Appendix

A

Miscellaneous Figures and Tables

Chapter #	Method of Installation	Type	R-value per inch	Approximate Cost (Contractor installed)
4	Vapr and Air Retarders	Polyethylene Vapor Retarder	N/A	4 mil; $0.10 per square foot
		Polyethylene Vapor Retarder	N/A	6 mil; $0.10 per square foot
		Asphalt Felt, 15 #	N/A	$0.10 per square foot
		Polypropylene Housewrap	N/A	$0.18 per square foot
7	Loose- Fill (Pour or Blown)	Cellulose	3.2 - 3.8	$1.81 per cubic foot
		Expanded Polystyrene	4.0	$3.20 per cubic foot
		Fiber glass	2.2 - 4.0	$1.63 per cubic foot
		Perlite	2.7	$2.91 per cubic foot
		Rock Wool	2.5 - 3.1	$1.64 per cubic foot
		Vermiculite	2.1 - 3.0	$ 2.91 per cubic foot
		Sawdust	2.2	N/A
		Slag Wool	2.2 - 3.0	$1.64 per cubic foot
8	Blankets: Batts or Rolls	Cotton	3.0 - 4.3	
		Fiber glass	3.0-3.8	3 1/2" thick, Kraft faced, $0.37 per square foot
				5 1/2" thick, unfaced., $0.51 per square foot
		Rock Wool	3.0-3.7	3 1/2" thick, Kraft faced, $0.40 per square foot
		Plastic Fiber	3.8 - 4.3	

Figure A.1 Quick reference insulation chart. (*R.S. Means Residential Cost Data-1999*)

Chapter #	Method of Installation	Type	R-value per Inch	Approximate Cost (Contractor Installed)
9	Sprayed-in-Place	Air Krete	3.9	
		BIBS (Blow-in-Blanket System)	4.0	
		DS Fiber Glass	4.0 - 4.27	
		Wet spray Cellulose	3.5 - 3.8	
		Wet spray Rock Wool	4.1	
10	Foamed-in-Place	Air Krete	3.9	
		Icynene	3.6 - 4.0	
		Closed Cell Phenolic	8.0	
		Open cell Phenolic	4.4	
		Polyisocyanurate	5.8 - 6.2	
		Polyurethane	5.8 - 6.2	
		Open cell Polyurethane	3.6 - 3.8	
		Tripolymer	4.6	
		UFFI	4.2	

Figure A.2 Quick reference insulation chart. (*R.S. Means Residential Cost Data-1999*)

Chapter #	Method of Installation	Type	R-value per Inch	Approximate Cost (Contractor Installed)
11	Rigid Board	Cellular Glass	2.63	
		Expanded Polystyrene (EPS)	3.6 - 4.4	$0.49 per square foot, 1" thick board
		Extruded Polystyrene (XPS)	5.0	$0.67 per square foot, 1" thick board
		Polyurethane Foam	5.6	
		Polyisocyanurate Board Foil faced	7.0 -8.0	$0.70 per square foot, 1" thick board
		Polyisocyanurate Board- Un-faced	5.6-6.2	
		Fiber glass	3.5 - 4.4	$0.51 per square foot, 1" thick board
		Fiberboard Sheathing Blackboard	2.6	
		Phenolic Foam	8.3	
		Cane Fiberboard	2.5	
		Perlite	2.8	$0.61 per square foot, 1" thick board
12	Radiant Barriersand Reflective Insulation Systems	Foil faced polyethylene bubbles		$0.46 per square foot
		Foil faced cardboard		
		Foil faced plastic film		$0.29 per square foot

Figure A.3 Quick reference insulation chart. (*R.S. Means Residential Cost Data-1999*)

EPA's Recommended Recovered Materials Content Levels for Building Insulation[1]

Product	Material	Postconsumer Content (%)	Total Recovered Materials Content (%)
Rock Wool	Slag	--	75
Fiberglass	Glass Cullet	--	20-25
Cellulose Loose-Fill and Spray-On	Postconsumer Paper	75	75
Perlite Composite Board	Postconsumer Paper	23	23
Plastic Rigid Foam, Polyisocyanurate/ Polyurethane:			
Rigid Foam	--	--	9
Foam-in-Place	--	--	5
Glass Fiber Reinforced	--	--	6
Phenolic Rigid Foam	--	--	5
Plastic, Non-Woven Batt	Recovered and/or Postconsumer Plastics	--	100

[1]The recommended recovered materials content levels are based on the weight (not volume) of materials in the insulating core only.

Figure A.4 Material content recovered or diverted from solid waste. (*EPA*)

Permeability of Materials to Water Vapor (Perms)

Material	Perms
Vapor Retarders	
Aluminum foil, 1 -mil	0.0
Polyethylene plastic film. 4-mil	0.08
Polyethylene plastic film. 6-mil	0.06
Kraft and asphalt building paper	0.3
Two coats of aluminum paint (in varnish) on wood	0.3- 0.5
Two coats exterior	0.9
Three coats latex	5.5- 11.0
Common building materials	
Housewrap type air retarder	
Expanded polyurethane, 1"	1.5- 5.0
Extruded polystyrene, 1"	1.1- 1.6
Polyisocyanurate	2-3
Tar felt building paper, 15-lb.	4.0
Insulation board, uncoated, 1/2"	50.0- 90.0
3-ply exterior plywood, 1/4"	0.7
3-ply interior plywood, 1/4"	1.9
Gypsum Wallboard, 3/8"	50
Brick masonry, 4"	0.8
Plaster, ¾"	15.0
Poured concrete wall, 4"	0.8
Glazed tile masonry, 4"	0.12
Concrete block, 8"	2.4

Figure A.5 Permeability of materials to water vapor.

Emissivity of Building Materials

Material	Emissivity
Anodize Black Coating	0.88
Carbon Black Paint NS-7	0.88
3M Black Velvet Paint	0.91
Catalac White Paint	0.90
Sherwin Williams White Paint	0.87
Brilliant Aluminum Paint	0.31
Epoxy Aluminum Paint	0.81
Finch Aluminum Paint	0.23
Anodized Aluminum	
Black	0.82
Blue	0.87
Brown	0.86
Clear	0.76
Green	0.88
Gold	0.82
Plain	0.04
Blue Anodized Titanium Foil	0.13
Aluminum	
Highly Polished	0.039-0.057
Commercial Sheet	0.09
Heavily Oxidized	0.20-0.31
Surface Roofing	0.216
3M Aluminum Foil	0.03
Brass	
Highly Polished	0.028-0.037
Dull Plate	0.22
Buffed Copper	0.03
Constantan-Metal Strip	0.09
Buffed Aluminum	0.03
Polished Copper	0.023
Thick Oxide Layer Copper	0.78
Steel, Polished	0.066
Stainless Steel	
Polished	0.11
Machined	0.14
Sandblasted	0.38
Boom-Polished	0.10
Vapor Deposited Coatings	
Aluminum	0.02
Aluminum on Fiberglass	0.07
Aluminum on Stainless Steel	0.02

Figure A.6 Emissivity of building materials.

Identifying Old Insulation

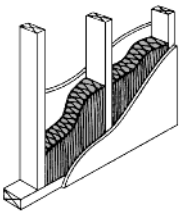
Material	Description	R-Value per inch
Asbestos	Mixed with other insulation materials; requires testing	1
Fiberglass blanket	Pink, yellow, or white	3.2
Loose-fill cellulose	Shredded newspaper, gray, "dusty"	3.5
Loose-fill fiberglass	Pink, yellow, or white loose fibrous material	2.2
Loose-fill rockwool	Denser than fiberglass, "wooly", usually grey with black specks (some newer products are usually white)	2.9
Perlite	White or yellow granules	2.7
UFFI	Whitish grey or yellow, very brittle foam	4
Vermiculite	Gray or brown granules	2.2
Wood products	Sawdust, redwood bark, balsa wood	1

Note: R-values are for old insulation only. They take into account settling as well as r-values for old materials that may have changed with new products.

Figure A.7 Identifying old insulation. *(Home Energy Magazine)*

2 x 4 Wood Stud Partition

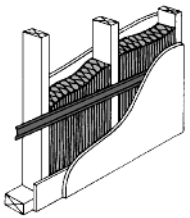
2 x 4 wood studs 16″ o.c.
CertainTeed 3½″ (R-15) Fiber Glass Batts
½″ regular gypsum wallboard



STC 39
Fire Rating 1 hr.

2 x 4 Wood Stud Resilient Channel Partition

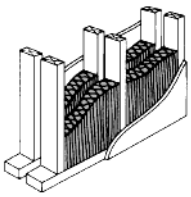
2 x 4 wood studs 16″ o.c.
CertainTeed 3½″ CertaSound Batts
Resilient channels 24″ o.c. one side
⅝″ type "X" gypsum wallboard



STC 50
Fire Rating 1 hr.

Double Wood Stud Partition

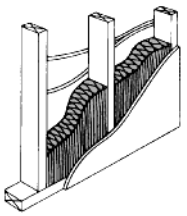
2 x 4 wood studs 16″ o.c. (double row)
Separate 2 x 4 wood plates
CertainTeed 3½″ CertaSound Batts all stud spaces
½″ regular gypsum wallboard



STC 57
Fire Rating 1 hr.

Exterior Wood Stud Wall

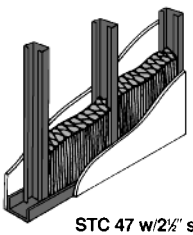
2 x 4 wood studs 16″ o.c.
CertainTeed 3½″ CertaSound Batts
Interior: ½″ regular gypsum wallboard
Exterior: ½″ gypsum sheathing
⅜″ exterior plywood



STC 38
Fire Rating 1 hr.

Steel Stud Partitions

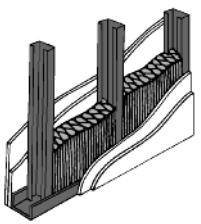
2½″ or 3⅝″ steel studs 24″ o.c.
CertainTeed 2½″ or 3½″ CertaSound Batts
⅝″ type "X" gypsum wallboard



STC 47 w/2½″ studs
STC 50 w/3⅝″ studs
Fire Rating 1 hr.

Steel Stud Partitions

2½″ steel studs 24″ o.c.
CertainTeed 2½″ CertaSound Batts
2 layers ⅝″ type "X" gypsum wallboard each side

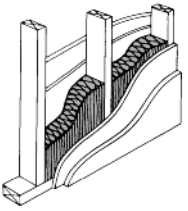


STC 54
Fire Rating 2 hrs.

Figure A.8 STC and fire ratings. (*CertainTeed*)

2 x 4 Wood Stud Partition

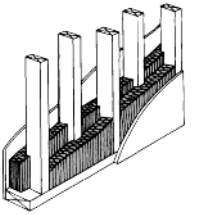
2 x 4 wood studs 24″ o.c.
CertainTeed 3½″ CertaSound Batts
2 layers ⅝″ type “X” gypsum wallboard each side



STC 46
Fire Rating 2 hrs.

Staggered Wood Stud Partition

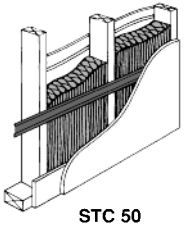
2 x 4 wood studs staggered 16″ o.c.
2 x 6 wood plates
CertainTeed 2½″ CertaSound Batts all stud spaces
½″ regular gypsum wallboard



STC 50
Fire Rating 1 hr.

Exterior Wood Stud Wall

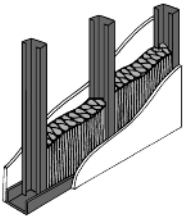
2 x 4 wood studs 16″ o.c.
CertainTeed 3½″ CertaSound Batts
Interior: resilient channel ⅝″ type “X” gypsum wallboard
Exterior: ½″ gypsum sheathing
⅜″ exterior plywood



STC 50
Fire Rating 1 hr.

2½″ & 3⅝″ Steel Stud Partitions

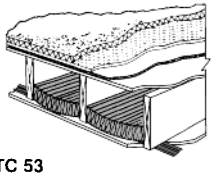
2½″ or 3⅝″ steel studs 24″ o.c.
CertainTeed 2½″ or 3½″ CertaSound Batts
½″ regular gypsum wallboard



STC 45 w/2½″ studs
STC 47 w/3⅝″ studs

Floor/Ceiling Construction

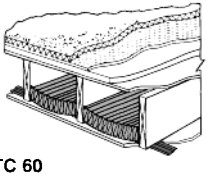
Wood Joists 16″ o.c.
CertainTeed 3½″ CertaSound Batts
Resilient channel
½″ type “X” gypsum wallboard
⅝″ plywood subfloor
⅜″ particle board underlayment
Carpet & pad



STC 53
IIC 73
Fire Rating 1 hr.

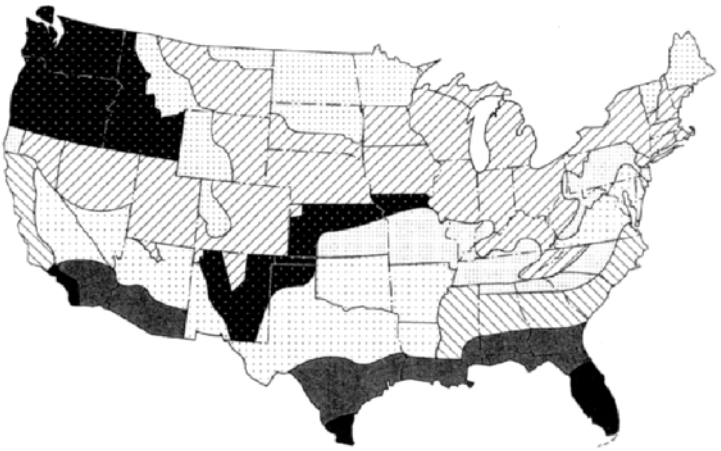
Floor/Ceiling Construction

Wood Joists 16″ o.c.
CertainTeed 3½″ CertaSound Batts
Resilient channel
½″ type “X” gypsum wallboard
⅝″ plywood subfloor
1½″ cellular or light weight concrete
Carpet & pad



STC 60
IIC 73
Fire Rating 1 hr.

Figure A.9 STC and fire ratings. (*CertainTeed*)



Insulation zone	Ceilings below ventilated attics: Electric resistance	Ceilings below ventilated attics: Gas, oil, or heat pump	Floors over unheated crawl spaces, basements: *All fuel types*	2×4 exterior walls: *All fuel types*	2×6 walls for new construction: *All fuel types*	Crawl space walls
1	R-49	R-49	R-19	R-13 or R-11	R-19	R-19
2	R-49	R-38	R-19	R-13 or R-11	R-19	R-19
3	R-38	R-38	R-19	R-13 or R-11	R-19	R-19
4	R-38	R-38	R-19	R-13 or R-11	R-19	R-19
5	R-38	R-30	R-19	R-13 or R-11	R-19	R-19
6	R-38	R-30	R-19	R-13 or R-11	R-19	R-19
7	R-30	R-30		R-13 or R-11	R-19	R-19
8	R-30	R-19		R-13 or R-11	R-19	R-11

Figure A.10 Recommended R-values and fuel types. (*U.S. Department of Energy*)

Material Description	Density (lb/ft³)	R-value	
		Per-Inch Thickness	For Listed Thickness
Building Boards, Panels, Flooring			
Gypsum or plaster board, ⅜ in.	50	—	0.32
Gypsum or plaster board, ½ in.	50	—	0.45
Gypsum or plaster board, ⅝ in.	50	—	0.56
Plywood (Douglas Fir)	34	1.25	—
Plywood or wood panels, ¾ in.	34	—	0.93
Hardboard, medium density	50	1.37	—
Particle board			
Low density	37	1.85	—
Medium density	50	1.06	—
High density	62.5	0.85	—
Wood subfloor, ¾ in.		—	0.94
Finish Flooring Materials			
Carpet and rubber pad		—	1.23
Cork tile, ⅛ in.		—	0.28
Terrazzo, 1 in.		—	0.08
Tile—asphalt, linoleum, vinyl, rubber		—	0.05
Wood, hardwood finish, ¾ in.		—	0.68
Insulating Materials			
See Appendix A			
Masonry Materials—Concretes			
Cement mortar	116	0.20	—
Gypsum-fiber concrete			
87.5% gypsum, 12.5% wood chips	51	0.60	—
Lightweight aggregates including expanded shale, clay or slate; expanded slags;			
cinders; pumice; vermiculite; also cellular concretes (by density)	120	0.19	—
	100	0.28	—
	80	0.40	—
	60	0.59	—
	40	0.86	—
	20	1.43	—
Sand and gravel or stone aggregate			
oven dried	140	0.11	—
not dried	140	0.08	—
Stucco	116	0.20	—

Figure A.11 R-value of common building materials. (*Clemson University*)

Material Description	Density (lb/ft³)	R-value Per-Inch Thickness	R-value For Listed Thickness
Masonry Units			
Brick, common	120	0.20	—
Brick, face	130	0.11	—
Concrete blocks, rectangular core			
Sand and gravel aggregate			
2 core, 8 in., 36 lb.		—	1.04
same with filled cores		—	1.93
Lightweight aggregate (expanded shale, slate or slag, pumice)			
3 core, 6 in., 19 lb.		—	1.65
same with filled cores		—	2.99
2 core, 8 in., 24 lb		—	2.18
same with filled cores		—	5.03
3 core, 12 in., 38 lb.		—	2.48
same with filled cores		—	5.82
Stone, lime or sand		0.08	—
Plastering Materials			
Cement plaster, sand aggregate	116	0.20	—
Sand aggregate, $\frac{3}{8}$ in.		—	0.08
Sand aggregate, $\frac{1}{2}$ in.		—	0.15
Gypsum plaster			
Lightweight aggregate, $\frac{1}{2}$ in.	45	—	0.32
Lightweight aggregate, $\frac{3}{8}$ in.	45	—	0.39
Lightweight aggregate on metal lath, $\frac{3}{4}$ in.		—	0.47
Perlite aggregate	45	0.67	—
Sand aggregate	105	0.18	—
Sand aggregate, $\frac{1}{2}$ in.	105	—	0.09
Sand aggregate, $\frac{3}{8}$ in.	105	—	0.11
Sand aggregate on metal lath, $\frac{3}{4}$ in.		—	0.13
Vermiculite aggregate	45	0.59	—
Roofing Materials			
Asbestos-cement shingles	120	—	0.21
Asphalt roll roofing	70	—	0.15
Asphalt shingles	70	—	0.44
Built-up roofing, $\frac{3}{8}$ in.	70	—	0.33
Slate, $\frac{1}{2}$		—	0.05
Wood shingles		—	0.94
Siding Materials			
Shingles			
Wood, 16 in., 7.5 exposure		—	0.87
Wood, double, 16 in., 12 in. exposure		—	1.19
Siding			
Asphalt roll siding			0.15
Hardboard siding, $\frac{7}{16}$ in.	40	—	0.67
Wood, drop, 1 × 8 in.		—	0.79
Wood, bevel, $\frac{1}{2}$ × 8 in., lapped		—	0.81
Wood, bevel, $\frac{3}{4}$ × 10 in., lapped		—	1.05
Wood, plywood, $\frac{3}{8}$ in., lapped		—	0.59
Aluminum or steel, over sheathing		—	0.61
Woods			
Maple, oak, and similar hardwoods	45	0.91	—
Fir, pine, etc.	32	1.25	—
..... $\frac{3}{4}$ in.	32	—	0.94
..... 1.5 in.	32	—	1.88
..... 5.5 in.	32	—	7.14

Figure A.12 R-value of common building materials. (*Clemson University*)

AIR SURFACES

Position of Surface	Direction of Heat Flow	Type of Surface: Non-Reflective Materials	Reflective Aluminum Coated Paper	Highly Reflective Foil
		Resistance (R)	Resistance (R)	Resistance (R)
STILL AIR				
Horizontal	Upward	0.61	1.10	1.32
45° slope	Upward	0.62	1.14	1.37
Vertical	Horizontal	0.68	1.35	1.70
45° slope	Down	0.76	1.67	2.22
Horizontal	Down	0.92	2.70	4.55
MOVING AIR (any position)				
15 mph wind	Any	0.17 (winter)	--	--
7½ mph wind	Any	0.25 (summer)	--	--

AIR SPACES

Position of Air Space and Thickness (inches)	Heat Flow Dir.	Season	Types of Surfaces on Opposite Sides: Both Surfaces Non-Reflective Materials	Aluminum Coated Paper/ Non-Reflective Materials	Foil/ Non-Reflective Materials
			Resistance (R)	Resistance (R)	Resistance (R)
Horizontal ¾	Up	W	0.87	1.71	2.23
¾		S	0.76	1.63	2.26
4		W	0.94	1.99	2.73
4		S	0.80	1.87	2.75
45° slope ¾	Up	W	0.94	2.02	2.78
¾		S	0.81	1.90	2.81
4		W	0.96	2.13	3.00
4		S	0.82	1.98	3.00
Vertical ¾	Down	W	1.01	2.36	3.48
¾		S	0.84	2.10	3.28
4		W	1.01	2.34	3.45
4		S	0.91	2.16	3.44
45° slope ¾	Down	W	1.02	2.40	3.57
¾		S	0.84	2.09	3.24
4		W	1.08	2.75	4.41
4		S	0.90	2.50	4.36
Horizontal ¾	Down	W	1.02	2.39	3.55
1½		W	1.14	3.21	5.74
4		W	1.23	4.02	8.94
¾		S	0.84	2.08	3.25
1½		S	0.93	2.76	5.24
4		S	0.99	3.38	8.08

Figure A.13 Air R-values. (*D. Richard Stroup*)

Building Part	Construction Materials	R-value
Roof/Ceiling	Outside Air Film	0.17
	Shingles	0.44
	Building Paper	0.06
	Plywool ½"	0.62
	Attic Air Film	0.61
	Insulation	19.00
	Gypsum Board, ½"	0.45
	Inside Air Film	0.61
	Total R-value (R_T)	21.96
	U-value ($1/R_T$)	**0.045**
Wall	Outside Air Film	0.17
	Siding, Wood ½" x 8" Lapped	0.81
	Sheathing, Plywood ½"	0.62
	Insulation	11.00
	Interior Finish Gyp. Bd. ½"	0.45
	Inside Air Film	0.68
	Total R-value (R_T)	13.73
	U-value ($1/R_T$)	**0.073**
Header Joist	Outside Air Film	0.17
	Siding	0.81
	Sheathing	0.62
	Header, Wood 1½"	1.88
	Insulation	11.00
	Inside Air Film	0.68
	Total R-value (R_T)	15.16
	U-value ($1/R_T$)	**0.066**
Sill	Outside Air Film	0.17
	Siding	0.81
	Sheathing	0.62
	Sill — Wood 5½"	6.88
	Inside Air Film	6.88
	Total R-value (R_T)	9.16
	U-value ($1/R_T$)	**0.109**
Foundation	Outside Air Film	0.17
	Conc. Blk 8"	1.11
	Insulation	5.00
	Interior Finish Gyp. Bd. ⅜"	0.32
	Inside Air Film	0.68
	Total R-value (R_T)	7.28
	U-value ($1/R_T$)	**0.137**

Figure A.14 Typical R- and U-value calculations. (*Harold B. Olin, AIA*)

WALL DESCRIPTION	U VALUE (WINTER)	HEAT GAIN BTU/HR/SQ FT (DARK COLOR) AVERAGE ORIENTATION	HEAT GAIN BTU/HR/SQ FT (DARK COLOR) WEST ORIENTATION	TIME LAG (HR)	AMPLITUDE DECREMENT FACTOR
8'' brick and lightweight concrete (100 lb density) block 2'' polystyrene insulation board ½'' gypsum wallboard	0.073	2.06	1.75	4	0.40
6'' precast concrete (140 lb density) sandwich panel 2'' polyurethane core	0.065	1.82	1.55	4	0.40
½'' plywood siding ½'' insulation board sheathing, wood studs. Full batt (R-11) insulation ½'' gypsum wallboard	0.076	3.05	4.60	2	0.75
4'' brick veneer ½'' insulation board sheathing. Wood studs full batt (R-11) insulation ½'' gypsum wallboard	0.077	2.18	1.95	4	0.62
8'' brick wall (hollow units) 1'' x 2'' furring. ½'' gypsum wallboard	0.316	7.37	5.90	6	0.25

Figure A.15 Thermal time lag of typical wall assemblies. (*Donald Watson / Kenneth Labs*)

SOLAR INTENSITY AND SOLAR HEAT GAIN FACTORS FOR 40°N LATITUDE

DATE	SOLAR TIME (A.M.)	DIRECT NORMAL (BTUH/SQ FT)	SOLAR HEAT GAIN FACTORS (BTUH/SQ FT)					SOLAR TIME (P.M.)
			N	E	S	W	HOR	
Jan 21	8	142	5	111	75	5	14	4
	10	274	16	124	213	16	96	2
	12	294	20	21	254	21	133	12
Feb 21	8	219	10	183	94	10	43	4
	10	294	21	143	203	21	143	2
	12	307	24	25	241	25	180	12
Mar 21	8	250	16	218	74	16	85	4
	10	297	25	153	171	25	186	2
	12	307	29	31	206	31	223	12
Apr 21	6	89	11	88	5	5	11	6
	8	252	22	224	41	21	123	4
	10	286	31	152	121	31	217	2
	12	293	34	36	154	36	252	12
May 21	6	144	36	141	10	10	31	6
	8	250	27	220	29	25	146	4
	10	277	34	148	83	34	234	2
	12	284	37	40	113	40	265	12
June 21	6	155	48	151	13	13	40	6
	8	246	30	216	29	27	153	4
	10	272	35	145	69	35	238	2
	12	279	38	41	95	41	267	12
Jul 21	6	138	37	137	11	11	32	6
	8	241	28	216	30	26	145	4
	10	269	35	146	81	35	231	2
	12	276	38	41	109	41	262	12
Aug 21	6	81	12	82	6	5	12	6
	8	237	24	216	41	23	122	4
	10	272	32	150	116	32	214	2
	12	280	35	38	149	38	247	12
Sep 21	8	230	17	205	71	17	82	4
	10	280	27	148	165	27	180	2
	12	290	30	32	200	32	215	12
Oct 21	8	204	11	173	89	11	43	4
	10	280	21	139	196	21	140	2
	12	294	25	27	234	27	177	12
Nov 21	8	136	5	108	72	5	14	4
	10	268	16	122	209	16	96	2
	12	288	20	21	250	21	132	12
Dec 21	8	89	3	67	50	3	6	4
	10	261	14	113	146	14	77	2
	12	285	18	19	253	19	113	12
			N	W	S	E	HOR	PM

Figure A.16 Solar heat gain factors: sample. (*John I. Yellott*)

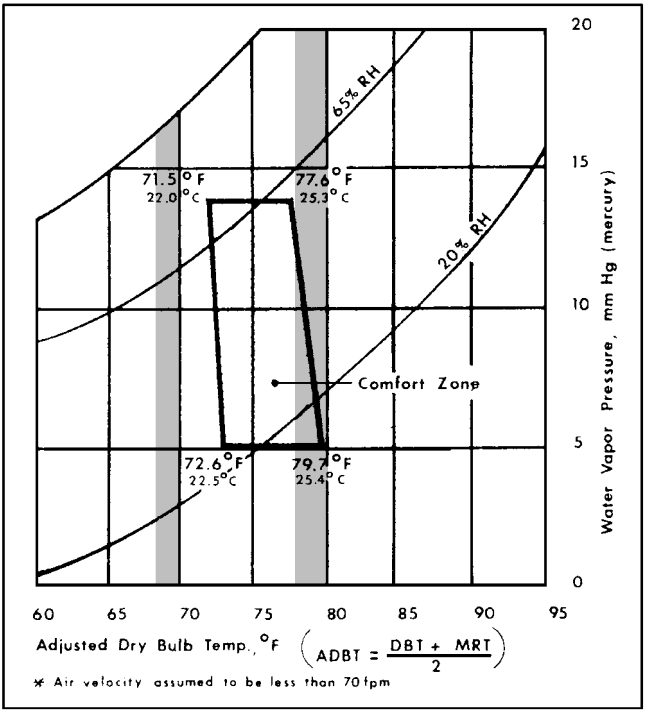


Figure A.17 ASHRAE comfort envelope. (*Harold B. Olin, AIA*)

1. Wrap and tape ductwork with fiber glass duct wrap.

2. Patch rips or tears in vapor retarders before installing the interior finish.

3. Pack insulation into small cracks around doors and window frames to help eliminate cold spots. (If using faced insulation, peel off the facing material before filling in small areas.)

4. Wrap water heater with a fiber glass Water Heater Blanket. (Use fiber glass Water Heater Top on electric water heaters only!)

Figure A.18 Miscellaneous insulation applications. (*Owens Corning*)

5. The first step in an exterior wall or sound control project is to seal all penetrations in the walls, such as those for electrical wires and outlets, using an application of Owens Corning *PinkSeal* foam sealant. Any place that air could leak through is a place where sound could leak through also. (Note: Do not use expanding foam sealants around windows and doors because they might cause jamming or misalignment.)

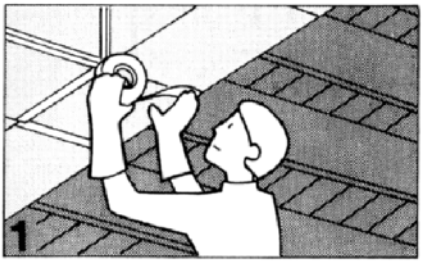
6. Insulation must be fitted properly around pipes, wiring, electrical boxes and heating ducts. On the exterior walls, the insulation must always be installed behind the water supply pipes. There should be no gaps or spaces between insulation pieces. These are places where energy would be lost for the life of the house.

7. Insulate pull-down stairways with fiber glass blanket insulation laid on and around a built-up framework. Scuttle holes can be insulated by attaching insulation directly to the board with an adhesive.

8. Caulking and sealing all penetrations can help to stop air infiltration.

Figure A.19 Miscellaneous insulation applications. (*Owens Corning*)

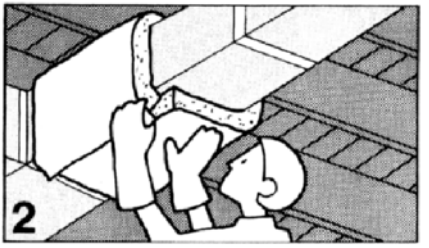
You should wrap all ducts with insulating blankets. At least two inches of insulation is desirable. If the supplier does not have the two-inch foil-backed duct insulation, then you can use a combination of 1" unfaced (no foil) and 1" foil or vinyl backed duct insulation.



Tape all duct joints and seams before you insulate the ducts to prevent any air leakage.

Cut the insulation long enough to have a two-inch overlap of vapor barrier. You need this overlap to staple the insulation. Place the vapor barrier (foil or vinyl side) away from the ducts.

If your ducts already have some insulation, check to see if any moisture has collected in it. If so, it would be best to replace it with new insulation. But, if the old insulation is still in good condition, and you need to add more to get the desired two-inch protection, be sure you make a number of slashes at six inch intervals through the old foil vapor barrier before you add the new foil-backed insulation.



Pull the insulation snug, *not tight*, to reduce air pockets. If you pull the insulation tight, you will reduce its insulating value.

After you have wrapped the ducts, tape the edges of the various pieces of insulation with special duct tape. This foil vapor barrier will keep moist air from reaching the cool ducts in summer and will protect the insulation from moisture damage. Note: Remove part of the insulation cover foil and make sure it overlaps where the two ends of insulation join together. Then after taping, staple the tape so it won't come loose and seal the holes made from stapling with insulation tape.

Figure A.20 HVAC duct insulation. (*Edison Electric Institute*)

Duct Insulation R-Value Requirements

Zone Number	Ducts in Unconditioned Spaces (i.e. Attics, Crawl Spaces, Unheated Basements and Garages, and Exterior Cavities)	Ducts Outside the Building
Zones 1-4	R-5	R-8
Zones 5-14	R-5	R-6.5
Zone 15-19	R-5	R-8

Figure A.21 Duct insulation. (*1995 Model Energy Code*)

Minimum Insulation Thickness for HVAC Pipes[a]

Piping System Types	Fluid Temp Range (°F)	Insulation Thickness in Inches by Pipe Sizes[b]			
		Runouts 2 in.[c]	1 in. and Less	1.25 in. to 2 in.	2.5 in. to 4 in.
Heating Systems					
Low Pressure/Temperature	201-250	1.0	1.5	1.5	2.0
Low Temperature	120-200	0.5	1.0	1.0	1.5
Steam Condensate (for feed water)	Any	1.0	1.0	1.5	2.0
Cooling Systems					
Chilled Water	40-55	0.5	0.5	0.75	1.0

(a) The pipe insulation thicknesses specified in this table are based on insulation R-values ranging from R-4 to R-4.6 per inch of thickness. For materials with an R-value greater than R-4.6, the insulation thickness specified in this table may be reduced as follows:

$$\text{New Minimum Thickness} = \frac{4.6 \times \text{Table Thickness}}{\text{Actual R-Value}}$$

For materials with an R-value less than R-4, the minimum insulation thickness must be increased as follows:

$$\text{New Minimum Thickness} = \frac{4.0 \times \text{Table Thickness}}{\text{Actual R-Value}}$$

(b) For piping exposed to outdoor air, increase thickness by 0.5 in.
(c) Applies to runouts not exceeding 12 ft in length to individual terminal units.

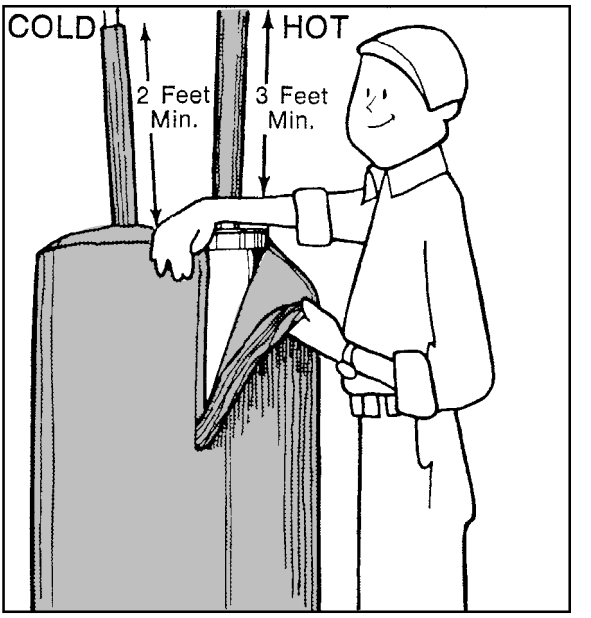
Figure A.22 Insulation thickness for HVAC piping. (*1995 Model Energy Code*)

Minimum Insulation Thickness for Circulating Hot Water Pipes

Heated Water Temperature (°F)	Insulation Thickness in Inches by Pipe Sizes[a]			
	Non-Circulating Runouts	Circulating Mains and Runouts		
	Up to 1 in.	Up to 1.25 in.	1.5 - 2.0 in.	Over 2 in.
170-180	0.5	1.0	1.5	2.0
140-160	0.5	0.5	1.0	1.5
100-130	0.5	0.5	0.5	1.0

(a) Nominal pipe size and insulation thickness.

Figure A.23 Insulation thickness for hot-water piping. (*1995 Model Energy Code*)



In addition, you might want to investigate a relatively inexpensive water heater insulation kit. Hot water tanks (except super-insulated tanks) generally are not insulated very well, so an extra layer of protection will keep the heat from being lost through the walls of the tank. *Be sure to read the instructions on the kit carefully,* especially for directions on keeping uncovered any doors, vents or relief valves. This is especially true for gas and oil-fired water heaters—a proper mixture of additional air with combustion or exhaust gases is needed to assist in the safe passage of combustion products to the outside. For instance on gas-fired water heaters, the draft hood on the vent pipe should be kept free of blockage. If your hot water piping runs any long distances and is exposed, you probably are losing expensive heat from your hot water system. You can wrap the pipes with thermal tape and eliminate this wasted energy.

Figure A.24 Water heater insulation. (*Edison Electric Institute*)

Air Leakage	Joints, penetrations, and all other such openings in the building envelope that are sources of air leakage must be caulked, gasketed, weatherstripped, or otherwise sealed. The maximum leakage rates for manufactured windows and doors are shown on the reverse side. Recessed lights must be type IC rated and installed with no penetrations or installed inside an appropriate air-tight assembly with a 0.5-in. clearance from combustible materials and 3-in. clearance from insulation.
Vapor Retarder	Vapor retarders must be installed on the warm-in-winter side of all non-vented framed ceilings, walls, and floors. This requirement does not apply to the following locations nor where moisture or its freezing will not damage the materials. • Texas — Zones 2-5 • Alabama, Georgia, N. Carolina, Oklahoma, S. Carolina — Zones 4-6 • Arkansas, Tennessee — Zones 6-7 • Florida, Hawaii, Louisiana, Mississippi — All Zones
Materials and Insulation Information	Materials and equipment must be identified so that compliance can be determined. Manufacturer manuals for all installed heating and cooling equipment and service water heating equipment must be provided. Insulation R-values, glazing and door U-values, and heating and cooling equipment efficiency (if high-efficiency credit is taken) must be clearly marked on the building plans or specifications.
Duct Insulation	Supply and return ducts for heating and cooling systems located in unconditioned spaces must be insulated to the levels shown on the reverse side of this sheet. Exceptions: Insulation is not required for exhaust air ducts, ducts within HVAC equipment, and when the design temperature difference between the air in the duct and the surrounding air is 15°F or less.
Duct Construction	Ducts must be sealed using mastic with fibrous backing tape. For fibrous ducts, pressure-sensitive tape may be used. Other sealants may be approved by the building official. Duct tape is not permitted. The HVAC system must provide a means for balancing air and water systems.
Temperature Controls	Thermostats are required for each separate HVAC system in single-family buildings and each dwelling unit in multifamily buildings (non-dwelling portions of multifamily buildings must have one thermostat for each system or zone). Thermostats must have the following ranges: Heating Only — 55°F - 75°F Cooling Only — 70°F - 85°F Heating and Cooling — 55°F - 85°F A manual or automatic means to partially restrict or shut off the heating and/or cooling input to each zone or floor shall be provided for single-family homes and to each room for multifamily buildings.
HVAC Piping Insulation	HVAC piping in unconditioned spaces conveying fluids at temperatures above 120°F or chilled fluids at less than 55°F must be insulated to the levels shown on the reverse side of this sheet.
Swimming Pools	All heated swimming pools must have an on/off pool heater switch. Heated pools require a pool cover unless over 20% of the heating energy is from non-depletable sources. All swimming pool pumps must be equipped with a time clock.
Circulating Hot Water	Circulating hot water systems must have automatic or manual controls and pipes must be insulated to the levels shown on the reverse side of this sheet.
Electric Systems	Each multifamily dwelling unit must be equipped with separate electric meters.

Figure A.25 1995 *Model energy code* basic requirements. (*1995 Model Energy Code*)

	Requirement	Installed (Y/N)	Comments
Pre-Inspection			
• Approved Building Plans on Site (104.1)	_____	_____	_____
Foundation Inspection	*Inspection Date* _____	*Approved: Yes* ___ *No* ___ *Init.* _____	
• Slab-Edge Insulation (502.2.1.4)	_____	_____	Depth: _____
• Basement Wall Exterior Insulation (502.2.1.6)	_____	_____	Depth: _____
• Crawl Space Wall Insulation (502.2.1.5)	_____	_____	Depth: _____
Framing Inspection	*Inspection Date* _____	*Approved: Yes* ___ *No* ___ *Init.* _____	
• Floor Insulation (502.2.1.3)	_____	_____	_____
• Glazing and Door Area (502.2.1.1)	_____	_____	_____
• Mass Walls (502.1.2)	_____	_____	_____
• Caulking/Sealing Penetrations (502.4.3)	_____	_____	_____
• Duct Insulation (503.9.1)	_____	_____	_____
• Duct Construction (503.10.2)	_____	_____	_____
• HVAC Piping Insulation (503.11)	_____	_____	_____
• Circulating Hot-Water Piping Insulation (504.7)	_____	_____	_____
Insulation Inspection	*Inspection Date* _____	*Approved: Yes* ___ *No* ___ *Init.* _____	
• Wall Insulation (502.2.1.1)	_____	_____	_____
• Basement Wall Interior Insulation (502.2.1.6)	_____	_____	Depth: _____
• Ceiling Insulation (502.2.1.2)	_____	_____	_____
• Glazing and Door U-Values (502.2.1.1)	_____	_____	_____
• Vapor Retarder (502.1.4)	_____	_____	_____
Final Inspection	*Inspection Date* _____	*Approved: Yes* ___ *No* ___ *Init.* _____	
• Heating Equipment (102.1)			
Make and Model Number	_____	_____	_____
Efficiency (AFUE or HSPF)	_____	_____	_____
• Cooling Equipment (102.1)			
Make and Model Number	_____	_____	_____
Efficiency (SEER)	_____	_____	_____
• Multifamily Units Separately Metered (505.2)	_____	_____	_____
• Thermostats for Each System (503.8.3)	_____	_____	_____
• Heat Pump Thermostat (503.4.2.3)	_____	_____	_____
• Window and Door Air Leakage (502.4.2)	_____	_____	_____
• Weatherstripping at Doors/Windows (502.4.3)	_____	_____	_____
• Equipment Maintenance Information (102.2)	_____	_____	_____

Figure A.26 MEC field inspection checklist. (*1995 Model Energy Code*)