Knowledge of codes, techniques, and materials is the best defense against loss of life and property.

Fighting Fire with GOOD DESIGN

by PAUL HANKE

Close to 12,000 Americans lose their lives each year to fire, along with 300,000 injured. Property loss is in the billions. A report in the Feb. 15, 1984, issue of *Contractor* puts the number at an average of 25 deaths per day and states that "the U.S. fire death rate per capita is the highest in the world." According to Edward Allen, writing in *How Buildings Work,* "Our rate of fire death is about ten times that of the average European country," leading one to conclude, he says, "that the design of our buildings with respect to fire safety has not been of a very high standard."

What can be done to prevent these needless deaths, injuries, and property damage claims? In order to adequately discuss prevention, we need to briefly review how fires occur.

How Fires Happen

In many ways, a building is a fire waiting to happen. To begin with, a building is a concentrated (and large) supply of fuel and/or flammable materials. Add to that the many potential sources of ignition contained within—such as fireplace sparks, faulty wiring, and burning cigarettes—and a plentiful supply of oxygen. When fuel, ignition, and oxygen converge, fire results. Once ignited, the fire consumes fuel and oxygen and produces heat, gases (often toxic and a major source of deaths), and particulate emissions. This process may be very rapid, or the fire may smolder for a long time before finally bursting into flame. Once burning, fire spreads from place to place, often rapidly, unless contained or extinguished.

Like a stove, the building concentrates heat and gases. Vertical passages, such as stud cavities or stairwells create a convective draft (hot air rises, sucking in fresh air), which further fans the flames. In addition, the cavities offer passageways for smoke and flames to other parts of the structure. According to the report in *Contractor*, when the MGM Grand Hotel burned in Nov. 1980, killing 85 people, 61 of them died from smoke inhalation in remote parts of the building—far removed from the fire itself.

This brings us to another aspect of fire safety—providing a safe means of escape. The escape route must be accessible, obvious to alarmed people, and properly-sized. The building must also be accessible to firefighters. All of these factors must be considered and dealt with as part of any strategy to control fire, injury, and property damage.

Getting Out Alive

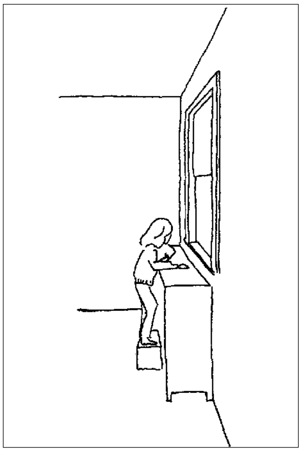
Our first aim when designing and constructing fire-resistant buildings is to save lives and prevent injury, then to limit property damage and prevent the spread of the fire to other parts of the structure and to adjacent buildings. That is why the first provisions of most major fire codes deal with occupant loads, and means of egress (escape).

If a fire starts, we have to warn occupants, allow them to escape, compartmentalize the fire to limit its spread, restrict the flammability of both construction materials and building contents, and make provisions for firefighting, either by alert occupants, or by trained firefighters. Let's look at each of these strategies in turn.

The escape. Many fires build up so rapidly that occupants have only 2-1/2 minutes after ignition to escape from the fire zone. That's not very long if you are frightened, confused, choking, unable to see, asleep, panicked, four stories up, or in a mob of disoriented people. Building codes therefore devote considerable attention to "occupancy loads" and the uses to which a building will be put (residential, assembly buildings, theaters, day-care centers, for example), as well as to the details of construction. These first factors, while important, are beyond the scope of this article, but we can take a look at the concept of egress.

"Means of egress," as defined by the National Fire Protection Association (NFPA) is "a continuous and unobstructed way of exit travel from any point in the building." This includes the actual exit point itself (that is, a door, window, chute, or other opening). One important point is that halls, stairs, and doors should be wide enough for the number of people involved (typically 36 to 44 inches, depending on occupant load).

A 22-inch wide "unit" doorway will presumably pass 40 people per minute, with additional allowances for every 12-inch increase. However, a door 32 inches or wider may be required to permit wheelchair access. Other common egress requirements govern emergency lighting and exit signs, panic bars, maximum travel distance, wire glass in fire doors, corridor sizes, and stair tread/riser specs.



Small Homes Council

Illustration 1. *Every sleeping room should have at least one exterior door or an operable window at least 22 inches wide and at least 5.7 square feet in area. If emergency windows have high sills (44 inches max.), then built-in shelves or a solid piece of furniture should serve as a step stool.*

Bedrooms in single-family houses are required to have two means of escape, one of which may be an operable window. Code requirements vary for egress windows, but typically they must have a clear opening width of at least 22 inches, and a net opening size of 5.7 square feet (see illustration 1). Additionally, the windowsill height must not be more than 44 inches from the floor to allow children or the infirm a fighting chance to reach the window in an emergency. Finally, the window must open from inside without the use of special tools.

Beyond these specific requirements, the designer must think about what lies on the other side of the window. Is it a lawn at grade level, a flat or steep roof, or a three-story leap to the pavement? Which would you prefer? Also remember that egress pathways for residential buildings can not pass through apartments or rooms not under the immediate control of the occupant.

To my continuing dismay, both of these requirements are frequently violated in the "well-designed" earth-sheltered houses that appear periodically in national building magazines. In one such house, a single bedroom had an egress window, and an occupant would have had to pass through five rooms and six interior doors to reach an exit (actually a hallway leading to the garage). Remember, most people who per-

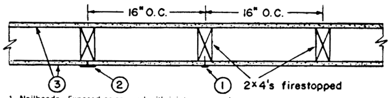
Fire Separation and Fire Walls

Build them Right

by Stan Baranowski and Bruce Martin

Design No. U305
Assembly Rating—1 Hr.

Bearing Wall
Finish Rating—See Item 3.



1. **Nailheads**—Exposed or covered with joint compound.
2. **Joints**—Exposed or covered with fiber tape and joint compound, except where required for specific edge configuration. For tapered, rounded-edge wallboard, joints covered with joint compound or fiber tape and joint compound. As an alternate, nom 3/32 in. thick gypsum veneer plaster may be applied to the entire surface of Classified veneer baseboard. Joints reinforced.
3. **Wallboard, Gypsum***—5/8 in. thick wallboard paper or vinyl surfaced, with beveled, square, or tapered edges. Wallboard nailed 7 in. O.C. with 6d cement-coated nails 1 7/8 in. long, 0.0915 in. shank diam and 1/4 in. diam heads. When used in widths of other than 48 in., wallboard is to be installed horizontally.
   - **Canadian Gypsum Co., Ltd.**—Types SCX, SHX, WRX (finish rating 26 min), Type C (finish rating 26 min).
   - **Celotex Corp., The**—Type 1, Type SF3 (finish rating 20 min), Type A (finish rating 21 min), Type B (finish rating 20 min) or Type C (finish rating 21 min).
   - **Domtar Construction Materials**—Type GF2, C or Type 9.
   - **Domtar Gypsum America, Inc.**—Type 1 (finish rating 26 min), Type 4 (finish rating 26 min), Type 5 (finish rating 26 min), or Type 9 (finish rating 26 min).
   - **Domtar Industries Inc.**—Type C or IX.
   - **Flintkote Co.**—Type III (finish rating 20 min) Type IV (finish rating 20 min), or Types VI, VII, VI-SD or VI-SHX (finish rating 23 min).
   - **Georgia-Pacific Corp., Gypsum Div.**—Type GPFS1 (finish rating 20 min), Type GPFS2 (finish rating 20 min), Type GPFS3 (finish rating 20 min), Type GPFS4 (finish rating 20 min) or Type GPFS6 (finish rating 26 min).
   - **Gold Bond Building Products**—Type FSW (finish rating 20 min), Type FSW-G (finish rating 20 min), Type FSW2 (finish rating 24 min), Type FSW3 (finish rating 20 min), Type FSW4 (finish rating 20 min), Type FSK (finish rating 20 min) or FSK-G (finish rating 20 min).

UL Design #U305 is one of the most common wall assemblies in light residential construction where a one-hour fire separation is needed. Reprinted from UL manual with permission from UL Fire Resistance Laboratory, Northbrook, Ill.

In June 1982, the K-Mart Distribution Center near Philadelphia went up in flames—causing $100 million in damages. The 1.2 million square foot building had been fully sprinklered and divided by fire walls into 4 quadrants. Yet, the building was completely destroyed. The fire spread because of weak links in the fire protection system The fire walls had no doors, and although there was a deluge-type water curtain exploding aerosol cans shot through the openings and spread the fire. There were other contributing factors, including a fuel load that overwhelmed the sprinkler system.

A building can be susceptible to fire depending on its contents, uses, and basic fire safety construction. The first two factors vary quite a bit from building to building, and it is important to take them into account when designing the building and its fire protection system. But there are basic practices that must be followed to produce a highly fire-resistant building. What follows is a look at fire and fire-separation walls from the perspective of the BOCA Basic Building Code. BOCA (Building Officials and Code Administrators) requires that each element in a building meet a minimum hourly rating depending on the size and height of the building and its occupancy. The hourly rating—as defined by one of the major testing agencies—is based on the "ability of the construction to retard heat transmission while containing a fire, to retain its structural integrity, or both."

Fire Separation Walls

The example shown above, UL Design #305, is one of the most common wall assemblies in light residential construction where a one-hour fire separation is needed. (Factory Mutual's "Wall Construction 16" is virtually the same.) Typically, a one-hour wall would be used to enclose exit routes and boiler rooms, and to separate tenants within one building. It is important to note that the fire rating is for the assembly as a whole: in this case, two layers of 5/8-inch wallboard with an air space (the void between studs). A wide range of other assemblies are listed by Underwriter's Laboratories and Factory Mutual using other materials. (For more information contact them directly:
Factory Mutual Research Institute is located at 1151 Boston-Providence Turnpike, Norwood, MA 02062); Underwriter's Laboratories is located at 333 Pfingsten Road, Northbrook IL 60062.) Steel studs may be used when incombustible construction is required. Other wall surfaces are listed as well, including lath and plaster, and sheet metal.

Any wall assembly can provide a reliable fire-separation wall if it's built in accordance with the listing. Walls with gypsum board can achieve ratings of two hours or more. Problems can arise, however, during or after construction when the subs install mechanical systems. Plumbing, electrical, and heating penetrations are often poorly sealed—allowing fire a weak spot through which to attack the assembly. Another weak point is created by fiberglass tub enclosures mounted on party or corridor walls, if gypboard or other suitable materials are not installed behind them. This was the problem in several notable condominium fires that spread from unit to unit through the shower areas.

Another problem is the use of staggered-stud or double-stud walls. These wall designs, used mainly for sound control, leave a continuous void within the wall cavity. Once fire enters this type of wall, it can spread rapidly across the length of the wall. This creates a serious problem for firefighters, and renders the wall useless as a barrier to fire. We are not aware of any staggered-stud design with an approved listing. The traditional single-stud design creates cavities that are fire-stopped at the sill and head. The integrity of each cavity is maintained by limiting the placement of electrical receptacles. They must be at least 24 inches apart and not back-to-back in the same bay. No more than 100 square inches of openings are permitted in each 100 square feet of wall area.

True Fire Walls

Our discussion so far has focused on rated walls that are part of the structure. These may be non-bearing partitions or a party wall in a duplex, extending from foundation to roof deck (with the ridge vent fire-stopped). While commonly referred to as fire walls, these are more accurately called fire-separation walls. These are distinct from true fire walls. A true fire wall is a structurally independent, incombustible, fire-rated wall, generally of masonry construction. The key phrase is "structurally independent." While it serves as a barrier to the spread of fire, it must also be able to withstand the collapse of the structure on either side without itself collapsing.

Fire walls extend from the foundation through the roof decking with a parapet at least 32 inches high. (Fire walls may terminate at the underside of incombustible roof decking in some cases.) They are normally used to subdivide large structures or to segregate high hazard areas from others. They may also be used where incompatible construction types are joined or where new construction joins a non-complying structure.

Since fire walls serve both as a barrier for fire and as a structurally independent unit, a conservative approach to design and construction is required. In our jurisdictions a design stamped by a licensed structural engineer is required, and no penetrations of the fire wall are permitted, other than openings protected by appropriately-labeled doors.

All services, including conduits, heating or cooling pipes or ducts, and even sprinkler piping, must be routed under or around the fire wall or provided separately.

The reasons for this are twofold. Piping penetrations have been known to conduct enough heat to ignite combustible material on the unexposed side, and the collapse of the exposed structure can (and has been shown to) pull down the wall.

Even when installed "to code," things can go wrong, as in the K-Mart building in Philadelphia. But by understanding fire and building codes, and using good construction practices, a great deal of damage can be eliminated. The goal is to build safe structures. ■

Stan Baranowski has a B.S. Degree in Fire Science Technology and two and a half years of experience as a fire inspector for the State of Vermont. He is also a firefighter with the City of Montpelier, Vermont. Bruce Martin has eight years of experience as a fire inspector, four for the State of Vermont. Both have studied at the National Fire Academy, Emmitsburg, Maryland.

ish in residential fires die asleep in their bedrooms, overcome by gases before attempting escape, so at least give them an avenue for escape. This brings us to another important aspect of fire safety.

Sounding the alarm. Single-family residential codes usually require a minimum number of approved smoke detectors, hard-wired into the household electrical system. Battery-operated devices are sometimes allowed for existing buildings, but occupants may neglect to change batteries.

Whatever the power source, smoke alarms sound a loud warning when they detect the presence of particulate matter in the air. The devices may be either *ionizing* (where a beam from a tiny radioactive source is interrupted by the smoke), or *photoelectric* (where a light beam serves the same function).

The ionizing-type of detector is generally considered safe because it does not emit more radioactivity than normally found in background conditions. A few years ago, however, the Ralph Nader Health Research Group challenged *Consumer Reports* on this question, pointing out in particular that the radioactive *americum* used in smoke alarms has the ability to cause cancer at low doses. Consumers Union countered that Nader's group overestimated the risks from the radiation and didn't give enough credit to the ionizing detector's higher sensitivity to open fires—the major type of household fire.

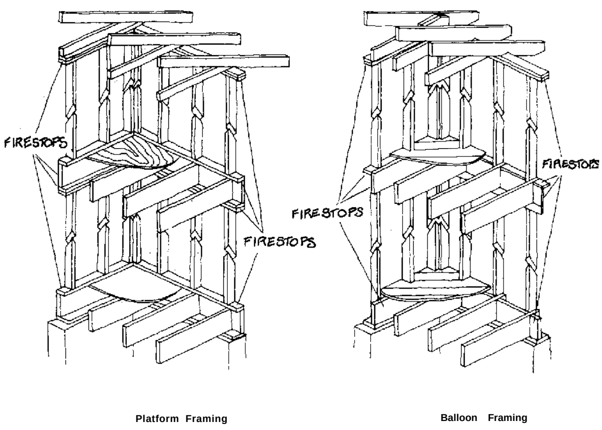
The NFPA points out that 90 percent of all fire-related deaths in 1982 occurred in houses that didn't have functioning smoke detectors, and a study at the Ohio State University Building Research Lab concluded that 59 percent of fire deaths from asphyxiation could have been prevented by smoke detectors. So whichever type you choose, make sure the houses you build are provided with smoke alarms.

At a minimum this means one detector outside each separate sleeping area, installed per the manufacturer's instructions. For increased levels of protection, provide another at the head of basement stairs and all stairs to occupied areas. And if you are building upscale houses with a fireplace in the master bedroom, by all means put a smoke alarm in the room itself. (I know an architect who awoke naturally one night to find a smoldering fire in his bedroom from sparks which had escaped from the fireplace.) A third level of protection can be achieved by adding *heat* detectors in various locations to supplement the smoke alarms and warn of rapidly developing—as opposed to smoldering—fires.

Once you have provided an alarm system and made it possible to escape from the building, you can turn your attention to making the building itself fire-resistant.

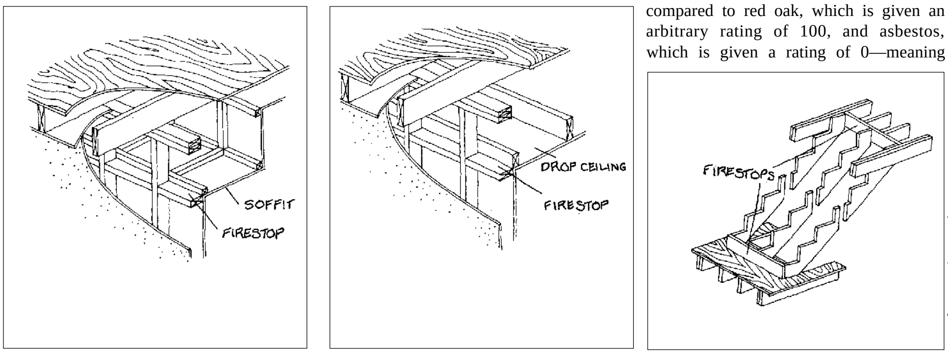
Controlling the Fire

No building is fire*proof.* Even steel, which we generally consider to be incombustible, rapidly loses its tensile strength when heated. This could result in structural collapse. Consequently, structural steel is often required to be encased in concrete (which is adversely affected by fire as well) or otherwise insulated from fire. Heavy timber frames may actually be more fire-resistant than steel. In any case, the best we can hope for is to make a building fire-*resistive.* Codes, articles, and references such as *Architectural Graphic Standards* give us examples of different types of fire-resistive construction and



From Wood Frame Design, *by Western Wood Products*

Illustration 2. *One advantage of platform framing (left) is its built-in fire stops. Balloon framing (right) requires added fire stops between floors.*



Wood Frame Design, *by Western Wood Products*

Illustration 3. *To keep fire from spreading through concealed spaces, interconnections between vertical and horizontal spaces should be fire-stopped. Examples include the soffit (left), drop ceiling (center), and stair stringers (right).*

their ratings. Fire walls are discussed in detail elsewhere (See "Fire and Fire-Separation Walls"). Here we will focus on a smattering of other fire-resistive methods, materials, and details that may be encountered in building design and construction.

Fire stops and draft stops. As noted earlier, fire and smoke often spread unnoticed throughout a structure through concealed cavities such as stud joist spaces, attics, ductwork, or chases. Fire stops and draft stops work to prevent this by compartmentalizing the building. Fire stops block off small areas and draft stops block large areas.

Probably the most familiar fire stops are the top and bottom plates of a typical stud wall. Since flames must burn through 1-1/2 to 3 inches of solid wood to penetrate between floors, he rise of smoke is slowed considerably. *Balloon-frame* walls, however, do not have their top plates at floor level, and require special attention. Solid blocking (2 inches minimal) must be placed between studs and joists, as shown in this type of construction (see illustration 2). Fire stops may also be required at soffits, the edges of cove ceilings, and at the top and bottom of stair stringers (see illustration 3). Gaps around ducts, vents, and chimneys should also be fire-stopped (more on chimneys later).

Draft-stopping (using plywood or gypsum board) is typically required every 3,000 square feet in attics and between webs of open-chord trusses in commercial buildings. For dropped or suspended ceilings this is reduced to 1,000 square feet. Some codes require gypsum board on the webs of open-web parallel-chord trusses to limit opening sizes (or optionally require 5/8-inch Type-X gypsum board ceiling). Others reduce the draft-stop limit for this type of construction to as little as 200 square feet: Single-family residences should have draft stops at 500 square feet for floor/ceiling assemblies with dropped ceilings or open web trusses (see illustration 4). In multi-family units they should be provided wherever tenant separation walls do not extend to the second-floor plywood.

Breaking up the building into compartments is also the rationale behind code provisions for floor separation, self-closing fire doors, and restrictions on shafts, elevators, and stairwells. For example, a solid wood door with a self-closer is recommended between house and garage in residential construction, both as a draft stop and to prevent infiltration of dangerous carbon monoxide gas.

Each of the above details helps to compartmentalize fire, but perhaps the most important consideration is providing one-hour rated fire walls for vertical shafts between floors (called "floor separation" in code jargon). According to the *Fire Protection Handbook,* vertical shafts are responsible for 50 percent of the fire casualties in 500 cases studied, so study code requirements in this area and comply with them.

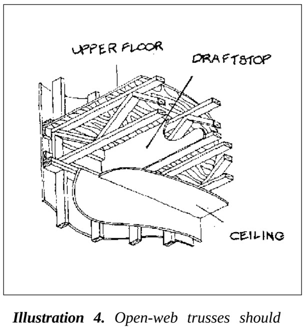


Illustration 4. *Open-web trusses should be draft-stopped in multi-family dwellings and commercial buildings at intervals specified by code.*

Materials, tests, and assemblies. To rate the fire-resistance of a type of construction, the entire assembly (such as a ceiling, joists, and subfloor) must be considered, not just the individual components. For instance, the ceiling of a floor/ceiling assembly may fail after 20 minutes, but the whole assembly may last an hour. Hence there is no such thing as a one-hour *door*. The *whole assembly* (door, frame, etc.) is rated. A particular material may have its own rating, however, such as 20-minute gypsum board required over foam plastic insulation board on interior applications. board are also rated for *flame spread* and *smoke development* (class A, B, or C, with C being the poorest), based on Underwriters Lab (UL) tests. The smoke rating is based on the time required to obscure an exit in a 5,000 cubic foot room. Both it and the flame spread are measured in a tunnel and compared to red oak, which is given an arbitrary rating of 100, and asbestos, which is given a rating of 0—meaning no smoke, no flame.

Fire-retardant surface treatments such as special paints, which delay ignition or slow flame spread, may raise the rating of a material one class, but they must be kept in good repair to remain functional and reliable. These products are generally intended for interior use, and typically contain chemicals that "foam-up" to form an insulating layer upon exposure to heat. They may also aid charring of the wood's surface while reducing pyrolysis (chemical decomposition by heat).

One final note before we leave this area—plumbing and similar penetrations should be sealed with an incombustible sealant (caulk) both as a fire stop and to reduce air infiltration and vapor transmission.

Fire-retardant wood. Lumber and plywood containing chemicals that retard fire are also commercially available. These chemicals, typically inorganic salts such as zinc chloride or boric acid, are forced into the wood fiber by pressure treatment and have been shown to be effective on wood that has been in service for 40 years. These chemicals act differently than surface treatments, primarily by reducing the release of flammable products and heat. The wood may actually self-extinguish in the absence of a direct source of flame, but does still char and decompose. The flame spread rating of pressure- treated wood is typically less than 25.

On the down side, fire-retardant wood may lose some strength. Until recently, 10 percent was the across-the-board code reduction. Also, the chemicals may leach out, especially at high relative humidities (above 80 percent) due to increased moisture absorption. Finally, it can be corrosive to metals such as nails and truss plates. More recent products, such as Dricon (Koppers Co.), claim to have overcome some of these problems. Regardless, all such products remain somewhat abrasive to cutting tools, and all are more expensive than ordinary products, adding an estimated $3,000 to the price of an average new home, according to Koppers' literature.

Miscellaneous details. What about the flammability of the aforementioned plastic foam boards? With the possible exception of the phenolics, plastic foams such as urethane and polystyrene are flammable and give off toxic gases (such as cyanide) when burning. The manufacturers claim that these gases are no more toxic than other combustion products, and note that mattresses and sofas are often stuffed with urethane, and that wool carpets and furnishings also emit cyanide when burned. Nonetheless, foam boards require a minimum 20-minute fire barrier (such as 1/2-inch gypsum board) when used on exposed interiors. One exception is for trim components such as foam egg-and-dart moldings and other such imitations of traditional wood. These are allowable if they are limited to less than 10 percent of the wall or ceiling surface area and are evenly distributed about

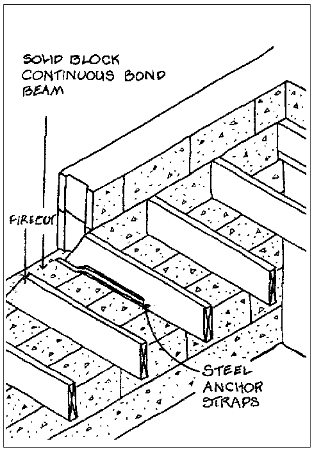


Illustration 5 detail.

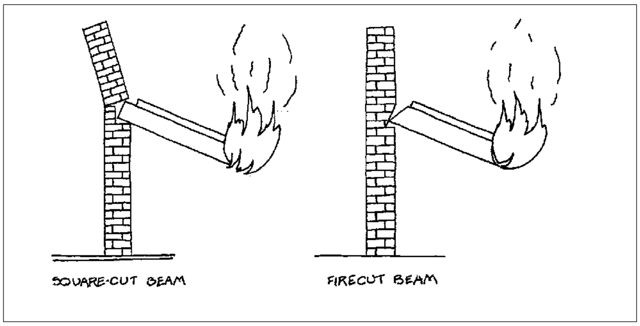


Illustration 5. *A 45 degree cut in the end of a beam will allow it to full out of a masonry wall without toppling the wall. Firecutting is recommended in all masonry construction. See detail above for an example of firecutting in a masonry block wall.*

the room.

Masonry walls (block or brick) are in themselves incombustible. But if a fire were to burn through floor framing with square cut ends, the resulting lever action might topple the wall, injuring bystanders or firefighters. The answer is a *firecut* on the joist end (see illustration 5, on the preceding page) which allows the joist to rotate free if the floor collapses.

Interestingly, according to the NFPA *Life Safety Code Handbook,* experience has shown that traditional. floor coverings, such as hardwood or resilient tile, do not contribute to the early growth of fires. But you may have to get approval or use rated materials for products such as carpet or "artificial turf."

Like other products, roofing materials vary in their fire resistance. Asphalt shingles may be purchased with class A, B, or C ratings, while wood shingles are prohibited in some jurisdictions due to their extreme flammability (fire retardants quickly leach out when exposed to rain). Slate and metal roofing, of course, are pretty resistant to flying embers, but for some reason clay tiles (virtually fireproof, and used widely in Northern Europe) have not caught on in New England, despite their availability in this country.

Hearths, chimneys, penetrations, and wall protection. In a class by themselves in terms of fire safety, are masonry and insulated metal chimneys. According to Jay Shelton in his book *Wood Heat Safety,* good detailing around masonry chimneys requires attention to several points. First, it is important to maintain a 2-inch clearance from all wood framing. The intense heat of a chimney fire can directly ignite wood that touches the masonry, and long-term exposure to relatively low heat can *pyrolize* the wood, lowering its ignition point. Plywood, according to Shelton (who in general prefers stricter Canadian standards to those in the U.S.) can come within 1/2 inch of the masonry, and gypsum board may touch, forming a fire stop (see illustration 6). Trim should be separated from the masonry by at least 1/8 inch of incombustible material such as cementitious panel on stoveboard.

Where chimney connectors *absolutely must* pass through a wall or floor, follow NFPA guidelines: either an insulated fluepipe with 2-inch minimum clearance all around, or a ventilated metal thimble at least 6 inches larger in radius than the pipe (for example, an 18-inch diameter for a 6-inch pipe). Such larger thimbles are not readily available and may have to be custom-made. In no case should the airspace around a masonry or insulated metal chimney be filled with insulation, which is somewhat problematic where either type penetrates a roof or exterior wall.

Insulated metal chimneys themselves deserve some attention in terms of fire safety. Several years ago the Reinsurance Association of Minnesota (RAM) created quite a stir in the woodheating industry by advising policy-holders not to install insulated metal chimneys. They based this on studies by Underwriters Labs of Canada (ULC) that found greater damage in metal units than masonry ones from creosote chimney fires. Further research revealed that exposures to 2100°F temperatures were required to generate the distortion found in insulated metal flues. This led to a new Canadian testing standard

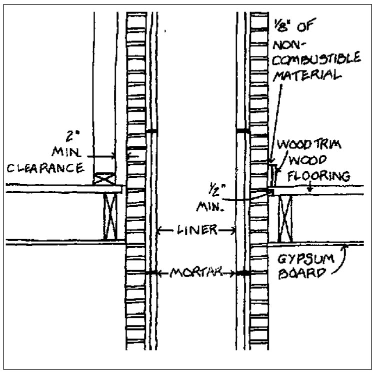


Illustration 6. *In this detail, the gypsum-board ceiling (or sheet metal) forms the firestop. This detail is recommended by wood-heating authority Jay Shelton, and by the Canadian Heating, Ventilation and Air Conditioning Code.*

(ULC S629M) and a new breed of 2100°F-rated chimneys. After investigation by the Consumer Products Safety Commission in the U.S. and considerable foot-dragging by the industry, a new U.S. standard (UL103-HT) was adopted which also has a 2100°F rating, but it again is not as strict as its Canadian counterpart. In specifying or purchasing metal chimneys, make sure you get the new 2100°F equipment, preferably of Canadian manufacture, and install according to the instructions.

It is important to maintain a 2-inch clearance from all wood framing. The intense heat of a chimney fire can directly ignite wood that touches the masonry.

Woodstoves require proper clearances (specified by the manufacturer, NFPA, or local codes), and floor and wall protection. Wall protection may be provided by 4 inches of masonry in contact with the wall, or by a ventilated reflective metal or masonry shield spaced 1 inch from the wall. For details, see Shelton's book. Most codes accept only factory stoveboards as floor protection, but Shelton thinks 4 inches of brick or 2 inches of crushed stone (or stone pavers set on 2 inches of sand) over sheet metal is an acceptable alternative for stoves with legs at least 6 inches long.

Putting it Out

If despite all your best efforts in the above areas, a fire still starts, the final line of defense is to have a sprinkler system. Sprinklers were invented in 1874 by Henry S. Parmelee to protect his piano factory, and were used primarily to protect warehouses and factories until the late 1940s. But following several disastrous nightclub and hotel fires, building officials began to consider and mandate the use of sprinklers for life safety reasons, and applications spread to public buildings and multi-family residential structures. Now, with the advent of new technology, sprinklers are a possibility for single-family homes.

Are sprinklers effective? According to the National Fire Sprinkler Association (NFSA), an umbrella industry group, there has never been a multiple

In most cases, fires are quickly extinguished by the firing of only one or two sprinkler heads. The amount of water put out by fire hoses to do the same job is many times more.

loss of life in a fully-sprinklered building (except for firefighters and explosions). Moreover, an NFPA study for the years 1971-75 found that a mere 20 lives per year are lost in the U.S. in sprinklered buildings, as opposed to 8,000 in unsprinklered buildings. Finally, it is estimated that over 60 percent of the lives lost annually to fire are in one- and two-family homes.

Are sprinklers reliable? Detailed fire records have been kept in Australia and New Zealand since 1886, and research there through 1968 has shown that over 99 percent of all fires in sprinklered buildings were extinguished or controlled by the sprinklers. The success rate for high-rise buildings in New York City from 1969-1978 was over 98 percent. The NFPA reports a success rate of 96.2 percent. Need any more convincing?

They may work, but what about water damage? In most cases blazes are quickly extinguished by the firing of only one or two sprinkler heads. The amount of water put out by fire hoses to do the same job is tens to hundreds of times more. Nonwater systems are available for commercial buildings containing valuable contents such as artwork.

And what about costs? The NFSA estimates an added cost per square foot of 50 cents to $1.50 for commercial new construction, and quotes retrofit installations at perhaps 50 percent more. The new breed of residential sprinklers could add as much as $7,000 to the cost of a new house. These costs may be partially offset, however, by lower insurance costs, or by more favorable code treatment in other areas, such as fire-resistive materials, travel distances to egress, square footage, or building heights—any of which can be the key to your project's economic feasibility.

There are two standards for sprinkler design and installation. NFPA 13 covers commercial work, while the more recent 13D covers single-family residences and trailers. The latter recognizes the development of quick-response residential heads (in 1981) allows use of polybutylene or PVC piping, and sets standards for layout and installation. In residential applications, one sprinkler can protect 144 square feet when placed 8 to 12 feet apart, 6 feet from the wall, and 4 inches from the ceiling. For more information read *Built Not to Burn* (see Resource List) or contact the NFPA, or the NFSA.

Cutting Our Losses

So, how do we fight fires? By careful compliance—in spite of the fact that codes often seem designed solely to raise construction costs and frustrate both builders and architects. Also by compartmentalizing fires, enabling people to escape, and sprinklering. By more attention to these areas, perhaps we can save more lives, cut our financial losses, and erase the national black eye we have in this area. ■

Paul Hanke is an architectural designer living in Waitsfield, Vermont and a regular columnist for New England Builder.

Resource List:

NFPA Life Safety Code Handbook. James Lathrop, ed. (National Fire Protection Association; Quincy, Mass; 1981). Provides informative commentary on the reasons behind code requirements.

BOCA National Fire Prevention Code 1987. BOCA (Building Officials and Code Adminstrators; Country Club Hills, Ill.). Issued every three years. Great bedtime reading.

BOCA Basic Building Code. BOCA, see above. Other model codes exist. Check your local jurisdiction to see which applies to you.

Contractors Guide to the Code. Jack Hageman (Carlsbad, Calif.; Craftsman Book Co.; 1983). A useful guide.

"Improved Fire Safety," by NFPA (National Forest Products Association 1619 Massachusetts Ave., Washington, DC 20036). Pamphlet describes fire-stopping and draft-stopping.

Wood Heat Safety. Jay Shelton. (Charlotte, Vt.; Garden Way Publishing; 1979). The "bible" on this aspect of fire safety.

National Fire Sprinkler Association. Box 1000, Patterson, NY 12563.

National Fire Protection Association. Batterymarch Park, Quincy, MA 02268.

Built Not to Burn: The Residential Fire Sprinkler Resource Book. (Belzak, Inc., 380 Interstate North Parkway, Suite 415, Atlanta, GA 30339; 500 pages; $75).