Staying Alive

(For firefighters. If you're here for the Bee Gees, John Travolta, or Saturday Night Fever, that might be tomorrow night!)

Presented by

FF/EMT/Chaplain Jeff Sturgess

Created in memory of Ridgefield VFD Past Chief Earl Sturges and in honor of our brothers who have made the ultimate sacrifice.

Objective

The goal of this class is to reduce the risk of firefighter injury or death through an increased awareness of modern residential home construction and some of the risks contained within them. The ultimate goal is staying alive.

Overview

- Statistics
- Modern Residential Building Construction
- How This Applies to Firefighting

Statistics

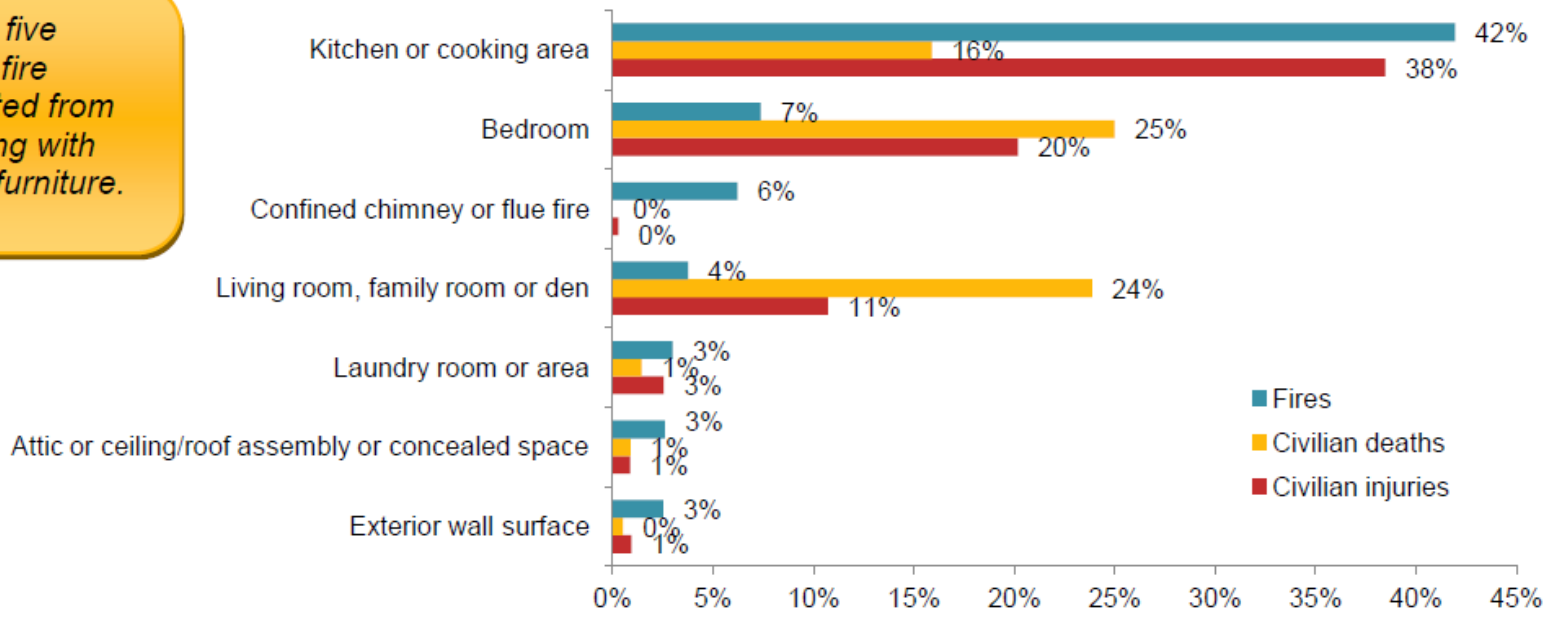
One-Stop Data Shop
Fire Analysis and Research Division
One Batterymarch Park, Quincy, MA 02169
Email: osds@nfpa.org
www.nfpa.org

Home Structure Fires, by year 1977-2011

Source: *Fire Loss in the United States during 2011* Michael J. Karter, Jr. NFPA, September 2012 and previous reports in the series.

Leading Areas of Origin in Home Structure Fires: 2007-2011

Fact: *One in five (18%) home fire deaths resulted from fires beginning with upholstered furniture.*



Reference: http://www.nfpa.org/~/media/Files/Research/NFPA%20reports/Occupancies/oshomes.ashx

Statistics

Fire-related Firefighter Injuries

- Ninety-five percent of all firefighter injuries occur at the scene.
  - 50% of these injuries occur outside the structure
  - 45% occur inside the structure
  - Balance occur enroute/returning, station, and other locations

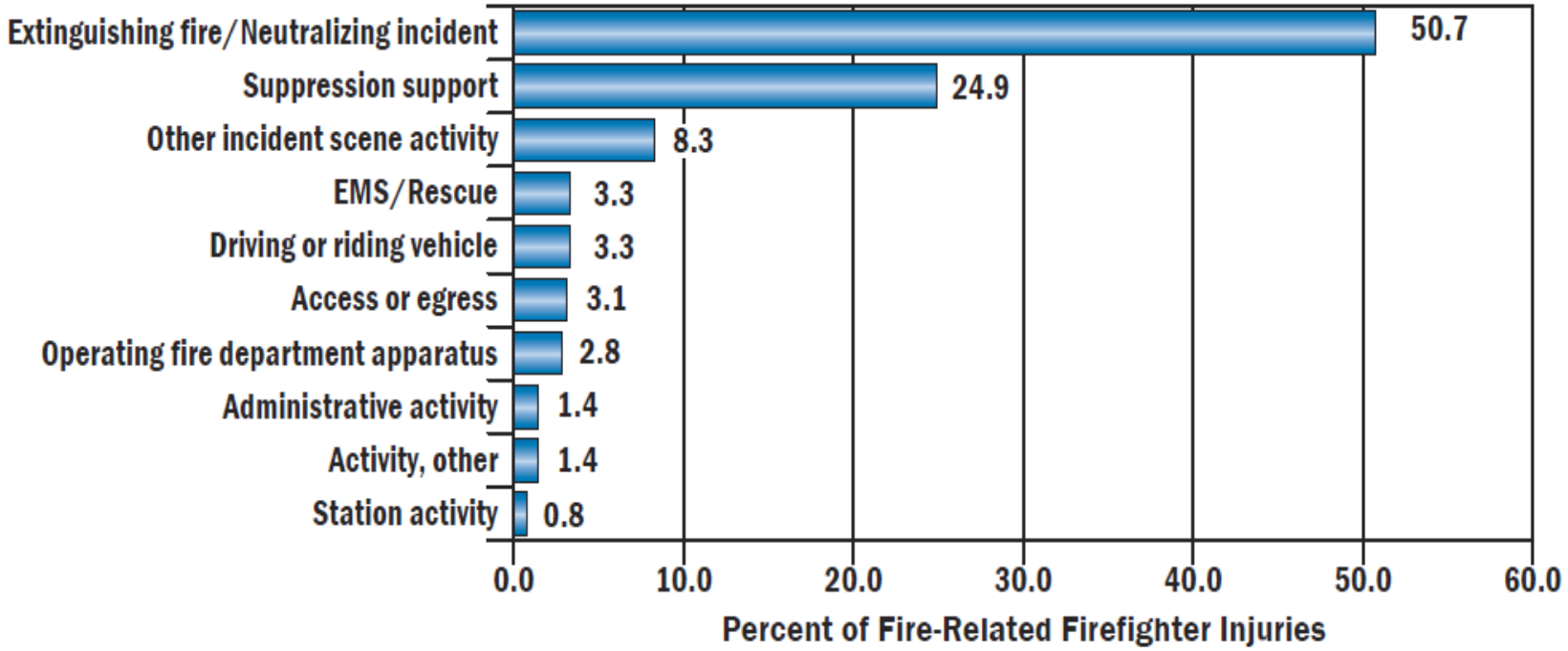
- As shown in Figure 9, the largest percent of firefighter injuries occur while extinguishing the fire/neutralizing the incident (51 percent). This is followed by suppression support and other incident scene activity, which make up 25 percent and 8 percent of firefighter injuries, respectively.

Reference: http://www.usfa.fema.gov/downloads/pdf/statistics/v11i7.pdf

Statistics

Fire-related Firefighter Injuries

Figure 9. Fire-Related Firefighter Injuries by Type of Activity (2006–2008)



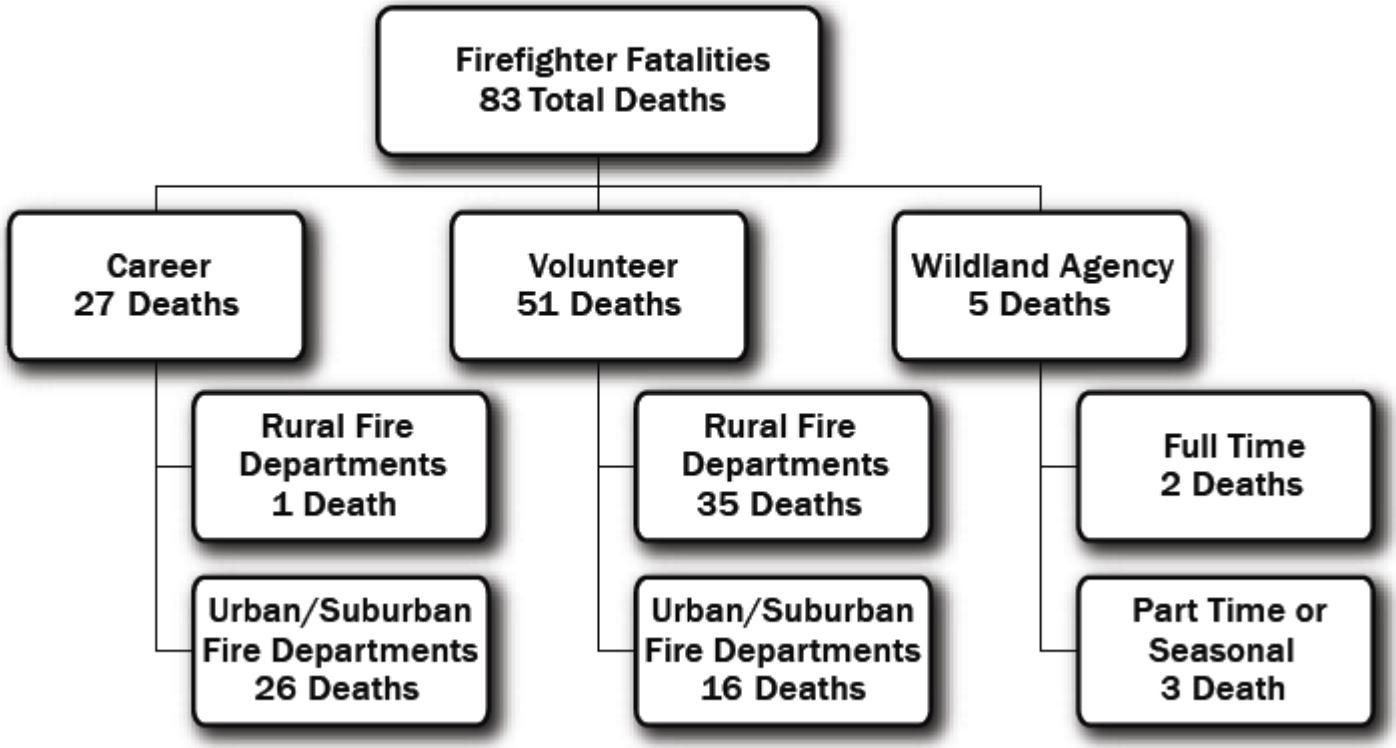
Source: NFIRS 5.0.

Note: Only includes injuries where type of activity was provided.

Statistics

Firefighter Deaths

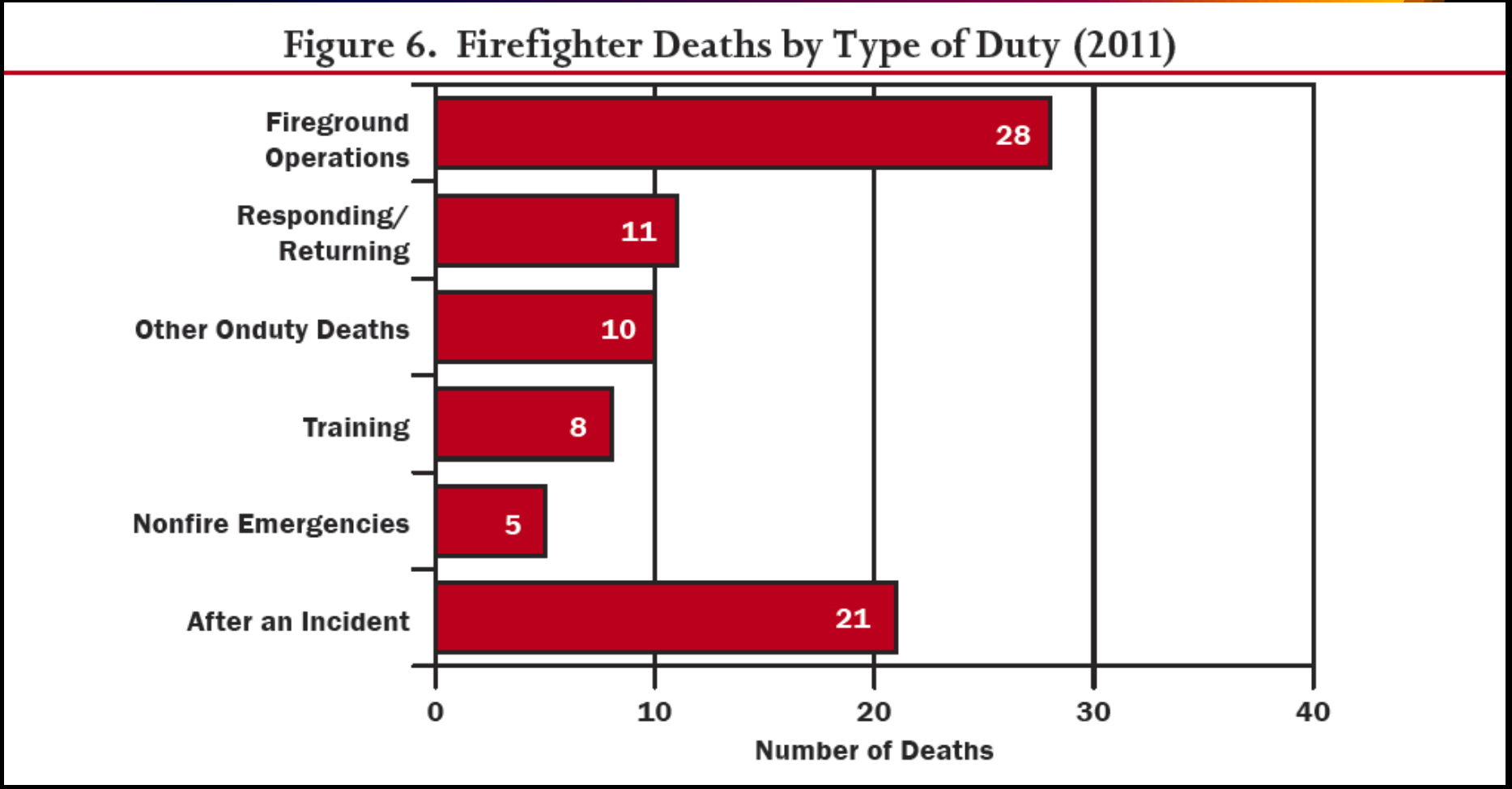
Figure 3. Career, Volunteer, and Wildland Agency Deaths (2011)



Reference: http://apps.usfa.fema.gov/firefighter-fatalities/fatalityData/statistics

Statistics

Firefighter Deaths



Reference: http://apps.usfa.fema.gov/firefighter-fatalities/fatalityData/statistics

Statistics

Firefighter Deaths (2012 provisional)

- 64 firefighter deaths total in 2012
  - 21 fire ground deaths
  - 19 deaths responding to/returning from calls (not necessarily in accidents)
    - 8 collision/rollover
    - 7 sudden cardiac event/stroke
    - 2 shot on arrival
    - 2 struck by falling trees
  - 8 deaths during training
  - 4 deaths at MVA's (2 struck, 2 cardiac)
  - 12 deaths were not emergency related but occurred while on duty
- Sudden cardiac events and strokes were the cause of 27 on-duty deaths (42% of all deaths combined)
- Reference: http://www.nfpa.org/~/media/Files/Research/NFPA%20reports/Fire%20service%20statistics/osfff.ashx

Basic on-scene safety

- Is the fire on side bravo?
  - https://www.youtube.com/watch?v=LnDahb_TSf0
- Any warning signs 3 seconds into this video?
  - https://www.youtube.com/watch?v=aTQWNCeCBvQ&list=PLEBA921E22BA549C7
- Baltimore 2010. Is PPE adequate?
  - https://www.youtube.com/watch?v=ZO3zQXx4gIo&list=PLEBA921E22BA549C7
- How about here – Is PPE adequate?
  - http://www.youtube.com/watch?v=B5wvCvmXnLs&feature=share&list=PL56imwbtQMhi3OkljfG7hNwemJSsasPZk

Modern Residential Building Construction

Modern Residential Building Construction

Floor joists

THEN (conventional)

- 2x6, 2x8, 2x10 sawn (solid wood) floor joists
- Large mass = longer burn time

NOW (lightweight)

- Engineered I-joists for floors
- Small mass = shorter burn time
- 7/16 Plywood or oriented strand board (OSB) sheathing

Modern Residential Building Construction

Engineered I-joist

- Floor joists – 2x3 wood based top and bottom flange with oriented strand board (OSB) web.

Modern Residential Building Construction

Joist comparison

(a) Traditional joist (T)

(b) Engineered I-joist (E)

Joist comparison

Table 25. Dimensional Lumber Comparisons

Supports	Time to failure
Dimensional Lumber (2 x 10) w/ 100% Loading	7:00
Old Dimensional Lumber (2 x 8) w/ 100% Loading	18:05

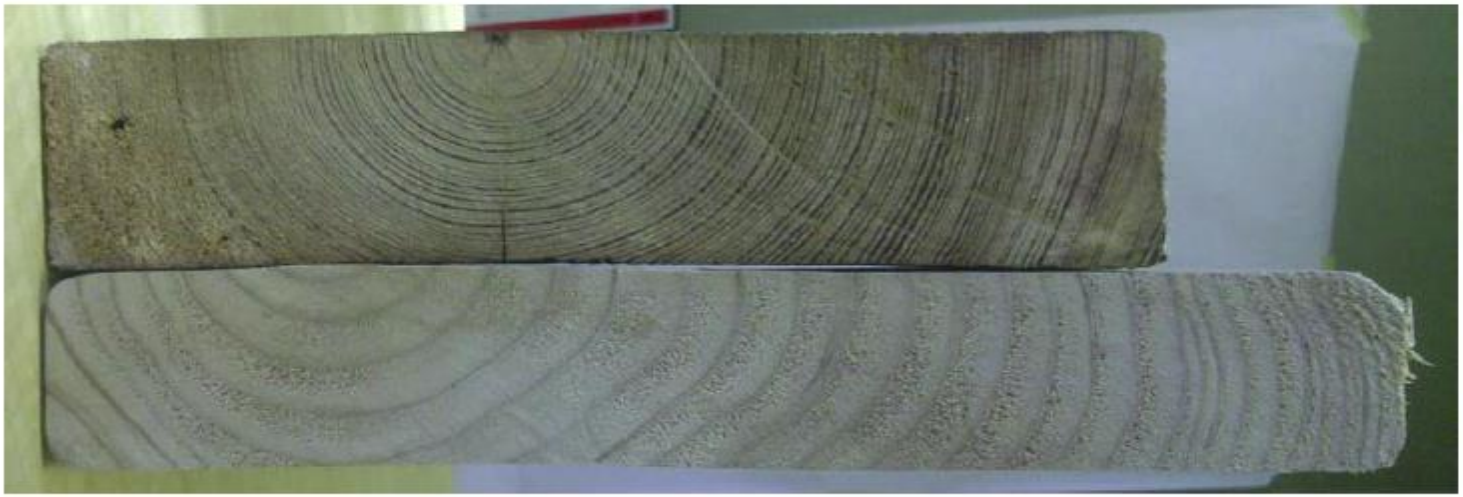


Figure 99. Comparison of the modern 2 x10 to the old 2 x 8.

Reference:
http://www.ul.com/global/documents/offerings/industries/buildingmaterials/fireservice/basementfires/2009%20NIST%20ARRA%20Appendix%20B%20-%20Fire%20Service%20Collapse%20Hazard%20Floor%20Furnace%20Experiments.pdf

Modern Residential Building Construction

Reference:
http://www.ul.com/global/documents/offerings/industries/buildingmaterials/fireservice/basementfires/2009%20NIST%20ARRA%20Appendix%20B%20-%20Fire%20Service%20Collapse%20Hazard%20Floor%20Furnace%20Experiments.pdf

Modern Residential Building Construction

Engineered I-joist failure

Reference:
http://www.ul.com/global/documents/offerings/industries/buildingmaterials/fireservice/basementfires/2009%20NIST%20ARRA%20Appendix%20A%20-%20Fire%20Resistance%20Tests%20on%20Wood%20and%20Composite%20Wood%20Beams.pdf

Modern Residential Building Construction

Engineered I-joist failure

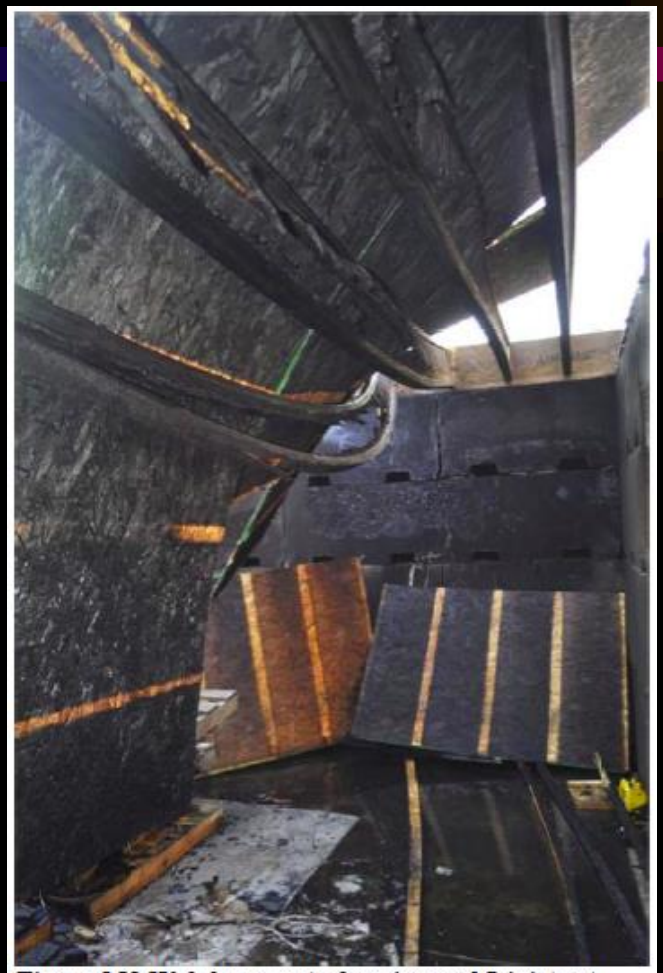


Figure 158 Web burn-out of engineered I-joists at rear section of floor area.

Reference:
http://www.ul.com/global/documents/offerings/industries/buildingmaterials/fireservice/basementfires/2009%20NIST%20ARRA%20Appendix%20C%20-%20Full-Scale%20Floor%20System%20Field%20and%20Laboratory%20Fire%20Experiments.pdf

Lightweight construction – many joist types

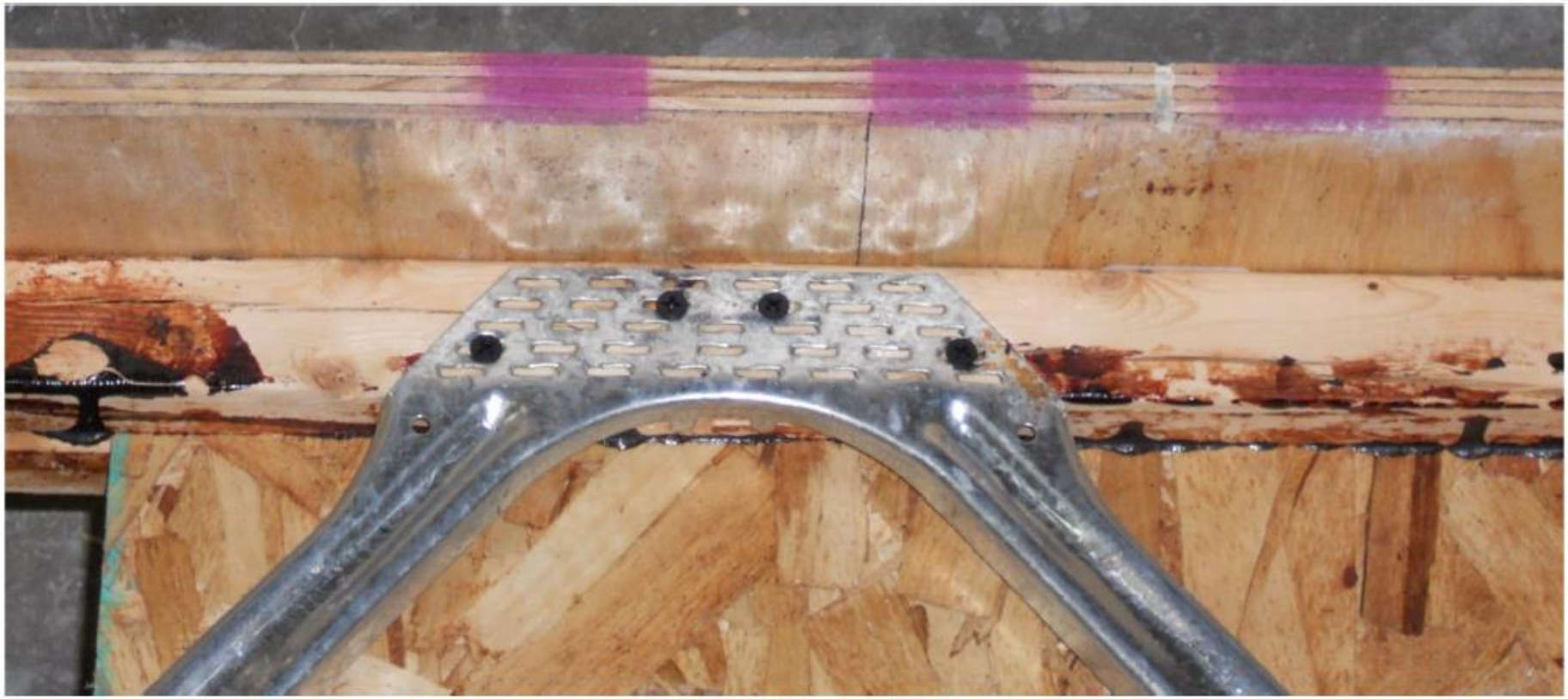


Figure B-13: Steel/wood connection in hybrid joist (H3) reinforced with screws

Reference:
http://www.ul.com/global/documents/offerings/industries/buildingmaterials/fireservice/basementfires/2009%20NIST%20ARRA%20Appendix%20A%20-%20Fire%20Resistance%20Tests%20on%20Wood%20and%20Composite%20Wood%20Beams.pdf

Hybrid joist failure

Modern Residential Building Construction

Traditional floor test

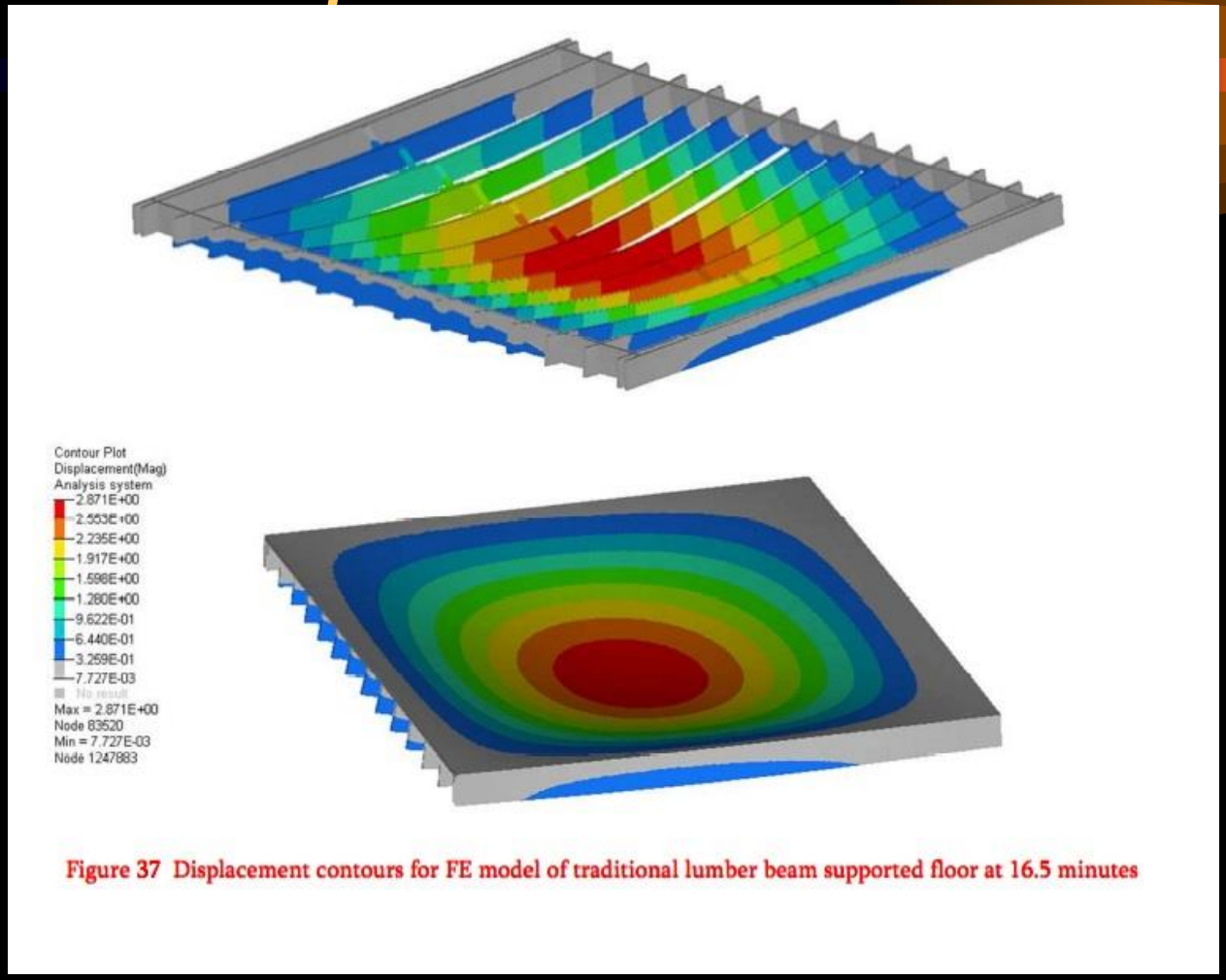


Figure 37 Displacement contours for FE model of traditional lumber beam supported floor at 16.5 minutes

Reference:
http://www.ul.com/global/documents/offerings/industries/buildingmaterials/fireservice/basementfires/2009%20NIST%20ARRA%20Appendix%20E%20-%20Modeling%20the%20Thermal%20and%20Structural%20Behavior%20of%20Wood%20Beams%20in%20a%20Fire%20Environment.pdf

Modern Residential Building Construction

Lightweight floor test

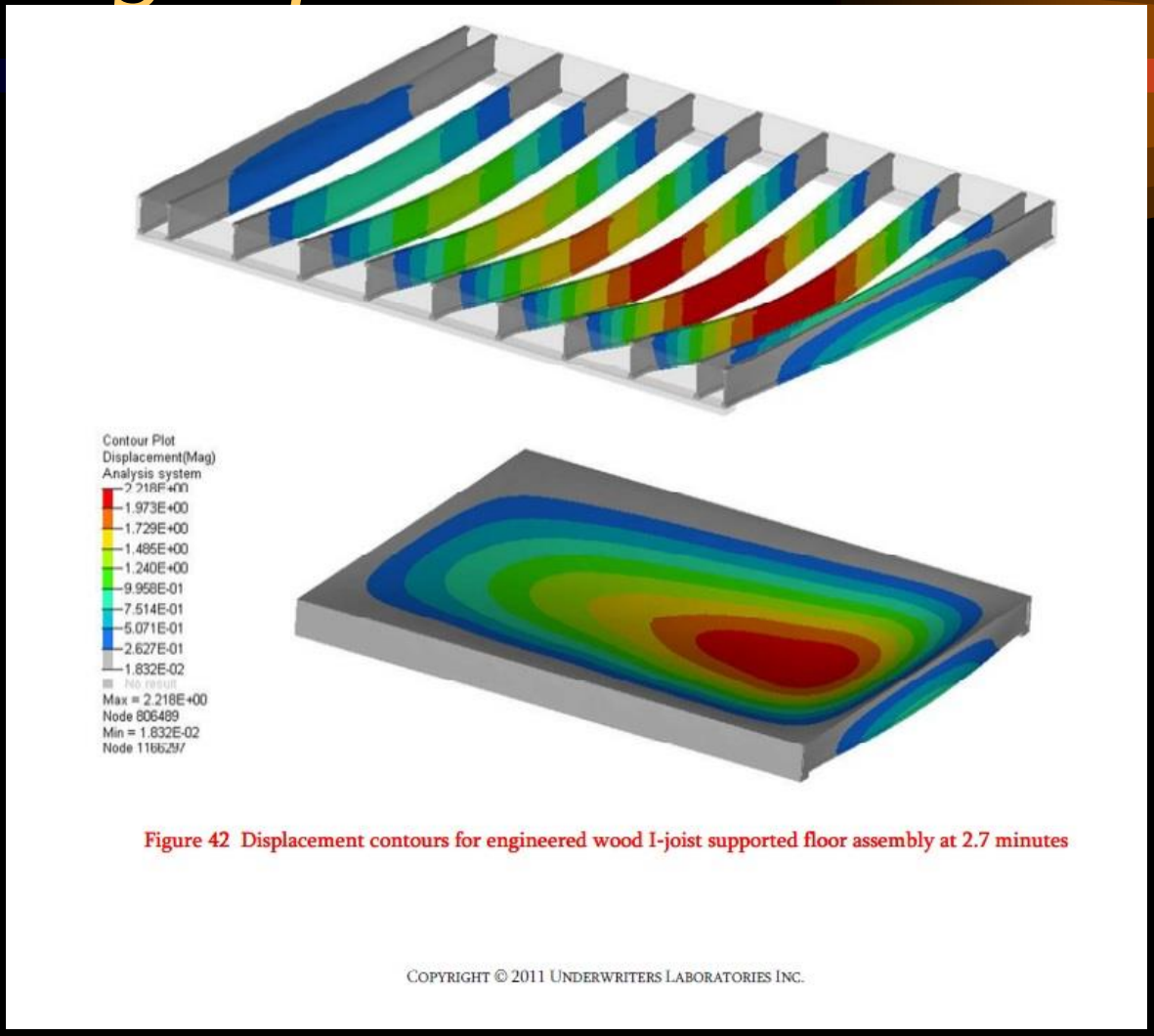


Figure 42 Displacement contours for engineered wood I-joist supported floor assembly at 2.7 minutes

Reference:
http://www.ul.com/global/documents/offerings/industries/buildingmaterials/fireservice/basementfires/2009%20NIST%20ARRA%20Appendix%20E%20-%20Modeling%20the%20Thermal%20and%20Structural%20Behavior%20of%20Wood%20Beams%20in%20a%20Fire%20Environment.pdf

Modern Residential Building Construction

Joist type failure comparison

Joist #	Joist Type	Joist Depth (in)	Sheathing	Joist Insulation	Special Features	Failure Time (min:sec)	Failure Mode
T1	Dimensional lumber	9 1/4	No	-	-	15:35	Cross-section reduction
T2	Dimensional lumber	9 1/4	No	-	-	13:05	Cross-section reduction
T3	Dimensional lumber	9 1/4	Yes	-	-	**16:40**	Cross-section reduction
T4	Dimensional lumber	9 1/4	Yes	-	-	**20:40**	Cross-section reduction
T5	Dimensional lumber	9 1/4	Yes	-	-	16:50	Cross-section reduction
E1	Engineered I-joist	11 7/8	Yes	-	-	**6:15**	Web burn through
E2	Engineered I-joist	11 7/8	Yes	-	-	**6:25**	Web burn through
E3	Engineered I-joist	11 7/8	Yes	Intumescent coating	-	24:05	Web burn through
C1	Castellated I-joist	16	Yes	-	-	7:10	Web burn through
C2	Castellated I-joist	16	Yes	-	-	6:50	Web burn through
H1	Hybrid joist	14	Yes	-	-	6:00	Connection failure
H2	Hybrid joist	14	Yes	-	-	6:00	Connection failure
H3	Hybrid joist	14	Yes	-	Reinforced connection	6:20	Connection failure
H4	Hybrid joist	14	Yes	-	Reinforced connection	6:50	Connection failure

Modern Residential Building Construction

Roofing

Conventional roof

- 2x6, 2x8, 2x10 sawn (solid wood) roof trusses
- Large mass = longer burn time
- 1x6 roof sheathing
- More expensive and takes longer to build
- Roof gets strength from the size of the lumber (mass)

Lightweight roof

- 2x4 based
- Small mass = shorter burn time
- Cheaper than conventional and faster to build
- Roof truss is assembled using metal gusset plates
- Roof gets strength through compression and tension of the truss
- Series of triangles
- Designed to shift load to load bearing walls
- The sum of all components provide strength

Truss Jig

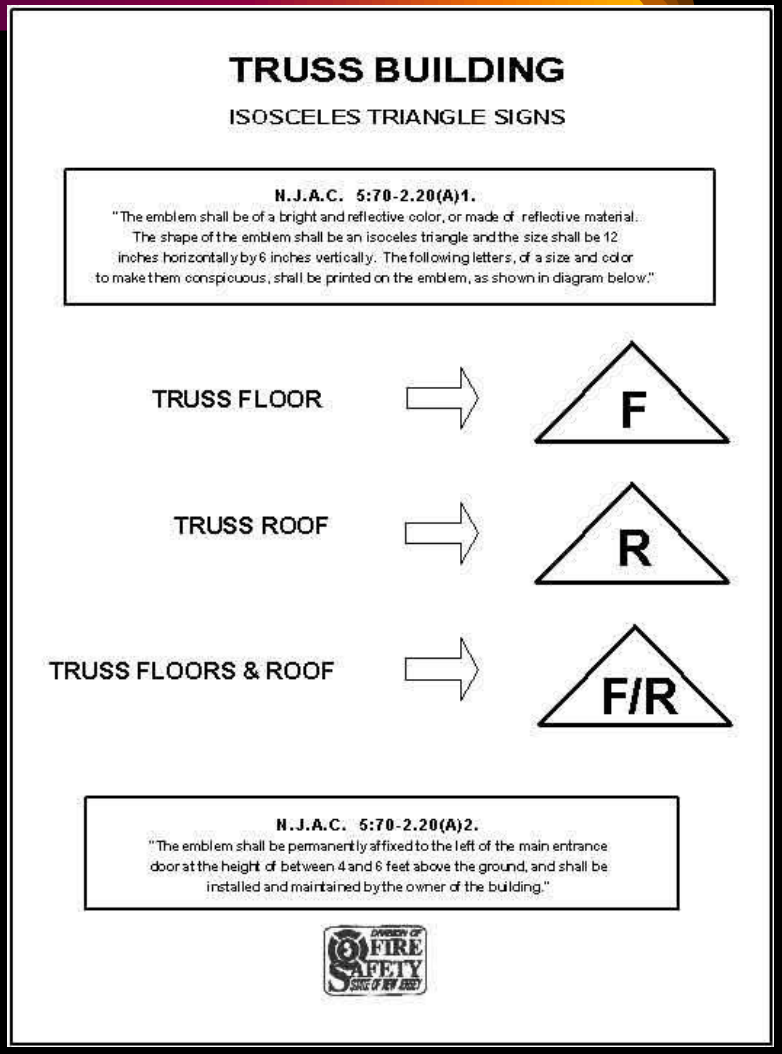
Modern Residential Building Construction

Lightweight truss

New Jersey identification placard

- Several states (NJ, NY, FL, VT, and MS) and municipalities require new homes to have a reflective placard on side alpha identifying the construction type. This ensures firefighters are aware of the construction dangers prior to entry.

- Reference: http://www.trussid.com/tisnewjerseycode.htm



Other issues with modern construction:

Modern Residential Building Construction

Hint: pull-down ladder required

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Hidden dangers – gas furnace in attic

Modern Residential Building Construction

Siding and Soffit

- Many older homes were brick. Many homes built today use vinyl siding. Under this is often a vapor barrier, and that is stapled to the house sheathing (usually OSB).
- All of these products are combustible at various temperatures.
- Soffit vents are used to create airflow in the attic, expelling hot air through a ridge or gable vent. This keeps the attic space cooler, resulting in energy savings and an increased longevity of the roof.
- Outdoor grills used too close to the house, not started properly, or with poorly maintained propane tanks or gas lines can quickly lead to the combustion of the siding. Once this fire climbs to the soffit vent, the fire can quickly consume the unrestricted attic space.

Modern Residential Building Construction

Siding and Soffit

Modern Residential Building Construction

Garage Doors

Modern Residential Building Construction

Garage close calls

- Vent mishap
  - http://www.youtube.com/watch?v=2nt0DT0nXq8
- How many things are wrong with this?
  - http://www.youtube.com/watch?v=RjPbw7dRt4A

Modern Residential Building Construction

Garage Doors

How This All Applies to Firefighting

How This All Applies to Firefighting

Food for Thought – Ridge Vents

- UL, Chicago FD, and IAFC conducted a series of tests.
- **Structural performance of the roof assemblies.** Initially, there was a significant amount of smoke emitting from the continuous plastic ridge vent at the beginning of the modern roof assembly test. As the temperatures increased, the continuous plastic ridge vent melted and collapsed. The initially heavy smoke pattern emitting from the continuous ridge vent diminished to a light indistinguishable smoke trail, although the fire was still raging below. The excessive heat created by the fire was, in effect, restricted from venting vertically through existing natural openings and created an excessively untenable condition below the roof in the attic and the occupied floor areas below the attic as the ceiling finishes failed.
- Reference: http://www.fireengineeringuniversity.com/courses/33/HTML/section_print.htm

How This All Applies to Firefighting

Food for Thought – Thermal Imagers

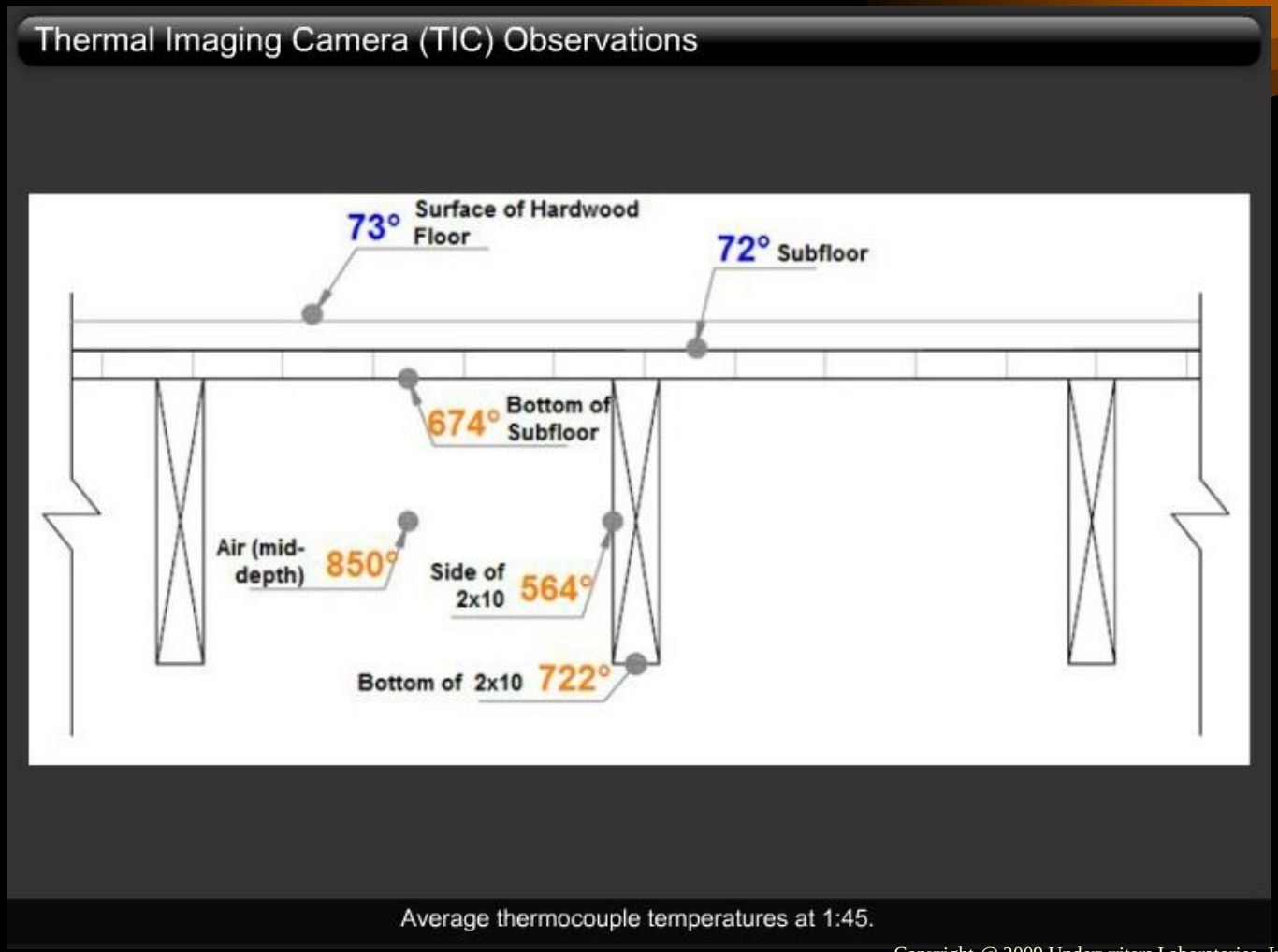
- **Thermal imaging cameras (TIC) DO NOT provide an adequate indication of a weakened floor or pending collapse.**

- TICs detect variations in surface temperatures for objects in the field of vision.
- Testing showed average temperatures below the floor were in excess of 1,200°F while average temperatures on top of the carpet were less than 100°F.
- The application of water during fire suppression operations will also further mask these thermal signatures in the TIC camera's field of vision.
- In heavy smoke, you may not be able to see the TIC screen. Don't rely on the TIC as a substitute for basic skills.

- **References:**
  http://www.ul.com/global/documents/offerings/industries/buildingmaterials/fireservice/basementfires/2009%20NIST%20ARRA%20Appendix%20B%20-%20Fire%20Service%20Collapse%20Hazard%20Floor%20Furnace%20Experiments.pdf **and**
  http://www.isfsi.org/uploads/fireengineeringarticle.pdf

How This All Applies to Firefighting

Food for thought – Thermal Imagers



How This All Applies to Firefighting

Food for Thought – Sounding the Floor

- **Sounding the floor for stability is not reliable!**

- A common fire service practice to determine the structural soundness of a floor before working on it is to sound or strike the floor with a tool such as a haligan bar or an ax to see if sponginess or softness can be felt. Striking the floor would result in hitting solid OSB floor decking although the joists below the floor may be compromised. This would be masked even further if there was a finish floor such as carpet, hardwood or tile on top of the sub flooring.
- When possible the floor should be inspected from below prior to operating on top of it.

- **Reference:**
  http://www.ul.com/global/documents/offerings/industries/buildingmaterials/fireservice/basementfires/2009%20NIST%20ARRA%20Appendix%20B%20-%20Fire%20Service%20Collapse%20Hazard%20Floor%20Furnace%20Experiments.pdf

How This All Applies to Firefighting

Food for Thought - Sounding the Floor

- Critical information like the type and span of the joist below, whether or not it was built to code or modified by the homeowner, whether it is protected by drywall, and how long it has been burning are all unknown to the responding firefighters.
- Multiple tests by UL and NIST clearly indicate there are no collapse indicators that guarantee the floor system is safe to operate on. Sounding the floor, floor sag, and thermal imager readings, even when combined, do not provide enough information to guarantee that the floor will not collapse below you. Flooring systems are composed of materials (carpet, padding, ceramic tile with a cement board base) that restrict the flow of thermal energy through them. Flooring materials could be on fire below, virtually undetectable from above via TIC.

How This All Applies to Firefighting

UL's 2008 Report: Structural Stability of Engineered Lumber in Fire Conditions

- Based on this report, the lightweight construction, the increased fuel load, and the synthetic petroleum-based materials in modern structures all contribute to much greater fire growth.
- Faster fire growth significantly increases the probability of sudden catastrophic structural failure in these buildings.
- Time is working against us when fighting fires.
- Time is a luxury we don't have when responding to these lightweight construction fires; catastrophic structural collapse and firefighter fatalities could be the end result.

- Reference: http://www.fireengineering.com/articles/2008/11/entering-through-the-door-falling-through-the-floor-catastrophic-structural-collapse.html

How This All Applies to Firefighting

Modern Construction: Tight Buildings

- As a result of well-insulated and tightly sealed construction and the addition of plastics and synthetics in room finishes and furnishings:
  - The growth of room-and-contents fires is more rapid than in the past
  - Fires burn hotter than in the past
  - The burn time before flashover has been reduced
  - The well-insulated walls slow the transfer of heat from the fire through the wall to the exterior of the building or to the next room and reflect more heat back into the room
  - More rapid increase in temperature in the room of fire origin than in the past
  - The reduced amount of infiltration results in a fire that is even more ventilation-controlled than in the past.

How This All Applies to Firefighting

NIST, UL & FDNY Governor's Island Test

- These agencies performed a series of live burns to evaluate the effects of wind, wind control devices, and external water application to evaluate the benefits to firefighters and building occupants in a fire.
- FDNY Battallion Chief George Healy (Queens NY):
  - "Years ago you could break a window and it took the fire several minutes to develop — or tens of minutes."
  - "Now we're learning when you vent that window or the door, the fire is developing in, say, a minute with the available oxygen."
- In all cases, externally applied water suppressed the fires, causing at least a 50% reduction in temperature in the corridor and stairwell.
- Brooklyn Firefighter Robert Wiedmann was severely burned in a fire that fed quickly on furnishings and air from opened windows.
- Reference (Full NIST Governor's Island report): http://fire.nist.gov/bfrlpubs/fire09/PDF/f09015.pdf

How This All Applies to Firefighting

NIST & FDNY Governor's Island Test

- Door control is the most basic means to control the flow path in the building.
- Entry firefighters should secure the door until the suppression crew has a fully charged, air purged, and stream tested line at the door.
- In one test, a flow path existed through the apartment into the stairwell and up to the open bulkhead door.
- At 70 seconds: the majority of the living room window had self vented and the living room has transitioned to a post-flashover condition with flames floor to ceiling. Temperature measurements at 4 ft above the floor along the flow path on the fire floor were in excess of 752 ºF.
- The velocity of the hot gas flowing out of the bulkhead was approximately 22 mph and the temperature at the bulkhead was over 1832 ºF.
- Once the bulkhead door was closed, the wind driven condition stopped.
- Within seconds of closing the bulkhead door, the velocity at the bulkhead was reduced to 0 mph and within 90 s the temperature at the bulkhead had decreased to approximately 392 ºF.

How This All Applies to Firefighting

Northbrook, IL - UL Vent and Fire Test

- In the two story ventilation experiment the temperature was 430 °F at ventilation (600 s), exceeded the firefighter tenability threshold of 500 °F at 680 s and reached 1110 °F at 780 s.
- Both of these experiments show that opening the front door needs to be thought of as ventilation as well as an access point. This necessary tactic also needs to be coordinated with the rest of the operations on the fireground.
- A simple action of pulling the front door closed after forcing entry until access is ready to be made as part of the coordinated attack will limit the air to the fire and slow the potential rapid fire progression.
- Reference: http://www.ul.com/global/documents/offerings/industries/buildingmaterials/fireservice/ventilation/DHS%202008%20Grant%20Report%20Final.pdf

How This All Applies to Firefighting

Northbrook, IL –UL Vent & Fire Test

- The most startling results of UL's excellent full-scale live burns of one- and two-story homes include the following:
  1. In a one-story home, firefighters have approximately 100 seconds from the time we open the front door (we never think of this as ventilation, but it is) until the place lights up and the conditions inside become untenable.
  2. In a two-story home, we have approximately 200 seconds until the house becomes untenable when fire has spread from one room of fire.
  These numbers are based on test data, and if firefighters or occupants open other windows and doors, the times to untenability are significantly lower and less predictable.

- References: http://www.fireengineering.com/articles/2011/06/ul-vent-study.html and also http://www.ul.com/global/eng/pages/offerings/industries/buildingmaterials/fire/fireservice/ventilation/ (See executive summary and full report)

How This All Applies to Firefighting

2013 NIST/ISFSI Spartanburg, SC

- Opening doors and windows on a house that has a ventilation-limited fire will increase the temperature, which can make fuels ignite almost immediately in an environment that previously wouldn't have supported combustion. (also illustrated at the Governor's Island test.)
- Applying water into the fire space results in a greater than 750° temperature reduction.
- Spraying smoke does not have a negative effect. Firefighters should spray smoke to lower the temperature and reduce pyrolysis. Smoke is fuel, so spraying water on hot fuel is a logical move.

- Reference: http://firechief.com/fireground-operations/flashover-research-could-change-future-firefighting-tactics?page=1

How This All Applies to Firefighting

2013 NIST/ISFSI Spartanburg, SC

- It will be argued that this method will produce steam that could harm the occupant and firefighter but Spartanburg burns showed that in order to survive a room and contents fire in a single-family detached dwelling smaller than 1,400 square feet, an occupant or firefighter needs to be in a separate room from the fire with the door closed.
- In the tests, a occupant or firefighter could have survived the fire, even a multiple room-and-contents fire if he or she kept the door closed and the fire department immediately applied water upon arrival. This assumes that the arrival time is prior to the failure of the door, which would vary depending on the type of door, plus the amount of air flow to the fire, and other factors.

Reference: The formal report has not yet been released by NIST. These tests took place in January of 2013.

How This All Applies to Firefighting

Starting to Put it All Together…

- Assistant Chief Jerry Knapp writes in Fire Engineering: Consider what happens if we apply current strategy and tactics. We arrive to find smoke venting from one or more windows and reports of people trapped in a single-family home. Current practices have us force the door and enter the home for a search. Search teams enter without a hoseline and conduct an aggressive and rapid primary search. In a two-story home during nighttime fires, searching the upstairs bedrooms is a priority, so we often dash up the stairs. If water is not applied with the time frames listed in the points above, the search team will likely be caught in untenable conditions and will be attempting to bail out windows in a last-ditch effort to save themselves. Case histories prove that often it is luck that determines if they survive or not.
- What does this mean to us on the fireground? Assume a house fire is going to flash over, and plan for it; interior overly aggressive search tactics we know and trust may be just too dangerous to use now under some conditions. It is absolutely critical to get decisive amounts of water on the fire to ensure the safety of our members.
- Maybe we should consider using vent-enter-search (VES) techniques as a good alternative to forcing the front door and dashing up the stairs. VES, developed and used by the Fire Department of New York, increases the safety of members by having them enter through the second-floor windows and conduct a search operation while already in an area of refuge--a bedroom with a closed door separating them from the active fire.

How This All Applies to Firefighting

Can we do it?

- The benchmark of 100 and 200 seconds to flow decisive amounts of water must be made a standard operating procedure (SOP) and a constant training objective. Sure, you say, any engine company can do that, but can they really? Can they do it every time? The only way to ensure it is to make it a training objective. Consider some of the variables firefighters must contend with when deploying hoselines--long stretches down driveways; garden apartments; cars with tires that seem to just grab hoselines; fences impeding the stretch; preconnected lines that may be short; dead loads that have to be estimated properly. Don't forget overcoming problems such as kinks, couplings hung up on door frames or steps, and so forth. It is easy to sit in the office and say, "Hell yea, we can do that!" It is another thing to actually test it in training or on the fireground.

How This All Applies to Firefighting

Video Comparisons of Structure Fires

- Open doors and windows are ventilation!
- Could you vent any more here:
  - http://www.youtube.com/watch?v=3M9qo2FUqKg
- Compare this College Park interior attack:
  - http://www.youtube.com/watch?v=JKYW6uK4vDI
- With this attack:
  - http://www.youtube.com/watch?v=qoiRBdp3MnE

How This All Applies to Firefighting

2013 NFPA SCBA Standard

- Following some of these tests, the NFPA issued an alert noting that fires in modern buildings burn hotter and faster than those in older structures, resulting in temperatures hot enough to melt or otherwise damage the SCBA facepiece lens. Damage to the lens can breach the respiratory protection, exposing the wearer to superheated air and toxic combustion products.
- There are at least 3 recent fatalities associated with failed facepieces.
- The new NFPA standard will include a universal PASS sound, an increase from 25% to 33% for the low air warning, new facepieces, and better communication abilities.
- References: http://www.nist.gov/el/fire_research/nfpa-072512.cfm and http://scott2013firefighter.com/2013-nfpa-standards/

How This All Applies to Firefighting

"Pushing fire" myth

- The UL study referenced below investigated the theory of "pushing fire" whether from the exterior or the interior. Many departments think pushing fire will increase damage by spreading the fire and will lower the tenability in the house for potential victims.
- After examining the temperatures from the 15 burn experiments, there is no evidence of "pushing fire."
- There were also no temperature spikes in any of the rooms, especially the rooms adjacent to the fire room.
- It appears that in all cases, the fire was slowed down by the water application and that external water application had no negative impact on occupant survivability.

Reference:
http://www.ul.com/global/documents/offerings/industries/buildingmaterials/fireservice/ventilation/DHS%202008%20Grant%20Report%20Final.pdf

How This All Applies to Firefighting

"Pushing fire" myth

- Things got *better* in every experiment when water was applied from the outside.
- This is not to say that an interior attack is not the right tactic in many situations, but when water can be applied quickly to the fire, the benefits of improving conditions inside the structure for both occupants and firefighters were measurably increased.
- Although room temperatures were not affected by the use of fog patterns/streams, there was an impact on visibility or the disruption of the thermal layer in two of the experiments.
- The disruption is caused by air in the fog stream.
- Additionally, the fog pattern created steam, which can burn FF's.
- However, using a straight stream introduced no air and did not impact the thermal layer.

An initial exterior attack could have been used well here (Additional videos show this was later mostly fought externally and the house was mostly saved.): https://www.youtube.com/watch?v=RW-yyOpZ0h8

How This All Applies to Firefighting

Smooth bore or combination nozzle?

- At equal flows and pressures, the solid stream from the smooth-bore and straight stream from a combination nozzle:
  - Look alike
  - Have the same reach and reactions
  - Strike with equal impact force
  - Are equally turbulent
  - Are of a similar droplet size

- Video demonstration of effects: http://www.youtube.com/watch?v=vkNFPWyidlc
- Video demonstration of streams: http://www.youtube.com/watch?v=atER22aomIs

References: http://firechief.com/suppression/ar/smoothbore-combination-nozzle-comparison-201110 and http://www.fireengineering.com/articles/print/volume-157/issue-2/features/nozzle-tests-prove-fireground-realities-part-3.html

How This All Applies to Firefighting

Smooth bore or combination nozzle?

- Both streams are identical once they are a few feet from the nozzle. Neither stream is solid. Both are composed of large droplets.
- Both are equal in quality, reach and impact force, and are affected equally by wind.
- Neither the smooth-bore nor the combination nozzle in a straight stream setting has any great effect on air movement. (Will not “push fire”)

How This All Applies to Firefighting

Smooth bore or combination nozzle?

- A 15/16-inch solid bore nozzle, at 50-psi nozzle pressure and flowing 180 gpm caused approximately 510 cfm of air to be moved into the fire area. The straight stream from a combination nozzle performed similarly.

- Combination nozzles used in the fog position cause massive air movements into the fire area. Although the quantity of air moved exceeded the measurement capability (2,000 cfm), research suggests that a typical 1 3/4-inch fog stream flowing 150 to 180 gpm will move 6,000 to 10,000 cfm of air into the fire area!

How This All Applies to Firefighting

NIOSH

- For incidents where there is a firefighter death, we are fortunate in that the National Institute for Occupational Safety and Health (NIOSH) conducts an investigation and publishes a comprehensive report. This report isn't intended to place blame but is made public and is intended for learning what went wrong to prevent similar situations.

How This All Applies to Firefighting

http://www.cdc.gov/niosh/fire/pdfs/face200923.pdf

New York *August 24, 2009*

- On August 24, 2009, a career lieutenant died following a floor collapse and a career firefighter died trying to rescue the lieutenant. The career lieutenant followed a hoseline into the structure with 2 firefighters trailing. The floor collapsed, sending the lieutenant into the basement and the other two exited after shelving fell on them. The lieutenant made several mayday calls but command was unsure where he was since they had been unable to access the basement. A member of the FAST team went in to rescue the lieutenant. The FAST firefighter was not accounted for as missing until the 3rd accountability check, 50 minutes after the mayday. Both firefighters were found next to each other in the basement, their SCBA's depleted and with his PASS device still alarming.

How This All Applies to Firefighting

NIOSH Recommendations

- Recommendation #1: Fire departments should ensure that all personnel are aware of the dangers of working above a fire, especially a basement fire, and develop, implement, and enforce a standard operating procedure (SOP) that addresses strategies and tactics for this type of fire.
- Recommendation #3: Fire departments should ensure that crew integrity is maintained at all times on the fireground.
- Recommendation #6: Fire departments should ensure that fire fighters use their self-contained breathing apparatus (SCBA) and are trained in SCBA emergency procedures.
- Recommendation #7: Manufacturers, equipment designers, and researchers should conduct research into refining existing and developing new technologies to track the movement of fire fighters inside structures.

How This All Applies to Firefighting

http://www.cdc.gov/niosh/fire/reports/face201114.html

Indiana *June 15, 2011*

- On June 15, 2011, a 40-year-old male career fire fighter (volunteer chief elsewhere) lost his life at a church fire after the roof collapsed, trapping him in the fire. Units arriving on scene observed visible flames and heavy smoke coming from the roof of the church. The interior crew was initially met with visible conditions, light smoke, and no visible fire within the church. FF3 and FF1 took turns operating the hoseline toward the ceiling in an attempt to control the fire. FF5 and the victim noticed fire coming from recessed lighting within the ceiling above them. The victim stated to FF5, "This could get bad really quick." A decision was then made to evacuate the building due to the amount of fire burning above the fire fighters. Then, a small portion of the ceiling fell into the sanctuary hitting FF2, exposing heavy amounts of fire above the ceiling level that was too much to be handled with the single hoseline. The victim stated to FF5, FF2, and FF4, "We need to get out now." Due to the magnitude of the fire, the fire department was unable to return to the collapsed area to rescue the victim. The victim's body was later recovered after the fire was extinguished

How This All Applies to Firefighting

NIOSH Observations

- Lightweight roof truss system, believed to be 2- by 4-inch and 2- by 6-inch lumber connected with gusset plates.
- Fire fighters interviewed do not recall seeing vehicles parked at the church.
- No additional equipment was initially brought in with them, such as a thermal imaging camera.

How This All Applies to Firefighting

NIOSH Recommendations

- **Recommendation #3**: Fire departments should conduct pre-incident planning inspections of buildings within their jurisdictions to facilitate development of safe fireground strategies and tactics.
- **Recommendation #5**: Fire departments should be aware of potential hazards associated with lightweight wood truss structures that have been exposed to fire for an extended period of time and acknowledge the potential for a collapse within a structure.
- **Recommendation #8**: Fire departments should familiarize and continually train all personnel in building construction types and safety considerations.

How This All Applies to Firefighting

NIOSH's most repeated recommendations

- ***Fire departments should:***
- Ensure that fire fighters are properly trained in air management.
- Ensure that thermal imaging cameras (TICs) are used to locate the seat of the fire.
- Ensure that all personnel are aware of the dangers of working above a fire
- Ensure fire fighters are trained in the procedures for searching above the fire.
- Ensure that a separate incident safety officer, independent from the incident commander, is appointed at each structure fire.
- Ensure that the incident commander (IC) receives interior status reports and performs/continues evaluating risk-versus-gain.
- Ensure that fire fighters are trained and retrained on Mayday competencies.
- Ensure that truck companies announce the placement of egress ladders over the radio.
- Ensure that interior attack crews advance with a charged hoseline.

What is the best way to minimize these dangerous fire conditions?

How This All Applies to Firefighting

Sprinklers

- In Howard County, sprinklers have been required in all residential new construction since January 2011.
- Unfortunately, most homes in our first due area were built prior to this requirement.

How This All Applies to Firefighting

Sprinklers

- Only the sprinkler heads that are affected by heat activate.
- Sprinkler heads minimize damage by only using 8 – 24 GPM.
- Sprinkler comparison video:
  http://www.ocfa.org/_uploads/video/sprinkler1.wmv
- The NFPA has no record of a fire killing more than two people in a completely sprinklered building where the system was properly operating, except in an explosion or flash fire or where industrial fire brigade members or employees were killed during fire suppression operations.
- One caveat: Attic spaces typically do not have sprinkler protection. Lightning strikes causing fires originating in the attic can overwhelm a sprinkler system.

How This All Applies to Firefighting

St. Louis apartment complex fire

How This All Applies to Firefighting

St. Louis apartment complex fire

How This All Applies to Firefighting

Smoke Alarms

Almost all homes have at least one smoke alarm, but three out of five home fire civilian deaths in 2007-2011 resulted from fires in homes in which no smoke alarm was present (37%) or at least one was present but none operated (23%).

Source, Home Structure Fires, Marty Ahrens, April 2013
NFPA Fire Analysis & Research Division

How This All Applies to Firefighting

- If residential structure fires are so dangerous, why do we do offensive interior attacks when possible?
- To protect life and property. In 2011, there were 1,389,500 fires reported in the United States, causing 3,005 civilian deaths, 17,500 civilian injuries, and $11.7 billion in property damage.
- Often, even saving a few pictures or photo albums means the world to victims of house fires. I can assure you that it is never an easy decision for a chief or incident commander to make. That's why 360 size-ups, interior reports, and risk management strategies are essential. That's also why our By Laws require chief officers to have progressive officer experience and meet officer qualifications.
- Reference: http://www.nfpa.org/research/fire%20statistics/the%20us%20fire%20problem.aspx

- We say we’re brothers.
- We take pride in our Class A’s, knowing when we’re most likely to wear them.
- We lower the flags.
- We cry when we hear those bagpipes.
- Yet, if we fail to learn from what contributed to the death of our brothers, we also fail to honor them and their ultimate sacrifice was made in vain.

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- UL – See structural stability reports here:
  - http://www.ul.com/global/eng/pages/offerings/industries/buildingmaterials/fire/fireservice/lightweight/
- UL – ventilation study (see exec summary, full report, and videos here
  - http://www.ul.com/global/eng/pages/offerings/industries/buildingmaterials/fire/fireservice/ventilation/
- UL Impact on Ventilation on Fire Behavior (sections 9 and 10 highly recommended, pg 283 is eye opening) Full report:
  - http://www.ul.com/global/documents/offerings/industries/buildingmaterials/fireservice/basementfires/2009%20NIST%20ARRA%20Appendix%20C%20-%20Full-Scale%20Floor%20System%20Field%20and%20Laboratory%20Fire%20Experiments.pdf
- Great article on the meaning of aggressive fire attack
  - http://www.firefighternation.com/article/strategy-and-tactics/challenging-traditional-meaning-aggressive-fire-attack
- Attached garage fires (a must read)
  - http://www.fireengineering.com/articles/print/volume-164/issue-3/features/fire-tactics-for-attached-garages.html

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  - http://www.fireengineering.com/articles/2008/11/entering-through-the-door-falling-through-the-floor-catastrophic-structural-collapse.html
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  - http://tmfire.us/BUILDING%20CONSTRUCTION.pdf
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- How the lightweight truss is built
  - http://www.firehouse.com/article/10499153/how-the-lightweight-truss-is-built
- Ventilation on a lightweight roof (exceptional reading)
  - http://www.fireengineering.com/articles/print/volume-164/issue-12/features/ventilation-operations-on-lightweight-roofs-a-viable-operation.html
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  - http://www.isfsi.org/uploads/fireengineeringarticle.pdf
- NIOSH report on working above fire damaged floors
  - http://www.cdc.gov/niosh/docs/wp-solutions/2009-114/pdfs/2009-114.pdf
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  - http://www.firefighternation.com/article/firefighter-safety/interview-definitive-guide-fireground-riskbenefit-analysis
- Fireground rules of engagement audio with editor of Fire/Rescue magazine
  - http://www.firefighternation.com/article/firefighting-operations/interview-fireground-tactical-rules-engagement
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  - http://newsfeed.time.com/2012/07/14/hotter-and-faster-how-to-fight-a-modern-fire/

Additional Videos and Online Courses

- So many things wrong with ventilation here. Fairfax. RIT not going in:
  - http://www.youtube.com/watch?v=K4aVEllPwLQ
- FDNY now using a "Close the Door" public safety video
  - http://greenmaltese.com/2013/02/close-the-door-for-life/

- UL basement fire course
  - http://lms.ulknowledgeservices.com/catalog/display.resource.aspx?resourceid=356711
- UL ventilation course
  - http://content.learnshare.com/courses/73/306714/player.html
- UL engineered lumber course
  - http://content.learnshare.com/courses/73/187716/player.html
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