Remedy

Slide 16-25

B. How to look at constitutional issues.

The investigator must understand:

1. What constitutional and other laws **apply** to each step in an investigation and prosecution.
2. What must be done in order to **comply** with each of the applicable legal requirements.
3. What the **remedy** is for any alleged or actual violation of the legal requirements.

APPLICABILITY

- Reasonable expectation of privacy considerations.
- Home, car, person, bags, motel room, etc.
- Plain view and abandoned property.
- Physical characteristics.
- Cell phones have paramount expectation of privacy because so much private information.

Slide 16-26

C. Applicability.

1. When the government acts, civilians may have varying degrees of privacy interests.
 - a. There is a privacy interest in a residence, motel room (often used as a residence), or maybe even in a guest room in another person's home.
 - b. There is a privacy interest in personal property such as bags, purses, luggage, etc.
 - c. There is often a privacy interest in a vehicle; however, a vehicle in a public place has a lessened privacy interest.
 - d. In *Riley v. California*, the USSC held that searches of cell phones may not be conducted without a warrant, unless an exception to the warrant requirement exists.
 - That decision has been extended to many, if not most, other electronic devices including GPS monitors and flash drives.
 - In *Carpenter v. United States*, the United States further held that although information contained on cell phones is available to third-party cellular phone companies, the information still carries a reasonable expectation of privacy.
2. These opinions are supported by the use of security features such as pins, fingerprint, and facial swipes, and the enormous amount of personal content that is often contained on the devices such as bank information, videos, etc.
3. As a result, when an investigator seeks to gather information from an electronic device, a separate search warrant for electronic devices should be obtained in addition to any other search warrant for the place where the electronic item(s) is located.
4. Separate search warrants may need to be obtained for vehicles that are present on real property that is being searched as well, especially if the vehicle is not one that belongs to the owner of the land where the vehicle is located.
5. Similarly, search warrants for people who are located at property that is being searched may also be required, and the rules regarding searches of people vary depending on whether the place being searched is a private residence or a business and whether the evidence sought to be located has been or can be located without searching the people present at the place of the search.

- a. There may be a protected interest in items that can be seen by investigators in plain view (to seize it, there must be a legal right to access).
- b. What is or is not abandoned personal or real property must be determined before the right to a privacy interest can be determined.

COMPLIANCE

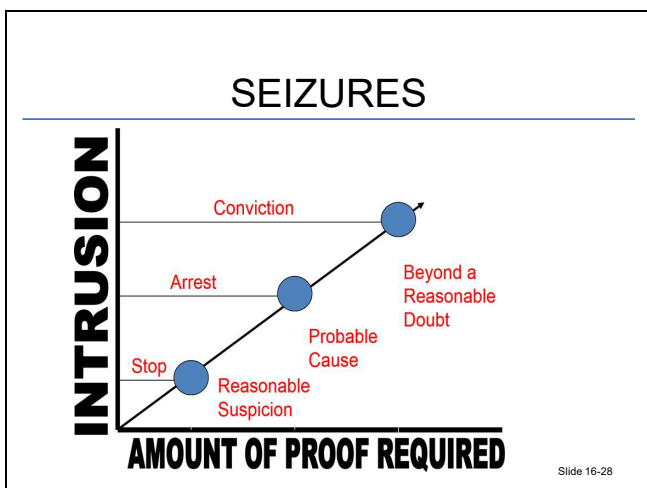
- Is the search or seizure reasonable?
- Reasonable depends on individual circumstances.
- If search is with warrant, are the warrant's limits being followed?



Slide 16-27

D. Compliance.

1. A search with or without a warrant must be reasonable.
2. A search of a residence typically includes the building and area within the curtilage of the home.
3. Curtilage is the area immediately surrounding the home and areas that are regularly used as part of the home.
4. A search of a vehicle typically includes inside the glove compartment, console, and trunk, but does not normally include inside door panels.
5. If there is a warrant, areas to be searched, such as additional structures, should be included in the warrant description of the premises.
6. A search of a residence does not include searching electronic devices.
7. Additional warrants are necessary to search electronic items.



E. Seizures.

1. To stop a person, an officer must have reasonable suspicion a crime has, is, or is about to be committed.

Reasonable suspicion is a particularized and objective basis for suspecting the particular person of criminal activity based on the totality of the circumstances.

2. To arrest a person, an officer must have probable cause.
 - a. Probable cause to arrest is facts and circumstances, at the moment of arrest, within the officer's knowledge, together with reasonably trustworthy information the officer had, that is sufficient to warrant a prudent person in believing the defendant had committed, or was committing, an offense.
 - b. Basically, probable cause means the defendant probably committed a crime.
3. Remember, probable cause is only the minimum standard needed to arrest; to gain a conviction, there must be proof beyond a reasonable doubt.

SEARCH AND SEIZURE

- Fourth Amendment prohibits unreasonable searches and seizures.
- Test is totality of circumstances.
 - case-by-case basis.
- Requires probable cause for warrants.
 - particularly describe place/person/item to be searched and/or seized.

Slide 16-29

F. Search and seizure.

1. Describe the place or person so specifically that another officer would know where or who to search.
2. Photographs may also be attached to a search warrant and can be easily obtained from the internet for identification of the place to be searched.
3. In addition to an address, a building should be particularly described, including such information as: single-family, one-story brick residence with black shutters. Address is 178 Fort Mill Road, Emmitsburg, Maryland 21727.
4. Include all the information that supports your reasonable expectation that evidence of a crime is located at the place to be searched.
5. The investigator may desire to keep some information from the public until the investigation is complete; however, sufficient information to support a finding of probable cause must be included.
6. In places where someone has a reasonable expectation of privacy, you will need a search warrant or an exception, such as consent.
7. Even if there is consent to search, even if the consent is in writing, many defendants later claim the investigator did not have valid consent.

PROBABLE CAUSE TO SEARCH

- Probable cause means:
 - crime probably has been, is being, or is about to be committed.
 - evidence of the crime.
 - is probably at place to be searched.
- Probable cause depends on the totality of all circumstances related to the case.

Slide 16-30

G. Probable cause to search.

1. Probable cause is the standard required to search a person, or a place, or to arrest a person.
2. Probable cause is a fluid concept that depends on an assessment of probabilities in each particular situation.
3. Basically, probable cause is a fair probability that evidence of a crime may be in a certain place.
4. The information is time sensitive because there must be an expectation that the items believed to be there will still be there.

SEARCH WARRANT

- Make sure there is probable cause for what the search would be used to locate.
- Be cognizant of constitutional issues protecting defendant's rights.
- Consider reasonable expectations of privacy in place: car, home, motel, purse, etc.

Slide 16-31

H. Search warrant.

1. Make sure there is probable cause for what the search would be used to locate.

2. Be cognizant of constitutional issues protecting defendant's rights.
3. Consider reasonable expectations of privacy in place: car, home, motel, purse, etc.

PROBABLE CAUSE SUMMARY

- May or may not need a search warrant, depending on situation.
- Golden rule: When in doubt, obtain a warrant.



Go Get A Warrant

Slide 16-32

I. Probable cause summary.

1. May or may not need a search warrant, depending on situation.
2. Golden rule: When in doubt, obtain a warrant.

SEARCH WARRANT EXCEPTIONS



Slide 16-33

J. Search warrant exceptions.

**SEARCH WARRANT
EXCEPTIONS - EXAMPLE**

- Consent.
- Incident to Arrest.
- Public Safety.
- Community Caretaking.
- Vehicle in Public.
- Plain View.
- Hot Pursuit.
- Exigency.
- Protective.
- Inventory.

Fire Scene Exception, like others, is limited to original justification by reasonable expectation of privacy.

Slide 16-34

1. Searches can be legal without a warrant (and a warrant can be obtained in addition to these other legal searches).
2. Consent search can be obtained from a person with an apparent privacy interest in the property.
3. Consent searches can be limited in any manner including scope and duration, and consent can be revoked at any time.
4. It is best to obtain written consent to better prove consent, though written consent is not required.
5. Search incident to arrest affords the opportunity to search the person and the area within their immediate control to prevent the use of weapons or the destruction of evidence (except searching a vehicle incident to arrest is generally prohibited).
6. Exigent circumstances can provide a legal opportunity to search without a warrant if there is an objectively reasonable belief that evidence will be destroyed or persons will be harmed in the time it would take to obtain a search warrant.
7. Protective searches apply to people, vehicles and structures and allow for limited cursory searches often referred to as “frisks” for weapons but only when there is a reasonable belief the person possesses or has quick access to a weapon and is likely to use it.
8. Protective limited searches in residences during service of an arrest warrant may extend beyond the area adjacent to where the arrest occurs when reasonable suspicion exists that there are weapons and people who may harm the arresting officers.

9. An inventory search protects the rights and property of the owner by detailing items inside the vehicle when it is seized.
10. An inventory search also protects the officers and the agency by preventing false claims by a defendant of loss of property.
11. A proper inventory search must be pursuant to agency policy, and it must be done with each vehicle seized.
12. If there is no reasonable expectation of privacy in a place or a thing, no Fourth Amendment violation can occur because no protected search has occurred.
13. The person or people with a reasonable expectation of privacy are the only people who can challenge the legality of the search.

CONSENT

- Can be revoked or limited at any time.
- Given by person with expectation of privacy and capacity to consent.
- Objection by person with expectation of privacy who is present invalidates consent of another.



Slide 16-35

K. Consent.

1. Only a person with an apparent reasonable expectation of privacy has authority to consent to a search.
2. Only defendant with a reasonable expectation of privacy has standing to challenge a search.
3. If probable cause did not exist prior to the consent search, it may develop, so that if consent is revoked, a search warrant may be obtained.
4. Always better to get consent in writing.
5. Can use a standard form that grants consent for a reasonable period of time.

6. Even if a search warrant has been obtained, consent can provide additional protection for the search.
7. Many defendants consent to searches prior to the existence of probable cause (investigators should consider asking for consent).
8. You cannot remove the person granting consent from the scene. They must remain on scene, so if they decide to revoke their consent at any time, they may be permitted to do so.

PLAIN VIEW

- View from place where officer has a lawful right to be.
- Immediately apparent probable cause to believe evidence of a crime.
- Lawful access to seize.



Slide 16-36

L. Plain view.

1. Plain View Doctrine requires:
 - a. An object can be seen, smelled, touched, tasted or heard from a place the officer has a legal right to be.
 - b. The object is immediately identified as evidence of a crime.
 - c. The officer has a legal right of access.
2. Vehicle stop provides opportunity to view, etc., and opportunity to seize, because vehicles are mobile and there is a lower expectation of privacy.
3. Residence opportunity to view from a legal distance does not necessarily provide legal access to seize (may get consent or have exigency).
4. Observation in public place provides legal access to seize.
5. Response to what turns out to be a crime scene often provides legal access.

EXIGENCY

It is reasonable to search and seize without warrant because:

- Probable cause and emergency circumstances do not allow time to obtain warrant.



Slide 16-37

M. Exigency.

Exigent circumstances – totality of the circumstances test considering among other possible factors:

1. Objectively reasonable belief destruction of evidence is imminent.
2. Likelihood of violence against officer.
3. Seriousness of offense.
4. How much time it would take to obtain a search warrant.
5. If investigator had opportunity to obtain a search warrant previously, but did not do so, there is less chance exigency exists.

REMEDY

Exclusion of evidence obtained in violation of constitutional safeguards – exclusionary rule.



Slide 16-38

N. Remedy.

1. Evidence obtained in violation of the 4th Amendment cannot be used against the defendant (that evidence will be excluded).
2. The purpose of the exclusionary rule is to deter officers from committing 4th Amendment violations.
3. There is no benefit to an officer in obtaining evidence that will be excluded as the result of a violation.
4. When a defendant claims a 4th Amendment violation, a suppression hearing will be required, either pretrial or during the trial, but outside the presence of the jury.
5. At the hearing, the investigator must explain under oath the details of the search and justify, if applicable, the government actions.

EXCLUSIONARY RULE FOR FOURTH AMENDMENT VIOLATIONS

- Bars use of illegally seized evidence for all purposes.
- Bars use of all derivative evidence as “fruit of the poisonous tree.”



Slide 16-39

O. Exclusionary rule for Fourth Amendment violations.

1. Not only is all evidence obtained in violation of the 4th Amendment excluded, but all evidence obtained as a result is excluded.
2. The “fruit of the poisonous tree” rule means that potentially all evidence located after the violation may be excluded.
3. After exclusion of the evidence illegally obtained and the evidence located later as a result of the illegality, there may not be enough evidence that is admissible to prove the conviction.

GOOD FAITH EXCEPTION TO EXCLUSION

When a warrant has been issued by a judge or magistrate, if search warrant is insufficient, proceeds of search may still be admissible, unless:

- Misleading.
- Not neutral and detached.
- Lacks particularity.
- Probable cause belief unreasonable.

Slide 16-40

P. Good faith exception to exclusion.

1. If an officer searches with a search warrant that a court later rules to be invalid, evidence seized with the warrant may still be admissible.
2. If a reasonably well-trained officer would not have known the warrant was invalid (the particular officer involved is not the standard).
3. The rule applies because there is no need to deter officers if they would not have realized the warrant was invalid.

TWO TYPES OF SEARCH WARRANTS

- **Criminal** – locate evidence of crime.
 - Probable cause crime was committed.
 - Probable cause evidence of crime located in place to be searched.
- **Administrative** – inspect for safety.
 - Probable cause fire occurred.
 - Probable cause evidence of fire cause in place to be searched.

Slide 16-41

Q. Two types of search warrants.

1. Criminal warrants for search and seizure of evidence of a crime require probable cause that a crime has been committed.

2. Administrative warrants for inspection of a fire scene to ensure safety of the structure require probable cause that a fire has occurred and that evidence leading to a determination of the origin and cause of the fire are probably at the scene.
3. Warrants require an oath by the applicant that all the information contained within the warrant application is true, a statement sufficient to support probable cause (of a crime or that a reason exists to inspect), a particular description of the place to be searched (address and description and or photograph), a particular description of the items to be seized (specific enough to justify the seizure but not so specific it prevents reasonable seizure) and must be independently approved by a judge or magistrate.

CRIMINAL SEARCH WARRANT

Must include:

- Purpose, scope, and time of search.
- Probable cause basis.
- Specific description of location.
- Specific description of evidence sought.

Limited by:

- Four corners, time for service, purpose.



Slide 16-42

R. Criminal search warrant.

1. Name the crime suspected and owner of property.
2. Statement of probable cause – Include personal observations, hearsay from other officers or civilians and information from documents.
3. Location – address and name of owner or property may be helpful.
4. Specific description of location – address or detailed description of building if no address, and include descriptions of particular vehicles and/or additional buildings to be searched on the property.
5. Time to be initiated and completed – There are time limits (for example a search warrant may only be valid if executed within 48 hours; depends on state statutory requirements).
6. Items to be seized – Describe specifically enough so an officer unfamiliar with the case can make appropriate seizures.

7. Documents – Describe particular items such as ownership documentation, etc.
8. Evidence at crime scene of unknown origin – blood-stained items, weapons such as knives, firearms, fingerprints, fired and unfired bullets and casings, footwear impressions, trace hair and fiber evidence, and any and all evidence that pertains to the arson.
9. Computers and electronics including cell phones and flash drives, etc., need separate search warrants (separate from the building, vehicle or person searched).
10. Description of Fire Scene Evidence may include ashes, fuses, fuse trails, adhesive tape, burned furniture, fibers, hairs, accelerants, physical layout of the premises, fire alarms and extinguishers, “and other evidence tending to show how the fire started and spread.”

ADMINISTRATIVE WARRANT

Include in the affidavit:

- Authority – statute citation defining duties as investigator, officer, or fire marshal.
- Purpose – such as “determining origin and cause of fire necessary to ensure safety of property owners and community.”
- Probable cause – identify fire by location and time.

Slide 16-43

S. Administrative warrant.

Include in the affidavit:

1. Authority – statute citation defining duties as investigator, officer, or fire marshal.
2. Purpose – such as “determining origin and cause of fire necessary to ensure safety of property owners and community.”
3. Probable cause – identify fire by location and time.

SEARCH AND SEIZURE ISSUES SPECIFIC TO ARSON CASES



Slide 16-44

MICHIGAN V. TYLER 436 U.S. 499 (1978)

- Furniture store.
- Firefighters see containers of flammable liquid during fire suppression.
- Origin and cause interrupted due to darkness and smoke.
- Search resumed at daybreak and evidence of arson collected.
- Returned later to collect more evidence.

Slide 16-45

T. Michigan v. Tyler.

1. 1-21-1970, 12:00 am: Fire department responds to fire at Tyler's Auction Furniture Store and discovers containers of flammable liquid and calls law enforcement.
2. Officer arrives and takes pictures, but further investigation is hampered by smoke and steam; fire is extinguished at 4:00 am. Fire chief and investigators take containers and leave the scene.
3. 8:00 am: Fire chief returns 1 hour later. Another examination of scene is made by fire and law enforcement officials, and carpet with burn patterns and tape is collected.
4. 2-16-1970: A different investigator takes additional photographs, several other visits follow, and more evidence is collected.

5. Loren Tyler and Robert Tompkins were convicted of conspiracy to burn real property (and Tyler of burning insured property with intent to defraud).

MICHIGAN V. TYLER (1978)

- Warrantless entry justified.
- Fire is exigent circumstance.
- Once on scene may remain for reasonable time to investigate fire cause.
- Search once daylight and smoke cleared reasonable under circumstances.
- Evidence obtained later excluded due to unlawful entry after emergency over.

Slide 16-46

6. USSC finds fire is an exigency that allows lawful access by fire officials, and evidence of a crime in plain view may be seized.
7. Fire officials must extinguish fires and promptly determine origin and cause to prevent recurrence such as faulty wiring or defective furnace and to preserve evidence from intentional or accidental destruction.
8. Re-entry 4 hours later was a continuation of the earlier search that was hampered by the fire itself; no purpose in requiring a warrant.
9. Evidence of a crime discovered during this time is admissible in a criminal prosecution.
10. Evidence obtained by unlawful entry at later times after emergency had ended, and without consent or warrant, was excluded at retrial.

MICHIGAN V. CLIFFORD 464 U.S. 492 (1984)

- Private residence – no one home.
- Owner requested insurance company board up windows.
- Investigator arrival 6 hours after fire out.
- Water being pumped out upon arrival.
- Began investigation area most damage.
- Discovered origin and cause of fire there.
- Searched remainder of residence.

Slide 16-47

U. Michigan v. Clifford.

1. 10-18-1980: Raymond and Emma Jean Clifford's residence was the scene of an early morning fire while family was out of town camping.
2. The fire was extinguished and all officials left at 7:00 am. At 8:00 am, fire investigator is notified but does not respond until 1:00 pm due to other assignments.
3. Cliffords requested neighbors arrange for house to be boarded up and work crew was doing that already and pumping water out when investigator arrived.
4. Investigator located a Coleman fuel can in the driveway and waited 30 minutes until the water was pumped out before entering.
5. Upon entering, the investigator quickly confirmed the origin was under the stairs in the basement with more fuel cans and a Crock-Pot with a timer.
6. Further search revealed closets and furniture full of old clothes, nails in the walls but no pictures, and only wires for a video machine in the upstairs.
7. Pretrial motion to suppress evidence.

MICHIGAN V. CLIFFORD (1984)

- Secured residence indicated reasonable expectation of privacy.
- No exigency when entry made after emergency ceased.
- Unreasonable search without warrant or other lawful justification for entry.
- Single can of fuel in driveway only evidence not excluded.

Slide 16-48

8. An expectation of privacy exists in fire-damaged property.
9. Residential property has a higher expectation of privacy than business property, and especially here where the owners were having it secured.
10. Re-entry for an inspection to determine origin and cause requires a warrant because there is an expectation of privacy that must be protected.

11. An administrative warrant would have provided lawful access to the home until the origin and cause was determined.
12. Once the additional cans and the Crock-Pot were located and determined to be the origin and cause of the fire, any further search required probable cause.
13. All the evidence including testimony about the search inside the home itself was illegally obtained and is excluded.
14. The can located in the driveway in plain view and where an officer was approaching to attempt to do a knock and talk is admissible.
15. Single can probably not sufficient to provide probable cause; without other untainted evidence, a conviction is not possible.

LEGAL ENTRY - FOUR OPTIONS

1. Consent – may be sought in addition to other methods of lawful entry.
2. Criminal Search Warrant – requires probable cause of crime.
3. Administrative Search Warrant – requires probable cause of fire.

Slide 16-49

V. Legal entry – four options.

1. Remember the issues surrounding consent discussed earlier in search warrant exceptions section of this unit.

LEGAL ENTRY - FOUR OPTIONS

4. Fire Scene Exception –

A type of exigent circumstance:

- Emergency is the fire.
- Entry during emergency.
- Duration limited to reasonable time.
- Purpose - make safe by determining origin and cause of fire.
- Applies to fire investigator and “others.”



Slide 16-50

- ## FIRE SCENE EXCEPTION EXIGENCY

A photograph showing two firefighters in full protective gear. One firefighter is in the foreground, holding a hose that extends across the frame. Another firefighter is slightly behind and to the right, also holding a hose. They are positioned in front of a building with two distinct fire points. The fire on the left is labeled with a red number '1' and the fire on the right is labeled with a red number '2'. Both fires are intense, with large flames and thick black smoke rising from them. The building appears to be made of concrete or metal panels. The ground is a light-colored, possibly paved area.

Slide 16-51

1. These are the reasons for warrant exceptions for initial entry.
2. Basically, the fire scene exception is an exigent circumstance and a public safety exception.

FIRE SCENE EXCEPTION EXIGENCY

- Justifications for fire scene exception.
- Prompt determination of fire's origin and cause may be necessary to prevent continuing dangers and recurrence.
 - e.g., faulty wiring or defective furnace.
- Prevent immediate destruction of evidence if fire continues or recurs.

Slide 16-52

3. When fire personnel arrive at the scene of an ongoing fire, access to the property is legal, and they can remain for a reasonable time.
4. The purpose for such access is to extinguish the fire and to allow a determination of the fire's origin, and to be sure no continuing danger exists.

FIRE SCENE EXCEPTION EXIGENCY

- Entry after emergency or after reasonable time to determine origin and cause.
- Requires another legal justification.
- Consider consent.
- If suspected arson with probable cause, may seek search warrant.
- May seek administrative warrant.

Slide 16-53

5. Once the property is no longer being actually secured by the fire investigator, re-entry will require some other form of legal access.
6. Leaving the property unattended for a very short amount of time may be later justified; however, someone should remain on the premises.
7. Since the purpose is to make sure there is no further danger, it makes better sense to have someone stay.
8. An unsecured crime scene creates many obstacles to overcome, as proof that the scene was not altered would in effect be impossible.

9. Once the scene is left unattended, an administrative warrant for an inspection can provide access for additional inspection activities.
10. Once probable cause is developed to believe a crime has been committed, re-entry will require a search warrant.
11. If re-entry is to inspect and probable cause develops during the inspection, a search warrant must be obtained to search the remainder of the property after the origin is determined.
12. Consent or some other exception may provide access, however, a search warrant is always helpful.

FIFTH AMENDMENT

"No person shall be held to answer for a capital, or otherwise infamous crime, unless on a presentment or indictment . . . nor shall any person be subject for the same offence to be twice put in jeopardy of life or limb; nor shall be compelled in any criminal case to be a witness against himself, nor be deprived of life, liberty, or property, without due process of law . . ."

Slide 16-54

X. Fifth Amendment.

Three important aspects of the 5th Amendment.

1. Double Jeopardy clause.
2. Right not to incriminate oneself.
3. Due Process clause, which means fairness to a criminal defendant requiring notice of the charges and possible punishment, and an opportunity to defend against the charges.
4. The 14th Amendment makes the 5th Amendment Due Process clause applicable to the states (because the 5th Amendment clause applies only to the federal government).

VOLUNTARY STATEMENTS

- 5th Amendment Voluntariness protects people when questioned by police (or agent) while in police custody.
- Custodial police questioning is somewhat inherently coercive.
- Voluntary statements admissible against defendants.
- Criminal defendants not required to testify.

Slide 16-55

VOLUNTARY STATEMENTS

Test for voluntariness is voluntariness:

- Consideration and balancing of all facts surrounding the particular statement.

Question is whether the statement was a:

- Result of decision of one's own free will or result of coercion.



Slide 16-56

Y. Voluntary statements.

Statement made by a defendant while in law enforcement custody, or custody of an agent of the government, must be knowing, voluntary, and understanding using a totality of the circumstances test.

1. “Knowing” basically means a realization that a statement may or may not be made.
2. “Understanding” means a realization that the decision to make a statement is a choice for the defendant to make.
3. Understanding does not require a particular intelligence level or IQ, nor does it necessarily require sobriety.
4. Factors to consider regarding “understanding” include:
 - a. A defendant’s prior experience in the criminal justice system.

- b. Whether the defendant's responses are responsive to the questions asked.
 - c. Whether the defendant acknowledged they understood their Miranda rights.
5. Voluntariness means not coerced and instead made of one's own free will.

VOLUNTARINESS FACTORS

- Age.
- Mental capacity.
- Length of questioning.
- Number of officers.
- Access to food, water.
- Perceived ability to leave.
- Prior criminal experience.
- Knowledge of ability to end questioning.



Slide 16-57

VOLUNTARINESS FACTORS

- Education.
- Promises.
- Threats.
- Lies.
- Location.
- Restraints.
- Pain/injury.



Slide 16-58

Z. Voluntariness factors.

1. No two interrogations will be the same, because all facts surrounding the statement must be considered and balanced.
2. Promises such as those to secure a particular result, such as sentencing or bond, should not be made. Such reference, if made at all and under extreme caution, may be deemed allowable if limited to explaining all charging and sentencing recommendations will be made by the prosecutor, and the investigator will merely inform the prosecutor regarding cooperation.

3. Lies, such as implying more evidence exists than the officers have knowledge of, may be allowable depending on the balance of other factors.
4. When restraints are necessary, such as for officer safety during transport, it is important to inform the suspect of the purpose of the restraints.
5. It is helpful to explain to a defendant that they are free to leave, even if the officer knows an arrest warrant will be served, as long as under the circumstances a reasonable person would feel free to leave.
6. Escorting the defendant to and from places such as the bathroom and to smoke may not be seen as diminishing voluntariness if it is explained, for example, that all persons including victims and witnesses must also be escorted within the investigative division.
7. When safe to do so, open doors, do not block access to exits, do not display weapons, do not speak or act with aggression, and provide breaks as well as food and drink or an opportunity to smoke during long interviews.

MIRANDA

- Miranda warnings protect voluntariness.
- Right to remain silent.
- Statements will be used against defendant.
- Right to have attorney present.
- Right to appointed counsel, if indigent.
- Required when:
 - Custody + Interrogation

Slide 16-59

AA. Miranda.

1. Miranda is not itself constitutional.
2. Miranda was designed by the USSC to protect the voluntariness requirement of the 5th Amendment right not to incriminate oneself and to prevent police coercion.
3. For these reasons, Miranda warnings must be provided prior to custodial interrogation.

MIRANDA

- Custody depends on totality of circumstances, and is an objective test.
- Custody for Miranda purposes means a reasonable person in defendant's position would not feel free to leave.
- Interrogation means questioning or other act officer should know will cause incriminating response.

Slide 16-60

4. Custody for Miranda purposes means under arrest, or a restraint of freedom like an arrest.
5. Custody involves restraint by police or an agent of the police, and while tests for agency vary from state to state, generally agency depends on the primary purpose of the potential agent and the degree of involvement by the police.
6. For this reason, restraint by hospital policy, which does not involve police action, is not custody.
7. The proper test for custody is whether a reasonable person in the defendant's position would feel they were not free to leave.
8. The test is objective; therefore, the subjective beliefs of the officer and the defendant are not dispositive.
9. Interrogation is a legal term meaning any questioning whatsoever by the police or an agent of the police while a person is in custody.
10. Interrogation also includes statements or actions designed to obtain a statement to be used against a defendant.

MIRANDA

- Clear invocation of right to silence.
 - Must be scrupulously honored.
- Clear invocation of right to attorney.
 - Questioning must stop.
 - Lasts for duration of custody.
- Statements without interrogation still admissible.
- Defendant may reinitiate – but re-warn.

Slide 16-61

11. Questions by others who are not officers or agents of the government is not interrogation.
12. For example, when a parent tells a defendant to tell the officer the truth, this is not interrogation unless the officer was involved in getting the parent to persuade the defendant to talk.
13. Officers are required to obtain information from defendants upon admission to jail, such as name, address, date of birth, etc. Generally, asking these questions, commonly referred to as booking questions, is an exception to the Miranda requirement (unless the answers are going to be used against the defendant).

MIRANDA

- 6th Amendment right to counsel.
- Also protected by Miranda.
 - Applies once before magistrate/judge.
 - Regardless of custody.
 - Only to applicable offenses.
- Juvenile Miranda.
 - Additional warnings vary state to state.
 - Definition of juvenile also varies.



Slide 16-62

14. A case must be proven with something more than simply what the defendant tells.
15. A confession alone, absent evidence that the crime occurred and that the defendant did it, is not permissible.

16. There must be evidence independent of what the defendant says, either admission to some facts or even a full confession to a crime, to meet the burden of proof.
17. This ensures that only the guilty are convicted and prevents people who are not guilty from being convicted of crimes that did not occur, or for crimes someone else committed.

DOUBLE JEOPARDY

Double Jeopardy clause prohibits:

- More than one trial for same crime.
- More than one punishment for same crime.

Double Jeopardy clause does not apply to:

- Civil sanctions or forfeitures.
- Administrative sanctions.
- Different crimes.

Slide 16-63

BB. Double Jeopardy.

1. Double Jeopardy clause means the government generally has one chance to obtain a conviction.
2. Criminal responsibility is separate from civil liability. Think O.J. Simpson.
3. The standard is higher in criminal court (beyond a reasonable doubt), and even if a jury is unable to unanimously agree on guilt beyond a reasonable doubt, they can still be sued.
4. In civil court, the burden of persuasion is preponderance of the evidence, which means more than 50%.

DUE PROCESS

- 5th Amendment requires fairness to criminal defendants.
- Notice of charges and possible punishment.
- Opportunity to defend.
- Due process requires providing evidence helpful to defendant and his defense.
- Includes statements and physical evidence.

Slide 16-64

CC. Due process.

Due process has both procedural and substantive components.

1. Brady v. Maryland is the source for discovery requirements, pursuant to the 5th Amendment's due process clause.
2. Giglio v. U.S., 405 U.S. 150 (1972) requires that the prosecution provide information about its witnesses. This includes any promises not to be prosecuted or if the witness has any criminal history or their truthfulness or veracity has been called into question before, e.g., if your investigator has been reprimanded for lying about the facts surrounding a traffic stop or convicted of driving while intoxicated (DWI), etc.

IV. EVIDENCE

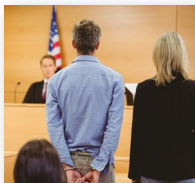
EVIDENCE



Slide 16-65

TYPES OF EVIDENCE

- Demonstrative: tangible items.
 - Physical evidence: gas cans, samples.
- Documentary:
 - Writings: receipts, insurance forms.
- Testimonial:
 - Witness statements during court.



Slide 16-66

A. Types of evidence.

1. Physical pieces of evidence are very important and are helpful to juries to better understand the case.
2. Chain of custody is important for items of physical evidence for two reasons: to identify the items as related to this case, and to show that the item has not been subject to change by unknown means.
3. Photographs, diagrams, videos and demonstrations, when properly and carefully presented, may show the jury the danger involved in fire cases and help explain how the fire occurred or developed.
4. Pieces of burnt carpet and other items that were collected from the scene make the case real for the jury, who otherwise just hear a story.
5. Documentary evidence can tie a defendant to a crime.
6. Testimony is the largest piece of evidence for each trial.
7. Written witness statements are not admissible in a criminal trial unless and until the witness takes the stand (except for defendant statements) due to the Confrontation clause of the 6th Amendment.
8. Testimony allows the jury to assess the reliability and credibility of a witness firsthand by observing and listening to what they have to say.

SPOILIATION AND DESTRUCTION OF EVIDENCE



Slide 16-67

B. Spoliation and destruction of evidence.

SPOILIATION AND DESTRUCTION OF EVIDENCE

- Spoliation – Civil – intentional or negligent loss, destruction, or material alteration of evidence.
- Discovery violation – Criminal – intentional or negligent loss, destruction, or alteration of evidence defendant is entitled to.
- Remedies – exclusion, dismissal, inferences, limitations, civil suit, or conviction.

Slide 16-68

1. The collecting investigator and agency, and the government or party bringing an action, must retain and preserve evidence.
2. Destruction for purpose of depriving defendant of exculpatory evidence, or negligent destruction when exculpatory value was apparent, is concern with spoliation.

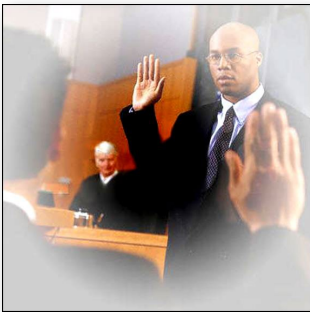
Example: If fire was probably caused by curling iron, but you cannot rule out coffee pot, collect and preserve both.

3. Just because there will not be a criminal prosecution does not mean there will not be a civil suit.
4. Once evidence is collected, there needs to be an agency policy for preservation and destruction.

5. If there is a criminal case, the prosecutor should be consulted. If there is not, the prosecutor cannot advise concerning destruction.
6. Many statutes require preservation of body fluid evidence for particular duration.
7. Bad faith destruction of evidence will subject both the investigator and the prosecutor to the most severe sanctions; in some jurisdictions, prison.

V. TESTIMONY

TESTIMONY



Slide 16-69

LAY TESTIMONY

- Observations from direct knowledge.
- Familiarity with complete investigation.
- Credible communication skills required.
- Firefighters are often fact witnesses.
- Essential to explain what is known.

Slide 16-70

A. Lay testimony.

1. Lay witnesses are fact witnesses; they describe for the jury what they know because they saw, heard, smelled, felt or tasted something.

2. The facts of a case are essential because they tell the story of when the event occurred, where it happened, what was seen, heard, etc.
3. The jury ultimately must decide whether they believe the witnesses to convict or punish a defendant, so credibility is essential.
4. In order for the jury to understand the evidence, a witness must understand it and be able to explain it.
5. All witnesses are fact witnesses, except those few witnesses who are called upon to give an opinion about something not generally known or understood.
6. Lay witnesses can give opinions in a few areas that regular life experiences provide information to support, such as:
 - a. The approximate speed a vehicle was traveling.
 - b. Appearance of intoxication.
 - c. Appearance of mental impairment.
 - d. How a person appeared emotionally and/or physically.

EXPERT TESTIMONY

- Opinions based on special knowledge, training, skills, education, or experience.
- Help jury understand evidence.
- Reasonably reliable. (FRE 702)
- Ultimate issues, such as fire classification.
- Not ultimate issues, such as who did it, or if defendant had mental ability to do it.

(FRE 704)

Slide 16-71

B. Expert testimony.

1. Only expert witnesses can provide opinions on ultimate facts and issues, such as if and how something happened that no one actually has firsthand knowledge about.

2. In order to qualify as an expert, a judge must determine the witness has information that will assist the jury in determining whether something is more or less likely to have occurred.
3. In many cases involving experts, the entire case is essentially a “battle of the experts” opinions.
4. Federal Rule of Evidence 702 & 704.

EXPERT TESTIMONY

- Expert testimony exposes expert to cross-examination on all aspects of their opinions.
- Fire investigation experts should be familiar with NFPA 921 and its terms.
- Be prepared to explain the terms and concepts in 921 in a non-technical manner, so the jury can understand what is known.



Slide 16-72

5. To prevail at trial, an expert must be prepared, knowledgeable about the entire case, and be able to explain procedures and mistakes.
6. Experts must remember it is the opposing attorney’s job to discredit the expert, if possible, and may do so on the basis of bias, lack of knowledge, skill, education, training, experience, or failing to have completed a thorough and competent investigation, or failing to follow proper or recommended procedures or ethical standards.
7. Experts must display the knowledge and professionalism they possess, and do so in a credible and likeable manner, while making the fire investigation and its results clear.

STANDARDS FOR ADMISSION OF EXPERT TESTIMONY

Frye Test – original test for expert testimony.

- Relevant.
- Reliable.
- Reliable means.
 - Generally accepted.
- Method must be generally accepted in the relevant scientific community.



Slide 16-73

C. Standards for admission of expert testimony.

1. The Frye test is also referred to as the general acceptance test.
2. “Relevancy” means the expert’s opinion must be related to the case.
3. “Reliable” means the opinion is actually helpful to the jury.
4. Under Frye, an expert witness may only qualify to testify as an expert if the methods used are generally accepted as reliable in the particular scientific community (here, the fire investigative community).
5. Frye was convicted of murder, but at trial, his attorneys attempted to introduce expert testimony about a blood pressure deception test.
6. USSC held the test was not reliable because it had not gained general acceptance in the scientific community.

STANDARDS FOR ADMISSION OF EXPERT TESTIMONY

Daubert Test – replaced Frye in many courts.

- Relevant.
- Reliable.
- Reliable decided by judge based on:
 - Sufficient information (facts/data).
 - Method can produce valid results.
 - Applied method to facts in this case.

Slide 16-74

7. Some states are “Frye States,” some states are “Daubert States,” and some states are Hybrid States that use their own test.
8. The federal government utilizes the Daubert standard.
9. All courts require that an expert opinion be relevant to the case, and that the opinion be reliable.
10. It is the requirements for showing reliability that vary.
11. Frye requires that the particular scientific community has already accepted the method as reliable, and that the particular method be generally accepted as reliable within that area of expertise.

**STANDARDS FOR ADMISSION OF
EXPERT TESTIMONY**

- Daubert Test – judge is gatekeeper and considers all information.
- Common considerations include:
 - General acceptance.
 - Involvement of scientific community.
 - Set and maintained standards.
 - Testing and results.
 - Publication.
 - Peer review.
 - Rates of error.

Slide 16-75

12. The Daubert test came about because the USSC recognized that science evolves, and that a method may be reliable, although still relatively new, and has not yet gained recognition as generally accepted as reliable throughout the particular area of expertise.
13. No particular consideration is required or determinative.
14. Whether the method is determined to be reliable is largely at the trial court’s discretion and can only be overturned if it can be shown the judge did not use reason in deciding the issue.

EXPERT TESTIMONY CHALLENGES

- Understand the applicable test.
- Find out:
 - If opinions are being challenged.
 - ✓ If so, on what basis.
 - Are there opposing expert opinions.
 - ✓ If so, what are they and who is expert.
 - If/when hearing will be set.
- Be prepared.

Slide 16-76

D. Expert testimony challenges.

1. In many cases, the opinions will be challenged either by an expert or by opposing counsel.
2. Whether a witness even qualifies as an expert is the first challenge.
3. If the witness is not able to qualify as an expert, the witness will only be able to testify as a fact witness to observations, and not to opinions, such as where and how the fire started or the fire classification.
4. Cross-examination may be extensive and heated but remain calm and professional to maintain credibility, which is paramount.
5. Challenges to admission of expert testimony may occur multiple times, such as outside the presence of the jury, then again in the jury's presence.
6. Prepare prior to trial to answer qualification questions, opinion questions, and potential cross-examination questions.

CURRICULUM VITAE

- A curriculum vitae is a document that describes a witness's qualifications of expertise based on:
 - Knowledge.
 - Skill.
 - Experience.
 - Training.
 - Education.
- FRE 702



Slide 16-77

- E. Unlike a resume, a curriculum vitae (CV) does not need to include every job or profession the person has performed, nor does it need to include information unrelated to the particular case the CV is being provided for.

CURRICULUM VITAE

- To qualify as an expert, a CV must be provided.
 - To allow judges, juries and the parties to evaluate expertise of the witness.
 - To provide opposing parties opportunity to stipulate to the expertise of the witness.
 - To provide opposing parties opportunity to challenge the expertise of the witness.
- Rules of Evidence provide requirements about when the CV must be provided and vary by jurisdiction.

Slide 16-78

- F. As a result, an expert may have different CVs for different types of cases such as fire investigation and bomb-related investigations.
- G. In situations where an expert has different CVs, some information may be omitted or the information may be shifted to appear in a different order to correspond to the purpose of the CV.

CURRICULUM VITAE

A CV is similar to a resume, but:

- Is specifically directed at a particular area.
- Need not include unrelated information.
- Must be kept current.
- Must be timely provided to opposing parties.

Slide 16-79

- H. CV tips.

1. Information contained within a CV, and the order in which it is arranged, may be subject to agency or personal preference.
2. CVs often begin with the expert's name, job title and agency contact information centered at the top of the first page of the document.

CURRICULUM VITAE

- Knowledge is information a person possesses.
- Skill is the ability to use information.
- Experience is the process of gaining information.
- Training includes completion of programs of instruction.
- Education includes degrees and formal education.

Slide 16-80

3. The words “curriculum vitae” are unnecessary and should not be included within the document.
4. The description of job duties may be contained within a paragraph or as bullet points beginning with action verbs.
5. The description of current and previous employment duties should include identification of the agency, job title and dates of service.

CURRICULUM VITAE

Should include:

- Current job title, employer and contact information.
- Description of current relevant employment duties.
- Description of previous relevant employment duties.
- Certifications.
- Education.
- Relevant training.

There is a Word template in Blackboard resource folder.

Slide 16-81

6. Certifications should be listed and identified as current or previous.
7. Education and training should be properly identified to avoid confusion or accusations of false representations.

For example, National Fire Academy (NFA) courses are considered “training,” and a Bachelor of Science degree in Forensic Science is “education.”

CURRICULUM VITAE

- Relevant teaching experience.
- Relevant publications.
- Prior relevant testimony.
- Any relevant documents published by the expert.
- Memberships and any offices held in relevant associations.
- Relevant specialized skills.
- Relevant awards and honors.

Slide 16-82

8. Training may be identified regarding each and every class attended or grouped into subcategories, and tested trainings may be identified if preferred.
9. When an aspect generally included within a CV does not exist, such as teaching experience, publication or prior testimony, there is no need to have a heading for that specific information.

CURRICULUM VITAE

- Ensure that all information is accurate.
- If information regarding total number of fires the expert has responded to, investigated, or been the lead investigator on is included:
 - Be certain of the exact number(s) provided.
 - Or specify the numbers are approximate.
 - + be certain approximate numbers can be validated.

Slide 16-83

10. When prior testimony is listed, make sure to identify testimony that was designated as expert testimony by a judge along with the appropriate field of expertise.
11. When opinion testimony was offered during a deposition, grand jury hearing or other proceeding that did not involve a judge designating acceptance of the opinions as those of an expert, make sure to identify them separately.

12. Specialized knowledge, training, education, or skills relating to the field of expertise, such as experience as a building inspector or electrical engineer, should be included when relevant to the case the CV is submitted for.
13. Inclusion of information that is either inaccurate or appears to be inaccurate reduces the credibility of the expert and can result in a court finding that the witness's opinions are inadmissible.
14. Inclusion of information that is inaccurate can lead to criminal conviction and punishment, loss of employment, loss of respect in the community and can expose the witness to civil lawsuit.

PRETRIAL MEETINGS AND CHALLENGES



Slide 16-84

I. Pretrial meetings and challenges.

When an investigator receives a subpoena to appear for a case, the investigator should contact the prosecutor to discuss trial preparation.

IMPORTANCE OF EFFECTIVE REPORTS

- Solves cases and often avoids trial and testimony.
- Testimony may be admitted, excluded, or limited due to contents.
- Reliable opinions result in favorable and fair results.
- Reflect directly on professionalism and credibility.

Slide 16-85

J. Importance of effective reports.

PRETRIAL MEETINGS

- Preparation is key to being an effective witness.
- When receiving a subpoena:
 - Review the entire file: reports of others involved, locate test results and evidence, call to schedule a meeting.
- Inform prosecutor whether testified before.
- Take the entire file.
- Take most recent CV.

Slide 16-66

K. Pretrial meetings.

1. The investigator must explain the origin and cause of the fire in terms of where and how the fire started; using a diagram and photos are a helpful way to begin the discussion.
2. Explain any mistakes in the report (like typos) and any mistakes in the investigation (like failing to collect evidence).
3. Know what a CV is and get a copy to the prosecutor or civil attorney you are working with.
4. Keep your CV updated and accurate; it will get shared by defense attorneys in preparation to attack the investigator's credibility. Keep all previous versions of your CV. When you are updating your CV, save it as a new version with the date in the document name.
5. Ask about any motions, pretrial rulings, or stipulations that you may need to be aware of prior to trial.
6. Sometimes both sides may agree to some fact or issue, and this results in a stipulation.
7. Examples of potential stipulations in fire cases include stipulating the investigator is an expert, or to the origin and/or cause of a fire.
8. The investigator may be asked to meet with the defense. If a decision is made to do that, consider inviting the prosecutor. This will help ensure the prosecutor is prepared and may be very helpful at trial to clarify what was said and done.

PRETRIAL MEETINGS

- Familiarize yourself with the opposing experts, their reports, background, experience, and previous testimony, and discuss this with your attorney.



Slide 16-87

9. Stay informed about the posture of your case. If there have been defense investigators and/or experts, find out who and what they reported.
10. Be prepared to justify, if appropriate, any problems or potential problems the defense expert claims exist in the investigation.
11. Be prepared to give an opinion and explain why the defense opinion is either correct or incorrect, misleading or otherwise inaccurate.
12. Any information known about the defense investigator and/or expert should be discussed with the attorney.

PROSECUTOR DUTIES

- Seek justice, not necessarily a conviction.
- Uphold the constitution.
- Zealously advocate.
- Dismiss or do not file when no probable cause exists.
- Disclosure of evidence to defense.
- Make no extrajudicial statements.
- Show proof beyond a reasonable doubt.

Slide 16-88

L. Prosecutor duties.

1. Government always has burden of proof on elements of crime(s).
2. Standard of proof in criminal is beyond reasonable doubt and civil is preponderance of the evidence.

3. Brady decision requires disclosure of exculpatory and mitigation evidence by prosecutors to defense.
4. Ignorance is no excuse for prosecutors; if any government agency or investigator has the info, prosecutor must provide it.
5. Prosecutor must review cases that are charged and agree probable cause exists, or they have a duty to dismiss the charges themselves or never file them to begin with.
6. Don't forget your Giglio obligations. Make sure you ask witnesses during preparation about any possible Giglio issues and disclose them immediately to the defense

PROBLEMS SPECIFIC TO ARSON CASES

Must prove that:

- Crime occurred.
- Who committed crime.
- Frequently circumstantial.
- Scene contamination.
- No sympathetic victim.



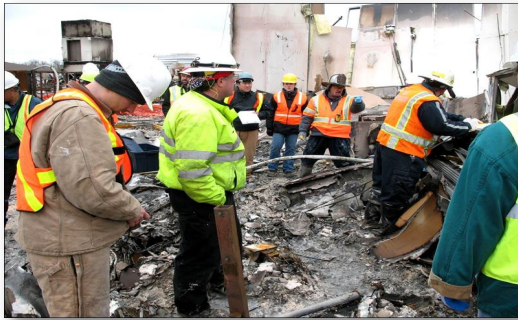
Slide 16-89

M. Problems specific to arson cases.

1. 1st issue - was there a crime, meaning that all elements of some fire-related offense can be proven beyond a reasonable doubt?
2. 2nd issue - who is criminally responsible for the crime, and can it be proven beyond a reasonable doubt they did it?
3. In many cases the fire investigator can determine that a fire was intentionally set by human hands, but proof of who set the fire is difficult to establish.
4. Prosecutors, judges and jurors tend to be very skeptical about whether there is enough proof in fire cases.
5. Prosecutors have more cases than they can try; trials are very time consuming, and other cases can be more easily tried and won.

6. Judges have to decide if there is sufficient evidence to go forward, and they do not like being overturned by an appellate court.
7. If the government loses at the trial stage, the case is usually over; and if the defendant loses, they can appeal, so generally the only time trial judges are at risk of being overturned is if the judge allows the case to go forward.
8. Prosecutors, judges and jurors prefer to have evidence like videos, crime scenes with fingerprints and DNA, and a sympathetic victim.
9. Fire scenes are inherently contaminated and compromised due to the fire itself and the fire suppression efforts.
10. Most often, the evidence is circumstantial (pieces of evidence that must be linked and pieced together to explain intent and identity).
11. Often the victim is an insurance company, and prosecutors, judges and jurors do not see them as sympathetic victims.
12. Fire cases are difficult to investigate and difficult to prove, but the defendants are dangerous, so hard work and dedication is imperative.

NEGATIVE CORPUS CHALLENGES



Slide 16-90

- N. Negative corpus challenges.

NEGATIVE CORPUS

- Corpus means body – focus of crime.
 - e.g., burned structure for arson.
- May prosecute without physical corpus.
- Must have evidence of the crime.
- NFPA 921 explains negative corpus is not proper, because it occurs when opinion is without any supporting evidence, except elimination of other causes.

Slide 16-91

1. According to National Fire Protection Association (NFPA) 921, *Guide for Fire and Explosion Investigations*, Section 19.6.5, opinions based upon negative corpus are not consistent with the Scientific Method, are inappropriate, and should not be used, because such opinions generate untestable hypotheses.

HOW TO AVOID A NEGATIVE CORPUS CHALLENGE

- Thorough investigation and documentation.
- Follow Scientific Method (and NFPA 921).
- If possible, clearly define area of origin.
- If rule out other causes, continue to use Scientific Method until a cause is identified and confirmed.
- Rule out undetermined by proving another fire cause.

Slide 16-92

2. Various courts throughout the country have taken different perspectives and approaches to handling the issue of negative corpus in cases involving fire investigation, and while those decisions only apply to the specific jurisdiction, it is very important to be aware of the problem raised by negative corpus, which often leads to exclusion of expert opinions in the field of fire investigation when the opinion is solely based upon ruling out other causes, such as accidental, as the basis for concluding the causation must then be incendiary.

ARSON REPORTING IMMUNITY STATUTES



Slide 16-93

O. Arson reporting immunity statutes.

1. Insurance agencies, investigators, and their investigations are an invaluable source of evidence for criminal fire investigators.
2. International Association of Arson Investigators (IAAI) has links to insurance associations that may contain helpful information.

ARSON REPORTING IMMUNITY STATUTES

- All states have arson immunity laws.
- Investigators can obtain insurance information such as:
 - Entire policy + notice and proof of loss.
 - History of prior claims.
 - Insurance investigator reports.
 - Witness statements.
 - Examination under oath (EUO).

Slide 16-94

3. This allows investigators to obtain the materials the insurance company has to use to prove fire and other crimes.
4. A contract requirement is that the insured must provide information, often including a statement made under oath, about what the insured knows about the fire. This is the examination under oath (EUO).
5. Failure to provide an EUO eliminates the insurance company's duty to pay the insurance claim.

6. The insured has incentive to provide the statements, which are often recorded, and documentation must also be signed regarding the insured's knowledge of the claim and specific descriptions of the claimed financial loss.
7. EUO questioning is conducted by a civil attorney retained by the insurance company.
8. While there are possible agent of government issues, as long as the insurance company is not acting as an agent of the government, constitutional provisions such as the 5th Amendment right not to incriminate oneself, Miranda requirements, and 6th Amendment right to counsel provisions do not apply.
9. Often, even when there is a lack of proof beyond a reasonable doubt concerning how the fire occurred, when the insured is responsible, and sometimes even when they are not, the information in the insurance file may support criminal charges for insurance fraud or other fraudulent crimes.

KEY POINTS TO REMEMBER

- Know the elements of fire crimes.
- Understand the role motives play.
- 4th Amendment prohibits unreasonable searches and seizures.
- 4 types of lawful searches:
 - Criminal search warrant.
 - Administrative warrant.
 - Consent.
 - Exigency.

Slide 16-95

P. Key points to remember.

1. Fire investigators must work with fire suppression personnel; they can help you preserve your scene.
2. Fire investigators must work with law enforcement officers; they typically bring the charges, perform custodial interviews, etc.
3. Law enforcement must work with fire investigators; they know what questions need to be asked because they know how fire behaves.

4. Fire investigators and law enforcement must work with prosecutors; approach them, invite them to watch you set something on fire, teach them to love fire as you do.
5. Get your prosecutor invested and motivated. Prosecuting fire crimes is difficult, but it's very rewarding to convict dangerous offenders.
6. Know what resources are available; fire professionals are usually willing to work together to assist and brainstorm.
 - a. Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) has resources available to state agencies, and they love to play with fire cases; they will dig, interview witnesses, provide expertise, etc.
 - b. State Fire Marshal has resources available to local agencies, and often has expertise that the local agencies do not have.
 - c. Insurance companies want to help you catch criminals; that saves them money, and if you cannot prove the arson, you may be able to prove a fraud.
 - d. K9 officers from various agencies are invaluable and are often on call 24 hours a day, willing to assist you.
 - e. Some state agencies can help attain phone records, find experts in electrical fires, vehicle fires, etc.

KEY POINTS TO REMEMBER

- Miranda required for custodial interrogation.
- Good reports solve cases.
- Expert testimony must be reliable.
- Best trial strategy is to be prepared.
- Credibility is key.
- Work as a team.
- Justice is the goal.

Slide 16-96

7. If the investigation is complete and professional, a case may be successfully prosecuted.
8. If the investigation is incomplete and unprofessional, even a factually strong case likely will not be successfully prosecuted.

9. A successful prosecution takes teamwork, and many different agencies may contribute. Do not be afraid to ask.
10. The investigator must explain the investigation and the results so that everyone understands what happened and who did it.

VI. SUMMARY



SUMMARY

In this lesson, you have learned to:

- Describe motives.
- Explain the impact of motives in fire case resolution.
- Evaluate constitutional considerations.
- Summarize the four types of lawful access by which an investigator may be legally on the premises to conduct a fire scene examination.

Slide 16-97



SUMMARY

- Identify applicable rules of evidence.
- Explain the importance of effective reports.
- Consider court preparation points for the new expert witness.

Slide 16-98

REFERENCES

Title 18 United States Code (USC), Section 844.

State v. Berry, 801 SW2d 64 (1990) citing “IL v. Gates, 462 U.S. 213 (1983).”

NFPA 921, Chapter 12, 2024 edition.

NFPA 921, Chapter 3, Section 3.3.190, 2024 edition.

NFPA 921, Chapter 4, Section 4.5.1, 2024 edition.

NFPA 921, Chapter 19, Section 19.6.5, 2024 edition.

This page intentionally left blank.

***UNIT 17:
SUMMATIVE STUDENT EVALUATION
AND COURSE SUMMARY***

This page intentionally left blank.



**UNIT 17:
SUMMATIVE STUDENT
EVALUATION AND COURSE
SUMMARY**

Slide 17-1

I. FINAL GROUP PRESENTATIONS

This page intentionally left blank.

ACTIVITY 17.1

Large Burn Cell Walkthrough

Purpose

This activity will serve as an introduction regarding concepts that will be discussed and demonstrated during upcoming fire dynamics and fire pattern instructional blocks.

Students will evaluate a fire scene on the first day of training and render an opinion as to the fire origin area(s). This activity will allow students to demonstrate their baseline knowledge, training and experience of fire dynamics and fire patterns.

Students will re-evaluate the fire scene during the second week of training. Students will apply newly learned concepts when identifying the fire origin area(s). Students will have the opportunity to change their original opinion of fire origin if needed.

Safety Precautions

- Safety glasses and hard hat are required.
- Follow all directions of instructors and range personnel.

Directions

1. You will conduct a 7- to 8-minute walkthrough of the large burn cell with an emphasis on identifying the fire origin area(s). You should conduct both an exterior and interior scene evaluation. You will develop theory of fire origin area by interpreting fire patterns and assessing compartment fire dynamics. You will render an independent opinion as to the fire origin area(s) which will be documented by placing a mark(s) on the provided scene diagram. You will turn your diagram in to the instructors when you complete the exercise.
2. The fire cause and classification is not to be considered during this exercise. The fire(s) was intentionally set and therefore classified as incendiary.

This page intentionally left blank.