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(Dwelling Contractor Qualifier License)

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A: Our mission at Wisconsin Contractors Institute is to make your continuing education a hassle free process. You are not required to take this course. However, you are required to complete 12 hours of continuing education every 2 years. These courses are provided to make your education as easy as possible.

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Q: Are these courses approved by the Wisconsin Department of Safety and Professional Services?

A: Yes, the courses are approved by the state of Wisconsin. The price chart below has the course approval number and expiration date. You can also view the course approval letters on our website.

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PRICES

Course Title (Course Approval Number)	Expiration Date	Hours	Cost
❑ Aging in Place (#21439)	2/26/2025	4	$40
❑ That Dangerous Damp (#21438)	2/26/2025	6	$60
❑ Energy Efficient Homes (#21580)	5/21/2025	2	$20
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Phone: _____ Email: _____

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** See instructions on the inside cover page to submit your exams and pay for your course.

Aging in Place

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That Dangerous Damp: Dealing with Water Inside

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Energy Efficient Homes

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WCI Wisconsin Contractors Institute

Aging in Place

Course Number 21439

4 Hours

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Continuing Education for Wisconsin Dwelling Contractor Qualifier Licenses

INTRODUCTION

I'll never forget the sick feeling in my stomach the first time the realization came to me. My once very active mother was making every excuse in the world not to leave the house in which I had grown up. She would not even allow me to take her to places I knew she loved. Her reasons were totally out of character and implausible. What was going on?

I will take you down the same train of thought where my thoughts flew. A year before, she had slipped on ice taking trash out from a back deck. Falling on the steps, she had broken one of her kneecaps. Given her advanced age, it was slow to heal. In the process, favoring one leg had put undue stress on the opposite side hip, which had begun to severely deteriorate. Now, though it seemed her knee had mended, she would not leave the home. And the suddenly obvious answer flashed into my mind.

My mother was afraid of her steps. Literally. The memory of the intense pain from the fall, coupled with the weakness in her hip, left her afraid and unsure of her ability to successfully climb down the front or back steps. Pain, and the fear of more pain, had made her a prisoner in her slightly elevated home.

Without saying anything, I drove to a nearby home improvement store. There I bought all the components I would need. Once back at her home, I spent the remaining hours of daylight installing sturdy railings leading down from her front porch to the walk below, and easy to grip handrails down from the back deck to the back yard.

Suddenly, my mother was once again free. But the year she spent in captivity was burned into my mind. My fault. My stupidity. I had no clue, because I had never known that kind of failure. And she was too proud to admit she was afraid or to ask for help.

I write this because my mother is not remotely an isolated case. There are millions of homes in our country where aging parents and other occupants face steps needed to exit from their homes. These are steps they no longer have confidence or strength to negotiate. They also face life with a bewildering array of technology with which they have never felt comfortable. Bathrooms have become dangerous places.

Their own second floors and basements are no longer even accessible to them. They must sometimes grope their way through a fog of confusion just to accomplish daily tasks that were once mundane and second nature. All the while they remain silent, because they don't want to "be a burden" and ask for help.

Some problems they face cannot be helped. But many can, with the simple installation of equipment and hardware, or a few modest changes in routine. This writing is to familiarize others with problems faced by our aging population and possibly ourselves, along with suggestions on how to mitigate these issues in our residences.

Because someone needs to remove the invisible bars.

THE SCOPE OF THIS WORK

Every design or building issue dealing with the disabled or handicapped cannot be dealt with here.

Massive laws have been passed for the purpose of guiding design decisions for buildings intended for use by the disabled. Many of these focus on commercial buildings financed with taxpayer funds, institutional projects where users regularly come when facing health challenges, and multi-family housing of various types, possibly used for occupancy by the elderly.

Where published guidelines for public facilities cross building types, I will touch on them. Since pictures are worth more than words, where possible, I will include graphic illustrations of guidelines from the United States Access Board. Understanding the intent of such rules can at least open a glimpse into similar issues also faced in less public settings.

My focus here, however, will be on private residences. Millions of private homes are becoming more difficult to use as we age. Aging-in-place simply refers to the desire to stay in a familiar home as long as possible in life. According to the Center for Disease Control, it is "ability to live in one's own home and community safely, independently and comfortably, regardless of age, income or ability level." The easiest way to do that is to adapt the living facilities to changes in physical capabilities anticipated to arise.

Otherwise, our beloved homes can slowly become prisons. And according to the AARP, over ninety percent of polled seniors want to stay home as they age. This obviously creates challenges for their children.

My intention with this course is to look at what can be done to make it possible to stay in our homes for as long as possible, despite the debilitating effects of advancing age. I wish to demystify what is needed to age-in-place, rather than in an institutional setting. And to hopefully do so, while not driving our children crazy with concern for us.

PROBLEMS TO BE EXPECTED WITH AGING

We have a long history of aging, pretty much since the beginning of time. It is no longer difficult to predict what will happen in our lives and bodies as we add to our years.

Balance will become a significant issue. This problem can arise from a loss of physical strength, effects of different medications, cognitive and visual impairments. Without thinking through a strategy to prevent or at least minimize falls, an issue with balance can become a significant health hazard. It's a really good idea to periodically determine if loved ones (or you) can safely do these:

- Climb up and down stairs with confidence
- Stand and sit down again on chairs, beds, toilets, etc.
- Get into, bathe and safely exit bathtubs and showers
- Drive and return from destinations, from a standpoint

of both physical and cognitive capability

- Bend down and pick up items from the floor or lower shelves
- Easily carry items like grocery bags and laundry baskets
- Successfully use public transportation
- Keep the home and property clean
- Properly use all appliances
- Manage personal health

A consequence of deciding to stay at home, whether alone or not, is the strong possibility of home accidents. Depending on the severity of the accident and whether injuries occur, if someone falls, they may not be able to get back on their feet. Cognitive issues like dementia can lead them away, but not necessarily back home. Extended periods of solitude, especially around holidays and in periods of inclement weather, can foster feelings of depression. In the presence of confusion and absence of assistance, medication use can turn dangerous when ignored, taken in excess or inadvertently combined with other medicine. Limited mobility leads to other issues like avoiding grocery shopping or failure to make scheduled health appointments. There are also various health conditions like strokes or Parkinson's disease where the victims can simply no longer function alone.

The trick lies in making such assessments, without letting the person you love realize that you are thinking about making changes in their lives. Regardless of the peace-of-mind such changes may bring to you.

Even if your loved one will allow you to make changes, it's a very good idea to ease into them gradually. Prioritize the changes you (and they) feel will be beneficial and set a time frame to implement them.

Discuss options and let the resident choose which ones will best meet their needs. Then accomplish agreed upon tasks in portions. Give those you love a chance to adapt to a few changes, before the next set is implemented.

If all that sounds like it will be easy, it won't.

EXPECT RESISTANCE

Don't Expect Gratitude:

Sometimes we just do what we have to do, regardless of the resistance faced. But don't expect aging loved ones to be grateful when we suggest or implement changes in their lives. Excuse me while I slip into my increasingly familiar role of an aging adult for a moment.

No one likes to change, not even us. We have set routines, set ways to do things, habits we cannot break if we tried, and even ways we've developed to do things based on many, many years of experience learning to get it right. Regardless of whether another way seems like a better choice to you, if we haven't decided on the necessity of change ourselves, it will most likely be nothing doing.

No one likes to admit they can improve or be improved, not even us. If we felt like there was a better way to accomplish something, we would already be doing it that way. What we generally don't care for, is someone younger than we are, telling us how much better they can make our lives. Especially when they are our children.

We don't really intend that anyone should decide for us, which of our possessions we will need to eliminate in order to declutter. What we own, we own for a reason. We'd rather take chances with falling than give that priceless item away. Store it in another place for a while? That's ridiculous. Why pay for storage when we can just keep storing it here?

No one likes role reversals, not even us. When we have been in charge our whole adult lives, we don't expect to have anyone dictate anything to us. We are the decision makers and problem solvers in our relationships. We have years of experience and hard-earned wisdom on our side. If we want your advice, we will ask for it.

No one likes admitting they need help, not even us. We have spent lifetimes helping others who need it. We have little interest in feeling helpless, tired, weak or damaged. Because in our minds, we are still strong, twenty-year-old problem solvers. To admit otherwise, will be to acknowledge the coming end of our time. Do we need help?

No, but thank you anyway.

Graduated Change

The best proven approach on how to get aging loved ones to let others help, is to implement changes in phases. Really! These are based on stages and correspond with phases of the aging slowly coming to terms with the idea that, somewhere along the line, agility has been traded for wisdom.

Phase 1 – Fairly Unaware:

At this point, while others may see problems developing, the resident does not. There is no motivation for them to live any differently than before. They won't discuss the issue, seek out information or acknowledge any need. At this point, there is no point in attempting to implement any changes.

Phase 2 – Pondering:

The resident is becoming aware that maybe, just maybe, problems are surfacing that it might be possible to counter. Maybe something should change. This realization is often triggered by a bad event, like a fall with injuries. Now the resident is at least open to discussing options and specific solutions to the things they now perceive to be issues.

Phase 3 – Implementing:

At this point, residents are ready to make changes and modifications. If changes are implemented gradually, resistance to them will be lessened. No more changes than are absolutely required should be made. It's not a bad

idea to discuss beforehand, what trigger events should precipitate which changes. Everyone should be aware that sometimes, necessary changes in one space may involve taking room from one that is adjacent.

Phase 4 – Maintenance:

Residents are beginning to even make changes in their behavior. Whatever will be necessary to maintain their status quo and remain at home. They realize a worsening of their situation might make that impossible. At this point, they will accept almost any changes that hold out hope. This is usually a point no one wants to reach. Winning probably wasn't worth it.

exam questions...

1. **Illustrated guidelines for handicapped access to public facilities were published by the _____.**
   a. National Handicapped Institute
   b. Center for Disease Control
   c. National Council for Aging-in-Place
   d. United States Access Board

2. **_____ is not one of the tests used to identify issues with balance.**
   a. Easily carry items like grocery bags and laundry baskets
   b. Successfully walk along the edge of a curb
   c. Properly use all appliances
   d. Climb up and down stairs with confidence

3. **Limited mobility can result in _____ and _____.**
   a. Failure to make health appointments, avoiding grocery shopping
   b. A sedentary lifestyle, no continued interest in golf
   c. Avoidance of visitors, loss of interest in family meals
   d. Increased fixation on herbal supplements, replacement of a primary physician

4. **When suggesting changes be made for aged loved ones, don't expect to encounter _____.**
   a. Gratitude
   b. An offer to pay for them
   c. Regulatory resistance
   d. Schedules with room in them

5. **_____ is one of the expected phases of the aged coming to terms with a need for change.**
   a. Despair
   b. Eagerness to move to the next phase in life
   c. A reasonable budget incorporating costs for renovations
   d. Pondering

POTENTIAL CHANGES AHEAD

Now you've been warned, how difficult and thankless your new role might be. Nonetheless, the whole experience of an aging population occupying a living environment will be examined here. We will systematically explore areas where concerns arise in navigating our environments as we age. This will be followed by known standards, the intent behind their development and possible solutions to the problem being discussed.

Items in italics that are underlined are basic starting points for modifications most likely to be needed.

Those items which are only italicized represent the next tier of changes also useful for aging-in-place.

Those items in normal print are good ideas for various reasons, but a bit lower on priority lists created by limited time and expense.

OUTSIDE THE HOME

Unless they don't intend to participate in life anymore, residents will sometimes need to leave their homes.

Public Transportation:

If driving has become impossible, then access to, and an understanding of, public transportation will become important if life is to be lived as fully as before. Public transportation has the potential to be reliable, predictable transportation for aging residents to get to necessary basic services, when they are too far away to walk.

Basic services needing to be accessed can include, but not be limited to; health and wellness locations like community recreation centers and parks, medical facilities and pharmacies, social and spiritual opportunities like libraries, worship, community services and educational opportunities, as well as healthy food options like grocery stores, farmers markets, restaurants and community gardens.

Walking is the oldest method of accessing needed services outside the home. It is still a reliable method and one that brings side benefits for health if done safely and often. If residents are willing to do so, the shortest walking distance with safe and accessible walking routes should be scouted out ahead of time.

When walking is not possible due to climate conditions, or simply no longer feasible, options exist to utilize various types of public transportation. It should be easy to access these services. Wayfinding signage should be located along normal walking routes, identifying transit hubs. Make sure transit hubs are clearly identified, exactly as they are marked on available transit maps. Make sure any caregivers are familiar with public transit routes, schedules and hubs.

Public transportation stops should be welcoming places, well-lit and offering a climate-protected place to rest while waiting. If they do not fit that description, it never hurts

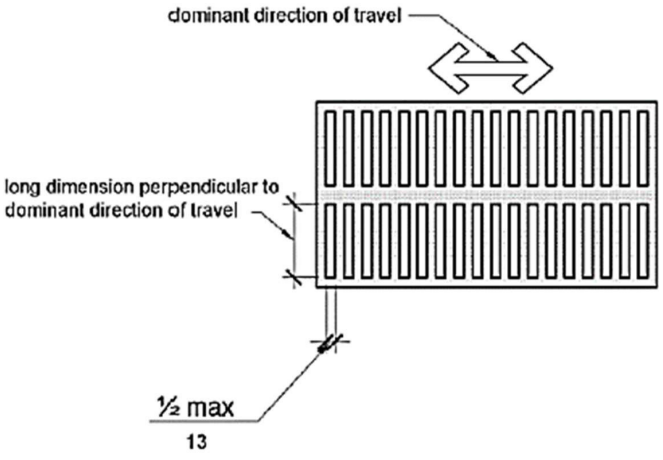
to ask your city to upgrade public transportation stops. See if they will include a bench, a structure for shelter or shade, a clock and a place to post schedules and maps.

Utilizing cabs and ride-share services is another means to access needed services. Help residents locate a convenient place close to their home to enter taxis and shuttles. This will preferably be a spot that is safe and has no curb. Even better if there happens to be covered seating adjacent to that pickup area.

Pick a Walking Route:

Evaluation of any walking route should include checking each step along the way. Are curb cuts in place on a chosen route to eliminate possibly painful step downs and step ups? If not, is a different route an option without adding excessive additional length? Are slopes in the route easily navigated? Steep slopes are painful to hips and knees. Is there comfortable separation or landscape barriers between the walk and fast- moving traffic? Is the path one the city maintains as snow and ice free? Are there any grates with openings along the way that could present a hazard to canes, walkers or even mobility-assist devices with thin wheels?

I mention grates because of a personal experience. Wheels from an older ten-speed bicycle are pretty much the same width as those on wheelchairs. Crossing a grate transverse to the directions of the slots presents few problems. Encountering one at night, while riding parallel to the direction of the slots, makes for an abrupt stop and road rash. The same danger exists when crossing them with wheelchairs or similar devices. The grate openings also present a tripping hazard for canes. Crossing such manhole covers is probably best avoided.



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Grate Openings with Potential Harm

Walking paths should be safe to traverse. Paved surfaces should have slip resistance designed in, with preferably at least a stiff broom finish. Paths should be slightly sloped to one side so water falling on them will drain away. Walking surfaces should be free of defects and easy to navigate. Sidewalk cracks or broken concrete can be deadly. Transitions between paving materials should be smooth.

Pathways leading into a building or transit hub shelter should be at the same plane as the floor. Crossing areas should be easy to negotiate. It's not a good idea if other potentially incompatible uses of the walkway, such as use by bicyclists, exist.

Walking paths should be easy to navigate. Simple routes between home and destination are the easiest to follow and least likely to be forgotten. The entire path should always be well lit. Gravel pathways are a poor choice, as they are difficult to walk through and impossible to roll through. Sidewalks should connect along the whole route. No detours into streets, or walking in streets, should be necessary.

The width of sidewalks controls the traffic on them, especially when wheelchairs are involved.

- 3 Feet: Single user
- 4 Feet: Two people can walk side by side
- 5 Feet: Two wheelchairs can pass
- 6 Feet: Two wheelchairs can travel together

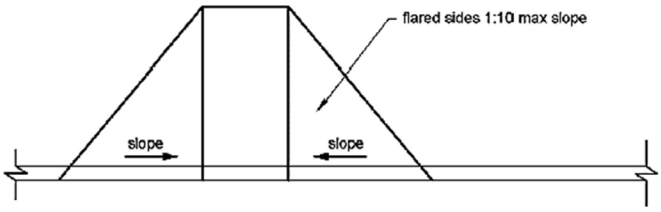
If possible, choose a walking route where the need to navigate steps can be absolutely avoided. But if stairs are in the route, they must have handrails. They should also have rounded edges instead of metal grate surfaces that easily create injuries in falls. Slip-resistant strips in contrasting colors on the edge of each stair tread is a bonus. It is always a good idea to provide weather protection for exterior stairs, if you have that capability. Exterior stairs should have risers no greater than six inches tall and treads no less than twelve inches deep.

Walking routes should be user friendly. If intersections must be crossed, are there crosswalks? Better yet, can walk signals be triggered on demand? Acknowledging that not everyone follows traffic laws, these are nonetheless welcome measures of safety for pedestrians. If the route is of any length, are there resting places available along the way? No matter the path taken, routes should all be wheelchair accessible in terms of width, surface and slope. If a ramp must be navigated along the way, it should have handrails, especially when a fall to a lower surface or landscaping is possible. A brightly colored strip should be at the edge of any surface beside a change in plane. This will alert walkers and wheelchair users to any potential change in plane. Similar changes in color can be used to designate roadways from walkways, with yet another color used for crosswalks.

Regardless of how it is accomplished, people should have a way to get outside and reconnect to the outdoors. This can be done in either public or private outdoor spaces. Just the ability to escape from a house that can quickly become confining, alleviates feelings of helplessness. Besides, daily access to fresh air and sunshine are welcome additions to a health regimen.

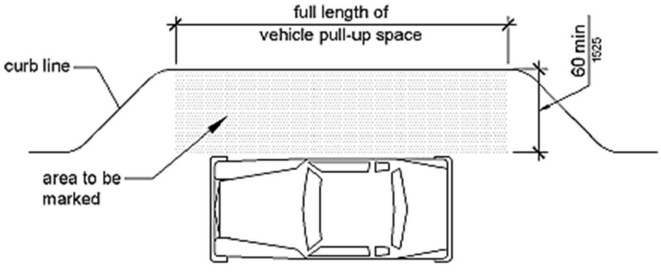
Outdoor Car Parking

Parking for older residents should be near their homes, the closer the better. Ideally this will be attached to the home, either under a carport or in a garage. But in older established homes, it may likely be street parking. In multi-family housing or congregate living facilities, parking lots will be used. In any event, curb cuts and sloped surfaces like the one shown below are desirable to eliminate the need to step up and over level changes like curbs.



Curb Cuts for Ramps from Parking

If a resident will be using public transportation like ride share services, taxis or busses, pull-up spaces are needed. These can be designed into congregate living and multi-family complexes. Some are just created by default, as when a bus or taxi pulls up alongside a curb cut and blocks traffic while passengers are loading.



Passenger Loading Zone

Provided parking spaces should have plenty of space and few obstacles. When these are provided and a resident must pull into covered spaces past columns and perhaps defining walls, hanging lightweight obstacles like tennis balls, touching the windshield at the right time, provide a good cue to determine when to stop.

Regardless of whatever other entries are being accessed, parking spaces should allow easy admission to a front entry on the main floor, preferably without navigating steps. The path from a parking area to the front door should always be paved. This sounds obvious, but residents should not have to walk significant distances in a parking lot or street to get to an access point allowing them to avoid a raised curb. If the front entry to the residence is raised higher than the parking area and walk, a sloped walk or ramp will be needed for access to the higher level. Pavement leading from parking to entry should be maintained free of cracks and settling.

Site Lighting:

Fading eyesight is a problem suffered by a vast population. Many accidents experienced by the elderly could have been prevented by adequate lighting in areas they needed to traverse. Guidelines are readily available to establish proper light levels for various tasks, to ensure it is neither too bright nor too dim. Dim lighting making it hard to define obstacles and bright lighting creates glare. Both are undesirable.

One very effective strategy is to focus light specifically where it is needed, effectively creating task lighting outdoors. When possible, use lights placed lower and closer to the task instead of more powerful lights mounted above. Use shielded lights to direct the illumination down to the surface without creating glare in other directions. Lighting experts will also use step-down lighting levels between areas needing more and less illumination. This is because contrast between areas of low light and areas of intense light will make it difficult for eyes to adjust quickly enough. Be aware that elements in various lamp types render color differently and choose light sources / lamps that provide good color rendition. Rather then a continuous use of power, use motion activated lights in areas not often used at night, like dumpsters, walking paths, etc.

Adequate lighting is also a component of wayfinding. Lighted pathways can function as a navigation tool to direct residents back to their homes. Few people like wandering off on darker pathways, especially at night. When signage or numbers are used to identify buildings, light up that identification to keep it highly visible. Provide lights along steps, ramps or any other change in height. Finding these level changes sight unseen, is almost always a bad surprise. In a similar vein, make sure the transition from a sidewalk to an entry is lit well enough that the entry will not be bypassed.

Site Furnishings:

If done well and with forethought, furnishings in an outdoor space can redefine it as just another living area, enticing residents out into fresh air. When outdoor gathering areas are being designed, just don't place them on sloped surfaces. Wheelchairs are hard to stop or start when gravity is in play. And a space large enough to accommodate a wheelchair should be at one end or the other of exterior seating. Besides wheelchair spaces, site furnishings should create places where walkers or talkers may sit, rest and catch their breath. Shade trees, canopies or shelters are used to create shade to protect those sitting from the sun, sunburn, wind or precipitation.

The ability to reconfigure any space, include outdoor gathering areas, increases the usability of that area. Moveable seating that is still heavy enough to resist scooting away from users is ideal to allow flexibility of use. Armrests on such seating are valuable to assist in rising or sitting. Seating should also have backs when possible. For easy use by the aged, seat heights for chairs should be between seventeen and nineteen inches high, with a seat depth of no more than twenty-four inches.

Other amenities can increase the attraction of outdoor spaces. If the tops of low walls enclosing planting areas are at seat height and wide enough, they can also be used for additional seating. If tables are used, they should be between twenty-eight and thirty-four inches tall with a minimum of twenty-seven inches of space below them for knees. There should be a clear floor space beside them to allow a wheelchair to approach. The outdoor space will remain far more enticing if waste receptacles are provided near outdoor seating areas.

exam questions...

6. **If life is to be lived as fully as before, public transportation will become important when _____.**
   a. The cost of driving outweighs the benefits
   b. The ability to park at typical destinations has become prohibitively expensive
   c. The task of driving has become impossible
   d. The physical condition of deteriorating roads results in too many repairs to residents' cars

7. **_____ are used to eliminate a need for possibly painful step downs and step ups.**
   a. Curb cuts
   b. Mobility-assist devices like Segways
   c. Paving materials graded absolutely flat
   d. Small, lightweight personal ramps

8. **Exterior obstacles that can prove to be hazardous to canes, walkers and mobility-assist devices are _____.**
   a. Thorn bushes
   b. Curb cuts
   c. Grates with openings
   d. Sloped pavement

9. **How wide do sidewalks need to be before two wheelchairs can pass one another?**
   a. 3 feet
   b. 4 feet
   c. 5 feet
   d. 6 feet

10. **The flared sides of a curb cut should have a maximum _____ slope.**
    a. 1:10
    b. 1:12
    c. 1:4
    d. 1:8

11. **Using outside lighting focused specifically where needed effectively creates _____.**
    a. Task lighting
    b. Universal illumination
    c. High contrast areas
    d. Lower utility expenses

12. **Outdoor gathering areas should not be placed on _____.**
    a. Concrete with broom finishes
    b. Plazas with flowering bushes
    c. Surfaces known to retain heat
    d. Sloped surfaces

Landscaping:

Careful landscaping of a site is a means to create beauty. Unfortunately, it can also accidently create hazards for the aging.

After landscaping is finished, it will still be necessary to move through a site. On a sliding scale from poor to good, pea gravel is the worst surface for mobility, followed by grass, pavers as an average surface and finally, rough concrete as the best option. Provide hard, slip-resistant surfaces on which to navigate through the outdoors. Grass and gravel are tripping hazards and difficult for mobility assist devices. Walks made from materials like flagstone are beautiful, but natural paving materials are not always uniform in size. Make sure uneven surfaces don't create tripping hazards. When using any pavers, small gaps are easier to navigate than large gaps between them. When creating them, mark the edges of walks or ramps with a contrasting color.

Some landscape materials are more user friendly than others. Avoid using metal landscape bed edging, as this is hard to see and can cut the unwary. Use bulkier materials instead. Exposed tree roots in walkway areas will obviously be a tripping hazard, but cutting and removing them will likely kill the tree. It's best just to reroute pathways so roots are not exposed or disturbed. Though it interrupts views and landscaping, fencing around property, especially in the rear of the home, can help easily disoriented users maintain a sense of privacy and stay inside safe boundaries.

Plants used should be chosen for what they will add to the user experience. Shade trees along a walkway are a welcome relief on hot days. Unless allergies come into play, flowers are always delightful. Shrubs in front of a home help soften the transition between building and land, but don't plant shrubs in such a way that they obscure sight of an entry. That can create unease that an intruder may be hiding behind them. Don't plant shrubs that grow aggressively and will need constant pruning to maintain a clean appearance. Choose plants that change color to help track seasons, smell good, don't contain or emit known allergens, are not poisonous, don't drop seed pods on walk surfaces, don't attract pooping birds and don't attract unwanted pests, animals or insects. Running away from a stinging insect isn't much of an option for aging resident, and a rapidly escalating heart rate isn't welcome either. Any plants attracting bees should be located well away from points of entry.

Gardens:

If gardening has been a part of someone's life, suddenly not being able to do so can create a real sense of loss. But gardens present multiple dangers from maneuvering on loose soil (not even possible if a mobility assist device is needed) to issues caused by repetitive kneeling, bending and standing back up. The following elements added to garden areas can eliminate some of these risks.

Raised beds at various heights allow planting, weeding and

harvesting without excessive bending. Pathways between beds can even be paved and wide enough to allow a wheelchair to turn toward the planter. Recesses under planters that are higher than knees, allow better access for those in wheelchairs. Such raised planters should not be so wide as to limit the ability to reach from a wheelchair to the other side.

If planned for ahead of time, gardening can remain enjoyable well into the aging process. If the expense is not an issue, greenhouses can enable gardening all year long. A water source and a hose for watering plants should be nearby. One possible setup is the placement of a drip hose system above planters that waters everything below when the water is turned on. Tools should be near the garden area, so obtaining and returning them is easy. A seat or bench very close to the plants, is useful for resting. Even better would be a resting spot that incorporates some method for being shaded from the sun while doing so.

Given the potential for falls, weariness to set in and problems arising from heat, it is a good idea to make sure gardeners have a device on them to call for help, should that become necessary.

Private Exterior Spaces:

Since access to public outdoor spaces might be difficult for aging owners of single-family homes, let's briefly discuss getting decked in private.

An important contributor to overall well-being is use of an outdoor space where contact can be made with nature. Getting on and off patios and decks can be problematic as disabilities occur and problems increase. To begin with, to reduce risk of water seeping inside, existing decks and patios are often constructed one or two steps down from living levels, making them impossible for the physically impaired to use. If a deck cannot be constructed on top an existing lower patio, to create a new surface up near floor level, then a ramp down must be constructed to obtain access to that area. If a deck is constructed to bring the outside surface nearly to level, the edges of that deck will be high enough above the existing grade to constitute a hazard. Edge protection or railings should also be provided to prevent falls, even if the height difference is not enough to trigger a railing requirement by code.

Changes in levels is the problem to overcome. Ideally, interior and exterior surfaces would be at the same level, but this is very hard to accomplish. Accomplishing it would still lead to other moisture penetration issues, like melting snow alongside a sliding door flowing inside. If wheelchair access is important, a decent drop from the top of a threshold to an outside surface is best kept to a maximum of 1/2". Standard doors and French doors use a lower threshold than sliding doors. The latter often uses a threshold that is several inches high, which must then be climbed over by users. Tracks for sliding glass doors can be recessed down into floors, but this creates additional problems and pockets where water will reside, so it is rarely done. Small ramps are possible inside and outside a threshold to help transition over one with a mobility assist device.

While stepping over a threshold, or down onto a deck surface, it is easy to slip or trip. Surfaces of outdoor spaces should be non-slip, even when wet. If the surface material does not have this as a natural characteristic, coatings can be added to provide it. This type of treatment should also be applied to exterior stair treads. Whether on stairs or the deck, outdoor surfaces should be self-draining to prevent accumulation of ice. Uneven surfaces or those containing raised edges will present a problem when using canes. The matrix below compares exterior deck and patio surface materials based on care, hazards in use, and ease of mobility.

Material	Cost	Ease of Care	Hazards			Ease of Mobility		
			Least Glare	Slip Resist	Trip Resist	Feet	Walker	Wheel chair
Synthetic Decking	Mid	Med Maint	High Glare	Low Slip Resist	Low Trip Resist	Hard	Hard	Hard
Wood	Mid	High Maint	Med Glare	Med Slip Resist	Low Trip Resist	Medi-um	Hard	Hard
Pavers	Low	Low Maint	Least Glare	Med Slip Resist	Low Trip Resist	Medi-um	Hard	Medium
Concrete with a broom finish	High	Low Maint	High Glare	Med Slip Resist	High Trip Resist	Easy	Easy	Easy
Traffic Coating	Mid	Med Maint	Med Glare	Med Slip Resist	High Trip Resist	Hard	Medi-um	Easy

The use of outdoor spaces by the aged is often predicated on how safe it feels to do so. Decks set outside the exterior plane or face of homes are felt to be less user-friendly than porches and alcoves recessed into the mass of the building. There is something comforting about partial enclosure. When even a slightly raised surface has no railings or obstacles around the perimeter, those open edges off which a wheelchair or walker can roll make users uneasy. Perhaps this is why, sometimes a view is offered in lieu of a deck. A railing across a balcony door, even with no balcony outside, will offer similar views as a balcony and give the impression of access to an outside space.

Exterior Wayfinding:

A not so true story (I think) is told of an elderly gentleman, sitting and sobbing on a park bench. A sympathetic policeman stops to ask him what is wrong.

"I can't go home."

"But why? Mortgage issues? Rent problems?"

'No! I own my house outright. And it's a beautiful comfortable home."

The policeman frowns

"Okay? Did you get into an argument with your wife?"

"No. She still looks like the beautiful twenty-four-year-old I married forty years ago. Still as loving as ever. Still a great cook."

Now the policeman is getting irritated.

"Well it sounds like you have every reason to go home. What's the problem?" "I have no idea where I live."

No matter how may amenities you have in your home or reasons to go there, if you can't find your way out and back home, you will quickly learn not to leave it.

This is a true story. I have a sister who once lived in a neighborhood comprised of many homes built after WW2. They were all very similar in appearance. One evening, while her husband was at work, a very drunk neighbor quietly eased in her front door, laid down on her couch and promptly went to sleep. Even without alcohol involved, correctly identifying a residence from many others that look similar, can be difficult for those with any memory issues.

Exterior identification or wayfinding markers are welcome additions to neighborhoods. Large maps posted outdoors, showing the neighborhood and nearby points of interest, are an amenity enjoyed by many. The signs used should have large text, few words, symbols and color coding. If they are used outdoors, light the signs up to be visible at night. In lieu of signage, recognizable and consistent landscape features can be used to help identify locations and features.

Building Exterior:

What is chosen for exterior cladding materials becomes important, because many maintenance activities traditionally associated with home ownership will become increasingly difficult or impossible as aging occurs. With new homes, material choices are easy. Changes to existing homes are difficult, but if they can be done, the following criteria should be considered. *Exterior materials are best if they are low maintenance, requiring little ongoing effort to keep looking good. Examples include brick and vinyl siding. Plants and shrubs around the home should also require little maintenance to keep looking good. They should be slow growing and remain compact.*

Accommodating Pets:

Companionship of an animal, especially if that has been a constant in previous years, is an excellent way to overcome feelings of loneliness or isolation. But pet ownership does create its own set of concerns, when mobility and strength become limited.

Accessories are a key part of making pet ownership easier. *Automatic pet feeders are a great feature.* A lightweight, easy to use vacuum can be purchased to easily remove shed hair. A cat box on a raised platform or shelf makes changing kitty litter much easier. A waste receptacle with wheels or castors near a litter box is helpful as well. A raised utility tub is useful to bathe pets without stooping. A secure place to tether animals in place while bathing them can also be provided.

Be aware that when walking a large dog, if the animal decides to leave the vicinity in a hurry, despite an aged owner holding the other end of the leash, someone will get hurt. Better to have a dog run built so the animal has access to some freedom, grass and the outdoors. If an animal can be trained to go to the bathroom on a concrete portion of such a run, a hose can periodically wash the mess left behind, off onto nearby ground. A dog door leading directly into such a run is very welcome on days of inclement weather.

Outside the Entry:

The area directly outside the main entry, for various reasons, seems to be a prime place for accidents to happen. These can be minimized by making some of the following changes. *If possible, eliminate steps leading to entries. There should be at least one handicapped accessible path into the home, involving no level changes. Keep approaches to the building free from debris, loose building materials, rocks and clutter. The entire pathway from a car to the front entry should be well lit. Secure handrails should be on each side of any steps.* Paving near a residence can have radiant or hot water heating systems installed to easily melt ice that accumulates on it.

Other changes center more on process of entering. *A minimum thirty-six-inch-wide entry door will provide the necessary thirty-two inches of clear passage through the entry. A motion sensor light should trigger when the resident approaches and be aimed to adequately light up the entry lock. The doorbell should be in an obvious accessible location.*

exam questions...

13. **_____ is an exterior surface considered to be the worst for mobility.**
    a. Pea gravel
    b. Concrete with a stiff broom finish
    c. Cinder block with minor gaps between
    d. Permeable paving

14. **Plants that _____ should be located well away from points of entry.**
    a. Produce poisonous berries
    b. Attract bees
    c. Have thorns
    d. Stay compact as they grow

15. **Raised planters in gardens should not _____ .**
    a. Be too wide to reach across with a wheelchair
    b. Contain plants that cross pollinate
    c. Be made from base materials which rot
    d. Be cost prohibitive to construct

16. **To permit wheelchair access, a drop from the top of a threshold to an outside surface is best kept to a maximum of _____ .**
    a. 1 /4″
    b. 7 /8″
    c. 3 /4″
    d. 1 /2″

17. **As a flooring surface, pavers are considered to have _____ and _____ .**
    a. High maintenance, high glare
    b. Medium glare, high trip resistance
    c. Low maintenance, low trip resistance
    d. Medium maintenance, medium glare

18. **Large maps posted outdoors are considered as a component of _____ .**
    a. Establishing neighborhood boundaries
    b. Wayfinding
    c. Marking political districts
    d. Locating available real estate

19. **_____ is an important criterion for choosing exterior building materials as aging occurs.**
    a. Low levels of reflectivity
    b. Low maintenance
    c. Resistance to insect infestation
    d. Colors complimentary to the neighborhood

20. **A cat box _____ makes changing kitty litter easier for the elderly**
    a. With an attached scoop
    b. With a lid to control pet access
    c. Already inside a trash container
    d. On a raised platform

21. **If possible, _____ should be eliminated leading to entries of homes.**
    a. Doors containing keyed access
    b. Wind chimes
    c. Steps
    d. Parking spaces

COMMON AREAS IN MULTI-FAMILY

While living units in multi-family settings are not the primary focus of this course, they do need to be discussed, since they provide housing for many who no longer feel comfortable living alone. Layout changes are not generally possible in individual units in these buildings. But the common areas can be changed by managers. These are typically spaces for security purposes, restrooms, exercise functions, wellness needs, shared spaces for social activities, fellowship or recreational opportunities, offices for building management and services such as trash collection, mailrooms, laundry, coffee areas, libraries and kitchen / dining areas. These are all connected with horizontal travel spaces like corridors and vertical transportation like elevators, acting as streets through the community.

We will briefly examine these shared spaces, one function at a time.

Circulation – Lobby:

A lobby should provide a core function of building security, allowing residents inside but preventing unwanted visitors from entering. This can involve intercom systems where residents buzz in expected visitors after being contacted. It can also involve keyless entry by means of proximity readers that detect authorized entry cards. Understand that every type and level of security creates its own problems for forgetful residents. But as these buildings often house a vulnerable population, some security will still be needed. That may even require a staffed front desk.

A lobby should accommodate a visitor / resident waiting and visitation area. This would be a place where residents can even conduct business with visitors without inviting them into their living spaces. Comfortable seating and tables should be in the space, with plenty of room available for maneuvering around them. Lobbies should have clusters of seating to facilitate small group gatherings and social interaction. They should have comfortable seating on which to wait, with a good line of sight to both a front desk or front office area and any outside transportation pick-up area. The front doors should be in sight and offer a clear view of approaching visitors. Having other public gathering spaces, like coffee area or lounges, encourages social interaction between residents

The lobby should be a prominent place to obtain information. Bulletin boards can be used to post info on sales items, local events, needs of residents and so forth. Public transportation schedules and numbers to call for information can be posted here, as well as maps of surrounding areas to be used for quick reference before leaving.

Lobbies should have non-slip flooring that will not catch at heels or inhibit motion-assist devices. A grate over a recessed drain, or a walk-off mat in the front entryway, will help keep moisture from shoes off lobby floors during inclement weather. This will also reduce wear and tear on that flooring.

Interior Wayfinding:

In many buildings, it's easy enough to get lost by just failing to pay attention or encountering any form of distraction. Dimming eyesight and fading memory will make navigation to a desired location even more difficult, especially in large buildings with many spaces that appear somewhat alike. There are ways to make successful navigation a bit more probable.

Use consistent surface treatments for similar rooms or spaces with similar functions. These will provide visual and tactile clues as to what type of space a resident is entering. Color, large text and graphics can make finding destinations a bit easier. In a multi-floor building, having public spaces on each level themed in a different color can be very helpful in instantly determining on which level you exited an elevator. Distinctive furniture in the lobby off each elevator opening also provides visual clues as to which floor has been accessed.

Signage is always helpful. Large colored graphics and signage can be even more helpful at access points to each level and entrance. Graphic icons can be used to identify common community rooms and services. Make sure there is plenty of lighting to properly illuminate wayfinding clues.

Mail Rooms:

In most multi-tenant buildings, there will be some central place, usually near the lobby, where residents come to pick up mail that has been delivered to them. The mail area should be very visible from management offices and from the waiting area. As there will be peak times when residents come for letters, there should be plenty of room to maneuver inside such a mail pickup space.

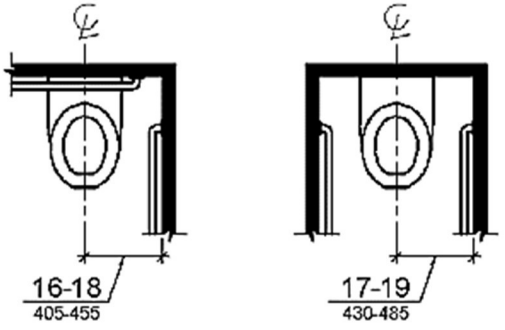
Mailrooms will function best if hardware and equipment in them is designed with aged users in mind. All mailboxes should be easily accessed from wheelchairs. There should be shelves to set mail and packages upon. Locks and hardware on individual mailboxes should be easy to operate. Parcels needing to be mailed out should be able to be placed in a secure bin to await pickup by delivery services. Finally, in an age where residents are inundated with unwanted mailings, a recycle bin in the mailroom area is a handy place to dispose of junk mail before transporting desired letters back to a living unit.

Administration Offices:

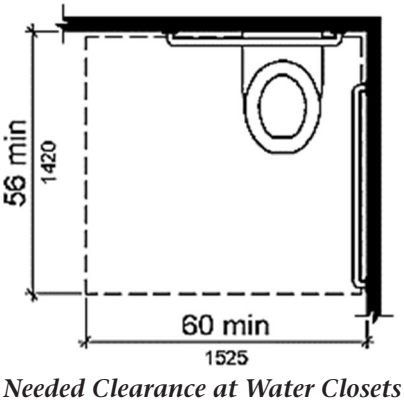
Spaces for building administrators or support staff are often needed in multi-tenant buildings. If they are used, administration offices should have a clear view of the front entry and have excellent visibility of the lobby. This can be accomplished with windows or even half walls open to other common areas, like mailrooms, elevators and dining areas. Signage should clearly identify the office area to both residents and visitors. Finally, seating should be provided near offices for residents or potential residents, waiting to meet with staff.

Common Restrooms:

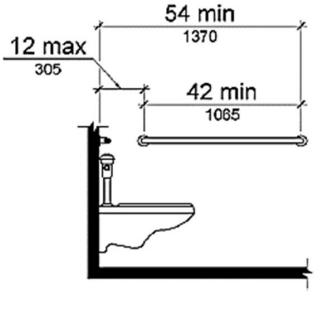
If residents in a multi-unit structure are expected to interact with each other in gatherings, a necessary amenity will be common restroom facilities. Those suffering from incontinence will avoid public gatherings and other opportunities for socialization, if quick access to toilet facilities is not an option. Common restrooms should be as close as possible to other amenities used as gathering spaces to reduce time needed to get to them.



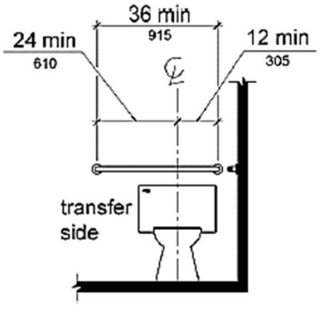
Water Closet Locations



Needed Clearance at Water Closets



Side Wall Grab Bar



Rear Wall Grab Bar

It goes almost without saying, that restrooms for common use in buildings intended to serve the elderly, should be designed in full compliance with guidelines for handicapped use provided by the ADA. The diagrams above give a good indication of needed floor space and preferred locations of support bars placed in toilet facilities to facilitate use by the handicapped. Making several accessible, single use, unisex restrooms is often a better and more private use of space than traditional restrooms for each gender containing multiple stalls. When installing such toilet rooms, doors should be designed to swing out. This is so staff or a family member can get inside the room to help, if a user has fallen while inside. In any event, call buttons for help should also be provided inside restrooms.

Storage Areas:

In dealing with gatherings of an aging population, there will always be items that will have been left in private rooms that residents wish they had remembered to bring with them before arriving. A common storage space will go far to eliminate the need for residents to make multiple trips back and forth to their private spaces for small things. A storage closet near the lobby can be used to store often needed items like mobility assist devices, power cords, evacuation chairs, phone chargers, etc.

On a larger scale, there will also be a need in multi-tenant buildings for longer term storage. Residents will periodically need to eliminate belongings to reduce clutter and open more floor space for maneuverability. There will be possessions carrying deep significance for the owners and they will not willingly, permanently relinquish those items. Even knowing they will likely never get to use them again, they will want them stored nearby, just in case. If storage spaces / units are provided in a common facility, on-site or nearby, that are accessible only to residents, locks and hardware should be easily understood and easily gripped. Carts, dollies or some other method of transporting goods from storage unit to living unit should be provided for use on a temporary basis.

Even a place to store seasonal decorations will be valuable to an aging population.

Common Dining:

Eating together in a shared meal must be the absolute oldest form of communion and bonding. In multi- tenant buildings, this community function can be met in spaces ranging from full kitchens and dining rooms created for provided meals or community potlucks, to small cafes and coffee house type spaces. With nearby storage and built-in flexibility (and staff to rearrange furnishings) these can be multi-functional spaces also usable for anything from movies to crafts, card games and other social activities. When not used for eating, classes can also be conducted in these spaces for subjects like nutrition and healthier cooking. As with any other space where mobility assist devices may be used, there should be plenty of space around furniture that has been set up.

Laundry Facilities:

Because it becomes a good place to visit with friends, another heavily used area is a community laundry room. This space should be provided in a convenient location. The entrance should be capable of being opened without the use of hands. Given that water and soap will be present in abundance, non-slip flooring is important in this room.

Machines should be arranged in a laundry for the aged, somewhat differently than those found in commercial facilities. Machines should be easily accessed without bending over. If machines are front loading, they should be raised off the floor on a platform. Machines should not be clustered by function, but rather grouped by process. They should be placed in a linear fashion by task, with a wash tub, followed by a washing machine, followed by a dryer, then by a folding table or counter and rods on which to hang warm clothes to minimize wrinkles. It should be very convenient to move clothes down the line in the process. Rods for hanging clothes should also be low enough to be accessible from wheelchairs.

Accessories should be in such rooms that are useful to the elderly. Wheeled laundry carts, incorporating storage below and a rod above, should be available to transport laundry to and from residents' rooms. Countertops for folding clothes should be at different heights to accommodate working while standing, seated or while seated in a wheelchair. These counters are best located at twenty-eight and thirty-four inches above the floor. The work should be capable of being done in a seated or standing position. Since the generation being referenced still believes in using them, pull-out ironing boards housing community irons can also be provided in this room. For all jobs, there should be task lighting over work areas, located so shadows are not cast on the work being done.

A large component of using such a space is the potential for socialization. Either in the laundry room or better yet, in an adjacent space, there should be comfortable seating and entertainment in the form of television or reading materials. That way, residents can pass time waiting on clothes and visiting with others. This is a good place to house shelves for a book exchange. Laundries are also excellent places in which to place bulletin boards for posting event information.

Community Room:

Loneliness is an ailment far too common in an aging group. If a space to do so is provided, participating in community activities can ease feelings of loneliness and isolation.

A centrally located space can be created to house activities as diverse as watching movies or sporting events, organized discussions, playing cards, doing crafts, attending classes or just engaging in mixers or social events like dances. The key to actively utilizing such a

space is making it as flexible as possible for as many uses as possible. This will likely entail storage space adjacent to the community room, and staff to rearrange furniture as necessary. Furniture in the meeting area should be placed in such a way to provide either privacy or a choice to join small groups.

With any such space, successful use of it will depend on it being designed to be useful. There should be a lot of visibility into this space, possibly with large windows between it and hallways. Ample natural light and artificial light should be provided for users. There should be plenty of room to accommodate mobility assistance devices. Separate temperature control for this space is probably a necessity. If not already done elsewhere, this is another excellent place to house a community library.

Fitness Center:

Exercise is by far the best and most recommended preventive measure to slow down, and sometimes reverse, deterioration of bones, tendons and muscle tissue. Common rooms for moderate exercise will be used, partly to fight deterioration, but also because needed exercise is much easier to do when meeting others to whom you make yourself accountable. But … given tendencies toward inadvertent injuries of joints and muscles, equipment within, and recommended exercises in an area set aside for fitness, should be designed and chosen by a professional.

Walking the long way to destinations in corridors or limited climbing of stairs (if residents have the capability) are also excellent ways to obtain exercise.

Smoking Area:

There still exists a generation that was taught that smoking cigarettes was cool and just not informed of their addictive nature until it was too late. They will be present in multi-tenant buildings and still needing to indulge that habit. Provide a separate area for their use, with no return air to the main system and a direct exhaust to the exterior. Provide entertainment and comfortable seating inside the space. That way, those who smoke can do so in comfort, without their smoke disturbing others with breathing issues.

exam questions...

22. _____ and _____ both act as streets through multi-family communities.
a. Laundries, ATM machines
b. Corridors, elevators
c. Concrete pavers, gravel paths
d. Lobbies, dining areas

23. Which of the following is not true of a lobby?
a. It's a good place to post transportation schedules
b. They should utilize non-slip flooring
c. Plants used in them should require minimal watering
d. They should permit small group gatherings

24. Color, large text and large graphics are all considered useful for _____ .
a. Establishing interior decorating themes
b. Warning intruders
c. Flooring surfaces
d. Interior wayfinding

25. In an age of junk mail, _____ are a useful addition to mail rooms.
a. Recycling bins
b. Shelves for sorting
c. Receptacles for packages
d. Armed guards

26. Which of the following is not true of common restrooms?
a. A lack of them discourages the incontinent from attending public gatherings
b. Several unisex bathrooms are preferred over those with multiple stalls
c. They should be in full compliance with ADA guidelines
d. They should contain long term storage for supplies like toilet paper

27. Items like mobility assist devices, power cords, evacuation chairs, phone chargers, etc. should be available for use in a closet near the _____ .
a. Lobby
b. Common dining areas
c. Waiting area off a laundry
d. Staff offices

28. Appliances in common laundry areas should be grouped by _____ .
a. Function
b. Process
c. Shape
d. Height

29. One common space used to slow down bone deterioration is _____ .
a. A common dining area with available meals
b. A covered front entry open to breezes
c. A fitness center for moderate exercise
d. A home theater with well-padded seating

30. A separate area should be provided for part of the general population to _____ in comfort.
a. Jog in loose clothing
b. Dance
c. Smoke
d. Practice yoga

INSIDE AN INDIVIDUAL HOME

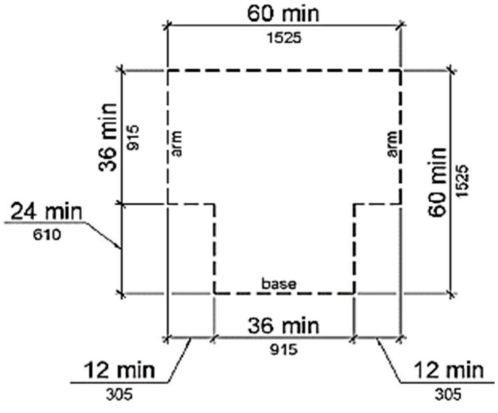
While preceding subjects dealt with overall concepts applicable to exterior concerns and congregate living facilities, the remainder of this course will deal with changes inside individual homes. This is because for most of our aging population, inside their existing homes is where changes will need to be made, if they have any hope of aging-in-place.

In General:

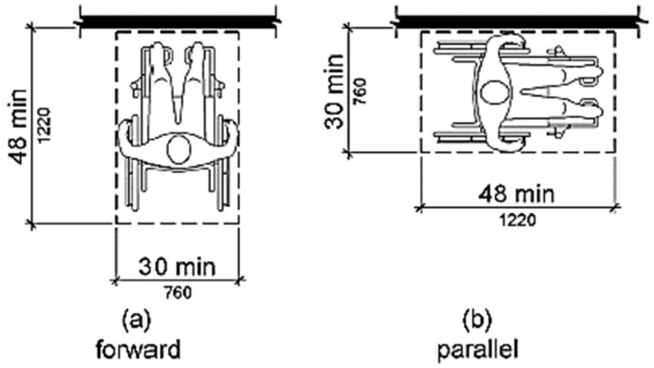
To better be used for aging in place, will be creating needed space in a building that is already full of a lifetime of treasures. But this will be a necessary first step. *Declutter the house and try to eliminate anything no longer necessary. This will free up needed space for circulation. Remove trip hazards from paths to be taken.* In the long run, any headway gained will be worth it for aging loved ones irritated at changes occurring in their lives. Easy ways to accomplish tasks like clothes washing or cooking, and practical solutions to challenges faced in bathrooms, can foster feelings of continued independence for residents aging-in-place. A second component of freeing up needed space is this. If help will be needed for certain tasks like bathing or cooking, make sure there is enough space to accommodate both the resident and an aide.

Space is the operative word in adapting a home to aging-in-place. Open plans allow for flexible use when mobility assist devices are needed. There should be multiple spaces with enough clearances in which a resident can turn around, if confined to a chair. *At a minimum, there should be a five foot by five foot turning area in the living area, kitchen, a bedroom and a bathroom. If it can be created, there should also be a 5 foot by five foot turning area at the end of a hallway. Better yet, can an extra wide hallway can be created without dead ends requiring a turn-around in tight spaces?* A side benefit of opening and freeing up space is the creation of more clear lines of sight. These allow caregivers and residents to stay in visual contact, often a source of comfort to both. An open line of sight to the exterior can also be a source of comfort to the homebound.

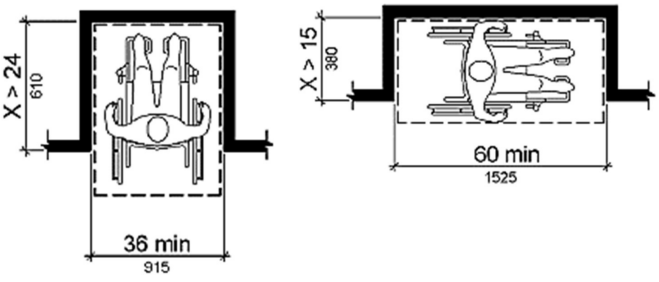
The following illustrations give an indication of the amounts of space that are necessary to properly navigate in a wheelchair. This needed space is the same, regardless of whether a wheelchair is being used in a public setting or in a private home.



Clearances for a "T"-shaped Wheelchair Turn



Clear Floor Spaces Needed for Maneuvering



Forward Approach *Parallel Approach*

Clear Floor Spaces Needed for Maneuvering in Alcoves

Trying to make an existing home with multiple levels, totally available for use while aging-in-place, may prove to be impossible. Deteriorating knees, hips and backs may simply not safely permit climbing steps. *If possible, all necessary spaces in a home should be made available on one single level, with no steps between them.* Even when they are on the same level, smooth transitions should be possible between flooring of different types and thicknesses. Don't allow tripping hazards to remain. *If renovating with new finishes, when selecting them, try to choose finishes which result in easy-to-clean surfaces.* If possible, use low-emission finish materials in renovations, that will not emit gasses into the internal atmosphere as they continue to dry. Interior traffic flow and choices of finishes will have a large impact on how long an aging resident can safely remain in their own home.

Sometimes, it will be very helpful to minimize the amount of movement an aging resident will need to perform in daily functions. *If lines of sight are not in place, both video phones and intercom systems can make it easy to communicate between spaces without moving from one position.* Multiple phone jacks and multiple phone extensions will reduce how far a resident must travel to answer a call. *A central vacuum system is a welcome alternative to dragging a stand-alone vacuum from space to space.*

Sooner or later, if an aging loved one wishes to remain in place in their home, they will accept that some level of compromise will be needed in how they were accustomed to living. Don't overlook the idea that a space used for one function in the past, can have that function changed to accommodate new life requirements. Living rooms

can become bedrooms as easily as bedrooms can become studies, once a door is removed. Repurpose available space as needed, not based on past or traditional use.

Storage will be needed to accommodate aging-in-place. Places to store mobility assist devices out of the way until they are needed is a nice touch. Storage should be available in numerous locations and duplicate items can be made available to minimize memory issues. In this way, residents won't need to traverse much distance to get to another pair of glasses, keys, etc., should they be unable to locate the last ones they had.

Flexible Spaces:

Sometimes, due to an inability of residents to navigate level changes, otherwise inaccessible space becomes freed up for other uses. *If a caregiver will be needed, can a separate apartment be created for that purpose and /or rented out for secondary income until needed? This is an especially pertinent question if previously accessible living space is on a second or lower level. If a little more space on a main level is available than is currently needed, designate a flexible space that can be used as a playroom for visiting children, an office, or if combined with a bathroom and kitchenette, used as a small apartment for a parent to age-in- place.*

Foyer / Entry:

The transition between the exterior and interior of a private home is often the place most hazardous to the aging. But it doesn't need to be fraught with potential missteps. Wayfinding signage can be located inside a house entry that guides residents to the nearest transit stops. Posting copies of public transportation schedules and maps near the front door can aid in memory and in planning excursions. When looking for home, the address of the building should be in large text outside the entry. Upon arrival, a navigable surface should be provided from the pick-up area or parking area to the front entry. In multi-tenant buildings with internal corridors, level changes should not be a problem between the entry, hallway and the units either.

The passage up to a front entry should be an easy one. Paving outside should be even with or only slightly lower than flooring on the inside of the entry. Otherwise, sloped paving or a ramp may become necessary. *Thresholds at entries to the home should be flush if possible, but at most, have a drop of one-half inch to the exterior and one quarter inch to the interior. Lobbies or foyers should have devices like shelves inside and out for packages, making it possible to free up hands to open the door.*

Visibility should be excellent at entryways. The door should be clearly lit at night, with light placed so the entering resident does not create shadows on the card reader or keyhole. In buildings with interior corridors, adequate lighting should be inside the hallway with readily identifiable entry doors to each unit. In either instance, a light switch for the interior of the home should be available immediately upon entering. Those seeking entry should be protected from the weather while doing so. Since fatigue is a contributing factor to falls, a bench or other means of sitting should be provided outside the front entry.

Once past the door, a bench or other means of sitting should also be provided inside the front entry. A closet should be nearby where a coat can be hung. A bench to sit on and remove wet boots, and a place to drop off a wet umbrella in a foyer, will both prevent water being carried inside onto other flooring surfaces. A closet is important so removed items are not left on the floor to become tripping hazards.

The introduction of moisture into a foyer is almost certain. *For this reason, entry surfaces inside the foyer and outside an entry, should be slip-resistant.* Walk-off mats, inside and out, can be useful in reducing tracked-in moisture.

Because of their vulnerability, security is often on the mind of the aging. An audible and visual cue should alert residents when visitors or deliveries are at the door. *It should always be possible for residents to determine the identity of a visitor, without first opening the door. Dual height peepholes make this possible for standing residents or those using mobility assisted devices. Viewing panels do this as well but can create issues with security.* Regardless of whether they can be seen or not, it should be possible to communicate with visitors without first opening the door. A locked drop box that goes through the wall can be used for small deliveries such as medicine, without requiring the front door be opened to a stranger.

Hardware used to open a front entry should be easy to use. *Entry doors should have push or lever style hardware*. Lever hardware is even available that can be operated by a card reader for easy access. *If a traditional key will be used, have the lock be a contrasting color from the door, so the keyhole location is easy to discern.*

exam questions...

31. _____ will be one of the most difficult tasks faced in preparing a home for aging-in-place.
a. Accumulating cash reserves
b. Decluttering
c. Preparing logical arguments
d. Deep cleaning

32. An area considered minimal for turning around in a wheelchair has _____ .
a. Hard surfaces for flooring
b. A clear five- foot radius
c. Grab bars to assist in rotation
d. No raised areas within it

33. _____ is a side benefit of opening and freeing up space.
a. Clear lines of sight
b. Space in which to place more furniture
c. Creation of an echo chamber
d. An ability to utilize a pull-out sofa

34. When planning maneuvering, the amount of floor space occupied by a wheelchair is considered to be a minimum of _____ .
a. 48″ x 30 ″
b. 60″ diameter
c. 48″ x 60″
d. 32″ wide

35. If possible, all necessary spaces in a home where aging-in-place can occur should _____.
a. Be in clear line of sight
b. Contain space for a hospital bed
c. Be available on one single level
d. Contain at least one phone jack

36. Thresholds at entries to homes should be _____ if possible.
a. Flush
b. Made only of synthetics
c. Plastic
d. Water repellant

37. _____ make it possible to receive small deliveries without opening the front door.
a. Dual height peepholes
b. Pre-paid delivery options
c. Staff on duty
d. Locked drop boxes

Living Room:

The name of this room is a clue that residents will want to spend a lot of time in it, if they can. This room should have enough space to house different furniture arrangements, while still maintaining clearance around furniture to maneuver, even with mobility assist devices. If there is shelving, some should be accessible from wheelchair height. If doors are provided in front of shelving, glass in them will make it easier for forgetful residents to determine what is inside.

Choosing proper flooring will do much to enhance the usability of this space. Changes in flooring color can alert residents with poor eyesight, that they are transitioning to another space or room. It will be tempting to let carpet remain or use rugs to add a feeling of warmth. Unless they are taped to the floor or have rubber backing, area rugs may wind up being tripping hazards.

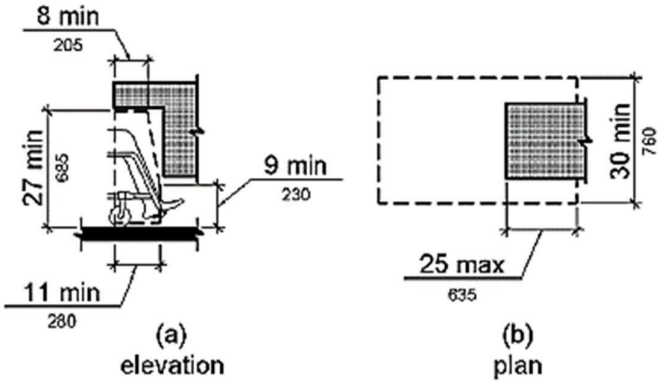
There is a built-in problem with large overstuffed furniture, that even healthy and fit users find problematic. If the seats are too deep or too low, getting in and out of a seat quickly presents a challenge. One answer to this is to eliminate as many reasons as possible to need to rise quickly. Universal remotes can be obtained with large icons that can control heating/cooling, lighting, television, security and even answer the phone. Some are programmable to perform multiple tasks with one touch of a button, to fit a different desired scenario. If such a remote is purchased and programmed, make sure its use is easily understood.

Kitchen / Dining:

Perhaps not so much with recent generations, but cooking was a central part of the lives of our elders. Appetite somewhat diminishes with aging and eating may become less enjoyable, but not doing so will have devastating health consequences. Since the ability to leave and pick up food can also become restricted, continued easy use of a kitchen will be very important. The following are just a few considerations to make that possible.

Safety will always be a big priority in kitchen use. Make sure stoves don't have knobs that turn easily to initiate a flow of gas, when knobs are merely bumped. Induction cooktops are a great invention and worth investigating. Install smoke and carbon monoxide detectors and test them regularly.

As aging progresses, extra space may be needed in kitchens to perform ordinary tasks. If a mobility-assist device is in use, it may not be possible to approach a task location from the same direction as before. As shown below, there are code recommended clearances for kitchen tasks and in dining rooms. Meet or exceed these space requirements.



Required Knee Clearances

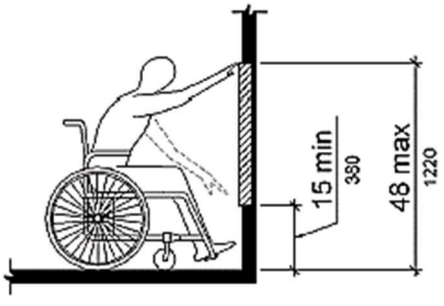
Operating space to properly use appliances is a big part of adapting kitchens to facilitate aging-in-place. It is important that doors needing to be opened, like oven and dishwasher doors, have space to do so, even when the user is in a mobility assist device. Verify there is room to approach and operate each appliance. Dishwashers should still be next to sinks for ease of plumbing and for loading. Make sure there is open work space on countertops next to appliances.

Kitchen / Dining Cabinets:

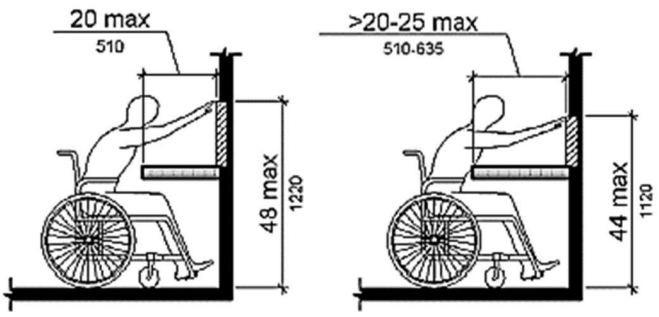
Some thought will need to go into cabinet and countertop use. Most existing kitchens will not work well for the elderly. *Some base cabinets may need to be removeable to create knee space for wheelchair users.*

Countertops may need to be changed or adjusted. *Provide support in the walls for varied heights of counters and cabinets.* Adjustable height countertops with knee space below, work great when one family member uses a mobility assist device. The top of such a work space should be no more than thirty-four inches above the floor. Lower breakfast bars that are open below, also work very well with wheelchairs. Rounded corners on countertops reduce injuries from contact. *Make sure there is space beside each appliance to set dishes down.* Use low reflective materials for countertops to reduce glare. If new counters are being ordered, *specify a colorful edge banding to define the edges of countertops, especially if the countertop and floor will be similar in color or shade.*

The following illustrations designate counter heights that are best for use with wheelchairs.



Unobstructed Forward Reach



Obstructed Forward Reach

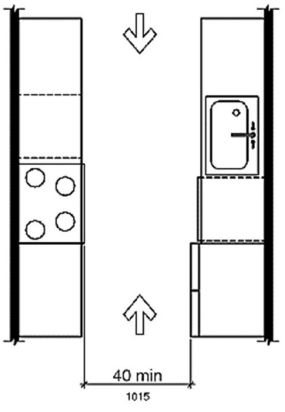
Cabinet use may also require some scrutiny. Some thoughts follow that may be useful to assess the same.

How cabinets are used, changes as the difficulty of doing so increases. Consider replacing base cabinets with drawer base cabinets. Consider lowering upper cabinets to make it easier to reach them. *Consider leaving some shelving open for frequently used items. Ideally, such items should be kept no lower than waist level and no higher than shoulder level. Pull down shelving works well for seniors. Base cabinets with pull- out drawers and / or Lazy Susan's are much easier to use than ones with shelves.* Pantries or pantry cabinets help eliminate the need to store food in upper cabinets. Do not install cabinets at all that must be reached by leaning over potentially hot surfaces.

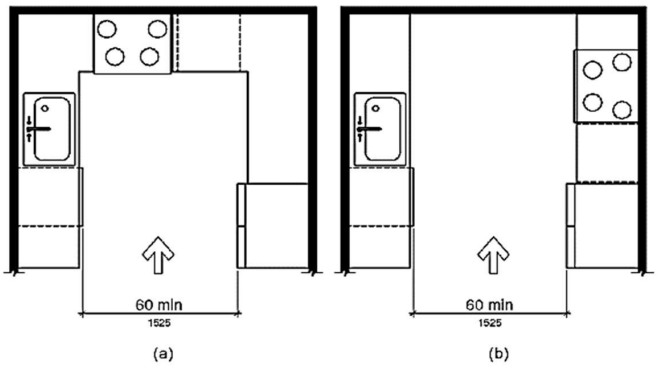
Changing cabinet accessories can also make them easier to use. Soft closing cabinets are preferred by aging residents. *Loop cabinet pulls are easiest for aged fingers to engage. Round knobs and doors and drawers without hardware are difficult to use. Lighting mounted under upper cabinets works well as task lighting to supplement general overhead lighting.* Glass doors on cabinets, or labels on doors, help residents determine what is in them at a glance. If dealing with dementia, lockable cabinets may be needed for some medications or foods to which a resident is sensitive.

Kitchen / Dining Appliances:

Besides establishing or maintaining work triangles, kitchen layouts for aging-in-place must include consideration of the space needed to approach appliances and task areas. Some example layouts below illustrate space needed to properly do so.



Kitchen Layouts



Kitchen Layouts

In addition to these, there are general guidelines for safe use of kitchens by the elderly. *To begin with, all appliances should have easily understood controls.* Push button controls are better than knobs needing to be twisted. *There should be a clear space of thirty inches by forty-eight inches in front of each appliance, or an area in which to turn with a sixty-inch diameter.* Thoughts on specific appliances follow.

Floor space should be available beside dishwashers to properly and easily load them. *Raise dishwashers if needed for easier access and use ones with easy to read controls.* There are even drawer dishwashers available that can be mounted under the counter, which are ideal for use whether standing or seated.

Do not mount microwaves above stoves. It is far safer to have them on countertops, mounted in a wall or in lower cabinets, especially when a resident uses a mobility assist device.

To maximize access by users in wheelchairs or scooters, side by side refrigerator / freezer combinations are a great choice. If these are not an option, a unit with the freezer drawer at the bottom is also quite usable.

Stoves are the appliance most frequently needing changed for purposes of safety. *If replacing a stove or oven is an option, avoid gas appliances. Electric or better yet, induction cooktops, are much safer. If dementia is a concern, a lockable cover or kill switch can be installed, with the switch hidden somewhere it is not obvious. A downdraft feature can be incorporated to draw heat away from the user. Lights should indicate when a surface is still hot. Side swing or a wall oven are the best choices for this appliance.* If using a wall mounted oven, place it at a height to minimize bending and lifting. Provide anti-tipping brackets on appliances, especially on stoves.

<u>Kitchen / Dining Plumbing:</u>

Kitchen sinks may also need to be modified for continued use as residents age. Sinks should be shallow enough from front to back, that faucets can be reached from a sitting position. *Faucets should use lever style handles and pull-out spray faucets.* Faucets should have mixing valves incorporating anti-scald protection. Limit faucet rotation to prevent spills. Faucets with sensors can eliminate the need to use hands. Pedal controls can also be installed to make the use of faucets hands-free. If knee space is created below to allow chair access, cover or wrap any exposed piping capable of being touched, to prevent burns.

exam questions...

38. Unless they are taped down or have proper backing, _____ may become tripping hazards.
a. Wipe-off mats
b. Area rugs
c. Office chair mats
d. Chairs on castors

39. _____ are a great invention keeping kitchens safe to use.
a. Induction cooktops
b. Wall mounted pot sprayers
c. Drop-in sinks with knee space
d. Shorter bar stools

40. There should always be _____ on counters next to appliances.
a. Open work space
b. Racks for commonly used dishes
c. Backdraft exhaust hoods
d. Medication dispensers

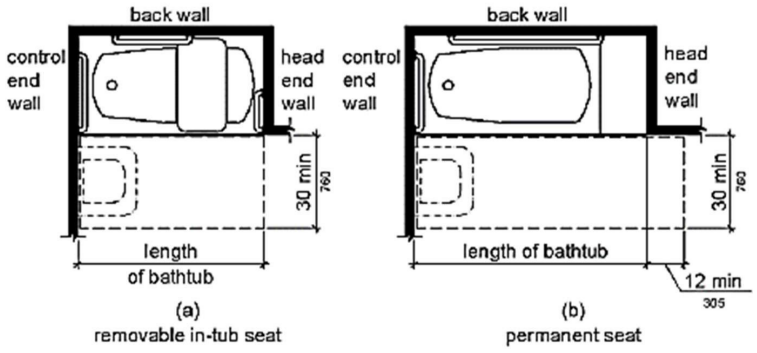
41. Frequently used items should be on shelving, no lower than _____ and no higher than _____ .
a. Lap height, head height
b. 24", 57.5"
c. Counter height, eye level
d. Waist level, shoulder level

42. _____ is the item in kitchens most often needing to be replaced for reasons of safety.
a. The flooring
b. The stove
c. The water mixing valve
d. The gas shut-off valve

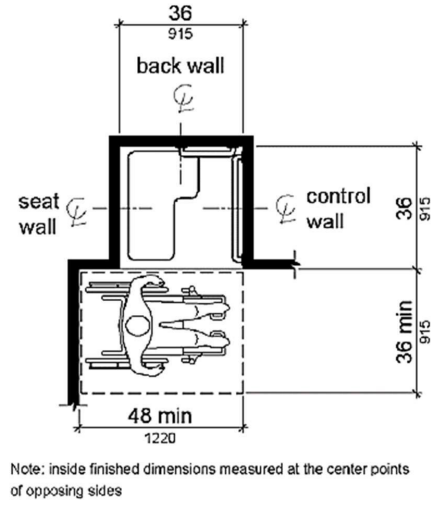
Bathrooms:

A bathroom that works well for the elderly is a critical element in making it possible to age in place. There should be a full bath accessible on the main living level of the residence. As with kitchen use, space will be a critical component in making this possible. If wider doors are needed to properly access this room, consider a pocket door, or even the use of clear offset or expandable hinges *There should be a turnaround space inside the main bathroom, at least thirty inches by forty-eight inches, or a circle with a minimum radius of sixty inches.* If a caregiver is needed to assist in bathing, make sure there is enough space in a shower to permit that. Water controls should be accessible to the caregiver.

The following diagrams show recommended space around bathroom fixtures. Most will not be attainable in retrofits, but they set goals for which we can reach.

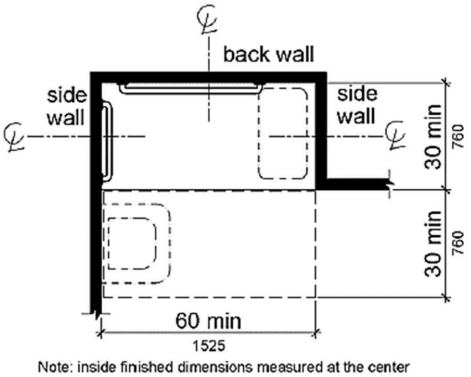


Clearances for Bathtubs



Note: inside finished dimensions measured at the center points of opposing sides

Transfer Shower Size / Clearance



Note: inside finished dimensions measured at the center points of opposing sides

Standard Roll-in Shower Size / Clearance

In such bathrooms, there should be an accessible height toilet or a standard toilet with a raised seat. *The top of that seat should be between seventeen and nineteen inches from the seat to the floor or be height adjustable.*

Existing lavatories will most likely need replaced or modified to become more accessible. A wall mounted sink with a removeable base cabinet can be used to provide necessary knee space, by just removing the cabinet. Pedestal sinks allow easier access to chairs but will most likely not provide enough room on top for personal items. *Since pipes will be in proximity to knees, use a mixing valve with thermostat settings to prevent accidental scalding. The maximum allowable water temperature should be 120 degrees. If possible, install pressure balanced faucets. Faucets can also be pedal-controlled or have lever handles.*

As a primary means of bathing, showers for elderly use require special attention. *Stand-up showers need to be a minimum of thirty-six inches wide and are best with built-in antibacterial protection.* Use a hard enclosure with a curb free door, not a curtain that will provide no help to a falling resident. Doors on tracks should not be installed on top of tubs, as they will be a major obstacle to climb for someone exiting the tub. *Showers should be without curbs or at the most, have only a low threshold. This way, wheelchairs or seats can be rolled into them. There should be a fold-down seat in the shower or a standalone bath bench. Texture strips or non-skid rubber mats, added to the bottom of tubs and showers, will prevent slipping.*

Tubs are difficult for the elderly to use. Some models are available allowing entry at floor level, with a self- sealing door that can be closed before filling the tub. But these are very expensive and not often able to be purchased. *Lower height bathtubs are a compromise, as they are easier to enter and exit. These units have the disadvantage of holding less water, and still require balance, coordination and strength to use.*

Regardless of whether in a tub, shower or combination thereof, a handheld shower spray should be used with offset controls and at least a six-foot-long hose. That will help prevent spray making it out on the floor outside the unit. Tub/shower controls should be offset from the center.

Bathroom Cabinets:

Cabinetry inside existing bathrooms will likely need to be changed. Provide backing inside walls for adjustable or varying height countertops, with removeable base cabinets for when knee space is needed. If a wheelchair need be accommodated, standard vanity cabinets are not an option. Install a wall-hung sink so there will be knee space below it. The top of such a sink should be a maximum of thirty-four inches above the floor. If lower cabinets can still be used, base cabinets with pull-out drawers work better than cabinet doors with shelving behind them. If a vanity is long enough, one cabinet can be left out below to create a knee space for grooming. Where knee spaces have access to pipes, wrap plumbing to prevent burns.

Additional changes to bathrooms can help maximize use. Rounded countertops will minimize injuries. Use countertop materials that are not very reflective, to minimize glare. *A colored stripe on the edge of counters may be needed to distinguish counter edges from the floor below.* Should there be wall mounted cabinets, provide them with glass shelves so contents are easily identified.

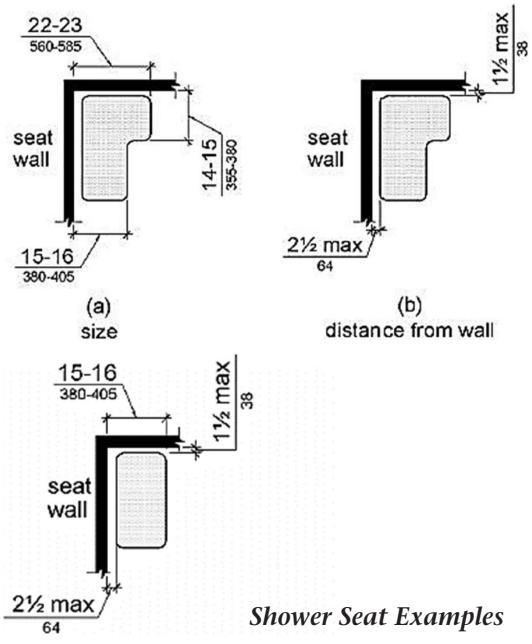
Bathroom Hardware:

Aging and especially arthritic hands will appreciate further attention to details. Loop cabinet pulls work best for aging-in-place. Round knobs and doors and drawers without hardware are difficult to use. Bar pulls can catch on clothing and initiate falls. If dealing with dementia, lockable cabinets may be needed for some medications.

Bathroom Accessories:

Installing certain accessories in bathrooms provides additional measures of safety. This is especially true of adding grab bars. *If possible, install bars at the toilet and near tubs and showers. Provide backing inside walls for grab bars to which a resident can cling when slipping or stepping in or out of a bath or shower. These grab bars should support up to three hundred pounds.* Grab bars in the shower and by the toilet should have backing behind them as well. Towel rods should never be used for support.

Seats should be available for use in showers and tubs. These can be fold-down versions, permanently built- in or just a portable stool. The best option for safety is a built-in shower seat. Some examples of seat configurations are shown below.



Shower Seat Examples

Some modifications are easy to accomplish. Mirrors should be hung at a height and be tall enough to accommodate someone sitting or standing. Installing mirrors that can be angled downward is one way to accomplish this. *Pick a dispenser model that makes it possible to restock toilet paper with one hand.* Place towel bars and shower robe hooks very close to exits from showers and tubs. Users should not have to stretch and risk falling off balance, to get a towel or robe. Have storage easily accessible in bathrooms for personal items and supplies for incontinence.

Bathroom Finishes:

As with any space where water will be present, options for finishes should be carefully considered. *Provide slip resistant flooring in areas where standing water can occur.* When considering slip resistance, using smaller tiles with more grout lines creates more slip resistance than using larger tiles. *Rugs commonly used as a warm place to set feet in bathrooms, can be tripping hazards. If used, they should have rubber backing or be secured down with double-sided tape.*

Selected materials should be easy to clean, preferably without creating hard to clean corners at intersections. Epoxy grout is the best choice for resisting the build-up of contamination.

Use tiles at the base of walls that present a clear color contrast to the flooring. This will help residents clearly identify the transition points of room boundaries.

Bathroom Power:

Make sure there is enough light in bathrooms to perform needed tasks. Lighted switches will help older residents easily locate the controls at night. *One light should be above the shower or tub.* Make sure mirrors are well lit on each side to eliminate shadows. Night lighting, or lights triggered by motion, also come in handy during middle of the night visits.

Placement and replacement of electrical outlets in bathrooms are dictated by safety concerns. Don't place outlets right next to sinks where they will be directly exposed to water. All outlets in proximity to wet locations should be GFCI outlets. Make sure outlets above cabinetry can still be reached from wheelchairs. Outlets can also be placed on the face of cabinetry but must not be located where spilled water can run over their face.

Other safety concerns may dictate additional electrical changes. Have an emergency call button or cord in bathroom locations reachable from the most likely locations for falls. Heat lamps above the shower / tub are also appreciated by those who are sensitive to cold.

exam questions...

43. The top of an accessible toilet should be between _____ and ____ inches.
a. 14, 16
b. 15, 17
c. 16, 18
d. 17, 19

44. The primary means of bathing for the elderly is _____ .
a. Sponge bathing
b. Entry level tub with a sealing door
c. In a shower
d. With assistance from an aide

45. The best cabinet hardware for use with arthritic hands is _____
a. Loop cabinet pulls
b. Round knobs
c. Drawers with no pulls
d. Bar pulls

46. _____ should be provided in any space where standing water can occur.
a. Water absorptive flooring
b. A floor drain
c. Epoxy grout in joints
d. Slip resistant flooring

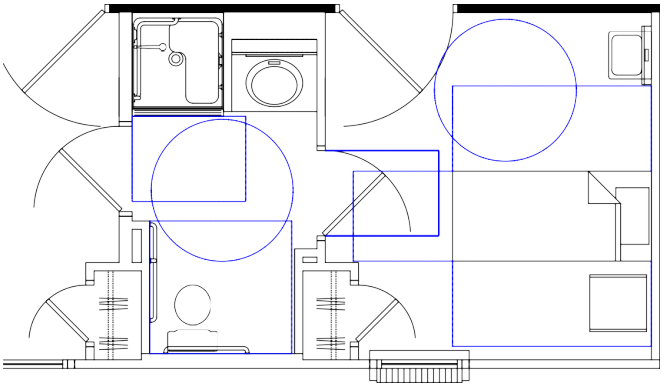
47. Any place where they are in proximity to water, power outlets should be _____ .
a. At least 48" above the floor and 12" above a counter
b. On a GFIC circuit
c. Well lit and easily located at night
d. Connected to an audible alarm

Bedrooms:

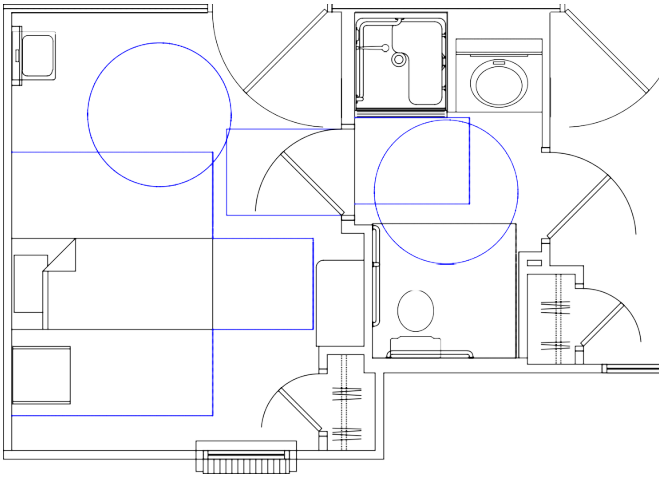
As health deteriorates and mobility decreases, more and more time will be spent in bed. That sounds like an amazing opportunity, unless someone has no choice otherwise.

Space will again be an issue in this room. There may be real difficulties obtaining this in existing homes, if a wheelchair must be used to access an existing bedroom. That will be discussed in other sections. The more cluttered the bedroom, the more difficult it will be to move from the bedroom to a nearby bathroom, or to the rest of the home. *There should be enough space in any bedroom to maneuver around the furniture, which at a minimum should be a bed and a dresser. At least one nightstand should also be able to be accommodated.* Glasses, false teeth, needed medications and remote-control devices should be within easy reach of the bed.

The diagrams below indicate some clearances desired around a bed and in an adjacent bathroom.



Layout of Bedroom and Adjacent Bath with Needed Clearances in Blue



Layout of Bedroom and Adjacent Bath with Needed Clearances in Blue

Enough space should be in this room to accommodate a hospitable type bed, should one become necessary. If an existing bed will be used, m*ove the bed against one wall to prevent it sliding away while being sat upon or entered. If the height of the existing bed makes it difficult to use, raise it by using a thicker mattress or lower it with a thinner one as needed. Attach a handrail to a wall near the bed to support a resident when they first arise. This will give time for circulation and balance to increase before further movement.*

Power considerations for a bedroom are as follows. Two ways switches are handy for lights in bedrooms, one at the door coming in and the other next to the bed. There should be a clear line of sight or a clear path from the bed to a bathroom at a minimum. If there are no night lights to illuminate the path from bedroom to bathroom, a light switch should be near the bed to turn lights on. Phone jacks or charging stations should be next to the bed, so aging residents don't have to struggle out of bed to answer a ringing phone. The more items in the room that can be controlled with a remote device, the better. Universal, programmable devices for this can be purchased.

Bedroom Closets:

Existing closets may be difficult to retrofit, if the following needs cannot easily be accommodated. *Doors should be wide enough to present easy access to closets, even using a wheelchair. If a closet is a walk-in, it will also need enough clear floor space inside in which to turn such a wheelchair around.* Closets can be used both to hang clothes and store other household goods. Consider turning portions of closets into drawers to hold clothes and eliminate the need for dressers in the adjacent bedroom. *Closets should have adjustable rods and shelves.* One or more clothes rods should be low enough to be accessed from a wheelchair. *If possible, closets should have a light inside, with a protective cover on the light to prevent breakage.*

Bedroom Flooring:

Consider the following when choosing finishes for bedroom floors. Wood floors are easier to maintain dust free by users suffering from allergies, but this choice will often seem stark to residents used to softer flooring. And obviously, softer flooring is a safer choice for those prone to falls. Carpet can add a feeling

of warmth to the floor, but if used, it should have a low, tight pile that minimizes the possibility of tripping or stumbling. Heavy patterns on carpet can be interpreted as obstacles by aging eyes. One often used alternative to carpets is providing wood flooring, but also area rugs beside beds. *Note that loose area rugs can be a real tripping hazard and if not secured to the floor, a slipping hazard. If used, they should have rubber backing or be secured down with double-sided tape.*

Laundry Room:

Access to, and the use of a laundry facility in the home, will need to be accommodated. *Given increasing issues with balance and strength, a laundry room located near bedrooms will reduce the distance baskets will need to be carried. A direct opening, even if only a chute between laundries and bedrooms, is even better.*

Door selection, and the space taken up by the swing of the door, are important in laundry spaces. If machines are in an alcove off a hallway or another room, bi-fold doors on a laundry closet will block part of the opening, even while open. If possible, barn doors are an option that does not result in partial blockage of laundry closet openings. *There should be turning radiuses inside actual laundry rooms and outside laundry closets opening to hallways. If a room is designated for use as a laundry area, the door must be wide enough to allow passage of mobility devices.*

Wheelchair use should be accommodated. *Seated users will find front load washers and dryers much easier to use than other models. It may be necessary to use a platform or a base from the manufacturer to raise them between twelve and fifteen inches off the floor. Easily understood controls should be on the front face of appliances.*

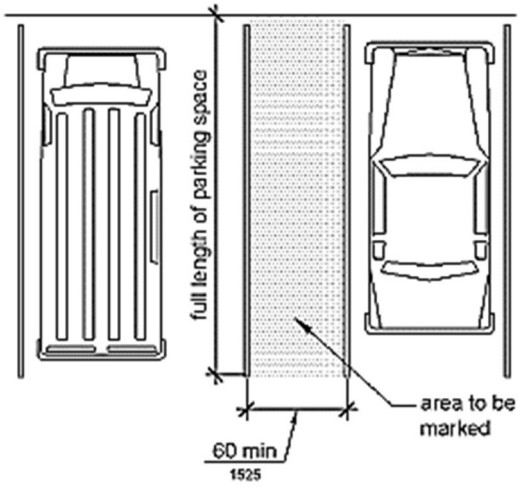
As with any other space, built-in accessories can make a laundry area more functional and facilitate extended use. There should be lower shelving in or near laundry facilities, on which to store laundry supplies. A folding counter accessible from a seated position is needed as well. A rod accessible from a seated position should be available to air dry clothing. Fold-out ironing boards can be used in rooms with more limited floor space.

Garage or Carport:

Until circumstances of health prohibit the continued use of personal vehicles, no one will willingly surrender their freedom to do so. Ways to safely access, enter and leave such vehicles will need to be planned.

In inclement weather, it's important to have a covered carport or garage, or a place to board like a covered drop-off. If vehicles are stored inside, it's going to take more width than is normally allocated in garages and carports, for aging residents to get into and out of them. If an accessible van and car are parked side-by-side, there must be five feet between them, even in a garage, to permit access into the van.

The illustration below delineates space requirements needed for access into and around a vehicle, even when it is stored in a private garage.



Car Parking Requirements

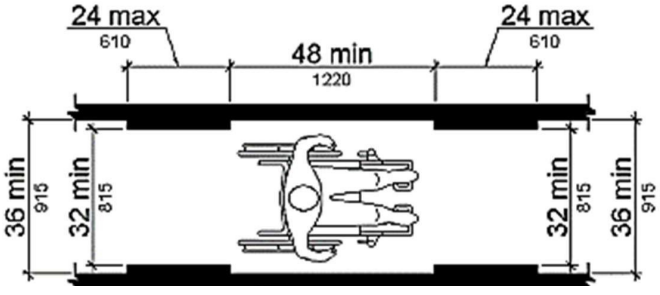
There will be additional changes possibly necessary to allow use of garages as aging-in-place occurs. *Raising garage door heights to eight feet instead of seven feet will provide needed clearance, if vans are needed.* Some handicapped transport vehicles require a nine-foot-high opening. *If possible, make the entrance into the home at the same level as the garage or carport. If that is not possible in an existing home, build an accessible ramp to make up the difference in height. If there is absolutely no space for a ramp and steps must be left in place to access a residence from the garage, there must be sturdy handrails installed on each side of those stairs.*

Storage Areas:

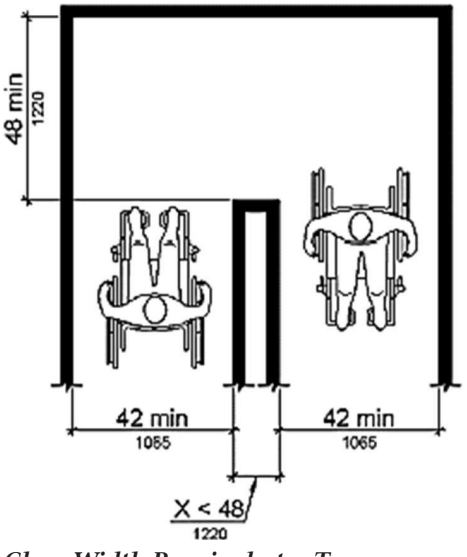
Certain storage areas, if able to be created in the home, can help mitigate issues in aging. Provide a closet where commonly used items like batteries, power cords, toilet paper, etc. can easily be stored and reached, even when seated. Provide a place for dedicated storage of mobility assist devices when not in use. Provide a closet with an adjustable height clothes rod to use for off-season storage. Make sure all such storage areas are wheelchair accessible.

Hallways / Corridors:

Changing hallways to increase accessibility will be very difficult to accomplish, but if possible, can also add many years to the ability to continue using a private residence. As can be seen from the illustrations below, and in the section on doors, it is one thing to travel down a hallway in a wheelchair and quite another to negotiate a turn.



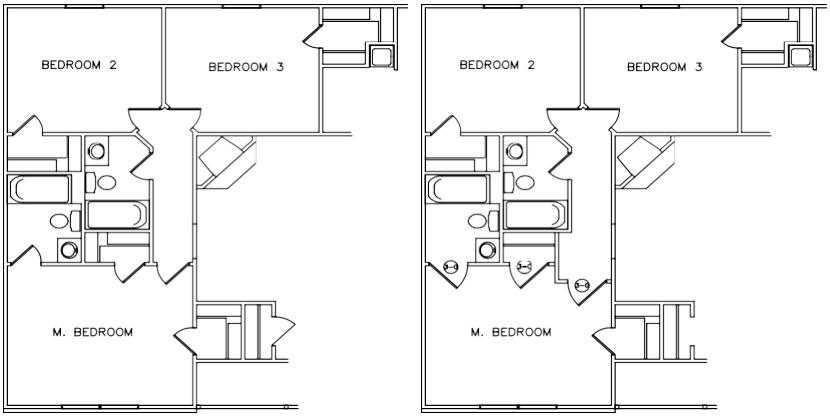
Clear Width of Accessible Route



Clear Width Required at a Turn

Recommendations are made in most manuals on accessibility, that hallways should be at least three feet wide and preferably wider. Most hallways in existing homes are already a minimum of three feet wide, so this requirement seems easy enough to meet. Turning in that hall width and entering a doorway to one side of the hall is nearly impossible. Since almost every bedroom and bathroom door in existing homes are entered sideways off a three-foot-wide hallway, it is easy to see a major problem arising.

If a hallway absolutely needs to be widened to allow aging-in-place in a mobility assist device, keep this in mind. In almost every existing home, one wall defining a hallway will be a load-bearing wall and one will not. It is very expensive and may not be possible to relocate a wall carrying a truss or floor load above it. The other side of the hallway is easy to move, if there is a willingness to also remove and replace ceiling and floor finishes to either side of the wall needing relocated. In the example included below, the simplest solution was to remove part of a closet to make a usable turn around space available. Then doors were widened, and the swings altered to make the master bedroom usable for a wheelchair, despite being slightly smaller. Note that these changes did not even provide a minimum 60 inch turn radius.



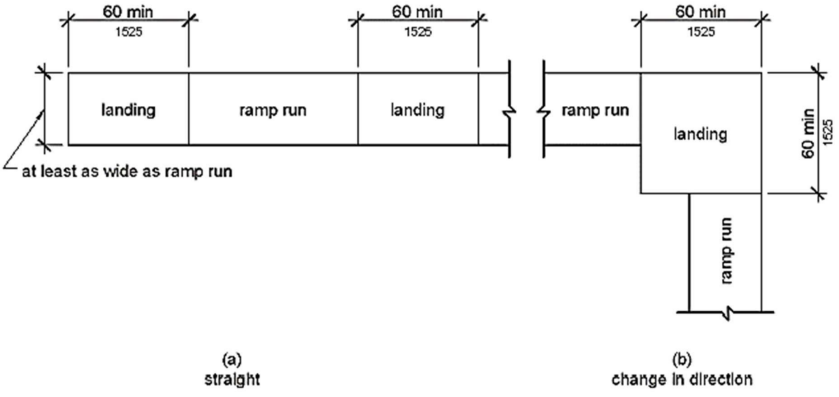
EXISTING LAYOUT REVISED LAYOUT

Alterations Made to Obtain Handicapped Accessibility

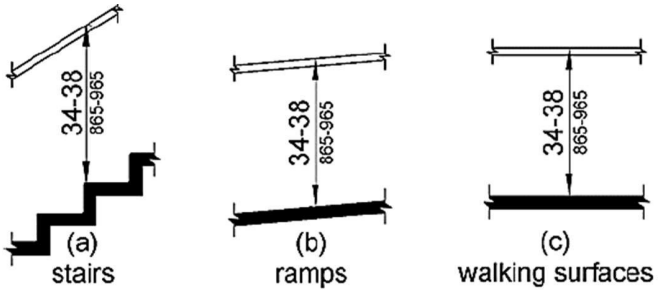
Ultimately, a hallway is a path from one function in the home to another. Pathways can involve halls, ramps, stairs or elevators, but each should be designed or modified to maximize safety. If wheelchairs or mobility assist devices will be needed, there should be no steps or steep inclines without options provided for an alternate route. If the path to be taken involves any length, a place or two in the route to stop, sit down and rest should be provided. Handrails on both sides of hallways give extra support when needed. *Regardless of length or needed accessories, all pathways should be well lit.*

Stairs and Ramps:

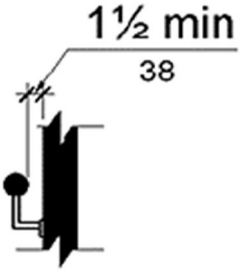
A pathway to enter a home, from a garage, a parking area or even from the street, may involve stairs and ramps. Illustrations below show desired clearances in some aspects of these two types of pathways.



Ramp Landings



Handrail Heights



Handrail Clearance

Stairs and ramps have some needs in common. *Both should have handrails on each side. These handrails should be one and one quarter inches in diameter. Non-slip surfaces are a must on both. Stairs and ramps should be well lit. If level changes are minimal, and there is space to provide one, ramps are preferred over stairs.*

When ramps are utilized, they should be no steeper than a one-inch rise for each foot in length. The maximum rise for any single length of a ramp should be thirty inches. *Five-foot-wide landings are needed at entries and exits to ramps. If in the open, raised curbs at least two inches high are needed on the sides of ramps to prevent wheels from slipping off.* If inside, long hallways are excellent places in which ramps can be easily added to transition between levels. But entry doors

alongside ramps will need to be relocated, so they are not in the middle of a ramped hallway.

In many cases, due to space constraints, stairs will still be needed to accomplish changes in levels. This must be done, despite knowing stairs can be dangerous for people with deteriorating hips, knees, backs, vision, etc.

Measures can be taken to lessen potential harm. *Stair edges can be highlighted with contrasting colors or some other way to visually distinguish the edges of treads*. Stairs with shorter risers and fewer steps between landings are easier for the elderly to navigate. Interior stairs should have risers between four and seven inches tall and treads should be between eleven and fourteen inches deep. Stairs with intermediate landings that change direction can shorten the distance that will be fallen, should a slip occur. Provided landings should be the full width of a stair and at least five feet long.

Consider placing a call button near floor level at the bottom of stair runs, to call for aid in the event of an accident.

exam questions...

48. There should be _____ between a bedroom and a bathroom to be used.
a. A clear line of sight
b. Hard surfaced flooring
c. No place for a pet to lie
d. Less than four steps

49. If front loading laundry appliances are used, they should be raised off the floor _____.
a. On recessed pedestals
b. Between 12-15 inches
c. No more than 24 inches
d. High enough to create knee space below

50. The minimum clear width needed in a residential hallway is _____ .
a. 48″
b. 32″
c. 36″
d. 39″ if chair is motorized

51. The best wall to modify when creating wider hallways is one that _____ .
a. Is not load bearing
b. Has the fewest doors to replace
c. Has the fewest outlets on it
d. Is the furthest from the HVAC grilles

52. _____ is the minimum recommended length of landings at the ends of ramp slopes.
a. 48″
b. Twice the ramp width
c. 60″
d. One and one half the ramp width

53. Which of the following is not needed on stairs and ramps?
a. Runs in one direction only
b. Handrails on both sides
c. Adequate lighting
d. Non-slip surface

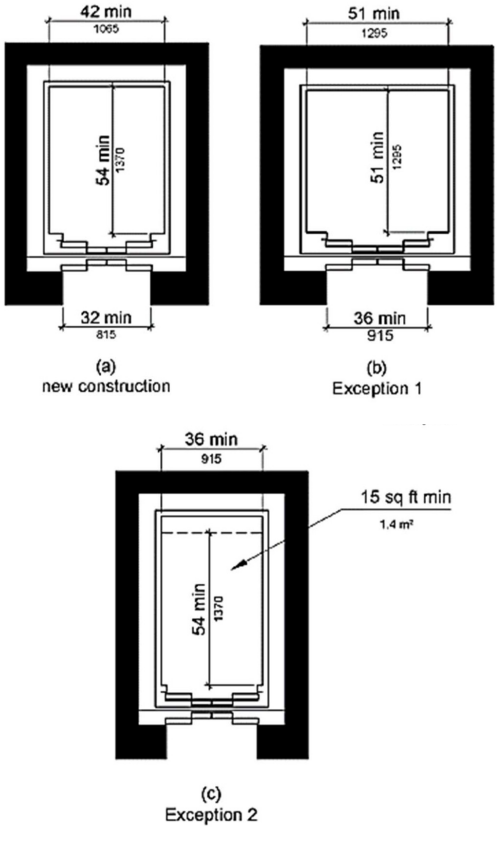
Additional Vertical Transportation:

Vertical transportation is in no way considered a necessity. Other levels than the main floor of a home might simply become inaccessible, if stairs cannot be climbed and a lift cannot be installed. These can be closed off, used only as guest quarters and storage, or accessed from outside the home and used as rentals. Usually the only way to regain that space for a handicapped resident is to install a chair lift or some form of an elevator.

If one is provided, an elevator should be easy to locate and easy to use. In most homes, full size elevators are not options, but rather a Limited Use elevator is installed. *Platform lifts use the least amount of space where there is no space for ramps, limited use or full-size elevators.* Most elevators, if their controls are large enough to be easily seen and used, have already been designed for use by the physically impaired. *If building a new home, even if not needed now, plan a couple closets to be located directly above one another. These should incorporate removeable floor framing so a chase can be created later for a lift or elevator, should one be needed in the future. These should be the minimum dimensions of the intended elevator.*

Chair lift products that can propel a seated person up and down an existing flight of stairs are available and getting better with each passing year.

Illustrations below indicate dimensions of some Limited Use Elevators, to give some idea of space that might be required on each level to be accessed.



Space Requirements for Limited Use Elevators

Finishes in General:

'Contrast' is one operative word when it comes to choosing finishes for aging-in-place. *Floors and walls should be of contrasting colors, so it is easy to distinguish the different planes*. Contrasting colors for countertops, cabinets and flooring can give visual cues to those with poor eyesight looking downward, as to which surfaces are which.

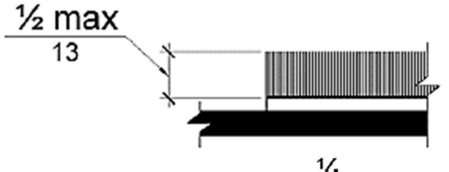
The second operative word is 'cleanability.' Choose durable surfaces for floors, walls and countertops to make them easier to clean. Hard surface paints like epoxy or enamel are easier to clean than other choices. Curved bases and rounded transition points, where base materials meet walls and floors, are easier to clean than ninety-degree corners.

Flooring:

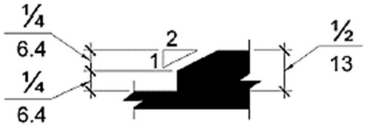
Choices made regarding flooring are of special concern to aging residents. This is simply because falls are so dangerous to their future.

As is the case with bedrooms, durable, hard flooring materials like wood, vinyl and concrete are best used underfoot, where a tendency to shuffle can cause falls. The idea is to reduce situations where feet and heels can catch on a change in elevation of flooring like the piling of a carpet. Also like in bedrooms, carpet is sometimes desired for warmth. If used, limit carpet to small areas and use only carpet with tight, short piles that are easy to clean. Use a firm pad below such carpet. The firmer the carpet and backing, the easier it to roll over and less likely it is to trip over. Many options for this type of flooring are available in commercial grade carpets. Area rugs with bound edges are sometimes considered, so they can be picked up and cleaned. But area rugs on hard surfaces can slip away and their edges, higher than surrounding flooring, still represent tripping hazards. If used, area rugs should have rubber backing and / or be secured down with double-sided tape.

Level changes present hazards as well, even level changes like transitions between hard floors and rugs or carpets. Recessed areas in concrete floors can be provided in new construction, to set area carpets down into, but this is not likely to happen in renovations. The best option is to create recessed areas with other types of raised flooring materials around the carpet, that will result in any carpet being used, being flush with surrounding surfaces. *Transition strips between adjacent flooring types of different heights that do exist, will help prevent tripping. Difficulty in walking over such changes can also be overcome with the use of a cane. Diagrams below indicate maximum suggested height changes for safety.*



Suggested Carpet Height



Beveled Level Change

Slipping on flooring presents as great a danger as tripping over it. *Get rid of any flooring that is slick, especially when wet. Use only non-skid flooring with a matte finish. If floors are to be polished, use a non- glare wax that is not slippery. Softer, more resilient flooring like cork, rubber or linoleum, is gentler on feet and can absorb some of the impact from falls. Using slippers with non-slip soles can create a measure of safety in the meantime.*

Understanding problems created by flooring colors and patterns will also help minimize problems. *The color of flooring should be changed at edges where a level change is about to occur.* Darker colors with subtle patterns will somewhat hide stains. Avoid using flooring that has dark patches in a lighter field or dark lines that can be mistaken for holes or even large cracks. These can be confusing for someone with diminished vision, crossing the area. Even flooring patterns containing recognizable objects like flowers should be avoided. Residents with dementia may be confused enough to bend to try pick them up, potentially falling in the process. Bright colors with high contrast patters can be confusing. Stick with understated, uniform patterns.

As spills and incontinence are to be anticipated, hard surfaces and carpet that can easily be cleaned will be good choices. Keep in mind that unsealed concrete will absorb liquids of any type quite readily.

The matrix on the next page compares interior flooring materials based on care, hazards in use, and ease of mobility.

Windows:

In a startling late-night development, I once tried to break into a home where an aged member of our church had locked herself out. Imagine my sense of triumph when I managed to work a stiff paper clip through the joining sashes of a single hung window and pulled open the lock holding it shut. Imagine my surprise, when the window still could not be opened. It turned out my elderly friend had driven nails through each side of each sash of every one of her windows, into the window jambs. With that discovery, we called a locksmith.

For any who are wondering, nailing your windows shut is a good way to ensure that if rescuers do need to enter your home for any reason, and no time to await a locksmith, your glass is going to get broken.

Better options for window security, in homes owned by the elderly, do exist. Drop down or drop in bars to limit opening operations can be effective and easily utilized security measures. But they may also conflict with local fire regulations. It's a good idea to check first before installing them.

Besides security concerns, there are other factors making windows user friendly for aging-in-place. Keep in mind that different windows require different amounts of strength to operate. Sliders require less effort to open than single hung units. Crank out casements can be surprising

Material	Cost	Location	Ease of Care	Hazards			Ease of Mobility		
				Least Glare	Slip Resist	Trip Resist	Feet	WalCker	Wheel chair
Vinyl Comp Tile	Low	Back of Home	High Maint	Least Glare	Med Slip Resist	High Trip Resist	Easy	Easy	Easy
Luxury Vinyl Tile	Mid	Common Rooms	Low Maint	Med Glare	Med Slip Resist	High Trip Resist	Easy	Medium	Medium
Sheet Vinyl	Mid	Fitness / Bathrooms	Low Maint	Med Glare	Med Slip Resist	High Trip Resist	Easy	Easy	Easy
Rubber	High	Fitness	Med Maint	Least Glare	High Slip Resist	High Trip Resist	Medium	Medium	Medium
Porcelain Ceramic Tile	Mid	Lobby Reception Bathroom Corridor	Med Maint	Med Glare	Med Slip Resist	Med Trip Resist	Medium	Hard	Medium
Carpet	Mid	Office Quiet area Corridor Living	Med Maint	Least Glare	High Slip Resist	Med Trip Resist	Hard	Hard	Hard
Wood	Mid	Lobby Dining	High Maint	Most Glare	Poor Slip Resist	Med Trip Resist	Medium	Medium	Medium

difficult to operate, depending on the hardware used in their design. If windows close to the floor are also single-hung or double-hung windows, residents may find it difficult to stoop down and pull them up to allow in fresh air. While windows closer to the floor allow better unobstructed views, they also increase the potential for falling through glass. For this reason, glazing within eighteen inches of floor should be of tempered glass. *Large windows to admit daylight will improve moods and offset energy bills, by making the use of supplemental lighting unnecessary during daylight hours. Lower windows down to accomplish this or use taller windows with higher head heights.*

Ease of use will play a large part in how much windows are used to allow in fresh air and cross ventilation. *Window hardware needs to be easy to operate*. Window locks should be easily operated, requiring minimal gripping or pinching. *Select windows with maintenance free exterior and interior finishes.*

Window Coverings:

Window coverings obviously allow incoming levels of natural light to be adjusted by a resident. Blinds reduce views, but can also block them out entirely, partially dampen sunlight or even redirect it up toward the ceiling to indirectly light a space. Shades, whether automatic or manual, can provide complete coverage from glare in various levels of opacity. Shades can be installed to pull from the bottom up or from the top down. Drapes are an older alternative to shades. They are also a bit more difficult to operate and bring cleanability issues with them. For any covering device, pull cords can be difficult for arthritic hands to operate. Circular chains are considerably easier to grip and manipulate.

Doors:

Successful aging-in-place will always require access to any spaces needed to function independently. Very obviously, if an opening does not exist through which access can be accomplished, that space is no longer available for use to anyone using a wheelchair. For this reason, careful attention should be paid to needed access widths through openings and clearances around doorways.

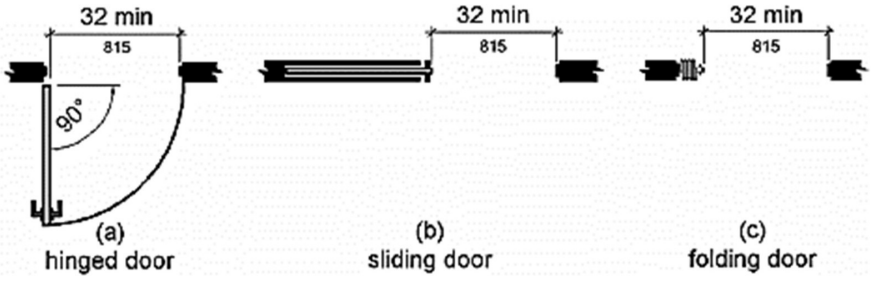
Needed Clearance Varies by Door Type:

There are certain minimum widths needed to permit passage of a wheelchair. This is generally thirty-two inches if the wheelchair is approaching the opening straight on. *Because door widths and hinge openings use up available width, if a swinging door is used, it needs to be a minimum of thirty-six inches wide. It should also use offset door hinges. If that is not available in any opening, it will be necessary to eliminate the door, change the door type or install a new and wider door.*

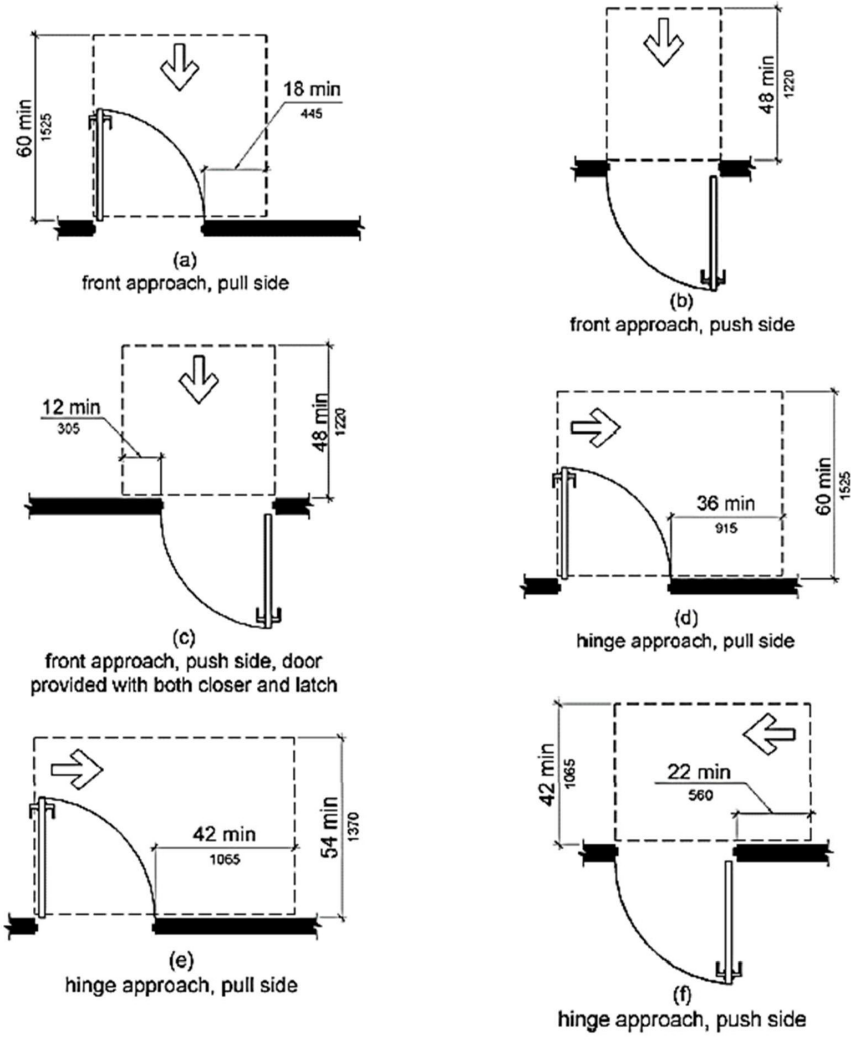
All doors, regardless of type or location, occupy space when they are open. Open doors should not block further access down a hallway. Bi-fold doors opening into hallways take only half the width of a hallway than do regular swinging doors. Other door types provide more clearance through openings, when the door is open. Given the absence of a door swing to maneuver around, sliding doors provide more clearance then swinging doors. Barn doors and pocket doors allow for full use of the entire doorway width. Just as a side note, most barn doors don't completely seal an opening for purposes of sight, sound or smell. But if wall space exists for the track, they are easy to retrofit in existing homes.

Regardless of type, doors must remain easy to operate for aged hands. Unless properly maintained, most pocket doors can develop problems sliding in their tracks and in locking when closed. Pocket doors needing to be grasped while in the pocket and pulled back out, are difficult for aging residents to use. *Patio doors and screens should be easy to lock. No door should require no more than five pounds of force to open.*

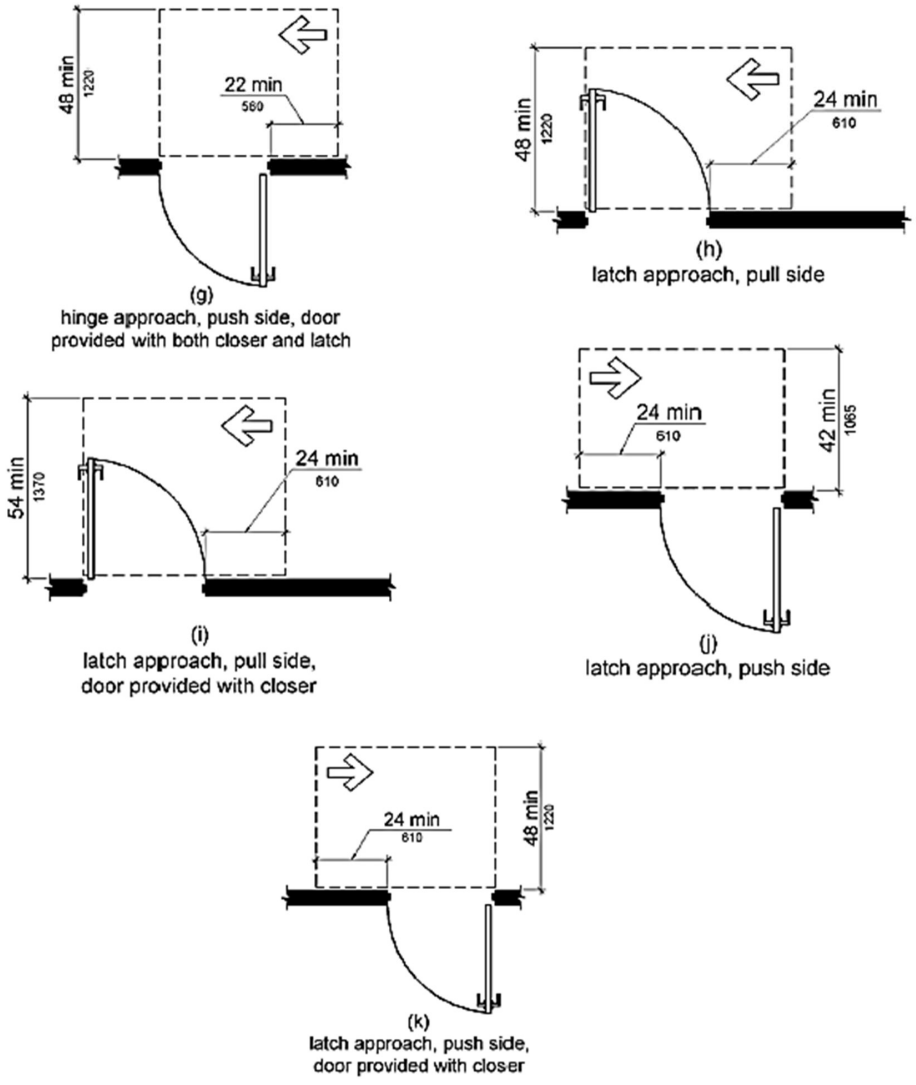
The following illustrations denote clear widths required at different types of doors, when approached from different directions. Almost no existing home can provide all these clearances, but they are worth trying to obtain.



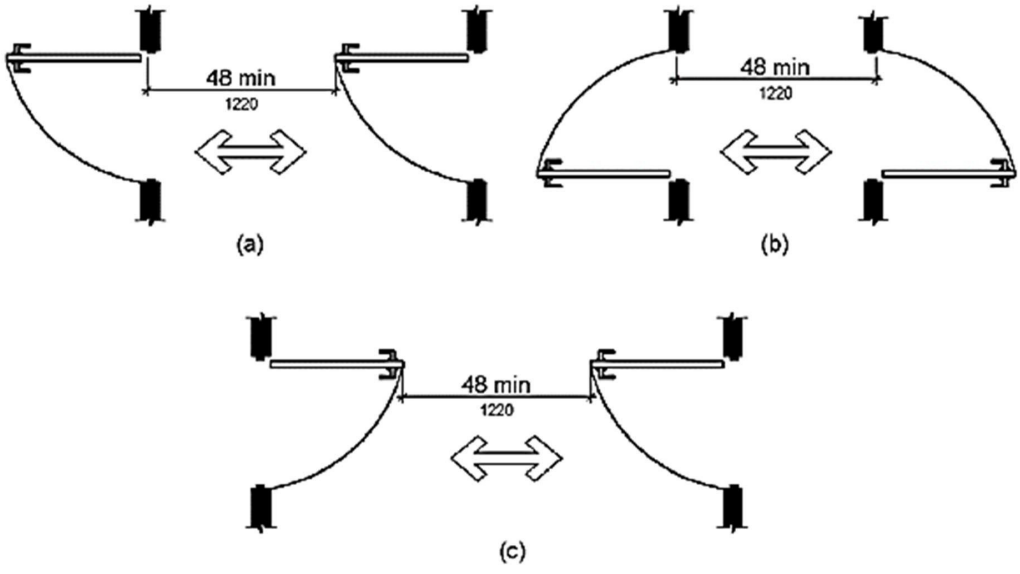
Clear Width Required at Doorways



Maneuvering Clearances at Swinging Doors



Additional Maneuvering Clearances at Swinging Doors



Maneuvering Clearances at Doors in Series

Hands-Free Entry:

Doors that are easy to operate will be used, while those which are not are better called 'barriers.' Doors that are automatically activated from a pressure pad or motion sensor, or that operate from a push plate, make entry while carrying packages much easier. They are also a lot more expensive than standard entry doors and seem less secure. But in buildings with multiple tenants, they are an asset. Easily operated double swinging doors, entering areas like laundry rooms, are useful when carrying baskets or using mobility assist devices.

Door Hardware:

While I have other issues creeping in with age, arthritis has thankfully not yet been an issue. But for a large part of the population, this is not true. This crippling condition makes the use of some door hardware difficult. *For this reason, and to compensate for loss of strength, door knobs should be changed out to handles. Lever handles are the easiest hardware to grip and turn.* Use of door hardware should not require pinching, a tight grip or unusual strength to turn. Doors that can be pushed open work well. Large loop pulls are good for barn doors.

Level changes from one side of a doorway to the other should be minimized or non-existent. Make sure all flooring transitions between rooms defined by doorways, have transition strips in place to help prevent tripping. *Thresholds that represent tripping hazards can be replaced with no-step or compressible rubber thresholds for safety and easier access for wheelchairs.*

The swing of a door will also need consideration when planning to age in place. Arrange doors to swing into rooms so access space leading to them is not compromised by the opening of the door. The exception to this is bathrooms. Bathroom doors should always be mounted to swing outward, since someone fallen inside will prevent an in-swinging door from being opened to help them. If a door will have a lock, it is best to have that door swing outward so hinges can be accessed and dismantled, in the event of an emergency and a non-responsive resident inside the room.

If able to be installed without compromising safety, glazing inserted in doors can help residents with wayfinding issues determine the use of a room before entering, as well as giving caregivers an unobtrusive glimpse inside.

Furnishings:

Continuing to use a home may require some changes in furnishings. Usually this will involve finding replacements which are smaller. Clearance must be first obtained and then maintained around furniture, so mobility assist devices can be used.

Some furniture is simply no longer usable as aging occurs and should be replaced for no other reason than that. Chairs and other seating lower than eighteen inches from the floor will be difficult to rise from. Bar stools are not very useful to the elderly either. If a seat goes back too far, the surface is too low to the ground to rise from easily or so soft the user sinks down in it, that couch or chair won't work well for anyone with back, knee, hip or arm strength issues. *Provide sturdy chairs with armrests so users can depend on them for support while rising.*

The ongoing human desire to change our environment by rearranging furniture can still be somewhat accommodated. Lightweight furniture, so long as it is still sturdy, is easier to rearrange if a change is desired. If furniture has wheels under it to assist in movement, they should only be on the front corners and not the back. Otherwise, furniture can roll backwards when users sit down, leading to bad falls. If furnishings will be moved often, select flooring that won't be scratched while doing so.

Furniture should also be selected to be physically friendly to users. Padded arms are a good idea for those who bruise easily. They should extend all the way to the front of the seating. If existing furniture to be retained doesn't have them, add firm foam pads to chair and sofa seats. If there are issues of incontinence, hard surfaces or waterproofed surfaces are easier to clean than those which are absorbent. Fabric should be easy to clean. Furniture designed with openings where seats meet backs is also easier to clean when liquid gets spilled on it. Liquid won't collect in crevices that do not exist.

Acoustics:

Hearing diminishes as aging occurs, especially in the high and low ends of the frequency spectrum. Some sounds can even become painful to eardrums less elastic than before. Unwanted noise will tend muddy the sounds residents are seeking to comprehend. Such hearing issues are very frustrating and those suffering from them, tend to isolate themselves.

Devices to assist in hearing are the best solution to this, but design choices in the home can also help somewhat. Since sound travels in a straight line, partitions can be used to block unwanted noise. Sound absorbent furniture, drapes and finishes can be used to absorb noise, reduce muddying echoes and increase clarity. Small seating areas encourage people into proximity, so conversation becomes easier.

ALARMS AND ALERTS

Everyone needs a helping hand from time to time. The trick is to be able and willing to let others know we need help.

Electronic devices can help notify others. *It's a good idea to obtain and have at hand for our elders, a personal emergency alert system. A flashing porch light or 911 switch is another option that can be made available. Direct wired alert systems are available that can be used to call for help from relatives, and / or police, fire and EMS services, at the touch of a button. Hopefully, this button will also be out of the reach of small children. Intercoms should be installed so residents can communicate with outside visitors from the bedroom, kitchen or living areas.*

Some emergencies are bigger than those coming from inside the home and the aged need to be prepared for those as well. Limited mobility might make it hard for some residents to get out of a building quickly. Use alarm devices with both visual and audible cues that are sensitive enough to heat, smoke and CO2 to give users plenty of time to respond. Potable water and medicines needing refrigeration should be stored in a small refrigerator connected to a small emergency generator. Such an emergency generator need only be sized large enough to power a refrigerator, alarm systems, the HVAC system and a few emergency lights and outlets. Enough non-perishable food should be on hand to last a few days as well.

Emerging Technologies:

New technologies are being developed that can be incorporated into home care to advance safety and create a better environment for aging-in-place.

Some gadgets are designed to minimize the need for personal daily verification of the safety of aged residents who live alone. Remote caregivers can monitor and engage with residents via tablets and avatars. Artificially intelligent 'pets' have been created to look just about like real ones, but need no grooming, food or waste disposal and suffer nothing when neglected. They provide needed company to minimize feelings of isolation and just need a power port. Humanoid robots are being developed to assist with household chores, while even providing a certain level of socialization.

Other automated devices serve to protect those aging-in-place. Automatic medication dispensers can help prevent accidental overdoses or omissions in taking medicine by confused patients. They can become large when they contain enough medications for a week or more, so setting dispensers on countertops can use up a lot of room. They can alternately be mounted on wall shelves, on walls or in niches. GPS based systems track dementia patients wearing a bracelet or key chain tag, without restricting their movement. The system monitors them as soon as they leave their home. It also alerts caregivers when the exit is made, so caregivers can also begin monitoring the wanderer. Video cameras, sending live streaming to monitors, help loved ones remotely monitor the wellbeing of residents from a distance.

Other Sensor Based Technologies:

A myriad of other sensors can protect the health and safety of the aged.

Many such devices track movement. Motions sensors throughout a living unit can detect movement so caregivers know when a patient is up and moving. Door monitors track and record every entry and exit. If motion stops, they can signal a fall and call for help. Wrist trackers can monitor steps and how many are taken, to ascertain levels of exercise. A voice activated wrist band can be used to give a wandering patient direction on how to return home. *Any alert devices that signal for help should include GPS positioning, otherwise help may arrive at a residence while the wearer of the device is elsewhere.*

Sensors can track daily activity inside a residence. Wireless, wearable sensors allow family members to connect from a distance without interfering in routines. Information is constantly being sent to a dashboard to pick up on early signs of trouble, like number of trips to a bathroom. Notification of changes in patterns give caregivers an option to personally check-in to verify all is well. Sensors can be placed to track eating habits by registering openings of a pantry or refrigerator door. Their lack of use might indicate a loss of interest in eating. Smart home technology can allow remote caregivers to verify that doors are locked at night, windows are secured, appliances that need to be, are turned off and so forth. Home safety sensors can be deployed to monitor unattended stoves and shut them off if the temperature gets too hot or they are left on too long. Water sensors can detect flooding in sensitive areas. Temperature sensors can monitor and regulate water temperatures to prevent scalding and even air temperature in the house to adjust HVAC unit thermostats.

Other sensors relay health information. Door sensors can be used to track how often a resident opens a medicine cabinet door or if they fail to do so at a predetermined time. Some sensors sync with automatic pill dispensers. Voice activation wristbands can be used to remind residents it is time to take medications, if sensors detect they have failed to do so. Some monitor and record vital statistics. Bathroom sensors can record the number of times a toilet is flushed and how long a resident is in a bathroom. There are even sensors that can detect a fall that is happening and deploy wearable air bags to minimize injuries. Sensors under pillows can detect and record sleep patterns, including when a user rises and lies back down. Some bracelet sensors can even detect REM patterns. Robotic devices monitor health and allow doctors to remotely complete medical examinations with aging residents in their homes.

HVAC SYSTEM CONCERNS

Decreased circulation occurring with aging makes us more sensitive to changes in temperature and air movement.

HVAC systems should be designed or modified with additional needs of the users in mind and they should allow individual control by users. *Make sure all bedrooms have an air return, introduce fresh air into the home mechanically with an intake on the system and use CO2 detectors to maintain a safe air quality.* Place supply and return vents in perimeter walls where they can be more easily adjusted, than when they are at floor level or even worse, at ceiling level. Avoid installing systems that distribute treated air with air movement strong enough to create drafts. If possible, locate possibly noisy air handlers by or over bathrooms or closets, not near sleeping or living areas. Likewise, locate outside condensing units away from windows that will be left open and away from outside gathering spaces. *HVAC systems should be designed so it is very easy to change filters, even from a seated position.*

Control of systems should be easily understood by aging users who do not care for new technology. *Large and easy to read and operate thermostats should be in a well-lit area at a comfortable height. Thermostats are available that accept wireless commands, voice activation or even pre-programming so residents won't need to be making constant changes.* Home automation systems can combine HVAC controls, lighting and security into one system, but may be beyond the capacity of some to properly operate.

Residents on limited incomes will appreciate any modifications that will lower ongoing utility bills. *Energy efficient units will be welcomed. Often these will be gas-fired furnaces with air-conditioning units joined to them. Seal ductwork with mastic. Seal the house with barriers to unwanted air infiltration. Verify that exterior walls are properly insulated and takes steps to remedy any which are not. If windows are being replaced, install energy efficient models with Low-E glass.* Protect ductwork from debris when renovations are in process, so dust does not accumulate in ducts to be blown back out later.

Climate control in individual spaces can be realized without necessarily changing a thermostat and altering the climate for the entire residence. Variable speed ceiling fans can increase comfort and mix air that has stratified into thermal layers. Make sure exhaust fans in bathrooms can quickly exhaust humid air and steam. Make sure they are not so noisy that they will just be left off. Exhaust fans can be switched to operate with the lights or even with an occupancy sensor. Radiant ceiling panels in bathing and dressing areas can be installed to be controlled by switches and will provide immediate warmth when needed and activated. Timers can be installed to turn them back off.

ELECTRICAL CONCERNS

General Lighting Concerns:

Electrical issues involved with aging-in-place primarily involve ensuring adequate lighting and a safe placement of enough outlets to minimize undue effort to plug in appliances. *Simple steps to be taken include raising electrical outlets and lowering switches as needed to increase usability. Another simple precaution is to place and somewhat secure, electrical cords and phone cords along the base of walls and out of the way of foot traffic.*

In the area of illumination, fading acuity of eyesight may require adding lighting to raise overall levels. Inadequate lighting can make navigation dangerous and make household tasks difficult to complete. One way to combat this is the use of general lighting at one level to keep down overall glare, while having other fixtures generate higher light levels at task locations. Having extra outlets available for portable lamps helps get light into needed locations. Touch control lamps can be purchased and are easy to control without fine motor skills. Illuminate steps, ramps and flooring level changes to help eliminate falls.

Added lighting can be controlled in intensity, glare and color. *LED lights can be used in in existing lights to free up capacity on existing circuits needed to power additional fixtures. LED bulbs can be purchased in a warm color range, between 2,700 and 3000 Kelvin. Look for a color rendering index close to 100.* Full spectrum bulbs can be purchased to simulate the appearance of daylight. *To avoid glare, some lights can be aimed at and bounced off ceilings and walls, to provide indirect lighting while avoiding glare from visible bulbs. Use automatic motion sensing lights in areas like hallways, kitchens and bathrooms to ensure they are lit when in use.*

A few other concepts concerning lighting are worth mentioning. Large windows can create a lot of contrast between themselves, the areas they illuminate and nearby non-daylit areas. Though their perceived darkness is somewhat of an illusion, those contrasting areas should contain additional light sources. Added light fixtures should also not be hung so low that residents must duck to avoid them.

Lighting Control Types:

Besides the addition of the lights themselves, some attention should be paid to how they are turned on and off. *This may sound simple, but light switches should be next to the entrance of each space they serve. It should not be necessary to cross a dark space to turn on lights. Switches and environmental controls should be between thirty-six and forty-eight inches above the floor. There should be a clear space of thirty inches by forty-eight inches in front of switches and controls.*

The type of switch installed will also determine how and even if provided illumination is used. Light switches should not require fine motor skills to operate. Small push buttons and slides are more difficult than simple toggle switches, large buttons and rocker switches. Light switches that are illuminated will prevent a search in the dark for the controls. Dimming switches can allow users to easily change lighting levels in a space. Occupancy sensors to turn on lights upon entry, eliminate the need to free up a hand for use. Programmable illumination that changes lighting scenarios at the touch of one button is ideal, but expensive.

A few additional changes involving lighting may also prove beneficial. *Lighting fixtures in crucial spots, like near entry points or in bathrooms, should contain at least two bulbs. That way, bulbs need not be immediately changed if one fails. Audible and visual light systems should be triggered by doorbells, smoke, fire or CO2 detectors.*

In a bit of reverse reasoning, a lack of light can also help deter residents with early dementia from wandering out through entryways. Darkened doorways are less inviting. This seems counterintuitive to the need for adequate light when entering the home, but levels can be controlled by having brighter entryway and foyer lights turned on by motion sensors.

Outlets:

Outlets should be plentiful and may need to be closer than the code mandated spacing of twelve feet. *Cords should not need to be stretched across open areas and become tripping hazards*. Place outlets and phone jacks where they will be convenient and easy to access, even from wheelchairs. These can be on the front of cabinets, islands or side walls. Higher outlets are easier to access than those near the floor. Do not locate outlets next to areas where they may get wet, unless they are on GFI circuits.

Homes should be also wired for security and for computers.

exam questions...

54. _____ tend to be used in residences, rather than full size elevators.
a. Escalators
b. Open lifts
c. Limited Use Elevators
d. Dumbwaiters

55. _____ should be used at edges where a level change is occurring.
a. Audible alarms
b. A change in flooring color
c. Two handrails with space to walk between
d. Strips of reflective tape

56. Drop down or drop in bars to limit opening operations of windows can conflict with _____ .
a. Fresh air intake
b. The use of tempered glass
c. The normal operation of locking windows
d. Local fire regulations

57. Approaching an opening straight on, _____ inches of clear opening is needed for wheelchair passage.
a. 34
b. 36
c. 32
d. 31.5

58. When carrying baskets, a door type permitting hands-free entry is a _____ .
a. Double swinging door
b. Pocket door
c. Barn door
d. Bi-pass door

59. It is a good idea to provide our elders with _____ .
a. Personal protection devices such as mace
b. Lessons in self-defense
c. Personal emergency alert systems
d. Maps showing clear directions home

60. _____ should be included on any alert devices used to signal for help.
a. An extra battery for emergency use
b. A small flashing light
c. GPS positioning
d. Personal identification of the user

OTHER AVAILABLE RESOURCES

General Aging-in-Place:

Enterprise Aging-in-Place Toolkit & Charrette Toolkit with added language for communities pursuing aging in place strategies - http://www.enterprisecommunity.com/solutions-and-innovation/enterprise- green-communities/re-sources/charrette-toolkit

Enterprise Aging-in-Place Existing Building and Site Evaluation Checklist - http://www.enterprisecommunity.com/resources/ResourceDetails?ID=0101080

Aging in Place – A Toolkit for Local Governments by AARP - http://www.aarp.org/content/dam/aarp/livable-communities/plan/planning/aging-in-place-a-toolkit-for-local-governments-aarp.pdf

National Aging-in-Place Council - http://www.ageinplace.org

National Institute on Aging - https://www.nia.nih.gov/

Design for Aging & Aging-in-Place Toolkit by American Society of Interior Designers (ASID) - https://www.asid.org/content/design-aging#.Vsetd00m6Uk

Design for Aging Knowledge Community – American Institute of Architects (AIA) - http://network.aia.org/designforaging/home

National Association of Home Builders Aging In Place Remodeling Information Site - https://www.nahb.org/en/consumers/homeownership/aging-in-place-vs-universal-design/aging-in-place- remodeling.aspx

APA: Planning Aging-Supportive Communities - https://www.planning.org/publications/book/9026902/

Finding a Certified Aging-In-Place Specialist from the National Association of Home Builders - https://www.nahb.org/en/find/directory-designee.aspx#sort=%40flastname44362%20ascending&f:@fdesignationsheldabbreviation44362subl_coveofacets_0=[CAPS]

Specific Topics:

Handbook for Designing Roadways for the Aging Population by the Federal Highway Administration - http://safety.fhwa.dot.gov/older_users/handbook/

Flooring Slip Resistance: Products that meet ANSI/NFSI B101.1-2009 - https://nfsi.org/certifications/certified-products/

General Building Resources:

International Code Council - http://www.iccsafe.org/

National Fire Protection Agency - http://www.nfpa.org/

Accessibility / Universal Design:

2012 Enterprise Green Communities Single & Multifamily Universal Design Specifications - http://www.enterprisecommunity.com/resources/ResourceDetails?ID=0084050

Americans with Disabilities Act - https://www.ada.gov/

Fair Housing Authority - http://portal.hud.gov/hudportal/HUD?src=/program_offices/fair_housing_equal_opp

Universal Design - http://www.universaldesign.com/

Health During Aging:

Alzheimer's Association - http://www.alz.org/

Alzheimer's Foundation of America - http://www.alzfdn.org/

Arthritis Foundation - www.arthritis.org

Silver Sneakers - https://www.silversneakers.com/

ADDITIONAL THOUGHTS

Cost:

Some of the upgrades recommended in the body of this text cost little or nothing. Some, such as upgrading to LED fixtures and bulbs, will pay back more over a few years than they initially cost. For information on what many of the recommended upgrades cost, the AARP has published a guide entitled 'HomeFit Guide.'

There are numerous agencies in the U.S. that offer assistance in making dwellings accessible for low-to-moderate income residents. In many cases, qualifications for these programs include:

- The occupant is physically disabled or has difficulty leading a normal life because of aging
- The unit under consideration is a permanent dwelling unit
- The total household income is below a stated threshold.

Weatherization Assistance programs are also available to provide energy-related upgrades. Priority is usually given to the aged and disabled. Utility companies are a good source of information for these.

Upgrading an existing home can be financially daunting. That is when prioritizing needed changes becomes critical. Renovations must be ranked in priority by cost, impact on the user and which changes are the next most critical to the well-being of the user. Renovations to kitchens and bathrooms seem to find their way to the top of such lists. Aging-in-place costs are best considered when spread out over time. Renovations may also need to be done in stages, if the home must remain occupied during renovations.

Additional Obstacles:

Besides opposition from the aging resident, and difficulties in funding needed improvements, there are at least three other parameters affecting an ability to make needed changes.

What's Behind This Wall:

The answer to this question is that in most buildings, we won't know what we are dealing with until we remove the finishes on the face of walls. Therefore, costs tend to creep up in renovation projects. Doing what we intend may involve relocating plumbing or wiring, adding needed blocking or performing unforeseen alterations needed to meet current building codes. If lead paint, lead piping or asbestos is encountered, it will need to be removed.

Cabinetry:

It is very unusual that existing cabinetry can be adapted to meet ADA recommendations for access, knee space, etc. While it is inexpensive to replace cabinet hardware for ease of use, removing the old and installing new cabinets will become costly.

Footprint:

Working inside the footprint of existing buildings can be frustrating. As stated before, it will likely be necessary to take space from one room to add it to another. In multi-tenant buildings, a unit can be sacrificed to create needed common areas, but that option doesn't exist in single-family homes. In the best cases, a bedroom will be available that can be sacrificed to make more room elsewhere. Unused dining rooms are often cannibalized to obtain additional needed space.

Walls can sometimes be eliminated to create more usable open spaces. When moving or removing walls, it will be very important to consider the electrical wiring and plumbing inside them, as well as whether the wall is a primary structural component providing bearing. While it is possible to remove portions of bearing walls, it is neither easy nor inexpensive.

CONCLUSION

It is rare to find anyone desiring to move from their home into a congregate care facility, due to aging. If they can at all manage to do so, those with homes and family they raised in those houses, will inevitably want to stay in their own house for as long as humanly possible.

Since inevitable consequences of aging will otherwise force them out, it will be up to us to determine the level of effort we are willing to exert to honor their wish to remain in place. Make no mistake about it. If not originally designed to be user friendly to the elderly, it will take ongoing time and expense to make the changes to a residence needed to accommodate them till their inevitable departure. Perhaps as much effort as it took them to adapt their homes for our arrival.

My hope is that this writing will help clarify, when and where our assistance can do the most good.

WCI Wisconsin Contractors Institute

That Dangerous Damp:
Dealing with Water Inside

Course Number 21438

6 Hours

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FOREWORD

The chorus of one well known song, begins with the words, "Sometimes, all I need is the air that I breathe, and to love you." In some cases, the singer might be better served, to just try to live on love.

Pollution in our environments is unquestionably a poor idea. Especially when we will be inhabiting that environment in the foreseeable, if inadvertently shortened, future. Even more dangerous, is when we bring pollution of any kind inside our homes, workplaces, and schools to live with us.

More and more, we are beginning to understand that there are serious acute and chronic health problems associated with breathing in contaminated air. Placed in the context of managing our health, managing water infiltration into spaces where we live and work, also takes on great significance. Materials and furnishings that have been damaged by water, unless correctly dried or removed, can become significant sources of microbiological contamination in the air. Health problems, resulting from breathing that air, can range from simple allergic reactions to chronic pulmonary diseases.

All buildings leak in some way, at some point in their life span. Knowing this, ways and methods have been developed to deal with this intrusion of water, during design, in construction, and in maintenance. The purpose of this work is to discuss how to respond with appropriate protocols, when our environments are invaded by unplanned water. We will touch on how to deal with moisture, and the ancillary problems associated with it, should moisture make its way inside, and remain. This is not if, but when, resident dampness begins to make our built environments, less habitable. Finally, we will touch on other sources of contamination in the air we breathe, and how to respond to those as well.

OVERVIEW OF MOISTURE RELATED PROBLEMS

Don't Let the Water In

Excessive water, meaning more than we intended or allowed for, in the design of a building, creates problems for both built structures, and for their inhabitants. We learn more about moisture intrusion, with each successive failure. And the idea really is to learn from past mistakes.

All buildings, at some point in their usable lives, will develop flaws that allow moisture to penetrate in an unintended fashion. Managing that water, once it gets inside, is necessary to reduce microbial growth that could endanger the health of inhabitants. Those health issues will range from simple irritation, to allergic responses, to life-endangering diseases. Legionnaires Disease is one famous result of poor air quality, that readily comes to mind.

The same moisture dependent organisms that endanger human health, can also work to destroy the building holding the people. This can be brought into perspective by noting that those tiny creatures we generally term as mold, given a good source of moisture as well, will eat organic building components, to grow and thrive.

Mold, not yet inside the human body

Assessing what has worked, or not worked, in times past, has led to the development of effective protocols addressing unwanted moisture intrusion. In this course, we will look hard at; sources of unwanted moisture, dealing with sources of its intrusion, problems resulting from its entry, and steps to take, once a leak has been discovered. That discovery of a leak involves water observed at the actual point of intrusion, discovery by the appearance of localized physical damage, or the appearance of mold, indicating the presence of excess moisture nearby.

Before further and more in-depth discussion of this topic, it would be helpful to look at some of the terminology involving the danger of allowing water to penetrate buildings, and associated consequences of not taking immediate steps, to remedy the problem.

Glossary of Terms Regarding Dampness and Mold

Air Barrier:
Any material, combination of materials or manufactured assemblies, intended by design, to control the movement of air across or through an exterior wall system or assembly.

Air Handler:
Equipment that includes a blower or fan, heating or cooling coils and related equipment such as controls, condensate drain pans and air filters. The description does not include ductwork, registers or grilles, or boilers and chillers.

Air Retarder:
A membrane with a water vapor permeance at least 5 perm, restricting air infiltration and exfiltration through an assembly, that still allows water vapor to diffuse though. Joints and seams in air retarders must be sealed to keep them effective.

Air/Vapor Retarders:
A membrane with both the water vapor resistance rating

of a vapor retarder, and the air infiltration rating of an air retarder. These are used to restrict the flow of both air and water vapor through building assemblies. When used, joints and seams, and other openings around vents, outlets, windows, etc., should also be sealed.

Alligatoring:
Shrinkage cracking of the bituminous surface of built-up or smooth surface roofing. It produces a pattern of deep cracks resembling alligator hide.

ASHRAE:
An anacronym for the American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc.

Asphalt:
A highly viscous hydrocarbon, from the residue left over after distilling petroleum, used to water-proof built-up roofs.

ASTM:
An anacronym for the American Society for Testing and Materials

Ballast:
Heavy materials like rock, gravel or pavers, used to weigh down roof membranes to prevent their uplift by wind

Bitumen:
A generic term for asphalt or coal tar pitch

Blister:
A spongy raised portion of roofing membrane, caused by pressure below from entrapped air or water vapor

Built-up Roofing (BUR):
Continuous roofing formed from laminated, saturated or coated roofing felts, alternated with layers of bitumen

Cant Strip:
A continuous triangular strip adhered in the junction formed by a horizontal roof meeting a wall or other vertical surface. They are installed to create a more gradual slope transition for flashing and roof membranes

Capillary Break:
A slot creating an opening, which is too large to be bridged by a drop of water This stops the passage of water by capillary action

Chase:
A dedicated path or raceway, cut or built into building elements, to accommodate electric, plumbing, or HVAC distribution lines

Cladding:
A face applied panel, intended to protect a structure against impact, decay, weathering, or corrosion

CMU:
An anacronym describing a concrete masonry unit.

Commissioning:
The testing and balancing of all of a new building's systems, to ensure their proper functions as designed, and train the operations staff in the use and maintenance of those systems, before the building is occupied by intended recipients.

Coping:
A protective waterproof cap over the top of a finished wall or parapet, to resist moisture penetration. They are typically sloped to direct water away from the wall beneath.

Crack:
A break in a protective membrane that was intended to provide a continuous layer of waterproofing

Cricket:
A small ridge, extending from a vertical face like a chimney, to a nearby sloped roof, to divert water away from, and around, the junction of the vertical face and sloped roof

Drainage or Drain Plane:
Any element placed between the "wet" and "dry" zones of an exterior wall system or assembly, off which water is intended to drain

Dry Well:
A rock-filled hole, placed to hold a calculated amount of drainage water, until it can be absorbed by the earth beneath

Eave:
The portion of the lower edge of a sloped roof, that overhangs a wall below

Enthalpy:
A measure of the total energy of a thermodynamic system, including both the energy needed to create a system, and the energy needed to establish its volume and pressure, used in displacing its surrounding environment to make room for itself

EPA
An anacronym for the Environmental Protection Agency

EPDM:
An anacronym for ethylene propylene diene monomer, a synthetic rubber used for single-ply roof membranes.

Expansion Joint:
Space left between two planar surfaces, allowing for planned expansion and contraction of those adjacent surfaces, under different seasonal and thermal conditions

Fascia:
A finish placed over, and capping, the exposed edges of a roof assembly or roof overhang.

Fishmouth:
A gap that has opened up in overlapping layers of felt, due to failures in the adhesion between the overlapped felts typically utilized in built-up membrane roofing

Flashing:
Overlapping sheet materials applied over, and sealing, membrane joints, drains, gravel stops and other places, where membranes are interrupted. Base flashing normally forms an upturned edge, and a cap or counterflashing comes down from behind a waterproof finish on a vertical surface above, and laps over the base flashing, to provide positive drainage over the flashed joint.

Forebay:
A small pool located before the primary inlet of a storm basin or other water management facility, intended to trap and settle out sediment and heavy pollutants, before they enter the main basin

Gravel Stop:
An angle with a raised flanged, face applied to the top of a fascia, to provide a clean edge to the top of the roof assembly, all the while preventing loose aggregate from washing off the roof.

HVAC:
An anacronym for heating, ventilation and air conditioning.

Hygrothermal:
A term pertaining to heat and humidity.

Impervious:
Neither absorbing, nor allowing the passage of water

Micromanometer:
A tool used to measure very small differences in pressure.

Modified Bitumen:
Asphalt with polymers added to its mix, to make it more flexible in cold temperature and less subject to flow in hot temperatures

OSB:
An anacronym for oriented strand board. It is a panel product, made of strand-type flakes, purposefully aligned in a specific direction. The alignment makes the panel stronger, stiffer and with better dimensional properties, than panels made with random flake orientation.

Parapet:
A part of a wall assembly, that extends above the plane of the roof behind it.

Permeance and Permeability:
The speed at which water vapor transmits through a given area of a flat product, driven by a specific difference in vapor pressure between its two surfaces, is measured in "perms."

Plenum:
A space between a suspended ceiling and the floor above it, often used for system distribution and sometimes as an air return. A plenum is usually designed to have less air pressure within it, than the space below it, so air being returned to the HVAC system will flow up into it.

Ponding:
Water that collects in depressions on a roof surface.

Psychrometrics:
Charting of the behavior and combinations of water and air, at specific temperatures. Included in this data is the dew point of moisture laden air at different moisture contents.

PVC:
An anacronym and generic term for single-ply plastic sheet membrane (polyvinyl chloride).

R-value:
The number of minutes (seconds) required for 1 Btu (joule) of energy to penetrate one square foot (square meter) of a material for each degree of temperature difference between the two sides of the material. This is used to measure a material's resistance to the passage of heat and the number used for the R-value is the reciprocal of that used to measure conduction (1/c)

Scupper:
An opening built in to allow water to drain through a wall, from an adjoining flat surface, usually a roof

Section:
A drawing showing the arrangement of materials comprising a structure, as though the structure had been cut through on a plane

Shingle-wise:
Overlapping materials, as is done with roof shingles, so water will run harmlessly down and over the joint, without penetrating

Slope:
The ratio between the measure of the vertical rise, and horizontal run, of any given slope

SMACNA:
An anacronym for Sheet Metal and Air Conditioning Contractors' National Association.

Soffit:
The finished surface on the underside of a roof overhang.

Spall:
A fragment, usually in the shape of a flake, detached from a larger mass by a blow, by the action of weather, by pressure, or by expansion within the larger mass.

Stem Wall:
The vertical portion of a retaining wall.

Sump Crock:
A hole, created to make a low void, where spilled or infiltrating fluids will collect for further handling

Swale:
A ditch covered with vegetation, created to channel and sometimes absorb surface water runoff

TAB:
An anacronym for test, adjust and balance

Tensiometer:
An instrument used to measure the surface tension of liquids.

Vapor and Air Retarders:
Materials inhibiting the flow of air and water vapor through building envelopes

Vapor Barrier / Retarder:
A film with a water vapor transmission rate of less than one perm, usually thin flexible materials like plastic, or coatings like paint or asphalt. These are effective in preventing condensation from occurring, when installed over the warm side of exterior assemblies.

WBDG:
An anacronym for the Whole Building Design Guide.

Weep Holes:
Small openings left in the outer wall of masonry construction, as outlets for water trapped between building components, to let it migrate back outside the wall

exam questions...

1. **_____ is defined as: Any material, combination of materials or manufactured assemblies, intended by design, to control the movement of air across or through an exterior wall system or assembly.**
   a. air a
   b. air handler
   c. air retarder
   d. alligatoring

2. **_____ is defined as: A highly viscous hydrocarbon, from the residue left over after distilling petroleum, used to water-proof built-up roofs.**
   a. ballast
   b. blister
   c. fascia
   d. asphalt

3. **OSB is an acronym for _____.**
   a. built-up roofing
   b. oriented strand board
   c. occupational standing board
   d. output sounding board

4. **_____ is defined as: An opening built in to allow water to drain through a wall, from an adjoining flat surface, usually a roof.**
   a. scupper
   b. shingle
   c. soffit
   d. spall

5. **WBDG is an anacronym for _____.**
   a. Western Building Design Guild
   b. Whole Building Design Guide
   c. Waterproofing Barrier Designations Guidelines
   d. Worldwide Barometric Delineation Guild

THE SCOPE OF THE PROBLEM

With some basic terminology defined, let's look at moisture damage to buildings, and their inhabitants, in a bit more detail. We will get far more specific shortly.

Moisture Damage to Buildings

In addition to causing health problems, moisture will damage building materials and components. That facility damage occurs at multiple levels. Since water and food are what most organisms need to thrive, prolonged exposure to moisture encourages infestation, within and on, organic building materials and HVAC system components. Molds, bacteria, and wood-decaying pests, like termites and carpenter ants, will suddenly feel right at home. Water interacts chemically with building components, causing structural fasteners, wiring, metal roofing and conditioning coils to corrode, making wood to rot, and causing adhesives used in flooring, sheathing, and roofing to fail. Wood will also swell or warp when it becomes wet. Water-soluble building materials, like drywall, can essentially dissolve. Masonry can be damaged by expanding ice during freeze-thaw cycles. The integrity of concrete can be destroyed by sub-surface salt deposits, carried there by moisture intrusion. Paints and varnishes can be damaged and become clouded. When wet, the thermal resistance of insulation is greatly reduced.

Monetary Loss Due to Moisture Problems

All these categories of problems, generate significant price tags, attributable to buildings being exposed for prolonged periods to moisture.

The direct cost of medical problems, associated costs of treatment, and ancillary losses of productivity, must be borne by someone. Annual medical costs of just asthma-related illnesses, attributed to exposure to dampness and mold, have been estimated at $3.5 billion in the U.S. alone. There are other health problems associated with damp buildings, and each problem carries its own annual medical price tag. Those are generally passed on as higher insurance premiums, to everyone.

Damage to the building also creates huge expenses. A significant proportion of these costs is borne by tenants and building owners. Money is lost when employees call in sick, due to illnesses like asthma. Even when employees remain present, reduced productivity can be expected when there are pervasive moisture-related health and comfort problems. There is obviously a huge cost associated with repair and replacement of corroded structural fasteners, wiring, and damaged moisture-sensitive materials. Increased insurance premiums will result from excessive claims for repair, especially if a water intrusion problem was known, but not remedied in a timely fashion. Loss of the use of building space, after damage and during renovations, will make it necessary to rent additional space for a time. There will be repair and replacement costs for damaged furniture, products and supplies. Damaged records, that cannot be salvaged, will create problems down the road, requiring plenty of unscheduled time for personnel to figure out and resolve.

General Mold / Moisture Intrusion

When materials in the building, from acoustic ceiling tiles to carpets and rugs, absorb and hold that moisture, they will continually release it into air in the building, until they have been dried or removed. When examining how to reduce financial loss from excess water, understand that moisture in buildings or building envelopes, is likely coming from one of the following sources:

1. Moisture is literally absorbed straight through external envelope materials.
2. Moisture is simply a matter of precipitation, or melting snow, that drains inside through cracks and holes.
3. Moisture, like melting snow, will be sucked inside through available openings, when air pressure inside is less than that externally. Basically, anywhere air can enter, water can follow.
4. Moisture enters the building through construction flaws, poor selection of materials, poor installation methods used during construction, or adjacent selected materials being incompatible with each other.
5. More moisture enters, held in humid outside air flowing in, than the building's HVAC system can eliminate.
6. Moisture enters in event that floods a building, like a plumbing leak, a spill, a leak in the fire suppression system, or an actual natural disaster affecting the integrity of the building envelope.
7. The last route by which water enters, is the introduction of excess moisture into the building by occupants. This is via poorly vented exhaust fans in kitchens and baths, from water spills, from water used in housekeeping tasks, humidity introduced in the breath of inhabitants, the uncontrolled entry of humidity from the exterior when doors or windows are opened, or plumbing fixtures being allowed to run or drip.

Unwanted moisture will find its way into buildings. This fact is attested to, by a proliferation of service companies, who contract to provide moisture abatement services for flooded structures. In this case, as in most others, solutions came into existence because of need.

It is easy to find sources of excess water, when materials near the leak are saturated. Leaks or burst pipes are immediately apparent. Not so easy, is when the source of intrusion is hidden from view, such as wet insulation in walls, or water entering through the foundation. Totally frustrating, is when a leak occurs in one location, but the water uses wires, ducts, etc., to travel some distance before dropping and making its presence known, nowhere near its actual point of entry.

There are straight forward steps that can be taken to reduce the chance of water intrusion. Specifying and using building materials that neither accept, or hold, moisture is one practical solution. For example, rigid insulation will not hold moisture, whereas cellulose insulation will absorb the same. Metal siding will repel it, but wood siding becomes saturated unless protected. Single ply membrane roofing offers no lapped joints, wherein moisture can reside, but that is not true of asphalt shingle roofing. Sandwich panels, containing insulation faced with steel or aluminum sheeting, are another prime example of materials, which by their nature, repel moisture.

Construction detailing is another example of forethought, taken before construction begins, to deny water entry. It is primarily based on a good imagination and an understanding of water behavior. Since precipitation tends to flow downhill, flashings below copings, below windows, above door and window openings, and above any break in the continuity of the building envelope, that lap down over the next shield in the water barrier, will help keep water from entering. If wind on the building face has potential to drive water up under flashing, then caulking should be specified, or other barriers put in place to prevent that. Capillary breaks can prevent water from bridging gaps. If there is a cavity into which moisture can enter and collect, weep holes should be provided to let that collected water drain from that cavity, back to the exterior. The devil is in the details, but unwanted moisture intrusion can be in the lack of them.

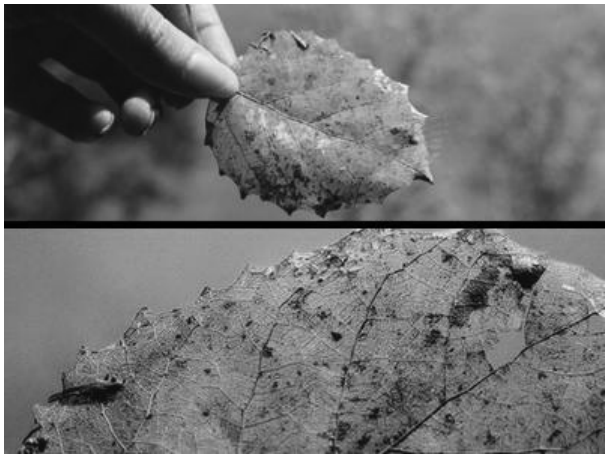
Material specification and detailing decisions are choices made during the design process. The idea is to create a continuous envelope of materials that repel water and will not allow moisture to diffuse through them into the interior.

Another useful tool is to find and eliminate any gaps in the envelope, through which moisture can get inside. Inspection during construction is the best time to do this, but this is also part of ongoing maintenance inspections. Indoor sources of moisture (other than the breath of inhabitants,) can be found and fixed or eliminated. Uncontrolled air movement, that pulls humid air in from the exterior, can be controlled with airlocks or other known design devices.

By far, the best approach to indoor air pollution by mold, is to do whatever it takes to just keep moisture from getting inside. Because once it gets a foothold, the growth of mold can follow.

The Mold / Moisture Connection

Unlike with moisture, there is no way to keep mold out of our buildings. With thousands of strains, mold is found everywhere, both indoors and outdoors.



Mold on leaves

The mere presence of mold does not indicate a problem. It becomes problematic, only when the amount of it increases past our tolerable limits. Excessive growth begins when mold spores land on a wet or damp spot and begin generating new colonies. Spores are released into the airstream and at that point, inhabitants with sensitivity to mold begin reacting. The goal then becomes, not to necessarily eliminate all types of mold (which is impossible), but to remove what is there and limit its future growth.

In any building, there will be users who are sensitive enough to mold to react to it. In some, that sensitivity results in respiratory diseases. Molds produce allergens (substances causing allergic reactions) and irritants that are troubling to sensitive individuals. Allergic responses include hay fever-type symptoms, such as sneezing, runny nose, red eyes, and skin rash.

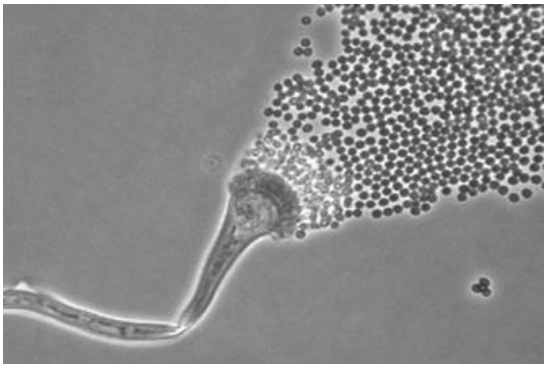
Moreover, allergic reactions to mold are more common than one might suppose. Responses to excessive mold can be immediate or delayed. Asthma attacks can be triggered in people already suffering from that disease. Mold exposure can irritate eyes, skin, nose, throat, and lungs of all users, whether they are sensitive or not. Allergic and irritant symptoms are the most common problems reported. But research on the effects of mold on health is still ongoing.

Plenty of information on health problems associated with mold, can easily be found. Health professionals are one source of data. State and local health departments are another. Detailed information can also be found on websites for the Center for Disease Control and Prevention, and the Environmental Protection Agency.

Definition of Mold

Though of differing species, all molds are fungal growths that can get a foothold and propagate on various damp organic materials. Sometimes referred to as mildew, molds are found indoors and outdoors, all year long. Exterior molds use plants and decaying organic matter, as a source of nutrition. They do the same inside, needing only moisture and a good source of carbon, found in building materials or contents. Mold growth occurs in areas of excess moisture, when tiny floating spores leave one colony, to land on a nearby moist surface and begin another colony. Moderate temperatures and nutrients are the only other conditions needed.

Molds (along with mushrooms and yeasts) are types of fungi. Molds are in the air and settle out on surfaces. Outdoors, molds are part of, and serve a significant function in nature. They break down organic matter and live in the soil, on plants, and on dead or decaying matter. Mold spores become airborne, when air moves across vegetative matter, or when plants, soil or other decaying matter is disturbed.



Magnified mold and its spores

There are thousands of species (often quantified as between 50,000 and 250,000) of mold, with more than 1,000 different kinds of molds found in homes and buildings in the United States. Molds spread and reproduce over time, when favorable growth conditions are present. These include food sources like paper facings on wallboard, wallpaper, ceiling tiles, wood, dust, and dead mold spores. All are good fuel for mold colonization. Sufficient moisture requirements will vary from one mold species to another, but generally, sustained relative humidity of greater than 70 percent, or wetted food source materials that remain that way more than 48 – 72 hours, will encourage mold colonization. It will begin first on a microscopic level, then slowly become visible. Mold growth can be any color, including black, white, green, purple or orange. Once mold growth begins, depending on the conditions and mold type, even in the absence of "visible water," the moisture in ambient relative humidity will be sufficient to sustain and maintain mold growth.

The presence of air-borne mold indoors, even when found in the types and concentrations as outdoors, are not generally considered atypical or problematic. However, mold growth (colonization) inside buildings or interstitial wall cavities, is not considered normal. Aerosolizing of these concentrations of colonizing molds, carries the potential for health problems and degradation of the integrity of the structure, should that level of growth, remain unchecked.

Mold is not a new health concern, not even in the workplace. No indoor space is ever really free of some type of mold or another, no matter how supposedly sterile. Molds are everywhere, and our exposure to them unavoidable. Some molds are considered toxigenic and are undergoing research to determine if they cause certain health problems, in and of themselves. But whether known hazards or not, accelerated growth of any strain of mold, is a sure indicator of an excessive moisture problem.

Controlling Mold Growth by Controlling Moisture

With the connection between moisture, mold, and health firmly established, we consider that mold growth involves four factors. Mold spores must be present, to be carried by air currents to other surfaces and building cavities. Once there, the spores must contact surfaces that are moist (relative humidity at or above 70%), contain organic nutrients, and are warm. In such a hospitable

environment, mold will grow and gradually destroy the surfaces to which it clings. We can't change the organic nature of building components, and we can't eliminate the initial presence of mold. But we can limit factors that make surfaces hospitable, by changing the relative humidity or temperature of exposed and hidden surfaces. Both changes are very good approaches to controlling mold growth.

Controlling the moisture content in building spaces carries other dividends. Excessive moisture also creates an inviting atmosphere for unwanted bacteria, mites, cockroaches, and other pests. Excessive moisture in wall and roof construction, increases the thermal conductivity of the building envelope. That reduces the effectiveness of the insulation package by as much as one half. Keeping moisture out of insulation yields financial rewards, in lowered utility costs.

All these factors make controlling the moisture content, in and through a building envelope, a subject of great importance.

exam questions...

6. **Prolonged exposure to water, makes building components hospitable to _____.**
   a. Ants, weevils, and rodents
   b. Mold, heat, and sprouts
   c. Bacteria, ants, and mold
   d. Strand orientation, security breaches, and termites

7. **Invading moisture destroys concrete by _____.**
   a. Depositing sub-surface salts
   b. Leaching cement out of the mixture
   c. Creating water stains that cannot be removed
   d. Redistributing soil beneath

8. **Estimated medical costs in the U.S., for the treatment of asthma related illness, is estimated to be in the range of _____.**
   a. 100-200 million
   b. 3-4 billion
   c. 400-500 thousand
   d. 28 dollars per person

9. **The decision to use building materials that do not accept or hold moisture is _____.**
   a. Generally requested by the building owner
   b. Mandated by most building codes
   c. A decision with severe financial consequences
   d. Made during the design process

10. **Mold is also sometimes called _____.**
    a. Mildew
    b. Shrooms
    c. Wart-root
    d. Scale

11. **There are thousands of species (often quantified as between 50,000 and 250,000) of mold, with more than _____ different kinds of molds found in homes and buildings in the United States.**
    a. 5,000
    b. 3,000
    c. 1,000
    d. 100,000

BEFORE BUILDING DAMAGE OCCURS

The best offense is a good defense. Based on this premise, the easiest way to deal with unwanted water is to make sure it can't get inside. We have touched on the use of construction detailing and what promotes water resistance. We have also discussed installation problems. Specifying the right materials to deny water residence is important. But are there any ways to keep water out, that are useful after the building has already been constructed?

Use of Rain Screens

One retrofit technology, available to stop the intrusion of water into walls, is the installation of rain screens. The best of these incorporate exterior cladding materials/ panels/screens, held away from the building to create an air cavity between it and the building, with a drainage plane behind it, placed on an airtight support wall. This assembly creates multiple ways for precipitation to be channeled away from the building.

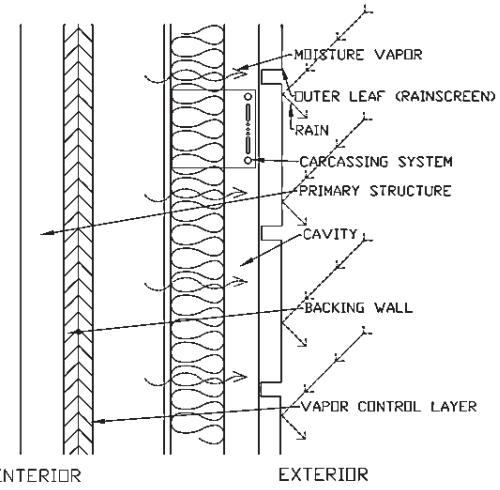


Diagram of a rain screen

The main concept of a rain screen is the creation of two separate planes. The outer plane sheds water, but still allows air to freely circulate behind it. The inner plane is relatively airtight. The circulating air around the screen, creates equal pressure on either side of the outer plane. This results in there being no external force, no pressure differential, to drive water inwards through the building envelope. Even though a difference in air pressure still exists, that would normally act to encourage water penetration through the outside face of the building, the rain screen denies precipitation access to that face. No free water will make it to the building face, to try to work its way inside.

Necessary Ventilation

Designing structures so they are airtight, is not a good approach to water resistance. It is possible to design buildings that are so airtight as to endanger occupants. I was peripherally involved in the last stages of construction of a high-end residence. Incorporating all the latest in spray foam technology, the home was so tight, fireplaces

had to draw combustion air down the chimneys. There was not enough oxygen in the home to sustain the flame. Of course, when they did this, they also pulled the rising smoke down and distributed it back into the home. Fixing that problem required punching holes through the walls beside the fireplaces, to give them some fresh air. The inhabitants of the house needed some as well.

To prevent pollutants from accumulating inside a building, to the point where they cause health problems for inhabitants, some level of ventilation will be required. Fresh air from outside will need to be introduced at the same time, and in the same amount, that interior air is being exhausted. This balance and ventilation was accomplished historically with leaky, drafty buildings, where copious amounts of outside air could enter. The buildings breathed air in and out.

Air can move in and out of buildings by infiltration, natural ventilation, or through mechanical ventilation. Modern buildings, built to satisfy energy codes, don't tend to be leaky or drafty. In these, ventilation must be obtained in one of several ways:

- When outside air enters through openings, joints, and cracks in walls, floors, and ceilings, and around windows and doors, that air intake is defined by the term 'infiltration.'
- Natural ventilation occurs in larger quantities, when doors and windows are opened, with air movement in or out, powered by pressure differentials and, sometimes by wind.
- There are also many mechanical ventilation devices, used to exhaust inside air and bring outside air into a building.
- Intermittent fans, like range hoods and bathroom fans, periodically remove air from a single room upon demand.
- HVAC systems use ducts and fans to continuously exchange stale inside air for fresh, filtered, and conditioned outside air.
- Apartments that have few windows and open to interior hallways, often depend almost entirely on mechanical systems for ventilation.
- It must be understood, that all outside air carries humidity in with it, that must somehow be addressed.

The rate at which all indoor air is completely replaced by an equal amount of outside air, is known as the air exchange rate. When there is little air exchange, because of tight construction and undersized, or missing, fans and other ventilation devices, the air exchange rate is low. When this happens, levels of indoor pollutants tend to rise. If there is a pollutant source present, higher concentrations build up over time, when they are not being exhausted, and there is insufficient fresh air to dilute them.

Sources of such indoor pollution are varied. They include gasses and particulate from interior building materials, finishes and furnishings, as well as the use of products like cleaning solutions. They can also include air-borne contaminants like mold spores, other biological organisms, and gasses from interior or exterior chemical use.

Improving Air Quality and Ventilation

Poor air quality is a problem that can be tackled by various means, including additional ventilation. Sources of pollution, once identified, can be entirely removed from use and from the building. Ventilation devices can be installed to introduce fresh air, to dilute concentrations of pollutants. Air cleaning devices can be installed as part of HVAC systems. Blocked air supply vents can be reopened. Windows can be opened to temporarily relieve air quality problems (unless the source of the problem is outdoors). If certain activities are causing the problem, those activities can be curtailed. Activities that are generating indoor contaminants, can also be moved outside the building. Relocate activities like sanding or stripping furniture, or painting various items, outdoors when that option is possible. Some newer mechanical systems include air-to-air heat exchangers, that allow the introduction of outside air, but precondition that air, as it enters.

If direct action to resolve air quality issues, cannot be taken by users of someone else's facility, those responsible for building operations should be approached and concerns expressed. At that point, a plan of action to resolve the problem should be requested.

The simplest approach to lowering pollutant levels in indoor environments, is to dilute their concentration levels with additional fresh air. Since most residential HVAC systems don't include means to bring in outside air, that can be done by opening windows, operating window or attic fans, or running window AC units with the vent control all the way open. Running exhaust fans will also decrease pollutant levels by exhausting air containing them. This happens, while simultaneously lowering the air pressure inside and increasing the rate of outside air infiltration.

There are two things that must be kept in mind when introducing outside air, to solve an air quality issue. Unless it happens to be the same temperature as the desired inside environment, an additional cost will be incurred to heat or cool that outside air. Moreover, and of more concern to the primary subject of this work, that outside air will also bring its inherent water vapor, its humidity inside. Once inside, that moisture must also be addressed.

Addressing Moisture Problems in Various Building Systems

Those tasked with maintaining buildings, from tradesmen who work on components to facility managers, inherit both the good and bad characteristics of structures, from those who designed them. The maintenance staff will be the ones who will deal with excess moisture. Their maintenance concerns regarding moisture intrusion,

will fall into primary categories of; site drainage systems, foundation integrity, wall integrity, roof and ceiling assemblies, plumbing systems, and HVAC system maintenance. Each of these areas of concern are addressed in more detail below.

Maintenance of each area of concern will involve; regular inspections; lubrication, cleaning and repairs prescribed during the inspection; documentation of problems and responses, and the possible development of operations plans and maintenance schedules.

The first step, the inspection step, can be simplified, using a troubleshooting guide for indoor water issues. One example is included below.

SYMPTOMS OF MOISTURE PROBLEMS	**PROBLEMS**	**POSSIBLE CAUSES**		
		DESIGN	**CONSTRUCTION**	**O&M**
Mold growth	Leakage through the envelope, due to rainwater or groundwater control	Missing or poorly designed components	Missing flashing or building wrap Surfaces slope inward to building Below grade drainage systems are damaged	Ground near the foundation settled Damaged rooftop curb flashing Shingles missing or roofing damaged
	HVAC system not removing humidity	AC equipment oversized AC equipment not designed for adequate dehumidification	Humidity sensors improperly wired	Chilled water set-point too warm Economizer set-point allows humid air to enter AC running continuously
	Condensation inside HVAC system, due to dirt on surfaces	Improper condensate drain design HVAC system surfaces insulated, or hard to clean		Cooling coils have not been cleaned Drain pan is clogged
	Wet materials were installed in building assemblies	Moisture sensitive materials are in contact with porous materials, exposed to water Maximum moisture content or emissions of materials was not specified	Flooring was placed on slab while still damp No vapor emissions test was done on slab	Penetrations created, during maintenance or installation of equipment, were left unsealed
Peeling paint Wood decay Corrosion	Rain or ground water intrusion into the building	Missing or poorly designed components	Missing flashing or building wrap Surfaces slope inward to building Below grade drainage is damaged	Ground near the foundation settled Damaged rooftop curb flashing Shingles missing or roofing damaged
Plumbing leaks / spills	Poor design Poor installation Poor operations or maintenance	Water lines located in places subject to freezing Poorly designed drain or shower pans	Defective pipe joints Accidental pipe penetration, by a fastener	Failure to inspect and repair plumbing problems
Water has reached materials intolerant to moisture	Capillary action drew it in through porous materials	Moisture barriers were not specified in design Drainage layer beneath slab was left out of design	Moisture barrier not installed Drainage barrier below slab was not installed	

Condensation	Warm, moist outside air enters building through cracks and holes, during hot humid weather Warm, moist inside air leaves building through cracks and holes, during cold dry weather Vapor barriers on outside walls were installed wrong Moisture sources not vented or poorly vented	Air barrier was left out of design No positive pressure building operation was specified Air barrier was left out of design Attic assembly air barrier was too hard to install Building is not operating at a positive pressure, while it is cold outside Vapor barriers were called for on both sides of an assembly Vapor barrier was specified on the wrong side of assembly Design of HVAC system overlooked venting moisture sources Insufficient ventilation was specified	Unintended gaps in envelope were created during poor construction Air barrier installed correctly, but holes cut through it for wires and pipes Unintentional vapor barriers were installed on other side, like vinyl wall cover, blackboards, mirrors, etc. There are leaks in exhaust ducts Exhaust systems are poorly balanced Exhaust dampers are closed	Access holes were not resealed after they were created HVAC system changes created an unintended positive pressure inside Unintentional vapor barriers were added after construction on other side Exhaust fan has a broken belt Exhaust ducts or grilles are clogged
Delamination Improper curing	Wet materials were installed in the buildings assemblies	Moisture sensitive materials are in contact with porous materials, exposed to water Maximum moisture content or emissions of materials was not specified	Flooring was placed on slab while still damp No vapor emissions test was done on slab	

- Problems occur when design intent is not met, because other equipment, besides that which was specified, is substituted for budgetary reasons.
- Air leaking through exterior envelopes, may be entering through holes created by tradesmen or maintenance personnel, but it could also be caused by changes in control sequences of fans and exhaust systems.
- Large sources of humidity indoors, like pools, saunas, and large showers, will aggravate problems with interior condensation.

This troubleshooting guide is just an example of what is possible. Numerous other problems and problem sources exist, which can be added to such an organizational aid. The best charts, are those which are customized by maintenance personnel assigned to each building. Because each building has its own peculiar flaws.

With or without such a chart, the following items should be considered during routine inspections of each major building system, each line of defense against water intrusion.

exam questions...

12. **The _____ is the rate at which all indoor air, is completely replaced by an equal amount of outside air.**
    a. ARF (Air Replacement Factor)
    b. Diffusion Factor
    c. Infiltration Gain (IG)
    d. Air Exchange Rate

13. **The main concept of a rain screen is the creation of _____ separate planes.**
    a. two
    b. three
    c. four
    d. several

14. **Air can move in and out of buildings by which of the following means?**
    a. infiltration
    b. natural ventilation
    c. mechanical ventilation.
    d. all of the above

15. **According to the Trouble Shooting Guide, if you are seeing peeling paint, wood decay, or corrosion, the problem is likely to be caused by which of the following?**
    a. Wet materials were installed in building assemblies
    b. Rain or ground water intrusion into the building
    c. Moisture sources not vented or poorly vented
    d. Vapor barriers on outside walls were installed wrong

16. **According to the Trouble Shooting Guide, if you are seeing delamination or improper curing, the problem is likely to be cause by which of the following?**
    a. Wet materials were installed in the buildings assemblies
    b. Vapor barriers on outside walls were installed wrong
    c. Condensation inside HVAC system, due to dirt on surfaces
    d. Leakage through the envelope, due to rainwater or groundwater control

17. **Regarding moisture intrusion, maintenance of each area of concern will involve which of the following?**
    a. regular inspections
    b. lubrication, cleaning and repairs
    c. documentation of problems and responses
    d. all of the above

Maintaining Site Drainage

If drainage systems on site, meant to channel water away from the structure, are not maintained, heavy rain or snow melt can cause unexpected flooding, with subsequent property damage. To prevent this, maintenance plans should be put in place to inspect and maintain site drainage. The runoff from impervious surfaces, like walks, parking areas, and roofs, should be diverted to swales designed to carry it away. Care should be taken, that future modifications to the site do not disrupt, destroy, or overload the designed and properly working site drainage systems.

A preventive maintenance plan for site drainage systems, should be created to insure they serve, and continue to serve, the purpose for which they were created. It should include a written overview of the intended operation of the drainage system. A frequency of inspection should be specified for each site system, as well as key items to be observed and verified. Maintenance activities necessary to keep each system working, like the removal of leaves and debris from inlets, should be specified. Maintenance agreements, pertinent to any site drainage systems, should be included in the manual, along with contact information for each contractor or tradesman liable to be involved.

A preventive maintenance plan should be created to cover maintenance of impervious surfaces. Make sure the design intent is clear, for how each surface is intended to drain. Create an inspection checklist to verify design intent is being met, and that runoff is making its way into a drainage system to be carried away. Develop clear instructions to be given to workers, so plowed snow is not placed in areas that will interfere with drainage, or wind up piled against the building. Lawn care workers should be informed of drainage systems and their work done, so they do not damage or obstruct components of the system, or its proper operation. Lawn care workers are also an excellent source of real time information, concerning how drainage really occurs on site.

Care should be taken to prevent further site modifications from damaging designed drainage systems. Verify beforehand that additional paved surfaces, even those topped with gravel, will not overburden existing drainage or water infiltration capacities. Those who maintain the site drainage systems, should be included during the planning of any additional impervious surfaces on site.

In all these efforts to maintain site drainage systems, records of problems and corrections should be kept. Photographic records of site conditions, will become valuable in establishing changes in site conditions, occurring over time.

Maintaining Foundations

Building foundations, besides supporting the structure above, are intended to prevent the intrusion of rainwater and snowmelt into spaces below occupied levels. But these seeming impregnable portions of the building, are

very vulnerable to attack from ground water, plumbing leaks, and condensation. Since these areas are not usually occupied, periodic inspections are especially critical to find and correct developing problems. This will reduce risk of serious damage to foundations, sometimes occurring when issues develop, but remain unresolved for a significant length of time. Tying back into the previous subject, one obvious precaution to take, is to ensure that site drainage systems always divert water away from the foundation. Periodic inspections to verify this should be scheduled and conducted. Maintenance of the foundations, should be periodically conducted as well. A checklist and work order system are useful tools for this.

Visual inspections on the exterior, can determine whether drainage systems are properly diverting water away from foundations. Soil settlement, or pooled water near the building, indicates a reason for concern. Roof drain leaders should all be in place and secured. New cracks in foundation walls are indicators of settlement, often due to the presence of water below that footing. Verify that walks and impervious surfaces, adjacent to the building, are still sloped and shedding water away from the structure. Newly planted or sprouted trees near drain lines, should be pruned or entirely removed before their roots can demolish or clog the drains. Exterior hoses and irrigation systems should be inspected and tested for leakage. Finally, inspections right after, or during, heavy rain or periods of rapidly melting snow, are always valuable to visually determine if water does indeed move away from foundations as intended.

Settling because drainage systems not maintained

Inspections on the interior of foundations can also identify developing problems. Again, newly developed cracks in foundation walls are indicators of moisture settlement below. Proper operation of sump pumps and internal drain systems should be verified. Seeping, or wicking through foundation walls, will often leave evidence of stains, damp surfaces, efflorescence, peeling paint, or surface mold. Musty odors are an olfactory warning sign of mold or rot. Check wood materials in foundation areas for swelling, warp or mold. Test and record the relative humidity and temperature in the enclosed foundation space. Check for any delamination of applied finish materials, such as flooring. Finally, look for condensation occurring on pipes and other hard surfaces.

Maintaining Walls

If interior and exterior walls are not routinely inspected, failures in their integrity can lead to invading moisture remaining unnoticed and not being repaired. Resulting problems will include expensive building repairs and potential health problems for inhabitants. It therefore becomes important to create and carry out routine inspection of walls, to detect moisture intrusion before serious problems result. Walls must also be routinely maintained, to make sure they fulfill their intended purpose of separating inside atmospheres from outside.

Inspections can pinpoint problems, before they become catastrophes. A record should be made of wall types, maintenance procedures, contact information for pertinent contractors, and a record of inspections that have been conducted. A checklist should be used for proper evaluation of each type of wall assembly. Problems should be marked on record copies of the exterior elevations, as problems are discovered. Special attention should be paid to copings, flashings, counter flashings, and the integrity of masonry walls. Photographic records should be included with details, of how each discovered problem was corrected.

Maintenance of walls includes both repairs, and ongoing periodic, visual inspections. This is especially important following heavy rains, preferably in every season, since outside temperatures can affect the performance of envelope components. Interior walls and ceilings should be checked for telltale signs of water damage. Any visible evidence of moisture, cracking, or movement should be noted. Masonry walls should be searched for cracked or spalled units, and deteriorated mortar. Mold and algae growths are sure indicators of the nearby presence of moisture. Remember that ivy and other plants, growing on masonry walls, are not only picturesque, but incredibly destructive to mortar joints. Ivy covered walls tend to leak water like a sieve. Periodically open weep holes in masonry with a stiff wire, without damaging the flashing behind them. Inspect caulking at openings and refresh or replace it, where cracked or containing voids. Inspect flashing materials for cracks, rust, open ends, or open joints. Repair any perceived problems immediately.

When done with each inspection and repairs, incorporate those notes, and attendant photographs, in a record logbook being kept for wall maintenance.

Roof leak affecting the wall below

Maintaining Roofing and Ceilings

Roof and ceiling assemblies are subject to damage from normal wear, severe weather, building movement, improper design, poor construction, and inadequate maintenance. It should go without saying, that when problems develop at the top, the intruding moisture will damage all it can successfully invade below. Uncorrected leaks, coming through the roof system, will impact inhabitant productivity, as well as quickly resulting in damage to contents and the structural integrity of the building. The focus in maintaining the weather resistance of roof to ceiling assemblies, should be on thorough maintenance plans involving periodic scheduled inspections, with immediate follow through to fix developing issues and concerns.

The first step in a preventive maintenance plan is to read and thoroughly understand, manufacturers and installation contractor's, warranty terms and conditions. That knowledge is very useful in developing a checklist and logbook to; observe and evaluate the roof, the curbs on which equipment is mounted, flashing attached to those curbs and to other surfaces with which the roofing intersects, drainage patterns on it, and traffic patterns of those who must traverse the roof. In the logbook, record roof types, their attendant drainage system components, installing contractor information, manufacturers of other systems and components affecting the roof integrity, roofing warranty information, and written and photographic records of all inspections. A roof plan should also be included in the logbook, detailing all features on the roof like scuttles, HVAC equipment, drains, gutters, downspouts, scuppers, vents and roof angle changes. Copies of that roof plan should be used each time, to locate and record, observed problems and repairs that were executed.

The purpose of periodic roof inspections should be to determine whether roofs are working as intended, to find signs of weakness, deterioration, or trouble spots, and to identify where repairs are needed. Care must be taken during the inspections, not to create damage. When ladders are typically used to inspect steep roofs, or access higher roofs, do not rest these ladders against the gutters. It can damage their sides or loosen them. When on the roof, take care to step on flat portions over structural members, and avoid stepping on side laps or standing seams of metal roofing.

While inspecting ceilings and roofs, look for these specific indicators of moisture intrusion.

- Check interior walls below them, and the ceilings themselves, for water stains or for structural distress.
- If you can easily access the bottom of the roof deck, look for water or insect damage, rust, settling, or other damage. Check the interior face of exterior walls below roofing members, for signs of movement or cracking.
- Exterior walls and roof overhangs should be checked for signs of moisture, cracking, or movement.
- Ponding on the ground, adjacent to the building, may indicate a blocked drainage component. Gutters may need to be cleaned or a downspout unstopped.
- Verify continuity of the roof edge and covering. Check for loose ends, gaps, metal deterioration, loose or missing fasteners, accumulated debris that indicates ponding, or physical damage to the roof surface. Pay special attention to flashings and counter-flashings. If caulk or roofing tar has been used for temporary repair, verify that the caulking is still intact and sealing as intended.
- Search for spots with soft roof insulation and cracked or discolored walls.
- Look for signs of moisture infiltration, anywhere surfaces intersect, like curbs, flashing, etc.
- Check for missing weather seals on equipment housings, and for damaged caulking where the supports penetrate roofing.
- If deflection of the roof was allowed for in the original design, make sure that roofing and flashing can still move independently of one another.
- Inspect the seal between caps, flashings and roofing, at hips, ridges, and valleys. Ensure there are no obstructions blocking water flow at the valley edges.
- Inspect the drainage systems to make sure fasteners are in place, sealants are still in good repair, nothing is missing, and no components are blocked. Use a snake to verify the open condition of drains suspected to be blocked. Do not use water for this. If a roof drain is blocked by ice, don't risk damaging the drain by chipping or breaking the ice.
- Inspect masonry weep holes for signs of dripping.
- Check for areas on the roof, where ponding may be occurring, especially near skylights, scuttles, curbs and other openings.
- Accumulated debris is another indication of

ponding. This problem must be addressed at once, even if it is an underlying structural issue, because standing water can and will rapidly deteriorate roof surfaces.

- Granules in gutters often indicate deterioration of the roofing, to which they were once bonded.
- On membrane roofs, pay special attention to areas between roof trusses and beams, as they are likely spots for deflection to occur.
- On membrane roofs, pay attention to joints between two sheets of membrane, and to changes in the angle of the roof, to verify separate plies are still properly bonded.
- On built-up asphalt roofs, look for blisters caused by air or water vapor trapped beneath. Check for cracks in the membranes, as well as splits, ridges, and uplift at seams.
- On elastomeric membrane roofs, inspect for open seams, shrinkage, backed-out fasteners, and damage after heavy winds.
- On ballasted roof systems, inspect for missing or displaced ballast and insulation boards, beneath the roof membrane.
- On adhered roof systems, check for loose membranes, displaced insulation boards and tented insulation fasteners and plates.
- On mechanically attached roof systems, note any cuts in the membrane, displaced insulation boards and tented roof fasteners and plates. Check for loose flashing, including at curb mounted HVAC units.
- On asphalt shingle roofs, check the tops of vertical slots between tabs. This area is usually the last place on a shingle to dry. Moss allowed to grow on these roofs, will keep the roofing damp. Use a water hose and nozzle to remove any growth. Spray downward, so water is not forced up under the shingle laps.

Disaster waiting to happen

exam questions...

18. Which of the following would be a reason for concern during a visual inspection of the exterior?
a. Soil settlement, or
b. pooled water near the building
c. both a and b
d. sloped walkways

19. _____ in gutters often indicate deterioration of the roofing, to which they were once bonded.
a. Gravel
b. Granules
c. Debris
d. Moss

20. Flashing materials should be inspected for which of the following?
a. cracks
b. rust
c. open ends or open joints
d. all of the above

21. On built-up asphalt roofs, look for _____ caused by air or water vapor trapped beneath.
a. blisters
b. rust
c. blockages
d. mold

22. On _____, inspect for missing or displaced ballast and insulation boards, beneath the roof membrane.
a. elastomeric membrane roofs
b. asphalt shingle roofs
c. ballasted roof systems
d. adhered roof systems

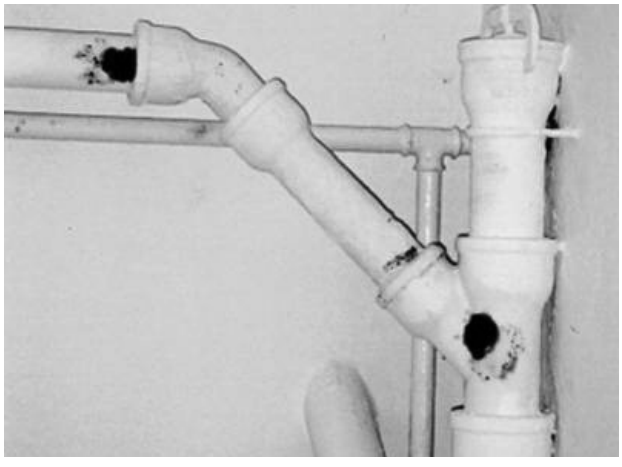
Maintaining Plumbing Systems

When plumbing systems are not maintained, flooding of the building, or the buildup of condensation can occur. Unless these normally out of sight, out of mind, plumbing components are inspected regularly, minor leaks in them can foster mold growth and damage to building components. They must be uncovered, inspected and maintained.

A manual should be created, establishing a set schedule for review of plumbing systems. These inspections should check piping and other distribution equipment, pumps, valves, fixtures like sinks that use water, water heaters and storage tanks, fire sprinkler systems, drainage system components, and insulation that covers pipes. Deteriorated joints and connections, showing evidence of leakage or corrosion, are of special and probably immediate concern. To be also noted, and at

least immediately insulated, are pipes carrying water that are in areas that may be subject to freezing. Or in areas that have suddenly become subject to freezing, because of current issues with a heating system. Better yet, place supplemental sources of heat in those areas. If they are not yet leaking, or have not yet burst, a bullet has been dodged.

Contact information for professionals, capable of responding to and correcting an emergency, should also be included in a plumbing maintenance logbook. As-built plans of the plumbing systems should be in there, locating shut-offs and valves that control zones and the overall plumbing systems. That is need-to-know information for at least someone on staff, at any hour of the day in the building.



Evidence of leaky pipe joints

Mold growth because of bathtub leak

Maintaining HVAC Systems

Inadequately maintained HVAC systems can become unexpected sources of water in building interiors. If humidity controls fail, more condensation occurs than was intended, or drain pans begin overflowing. Moisture damage will begin, and mold can begin to grow. Preventive maintenance plans should be created that set routine times for inspection, and compliance with equipment manufacturers' recommendations. At a minimum, inspections of HVAC system components should be conducted semi-annually. Inspections should also be conducted, following heavy rains or other events that might affect the performance of HVAC systems.

The maintenance guide / logbook should contain the following. Manufacturers' warranties, and recommendations for maintenance of their products, should be in there. Contact information for the installers of the equipment, as well as repair personnel should be included. A verifiable performance goal, set during design, should have procedures in place to determine whether the goal is being met. Records of all HVAC installations, as well as repairs to the same are important. Procedures to be followed, upon discovery of a problem, should be part of the logbook. Future replacement of equipment can be scheduled, so budgeting for the same can be included in current financial planning.

HVAC components should be inspected to insure they are properly supplying, returning, and conditioning air, and that systems set in place to remove or add humidity to the air, are still properly functioning. Specific HVAC items to be routinely inspected are numerous. Nonetheless, they should all be included in a preventive maintenance plan.

Thermostats should be checked for proper functioning, every fall and spring, or when complaints are received, that they don't seem to be working. If a thermostat is programmable, verify the time is set correctly, including for AM or PM, and the programming is for hours of occupancy. Place a calibrated thermometer next to the thermostat in question, but not touching the wall, to determine if the temperature of the wall surface is affecting the thermostat being inspected. If the thermostat reads more than one degree different than the thermometer, there is a problem. The thermostat should be cleaned, the mercury switch checked to verify it is level, and holes in the wall for control wires caulked, to prevent air in the wall cavity from affecting readings.

Control sequences should all be calibrated. All clocks on a controlled system should read the same, and have the correct time and date. Make sure that equipment operates as intended, in accordance with the programming of the control unit.

Outdoor air intakes should be inspected. Potential sources of contamination near air intakes, like idling vehicles, dumpsters, trash, or decaying materials, should be removed so odors are not pulled into the building. If it is not possible to remove them, it may be necessary to reconfigure and change the intake location. Debris screens behind intakes should be checked to verify they are free of clogging material, and no insects have nested in them. If outdoor intakes are near ground level, vegetation should be cleared away from them for a distance of at least five feet. Anyone mowing lawns, should make sure their mower discharge is directed away from any air intake, when they pass it.

The proper operation of outdoor air dampers, should be observed and verified. Trigger controls to force dampers to operate and watch to see if dampers really move. Adjustment or lubrication might be necessary to obtain proper operation. Outdoor air volumes that are entering the system, should be regularly measured for compliance with design intentions.

Cooling coils, pans, and condensate lines should be regularly checked for cleanliness, to proper function. All drain traps should be checked and filled with water whenever needed, to prevent sewer gases from entering back into the building, through floor drains. Ducts downstream from the cooling coil, should be regularly checked for mold growth, resulting from condensation blowing off the coil. If found on sheet metal, the mold should be removed by a specialist. If found in, or on insulated lining, the duct lining will need to be replaced.

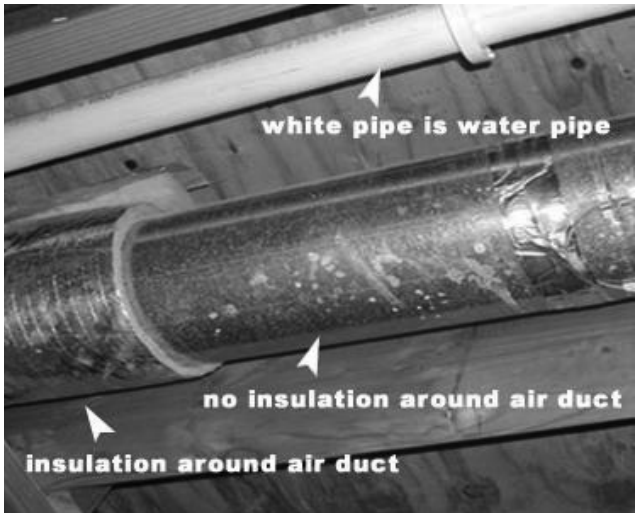
Evaporative cooling equipment should be checked for cleanliness, and for evenly distributed wetting across the full face of the pad. Clogged media should be replaced, so supply air is not constricted. That would result in high velocity air flow, pulling water off the media and directing it downstream, into the ductwork. Verify that overflow drains are working, and the media is not in contact with standing water in the sump, when the unit is not operating. Verify that controls are set to prevent the unit from operating, when it is raining outside. Otherwise, incoming air will be overloaded with humidity. Finally, as above, inspect ductwork downstream from the cooling coil for mold growth, and takes steps to remediate it, if found. But first, fix the problem that led to excessive moisture being present to support mold growth.

Visually inspect and replace HVAC system filters on a regular scheduled basis. When they become clogged, filters can be sucked out of their frames by the force of the airstream, leaving unfiltered air free to flow around them and enter the indoor environment.

Ductwork should also be inspected on a regular basis. If there is significant particle build-up, or mold is discovered to be present, sheet metal ducts should be cleaned, and contaminated duct liner or insulation replaced. Dented, damaged or disconnected ducts should be repaired or replaced. All seams should be checked, and those which leak, should be resealed with appropriate materials. Dirt and dust buildup around diffusers, is a telltale sign of missing filters or dirty ducts. Even cooling coils should be inspected, to verify there is no mold growth on them, contributing to spores in the airstream.

Return air plenums, when dirt and dust collect above ceilings, can result in a steady supply of particulate being returned to the airstream. Periodically inspect return air plenums for such buildup, but also check for discolored ceiling tiles below return air plenums. Water stained ceiling tiles, can also harbor mold growth and contribute spores to the return airstream.

Humidity controls, put in place as part of an HVAC system, should be checked to ensure they are in good working order. Hot humid air pulled in from the exterior, with no modification beforehand, will result in condensation on cooler surfaces inside. Monitoring temperature and humidity inside the building, allows better tracking of humidity sources. Dehumidification equipment should be tested, to verify it is in good working order.



Condensation on air duct

Making Your Home Weathertight

There is one built-in checklist, one easy type of inspection by building inhabitants, that is a good determinant as to whether air quality inside has been impaired. Energy codes are now being enforced that require weatherization of buildings, to reduce energy being expended for climate control. The 'tighter' a structure, the more care needs to be taken to minimize sources of air pollution from inside the building. Inhabitants must remain alert to, and check periodically for, stuffy air, condensation on cold surfaces, and other visible indicators of inadequate ventilation. Because, although weatherization does not usually contribute to the presence of pollutants, it will keep them inside, when once they would have been diluted or exfiltrated by natural ventilation.

There is a serious health risk, posed by the aggregation of different sources of indoor air pollution. Steps have been detailed that most building owners and users can take to minimize this problem. They are found in a safety guide, available from the U.S. Environmental Protection Agency (EPA) and the U.S. Consumer Product Safety Commission (CPSC). There is also a section on air quality in offices, and what you can do if you suspect your office has an indoor air quality problem.

exam questions...

23. One factor that has influenced the design of buildings that are more airtight, is _____.

a. American Medical Association guidelines for design
b. Energy code enforcement
c. Better a technology for HVAC units
d. Higher humidity levels than in the past

24. Deteriorated joints and connections, showing evidence of leakage or corrosion, are most likely of _____ concern.

a. little
b. immediate
c. no
d. some

25. Potential sources of contamination near air intakes include which of the following?

a. idling vehicles
b. dumpsters
c. decaying materials
d. all of the above

26. The '_____' a structure, the more care needs to be taken to minimize sources of air pollution from inside the building.

a. tighter
b. looser
c. more humid
d. smaller

27. True or false? Although weatherization does not usually contribute to the presence of pollutants, it will keep them inside.

a. True
b. False

DEALING WITH BUILDING DAMAGE FROM MOISTURE

Suppose that despite best efforts to repel it, despite best efforts to keep all lines of defense against moisture intact and working, the water still wins? The signs are unmistakable. Our senses assure us that rot is occurring, materials are decaying, and mold growth is happening before our very eyes. We have unwanted moisture, inside our living, learning, or working environment. How do we best respond, to reclaim what we built, and get it back, free of health risks?

Testing and Remediation of Dampness and Mold

The first thing to understand, is that there are no established standards for what constitutes acceptable levels of biological agents in indoor air. Short-term air sampling for mold spores, does not tend to yield results representative of actual exposures. What part of the presence of mold and its growth, that building inhabitants react to problematically, is still pretty much unknown. It might be the mold itself, a compound produced by the mold, bacteria, compounds released into the air when organic materials are broken down by mold, or something we don't even know enough to speculate upon. Visual inspections tend to be far more reliable than tests, in establishing a correlation between the known presence of mold, and health risks in building inhabitants, who are exhibiting symptoms or voicing complaints, about the indoor environment.

No testing to verify mold, needed here

We do know steps that should be taken in general, upon the discovery of mold. The water source needs to be isolated and repairs made immediately, to prevent further intrusion. If wet materials cannot be dried within 48 hours of exposure, they need to be removed. If visible mold is identified, exposure to it by the inhabitants must be minimized, until the mold can be safely removed. Then some time must be allowed to pass, to properly verify that mold growth has been stopped.

Those remediation tasks, to be undertaken after discovering mold growth, can be expanded as follows.

Testing for Contaminants

If an area that previously contained mold has been cleaned and bleached, that may have resolved the problem. But should mold reappear, the area continues to smell of mold, or the inhabitants continue to complain about air quality in the space, further steps will need to be taken.

The first step if odors persist, or visible mold reappears, is to repeat the cleaning and bleaching process. Materials like carpet, that remain wet and exhibit mold growth, cannot be properly cleaned. They will need to be discarded and replaced. But if complaints continue afterwards, sampling and inspection should be done by a trained remediation specialist, to ensure excessive concentrations of microbes are not still present in the

building. While doing so, appropriate respiratory and personnel protection should be used. Negative pressures may need to be set up in contaminated areas, to prevent spreading microbes to nearby areas during testing and cleaning processes.

Inventory Damaged Materials

To prevent the growth of mold following incursion by water, certain tasks have been found to be effective. They begin with the necessity of inspecting and inventorying, all water damaged building materials and furnishings. A written and photographic record should be made, for use with insurance claims and other financial and facility records.

This is a quick overview of how different water damaged building materials, will need remediation in different ways. Contaminated sheetrock will need to be removed and discarded with either few controls, or under controlled abatement procedures, depending on the degree of contamination. If ceiling tiles have been damaged by steam, they can be dried and monitored for future mold growth. If damaged by water, ceiling tiles will need to be discarded and replaced. Electrical system components will need to be inspected by a building inspector or electrician. Components that appear to be damaged or have their performance capability compromised, will need to be discarded. Furniture damaged by steam or potable water might be salvageable, but if other types of water damage occurred, it too will need to be discarded. Delaminated furniture will need to be replaced. Hard surfaces, which can include intact laminates and hardwoods, can simply be cleaned. If wood composites like particle board, were subjected only to steam, they can be air dried and monitored for developing problems. If they were damaged by other types of water, they will need to be removed and replaced. If carpet has been wet for less than 48 hours, it can be cleaned, disinfected, and monitored for future problems. If carpet has remained wet for more than 48 hours, it will need to be removed and replaced. Paper files, if non-essential, should just be discarded. Paper files that are essential, if they cannot be dried within the first 24 hours, can be cleaned, frozen, and then copied photographically.

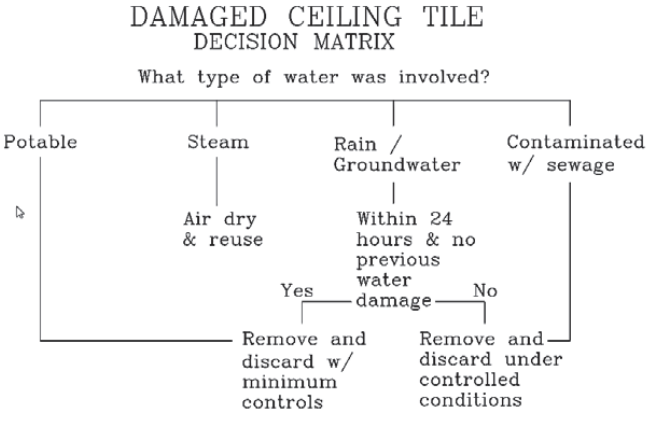
Far more detailed responses to water damage, in specific areas of loss, are discussed below. For each category, a decision matrix is included to use as a reference guide.

Inventory and Response to Ceiling Damage

As a rule, all wet ceiling tiles should be removed and discarded, within 24-48 hours of being damaged by water. If the ceiling tile was only damaged by a small steam leak, and the shape of the tile has not changed, it might be possible to air dry and reuse that specific tile.

Water stained ceiling tile

A decision matrix for dealing with water damaged ceiling tile is below.



Inventory and Response to Drywall / Plaster Damage

Time following exposure to water is the primary factor in response to drywall damage and to the insulation behind it. If restoration work can begin within 24 hours, damp drywall and insulation can be removed and disposed of, in a normal fashion. If more than 24 hours has elapsed, or there is already mold on the sheetrock from previous exposure to water, then controls will need to be put in place to prevent restorative work from spreading mold spores elsewhere. Damaged sheetrock will need to be removed up to at least 12" above the damaged areas.

A chalky surface can form on wet lathe and plaster, leaching minerals from the wall. Surface material which is loose, will need to be removed, and the remainder allowed to dry, before recoating the remaining surface with an antimicrobial paint. If a strong odor begins to develop in a plaster wall, it is damaged, will need to be removed under controlled circumstances, and replaced.

There are multiple controls that can be put in place, to contain the spread of mold spores and their dispersal into the airstream. Use of critical barriers to segregate work areas, establishing negative air pressure zones in work areas, and respiratory protection for workers, are all on the table. Handwashing while working, and showering

afterwards, are recommended procedures for working with water damaged materials.

Hard surfaces that do not absorb water, can be cleaned with detergent, followed by a rinse with a bleach solution. Another rinse with clean water is not recommended, since the idea is to allow the bleach to remain on the surface and inhibit further growth. The bleach solution should not be allowed to contact metals, like those in fasteners, because the chlorine content will cause metals to rust. Bleach should only be used in a well-ventilated area, and bleach solutions should never be used in conjunction with any other cleaning solutions., especially ammonia. Potentially deadly, poisonous vapors will result. Once cleaning is complete, heaters, dryers, or fans, or a combination thereof, should be used to finish the job and eliminate any remaining moisture.

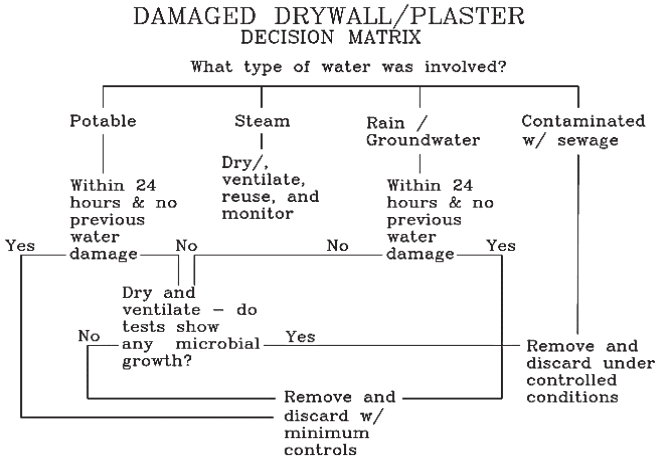
Water stains on drywall

Mold on drywall

Mold inside a wall cavity

Mold on the back side of drywall

A decision matrix for dealing with water damaged drywall or plaster is below.



Inventory and Response to Carpet Damage

Time following water exposure, and the source of water that caused the problem, both factor in how carpet damage is remediated.

If the carpet has been contaminated with water containing sewage backup, treatment will depend on the size of the affected area. Large damaged areas of carpet will need to be removed, the floor disinfected with bleach and water, thoroughly dried, and new carpet installed. If the area is small, the water should be extracted, the carpet in that area cleaned with bleach and water, that solution extracted, and the area thoroughly dried. If odors, or any other visible problems manifest, the carpet will still need to be removed and replaced.

Carpet that has become wet because of ground water, roof, steam systems or potable water system leaks, is treated in varying fashions, based on whether treatment can commence, before or after 48 hours has elapsed since the leak occurred.

If carpet has been wet (with no sewage back-up involved) for less than 48 hours, the carpet can most likely be saved. Get everything off the carpet, then use wet vacuums to extract as much water as possible. Afterwards, shampoo the carpet. Then rewet the carpet with a bleach solution, preferably not a solution containing biocides, since people can have reactions to those as well as microbes.

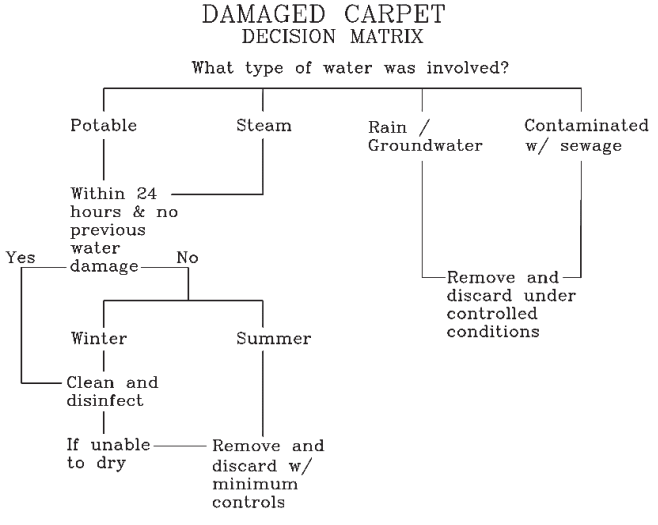
Steam cleaning, using water heated above the boiling point, can be used in lieu of treatment with a bleach solution. Extract excess water. Then, within 12-24 hours of treatment, carpet should be dried with dehumidifiers, dryers, and exhaust fans.

If carpet has been wet (with no sewage involved) for more than 48 hours, salvaging it will largely depend on the season. If damaged occurred in the winter, the previously described protocol can likely be used to salvage the carpet. If damaged in the summer, if the area involved is not in an air-conditioned space, and dehumidifiers were not immediately available and put into use, the best option will be to remove and replace the carpet. The problem necessitating that solution, is the combination of heat and humidity that will encourage rapid mold growth.

Following initial treatment of wet carpet to save it, should visible mold reappear, or an odor become apparent, the cleaning and drying process should be repeated only once. Afterwards, it is advisable to have expert testing done in the area, to confirm success in eliminating concentrations of mold. If such mold is still present, it will be necessary to remove and replace that carpet. As before, when damaged carpet is being removed and replaced, multiple controls should be put in place, to contain the spread of mold spores and their dispersion into the airstream.

Drying carpet

A decision matrix for dealing with water damaged carpet is below.



exam questions...

28. The water source needs to be isolated and repairs made immediately, to prevent further intrusion. If wet materials cannot be dried within _____ hours of exposure, they need to be removed.
a. 24
b. 48
c. 72
d. 96

29. True or false? If ceiling tiles have been damaged by steam, they must be discarded and replaced.
a. True
b. False

30. Paper files that are essential, if they cannot be dried within the first _____ hours, can be cleaned, frozen, and then copied photographically.
a. 72
b. 96
c. 24
d. 48

31. If a ceiling tile has been damaged by water contaminated with sewage, which of the following steps should be taken first?
a. Remove and discard under controlled conditions
b. Air dry and reuse
c. Remove and discard with no controls
d. None of the above

32. If carpet has remained wet for more than _____ hours, it will need to be removed and replaced.
a. 96
b. 72
c. 48
d. 24

33. Damaged sheetrock needs to be removed up to at least _____ above the damaged areas.
a. 6 inches
b. 12 inches
c. 18 inches
d. 24 inches

34. If drywall has been damaged by steam, which of the following steps should be taken?
a. Dry/ventilate, reuse, and monitor
b. Dry/ventilate then test for microbial growth
c. Remove and discard under controlled conditions
d. Remove and discard with minimum controls

35. True or false? Following initial treatment of wet carpet to save it, should visible mold reappear, or an odor become apparent, the cleaning and drying process should be repeated only once.
a. True
b. False

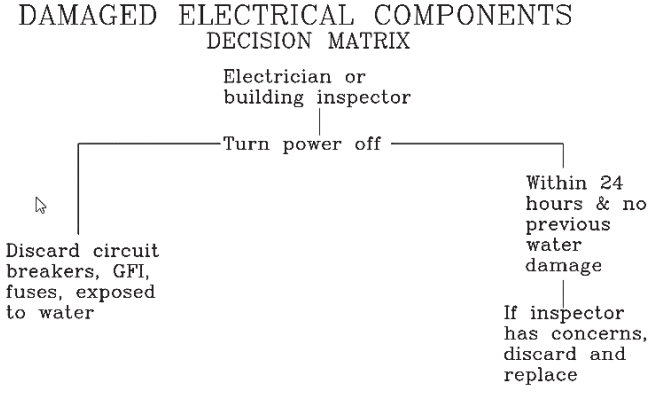
36. According to the Damaged Carpet Decision Matrix, if carpet has been damaged by potable water for over 24 hours in the summer, which of the following steps should be taken?

a. Remove and discard under controlled conditions
b. Clean and disinfect
c. Remove and discard with minimum controls
d. Air dry and reuse

Inventory and Response to Electric Systems Damage

Time passage, after exposure to water, is not a factor when evaluating components of electrical systems that became wet. All such wiring, fixtures, and outlets can be considered shock hazards, until they have been checked and cleared by a qualified inspector or electrician. Until then, power to that area should be cut off, also by a qualified electrician, since the panel may also present a hazard of shock. Any breakers or fuses that became wet, should automatically be replaced. Switches and outlets might be salvageable once dried, but should any doubt exist, replace those as well. Anything like motors, fixtures, etc. that became wet, should be opened, air dried, and inspected by a qualified inspector or electrician, before being reassembled and put back into service.

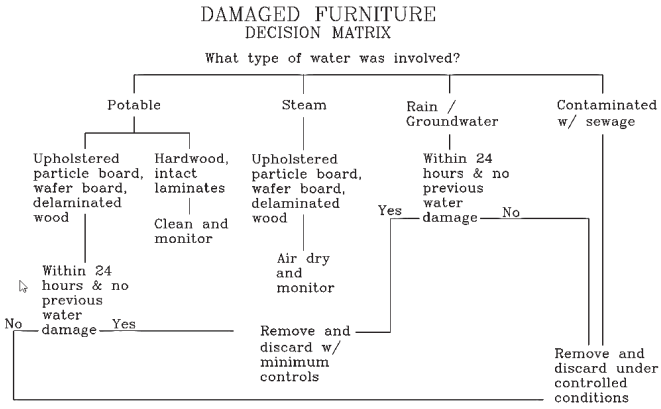
A decision matrix for dealing with water damaged electrical components is below.



Inventory and Response to Furniture Damage

The primary factor for evaluating furniture, that has been subjected to water, will be whether it is upholstered. If the water came from steam system leaks or drinking water, upholstered furniture should be dried within 24 hours and monitored in the future, for fungal growth or odor. Anything wet from other water sources should be discarded and replaced. Hardwood furniture surfaces can be air dried and cleaned with a bleach solution. Laminate furniture, that is delaminating, should always be thrown away and replaced. Likewise, furniture made of particle board should be replaced, unless it was because of a steam leak. Then, if it is still integrally sound, it should be dried, cleaned, and monitored for growth or odors.

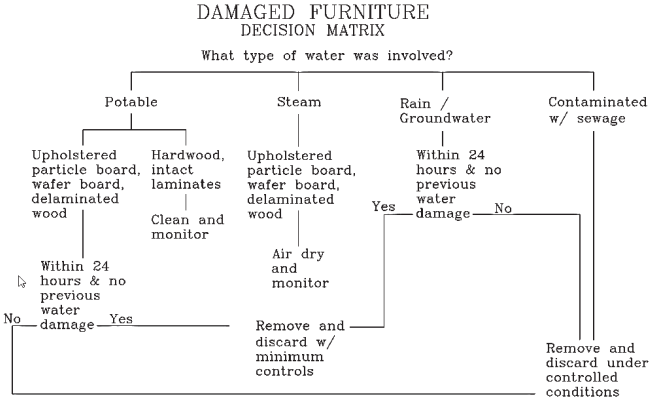
A decision matrix for dealing with water damaged furniture is below.



Inventory and Response to Paper / Records Damage

The primary factor for evaluating paper records, that have been subjected to water, will be whether the records are essential. If not, they should be discarded. If essential, they should be moved to an area where they can be dried, photocopied, and then discarded. If large amounts of essential paperwork cannot be dried immediately, they can be temporarily frozen in small batches, until they can be thawed, dried, photocopied, and then discarded. If paperwork was damaged by steam, it can be dried and monitored, until it is apparent there will be no mold growth. If mold appears, those records should also be discarded.

A decision matrix for dealing with water damaged paper records is below.



Specific Instructions for Specific Materials

Again, for use as a general checklist, the following recommendations are offered as a summary of the information above. A cheat sheet of sorts, on dealing with certain water damaged materials, after discovery of water intrusion.

- **Ceiling Tiles:** Get rid of them and replace them. Porous materials cannot really be cleaned. If the materials were glued on the ceiling or walls, there is a chance they contain asbestos. A material sample

should be tested for asbestos, prior to full removal and disposal, to determine if special care should be taken in handling damaged tiles.

- **Carpet and Backing:** Relocate everything sitting on top of it, extract all possible water with a wet vacuum system, use de-humidifiers to reduce humidity levels in the space, clean the carpet with a steam cleaner or a bleach solution, dry it again, and use fans to keep air circulating in the space till everything in it, is once again dry.
- **Cellulose Insulation:** Throw it away, disinfect and dry the substrates to which it was attached, replace it with new insulation
- **Fiberglass Insulation:** Throw it away, disinfect and dry the substrates to which it was attached, and replace it with new insulation
- **Electrical:** All wiring, light fixtures, and electrical outlets, that have become wet, are shock hazards. Turn power off in the area. Get a qualified building inspector or electrician, to inspect all components and decide whether they can turn power back on. All circuit breakers, GFI's, and fuses that became wet, need to be replaced. All motors and light fixtures, touched by water, need to be opened, allowed to air dry, and then inspected to verify there is no moisture in them, before they are reassembled and turned back on.
- **Books and Papers:** If they are wet and are not essential, just throw them away. Important papers and records should be dried, photocopied, and then discarded. If there are too many such records, to handle in a short time, freeze them in batches in separate plastic bags, and deal with thawing, recording, and then disposing of them, as time becomes available. If wet items have a high sentimental value, there are specialists who can help with their restoration.
- **Concrete or Cinder Block Surfaces:** Pull as much water as possible from inside them and off their surfaces, then use heaters, fans and de-humidifiers to finish drying them as quickly as possible.
- **Hard Surfaces, Porous Flooring (Linoleum, Ceramic Tile, Vinyl):** Vacuum water up off these, wipe them with a damp cloth and detergent, or a solution containing bleach, and allow them to thoroughly dry. Make sure the substrate below them, is also completely dry.
- **Non-Porous, Hard Surfaces (Plastics, Metals):** Vacuum water up off these, wipe them with a damp cloth and detergent, or a solution containing bleach, and allow them to thoroughly dry.
- **Upholstered Furniture:** If discovered immediately after the water event, vacuum all water from them with a wet vacuum. Dry them using a combination of heaters, fans and dehumidifiers. If vacuuming and drying is not completed within 48 hours, the furniture will likely need to be discarded. Restoration specialists may be able to restore pieces considered very important. If furniture has remained wet for over 48 hours before the damage is discovered, it needs to be thrown away and replaced.
- **Wallboard (Drywall or Gypsum Board):** If discovered immediate after the event, drywall may be dried in place, if there is no swelling, no discoloration, and seams are intact. The baseboard must be removed to properly inspect drywall. It is very rare that drywall can be salvaged like this, using a combination of heaters, fans and de-humidifiers, but it does happen on occasion. If wallboard cannot be dried, before 48 have passed after becoming wet, or if more than 24 hours have passed before damage discovery, cut the drywall out up to 12" above the highest point of apparent damage. If there is any question as to whether drywall is truly dry, a moisture meter can be used to check it. Compare that reading, to an area of drywall that was not damaged. Discard damaged, unsalvageable drywall, clean and thoroughly dry the substrate to which it was attached, then install new drywall.

Moisture meter

- **Wood Surfaces:** Get moisture off the furniture, paneling, or trim immediately. Finish the drying process with gentle heat, fans, and de-humidifiers. Be very careful when choosing to expose hardwood floors to heat. If they swell under the combination of heat and moisture, the wood will buckle and destroy itself. Finished wood surfaces can be cleaned with a mild detergent and allowed to air dry. Wet paneling should be pried away from the wall, so air can circulate behind it, then reattached, once it has been thoroughly dried.

In all cases, regardless of the material involved, the repaired or salvaged products should be closely monitored for a while, to make sure no visible mold growth appears, and no odor emerges, indicating hidden mold growth.

exam questions...

37. **True or false? Time passage, after exposure to water, is always a factor when evaluating components of electrical systems that became wet.**
    a. True
    b. False

38. **All electrical wiring, fixtures, and outlets are considered shock hazards and should be checked and cleared by which of the following?**
    a. a qualified inspector
    b. an electrician
    c. either a or b
    d. the home owner

39. **Upholstered furniture has been damaged by water that came from steam system leaks or drinking water should be dried within _____ hours and monitored in the future for fungal growth or odor.**
    a. 24
    b. 48
    c. 60
    d. 72

40. **If fiberglass insulation has been damaged by water, which of the following steps should be taken?**
    a. Throw it away
    b. Disinfect and dry the substrates to which it was attached
    c. Replace it with new insulation
    d. All of the above

41. **If _____ is damaged by water, you should pull as much water as possible from inside them and off their surfaces, then use heaters, fans and de-humidifiers to finish drying them as quickly as possible.**
    a. Wallboard
    b. Books and Papers
    c. Concrete or Cinder Block Surfaces
    d. Cellulose Insulation

42. **If _____ are damaged by water, you should vacuum water up off these, wipe them with a damp cloth and detergent, or a solution containing bleach, and allow them to thoroughly dry.**
    a. Wood Surfaces
    b. Upholstered Furniture
    c. Non-Porous, Hard Surfaces (Plastics, Metals)
    d. Ceiling Tiles

AIR QUALITY CONCERNS

Air Quality in General

It has been well established, that excessive amounts of mold in the air in occupied structures, can be unhealthy for inhabitants. Health related issues, linked to poor air quality, can be largely abated by minimizing our exposure to mold and its contaminants. As indicated above, once mold has secured a foothold, contaminated materials must be cleaned or removed, depending on how porous they might be and how quickly treatment began.

Moreover, the source of moisture that fueled the colony growth must be found and stopped. Otherwise, additional damage will occur to the building, its components, and inhabitants. Inevitably, with a steady supply of moisture, the mold will return. Prolonged hot weather is also conducive to mold growth. This is especially true, when combined with humidity from sources inside the building.

But mold is not the only problematic pollutant, found too often in the airstreams we inhabit.

Levels of Indoor Air Pollution

The primary cause of indoor air quality problems, are sources that tend to release particles or gasses, into the airstream. The secondary cause, resulting in high levels of such pollution, is inadequate ventilation. Not enough outside fresh air is being brought into the building, to significantly dilute pollutants in the airstream. While not enough polluted air is being removed, to affect the balance. With either issue, levels of pollutants tend to slowly rise, with concentrations often increasing during hot, humid weather.

Pollutant Sources

Sources contributing to pollution of air inside our buildings, are many and diverse. Building materials like; insulation containing asbestos, wet carpet, furniture, and cabinetry made of pressed wood, can release particulate into the air. Cleaning products, personal care products, and product sprays for hobbies, all contribute aerosolized particles. Combustion equipment, like wood burning stoves, fireplaces, furnaces, and even cigarettes, release fumes and particles into the airstream. Central HVAC systems, humidification devices, and associated ductwork can harbor bacteria and moisture, and add it to the air they deliver. Radon, pesticides, and other sources of outdoor pollution are happy to enter, whenever an open door or window presents an opportunity.

How much importance should be placed on any contamination source, depends on the level of pollutants it contributes, and how dangerous those emissions are to human health. Some sources, like an old gas stove that has not been properly maintained, will emit far more pollutants than a newer version. The danger of such sources, can largely be mitigated with replacement or much needed maintenance.

Also, important in considering pollution sources, is whether they contribute to the airstream continuously, intermittently, or on rare occasion. Automatic air fresheners, decaying or damaged building materials and furnishings, and some household products release contaminants on a continual basis. Smoking, using unvented heating equipment on demand, using solvents for cleanup of sporadic activities, using pesticides,

and cleaning products used in the home, all release sporadically into the air we breathe. Some sources, like chemicals used to strip furniture, or pine trees drying out during holidays, are rarely problems. But if there is inadequate ventilation, with multiple sources contributing, concentrations can rapidly build up in indoor environments.

We will later touch lightly on other sources of air contamination. But first, since it is the focus of this work, we look at indoor pollution related to mold growth.

Identifying Air Quality Issues

Observable changes in health, especially some noted earlier, can be very good indicators of problematic indoor air pollution. This is especially true, if they manifest immediately after environmental changes. These might include moving to another home or work location, treatment of the home or building with pesticides, or remodeling or refinishing projects. If you suspect that new health issues might be related to an environmental change, your doctor or a local health board might be able to help determine, whether you truly do have air quality issues.

Another way to ascertain whether recent changes are creating health issues, is to try to identify possible sources of air pollution in the new environment. Whether they are contributors or not, just awareness that they are potential sources, is a big step toward improving the quality of air being breathed.

An examination of lifestyle and activities is another way to decide, whether a home or work environment has indoor air issues. It is entirely possible, that the source of pollution is the user. Human activities have an inevitable impact on surrounding environments, indoors and out.

One last potential suspect that can quickly be ascertained, is whether sufficient ventilation is coming in and out of the air space. Moisture condensing on walls, smelly or stuffy air, stored books, shoes, and paper items becoming moldy, and HVAC equipment becoming dirty, are all indicators of inadequate ventilation. We become accustomed very quickly, to what our senses detect. To better determine if your environment stinks, step outside long enough to clear the nostrils, then take a deep breath upon reentering the air space.

Concerns about Air Quality

Risks to our health are inherent in day-to-day activities, in which we all engage. The degree of risk varies, based on what we know about hazards we encounter, how prepared we are to lessen the danger involved, and to what extent, our safety depends upon our own actions and decisions. Flying in planes? That we have little control over, other than the decision as whether to participate. But deciding to engage in various recreational activities, how we drive our cars, the environmental hazards to which we willingly subject our bodies? Those are levels of risk we choose. Some we would avoid, if we could so choose, especially if we were well informed about possible consequences of our choices.

Indoor air pollution fits well within that last description. Research in recent years has documented, that in many cases, the air we breathe inside where we live and work, is significantly more contaminated than air outdoors. Even in some of our largest cities, known for their poor air quality. This is because pollutants are far more concentrated indoors, than in the vast quantities of available air outside. Since we spend most of our time inside, health risks due to poor air quality, are much greater than most people would imagine.

The problem with contaminated airstreams inside buildings, is exacerbated by the fact that those most at risk from indoor air pollutants, are people who are often inside for the longest periods of time. These groups include small children, the elderly, the bed-ridden, and the chronically ill, sometimes from respiratory ailments.

Health Issues Related to Indoor Air Quality

There are immediate reactions, as well as long-term effects of breathing polluted indoor air. Some symptoms do not manifest for years.

Some effects show up after just one exposure. Often short-term and easily treated, they can include dizziness, fatigue, shortness of breath, headaches, and irritation of the eyes, nose, and throat. If the source can be identified, the most effective solution is to remove the person from the source of the pollutant. But since that is usually where they work, live, or attend school, physical separation is not often practical.

Symptoms of some diseases, already experienced by suffering building users, are exacerbated by exposure to indoor pollutants. Diseases in this class include asthma and hypersensitivity pneumonitis.

Whether there is an immediate reaction to indoor pollutants, will depend on factors peculiar to individuals. Sensitivities to certain chemicals and toxins vary widely between individuals. Age and pre-existing medical condition, play a large part in how a body reacts to stress put on its respiratory system. Some sensitivities to certain biological pollutants are learned reactions, based on repeated exposure. The same thing appears to be true, for some chemical irritants.

Since some symptoms mirror those of cold and flu viruses, it may be difficult to tell at first, whether indoor pollution is really causing health problems. An accurate record of when, and how symptoms appeared, tied to external sources and events that may have contributed pollutants to the airstream, is an invaluable diagnostic tool for health professionals. When symptoms abate upon leaving a certain place, and resume upon the person's return, that's a pretty solid indication of air quality issues. Pollution sources should be sought. If there are sources of high humidity in the building, or there is little ventilation, those are two problems that may quickly be addressed to seek relief.

Other health problems may manifest, only after long

periods of time have passed, or with repeated exposure to a polluted airstream. Some maladies, like COPD, heart attacks, or cancer are quite deadly or debilitating.

There is no consensus though, on what periods of exposure are safe, for which known sources of air quality contaminants. Further research is both necessary and ongoing. One thing is certain. If it is possible to improve the quality of air where we live, work, or breathe, failing to do so seems to be a foolish choice.

Health Concerns with Dampness

We may not know for sure, how much of certain pollutants it takes to have adverse effects in certain people, but some things we do know are health concerns. Many symptoms are caused or exacerbated by mold and damp.

The most common problem associated with mold, is allergic responses. Inhaling or touching spores can provoke a health response in someone who previously exhibited no sensitivity at all to mold. Symptoms tend to include sneezing, stuffiness, a runny nose, red, itchy, or watery eyes, and irritation of the ears, nose, and throat. But in people with known allergies, exposure to mold can also provoke wheezing, coughing, and shortness of breath. Studies have already linked long-term exposure to the worsening of pre-existing asthma symptoms. New studies indicate prolonged exposure to mold, can also cause asthma.

When lung inflammation occurs in people, whose immune systems become sensitized to organic dust, it is termed hypersensitivity pneumonitis (HP). It can be mistaken for pneumonia, except it does not respond to treatment with antibiotics. Signs appear within hours after exposure to mold and can last for 1-3 days. Symptoms can include; cough, muscle aches, chills, fever, sweating, excessive fatigue, weight loss, and shortness of breath. If the problem is work-related, that may only become apparent if symptoms wane and resume during holidays, and upon leaving and returning to work. With continued exposure and lung inflammation, scarring and other permanent damage to the lungs may result. HP is not contagious but is due to a person's immune system reaction to inhaled organisms, whether dead or alive. It has; however, been documented in multiple workers in buildings, that have mold and bacteria contaminated air conditioners. It has also been linked to those working in water damaged buildings, with recurrent leaks and high levels of indoor humidity.

With the asthma form of lung disease, airways become inflamed and spasm in response to a sensitivity, or irritating exposure. Episodes of shortness of breath, coughing, tightness of chest, and wheezing can ensure. If panic sets in, because of the struggle to breathe, it further dangerously restricts the bronchial tubes. This occurs, whether exposure is to a generally irritating substance, or one to which the asthma sufferer is already allergic.

In a fair number of cases, the sickness may have been caused or worsened by their workplace environment. Some organic substances, like wood from the western red cedar, are known risks for the development of asthma. Damp buildings have been shown to worsen the conditions of those already with asthma, and new research indicates they may trigger its onset.

Early diagnosis, and removal from environmental factors triggering asthma attacks, can significantly improve symptoms. Barring this as a possibility, identifying and eliminating the source of irritants is a good second option, if possible. The third level of defense, is to seek optimal medical treatment to keep the asthma under control.

Changes in Indoor Air Quality Attributable to Mold

One known irritant, to those already suffering from allergic or breathing disorders, is an excessive presence of mold. The chain of events leading to health problems, is the production of dangerous mycotoxins, from mold spores, which are produced by mold in the process of propagating itself. Symptoms experienced by people, who react to mold and its byproducts can include; fever, lung infections, irritation of the eyes, stuffiness, wheezing, and skin irritation.

As mentioned earlier, many types of mold are found everywhere in the natural environment. They do not pose a health problem, till they appear in our environments in dangerous quantities. Since such excessive growth is almost always fueled by excess moisture, the obvious best way to control mold, is to control moisture feeding it. But after the water issue has been resolved, the mold now present, will still need to be addressed and removed.

When symptoms begin to manifest in inhabitants, users can respond with technology to improve indoor air quality. Extra ventilation can be introduced. Better filters can be used in the airstream being delivered. Air filtration devices, like those utilizing activated carbon or HEPA filters, can be added to existing HVAC systems. Mold and asbestos abatement programs can be launched, involving significant renovations and alterations to buildings.

All these remedies have varying levels of success in improving indoor air quality. None will do so for long, if a source of moisture that is feeding mold growth, is not found and remedied.

Air Quality in Schools

The quality of air, found inside of our schools, is of special concern. This might be because their inhabitants are young and vulnerable, stuck inside for long periods of time, a somewhat captive population, and one that emits large quantities of humidity, simply by existing.

There are many reasons for moisture accumulations in schools. Temporary structures are often used for educational purposes, one example being temporary classrooms. Such utilitarian structures rarely have enough ventilation provided, to properly exhaust the amount of humidity generated inside them. Precipitation making its way into the building, resulting from delayed

or insufficient school facility maintenance, is a long-standing byproduct of community budgetary woes. Some moisture problems are simply the result of updated building practices, creating tighter building envelopes, that seal moisture inside, much more efficiently than previous, more drafty versions.

Because of, and usually in a combination of these typical issues, mold growth in school facilities tends to be an ongoing battle. Some simple remedies have been historically used, that go a long way toward resolving that problem.

One simple approach is to eliminate humidity sources usually found in schools, when that possibility exists. For example, showers and other areas that generate steam can be vented directly to the exterior, with exhaust fans. Dehumidifiers can be added to HVAC equipment to keep humidity levels down in the 30-60% range. Exhaust fans can be placed over dishwashers, ranges, and cleaning sinks in food service areas. Air conditioners can be installed, to additional perform as dehumidifiers, especially in areas like gymnasiums, where additional body heat is being expelled along with humid breath.

School buildings need to also be inspected periodically, for telltale signs of moisture, so leaks and spills can quickly be addressed. The smell of mold can usually be traced to a source. Discoloration on ceiling tiles, floors, walls, and window sills, usually has a water leak nearby. Water should not be allowed to stand in AC drip pans, simply because a float switch is jammed or has failed. Bathrooms can regularly be inspected for standing water and mold, indicative of plumbing leaks.

Moisture condensation, once spotted, can be addressed. Insulation or additional layers can be added over windows, around piping, on exterior walls, or in floors of unheated spaces.

When leaks occur, or signs of mold are spotted, a quick response will minimize additional damage. The leak should, of course, immediately be repaired. If leaks and spills are properly cleaned and dried within 24-48 hours, chances are good that mold growth can be prevented. Absorbent materials will still need to be quickly replaced, so it is best to keep extra replacements for these in stock, for quick access. Hard surfaces can easily be cleaned and disinfected, to become inhospitable to microbes. Mechanical rooms are a good place to check for such leaks.

Floors and carpets should be cleaned immediately, should there be evidence of moisture problems. If carpet is in a location where it becomes necessary to dry it on more than one occasion, get rid of the carpet and replace it with hard water-resistant flooring. Spots and stains should be removed immediately, in accordance with cleaning procedures, recommended by the material manufacturer.

They won't eliminate ongoing damage to school facilities from moisture accumulation, but such maintenance procedures, once implemented, will surely slow it down.

exam questions...

43. What is the primary cause of indoor air quality problems?
- a. Sources that tend to release particles or gasses, into the airstream
- b. Inadequate ventilation
- c. Not enough outside fresh air is being brought into the building
- d. Not enough polluted air is being removed from the building

44. Which of the following building materials can release particulate into the air?
- a. insulation containing asbestos
- b. wet carpet
- c. cabinetry made of pressed wood
- d. all of the above

45. True or false? Research in recent years has documented, that in many cases, the air we breathe inside where we live and work, is significantly less contaminated than air outdoors.
- a. True
- b. False

46. True or false? The most common problem associated with mold is allergic responses.
- a. True
- b. False

47. When lung inflammation occurs in people whose immune systems become sensitized to organic dust, it is termed _____.
- a. bronchitis
- b. pneumonia
- c. hypersensitivity pneumonitis (HP)
- d. HIV

48. To eliminate humidity usually found in schools, dehumidifiers can be added to HVAC equipment to keep humidity levels down in the _____ range.
- a. 75-100%
- b. 50-70%
- c. 30-60%
- d. 10-15 %

WHAT TO DO BEFORE MOLD OCCURS

Given what is certainly known about the health effects of mold, its occurrence on stored materials, or on building components, mold is a definite public health hazard. When discovered, it is subject to enforcement action or removal by any local Board of Health. Before forced involvement with regulatory agencies occurs, or expensive renovations become required, it is far better to take steps to insure mold does not gain a foothold. Prevention is far less painful than the cure.

There are a few specific areas, that when regularly inspected and maintained, can eliminate most of the known causes of mold growth and other moisture damage.

Below Grade Space

Spaces that exist below grade, especially in buildings used by the public, should periodically be inspected to insure water is not penetrating through foundations to damage interior materials. This inspection is especially important, following heavy rains. If any evidence of water penetration is discovered, that space should not be finished or converted to use. If already in use, below grade spaces should be closed off to the public, till the source of the leak can be found and eliminated. Such a remedy may not even be possible. Even if no leak has not yet manifested, as a precaution, only non-porous finish materials should be specified and used in spaces found below grade.

Water penetrating through foundation walls

General Building Condition

All elements of a building, which might affect the water tightness of the structure, should be thoroughly inspected. Foundation, floors, walls, doors, windows, caulking, roof, staircases, porches, chimneys, water removal elements, flashings, and columns that support the structure, fit this category. All these elements, and any others that if damaged or weakened, could result in unplanned gaps in the envelope, should be periodically examined. Holes, cracks, and loose places, even in the interior finishes, should all be immediately repaired upon discovery.

Doors and Windows

Windows should be maintained as follows, to maintain their intended resistance to moisture penetration. They should all open and close without difficulty, with all panes of glass intact and thoroughly caulked. Gaps between window frames and exterior walls should be caulked. If possible, there should be either a storm window, with caulking between it and the primary window, weather-stripping to fill any spaces between the primary window and the sashes, or the window be so well fitted, that no gaps greater than 1/32" exist between the primary window frame and operable sashes.

Exterior doors should be maintained as follows, to fulfill their intended resistance to moisture penetration. All doors should open and close without excessive effort, and all glass in them be unbroken and properly caulked. Cracks between the exterior walls and door frames should all be caulked. If possible, there should be either a storm door attached to the outer frame, with joints between its frame and the primary frame caulked, weather-stripping to close any gaps between doors and their frames, or so well fitted, that the largest gap between door and frame is less than 1/16" on the sides and 1/8" on the top and bottom.

Maintaining HVAC Systems

Plumbing, waste disposal, and heating and cooling systems need to be inspected and maintained, before small damage to them, grows to become significant. Frequent inspections should be conducted to find, and repair leaks, before they foster mold growth in nearby building components.

In buildings of all sorts, there is an array of equipment designed to exhaust moisture from various spaces and equipment in that building. Examples include; shower exhaust fans, those for restrooms, locker room vents, kitchen vents, and exhaust systems for indoor pools. Such exhaust systems need to vent directly to the exterior and be programmed to operate continuously, so long as water vapor exists in the area being vented. They should most definitely not vent into concealed attic or interstitial wall spaces, either intentionally or accidently, because joints in their ducts have separated. And it is not hard to imagine how fast mold growth will occur, if a ventilation system serving one of these wet areas, is damaged and remains in a state of disrepair, while the space continues to be used.

exam questions...

49. If there is not a storm window or weather-stripping to fill any spaces between the primary window and the sashes, the window should be so well fitted that no gaps greater than _____ exist between the primary window frame and operable sashes.

a. 1/32"
b. 1/16"
c. 1/8"
d. 1/2"

50. If there is not a storm door attached to the outer frame or a-stripping to close any gaps between doors and their frames, the door should be so well fitted that the largest gap between door and frame is less than _____ on the sides and _____ on the top and bottom.

a. 1/16" on the sides and 1/8" on the top and bottom
b. 1/8" on the sides and 1/16" on the top and bottom
c. 1/32" on the sides and 1/64" on the top and bottom
d. 1/16" on the sides and 1/32" on the top and bottom

51. True or false? Exhaust systems need to vent directly into concealed attic or interstitial wall spaces.

a. True
b. False

DEALING WITH MOLD IN THE AIR STREAM

But suppose, despite the best prevention programs, despite periodic inspections, excess humidity finds its way in, and is followed rapidly by excessive mold growth? It is in the air stream, and indoor pollution has now become a problem for the building inhabitants.

Reiteration of Basic Facts

Mold is found almost everywhere. It can grow on almost any organic substance it can consume, and many building materials fit that description. It only needs food, moisture and oxygen to multiply. Mold spores migrate to damp surfaces indoors, where they attach and begin new colonies. In locations where excessive moisture accumulates on organic surfaces, mold will grow and increase, so long as it remains undiscovered and untreated. The most effective way to control and inhibit mold growth, is to minimize or eliminate the source of the moisture on which it thrives. Left alone, mold will eventually consume whatever it is growing on. Even when mold remains unseen, its presence is usually announced by its characteristic odor, a musty, earthy smell. If occupants of a building are experiencing health issues that surface when they are in one location, and abate when they leave it, or if they detect mold by sight or by smell, they should alert health officials or building owners, and request remediation take place.

The general approach for dealing with excessive mold, is as follows. Mold can grow anywhere on almost any building material. There is no practical way to eliminate all mold. It must just be cleaned up, then ways found to control its growth by eliminating excess moisture. If there is a leak, plug it or fix it. Clean and dry wet materials within 24-48 hours. Clean mold off hard surfaces. Replace wet materials that cannot be quickly dried. Install insulation around pipes or add insulation to reduce condensation. Replace absorbent materials like carpet with hard surfaces, in areas prone to spills or drips. Then work to eliminate other sources of excess moisture. Control indoor humidity by venting bathrooms and other wet areas to the outside. Use air conditioners and dehumidifiers and increase the amount of ventilation. Use exhaust fans when doing household tasks involving water.

More specific approaches to controlling the growth of mold, once excess amounts are present, are as follows.

Controlling the Growth of Mold

The moisture source driving the mold growth needs to be identified. It is very likely to fall into one of these categories.

- Moisture was trapped in the building when wet materials were used during construction
- Moisture was trapped when methods used in installing materials included excessive moisture that had no opportunity to properly dry, before it became encapsulated.
- Defective materials, defective installation of materials, corrosion, or lack of adhesion between incompatible materials, caused gaps to open in the envelope.
- An unplanned event, like a plumbing leak or natural flood, occurred and subjected the building to excessive moisture.
- Lastly, some activity of the building user is introducing excess water into the building envelope.

General Prevention Strategy

When the presence of mold is confirmed, remediation measures should include the following steps at a minimum. These may need to be tweaked somewhat, based on specific conditions on site. If there are questions on procedures, those should be addressed to experts.

- Make sure site drainage systems are functioning and the ground is sloped away from foundations.
- Regularly inspect the building and HVAC systems, and make repairs immediately if the problems found compromise, or will compromise, the integrity of the envelope.
- Put equipment in place to maintain indoor humidity between 30-50%, and definitely below 60%.
- Verify that condensation and drip pans are functioning and properly draining.
- Make sure equipment that generates moisture, and building spaces that generate moisture, are vented directly to the outside, and duct connections are all secure.
- When water does inevitably finds its way inside, take immediate action to get the leak stopped.
- Clean up damaged areas and if possible, get them dried in the first 24 hours, and certainly in the first 48 hours. Damaged porous materials will probably need to be replaced anyway, and immediately discarding them, will open walls and ceiling spaces and allow air circulation to assist in the drying.
- Make long term repairs to eradicate whatever problem led to water, suddenly becoming available to foster mold growth. Given its pervasive nature, it is logistically impossible to completely eradicate all traces of it. But it will be difficult to win the war against excessive mold, if moisture continues to be available, with which surviving spores can thrive.
- If an active leak cannot be located, verify no existing sources of condensation are feeding the problem. Correct those, if found.
- If the moisture source is condensation, that is caused when moisture laden air meets a surface that is cooler than the dew point. Raise the temperature with insulation, or by increasing air circulation, or reduce humidity levels by eliminating leak sources, or installing air conditioning. Easy entry of humid outside air, can be prevented by installing airlocks and closing windows.

Procedures – Problem Found in First 48 Hours Following a Leak

- As mentioned repeatedly, if it can be done quickly, using logic and the physical location of the water at the time, find and stop the source of the leak.
- If moisture can be removed from the damaged area within the first 48 hours, and this includes removing wet building materials and furnishings, further abatement of mold is rarely necessary.
- Clean up the area and add fans and ventilation, to increase circulation
- Observe the area to make sure no signs of mold appear.
- If there are no visible signs, but an odor becomes apparent, request testing be conducted by an expert.
- If there are no further problems, reoccupy the space.

Procedures – Problem Discovered After 48 Hours Have Passed

- Mold growth is likely to have begun, and abatement procedures will probably be required
- Inhabitants of the space should find another space to use temporarily.
- The source of water infiltration will still need to be identified and corrected.
- Damaged materials will need to be cleaned, removed, and/or replaced in accordance with the decision matrixes given earlier. At this point, the solution will be a renovation project.
- Finish cleaning up the area and add fans and ventilation, to increase circulation
- Observe the area to make sure no signs of mold appear or reappear.
- If there are no visible signs, but an odor becomes apparent, request testing be conducted by an expert.
- If there are no further problems, reoccupy the space.

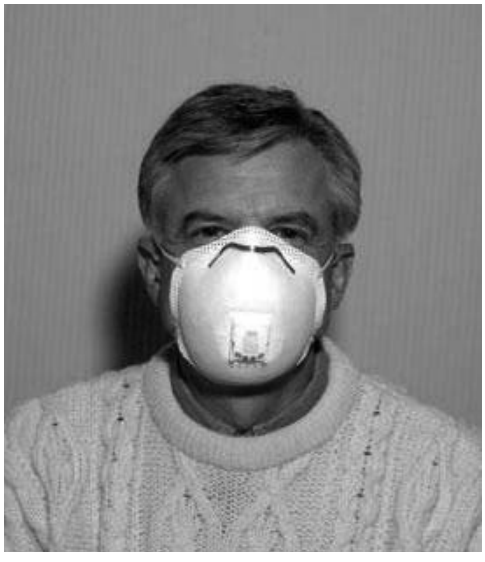
Minimizing further damage during restoration

Cleaning Up Mold

If mold is present, who should be involved in abatement, will depend somewhat on how much mold is there.

If the area involved is less than ten square feet, one individual can probably handle it. The Environmental Protection Agency has guidelines available for how to properly do so. Their recommendations can be summarized as follows. Items from additional sources have been included.

- Avoid exposing yourself or others to mold. Use of an N-95 respirator, available at many hardware stores, is recommended. Wear long gloves that extend to the middle of the forearm, so you don't touch mold with your bare hands. Wear goggles without ventilation holes, so mold spores do not get in your eyes.
- Note that if you are already sensitive to mold, have known allergies, or already suffer from respiratory ailments like asthma, you don't want to be the one cleaning up mold. It would be a good time to hire a professional.
- Fix the leak and dry all items thoroughly.
- Scrub mold off all hard surfaces and completely dry them.
- Throw away porous materials, like carpet or ceiling tile, that have become moldy.
- Clean areas that were covered, with a disinfecting cleaner containing bleach.
- Increase ventilation in the area, to thoroughly dry it out.
- Take care not to paint, or caulk over surfaces that are moldy. What is being applied will not properly adhere.
- If unsure how to clean any area or item, consult a specialist.



Use of an N-95 respirator

Use of additional personal protection equipment

If the water damage was extensive, and mold growth covers more than ten square feet, it is probably best to get expert help in handling remediation. The EPA also provides guidelines for procedures in this case, that can be summarized as follows. Items from additional sources have been included.

- Assess the size of the problem.
- Assign a manager to handle the problem, evaluate the situation, and develop a plan for remediation
- If the likely source of the water is contaminated, like sewage, it is best to verify that any professionals hired to assist in cleanup, have had experience in dealing with damage from contaminated water.
- Note that if someone is already sensitive to mold, has known allergies, or already suffers from respiratory ailments like asthma, that's not the right person for the job.
- It will most likely be necessary to relocate users out of the area, until remediation procedures are complete. This is because of the scope of work involved, the potential health effects on occupants, contacting and breathing spores loosened by work, and the difficulty of completing normal activities during the ensuing disruption.
- Fix the water or moisture problem. Stop the leak. Eliminate the source of condensation. Kill the problem.
- Make sure everyone dealing with the damage restoration, is wearing protective clothing and gear as described above.
- Clean with detergent, disinfect with bleach, and completely dry, moldy materials that are not porous.
- Discard materials that cannot be cleaned.
- Ventilate and air dry the space, and all affected materials.
- Check for any return of moisture, or of mold.
- If additional or hidden mold is discovered, reevaluate and begin again.
- Even though eliminated, mold may have cause permanent staining or discoloration. It may not be possible to restore damaged surfaces to their previous appearance. If that is the goal, it will be necessary to replace those materials, even if they are free of mold.

Permanent water stains on wood

There are some other key points to consider during the restoration process. If a contractor or remediation service is hired to perform the cleanup, make sure they have previous experience, dealing with mold. Ask for references. If there is any question as to whether the HVAC system has been infected with mold, do not turn it back on till it, and its ductwork system, have been inspected and passed by experts. Otherwise, spores can be distributed throughout the area served by the infected system, and health problems can certainly be expected to follow.

exam questions...

52. When water damage is discovered immediately, it will still be very hard to salvage water damaged materials that are _____
a. Metallic
b. Porous
c. Hardwood
d. Masonry

53. Which of the following personal protective equipment should be used when cleaning up mold?
a. An N-95 respirator
b. long gloves that extend to the middle of the forearm
c. goggles without ventilation holes
d. all of the above

54. When is it safe to turn on an HVAC system that has potentially been infected with mold?
a. Once it has been inspected and passed by experts
b. Once the spores have been fully distributed throughout the area
c. Once the mold has been mostly removed from the infected system
d. Once the HVAC system has been completely replaced

DEALING WITH OTHER POLLUTANTS IN THE AIR STREAM

Dealing with Pollution at the Source

Sources of emissions that decrease indoor air quality, are best handled by eliminating problems at their sources. Some, like materials containing asbestos, can be removed or encapsulated, so no more particulate from them can enter the airstream. Appliances like gas stoves or wood burning stoves, can be adjusted or repaired, to reduce the amount of gasses they emit to the atmosphere. If repair is not possible, replacement is always an option. Increased ventilation will always help, but source control is usually a cheaper solution. That is because fresh air brought into a home, will also need to be conditioned, and there is an ongoing price tag to do that.

Cleaning Up Air in General

When air quality concerns weigh on our minds, technology exists at several levels to clean it up. They range from simple table-top models, that scrub the air in small areas, to whole-house systems. Some air cleaners, those using far more sophisticated filters, are effective at removing particles from the air. Smaller, less expensive models will not do that. Simple air cleaners are not designed to remove pollutants that are gasses.

There are two components controlling the effectiveness of an air cleaner. One is how well a cleaning system collects, and removes pollutants from the inside air, expressed as a percentage efficiency rate. The second is how much air it draws through its filtering elements, expressed in cubic feet per minute. A cleaner that has a very high percentage efficiency rate but draws very few cubic feet per minute through its filters, is not an efficient cleaner. Likewise, a cleaner that has a low efficiency rate, but cycles a lot of cubic feet per minute through, is not efficient. And in either case, the continued performance of any cleaner will depend on maintaining it, according to the instructions of its manufacturer.

The strength of the source of the pollutant, will also impact the efficiency of an air cleaner. Table-top cleaners are not very effective at dealing with nearby sources that are strong. They do not remove the necessity of also ridding the building, or home, of the source of the pollutant. Those who purchase such models, hoping to eliminate the harmful effects of their smoking on others, while continuing to smoke near the cleaner, are generally disappointed by the results.

Houseplants have been touted as a natural way to improve indoor air quality and help remove pollutants. Although they clearly increase oxygen levels, there is no credible evidence that plants significantly reduce pollutant levels in any way. Moreover; the necessity of keeping plants watered, increases humidity levels in homes, increasing exposure to the risk of excessive mold growth.

Currently, reliance on air cleaner systems is not recommended by the EPA, to reduce radon levels. While air cleaners partially mitigate the effects of radon decay products, they make little difference in the amount of radon entering the home. Research is still underway, to determine if air cleaner systems can be altered, or improved, to more effectively treat problems with radon.

Measuring Levels of Radon

How can we know if radon is even of concern? Radon is colorless, odorless, radioactive and unfortunately, sometimes present in our homes and businesses. That is why testing is recommended, in situations conducive to its formation. Without testing, it is impossible to verify radon's presence, other than by the emergence of the health problems it can cause. Devices that measure radon are available and inexpensive. The EPA has published guidelines covering risks associated with various radon levels, and what corrective steps should be taken to mitigate it. Certain steps have proven to be effective in reducing radon, and some of these are automatically being included in construction of new homes.

Testing for other sources of indoor pollution can be expensive, so building owners tend to put that off. But these other sources of airstream contamination should be tested for, when health symptoms begin to manifest, specific sources or pollutants have been identified as potentially being present, or problems with ventilation become evident.

Dealing with Radon

It was mentioned that radon is radioactive, which means it will influence cell growth. This radioactivity occurs because radon is emitted by uranium, found in the ground on which buildings are built. Radon gas, odorless and invisible, is naturally released as uranium breaks down. The gas seeps up through the soil, up through concrete slabs and wood floors, through drains and sumps, and enters the living space. In some cases, it enters by infusing well water. Some building materials themselves emit radon, though they rarely cause problems, in and of themselves.

Any home, new or old, can develop a problem with radon. Well-sealed homes are even more problematic than older, more drafty structures. This is because newer, more energy tight structures, do a better job of trapping the rising gasses. Older buildings have more natural ventilation, to carry radon away and/or dilute the concentrations of it.

When it becomes trapped in the home's atmosphere, and concentrations of constantly produced radon slowly increase in the atmosphere in which we are also trapped, problems occur. We don't coexist well with invisible, radioactive gas.

Health Effects of Radon

Lung cancer (uncontrolled cell growth) seems to be the primary risk associated with radon. This is likely because

lungs are the first tissue to contact the radioactive gas, when we breathe it in. Health organizations concur that thousands of preventable lung cancer deaths are caused each year by exposure to high levels of radon. Smokers, who also live in homes with high radon levels, are especially vulnerable. Swallowing water, contaminated with radon, may also pose risks, but not nearly as severe as those connected with lung cancer.

Reducing Home Exposure to Radon

Take the minimal time, and minimal expense, to measure levels of radon in your home. Measure it with one of the many inexpensive kits that have been approved by the EPA. If you want to know how much is present, but do not wish to purchase a kit, there are qualified contractors who offer the service. Instructions come with the kits, but there are also guidelines available from the EPA on how to interpret test results.

If testing reveals unacceptable levels of radon, one immediate step to be taken, if possible, is to stop anyone smoking in the home. Tobacco smoke, combined with radon, poses a serious health risk. If radon is found in well water, that problem should also be immediately addressed. Guidelines for doing so, can be found at state offices that deal with radon.

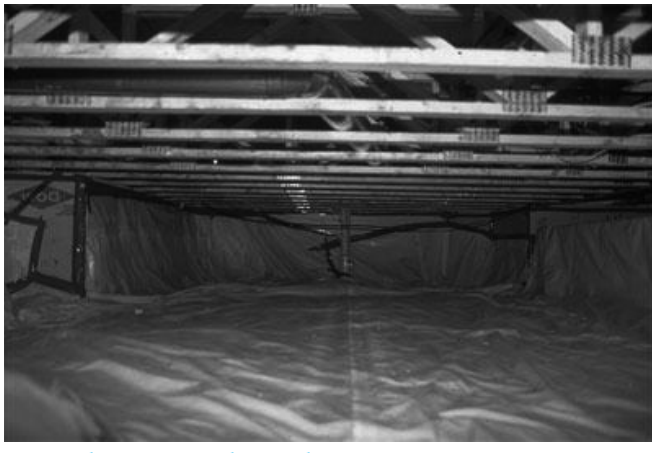
If tests indicate radon levels of concern, other steps can be taken to lower concentrations. Lowering such levels requires technical expertise. Trained radon contractors are available who can study the problem, test for air flow currents to establish convection routes, pinpoint areas of weakness where the gas is finding entry and suggest proper treatment methods. Most states have offices that will provide names of such qualified contractors, in specific locales.

Most types of radon reduction systems involve some loss of heated or conditioned air. It makes sense that one way to get rid of contaminated air, is to dump it outside. How much this will increase utility bills, will depend on your climate and the construction of your home. Systems that use fans, to remove rising radon from spaces below the home, are more effective in reducing radon levels and will only slightly increase electric bills. The difference lies in whether the radon is removed, before or after it enters living space.

Radon reduction systems are usually grouped by the type of foundation used in the home. They will differ, based on whether your home is slab-on-grade, on a crawl space, or built over a basement.

In homes built on a slab-on-grade, or over a basement, radon is usually removed by one of four types of soil suction. Active subslab suction is the most reliable, using suction pipes inserted through the slab, into the crushed rock or soil below the slab. These are then vented by a radon vent fan, directly to the outdoors. This powered venting, also creates a vacuum below the slab, further pulling contaminated air, in and away. Passive subslab suction uses the same types of suction pipes but relies on natural convection to draw contaminated air up and out, and foregoes the use of an exhaust fan. The perforated drain tiles used in some homes will help do this naturally. Another variation is called sump-hole suction. In this, when the home is already using a sump pump in a pit, the pit is capped, continues to drain water, but also serves as a location for the radon suction pipe outlet and radon fan. Block-wall suction is used in conjunction with hollow block foundation walls. This removes radon while depressurizing the walls, working somewhat like subslab suction.

Radon is dealt with somewhat differently in homes with crawlspaces. The most effective way involves installing vent pipes in the soil, along with a vent fan to push air outside. Then the floor of the crawl space is covered with high-density plastic sheeting with the joints sealed. This type of treatment is called submembrane suction. A less favorable option, is to use a fan to exhaust air from the crawlspace to the exterior, but that will also require bringing in outside air to replace it. That air will need to be treated for humidity, temperature, etc. Passive ventilation is accomplished by crawl space vents, already required in most crawl spaces by building codes. Note to the wise. If cold air is being introduced into the crawl space to mitigate radon levels, make sure any pipes in the crawl space are well insulated. If ducts distribute through a cold or hot crawl space, delivery of heated or cooled air will also be affected.



Properly protected crawl space

Built-in Radon Resistance

Some approaches to radon reduction are common sense. Sealing cracks in foundations and sealing openings between the foundation and living portions of a home, goes a long way in reducing exposure to radon in the living area. Pressurizing the living space, or the basement space above the slab, will create air pressure to resist the entry of radon gas. Reliance on such pressurization; however, precludes leaving doors or windows open, so it is not terribly practical in a residence. A heat recovery ventilator (HRV), brings in outside air, while using inside air being exhausted to pretreat that incoming air. These are effective in reducing levels of radon, by simply exhausting part of it and diluting what remains with fresh air. Natural ventilation, letting the wind blow through a building to carry away any contaminated air, is of course, the oldest air quality technology that can be implemented.

exam questions...

55. **True or false? There is credible evidence that houseplants are a natural way to improve indoor air quality and significantly reduce pollutant levels.**
    a. True
    b. False

56. Which of the following is true of radon?
    a. Radon is colorless
    b. Radon is odorless
    c. Radon is radioactive
    d. All of the above

57. The source of radon, rising through the soil, is _____
    a. Decaying vegetation
    b. Gasses from magma far below the surface
    c. An indication of cave systems below
    d. Decaying uranium

58. _____ (uncontrolled cell growth) seems to be the primary risk associated with radon.
    a. Lung cancer
    b. Brain cancer
    c. Pancreatic cancer
    d. Alzheimer's disease

59. Systems that use _____, to remove rising radon from spaces below the home are more effective in reducing radon levels and will only slightly increase electric bills.
    a. fans
    b. heated air
    c. conditioned air
    d. suction

SUMMARY

There was serious concern over the quality of the air, that athletes from all over the world would be breathing during the Olympics at Beijing. Given known results of air quality testing in that city, knowing the pollution I would pull into my lungs while competing outside, were I an athlete, I too would have been concerned. But most competitors made the choice to take the risk and endure that exposure.

Few of us choose to breathe contaminated air in our homes, schools, and workplaces. More and more, we are learning the health risks and complications associated with poor air quality. Known risks range from high concentrations of radon, other gasses, particles in the air stream, and organic compounds like spores from mold. We don't want to breathe those in. We often don't know we are doing so. But when we do find we are at risk, few are willing to leave their homes, quit their jobs, or drop out of school. That leaves us with the option to live with risks or take steps to lower those risks.

Knowing now, that many severe problems will arise from leaks and other sources of excess moisture in our buildings, we take steps to prevent the same. We can design in barriers, maintain existing systems, and move swiftly to minimize long term effects, when failures occur. And they will. Because all buildings leak in some way, at some point in their life span

Nature itself assures that we will always fight airstream issues in our enclosed environments. Humidity laden air will always flow from warmer areas of high pressure, to cooler areas of lower pressure. Radon will always rise through the soil, as deterioration occurs in the uranium beneath. Thousands of strains of mold exist, just seeking organic food like materials found in our buildings, and a moisture supply to proliferate. All organic materials are designed to decay in some way, adding particulate to the airstream.

The goal is to eliminate the potential harm, to reduce the risk posed by these processes, to users of the buildings we design, build, and maintain. Hopefully, basic knowledge of these natural processes, along with known ways to mitigate risks, has provided useful tools to lessen those health hazards.

In the context of the subject matter we explored, it is impossible that leaks will never occur at some point in the life of a building. It is impossible, that the quality of air being breathed by building inhabitants, will never be compromised. Whether that happens with mold, or because of other indoor air contaminates. Just by existing, by expanding and contracting under seasonal and climatic influences, buildings will develop flaws through which water and other pollutants will enter. But if we are qualified, and armed with knowledge to design, or build, in such a way as to delay such an occurrence. Or if we are hired to conduct maintenance to forestall such an event, what a shame if it happens on our watch.

exam questions...

60. **Humidity laden air will always flow from_____ _____.**
    a. warmer areas of lower pressure, to cooler areas of high pressure
    b. warmer areas of high pressure, to cooler areas of lower pressure
    c. cooler areas of high pressure, to warmer areas of lower pressure
    d. cooler areas of lower pressure, to warmer areas of high pressure

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INTRODUCTION

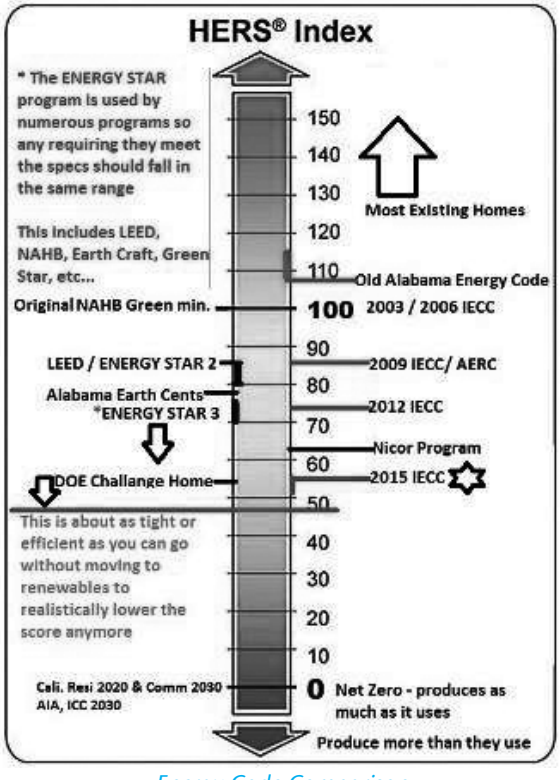
Decisions to improve energy efficiency stem from multiple sources. Enforceable energy codes dictate some choices in new construction. Budget concerns will determine the difference between the best life-cycle cost choices and what can actually be afforded. Home energy audits can identify existing points of energy loss and areas of potential improvement. Becoming aware of very old and emerging technologies that result in energy efficiency is enough to get the wheels turning for some. A desire to be part of improving the environment is motivation for many. Whatever the reason, the decision to help conserve our natural resources is a good investment in the future.

MOTIVATIONAL FACTORS

Energy Codes

In the U.S., buildings account for 40% of all energy used and 70% of electricity used. Energy codes being adopted and implemented are slowly changing building practices, resulting in reduced environmental impact, reduced energy bills and increased resale values for buildings. Advances in energy products like cool roofs and new lamp technologies make much of this possible.

These new model energy codes are minimum energy efficiency requirements for new buildings, additions and renovations. When adopted, they carry the same force of law as other building codes. The two model codes which are most in use are the International Energy Conservation Code (IECC), for all buildings and ANSI/ASHRAE/IES Standard 90.1 (ASHRAE Standard 90.1), for only commercial buildings.



Energy Code Comparison

The IECC includes ASHRAE Standard 90.1 by reference, sometimes letting it supersede IECC provisions. Once energy codes are adopted, expect state and local governments to perform inspections to ensure compliance.

Both the IECC and ASHRAE Standard 90.1 are continually updated in public forums. This transparency has resulted in widespread acceptance of these standards. Multiple market segments help maintain their relevance. These include: designers like architects, lighting designers, mechanical and electrical engineers, code enforcement personnel, legislators, builders, building owners, manufacturers, utilities, advocacy groups, the academic community and federal agencies like the Department of Energy (DOE).

Multiple Model Codes

The IECC is authored by the International Code Council through a process of consensus. ICC codes are updated every three years. Anyone who has established eligibility can submit proposed changes. They can participate in public hearings and comment processes, from which changes to the next code edition will be generated. Final votes on all proposed changes are made by members of government and honorary members. The revised version is then presented as an updated model code, available for state and local jurisdictions to easily adopt, implement and enforce.

ASHRAE Standard 90.1 also uses a consensus process, meeting ANSI requirements. Anyone may participate by submitting a maintenance proposal, addressing committees during their deliberations or submitting comments on proposed changes during a public review. Proposed changes are voted on by a committee tasked with updating and maintaining the standard.

Revisions occur on an ongoing basis, but publication of updated versions occurs every three years.

Before adopting either model energy standard, state and local jurisdictions may make changes reflecting regional practices or their own specific energy-efficiency goals.

Budget Concerns

Energy efficiency is the most cost-effective strategy to reduce utility bills. Passive ways to do so are the most effective. Passive solar design uses features of the site, the climate and the building design to minimize the use of

energy. Use reduction is the primary goal, regardless of the source of the energy. For example, given the minor heating demands of modern homes, south facing glass should be kept down in size and properly shaded to reduce solar gain and resulting cooling demands.

Caring for the Environment

It is possible to use eco-friendly materials in new constructions. Determining whether to use a particular material may require research to determine how friendly available options really are to the environment. Some are considered eco-friendly because they reuse other materials, like recycled cork panels and flooring, newspaper wood, bark siding and recycled steel, that are otherwise destined for landfills. Alternatives to using concrete for walls include straw bales, grasscrete, bamboo and hempcrete. Take time to find out what materials your builder is willing to use and ask if they will consider alternatives that are of interest. If enough consumers request use of certain materials, more builders will use them.

exam questions...

1. **In the United States, buildings account for _____% of all energy used.**
   a. 25
   b. 40
   c. 92
   d. 16

2. **Which of the following is one of the model energy codes commonly adopted by jurisdictions?**
   a. International Energy Conservation Code (IECC)
   b. SMACMA
   c. OSHA Rule 19
   d. Southern Building Code Council on Energy

GENERAL BUILDING ENERGY CONCERNS

This section will examine tried and true, mostly passive, ways to reduce energy use by means of how building envelopes are constructed. It focuses on how to make buildings more airtight and energy tight, and how to deal with leakage and loss points of conditioned air between internal and external environments.

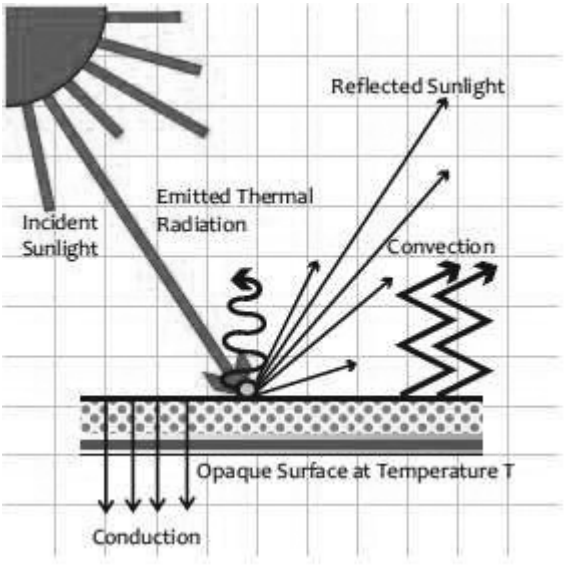
Roof and Wall Considerations

Cool Roofs

Cool roofs are best described as roofs made of reflective materials, designed to reflect sunlight and absorb less of its heat. This keeps buildings below them cooler during hot weather. These roofs use highly reflective paint, a reflective surface ply or highly reflective tiles or shingles to repel light. Climate will be a large factor in deciding whether to install one. Standard, dark roofs can reach 150° Fahrenheit in the summer. Changing the surface to make them a cool roof can drop surface temperature by up to 50°, reducing the air conditioning load inside.

Cool roofs can not only reduce air conditioning loads, but improve comfort levels in rooms like garages that are not served by air conditioning. They can also extend roofing material life before replacement.

Cool roofs are best used in hot climates. In cold climates, they can actually increase energy costs by reducing the solar gain through a roof that would have been beneficial for heating.



Roofs Can Be Cool

Cool roofs can benefit a microclimate, when widely used in one area. They do this by reducing local air temperatures in an urban island, lowering peak power demand to help avoid outages and reducing demand on power plants supplying the area. This results in fewer emissions of carbon dioxide, sulfur dioxide, nitrous oxides and mercury.

In warm, moist locations, cool roofs where moisture can condense are more susceptible to algae or mold growth. Some coatings include special chemicals inhibiting surface mold or algae growth for a few years. Care must also be taken in design and construction to ensure moisture does not accumulate in the assembly below the roof surface.

Making Roof Types Cool

Many roof systems are available, but the surface material exposed to the sun is what determines if a roof is cool. This means, with the appropriate surface or coating, almost any roof can be made to be cool.

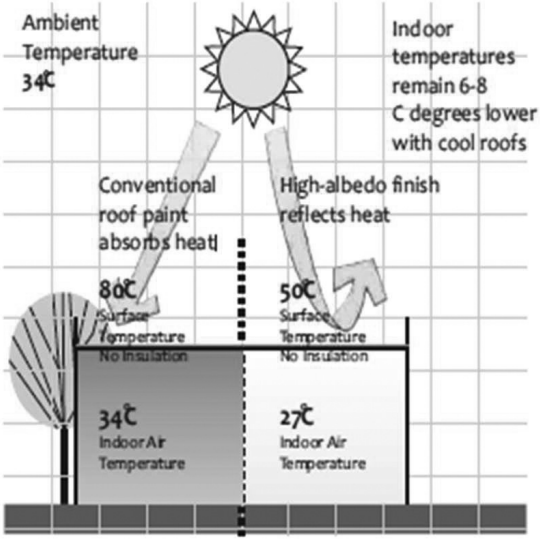
Cool roof coatings are white or have special reflective pigments. Some are like very thick paints, protecting roofs from ultra-violet light and chemical damage, while also offering moisture protection. Products are available for most types and slopes of roofs.

- Systems for Low Sloped Roofs

Single-ply membranes are pre-fabricated sheets, held down to a substrate with mechanical fasteners, chemical

adhesives or the weight of ballast like stones or pavers. If not already light in color, they can be made cool by resurfacing them with a reflective coating.

Built-up roofs consist of a base sheet, fabric reinforcement layers and a protective surface, usually bound together with asphaltic compounds. Sometimes they are also protected by a gravel ballast.



Low Sloped Cool Roof

The usually dark surface layer can be made cool in several ways. Reflective marble chips can be substituted for dark colored ballast. A coat of reflective mineral granules can be applied on site, or if new, in a factory. A cool coating can also be applied directly on top of the last asphaltic coat.

Modified bitumen sheet membranes are layers of plastic or rubber with reinforcing fabrics, surfaced with mineral granules or a smooth finish. These are sometimes used to resurface built- up roofs. Many sheet membranes can be obtained from manufacturers with a cool coating.

Spray polyurethane foam coverings mix two liquid chemicals together to react and expand into one solid piece, adhered to and covering a roof. These are very prone to mechanical, moisture and UV damage, and must have a protective coating. Those protective coatings are usually already reflective and cool.

- Systems for Steep Sloped Roofs

Shingle roofs are protected by overlapping pieces of fiberglass asphalt, wood, polymers or metal. The best option is to purchase cool asphalt shingles, surfaced with special coated granules that reflect sunlight. Coating existing asphalt shingles in place is neither recommended, nor approved by manufacturers. Other shingle types can also have cool coatings applied in the factory.

Tile roofs come in clay, slate or concrete pieces. They can be coated to provide custom colors and surface properties. Some are already reflective enough to be cool and others can be transformed with reflecting coatings into cool roof tiles.

- Systems for Low and Steep Sloped Roofs

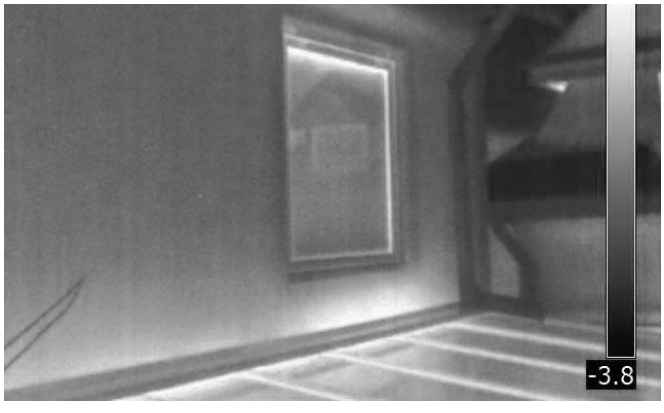
Metal roofs come with natural metal finishes, oven-baked paint finishes or granular coatings. Unpainted metals are good solar reflectors but perform poorly thermally, so they don't qualify as cool roofs. Paint can increase solar reflectance and thermal emittance, allowing metal roofing to meet cool roof requirements. Cool reflective coatings can also be applied to metal roofing.

- Green Roofs

These are not actually reflective, though they are considered to be cool roofs. Green roofs are used on flat or shallow- pit roofs, and range from basic plant cover to a full garden. These are used to manage storm water and create enjoyable open spaces on rooftops. They also insulate, lower A/C loads and reduce the urban heat island effect. They are expensive to put in place and must be carefully planned to ensure durability and drainage.

Avoiding Thermal Bridging

Thermal bridging is a major cause of heat loss in buildings. It occurs when heat moves through an object in an assembly that is more conductive than materials around it. The energy flows through the path of least resistance.



Thermal Bridges In Infrared

The R-value rating of a wall or roof assembly does not mean the entire assembly performs at that resistance level. Thermal bridges from framing materials and discontinuities in the system result in holes in the thermal envelope that insulate at much lower levels. The overall

performance of the whole assembly lowers when these areas are averaged into the whole.

It is not hard to find thermal bridges. Run a hand along a wall on a cold day and they will find you. These points of leakage not only impact energy use, but also quality of life. We tend to avoid really cold or hot walls and spaces, so bridges can make parts of a home unusable in certain times of the year.

Wood, metal and concrete spanning from face to face of an assembly conduct far more heat than insulation around them. But we usually have little choice other than to use some heat conducting material for framing. Studs made of rigid foam won't carry snow loads.

That said, there are existing methods to move toward bridge-free construction, and new and promising framing materials are being developed and tested.

- Some wood used in exterior framing, all of which acts as bridges, can safely be eliminated. Examples include headers in non-load bearing walls, unnecessary cripples and redundant corner studs.
- The use of metal fasteners of any kind that span from face-to-face should be avoided.
- If basement walls can be built of wood, that concrete thermal bridge can be eliminated.
- Leave batt insulation out of metal stud cavities. Instead, give up a couple inches of inside space and install a thick, seamless layer of board insulation over the face of the studs.

Using Reflective Surfaces

Radiation plays a large part in heat transfer in both heating and cooling scenarios, even with typical temperatures involved and no sunlight in play. It is a critical consideration for surfaces in sunlight or where large temperature differences exist between surface and surroundings, like with radiant heating, refrigeration, hot industrial surfaces and ice rinks. Reflective (low-emissivity) products are useful in most of these, but in certain applications, a high-emissivity (non-reflective) surface performs better. A basic understanding of reflectivity and emissivity helps in evaluating the use of reflective products.

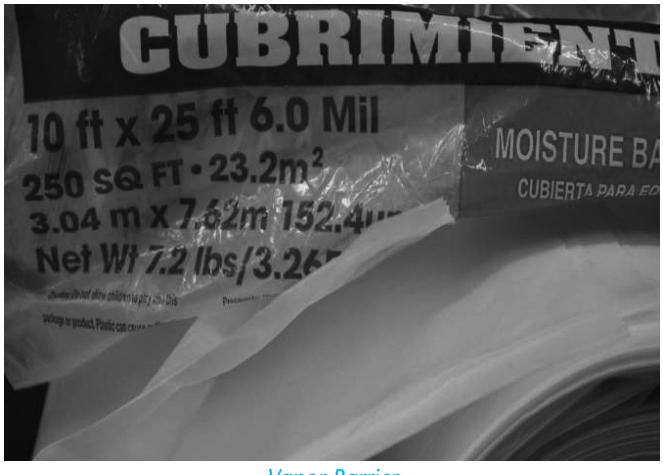
Reflectivity and emissivity are surface properties affecting radiation heat transfer, or how a reflective product performs. Radiation arrives at a surface and the percentage of radiation reflected back from it is called its reflectivity. Emissivity is a surface's tendency to emit radiation to other bodies. High emissivity means a surface will readily absorb radiation striking it, depending on the wavelength of radiation striking it, and emit it later. For example, a surface may reflect most of the wavelength of light hitting it, but not much ultraviolet or infrared radiation coming at it. Knowing these properties are interrelated can be helpful in understanding them. Low emissivity (Low-E) materials will save energy, should you want to reduce heat transfer.

Places where it's a good idea to reduce heat transfer include:

- Between interior objects (including people) and between interior and exterior surfaces of exterior wall assemblies, when interior air is being conditioned differently than the outdoors.
- Between exterior surfaces of a building and outside air, on both hot and cold days. Low-E glazing saves energy by reducing heat transfer with its surroundings.
- A low-emissivity ceiling in an ice rink, like one painted with a reflective aluminum paint. This may result in very good energy savings, by reducing radiation heat transfer between the warmer ceiling and the surface of the ice.
- A surface used as a radiant heater, like a radiator or a radiant floor, is a place where high emissivity is beneficial to enhance heat transfer from the radiator.
- Low-E surfaces on windows or walls are bad in rooms with high internal gains, like computer server areas or telephone rooms. In these, you usually want to get rid of heat at all times. The only time low-E surfaces help you in server rooms is when it gets so cold outside that you have to begin heating the space.

Use of Vapor Barriers and Their Location

A vapor barrier is a material used to retard water movement into and through walls. It is applied independently over the warm side of exterior walls or as an integral part of another facing material.



Vapor Barrier

Vapor barriers are also referred to as vapor diffusion retarders. These interfere with the movement of airborne vapor inside a wall cavity. They should be installed on the side of the cavity consistently exposed to the highest vapor pressure. In very hold or very cold climates, that distinction is easily made as being the warm side. In more temperate climates, that decision on location becomes more difficult.

In any event, care must be taken that only one vapor barrier, or material that can act as one, be placed in a wall

or roof system. Otherwise, moisture may become trapped between multiple barriers. Plastic sheeting, Kraft paper, foam plastic sheeting/insulation, solid vinyl wall covering and asphalt-impregnated building paper are all building materials known to act as vapor barriers. Not as well-known are unfaced insulation, building paper without asphalt compounds, plywood sheathing and building wraps like Tyvek. These all retard vapor flow to some degree.

Vapor barriers must be correctly installed to be effective. Insulation in cavities should fill all voids prior to installation of a vapor barrier. The vapor diffusion retarder must then be properly sealed at its seams, per its manufacturer's recommendations. Care must be taken to properly seal window and door openings. When fastening them to the building, they must be secure, but with no fasteners allowed to tear through a barrier, leaving holes through which moisture can migrate.

Vapor barriers in roof and wall systems should be on the warm inside of the exterior insulation in cold climates (some define this as 8,000 heating degree days or more). Vapor barriers in roof and wall systems should be on the exterior side of the exterior insulation in warm climates, where the greater demand is for cooling. A surface material impermeable to vapor is a good idea in these climates.

If heating and cooling loads for a region are roughly balanced, some choose to omit a vapor barrier altogether. They focus instead on paying more attention to balancing air pressure inside and out, as well as controlling infiltration. As a general rule, it's better not to have a vapor barrier than to install one in the wrong location. A good (bad) example of this would be placing vinyl wallcovering on the inside of outside walls in warm climates.

Roof to Ceiling Considerations

Venting Roofs to Control Energy Loss

- Guaranteeing Airflow

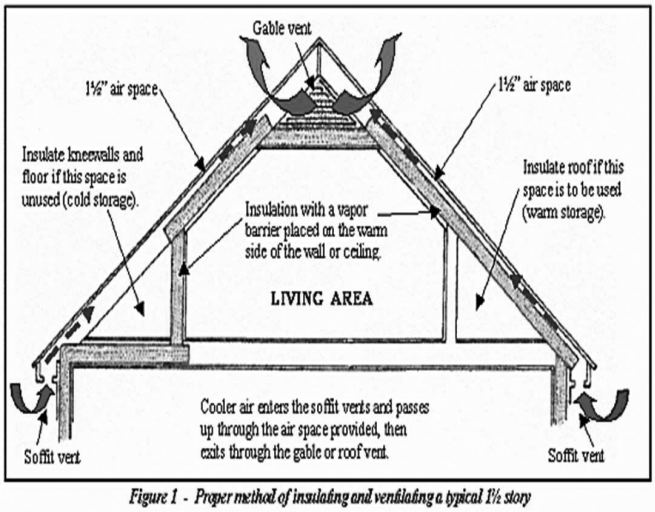


Figure 1 - Proper method of insulating and ventilating a typical 1½ story

Airflow

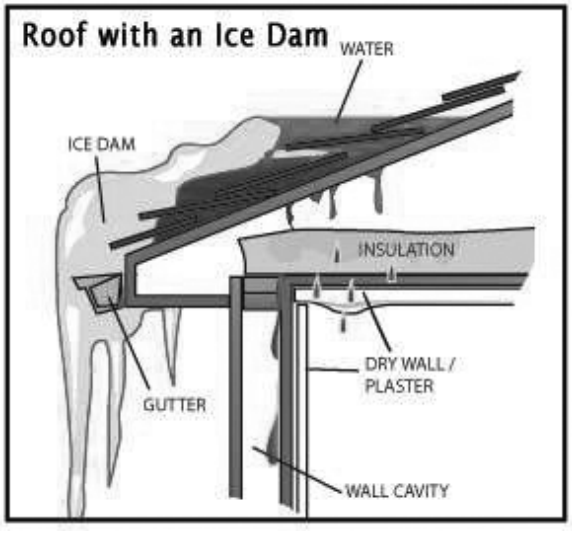
Roof ventilation works due to the fact that warm air rises. In the summer, solar gain heats air inside the attic and in the winter, heat escaping from your home does the same. In either case, venting needs to occur as cool air enters attics near eaves and ceilings and rises to exit near the peak. Ideally, equal amounts of air should enter low and exit high. The ultimate goal is for temperature and humidity levels in the attic to be allowed to equalize with those same conditions outdoors.

Soffit vents work very well for intake air, which can then exit passively through ridge vents or hood vents. Turbine vents use exterior wind energy to create vacuums that in turn, pull air out of the attic. Electric-powered vents are the ultimate air movers, but are unnecessary in most situations. Gable vents allow air in and out, but don't help air flow evenly throughout the attic.

- Poor Ventilation Equals Damage

Moisture damage is one result of poor ventilation. Warm, humid air tends to migrate upwards into an attic through ceilings. Condensation then forms on roof framing and sheathing, which can support rot and cause serious structural damage. The condensed water can also drip back down, on and through ceilings, causing mold and other issues.

Ice dams also result from bad ventilation. If an attic gets warm enough, escaping heat will melt snow on the roof, while the eaves still remain cold. When melting water from above flows down to the eaves, it freezes there again, forming a dam. Melting water still coming down the roof then encounters that dam and may back up under the shingles to cause damage.



Badly Vented Roof

- Ventilation Code Requirements

Building codes usually require 1 SF of vent area for each 300 SF of attic. This proportion assumes half the supplied vent area is high on the roof for outgoing air, and half is low near the eaves for incoming air. Otherwise, the required vent area must be doubled to 1 SF of vent area for each 150 SF of attic. These suggested numbers are minimums. There cannot be too much ventilation.

Insulation Systems

An obvious part of a well-insulated building shell will be the insulation placed therein. There are many products, available in many forms, to do just that. The following information may help in choosing which insulation product to include in an assembly.

Available Options for Insulation

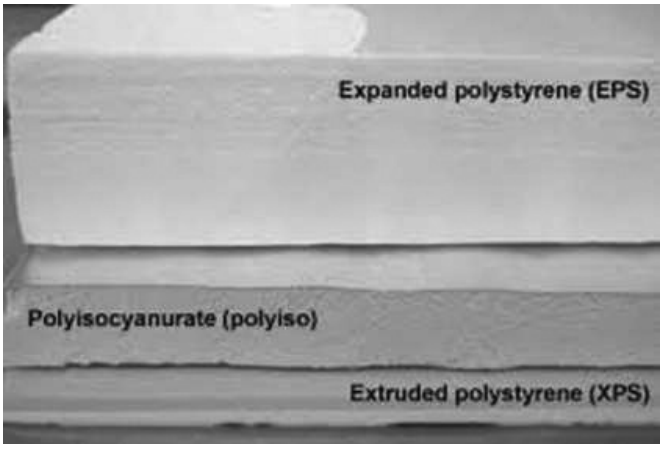
Type	Material	Where Applicable	Installation Methods	Advantages
Blanket: batts and rolls	FiberglassMineral (rock or slag) wool Plastic fibers Natural fibers	Unfinished walls, foundation walls, floors and ceilings	Fitted between studs, joists and beams, sometimes stapled in place through flanges on facings.	Do-it-yourself. Widths available for standard stud and joist spaces, that are relatively free of obstructions. Relatively inexpensive.
Concrete block insulation and insulating concrete blocks	Foam board, placed outside of walls (in new construction) or inside walls (in existing homes). Sometimes, foam beads or air are included in a concrete block mix to increase R-values	Unfinished foundation walls in new construction or major renovations, or inside walls (when using insulated concrete blocks)	Require specialized skills to properly install.Insulating concrete blocks are sometimes dry- stacked mortar and surface bonded	Insulating cores increases wall R-value.Insulating outside of block walls puts their thermal mass inside conditioned pace, to moderate indoor temperatures. Aerated concrete and autoclaved cellular concrete blocks have 10 times the insulating value of poured concrete walls.
Foam board or rigid foam insulation	Polystyrene Polyisocyanurate Polyurethane	Unfinished walls, including foundation walls Floors and ceilings Unvented low-slope roofs	Interior applications must be covered with 1/2-inch gypsum or other code approved fire barriers. Exterior applications must be covered to be weatherproof	High insulating value for relatively little thickness. Can block thermal bridges if installed continuously over framing.

Insulating concrete forms (ICFs)	Foam boards or hollow foam blocks with internal supports for reinforcing, used as forms when placing concrete	Unfinished walls, including foundation walls, for new construction	Installed and poured full of concrete to become part of the building structure	Insulation is literally built into the home's concrete walls, creating high thermal resistance
Loose-fill and blown- in	Cellulose Fiberglass Mineral (rock or slag) wool	Enclosed existing walls and other hard-to-reach places, cavities in new wallsUnfinished attic floors	Blown into place using special equipment, sometimes poured in place inside cavities	Can add insulation to existing finished areas, irregularly shaped voids and around obstructions.
Reflective insulation products	Foil-faced kraft paper, plastic film,polyethylene bubbles, or cardboard	Unfinished walls, ceilings and floors	Foils, films or papers fitted between wood framing members or over their face	Easy to use in standard spaced framing. Bubble-form is used if framing is across a space or other obstructions are present.Effective at preventing downward heat flow depending on spacing.
Rigid fibrous or fiber insulation	Fiberglass Mineral (rock or slag) wool	Forms air ducts in unconditioned spaces and elsewhere needing insulation to withstand high temperatures	HVAC contractors fabricate this insulation into ducts, either in shops or at job sites	Can withstand high temperatures.
Sprayed foam and foamed-in- place	Cementitious Phenolic Polyisocyanurate Polyurethane	In existing wall cavities, new open wall cavities, unfinished attic floors	Applied using small spray containers or in larger amounts as a pressure sprayed (foamed-in-place) product	Good for adding insulation to existing finished areas, irregularly shaped areas and around obstructions.
Structural insulated panels (SIPs)	Foam board Liquid foam Insulation core Straw core insulation	Unfinished walls, ceilings, floors and roofs in new construction	Construction workers fit SIPs together to form walls and roof of a house	SIP-built houses result in superior and uniform insulation, compared to more traditional methods and also take less time to build.

Besides the previous overview, it is beneficial to take a closer look at these various options for insulation products.

• Blanket - Batt and Roll Insulation

Blanket insulation is the most common insulation, widely available in batt or roll form. It consists of flexible fibers. These are often made of fiberglass, but can also be from mineral wool (rock and slag), plastic fibers or natural fibers, like cotton and wool. These products are available in widths made to fit standard spacings of stud, truss or rafter and floor framing. 2 x 4 walls can hold R-13 or R-15 batts; 2 x 6 walls accommodate R-19 or R-21 products.



A Few Types of Insulation

Continuous rolls are hand-cut and trimmed to fit empty cavities and available with or without facing materials. These facing materials, like Kraft paper, foil-Kraft paper or vinyl, can double as vapor or air barriers. Batts with special flame-resistant facings are used on basement walls and other places where the product will be exposed. Facings also help with installation by offering flanges through which fasteners may be driven into framing members.

The table below offers an overview of standard and high-performance (medium-density and high-density) fiberglass blankets and batts. It is for general comparisons only. Actual thicknesses, R-values and cost should be verified with a local building supplier.

Thickness in inches	R-Value	Est cost in cents/sf
3 1/2	11	12-16
3 5/8	13	15-20
3 1/2 (high density)	15	34-40
6 to 6 1/4	19	27-34
5 1/4 (high density)	21	33-39
8 to 8 ½	25	37-45
8 (high density)	30	45-49
9 1/2 (standard)	30	39-43
12	38	55-60

• Concrete Block Insulation

Concrete block walls are sometimes insulated, or built using insulating concrete blocks. Block walls in existing homes can be insulated from the inside, in some cases.

There are several ways to insulate concrete blocks. If the cores aren't already filled for structural reasons, empty ones can be filled with insulation to raise the wall's average R-value. Be warned though: block core filling with any type of insulation offers little in savings. This is because the solid parts of the block units, like webs and mortar joints, will still act as thermal bridges to conduct heat straight through.

It is more effective to place sheet insulation over block walls, either on the exterior or interior side. Exterior placement contains the thermal mass of the wall inside the conditioned space, helping to moderate indoor temperatures.

Some manufacturers incorporate polystyrene beads into materials used to make blocks, while other masonry units are formed to accommodate rigid foam inserts.

Autoclaved aerated concrete (AAC) blocks, and autoclaved cellular concrete (ACC) blocks are now both in market use. Precast ACC blocks use fly ash instead of high-silica sand, distinguishing them from AAC blocks. Developed in Europe, AAC blocks contain about 80% air and have 10 times the insulating value of poured concrete walls. These blocks are large, light and easily modified by ordinary tools. But AAC blocks will also readily absorb water, so they must be protected from moisture.

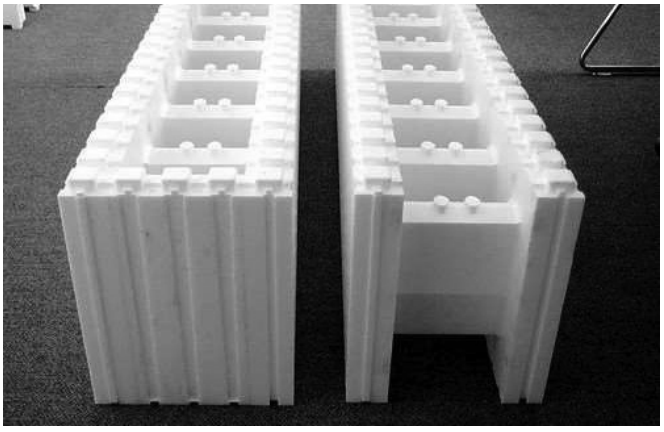
Hollow-core masonry units made of concrete and wood chips are also available. These blocks tend to be stacked without using mortar, then cores are filled with concrete and structural steel to hold them in place. Their wood component is also susceptible to moisture and insects.

• Foam Board or Rigid Foam Panels

Rigid foam insulation panels can be used almost anyplace, from the roof down to the foundation. They are placed as exterior wall sheathing, interior basement wall sheathing and in special applications like attic hatches. They can offer R-values up to twice that of other insulating materials of the same thickness. Being continuous, they interrupt thermal bridges through structural elements like studs. Foam boards are commonly made from polystyrene, polyisocyanurate and polyurethane.

• Insulating Concrete Forms

Insulating concrete forms are interlocking forms made of foam insulation, into which reinforcing is placed and concrete is then poured. The forms remain in place as part of the wall assembly. This results in exterior walls having a typical R-value of around R-20.



Insulating Concrete Forms

The forms are available as interconnecting foam boards or interlocking, hollow-core foam insulation blocks, to be locked together with plastic ties. Horizontal steel rebar reinforcing is usually added inside the block forms, along with vertical bars inside the cores, before concrete is poured.

The foam webs of which the forms are made can provide easy access for insects to bore through and groundwater to migrate. So some manufacturers make ICF forms treated with insecticide, and promote ways to thoroughly waterproof the resulting walls.

- Loose-Fill and Blown-in Insulation

Loose-fill insulation is small particles of fiber, foam or other materials that fill in and conform to any cavity, without disturbing structure or finishes. This makes it very useful for retrofits and locations where it is difficult to place other types of insulation.

Loose-fill insulation is commonly cellulose, fiberglass or mineral wool. All are made from recycled waste materials: cellulose from recycled newsprint, fiberglass from recycled glass and mineral wool from post-industrial waste. The table below compares these three materials.

Less common loose-fill insulation materials include polystyrene beads, vermiculite and perlite.

Loose-fill insulation can be used in either enclosed cavities like walls, or unenclosed spaces like joist spaces in attics. Cellulose, fiberglass and rock wool are typically blown in to achieve specified density and R-values. Polystyrene beads, vermiculite and perlite are typically poured.

The Federal Trade Commission issued a "Trade Regulation Rule Concerning the Labeling and Advertising of Home Insulation" (16 CFR Part 460). It contains the R-value Rule to prohibit unfair or deceptive practices. This Rule requires those who sell home insulation to disclose each product's R-value and information like thickness and coverage area per package, on package labels and fact sheets. R-value ratings of the product in place can vary, even between products of the same type and form.

Blowing In Insulation

For loose-fill insulation, each manufacturer determines R-values at settled densities and creates charts showing minimum settled thickness, minimum weight per square foot and coverage area per bag for various total R-values. This is because, as the installed thickness of loose-fill insulation increases, its density also increases due to compression under its own weight. So the R-value of the placed product does not change proportionately to its thickness. Coverage charts specify bags of insulation needed per SF of coverage area; coverage area for one bag of insulation; minimum weight per SF of installed insulation and the needed initial and settled thickness of that insulation, to achieve a particular R-value.

Recommended Specifications by Loose-Fill Insulation Material			
	Cellulose	Fiberglass	Rock Wool
Density in lb/ft3 (kg/m3)	1.5–2.0 (24–36)	0.5–1.0 (10–14)	1.7 (27)
Weight at R-38 in lb/ft2 (kg/m2)	1.25–2.0 (6–10)	0.5–1.2 (3–6)	1.6–1.8 (8–9)

For Attic Applications			
	Cellulose	Fiberglass	Rock Wool
OK for 1/2" drywall, 24" on center?	No	Yes	No
OK for 1/2" drywall, 16" on center?	Yes	Yes	Yes
OK for 5/8" drywall, 24" on center?	Yes	Yes	Yes

• Radiant Barriers and Reflective Insulation Systems

Unlike insulation systems resisting conductive and sometimes convective heat flow, radiant barriers on reflective insulation act to reflect radiant heat. These are usually installed in attics to reduce summer heat gain and lower cooling costs. Reflective insulation incorporates radiant barriers, like very reflective foils, into insulation systems with a variety of backings. These can include Kraft paper, plastic film, polyethylene bubbles or cardboard, as well as other insulation materials.

Radiant heat travels away from surfaces and heats anything solid that absorbs energy. It is mainly the sun's radiant energy that makes a roof hot. Most of that heat travels by conduction through the roofing assembly and into the bottom surface of the assembly. The heated bottom assembly surface then radiates heat energy down to cooler attic surfaces like air ducts and attic floors. Radiant barriers reduce the heat transfer from below the roof to other surfaces in the attic. They must be installed so the reflective surface faces an air space.

Radiant barriers are effective in hot climates, when cooling ducts are located in the attic. Radiant barriers in warm, sunny climates can lower cooling costs 5-10%. The reduction may be enough to justify a smaller A/C system. In cool climates, it's usually more cost-effective to just install more insulation.

• Rigid Fiber Board Insulation

Rigid fiber or fiber board insulation is either fiberglass or mineral wool panels, used mainly to form insulated ducts through which to distribute conditioned air. It is also useful when insulation must withstand high temperatures. Panels are readily available in thicknesses from 1-2.5 inches.

Air ducts of this material are fabricated by HVAC contractors. When placing it over the outside faces of metal ducts, they impale it on weld pins and secure it with speed clips or washers. They can also use special weld pins with integral washers. Unfaced boards can be finished with insulating cement, canvas or weatherproof mastic. Faced boards can be installed, with joints between boards being sealed with pressure-sensitive tape or glass fabric and mastic.

• Sprayed-Foam and Foamed-in-Place Insulation

Liquid foam insulation can be sprayed, foamed-in-place, injected or poured. It can be blown into walls, on attic surfaces or under floors to insulate and reduce air infiltration. Many installations yield a higher R-value than batt insulation of the same thickness. The expanding foam can fill even the smallest cavities, creating an effective air seal. Small pressurized cans of the material are used to seal holes and cracks at window and door frames, as well as electrical and plumbing penetrations.

Today, most of these materials use foaming agents without chlorofluorocarbons (CFCs) or hydrochlorofluorocarbons (HCFCs).

Sprayed Foam Insulation

There are two types of foam insulation, closed-cell and open-cell, both made from polyurethane. In closed-cell foam, high-density cells are filled with a gas to help the foam expand to fill spaces around it. Open-cell foam is not as dense and is more filled with air, giving the insulation a spongy texture.

The type of foam insulation chosen should depend on its use and your budget. Closed-cell foam has a greater R-value and better resistance to moisture and air leakage. It is also denser and more expensive to install. Open-cell foam is lighter and less expensive, but if used below ground level, could absorb water.

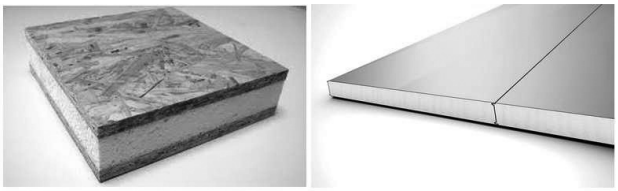
Common foam insulation materials include cementitious, phenolic, polyisocyanurate (polyiso) and polyurethane. Less well known are Icynene foam and Tripolymer foam. Icynene can be either sprayed or injected, making it very versatile. It also resists both air and water intrusion. Tripolymer foam, a water-soluble foam, is injected into wall cavities and offers excellent resistance to fire and air intrusion.

• Structural Insulated Panels

Structural insulated panels (SIPs) are prefabricated insulated structural panels, used as building walls, ceilings, floors and roofs. Offering superior and uniform insulation, compared to traditional construction, they offer energy savings of 12-14%. When installed properly, SIPs are very airtight, making a building quieter and more comfortable.

SIP (Structural Insulated Panels)

[11]IMP (insulated metal panels)



Structured Insulated Panels

SIPs have both high R- values and high strength- to-weight ratios. A SIP often consists of 4-8" of foam board insulation, laminated between two sheets. These can be of OSB or other sheathing materials. The interior and exterior face materials can be customized to meet specific requirements. The composite materials of each panel are glued, then pressed or placed in a vacuum to bond them together. Panels can be factory produced in various sizes or dimensions, up to units that are 8' x 24', requiring a crane to set them in place.

Manufacturing quality is critical for high-performing SIPs. They must be properly glued, pressed and cured, so they don't delaminate. They must also have smooth surfaces and edges, to be able to connect on a job site without gaps. SIPs are often also available with different insulating materials, but are filled most often with polystyrene or polyisocyanurate foam.

exam questions...

3. **Materials used to retard water movement into and through walls are called _____.**
   a. Waterproofing
   b. Exterior envelope guards
   c. Vapor barriers
   d. Rigid insulation boards

4. **_____ is a material used to form ductwork in uninsulated spaces.**
   a. Foam core plastic sheets
   b. Rigid fiber insulation
   c. Extruded plastic tubing
   d. Small SIP products

5. **Cool roofs are best described as _____.**
   a. Those incorporating a misting system on the surface
   b. Those encouraging societal trendsetters to occupy the building
   c. Those with at least double the minimum recommended insulation below them
   d. Those surfaced with light or reflective materials

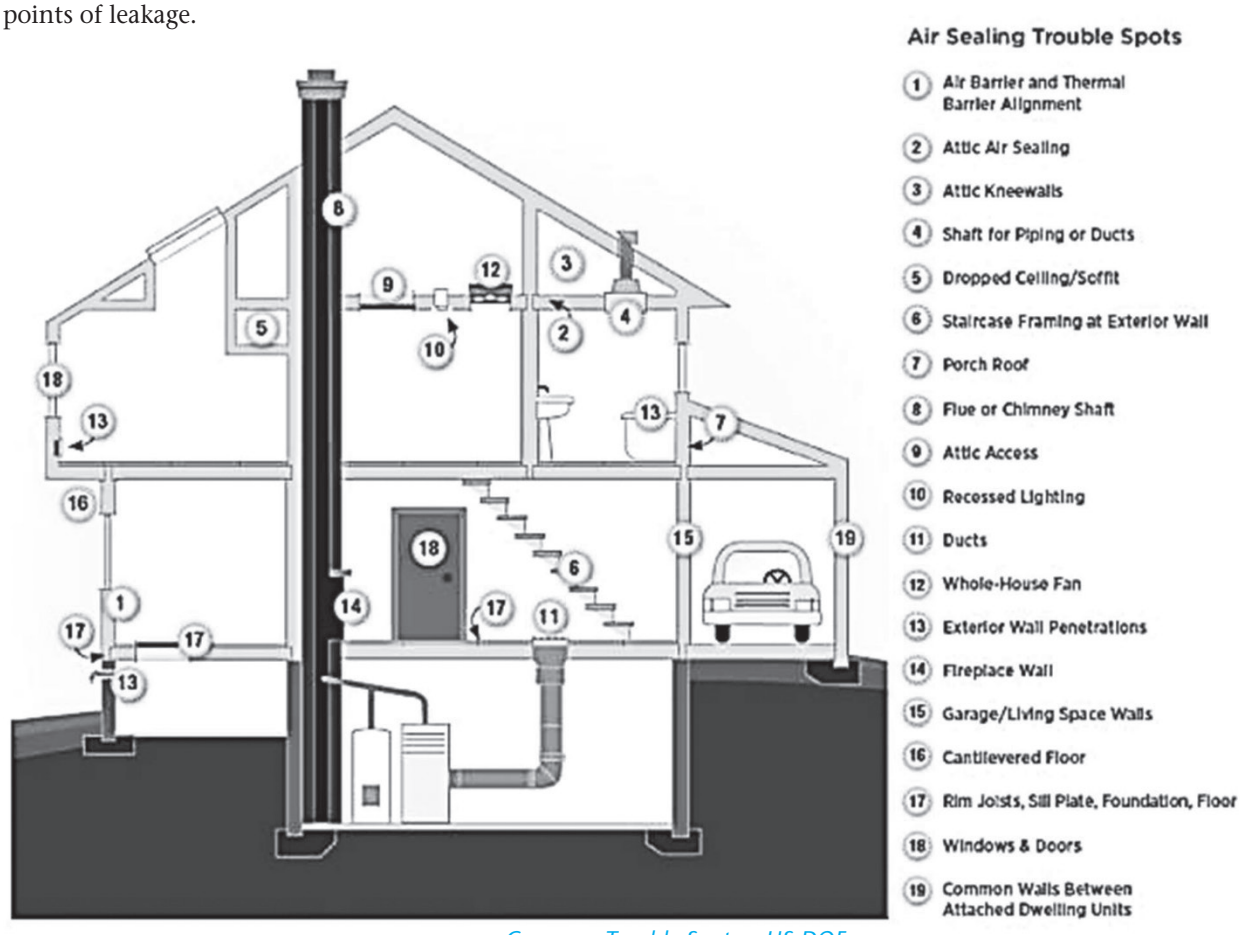
6. **When heat moves through an object in an assembly, that is more conductive than materials around it, that is described as _____.**
   a. An end around
   b. A thermal bridge
   c. Conducive transfer
   d. A complete design fail

7. **If heating and cooling loads for a region are roughly balanced, some choose to _____ .**
   a. Omit a vapor barrier altogether
   b. Maximize fenestration to encourage natural ventilation
   c. Use dark roofing to control solar gain
   d. Depend on exterior stucco for waterproofing

8. **When melting snow above warm attics, flows down to freeze on eaves, it creates _____ .**
   a. An ice dam
   b. A sheet of running water needed diverted
   c. Potential ice hazards down below on paved surfaces
   d. An instant thermal bridge

AIR INFILTRATION

Despite care taken in the other aspects of creating a building envelope, there will always be small or large gaps through which air can either infiltrate or exfiltrate. Care should be taken to find those gaps and manage the air flow through them. The illustration below shows known points of leakage.



Common Trouble Spots – US DOE

Common Leakage Points – Holes through the Envelope

- Air Sealing Your Home

Reducing the amount of air infiltration is a cost-effective way to cut utility costs, improve durability and increase indoor comfort. Caulking and weatherstripping are simple, effective sealing methods offering quick returns on investment. Caulk is used in cracks and openings between stationary house components, like around door and window frames. Weatherstripping seals between components that move, like doors and operable windows.

Making New Homes Airtight

Controlling air movement in and out is necessary for energy efficiency and controlling moisture. Climate-specific instructions on how to do this can be found at https://www.energy.gov/eere/buildings/building-america-climate-specific-guidance. But there are also general techniques and materials used to seal against air infiltration.

- Air Barriers

Air barriers block movement through building cavities, preventing leakage that can account for 30% or more of a home's energy costs. Although they stop air movement, such barriers may not also be vapor barriers. The proper location of either air or vapor barriers in building assemblies is dependent on climate and should be researched if there is any question.

Many structural and finish components act as air barriers. Sealing and caulking holes and seams between sheet goods like drywall, sheathing and subflooring will reduce air leakage. In addition, densely-packed insulation in wall cavities can reduce airflow and heat loss.

- House Wrap

House wraps are common air barriers, wrapped around a building exterior during construction. These are often fibrous spun polyolefin plastic, matted into sheets and rolled for shipping. House wraps may have other materials in them to help resist tearing. Sealing wrap joints with

tape improves their performance up to 20%. All wrap manufacturers offer special tape for this purpose.

• Airtight Drywall Approach

An airtight drywall approach (ADA) or a simple caulk and seal (SCS) approach, can also create a continuous air barrier inside a house. Either will significantly reduce air leaks and improve energy efficiency.

Maybe a Bit Too Airtight

Using ADA, seams, joints and openings in the interior drywall face are thoroughly sealed during construction. SCS is less disruptive to construction, because seams and gaps are sealed after the house is dried in and drywall has been completed. SCS is less comprehensive though, and some critical points inside building cavities may be missed that will be inaccessible once the drywall is in place. Tests on ADA and SCS-detailed homes indicate similar savings. It is prudent to install a heat or energy recovery ventilator after using either method of sealing, to ensure proper ventilation with fresh air.

Passive and Active Fresh Air

If too little outdoor air enters a home, pollutants can accumulate inside and build to levels causing health and comfort problems. Unless they are built with mechanical means of ventilation, homes designed and constructed to minimize outdoor air leakage may contain higher pollutant levels than other homes. However, because some weather conditions will drastically reduce how much outdoor air enters a home, pollutants can even build up in homes that are normally considered "leaky."

Replacing Exhausted Air with Treated Air

One way to lower concentrations of indoor air pollutants is to increase how much outdoor air comes inside. Many home heating and cooling systems, including forced air heating systems, do not mechanically bring fresh air in. Opening windows and doors, operating window or attic fans or running a window air conditioner with the vent control open, all increase the outdoor ventilation rate. Local bathroom or kitchen fans that exhaust outdoors remove contaminants directly from the room where the fan is located and create negative pressure, indirectly increasing the outdoor air ventilation rate.

Many new homes are now designed with mechanical systems bringing outdoor air inside. Some designs include energy-efficient heat recovery ventilators (also known as air-to-air heat exchangers).

Radon – Not Just Hype

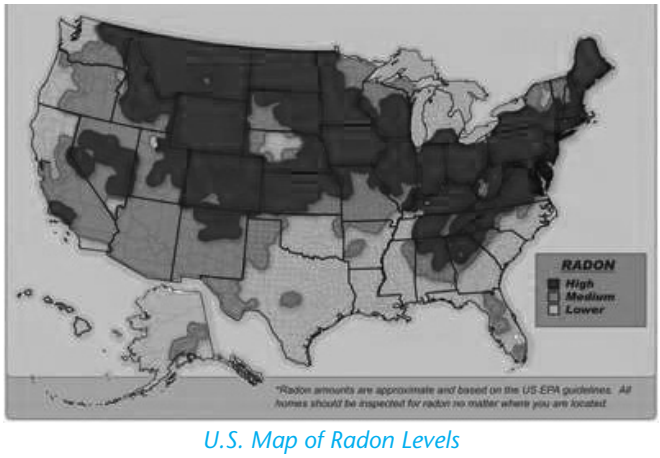
In homes that are too airtight, an unseen danger called radon may slowly become apparent.

• Dealing with Radon

Any home may have a radon problem: new and old homes, well-sealed and drafty homes, and homes with or without basements.

The most common source of indoor radon is uranium in the soil or rock on which homes are built. As uranium naturally breaks down, it releases radon gas which is a colorless, odorless, radioactive gas. Radon gas infiltrates up into homes through dirt floors, cracks in concrete walls and floors, floor drains and sump pits. When radon becomes trapped in buildings with airtight envelopes, concentrations build up indoors and increasing exposure to radon becomes a concern.

Sometimes radon enters the home through well water. In a small number of homes, the building materials can give off radon, too. However, building materials rarely cause radon issues by themselves.



U.S. Map of Radon Levels

• Health Hazards of Radon

The predominant health effect associated with exposure to elevated levels of radon is lung cancer. Research suggests that swallowing water with high radon levels may also pose risks, but these are believed to be much lower than breathing air containing radon.

Major health organizations (like the Centers for Disease Control and Prevention, the American Lung Association and the American Medical Association) agree with estimates that radon causes thousands of preventable lung cancer deaths each year. The Environmental Protection Agency (EPA) estimates that radon causes about 14,000 deaths per year in the United States; however, this number could range from 7,000 to 30,000 deaths per year. If you smoke and your home has high radon levels, your risk of lung cancer is especially high.

• Reducing Home Exposure to Radon

Measure levels of radon in your home. You can't see radon, but it's not hard to find out if you have a radon problem. Testing is easy and should only take a little time. There are many inexpensive, do-it-yourself radon test kits available through the mail, in hardware stores and other retail outlets. Buy a test kit that has passed EPA's testing program or is state-certified. These kits will usually display the phrase "Meets EPA Requirements." Then refer to the EPA guidelines on how to test and interpret your results.

If you prefer, or if you are buying or selling a home, you can hire a trained contractor to test it for you. EPA's voluntary National Radon Proficiency Program (RPP) evaluates testing contractors. A contractor who has met EPA's requirements carries an EPA-generated RPP identification card. EPA provides a list of companies and individual contractors on a web site, available to state radon offices. These offices can supply you a list of qualified contractors in your area. You can also contact either the National Environmental Health Association (NEHA) at http://www.neha.org or the National Radon Safety Board (NRSB) at http://www.nrsb.org for a list of proficient radon measurement and/or mitigation contractors.

You can learn more about radon through EPA's publications, A Citizen's Guide to Radon: The Guide to Protecting Yourself and Your Family From Radon and Home Buyer's and Seller's Guide to Radon. This publication is also available from your state radon office.

Ways to reduce radon in your home are discussed in EPA's Consumer's Guide to Radon Reduction. There are simple solutions to radon problems in homes. Thousands of homeowners have already fixed them. If lowering high radon levels will require technical knowledge and special skills, you can find contractors trained to fix radon problems. A trained radon reduction contractor can study the problem in your home and help you pick the correct treatment method.

Positive and Negative Pressure

Inside air temperature is important to occupant comfort, but air pressure is also a critical factor. Air pressure is defined as "the pressure within a container due to the compression of atmospheric gases." If the container is a car tire, the proper amount of air pressure inflates the tire and will affect gas mileage. If the container is a building, air pressure will affect temperature, air flow through the interior, air flow from interior to exterior and subsequent energy usage.

Interior air pressure will be either negative or positive, relative to air pressure outside. That will depend on the air-tightness of the building, the wind, air being exhausted and amounts of make- up air. Some definitions may help clear up confusion.

- Negative indoor air pressure – occurs when the inside air pressure is less than pressure outside, causing air to be pulled into the building as infiltration.
- Positive indoor air pressure – occurs when inside air pressure is greater than outside pressure, causing conditioned air to flow outside as exfiltration.

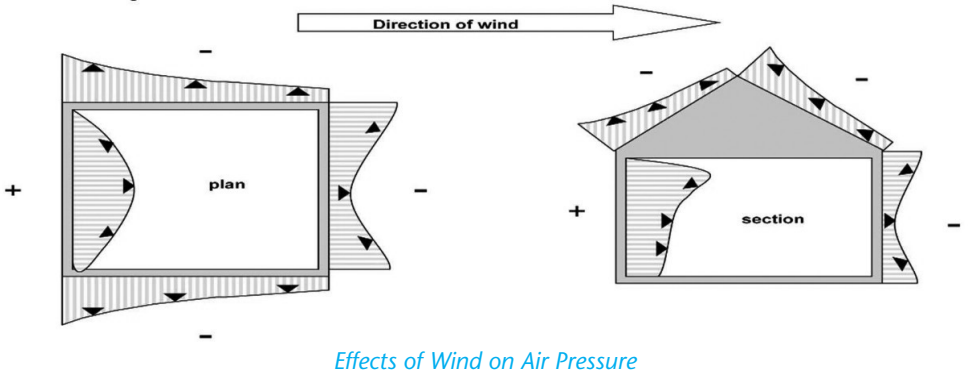
In general, it is best to have a slightly positive indoor pressure, especially during heating seasons. It is just too expensive to heat cold air pulled inside, when interior pressure is negative. Positive pressure also helps improve indoor air quality, because contaminants like smoke and dust will flow outside along with conditioned air from the interior atmosphere.

Realize that air exhausted out of a building must be made up. For every cubic foot of air exhausted, another cubic foot of air must be brought in and conditioned. If there is no make-up air system, or an HVAC system exhausts more air than is made up, the pressure inside the building will balance itself by drawing in outside air through every usable crack or opening.

There are obvious indicators of too much negative pressure in a building. People will begin complaining of cold drafts coming in openings. Exterior doors will be difficult to open and close. Odors will linger, like from diesel fuel or fork lift exhaust. High levels of carbon monoxide, radon or other dangerous gasses will also begin to accumulate.

Other indicators of too much negative pressure are not as obvious. A pilot flame will not stay lit. Visible soot or flame might roll out of the bottom of a furnace. Water heater recovery will slow down. You might experience back drafting of combustion appliances like gas water heaters, furnaces or fireplaces. Mold and mildew will begin forming, along with a musty smell of stagnant, stale air. There will be a rush of air coming in when opening an exterior door. Exhaust fans will also stop working properly.

The results of negative pressure will quickly become unsustainable. These are higher energy costs, higher maintenance costs, higher housekeeping costs and uncomfortable and unsatisfactory workplace or living conditions. The illustration below demonstrates how wind direction affects pressure inside a structure.



Effects of Wind on Air Pressure

Plugging the Holes

Larger gaps in building energy envelopes are sometimes known as windows, doors, and skylights. These fenestration elements are significant holes in energy conservation strategies.

Striving to make them as energy efficient as possible will save energy, reduce heating, reduce cooling and lighting costs and improve comfort levels inside.

The Danger Inherent in Airtight

Infiltration, into and through buildings and materials, occurs for multiple reasons. Wind can literally push itself in, can be drawn up by rising hot air, sucked in by ventilation fans and pulled up to higher spaces by a chimney effect. The force called infiltration does not transport liquid water, but it does bring in humidity in the air entering and surrounding structures. In the past, buildings were far looser in construction and frequent air changes helped control moisture by moving it out as easily as it was drawn in. Our newer, tighter buildings have lower rates of infiltration, and therefore fewer natural air exchanges. Moisture that does enter via infiltration has more time to saturate materials and then be drawn into and out of those materials, increasing humidity levels inside the building. Inadequately ventilated, damp air will cause rapid deterioration of many building materials. To stop the penetration and entrapment of this humidity, joints and cracks must be sealed (making the building even more airtight) and controlled air exchanges must be introduced through operation of the HVAC system. It is a bit of a balancing act though: an airtight building that cannot breathe at all will quickly become an unhealthy building to occupy.

Solutions to air quality problems in buildings include eliminating or controlling sources of pollution, increasing ventilation or installing air cleaning devices. Often a resident will improve indoor air quality by removing a pollution source, altering an activity, unblocking an air supply vent or opening a window to temporarily increase ventilation. In other cases requiring renovations or upgrading of building components, only the building owner or manager will be in a position to remedy the problem.

Window Frame Types

Windows are becoming more energy efficient while durability, aesthetics and functionality are being improved. When selecting new windows, consider frame materials, glazing or glass features, gas fills and spacers and the window's method of operation.

- Improving a frame's thermal resistance can contribute to its energy efficiency, especially its U-factor, or rate of heat transfer. Each type of frame materials has pros and cons, but vinyl, wood, fiberglass and some composite materials provide much better thermal resistance than metal.
- Although strong, light and almost maintenance free, metal or aluminum frames conduct heat quickly, making metal a poor insulating material. To reduce heat flow, metal frames should have a thermal break between the inside and outside of a frame or sash.
- Composite window frames are of composite wood products, like particleboard and laminated strand lumber. Some have polymer plastics mixed in. Composites are very stable, have equal or better structural and thermal properties than wood, and have better resistance to moisture and decay.
- Fiberglass frames are dimensionally stable, containing air cavities filled with insulation. This results in better thermal performance than wood or uninsulated vinyl.
- Vinyl frames are made of polyvinyl chloride with stabilizers to keep ultraviolet light from breaking down their material. These frames require no painting and resist moisture. Their hollow cavities can also be filled with insulation, making them thermally superior to standard vinyl and wood frames.
- Wood window frames insulate well, but require regular maintenance. Cladding them with aluminum or vinyl reduces maintenance, but using metal cladding will result in slightly lower thermal performance as heat transfers through it.

Window Glass Types and Coatings

Beside choosing frames, a type of glazing or glass should be selected which improves energy efficiency. Based on factors like orientation, climate and building design, different types of glass may even be more appropriate in different faces of the same home.

For very good information on energy efficiency of different glass types, visit the website of the Efficient Windows Collaborative at https://www.efficientwindows.org/gtypes.php

All Glass is Not the Same

Here are some terms that may be encountered when shopping for windows:

- Insulated window glazing refers to windows with

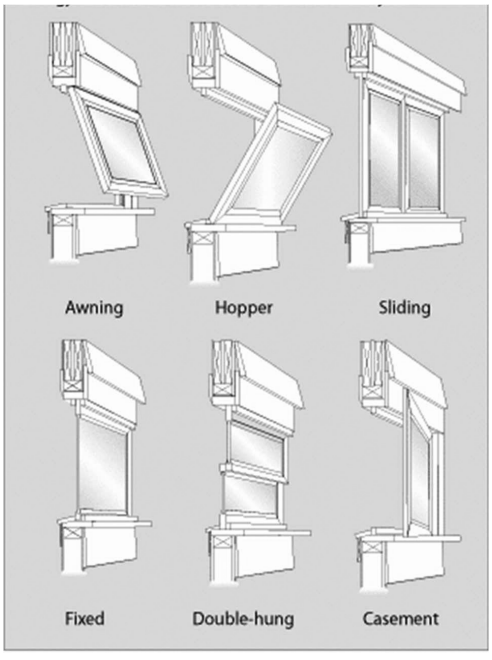
two or more panes of glass. These are held apart by spacers and hermetically sealed to create an insulating air space inside. Insulated window glazing primarily lowers the U-factor of a unit.

- Low-emissivity (low-E) coatings on glass control heat transfer through insulated glazing.
- Windows with these coatings typically cost 10-15% more than regular windows, but reduce energy loss by 30-50%. Low-E coatings are microscopically thin metal or metallic oxide layers, deposited directly on one or more of the panes. The low-E coating lowers the U-factor, and different coatings are available to allow for high solar gain, moderate solar gain or low solar gain. Most low-E coatings are applied in factories, but do-it-yourself products are available as films.
- A special type of low-E coating is one that is spectrally selective. These filter out 40-70% of normal heat transmission, while allowing in full transmission of light. They do this by reflecting only particular wavelengths of light like the infrared portions, while remaining transparent to others in the visible part of the energy spectrum. Advanced window glazing with spectrally selective coatings can reduce cooling requirements in hot climates by more than 40%.
- Gas filled layers of glass can also minimize heat transfer between the interior and exterior. Argon or krypton gasses are typically used, as both are inert, non-toxic, clear and odorless. Krypton is used when the space between layers must be thin, about 1/4". It performs better than argon at stopping energy transfer, but costs more. Argon can be used when the spacing between panes is larger, closer to 1/2". Sometimes argon is mixed with krypton to keep cost low, but increase the thermal performance.
- Spacers are used to keep and maintain layers of glass the correct distance apart. They accommodate thermal expansion and pressure differences, while preventing moisture and gas leaks.

Window Operating Types

Another consideration of energy efficiency has to be how windows operate, because some types have lower air infiltration rates than others.

- Awning windows are hinged at the top and open outward. Since the closed sash presses against the frame, they tend to have low air infiltration.
- Hopper windows hinge at the bottom and open inward. They also have lower air leakage, with closed sashes pressed against the frame.
- Single and double-sliding windows have two sashes that slide horizontally in a double-slider and one sash that slides in a single-slider. With no pressure against them when they are closed, they have higher air leakage rates.
- Fixed windows don't open. When installed properly, they're airtight, but not very useful where egress or ventilation is needed.
- Single and double-hung windows have two sashes that slide vertically. Both sashes slide in a double-hung window. Only the bottom one slides up in a single-hung window. With no pressure holding them closed against a frame or each other, these sliding windows have a high air leakage rate.
- Casement windows are hinged on one side and open outward. Since the closed sash presses against the frame, they also tend to have low air leakage.



Traditional Window Types

Selecting Windows

When choosing windows, there are multiple factors to consider. Look for those with ENERGY STAR labels. In cold climates, consider gas-filled windows with low-E glass to reduce heat loss. In warm climates, pick windows with coatings that reduce heat gain. In cold climates, the lower the U-factor, the better the thermal resistance. Look for U-factors for the entire window unit, not just the center-of-glass U-factors. You want to know the numbers that accurately reflect the performance of the entire product.

Storm Windows

Replacing single-pane windows with high-performance double-pane windows can be cost- effective. Another less expensive option might be installing exterior storm windows instead. They produce similar savings at a lower initial cost. Some storm windows can be installed by those living in apartments, to reduce air infiltration and reduce utility costs.

Older storm windows were clear glass, but new models offer low-E coatings to lower emissivity and reduce heat transmission. Storm windows with a low-E coating reflect heat back inside in the winter and reflect it back outside in the summer. Uncoated glass has an emissivity around 0.84, but low-E coated glass can be 0.16 or lower.

Storm windows can be operable or fixed in place to reduce

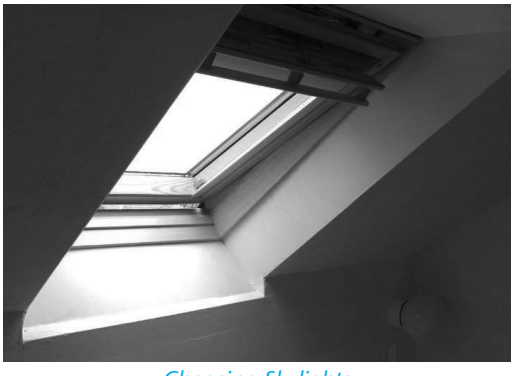
air leakage. In climates where heating is most in demand, low-E insulating storm windows and insulating shades are effective in reducing heat loss and energy costs. In warmer climates, solar control low-E storm windows will work better for energy savings.

Low-E storm windows offer multiple benefits. They cost about a fourth of complete window replacements. They are aesthetically pleasing, operable, reduce drafts, reduce noise and increase comfort. They offer similar energy savings to completely replacing windows and reflect radiant heat 35% more effectively than clear storm windows. They can help seal against air leakage and reduce it as much as 10%. Finally, low-E exterior or interior storm windows can save 12-33% on utility costs. These advantages yield a payback period of about 5-7 years.

Energy-Efficient Skylights

Energy-efficient skylights can provide daylighting and ventilation and minimize lighting costs.

Skylights on roofs can result in unwanted summer solar gain and winter heat loss. Various technologies can reduce these negatives, including heat-absorbing tints, insulated glazing and low-E coatings. A translucent insulation material like aerogel can even be inserted between layers of glazing for a more thermally efficient unit.



Choosing Skylights

Before selecting a skylight, determine what type will work best and where to place it, to optimize its contribution to daylighting and ventilation. Whether daylighting or heating potential is maximized or minimized will depend on a skylight's position. Skylights on north-facing roofs provide constant but cool illumination. Those on east-facing roofs get maximum light and solar gain in the morning. West-facing skylights provide afternoon lighting and heat gain. South- facing skylights offer the most heat gain in the winter, but also the most heat gain in the summer.

The actual size of a skylight affects the amount of illumination and solar gain in the space below. A skylight's area should not be more than 5% of the floor area in rooms with lots of windows, or 15% of the room's floor area in spaces with few windows.

Unwanted heat gain can be mitigated by placing skylights in the shade of deciduous trees or adding a movable window shade inside the skylight. Some units have special glazing to help control solar gain.

Energy-Efficient Doors

Exterior doors contribute significantly to air leakage and waste energy through conduction, especially when they are old, uninsulated, improperly installed or improperly sealed. Replacing weatherstripping or caulking exterior doors can save money and energy by reducing energy losses due to air leakage.

- Selecting New Exterior Doors

New exterior doors tend to fit and insulate better than older ones. Replacing existing doors with new ones might have a surprisingly short payback. If building new, consider buying the most energy-efficient doors possible. When seeking energy efficiency, first consider energy performance ratings relative to the local climate and your home's design.

The National Fenestration Rating Council (NFRC) label helps compare energy performance of different doors. An example is below.

National Fenestration Rating Council

The label shows the solar heat gain coefficient (SHGC) and U-factor for a door. A low SHGC is needed in warm climates and a high SHGC is best in a climate that is cool. SHGC measures how well a door keeps out solar gain, ranging from 0 to 1.

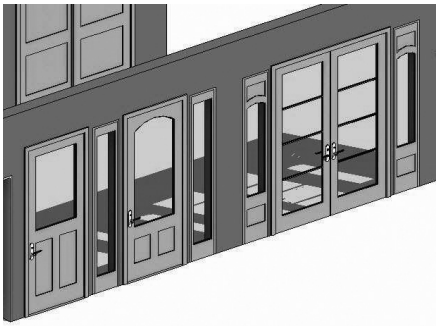
- Types of Doors

One popular door has a steel skin with a foam insulation core. It usually includes a magnetic strip seal as weatherstripping. If installed right and not bent, this door needs no further weatherstripping.

Most steel and fiberglass-clad entry doors offer R-values from R-5-R-6, excluding any windows in them. A 1-1/2" thick fiberglass door without a window offers over 5 times the insulating value of a solid wood door of the same size.

Sliding glass doors lose far more heat than other door

types, because glass is a poor insulator. Moreover, all the air leakage around weatherstripping on a sliding glass door can't be stopped and still allow use of the door. After years of use, the weatherstripping wears down, so infiltration increases. Sometimes, worn weatherstripping on sliding glass doors can be replaced.



Choosing Doors

Most modern glass doors offer metal frames with a thermal break between inner and outer parts of the frame. Models with several layers of glass or low-E coatings or gas between panes are a good investment, especially in extreme climates. When buying or replacing doors, swinging doors offer tighter seals than sliders. A door with one fixed panel will have less leakage than a similar door with two operating panels.

exam questions...

9. Which of the following is not a common air sealing trouble spot?
a. Joints between foundation walls and footings
b. Staircase framing at exterior walls
c. Common walls between attached swelling units
d. Shafts for piping or ducts

10. _____ doors lose more heat than any other door type.
a. Patio
b. Out-swinging
c. Antique
d. Sliding glass

11. Air leakage can account for _____ % or more of a home's energy costs.
a. 25
b. 30
c. 35
d. 80

12. When inside air pressure is less than pressure outside, air is pulled into the building by the process of _____ .
a. Infiltration
b. Exfiltration
c. Transpiration
d. Migration

EFFICIENCY BY DESIGN

This section will explore ways to save energy, based on design strategies and the employment of specific design approaches. The ideas explored here tend to work equally well for all buildings, regardless of the specific construction details involved.

Passive Energy-Efficient Design

Passive House Design is an all-encompassing strategy that relies on orientation, prevailing winds, airtight buildings, insulation, fresh air exchange and the use of energy-efficient components. Thick walls, triple pane windows and proper use of thermal mass contribute to success. Energy-efficient construction is a first step in long-term conservation of energy. Other factors included in this comprehensive strategy include:

- If using solar access for passive heating or cooling is intended, and solar access is not protected in your area, choose a deep lot with a north-south orientation and place your building on the north end of the lot so no one can block your sunlight coming from the south.
- The design of efficient space in a home is a good place to begin conserving resources. Don't build more space than is absolutely needed. Wasted space equates to more raw materials consumed, more energy lost in building and more energy lost in heating and cooling an unnecessary volume of conditioned air.
- The judicious use of landscaping can reduce HVAC loads on a home, as well as mitigating heat gain from surrounding surfaces.
- A heavily-insulated building envelope reduces heat loss through conduction. Even inside, if surfaces are of neutral temperature, our skin does not bleed heat out to them or absorb it from them, increasing personal comfort levels.
- Some recommend using up to 50% of a home's south side for glass. That works well in temperate zones, but is a huge heat loss in very cold weather. Using about 20% of the south side for glass results in moderate heat gain and loss, and pays off in a smaller demand on the HVAC system.
- In a fairly sealed home, indoor air quality will assume greater importance. Obtaining quality will be easier if low-processed materials like plywood, timber, tile, and cellulose or mineral wool insulation, were used in the construction. Finishes that will not continue to emit gasses like Volatile Organic Compounds (VOCs) are also a great idea, but will require some research to identify.

Using Site Features to Advantage

The side of a building facing south plays a large part in passive solar design. At least part of the structure should have an unobstructed "view" of the sun. Consider in planning that small trees will still grow, and later, buildings can be built to block your sunlight. If there are no solar access regulations in your area, use a lot that is deep from north to south and place the building on the north end. The goal is to collect heat coming with sunlight through south-facing windows and then store it in materials with thermal mass. What portion of the building's heating load this will provide depends on window size, season length, thermal storage mass and climate. Excess heat can be expelled with ventilation, but the windows will still provide natural light all year, lowering lighting costs.

Basic Elements that Work Together

- Windows collecting solar energy should face within 30° of south and not be shaded during heating days, from 9 AM-3 PM. During cooling seasons, windows should be shaded to avoid excess solar gain. Roof overhangs of a proper depth, relative to the seasonal inclination of the sun, can be used to control this gain.
- Thermal mass, like concrete, brick, stone or tile, can absorb heat from sunlight on heating days and absorb it from warm inside air during cooling days. There are other materials used for thermal mass, but it's best to use materials that can double for structural use. Dark colors absorb more heat than lighter colors.
- Solar heat stored in thermal mass can be distributed to other building areas by conduction, convection and radiation. Small fans and blowers can assist. Conduction is heat moving between two objects in direct contact, like a warm floor heating your feet. Convection is heat moving through air or water, from warmer areas like a sunspaces to the rest of the building. Radiation is energy traveling and penetrating other things, like our skin.
- The amount of incoming energy should be controllable. Roof overhangs can shade south windows during summer months. Other approaches include electronic sensors like differential thermostats that signal fans to turn on; operable vents and dampers allowing or restricting heat flow, low-emissivity blinds, operable insulating shutters and awnings.

Creating a passive solar home that works requires these variables be balanced. Insulation and air sealing, window location, glazing type and window shading, the location and type of thermal mass and auxiliary HVAC systems must fit the site and the owner's budget. Such aspects of design should also consider principles of direct gain, indirect gain and isolated gain.

- With direct gain, sunlight enters through south-facing windows and is absorbed into masonry floors and/or walls. As cooling occurs later in the day, that thermal mass releases stored heat back into the house. Water can store twice as much heat as masonry, but containers of water require additional structural support. Some existing buildings cannot support that weight.
- With indirect gain, mass for thermal storage is placed between south-facing windows and living spaces. The best example of this is a trombe wall, often an 8-16" thick masonry wall. One or two layers of glass are set about an inch in front of dark-colored masonry, which absorbs and stores heat. That stored energy then radiates into the living areas at a speed of about an inch per hour, so heat stored at 12 PM in an 8" wall will reach the living space around 8 PM.
- With isolated gain, the best example is a sunspace. These rooms, with plenty of windows for solar gain, can be closed off from the house with doors, windows and other operable openings. They can also be opened, to allow the heat from solar gain inside them to move inward into the rest of the home. Sunspaces can be a source of auxiliary heat, a sunny space for plants and a nice living area.

Passive Design for Site Considerations

In addition to winter heat, passive solar design should also consider summer comfort. This will entail design consideration of details and careful siting of the structure. Overhangs, awnings, shutters, and window coverings can be used to block summer solar gain. Careful use of deciduous landscaping will provide shade in the cooling season. Cool wind can also be pulled through a home by intentionally creating a chimney effect (we'll discuss this effect again later).

Landscaping for Climate

A microclimate is what immediately surrounds your home, and is important to consider when landscaping for energy efficiency. Your home may likely receive more sun, shade, wind, rain, snow, moisture or dryness than other nearby areas. For example, a sheltered building on a sunny southern slope will have a warmer microclimate, even in a cool region. In a hot-humid area, your site may be

comfortable because of shade and access to predominant breezes. Nearby water affects humidity and air temperature. Many site-specific factors determine which plants will grow, and that will matter. A well-placed and healthy tree, shrub or vine can offer shade, act as a windbreak and reduce energy use, sometimes up to 25%. Indigenous plants require much less water to keep them alive.

How landscaping is used to help conserve energy depends on where you live. The U.S. is roughly divided in four climate regions: temperate, hot-arid, hot-humid and cool.

Broadest Categories of Climate

The map above shows these four climate zones for the lower 49 states. Understanding the climate zone helps determine the best energy-saving landscaping strategies. Landscaping strategies vary by region.

- In temperate regions:
  - Maximize solar gain in the winter
  - Maximize shading of the building in the summer
  - Protect from winter winds with trees and shrubs on the north and northwest sides
  - Focus and aim summer breezes at the home
- In hot, arid regions:
  - Shade roofs, walls and windows
  - Allow summer winds if using natural cooling
  - Block or deflect winds from homes predominantly depending on air-conditioning
- In hot, humid regions:
  - Focus and aim summer breezes at the home.
  - Plant deciduous shade trees that allow low-angle winter sun to penetrate below them
  - Don't place planting beds requiring a lot of water, near the home
- In cool regions:
  - Plant dense windbreaks to block cold winter winds
  - Allow the winter sun to hit south-facing windows
  - Shade south and west windows from the summer sun, to prevent unwanted solar gain

Landscaping for Shade

Given that solar gain increases cooling costs, landscaping can save money in the long run. Shading and evapotranspiration from trees can lower surrounding temperatures by up to 6° F. Temperatures directly under trees can be 25° F cooler than those above asphalt. Knowing the size and shape of the shadow a tree will cast is very useful in planning, unless you are in a cool zone where cooling a building is a rare need. Then shade may not be desired at all.

Shade trees come in all shapes, sizes and densities. To block solar gain in the summer and let it in during the winter, choose deciduous trees. In warmer climates, plant them to the south of the building if they have high spreading crowns, and to the west if they have lower crowns, to block the setting sun. Don't plant deciduous trees on the south side in cooler climates, since solar gain will be desired year round. To continually block the sun and wind, use evergreens.

Slower-growing trees take awhile to generate full benefits, but usually live longer than faster growth varieties. With deeper roots and stronger branches, they better withstand damage from wind and snow. They also tend to be more draught resistant. Research the canopy spread of chosen trees and plant them far enough away that roots don't attack foundations and branches don't damage roofs. A 6-8' deciduous tree, planted near a building, will shade windows the first year. In 5-10 years, it can shade the roof.

Trees, shrubs and groundcover plants also shade pavement near the home, reducing radiation before it reaches your windows. Use plants to shade paved areas, like hedges by walks. Climbing vines on a trellis can shade patios. Vines on walls block solar gain but let breezes through. While shrubs near a home can also shade walls, take care that dense foliage doesn't hold water against building materials to create other issues. Let wind continue circulating around the home to keep the building and adjacent soil dry.

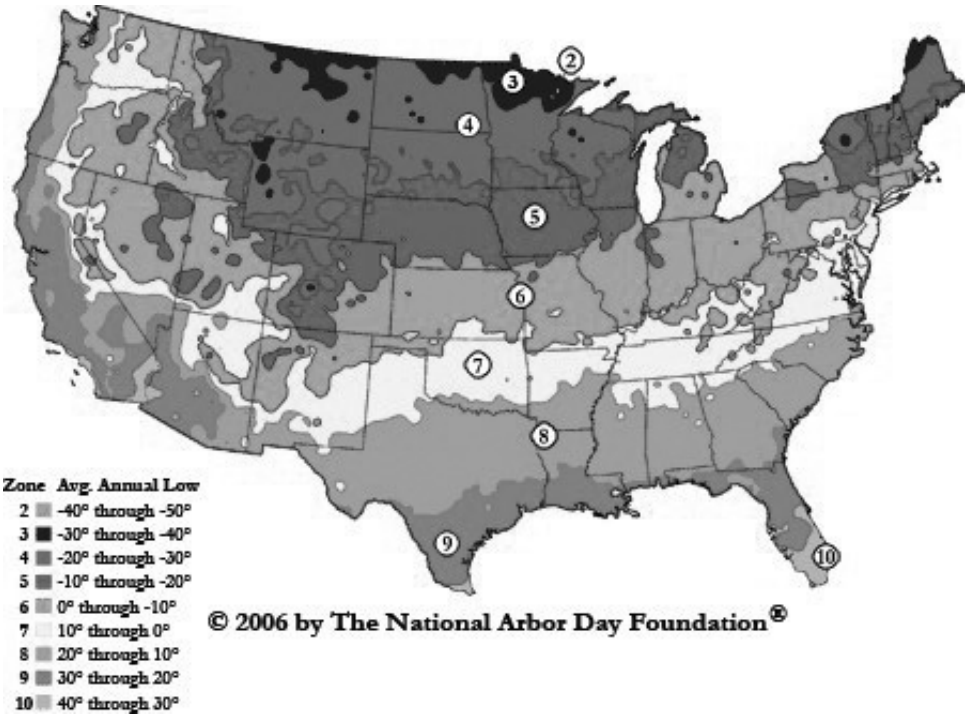
Landscape Windbreaks

Properly placed landscaping windbreaks also reduce heating costs, ever more effectively as the plants mature. They do so by reducing the wind chill near your home. Wind chill measures the rate of heat loss from surfaces exposed to wind and cold. That rate increases as the wind speed increases. Windbreaks reduce that wind speed as far away as 30 times their height. For maximum protection, windbreaks should be planted 2-5 times the mature height of the trees, away from the building, using trees and shrubs with low crowns. Evergreens on the north and northwest sides of the building are commonly used. Planting areas can be combined with walls, fences or earth berms to deflect wind up over the building. Windbreaks can also block unwanted sights, sounds and smells, protect livestock, help enhance the landscape and create a wildlife habitat. Avoid placing windbreaks where they will block desired solar gain from a winter sun.

Low shrubs or snow fences on the windward side of a windbreak will trap snow before it can pile up against a house. Shrubs planted to leave a clear foot of distance between them and the house also create dead air spaces that help insulate a house in the winter. If a building is not naturally ventilated and is air conditioned, the same shrubs can keep hot summer winds away from the house.

Water Conservation and Landscaping

Properly designed landscaping conserves water as well as energy. Certain plants have specific watering requirements. Evapotranspiration (Et) is how much water evaporates from the soil and transpires through the plant's leaves, requiring replacement by watering. Local water districts can supply information on the local Et rate, so irrigation can be planned accordingly. Then plants can be irrigated in the early morning, when Et rates are low, and before mid-day, when they are the highest.



Vegetation Growth Zones for Plant Growth

Xeriscaping is a systematic way to promote water conservation, primarily in arid regions. Here are seven basic xeriscaping principles:

- Plan ahead of time: set a game plan for water and energy conservation strategies based on regional climate and microclimate.
- Select plants and planting locations based on what already flourishes in your regional climate and microclimate. Group plants together that have similar water needs.
- Limit grass areas and avoid bluegrass that requires a lot of water. Use a hardier grass.
- Improve soil so it absorbs water better and encourages deeper roots.
- Use irrigation methods that water plants in each area most efficiently.
- Mulches keep plant roots cool, slow evaporation, keep soil soft and lower weed growth.
- Keep plants healthy by weeding, pruning, fertilizing and controlling pests.

Use plant species that thrive in the local climate. Once established, they require little maintenance and will not act as an invasive species. Local nurseries are happy to provide information on plants that are local to regions.

Passive Design Considerations for Sunlight

Lighting versus Fenestration

Our main source of natural light on Earth is the sun, coming at us during daylight hours whether we want it or not. We don't control the amount, duration and intensity of natural light coming to us. Sunlight contains the entire visible spectrum, from violet at one end to red at the other. It is necessary for our health and for photosynthesis for plants. Fire is another source of natural light.

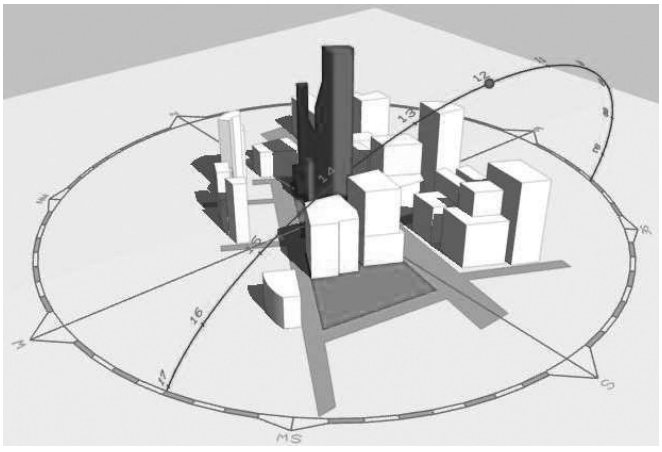
Since sunlight is available only in the daytime, we also convert electricity into artificial light, using incandescent lamps, compact fluorescent lamps (CFLs), light-emitting diodes (LEDs), etc. We control its quality, quantity and duration. We need it to work during hours of low lighting, but it does not cover the entire light spectrum and is usually neither conducive to photosynthesis nor the health of life forms.

Certain well-established levels of light (expressed in lumens) are required in order to perform certain tasks and do so safely. Natural lighting that can be introduced at sufficient levels is a preferable way to obtain that illumination. If natural light sources are not present, or are insufficient to provide needed levels of illumination, artificial lighting must be added or relied upon to obtain desired levels.

Compass Orientation

Site planning and building orientation play a large part in best utilizing incoming sunlight. This is especially

true when planning building openings and windows and choosing suitable materials to separate inside and outside climates. These tips on site orientation can definitely help optimize or minimize heat gain.



Plotting the Sun Path

- Orient the plan, not just the building profile, toward the sun. Place frequently-used rooms, like kitchens and living room, on the south side. This way, they can get sun in the winter and relief from the sun in the summer. Place patios and decks on the south side where sunlight enhances use for more hours per day and more days per year. Put lesser-used spaces like garages and laundry rooms on the north side of the house, to protect high-use living areas and act as buffers against winter winds.
- The north/south sun differential is exaggerated in mountainous regions, with significant climate differences within short distances. The best building locations are on south-facing slopes of mountains because low-angled sunlight may not reach a mountain's north face. Halfway up a mountain slope is best, since peaks are exposed to strong winds, and cold night air and water both flow down into valleys.
- Trees can provide needed shade on summer days, but can also block natural light when it is needed most. Deciduous trees on the south side will lose leaves in the winter, letting natural light through, while evergreen trees provide shade all year long. Age, species, growth rate and the mature canopy cover of existing trees on a site should also be considered in orienting a structure.
- Install windows, but not too many, basing the amount on the local climate. A good rule of thumb is to provide enough glazing to equal 5% of the conditioned square footage. But remember that while windows let light through, heat also leaks out, so too many windows can be detrimental during winter months.
- An east-west orientation is best, but the ridgeline orientation can be adjusted for other reasons by up to 20°, with the change having only a minimal impact on heat gain.
- Driveways and parking lots are made of materials that get hotter than the rest of the site. Stored heat there can affect the microclimate around an adjacent house; putting drives or parking north or east of the building reduces summer heat buildup in warm climates. In cold winter months in cold climates, a south or west oriented driveway can absorb solar gain, helping melt snow on it faster.
- Glass need not be placed completely vertically. It can be tilted relative to the angle of the sun, to maximize reflection in the summer and minimize reflection in the winter months.
- Consider prevailing winds, which predictably blow in from a single, general direction. This can be used to take advantage of summer winds for cooling and to block cold winter winds from chilling the home or piling snow against it. Detailed information about prevailing winds is usually available from local airports, libraries, the Internet or county agricultural offices. In the United States, cold winter winds usually blow in from the north and west, so minimal or insulated glazing is best on those building sides. Summer winds usually blow in from the south and west, so outdoor living spaces are oriented facing those. In coastal areas, breezes usually blow in from off the water. In mountain areas, cool winds will also flow downslope while warmer winds will tend to rise up the mountainsides.
- Property dimensions and layout may prevent the best possible building orientation to realize gains from passive design, but energy savings can still be realized. Features like low-E windows, good insulation, selective sealing against infiltration and the use of cool roofs can still be effective.
- Homes oriented to take advantage of the path of the sun, and that of prevailing winds, will require less heat and cooling, resulting in lower energy bills and increased indoor comfort.

Mind the Wind

Ascertaining Wind Direction

Besides its predominant temperature being based on its origin, wind generally moves at 10-15 mph, and creates positive pressure on the façade it is striking. As the wind goes around a corner, it speeds up considerably, creating strong negative pressure at building corners and some negative pressure on the rest of the building walls and roof. That positive or negative pressure will have a direct

impact on air leakage in and out of buildings. Remember, it is the pressure differential between inside and outside atmospheres that determines whether infiltration or exfiltration occurs.

A chimney effect is an internal wind inside of buildings. Created by hot air rising, it is really a difference in atmospheric pressure at the top and bottom of a building due to temperature variances. With a source of intake air and a place to exhaust, a chimney effect can move large volumes of air through a building. In the winter, warm air in a heated building is also lighter than cold air outside the building. That warm air bubble wants to rise up and out. When it does, it also pulls cold air in through gaps at the bottom. The reverse occurs when air conditioning.

The chimney effect is very useful for natural ventilation. Cool air can be drawn in low on the north side of a building, while air on the south side can be heated by solar gain through windows. Opening windows on the high south side will allow air to rise from the low northern openings, up and through the structure, and back out the high southern openings. In the process, cool ventilation air can be brought in from the north side and distributed through the whole building.

exam questions...

13. If trying for a passive house design, and solar access is not protected in your area, it's best to build on a deep lot with _____.
- a. A mature stand of evergreen trees
- b. A north-south orientation
- c. An opening in landscaping for prevailing summer winds
- d. Neighborhood covenants restricting amounts of paving

14. Air temperatures directly under trees can be 25% cooler than those above _____.
- a. Asphalt
- b. Concrete pavers
- c. Swimming pools
- d. Wood shake roofs

15. _____ is a systematic way to promote water conservation, primarily in arid regions.
- a. Parsimony
- b. Xeriscaping
- c. Slow-drip irrigation
- d. Selective landscaping

16. A good rule of thumb is to provide enough glazing to equal ___% of the conditioned square footage.
- a. 12
- b. 20
- c. 7
- d. 5

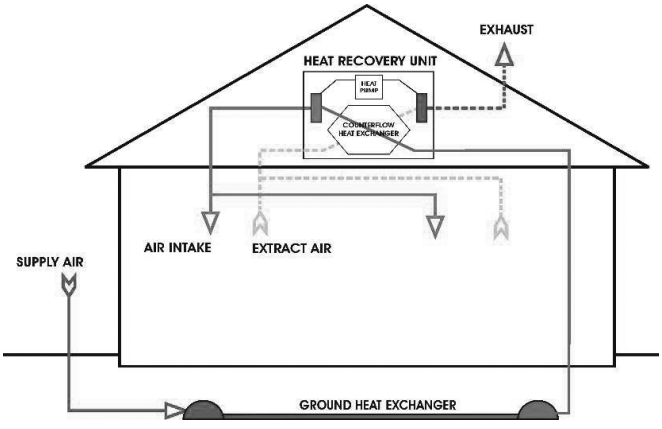
Energy Transfer from the Ground

Heat transfer will occur between buildings and ground, especially in earth-bermed and underground buildings. Passive cooling occurs as heat transfers into the ground. Ground-coupled heat pumps do the same thing mechanically. However, direct earth-contact heat transfer has many potential applications, since virtually every building is in contact with the ground by way of a basement, slab or crawl space. These are ways to capitalize on that guaranteed energy flow.

Earth Tubes

Many geothermal projects don't rely on tapping the heat of the Earth's core, but rather the difference between the desired indoor temperature and the earth's relatively constant temperature below the frost line. That ground is almost always at 4-6° Celsius, or 40-46° Fahrenheit. That is not an amazing difference in temperature, but it is reliable and useful, especially for geo-exchange ground source heat pumps.

A more passive system for earth-contact heat exchange is called an earth tube, or an earth to air heat exchanger. These are simply plastic or concrete pipes, buried underground, through which air is drawn into a building. As the air flows through the earth tube it is pre-warmed or pre- cooled by the ground's constant temperature, depending on the seasonal needs inside. The longer the tube, the more energy transfer occurs.



Earth Tube Heat Exchange

It doesn't seem like it would have much effect. But it's much cheaper to temper and pre-cool 98° F summer air with the temperature of the earth, than by using power. Likewise, it's much easier to temper and pre-warm 46° F incoming air to 76°, than it is to deal with incoming air coming straight inside at -10° F. A temperature swing of just 42° F Celsius saves tons of energy on air conditioning alone. The HVAC system gets a huge boost from the free pre-heating and pre-cooling of incoming air. Some experts estimate it can result in energy savings of up to 50%.

All this from a simple tube in the ground. The only mechanical component normally involved is a fan to draw air in through the tube. And the major cost of earth tubes

isn't even the pipes, it's digging the trench, so most earth tubes are installed during construction, when there is earth- moving equipment on the site anyway.

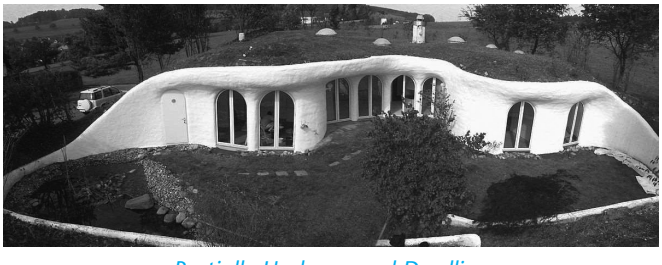
Berms and Buried Houses

One way of course, to benefit from the known heat transfer that occurs between buildings and earth is to surround your building with dirt. Besides being energy-efficient, homes built this way can be surprisingly comfortable and durable. There are two ways to surround a structure with earth: either place it below grade, or place it on grade and bring dirt up around it.

An underground structure is one that winds up being completely underground. Built on flat sites, these normally use an atrium or courtyard in the center of the design to provide an open feeling. Major living spaces surround the central open courtyard or atrium. Windows and doors on walls facing the courtyard provide light, solar heat, views and access to ground level by means of a stairway. Passive solar gain through windows will be a bit more limited than when the structure is above grade. Courtyard drainage and snow removal should be carefully thought out beforehand.

A bermed house is one built partially or wholly above grade, but with earth then banked up against one or more walls. An "elevational" design exposes one face, usually the south side, but covers the other sides with earth, to protect and insulate the house. Sunlight is allowed in through the exposed face to light and heat the home. Common areas and bedrooms usually access the exposed face, so legal egress can be made from sleeping areas. Skylights above shafts through the earth cover can be used for natural light and ventilation in other sheltered portions of the house.

In another version of bermed designs, windows and doors are protected by small retaining walls that protrude out like wing walls. Then earth is built up around the walls everywhere else, allowing cross-ventilation and natural light to enter from more than one side.



Partially Underground Dwelling

- Advantages and Disadvantages

As with any other design decision, there are pros and cons to creating earth-sheltered houses.

On the pro side, extreme outdoor air temperatures have less effect on an earth-sheltered home. There is less of an exterior to maintain, the earth provides insulation from both outdoor temperatures and from sound, and the home blends into the landscape. These homes can cost less to insure, being somewhat protected from wind, tornadoes, hurricanes and hailstorms.

On the con side, initial costs of building an earth-sheltered home can be as much as 20% more than conventional construction. These structures require more effort to protect them from water, both during construction and thereafter. They tend to be harder to resell, as some lenders will erect hurdles in the financing process.

- Site Microclimate

Before proceeding with the construction of an earth-sheltered home, analyze a building site's climate, topography, soil and groundwater levels.

- When considering climate, earth-sheltered houses are better options in zones having significant temperature extremes and low humidity. In these areas, earth temperatures vary less than temperatures of surrounding air, so the earth will absorb heat from the house in hot weather and insulate it during cold weather.

- Topography determines how easy it will be to build up and maintain earth around the building. Modest slopes require more excavation than steep ones, and flat sites will require extensive excavation. A south-facing slope in a region with moderate to long winters is ideal for an earth-sheltered building. South-facing windows can let in sunlight for direct heating, while the rest of the house is set back into the insulating slope. In regions with mild winters and hot summers, a north-facing slope might be ideal.

- Soil type will also impact the feasibility of earth-sheltered buildings. Granular soils like sand and gravel work best. They compact well for weight bearing, but their permeability also allows water to drain quickly. Cohesive soils like clay have poor permeability and tend to expand when wet. Bearing capacity of soils on a site can be determined by testing.

- A way to drain water away from a building is the best way to reduce water pressure against walls below grade. Natural drains to daylight are best, but other types of drainage systems can also be installed.

- Considering Construction Materials

Materials used for underground homes will vary based on site characteristics and design features. But all must provide a good substrate for waterproofing that can withstand pressure from moisture that will be present in the surrounding ground.

- Concrete is a common choice for perimeter walls, offering strength, durability and fire resistance. Concrete blocks with reinforced cores are also used and cost less than cast-in- place concrete.

- Steel is used for beams, bar joists, columns and reinforcement. If exposed to groundwater or precipitation, this metal must be protected against corrosion. If used, it must be done efficiently, as steel is also a relatively expensive material.

- Wood is used for both interior framing and light structural elements.

• Waterproofing

There are three primary ways to lower water damage risk to underground homes: choosing the site, drainage at and below the house surface and waterproofing the house. Several options are available for the last.

- Rubberized asphalt is coated with a polyethylene layer and applied directly to walls and roofs as sheets. This has a long life expectancy.

- Plastic and vulcanized sheets are common. Plastic options are high-density polyethylene, chlorinated polyethylene, polyvinyl chloride and chlorosulfonated polyethylene. Vulcanized membranes and synthetic rubbers include isobutylene isoprene, ethylene propylene diene monomer, polychloroprene (neoprene) and polyisobutylene. Seams with all of these must be properly sealed to prevent leaks.

- Liquid polyurethanes can be sprayed on where applying sheet goods is difficult. They can also be applied over insulation.

- Bentonite is panels made of natural clay, nailed to walls. It can also be applied as a sprayed material. When bentonite contacts moisture, it expands and seals the surface.

• Humidity

Summer humidity levels can be elevated in earth-sheltered houses. This moisture can create condensation on interior walls. Insulation on outside wall faces can stop walls from cooling to earth temperatures, but that also negates the idea of cooling in the summer using the differential between temperatures of the walls and earth. Other ways may be needed to lower humidity levels inside.

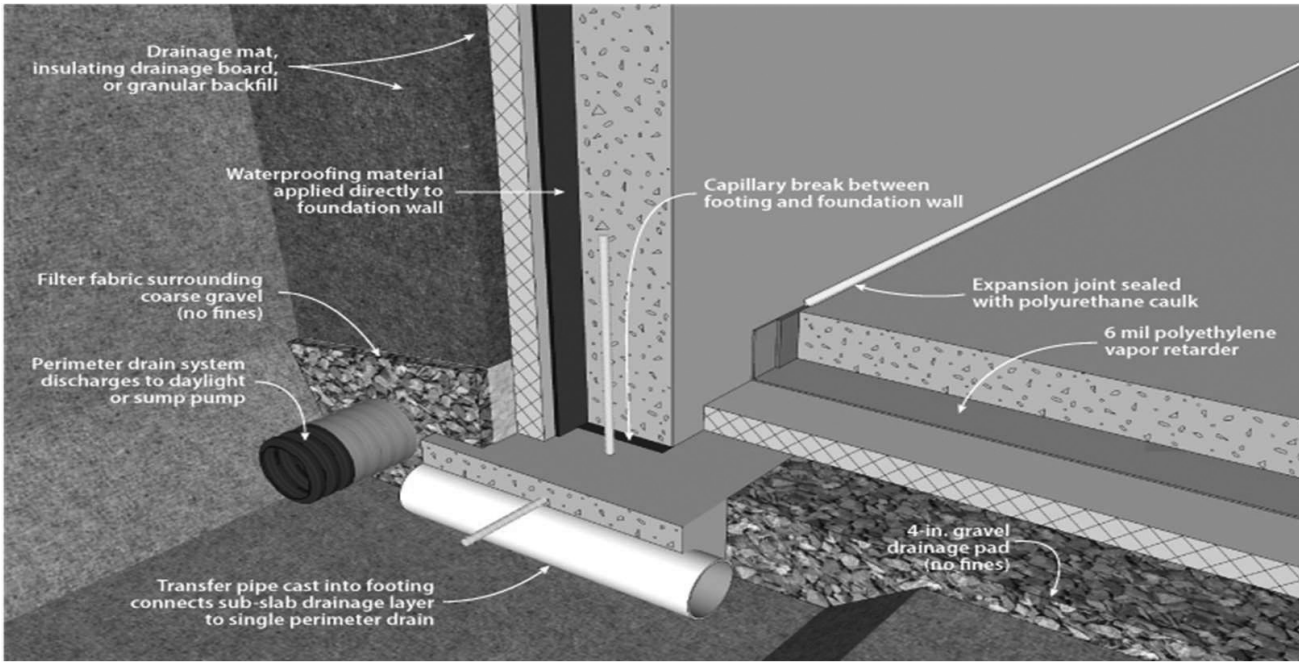
• Insulation

Underground buildings won't need as much insulation as conventional houses, but they must still be made comfortable. If insulation is placed on the outside of exterior walls, after the waterproofing has been installed, a layer of board should be installed to protect it from the earth.

The heat generated, collected and absorbed in the earth-sheltered envelope will thereby be retained inside the building envelope.

• Air Exchange/Air Quality

Adequate ventilation must be ensured inside earth-sheltered buildings. Combustion appliances should have a direct source of outside air for combustion and vent gases directly to the outside. Avoid indoor pollutants by avoiding the use of building materials and fabrics that continue emitting gasses, keeping indoor air healthy. An energy recovery system, exchanging heat in outgoing exhaust air with that of incoming fresh air, will lower heat loss and help insure good indoor air quality. In any case, these energy recovery systems are useful additions to any would- be energy-efficient home.



Waterproofing Takes Many Forms

Options for HVAC Systems

Since these are the primary users of energy in a home, the type, size and efficiency of the HVAC system that will condition inside air must be considered.

Life Cycle versus Initial Cost

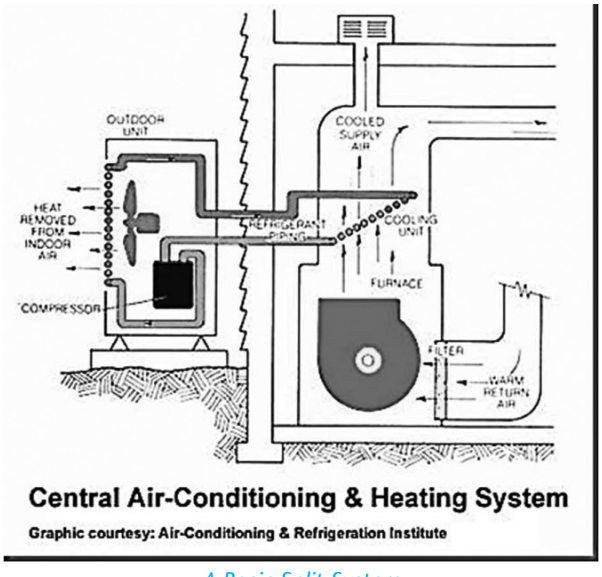
One variable in choosing an HVAC system involves its life-cycle cost, long-term payback or gain versus initial cost.

There's no right or wrong reason to invest in energy efficiency, whether for savings or reducing environmental impact, but cost does need to first be weighed against gains. For example, would you forsake hot water in favor of a gravity shower on the deck? Cook all your meals on a rocket stove? There is a stopping point most people reach when placing the need of the planet over their own comfort.

But comfort must not always be sacrificed to save money and increase efficiency. Instead, research the return on investment of various options to accomplish certain tasks. For example, one researcher claims gas water heaters are always cheaper than electric, but installing a solar water heating system will pay for itself in seven years, even though the solar system costs more up front.

This is a concept that holds true in many cases. An option that will save the most in the long run is usually a bit more expensive up front. That means extra capital spent initially can be treated as an investment for the future. That's only pertinent if finances permit extra expense up front, because few are willing to endure financial hardship on other fronts in order to save energy in the long run.

Pros and Cons of HVAC Choices



A Basic Split System

Most homes need HVAC systems to keep the building at a comfortable temperature all year round. Besides heating and/or cooling components, they are controlled by thermostats and incorporate filters to remove impurities and keep the air clean. Most systems also use ducts with vents to distribute conditioned air throughout the house.

- Four Basic HVAC System Types
  - Split systems are the most common HVAC system. They typically have a heating unit inside, fueled by gas or electricity, and a cooling unit outside that is powered by electricity.
  - Hybrid split systems are very similar, but with one additional feature. The heating component can be switched between gas and electric, allowing owners more control and potential savings as energy prices of each fuel fluctuate.
  - Duct-free systems, or mini-split systems, put individual HVAC units in each space, each with its own indoor and outdoor component, so there is no ductwork.
  - Packaged systems combine heating and cooling capabilities in one unit and are usually powered by electricity.
- Pros of HVAC Systems

The annual cost to operate an HVAC system year-round is a big factor in choosing one. Some types are more economical to run than others. Ductless systems are the most energy efficient and will result in the biggest savings over time.

HVAC system choices also depend on the house size. Split systems tend to be more energy efficient for large homes. Packaged systems offer better value for small houses and apartments. When adding a system to a stand-alone space, like a workshop that sees infrequent use, duct free systems that are individually controlled make more sense.

- Cons of HVAC Systems

The main drawback of HVAC systems is the upfront cost of units and ductwork. If a functioning system of vents and ducts is in place, replace the existing unit with another split or hybrid split system. Just installing ductwork can cost $35-55 / lineal foot. And upfront costs do not factor in yearly maintenance expenses. Duct-free systems, offering the lowest energy costs, also require the most ongoing maintenance. Even when well maintained, HVAC systems may need replacement every 10-15 years.

Physical appearance may be an issue in choosing a system. Ductwork and vents are easy to hide, making split systems aesthetically pleasing. There will still be a large cooling unit in sight somewhere outdoors. Duct-free systems may not have ducts, but they are large units, must be mounted on a wall in each room and are very hard to camouflage.

Pros and Cons of Creating Zones

It is difficult to condition air uniformly throughout a home. Things like direct sunlight, drafty windows, old equipment and bad ventilation mean you can switch from being warm to being chilled just by entering another room. Another factor in reduced comfort may be an outdated HVAC system that just can't keep up with changing outdoor temperatures. Since heating and cooling accounts for half the energy use in a home, replacing a worn out system may pay itself back pretty quickly. But if doing so, consider using zoning with the new system.

Zoning increase efficiency of use and reduces energy costs, because relying on a single HVAC setting for a whole building is wasteful. Zoned HVAC systems break down the geography of a building to provide solutions by individual floors, zones of use or even individual rooms, instead of sending the same conditioned air to all spaces. They usually have multiple thermostats controlling separate zones, diverting more cool air to hotter floors or spaces. A zoned system allocates the conditioned air, based on the needs of individual zones.

A typical zoning system uses a thermostat, a temperature control panel and dampers for each zone.

- Dampers installed inside ductwork control how much air passes through those ducts at a time. They are placed where ductwork is accessible, at the trunk, branches or the boot. Rather than shutting a vent, which means conditioned air will fill the branch duct and remain there, dampers reroute the volume of the airflow to where it's needed most. They work similarly to vents, but open and close automatically at the entry to ducts, rather than the terminal point. They maintain air pressure in the duct and just redistribute airflow as needed.
- When a zone temperature is set via a thermostat, the control panel opens and closes the appropriate dampers to meet the demands of zones.
- A zoned system has multiple temperature controllers, or thermostats, one for each zone.

Zoning distributes warm or cool air to individual zones on demand, instead of bringing an entire building to the temperature desired in one location. That can reduce utility bills by as much as 30%. That yearly savings will determine the financial feasibility of installing zoning capabilities.

exam questions...

17. _____ bermed house design exposes one face, usually the south side, but covers the other sides with earth.
a. A semi
b. An elevational
c. A submerged
d. A well insulated

18. The most common type of HVAC system used is a _____.
a. Duct-free system
b. Split system
c. Wood burning stove
d. Package unit

19. Ground below the frost line is almost always a constant temperature of _____ degrees Fahrenheit.
a. 40-46
b. 4-6
c. 33
d. 15-40

Options for Lighting

Lighting accounts for about 5% of a house's annual energy budget. Switching to energy- efficient lighting will result in the same lighting levels, but also cut energy bills. Just replacing bulbs in the most frequently used fixtures with bulbs that are ENERGY STAR rated will save up to $45 each year. Money-saving bulbs, like halogen incandescent, compact fluorescent lamp (CFL) and light-emitting diode (LED) versions, are all readily available.

Traditional incandescent bulbs use a lot of energy and are no longer manufactured. This is because 90% of the energy used was lost as heat, money just being thrown away. New types of bulbs use power more efficiently, in the same color choices and light levels.

Task versus General Lighting

One effective energy saver is to focus light specifically where needed, as task lighting. When possible, use lights placed lower and closer to the task instead of more powerful lights mounted above. Use shielded lights to direct illumination to a work surface, without creating glare in other directions. Lighting experts also use step-down lighting levels between areas needing more and less illumination. This is because contrasts between areas of low light and areas of intense light make it difficult for eyes to adjust quickly.

Be aware that elements in various lamp types render color differently. Choose light sources and lamps that provide good color rendition where it is needed.

Maximizing Available Natural Lighting

- Window Coverings

These obviously allow incoming levels of natural light to be manually adjusted. Blinds reduce views, but can also block them out entirely, partially dampen sunlight or even redirect it up to the ceiling to indirectly light a space. Shades, whether automatic or manual, can provide complete protection from glare in various levels of opacity. Shades can be installed to pull from the bottom up or from the top down. Drapes are an older alternative to shades. They are also a bit more difficult to operate and bring cleanability issues with them. For any covering device, pull cords can be difficult for arthritic hands to operate. Circular chains are considerably easier to grip and manipulate.

Many Ways to Block Light

- Light Shelves

Light shelves are horizontal, reflective surfaces, inside or outside of windows. They are used to either reflect light back outside or bounce it further back into the interior of a space, increasing light levels in places where natural illumination doesn't normally reach.

Energy-Efficient Lamp Technologies

Choices exist for energy-efficient lighting. As already mentioned, popular bulbs include halogen incandescent, compact fluorescent (CFLs) and light-emitting diodes (LEDs). They cost more than incandescent bulbs, but ongoing energy savings result in less life-cycle cost.

Controls, like timers, motion detectors and photocells turn lights off when not in use. Dimmers save electricity by lowering output. Fixtures must be chosen which are compatible with the bulbs and controls you intend to use.

When outdoor lights will remain on for long periods, it is best to use CFL or LED bulbs. Spiral CFLs can be used in enclosed fixtures that protect them from weather. CFLs and LEDs also come as flood lights, have been tested to withstand rain and snow and can be used in exposed fixtures. Some can be found with features like automatic daylight shut-off and motion sensors.

Halogen incandescent bulbs have a capsule inside, holding gas around a filament to increase efficiency. These come in many shapes and colors and can be used with dimmers. They meet minimum energy efficiency standards, but there are even more efficient options available now.

Halogen Incandescent

Compact fluorescent lamps (CFLs) are small curly versions of tube fluorescent lights from the past. Using about a fourth the power of an incandescent with the same output, typical CFLs have a payback of less than nine months, before savings begin accruing. CFLs use about a third the energy of a halogen incandescent.

CFLs

CFL bulbs come in multiple light color ranges, including warm (white to yellow) tones that were unavailable when first introduced. Covers over some versions further diffuse the light and provide a similar shape to traditional bulbs. Not all are dimmable, so packages must be checked if that capability is desired. Fluorescent bulbs do contain some mercury, so they should always be recycled when used up.

LEDs are solid-state lighting, using semiconductors to convert electricity into light. Once used mainly in traffic lights, LED lights are one of today's most energy-efficient technologies. ENERGY STAR-rated LEDs use 20-25% of the energy and last 15-25 times longer than traditional incandescent bulbs. They use 25-30% of the energy and last 8-25 times longer than halogen incandescent bulbs.

LEDs

LED bulbs are available in many products and often replace 40W, 60W and 75W traditional incandescent bulbs, reflector bulbs for recessed fixtures, small track lights, desk lamps, kitchen undercabinet lighting and outdoor lights. LEDs come in multiple colors, some can be dimmed and some work with daylight and motion sensors. They are used indoors and outdoors due their durability and performance in cold environments. You can also find solar-powered outdoor lighting using LEDs. Prices of these types of bulbs are also coming down, as more manufacturers enter the market.

Active Renewable Energy Technologies

Energy efficiency can also be realized through the purchase of active mechanical equipment to perform specific functions that reduce overall use of power.

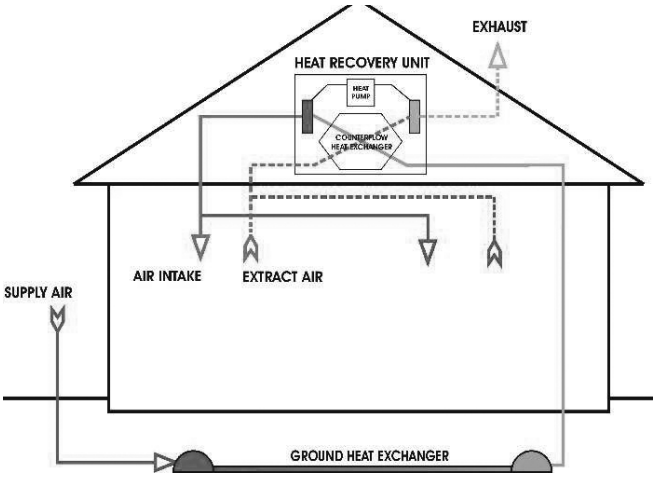
Energy-Efficient Kitchen Appliances

Energy can be saved in kitchens by purchasing more efficient appliances. ENERGY STAR ratings are available online for dishwashers, refrigerators and freezers, ranges and other common appliances.

Heat Recovery Systems

Heat recovery systems (MVHR) typically involve two primary aspects: mechanical ventilation and heat recovery.

Mechanical ventilation involves a duct working in conjunction with a fan to bring fresh air into a building. Another duct with a fan blows stale air out. Since both fans are powered and controlled, it is considered "mechanical" ventilation. A system with no power and no controls would be "natural ventilation."



Heat Recovery Unit

Heat recovery uses a heat exchanger, taking heat from warm air and giving it to cold air. Inside air is often warm, having been heated to make rooms more comfortable. Outside air is typically colder than indoor air for most of the year, especially through the night. A heat exchanger warms incoming cool air from the exterior, preheating it by exchanging heat from warmer, stale indoor air being exhausted.

The two air paths don't intermingle, so stale or contaminated air is not mixed with fresh air. Only heat is transferred in the heat exchanger.

Balanced Whole-House Ventilation

One principle used with heat exchangers is called "balanced whole-house ventilation." With this, the amount of air coming into the building through the MVHR exchanger matches the amount of air being exhausted through the MVHR. This allows the maximum amount of heat to be recovered from outgoing air.

Balanced whole-house ventilation typically includes the following:

- There are two grilles on the outside face: one for fresh air coming in and one for stale air leaving.
- Behind each grille is a short duct going directly to the heat recovery unit. One duct has cold fresh air from the outside coming in. The other has cold stale air being blown out, because the heat has already been taken from it in the exchanger. These two cold ducts need to be insulated from the building interior, so condensation doesn't form on them, using vapor impermeable insulation. And as part of the thermal envelope, these ducts must be airtight, sealed to both the air barrier of building envelope and to the MVHR unit.
- These two ducts connect to and pass through the MVHR unit in insulated ducts.
- Inside the MVHR, fresh incoming air passes through a filter to purify it, prevent particulate in it from clogging the heat exchanger and ensure the air is clean and healthy.
- Both supply and exhaust air streams pass through a counterflow heat exchanger. This mechanism can recover 75-95% of the heat, as opposed to a non-counterflow exchanger, which is limited to about 50% of the heat. Many MVHR units also have a by-pass function, so when outdoor air is warm and no heat needs to be recovered, the by-pass function reduces any risk of overheating.
- Both ducts have a small fan inside to blow air in the right direction.
- Two ducts come out the other side of the MVHR. One goes to all habitable rooms, like living rooms, bedrooms, etc., to deliver fresh air. The other duct returns to the MVHR from the same rooms where air is being extracted.
- Extracted air also passes through a filter to remove particulate from entering and blocking the heat exchanger.
- Both ducts contain silencers near the MVHR, so fan sounds won't transmit through the ducts and into rooms. Humming sounds from fans, even if quiet, are uncomfortable and undesirable.
- Where the ducts supply or extract air from rooms, a grille or vent is used.

Design Features of Energy-Efficient Houses

Whole-House Systems Approach

Optimizing energy efficiency requires a whole-house systems approach to ensure all variables, details and interactions affecting energy are considered. Occupant behavior, site conditions and climate are primary considerations. Others can include appliances and home electronics, insulation and air sealing, lighting and daylighting, space heating and cooling, water heating and windows, doors and skylights.

Ultra-efficient homes combine state-of-the-art energy-efficient construction, appliances and lighting with commercially available renewable energy systems, like solar water heating and solar electricity generation. The intent is to reduce home energy use much as possible, then supply remaining needs with on-site renewable energy systems.

Cutting Edge Ideas to Achieve Efficiency

Some energy conservation ideas are utilized, but are not yet generally accepted as being time tested.

- Recycle, filter and reuse waste water from washing machines, dishwashers and showers. Do the same thing with rain water and use it for cooling and irrigation.
- Solar powered systems are available to heat water.
- Heat exiting the cooling system can be used to preheat water coming into the water heater.

- Water heaters and floor heating systems can use the heat from a solar thermal collector.
- Liquid desiccant waterfalls not only look great, but help maintain humidity control.
- Photovoltaic (PV) solar panels can generate enough energy to handle cooling, heating, LED lighting and common appliances found in a regular house. When PV solar panels provide more electricity than needed, excess energy can be stored for later use in batteries.
- Building shells made of SIPs (structural insulated panels) are very energy efficient. Costs are about the same as framing with wood, but labor is saved since panels are prefabricated and shipped to be assembled on site. They are strong enough to withstand heavy snow and strong winds, while still tightly sealing and insulating the interior.
- Deep rafters can be filled with foam insulation to ensure tight construction and high R- values. The same thing can be done between wall studs.
- Clearstory windows and vent skylights make use of natural light.
- A artificial lighting controller can be programmed to adjust light levels according to people's circadian rhythms and mimic natural lighting conditions.
- Fresh air supply can be delivered through ventilation tunnels coming in from underground, to precondition the air using the earth's temperature. These are the earth tubes mentioned earlier.
- There are high-end controls that can monitor and adjust temperature, lighting and levels of humidity.
- Natural ventilation and thermal comfort can be achieved with a heat-recovery ventilator.
- Energy Recovery Ventilator (ERV) units and heat and humidity exchangers can help control temperatures inside.
- Vertical gardens allow growth of vegetables and fruits in small areas.
- Moveable curtains help reduce solar gain and maintain cool temperatures inside.

Proven Ideas with Low Cost to Implement

Some energy savings ideas are common sense, cost little or nothing to implement and rely on proactive users.

- Install a programmable thermostat to lower costs and manage HVAC systems efficiently.
- Air dry dishes when possible, instead of using a dishwasher drying cycle.
- Turn things off when not in use, like lights, TVs, entertainment systems, computers and monitors.

Lower Cost

- Plug home electronics into power strips and turn those off when equipment is not in use, to reduce wattage used in standby modes.
- Lower thermostats on water heaters to 120°F.
- Take short showers instead of baths, using low-flow showerheads to save hot water and reduce the need to heat more.
- Wash only full loads of dishes and clothes.
- Air dry clothes when possible.
- Change settings on thermostats when away from home. A change of just 3-5° F an lower utility bills. Changing settings by 10-15° F during a work day can save 5-15% of power used each year.
- Start a compost pile. Compost is organic waste kept in a pile or container, to decompose over time. It not only becomes valuable fertilizer for plants, but reduces the amount of trash produced on a daily basis.
- Installing low-flow showerheads improves water efficiency. These have a flow rate of less than 2.5 gallons per minute, rather than the conventional 5 gallons per minute.
- Seal air leaks in and around windows. If windows are drafty, add weatherstripping around frames. Add silicone caulk over cracks in drywall or apply shrink film to your windows. Sealing gaps and cracks is an easy way to lower energy costs.
- Electric and gas space heaters keep feet nice and toasty, but are really inefficient ways to heat space. Many use 1,500 watts of energy to run and will drain an energy budget. It's better to layer on clothing or invest in blankets, than to crank up thermostats or use space heaters.
- According the EPA, homeowners can save about $170 a year just being careful of water use. Don't run water while brushing teeth or shaving. Baths use 75 gallons of water, compared to an average of 17.2 gallons for a shower. Wait till there are full loads to run a clothes washer.
- Replace incandescent bulbs with more efficient varieties that offer longer lasting bulb life and use far less energy.
- Unplug cell phone and battery chargers, unless they are being used. According to Energy.gov, average chargers use 0.26 watts when not in use and 2.24 watts when connected to a phone. One charger won't have much impact, but multiple chargers powered on together can account for a measurable percentage of a home's energy use.
- Avoid washing clothes with hot water, using cold or warm water when possible. Some estimate that 90%

of energy used by a washer is spent heating the water, with the rest running it. Using cooler water can save a lot of energy.

Proven Ideas with Higher Cost to Implement

Other energy-saving ideas are still easy to implement. They just require some expenditure up front.

Higher Cost

- Adding insulation to your attic can seal air leaks and reduce utility costs. How much insulation is needed obviously depends on house size and regional climate. But according to HomeAdvisor.com, an average cost to blow in additional insulation is about $1,356.
- Solar panels aren't cheap, but have become a popular way to heat water and generate power. They can help save money in the long run, promote lower fossil fuel use and might make you eligible for annual tax incentives. They are most often installed on roofs and generate energy independently of your utility provider.
- Even with efficient doors, adding storm doors offers an extra layer of weather protection. Newer storm doors usually have low-E glass or a protective coating to reduce energy loss by up to 50%. Storm doors can last 25-50 years and can cost as little as $75.
- Have a professional energy audit conducted to pinpoint inefficiencies and energy waste in your home. This can identify savings opportunities and areas needing improvement.
- Buy ENERGY STAR products like refrigerators, televisions, stoves, washers and air conditioners. These meet energy-efficient specifications set by the EPA and use 10-50% less energy than standard choices.
- An annual tune-up of an HVAC system will keep components running at peak efficiency, saving money every month. A HVAC check-up ensures connections are tight, parts are lubricated and coils are cleaned. It also helps extend the time needed to replace the system, which can run as much as $2,000-8,000.
- Replace a computer every four years and consider replacing desktop computers with a laptop. These use up to 80% less electricity than desktop versions.

Investing in Efficiency

There are financial incentives to invest in energy-efficient purchases and improvements. These can be tax credits or rebates, or energy efficiency financing. Information can be found at:

Initial Cost

- https://www.energy.gov/savings/dsire-page
- https://www.energystar.gov/about/federal_tax_credits
- https://www.energy.gov/energysaver/incentives-and-financing-energy-efficient-homes/financing-energy-efficient-homes

Long Term Savings

An energy-efficient mortgage (EEM) can help you qualify for a more expensive home with energy upgrades.

Emerging Energy Efficiency Programs

Programs and partnerships are emerging to help building owners navigate through the complexity of energy saving options.

- The HVAC/Water Heating/Appliance Subprogram partners with labs and industries to develop cost-effective energy technologies. Heat pumps can potentially save up to 50% of the energy used by conventional HVAC systems in homes. This program focuses on technology for new heat pumps, heat exchangers and advanced household appliances. Heat exchangers are used in almost every application generating waste heat, a major research opportunity. Emerging non-vapor compression technologies may also reduce energy consumptions by 50%, with little to no carbon emission.
- Whole-Building Energy Modeling (BEM) is a versatile tool for building design, code compliance, green certification, qualifying for tax credits and utility incentives and offering real-time building control. It is being used to develop building energy codes and inform policy decisions.
- Emerging window and building envelope advances will also reduce energy consumption. To be accepted, these technologies must be delivered at a market-acceptable installed cost. Development is focusing on highly insulating materials and systems and tools to measure and validate building envelope performance. Development is also underway for improved labeling standards to better inform customers as to product performance.
- The Sensors and Controls Sub-program focuses on monitoring operating conditions of buildings and building equipment, operating at desired settings. These monitors enable cyber-physical systems for building energy management.
- The Solid-State Lighting Program leads and coordinates national efforts in developing LED and Organic Light-emitting Diode (OLED) lamp technologies.
- The Buildings-to-Grid Integration is seeking opportunities for building assets to integrate and transact with power grid operations. It defines transaction-based controls needed to control

building assets and operations, based on decisions incorporating values like cost, comfort, asset valuation and the renewable portion of power being used.

Buying and Making Electricity

Planning for Renewable Energy Systems

Before installing a renewable energy system, analyze existing power use and how it can be reduced, local codes and requirements, whether you want to operate your system on or off the electric grid and what energy generation options will work on the site. If a new home is being designed, incorporate provisions for power generation as part of a package, along with energy efficient siting and construction.

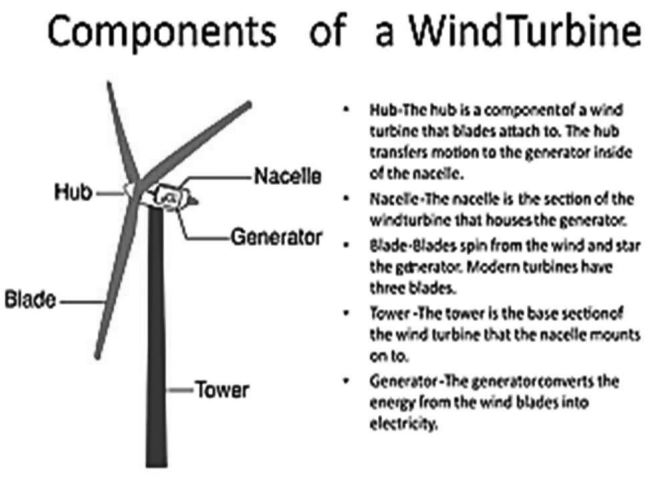
Renewable energy systems can be installed in building projects to generate power on site. Technologies to do so fall into broad classifications, like small solar electric systems, small wind electric systems, microhydropower systems and small hybrid electric systems (solar and wind).

- Small Wind Power Systems

If you have enough access to wind on your home site, small wind systems are cost- effective renewable energy systems, having zero emissions or pollution. They can lower power bills by 50-90%, avoid the cost of running power lines to remote locations and offer power even in extended utility outages. They can also provide power to spot applications, like pumping water on farms.

Wind is a naturally occurring resource. Turbines are used to convert the kinetic energy in wind into electricity. When the wind spins turbine blades, a rotor converts the energy into rotary motion to drive a generator. Automatic overspeed-governing systems keep rotors from spinning out of control in high wind.

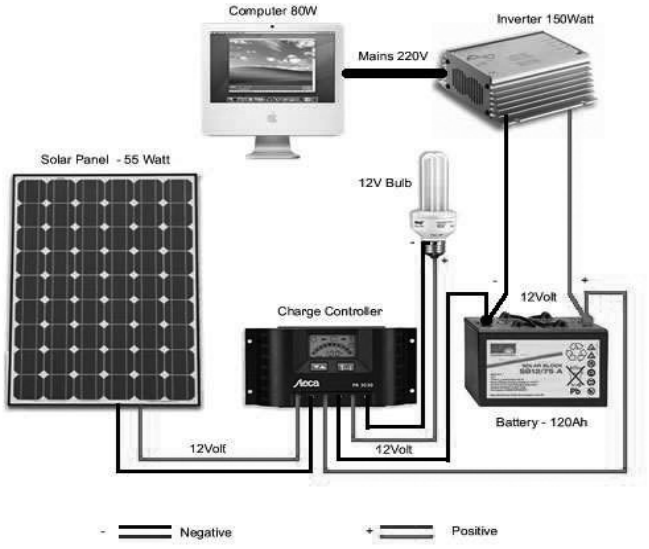
Wind systems can connect to the electric grid or stand alone off the grid. That makes these systems attractive in areas not already connected to a power grid.



Wind Power System

- Solar Power Systems

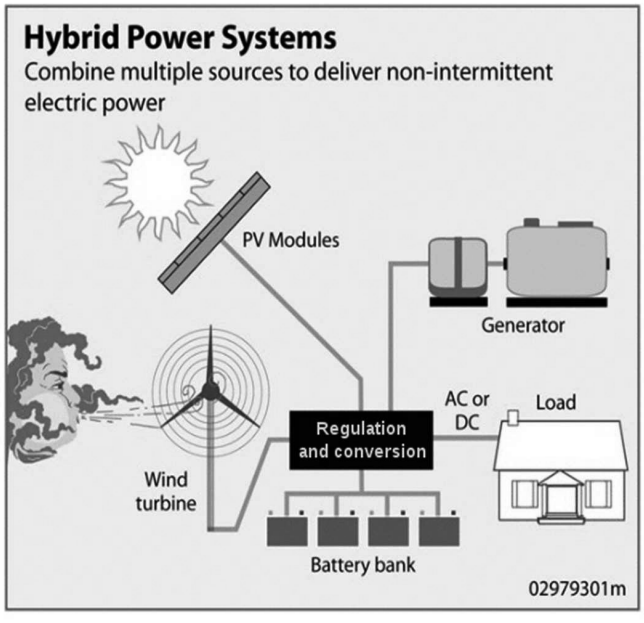
Solar electric or photovoltaic (PV) systems can produce electricity as well. These are often installed by owners to offset electricity costs. Federal tax credits and other state, local or utility incentives can offset some upfront costs of rooftop solar systems. There are also several financing options available for such renovations for homeowners.



Solar Power

- Hybrid Wind and Solar

A "hybrid" system, combining wind power and solar power technologies, offers advantages over either single system. Wind speeds are low in summer months, but the sun shines the brightest and longest. Wind is stronger in winter months, when there is less sunlight. Using both technologies means hybrid systems are more likely to be able to generate electricity when it is needed.



Hybrid Wind and Solar

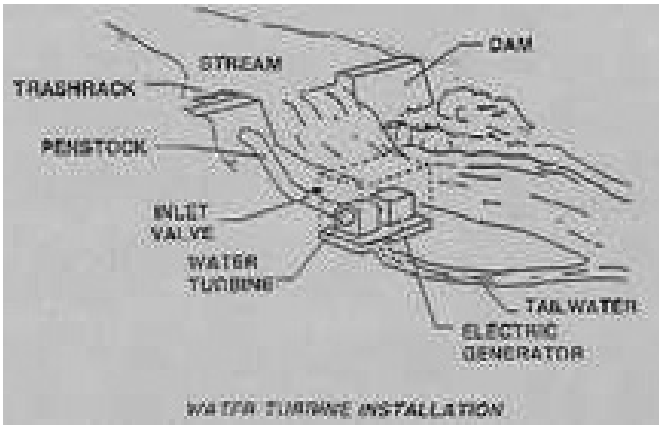
Hybrid systems tend to be stand-alone systems, not connected to a power grid. When neither wind nor solar components are producing, power is provided through batteries where it was stored or a back-up generator powered by conventional fuels. If the batteries run low, the generator can also be used to recharge them.

Despite their complexity, electronic controllers can operate all parts of a hybrid system automatically. A back-up generator can also reduce the size of the other necessary components, especially the battery storage capacity. Usually these storage units are large enough to supply needs when systems aren't charging, or sized to supply power for 1-3 days.

- Microhydropower Systems

If you have water flowing through your property, a small hydropower (microhydropower) system can be a simple, consistent source of renewable energy. These systems are sized to generate up to 100 kilowatts of power. A 10-kilowatt microhydropower system can power a large home or hobby farm.

A microhydropower system needs a turbine pump or waterwheel to change the weight of flowing water into rotational energy, and from there into electricity. These systems usually contain some basic components. The water conveyance is the channel or pipeline delivering the water. A turbine pump or waterwheel uses the force of the water to rotate. An alternator or generator converts rotational energy into electricity. A regulator controls the generator and wiring delivers the power to the building or other point of use.



Microhydropower System

Net Zero

In building terms, "net zero" refers to achieving an overall balance between emissions produced and emissions eliminated from the atmosphere. It is the stated reason to develop alternative energy sources that do not consume fossil fuels. Though I don't agree with them all, some interesting thoughts toward achieving net-zero construction were mentioned in a recent presentation I attended.

- Why guess when you can know? Use energy modeling and testing programs to identify failure points and places to improve.
- There is an entire Youtube channel set up to discuss ideas on how to reduce energy use.
- If net zero is set early as a goal, all team members can buy into it. Implementing it later in a project, as an afterthought, is difficult.
- Programs like PVWatts from the DOE help predict return on investments in alternative energy, based on available assets on a site.
- Geothermal systems are not really renewable, but are energy efficient when using a ground source heat pump.
- If streams are on site, small hydroelectric dams are useful. Very little return is realized on small wind turbines.
- The sun can be useful for solar heating of water, passive cooling via selection of overhangs and orientation on site, strategically placed glazing, trombe wall effects, light shelves to direct light inward, heating floors with the sun and heating other thermal masses.
- Right-sizing spaces means not building more area than needed, thus eliminating the need to heat, cool, ventilate and illuminate unneeded space. Design techniques can make smaller spaces seem larger and stacking floors is more energy efficient than putting spaces on a single level.
- Passive energy savings are better than active technologies. Ideas include; lots of insulation in walls and roofs, sealing against infiltration, efficient windows and doors, and reducing thermal bridges with framing at 24" on center, use of California corners and use of T-studs.
- Electrify everything, because while you can supply yourself electric power, you can't produce natural gas.
- Ductless mini-split HVAC systems are considered the most efficient. Air source heat pumps are recommended for use as furnaces.
- Induction cooktops are more efficient than using gas and much more than standard electric ranges.
- Be picky, but buy smart. Look for ENERGY STAR ratings on appliances. Purchase LED fixtures with built-in motion detectors and automatic shut-offs. Use condensing dryers instead of those that vent to the exterior.
- Reduce, then produce. Put in empty conduits and an empty breaker box to make it easy to add solar power later or possibly replace asphalt roof shingles with solar shingles.

Older Efficiency Technologies

All ideas for energy efficiency and conservation of resources are not new ideas. Here are just a few much older concepts that still apply today.

Energy-Efficient Straw Bale Homes

Straw bale buildings were used often between 1895 and 1940, but in the late 1990s building codes began acknowledging them as a viable material. One method for using these is a non-load-bearing or post- and-beam style. This uses a structural framework and fills in with bales. The other is a load-bearing or "Nebraska style." Roof loads are supported on top of stacked bales.

Despite historical use, straw bale construction still faces barriers. These include getting approvals from local officials, getting building loans or mortgages, obtaining homeowner's insurance and a lack of acceptance by the community. Local officials can provide information on both building codes and energy codes being enforced.

Building with Straw Bales

Energy-Efficient Log Homes

Log homes use solid logs for structure and for insulation. Realizing the full potential of log construction requires careful design, construction, and maintenance to achieve and sustain efficiency.

Log Construction

Energy-Efficient Manufactured Homes

Manufactured homes, also known as mobile homes, are not quite like their early predecessors. Current versions must be built to meet Housing and Urban Development (HUD) guidelines. They are on a permanent chassis and can easily be moved. Caulking and weather stripping, air sealing and energy-efficient lighting and appliances can make these structures energy efficient.

SUMMARY

In review, it seems there are many steps that can be taken, both during the design process and after structures are completed, to reduce our use of energy. These include passive steps like insulating and tightening the building envelope and installing more efficient doors, windows and skylights which are normally holes in those envelopes. In the design phases, choices can be made while positioning buildings on site, to strategically allow or preclude solar gain, admit or deny natural ventilation and maximize or minimize shade as needed for different seasons. After all has been accomplished that can be done to passively minimize energy use, active technologies can be installed to recapture energy or generate power for internal use or storage.

Reasons differ for the decisions made in undertaking renovations to an existing structure, or building new, in a quest for energy efficiency. Some decisions are mandated by increasingly stringent energy codes being enforced. Some are enforced prior to plan approval with compliance software like ComCheck. Some decisions are economical in nature, in an effort to reduce future ongoing utility costs. Some are made from an altruistic desire to better preserve our environment and natural resources for future generations.

Whatever the reason behind them, such decisions all result in a desirable conservation of our natural resources.

exam questions...

20. _____ is the anachronym used to describe an air system component typically involving two primary aspects, mechanical ventilation and heat recovery.

a. HVAC
b. MVHR
c. HEPA
d. VFAE

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