
Johns Manville
A Berkshire Hathaway Company
WALLS
THAT WORK
PRESENTED BY:
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Presenter
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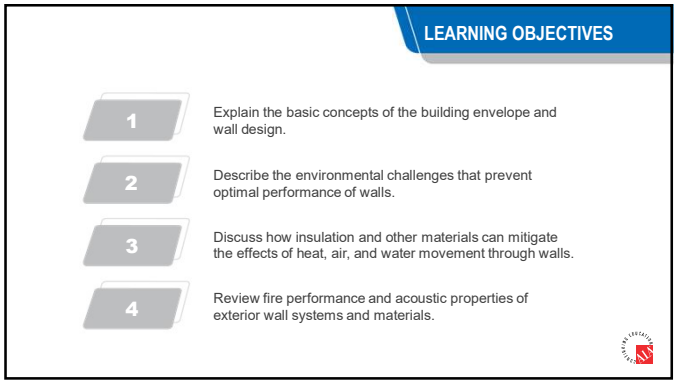
PROCEDURES
SCAN ME

2


LEARNING OBJECTIVES
1
Explain the basic concepts of the building envelope and wall design.
2
Describe the environmental challenges that prevent optimal performance of walls.
3
Discuss how insulation and other materials can mitigate the effects of heat, air, and water movement through walls.
4
Review fire performance and acoustic properties of exterior wall systems and materials.

3

WHAT IS THE BUILDING ENCLOSURE?

- The part of the building that physically ***separates*** the ***interior*** and ***exterior*** environments.
- Includes all exterior components (windows, walls, roof, floor) from the innermost to the outermost layers.
- Must control the movement of moisture, air, heat, and sound.
- Resist the spread of fire to allow for egress

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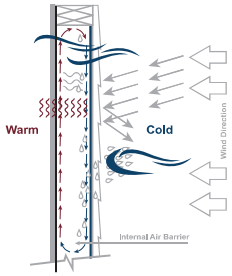
BUILDING SCIENCE OF WALLS

EXTERIOR WALLS NEED TO ADDRESS:

- **Water**
  - Precipitation
  - Vapor
- **Air**
  - Leakage
  - Wind-washing
- **Heat**
  - Transfer
  - Thermal bridging
- **Fire**
  - Means of egress
  - Combustibility
- **Sound**
  - Traffic noise
  - STC & OITC



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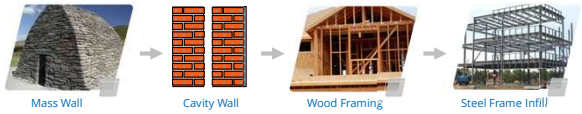
EVOLUTION OF WALLS

PURPOSE AND FUNCTIONS HAVE CHANGED OVER TIME

- Started with basic materials and purpose
- Evolved to more complex construction methods
- Functions, services, and expectations have increased
- Efficiency and performance lead to a more comfortable indoor environment.



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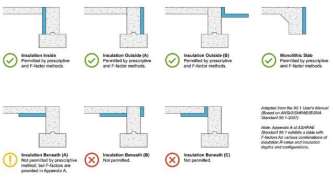
FOUNDATION

- Soil conditions and building weight drive system design.
- Water management and drainage are critical.
- Subgrade insulation is becoming mandatory.



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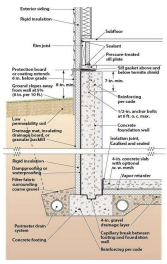
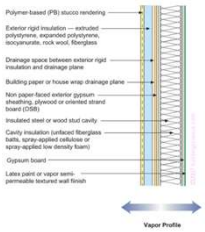
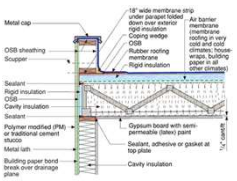
CONTEMPORARY ENVELOPE SYSTEMS







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ROOF

- Wide variety of materials and systems available.
- Subject to significant environmental exposure.
- Controlling the movement of water is critical.
- Climate can have a huge impact on longevity.

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LEARNING OBJECTIVE 1

1

Review the basic concepts of the building envelope and wall design.

1. Purpose is to separate interior space from external environment; includes windows, roofs, etc.
2. Designed to control the movement of water, air, heat, fire, and sound.
3. Today's wall systems are very complex and are expected to perform numerous functions.

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WATER CONTROL

- Moisture moves into and through the building enclosure in three ways:
  1. **Bulk water (leaks, capillary forces, absorption)**
  2. **Vapor intrusion with air movement**
  3. **Vapor diffusion**
- Moisture accumulation can result in damaged materials, mold, corrosion, rot and IAQ problems.

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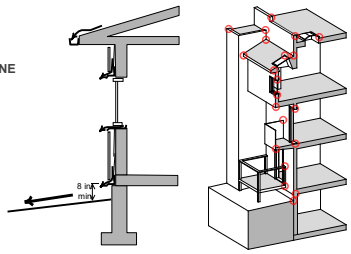
WATER CONTROL

NEED A CONTINUOUS DRAINAGE PLANE

- Drainage plane must be:
  - Water tolerant
  - Water repellent / non-wicking
- Air gap is important
- Integrated with flashings



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WATER CONTROL



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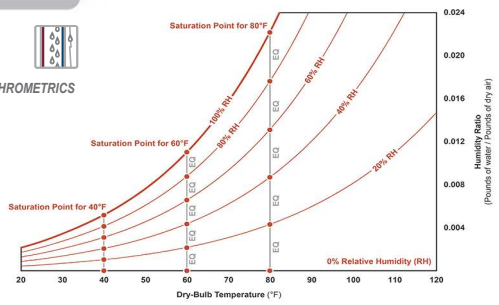
VAPOR CONTROL

PSYCHROMETRICS



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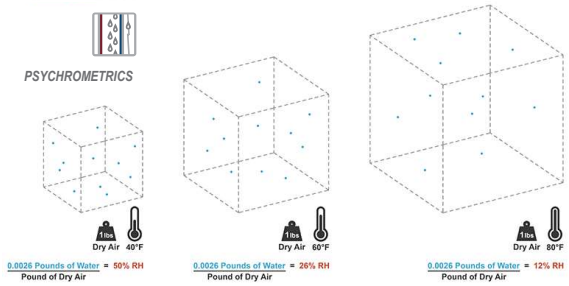
VAPOR CONTROL

PSYCHROMETRICS



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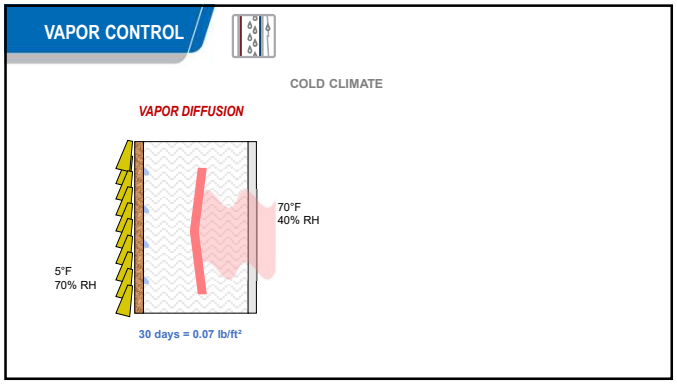
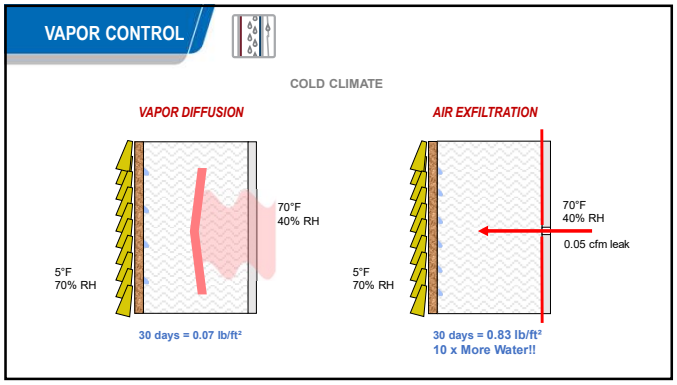

VAPOR CONTROL
COLD CLIMATE
VAPOR DIFFUSION
70°F
40% RH
5°F
70% RH
30 days = 0.07 lb/ft²

18


VAPOR CONTROL
COLD CLIMATE
VAPOR DIFFUSION
AIR EXFILTRATION
70°F
40% RH
5°F
70% RH
30 days = 0.07 lb/ft²
70°F
40% RH
0.05 cfm leak
5°F
70% RH
30 days = 0.83 lb/ft²
10 x More Water!!

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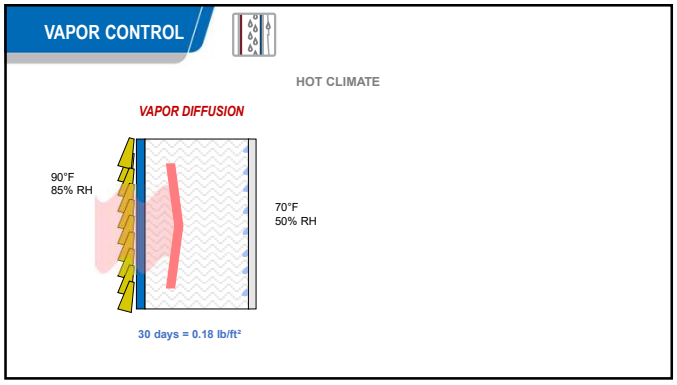
VAPOR CONTROL
HOT CLIMATE
VAPOR DIFFUSION
90°F
85% RH
70°F
50% RH
30 days = 0.18 lb/ft²

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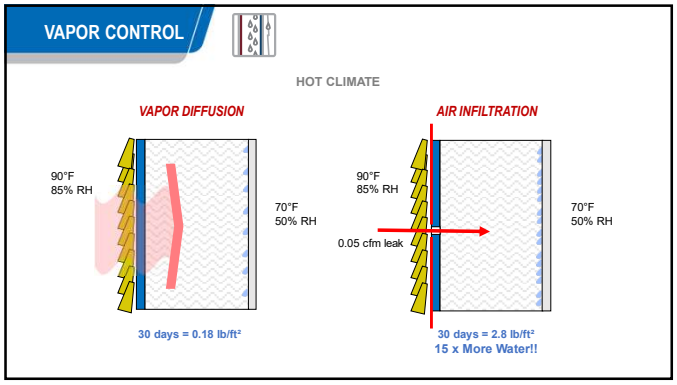
VAPOR CONTROL
HOT CLIMATE
VAPOR DIFFUSION
AIR INFILTRATION
90°F
85% RH
70°F
50% RH
0.05 cfm leak
30 days = 0.18 lb/ft²
30 days = 2.8 lb/ft²
15 x More Water!!

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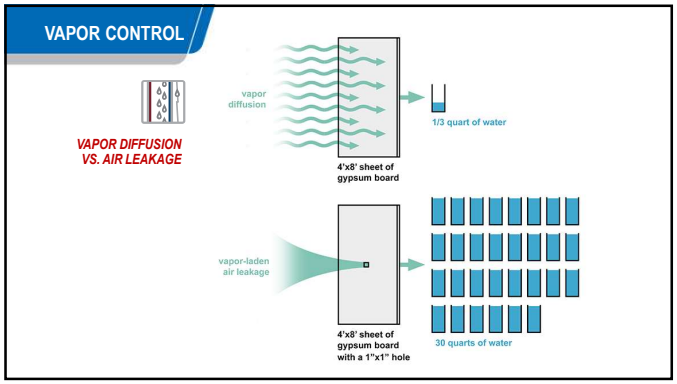
VAPOR CONTROL
VAPOR DIFFUSION
VS. AIR LEAKAGE
vapor diffusion
1/3 quart of water
4'x8' sheet of gypsum board
vapor-laden air leakage
4'x8' sheet of gypsum board with a 1"x1" hole
30 quarts of water

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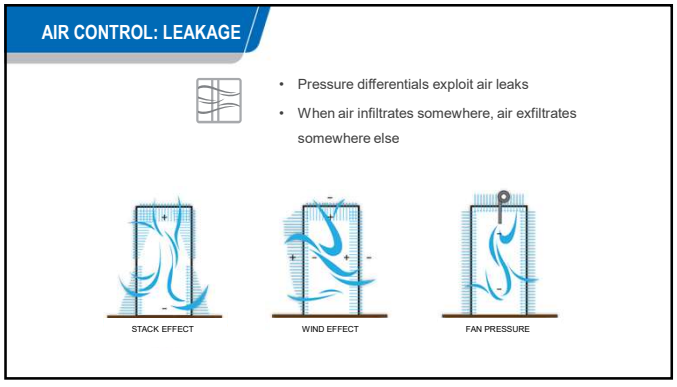
AIR CONTROL: LEAKAGE
• Pressure differentials exploit air leaks
• When air infiltrates somewhere, air exfiltrates somewhere else
STACK EFFECT
WIND EFFECT
FAN PRESSURE

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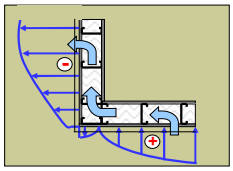
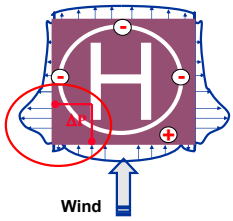
AIR CONTROL: WIND-WASHING

- Unconditioned air bypasses the exterior air barrier and enters into the wall cavity, but not into the interior of the building
- Especially prevalent at exterior corners and attic eaves





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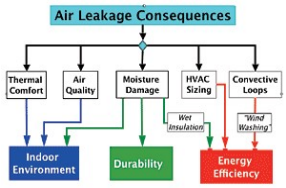
AIR CONTROL: LEAKAGE

- Degraded material performance
- Can affect interior air quality
- Potential impact on HVAC systems

"Air movement is the dominant factor in the transport of moisture through building envelope assemblies. It is also an important component of heat transfer. Many problems concerning building envelope deterioration can be attributed to inadequate or failed air barriers."

- National Research Council Canada



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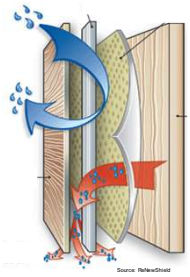
AIR & WATER CONTROL

COMMON CONTROL MATERIALS

- Exterior cladding
- Continuous Insulation (rigid board or spray foam)
- Building wraps (mechanically fasten, peel & stick)
- Liquid applied membranes / flashings
- Exterior sheathing
- Stud cavity insulation (unfaced / faced)
- Plastic sheathing (interior)
- Interior gypsum board
- Wall coverings (paint, finishes)



PROPER TREATMENT AND SEALING OF JOINTS, PENETRATIONS, AND TRANSITIONS IS CRITICAL FOR SYSTEM PERFORMANCE!

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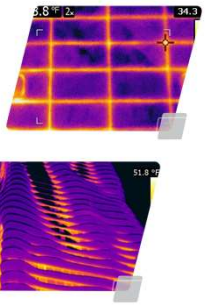
HEAT CONTROL

CONDUCTION

- Heat transfer by physical contact
  - Heat is conducted from higher temperature to lower temperature by vibrating molecules.
  - Dominant in solid materials (like framing).



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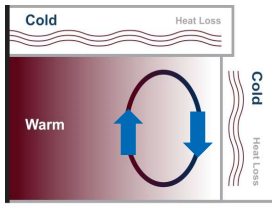
HEAT CONTROL

CONVECTION

- Heat transfer through movement of a fluid (i.e., air, water, etc.)
- As air warms it becomes less dense
- Warm air rises, along with the stored energy
- As air cools, it sinks and completes the loop



Building Cross Section

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HEAT CONTROL

RADIATION

- Heat flows (radiates) from warmer materials in all directions
- No medium needed
- People feel warm when near a warm surface and cold when near a cold surface

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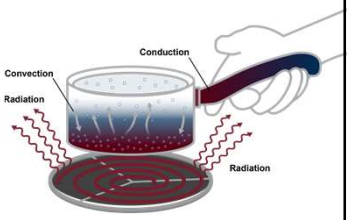
HEAT CONTROL



SUMMARY

- Heat movement is dynamic, controlling it is more complex. You can't rely on a single component – it requires a whole-system approach.

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LEARNING OBJECTIVE 2

2

Describe the environmental challenges that prevent optimal performance of walls.

1. Water penetration, especially the transfer of moisture via air movement.
2. Air infiltration/exfiltration and wind-washing.
3. Heat transfer via conduction, convection and radiation.

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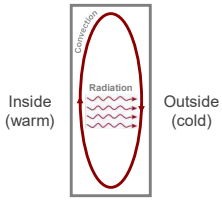
WALL HEAT TRANSFER

UN-INSULATED WALL CAVITY (NO AIR LEAKS)

- Radiation ~ 75%
- Convection ~ 25%



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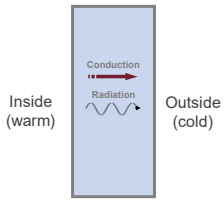
WALL HEAT TRANSFER

INSULATED WALL CAVITY (NO AIR LEAKS)

- **Thermal transmittance reduced by 75 – 90%**
- Suppress convective loops
- Conduction ~ 75%
- Radiation ~ 25%



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THERMAL BRIDGING

- Heat conducts **AROUND** the insulation through the structure.
- Thermal bridges "short-circuit" wall assemblies, allowing heat to bypass insulated cavities.
- Thermal bridging degrades wall performance by **40-60%** on average
- Common offenders:
  - Steel framing
  - Balconies
  - Slab edges
  - Window frames

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THERMAL BRIDGING

STRUCTURAL MEMBERS

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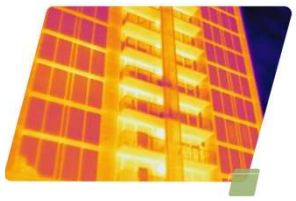
THERMAL BRIDGING

STRUCTURAL MEMBERS



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TYPES OF CONTINUOUS INSULATION

RIGID FOAM BOARD

SPRAY FOAM

MINERAL WOOL

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MATERIAL COMPARISON

FUNCTION	EPS	XPS	POLYISO	SPF	MINERAL WOOL
Drainage plane	w/ tape	w/ tape	w/ tape	✓	No
Below grade	✓	✓	✓	✓	✓
Vapor retarder (1")	2-6 perms	1.2 perms	<0.1 perms	1.1 perms	110 perms
Air barrier	None per ABAA	w/ tape	w/ tape	✓	None per ABAA
R-value	-4/inch	5/inch	≥6/inch	≥7/inch	≥4/inch
Wind	Look for manufacture assembly test data			No	No
Fire Performance	**Melts / Liquifies**	**Melts / Liquifies**	**Chars / Retains shape**	**Chars / Retains shape**	**Noncombustible**

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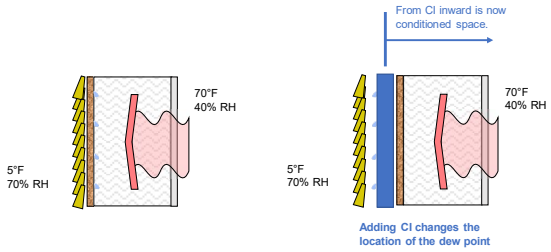
OTHER BENEFITS OF CONTINUOUS INSULATION

COLD CLIMATE



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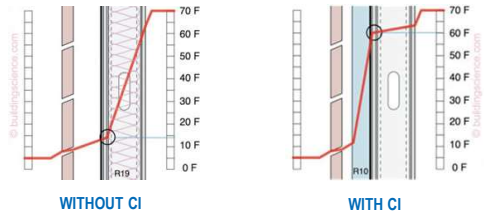
OTHER BENEFITS OF CONTINUOUS INSULATION

COLD CLIMATE



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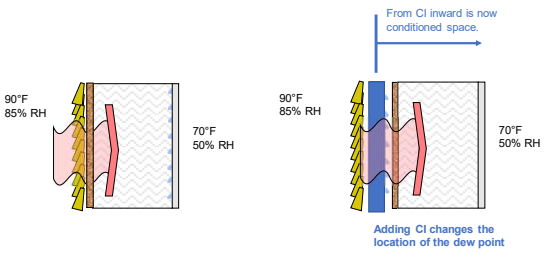
OTHER BENEFITS OF CONTINUOUS INSULATION

HOT CLIMATE



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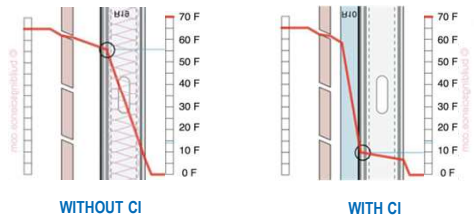
OTHER BENEFITS OF CONTINUOUS INSULATION

HOT CLIMATE



WITHOUT CI WITH CI

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LEARNING OBJECTIVE 3

3

Discuss how insulation can mitigate the challenges associated with heat, air, and water movement through walls.

1. Obstruct conduction and radiation.
2. Suppress air movement and convective loops
3. Raise temperature of materials to reduce condensation risk.
4. Use continuous insulation to reduce thermal bridging and exterior water intrusion.

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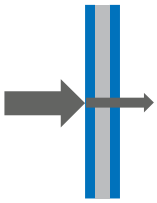
SOUND TRANSMISSION



- Walls, roofs, floors and ceilings prevent sound from traveling between adjacent spaces.
- **Transmission Loss**, the ratio of transmitted sound to incident sound, is measured for many constructions and products.
- **Sound Transmission Class (STC)** is the common single-number rating used.

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STC RATINGS

- Assembly test, **NOT** a material test.
- From a laboratory (expect performance loss from lab to job site)
- Single number rating measuring Transmission Loss from 125-4000 Hz, for speech and music.
- **Outside-Inside Transmission Class (OITC)** is better for transportation noise, 80-4000 Hz, values average about 10 – 15 points lower than STC.

STC	EFFECT
30	Loud speech understood
35	Loud speech heard but not understood
45	Some loud speech audible
50	Loud speech inaudible
60	Required for amplified sound

CHANGE	SUBJECTIVE CHANGE
0 – 2	Not noticeable
3 – 4	Just noticeable
5 – 8	Clear difference
9 – 10	Twice/half as loud

Source

STC 40 = perceived as a 95% reduction in sound transmission

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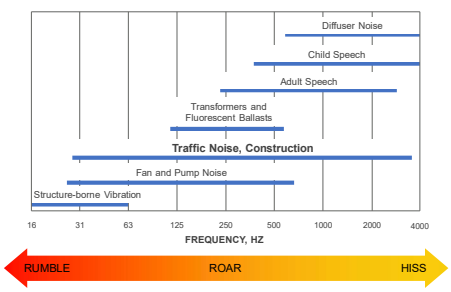
FREQUENCY RANGES



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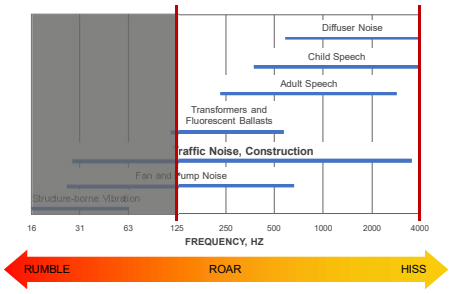
STC RANGE



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STC OF WALLS

COMMON EXTERIOR WALL ASSEMBLIES

ASSEMBLY	STC	OITC
2x4 framing, wood siding	40	25
EIFS / Stucco	45 – 50	30 - 40
Panelized / Rainscreen	30 – 50	20 – 40
Masonry / Precast / CMU	**50 – 60+**	**45 - 55**

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ACOUSTIC PROPERTIES

QUESTION	DETAILS		STC
Foam vs. fiberglass?		Fiberglass & ocSPF Closed-cell SPF ccSPF + FG hybrid	40 36 40
Insulating sheathing?		**Wall w/o CI** **Wall w/ foam CI** **Wall w/ Mineral Wool CI**	**40** **40** **44**
Insulation density?		Fiberglass (0.5 pcf) Mineral fiber (3 pcf) Cellulose (3 pcf)	40 40 40
Insulation fill?		0% full 20% 40% 77% - 100%	43 52 54 56 - 57
Foam board in roofs?		**1.5" foam board** **4.5" foam board**	**27** **27**

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MINERAL WOOL

AESTHETIC & ACOUSTIC BENEFITS OF MINERAL WOOL

- Many foam products are pink, blue or foil-faced and often include text, all of which can be exposed unintentionally.
- Mineral wool is more neutral and uniform in color, providing better aesthetics at exposed joints.

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TRANSMISSION SUMMARY

- **Higher STC/OITC = Less sound passes through**
- **Strategies to reduce sound transmission**
  - Add weight or mass (gypsum, concrete, etc.)
  - Add cavity insulation
  - Add vibration breaks (resilient channels, isolators)
- **Need to consider flanking**
  - Air leaks
  - Structural connections
  - Windows, doors and openings
- **Porous materials are best for sound control – less reverb**

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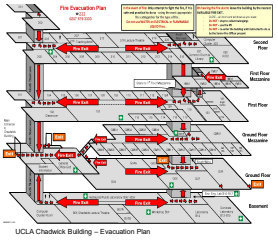
FIRE CONTROL

- A building's design, construction, and systems must allow for a **MEANS OF EGRESS** in the event of a fire
- Fire performance of buildings are dictated by:
  1. Height
  2. Floor area
  3. Use & occupancy classification (Group)



UCLA Chadwick Building – Evacuation Plan

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FIRE CONTROL

CONSTRUCTION TYPES (IBC CH. 5, 6)

- Type of Construction is a major driver in material selection
- A product's fire performance rating will dictate what kind of construction it qualifies for (there are exceptions)

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
	A	B	A[a]	B	A[a]	B	HT	A[a]	B
Primary structural frame[f] (see Section 202)	3[c]	2[c]	1	0	1	0	HT	1	0
Bearing walls Exterior[e,g] Interior	3 3[c]	2 2[c]	1 1	0 0	2 1	2 0	2 1/HT	1 1	0 0
Nonbearing walls and partitions Exterior	See Table 602								
Nonbearing walls and partitions Interior[d]	0	0	0	0	0	0	See Section 602.4.6	0	0
Floor construction and associated secondary members (see Section 202)	2	2	1	0	1	0	HT	1	0
Roof construction and associated secondary members (see Section 202)	1½[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	HT	1[b,c]	0

Combustible → Non-Combustible

- **Type V:** Combustible Construction
- **Type IV:** Non-Combustible Exterior Walls/ Combustible interior structural frames
- **Type III:** Non-Combustible Exterior Walls/ Combustible interior structural frames
- **Type II:** Non-Combustible Structure
- **Type I:** Non-Combustible Structure

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NFPA 285

Combustible materials **CAN** be used noncombustible construction

NFPA 285 ASSEMBLY TESTING

- Required when Type I – IV buildings greater than one story contain combustible materials in exterior walls.
- Measure of flame propagation via exterior wall assemblies.
- Test of the actual wall assembly, simulating a fire in a room measuring flame spread from floor to floor that runs for 30 minutes.
- Individual products must be approved as part of an assembly.
- Approved assemblies can be found in ICC and IAPMO Service Reports.

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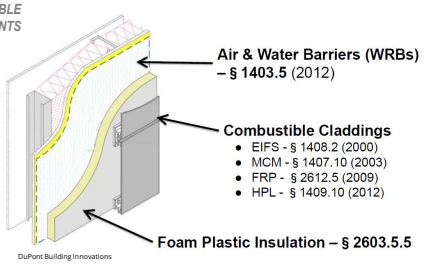
NFPA 285 TRIGGERS

IBC COMBUSTIBLE COMPONENT REQUIREMENTS



Air & Water Barriers (WRBs) – § 1403.5 (2012)

Combustible Claddings

- EIFS - § 1408.2 (2000)
- MCM - § 1407.10 (2003)
- FRP - § 2612.5 (2009)
- HPL - § 1409.10 (2012)

Foam Plastic Insulation – § 2603.5.5

DuPont Building Innovations

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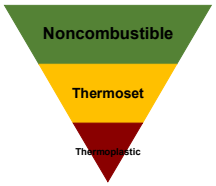
FIRE-PERFORMANCE DIFFERENCES

NOT ALL INSULATION MATERIALS ARE CREATED EQUAL

- **Fiberglass & mineral wool are noncombustible**
- **Thermoset** material (ISO/Polyiso, ccSPF)
  - Polymers interlock during curing process
  - Stays intact, retains shape, and chars
- **Thermoplastic** material (e.g., polystyrene)
  - Softens at 165°F
  - Melts at approximately 200°F
  - Will continue to burn, can liquify



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LEARNING OBJECTIVE 4

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Review fire and sound performance of exterior walls.

1. Building height, floor area, and occupancy dictate non-combustibility requirements of materials
2. Combustible materials can be used in Type I-IV construction pending NFPA 285 assembly testing
3. More approved assemblies available with Polyiso & SPF
4. OITC is a better measure for exterior wall systems
5. Adding weight/mass and/or fibrous insulation works best

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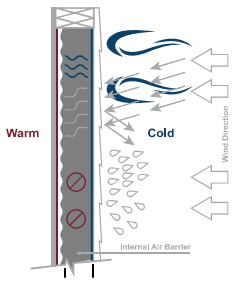
WALLS THAT WORK

EXTERIOR WALLS NEED TO ADDRESS:

- **Water**
  - Precipitation
  - Vapor
- **Air**
  - Leakage
  - Wind-washing
- **Heat**
  - Transfer
  - Thermal bridging
- **Sound**
  - Traffic noise
  - STC vs. OITC
- **Fire**
  - Means of egress
  - Combustibility



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QUESTIONS?

This concludes the American Institute of Architects Continuing Education Systems Course.

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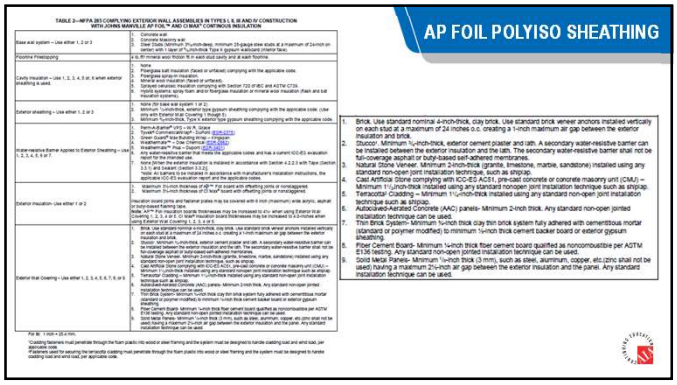
AP FOIL POLYISO SHEATHING

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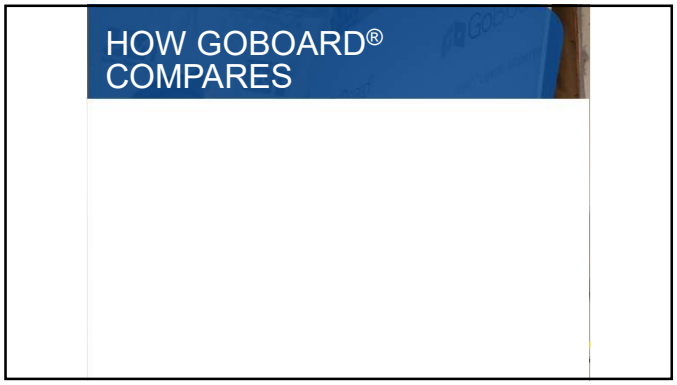
HOW GOBOARD®
COMPARES

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