POLITECNICO DI MILANO

Residential Heating and Cooling Load Calculations

Ref : Residential Heating and Cooling Load Calculations,
ASHRAE Handbook of Fundamentals 2013

Energy and Environmental Technologies for Building Systems
Piacenza Campus

Features of Residential Buildings

❖With respect to heating and cooling load calculation and equipment sizing, the following unique features distinguish residences from other types of buildings:

❖**Smaller Internal Heat Gains.**

❖**Varied Use of Spaces**.

❖**Fewer Zones.**

❖**Greater Distribution Losses**

❖ **Partial Loads**

Calculation Approaches for residential Buildings

❖In general, an hour by-hour analysis is required to determine the profile and find its peak.

❖Acceptable simplifications are possible for heating; however, for cooling, different approaches are used !

❖Heating calculations use simple worst-case assumptions: no solar or internal gains, and no heat storage.

❖The same calculation methods, with some changes in details, have been used for heating calculations for a long time.

❖The cooling calculation procedure were notably revised in 2005, based on the results of RP-1199 ASHRAE research project.

❖The prior methods used a cooling load temperature difference/cooling load factor (CLTD/CLF) form requiring only hand-tractable arithmetic

❖The new calculation procedure can be conducted by computer and is appropriate to promulgate 24 h, equation-based procedures.

❑ Residential Heat Balance (RHB) method

❖A 24 h procedure which allows detailed simulation of space temperatures and heat flows.

❖ It is based on ASHRAE research project RP-1199

❖It is a computer only technique

❑ Residential Load Factor (RLF) Method

❖RLF is a simplified procedure derived from detailed ResHB analysis of prototypical buildings across a range of climates.

❖The method is tractable by hand and can be mainly employed for quick load estimation.

❖RLF cooling loads are generally within 10% of those calculated with ResHB.

Load Components

✓ Opaque surfaces

✓ Fenestration

❖Ground and Basement

❖Ventilation and Infiltration

❖Internal Heat Gain

❖Distribution Losses

Design Conditions

❖**Indoor Conditions.**

Based on ASHRAE *Standard* 55 typical practices are the following:

✓For cooling: 24°C db and a maximum of 50 to 65% rh.

✓For heating: 20°C db and 30% rh

❖**Outdoor Conditions**

➢*Cooling:*

✓The 1% design dry- bulb temperature and mean coincident wet bulb temperature.

✓1% design dry- bulb temperature: is the temperature that the specific location will go above it 1% of the hours in a year, based on a 30-year average.

✓Load calculations also require the hottest-month dry-bulb temperature daily range, and wind speed. These values can also be found in climatic data , wind speed is commonly assumed to be 3.4 m/s.

✓The RLF method is based on mid-summer solar gains, which is acceptable for most of the common building as their experience their peak load in that time.

Design Conditions: Outdoor

➢Heating

✓99% design dry-bulb temperature

✓The 99% design dry-bulb temperature: is outdoor temperature that your locations stays above for 99% of all the hours in the year, based on a 30-year average.

✓Heating load calculations ignore solar and internal gains, providing a built-in safety factor.

✓Wind speed is assumed to be 6.7 m/s.

➢Note: two additional factors should be considered:

✓ Many locations experience protracted (several-day) cold periods during which the outdoor temperature remains below the 99% value.

✓Residences with significant leakage may have peak heating demand under conditions other than extreme cold, depending on site wind patterns.

➢How to take them into account:

Depending on the application and system type, the designer should consider:

✓ Using the 99.6% value or the mean minimum extreme as the heating design temperature

✓Alternatively, the heating load can be calculated at the 99% condition and a safety factor applied when equipment is selected.

ASHRAE, Climatic Design Information Example

Meaning of acronyms:

DB: Dry bulb temperature, °C

WB: Wet bulb temperature, °C

MCWB: Mean coincident wet bulb temperature, °C

Lat: Latitude, °

DP: Dew point temperature, °C

MCDB: Mean coincident dry bulb temperature, °C

Long: Longitude, °

HR: Humidity ratio, g of moisture per kg of dry air

HDD and CDD 18.3: Annual heating and cooling degree-days, base 18.3°C, °C-day

Elev: Elevation, m

WS: Wind speed, m/s

Station	**Lat**	**Long**	**Elev**	**Heating DB**		**Cooling DB/MCWB**						**Evaporation WB/MCDB**				**Dehumidification DP/HR/MCDB**						**Extreme Annual WS**			**Heat./Cool. Degree-Days**	
						0.4%		**1%**		**2%**		**0.4%**		**1%**		**0.4%**			**1%**							
				99.6%	**99%**	**DB / MCWB**		**DB / MCWB**		**DB / MCWB**		**WB / MCDB**		**WB / MCDB**		**DP / HR / MCDB**			**DP / HR / MCDB**			**1%**	**2.5%**	**5%**	**HDD / CDD 18.3**	
Iran, Islamic Republic of																										*17 sites, 14 more on CD-ROM*
ABADAN	30.37N	48.25E	6	4.0	5.5	47.8	22.4	46.8	22.3	45.8	22.0	28.8	35.3	27.5	35.3	27.2	23.0	32.6	25.5	20.7	32.5	10.4	9.2	8.1	413	3304
AHWAZ	31.33N	48.67E	22	4.8	6.0	47.8	22.8	46.8	22.6	45.8	22.3	28.2	35.7	26.7	37.2	26.4	21.9	33.0	24.0	19.0	32.8	9.0	7.5	6.4	429	3323
ANZALI	37.47N	49.47E	-26	1.4	2.7	30.6	25.3	29.9	25.1	29.2	24.8	26.8	29.4	26.2	29.0	26.0	21.2	29.0	25.3	20.4	28.5	11.3	9.3	7.3	1506	857
ARAK	34.10N	49.77E	1708	-16.6	-12.4	36.3	16.2	35.2	15.9	34.0	15.5	18.8	32.2	17.6	31.6	13.9	12.2	26.3	12.1	10.8	24.8	8.5	7.6	6.5	2424	879
BANDARABBASS	27.22N	56.37E	10	9.1	10.8	41.8	23.8	40.0	25.2	38.9	25.8	31.1	35.2	30.7	34.8	30.2	27.5	33.8	29.8	26.9	33.6	8.5	7.5	6.8	73	3246
ESFAHAN	32.47N	51.67E	1550	-7.9	-5.9	39.1	17.4	38.1	16.9	36.9	16.7	19.0	36.3	18.1	35.6	12.1	10.6	28.0	10.8	9.7	26.4	10.1	8.4	7.1	1968	1081
HAMEDAN	34.85N	48.53E	1749	-18.4	-14.3	35.6	17.1	34.5	16.5	33.2	16.0	19.1	32.7	18.0	31.5	14.0	12.3	26.2	12.5	11.2	26.0	10.3	8.6	7.3	2789	555
KASHAN	33.98N	51.45E	982	-5.8	-2.8	41.7	19.8	40.5	19.3	39.3	19.0	21.9	38.1	20.9	37.5	16.1	12.9	32.4	14.4	11.5	31.4	7.2	5.5	4.4	1460	1832
KERMAN	30.25N	56.97E	1754	-7.1	-5.1	38.0	16.2	37.0	15.7	36.0	15.5	17.7	34.5	16.9	34.2	10.9	10.1	22.6	9.6	9.2	22.6	11.0	9.3	7.8	1604	1028
SHAHID ASHRAFI ESFAH	34.35N	47.16E	1306	-8.1	-5.8	39.7	18.3	38.6	17.7	37.3	17.1	20.2	37.2	19.1	36.2	13.2	11.1	27.2	11.9	10.2	26.2	9.8	8.3	7.2	2054	1014
MASHHAD	36.27N	59.63E	999	-9.1	-6.1	37.1	18.4	36.0	18.1	34.8	17.7	21.7	33.3	20.5	32.7	17.6	14.3	29.5	16.0	12.8	27.6	8.9	7.6	6.6	2044	1022
ORUMIEH	37.53N	45.08E	1316	-11.6	-9.1	33.0	17.8	31.8	17.7	30.6	17.3	19.7	29.4	19.1	28.9	16.4	13.7	25.0	15.3	12.7	24.6	9.1	7.1	5.6	2873	452
SHIRAZ	29.53N	52.53E	1481	-2.2	-0.9	39.2	18.3	38.2	17.9	37.2	17.4	20.4	35.2	19.5	34.7	15.2	12.9	30.2	13.8	11.8	29.1	9.4	7.9	6.6	1353	1443
TABRIZ	38.08N	46.28E	1361	-11.2	-9.0	35.7	16.7	34.1	16.3	33.0	16.1	18.4	31.2	17.7	30.3	14.1	11.8	23.1	13.1	11.1	23.2	10.5	9.3	8.0	2638	814
TEHRAN-MEHRABAD	35.68N	51.32E	1191	-3.6	-1.9	38.7	18.6	37.2	18.3	36.2	18.0	22.2	32.7	20.7	33.2	18.2	15.2	30.5	16.1	13.3	28.6	11.1	9.6	7.8	1573	1546
ZAHEDAN	29.48N	60.91E	1378	-4.9	-3.0	39.1	16.5	38.1	16.2	37.0	15.5	18.7	33.9	17.5	35.0	12.8	10.9	25.1	10.6	9.4	20.9	11.8	10.0	8.5	1165	1462
ZANJAN	36.68N	48.48E	1663	-14.1	-11.3	34.0	15.8	32.7	15.9	31.4	15.4	18.4	30.1	17.5	29.0	14.0	12.3	24.0	13.2	11.6	22.9	10.2	8.4	7.1	2953	432
Ireland																										*2 sites, 14 more on CD-ROM*
CASEMENT AERODROME	53.30N	6.43W	93	-3.3	-1.7	22.7	17.3	21.2	16.6	19.9	16.0	18.2	21.3	17.4	20.1	17.0	12.3	19.6	16.2	11.6	18.8	15.0	13.2	11.7	3156	8
DUBLIN AIRPORT	53.43N	6.25W	85	-2.7	-1.1	22.0	17.1	20.5	16.3	19.4	15.7	17.9	20.7	17.1	19.6	16.7	12.0	19.3	15.9	11.4	18.4	13.4	12.0	10.6	3158	5
Israel																										*2 sites, 4 more on CD-ROM*
BEN-GURION INT. AIR	32.00N	34.90E	49	5.2	6.8	35.1	20.7	33.2	22.1	32.1	22.7	25.9	30.8	25.2	30.2	24.2	19.3	29.2	23.8	18.7	28.8	10.0	8.8	7.9	573	1369
SDE-DOV (TEL-AVIV)	32.10N	34.78E	4	7.3	8.6	31.2	23.6	30.3	24.3	29.8	24.2	26.8	29.4	26.1	29.0	26.1	21.5	29.0	25.1	20.3	28.5	11.9	9.7	8.2	509	1294
Italy																										*16 sites, 68 more on CD-ROM*
BARI/PALESE MACCHIE	41.13N	16.75E	49	0.8	1.9	33.9	22.7	32.0	22.4	30.6	22.0	25.2	29.7	24.2	28.9	24.0	19.0	27.7	22.9	17.7	26.9	9.4	8.2	7.2	1536	657
BOLOGNA/BORGO PANIG	44.53N	11.30E	49	-4.2	-3.0	34.1	22.7	32.9	22.6	31.4	22.0	24.7	31.0	23.8	30.1	22.9	17.7	28.2	21.9	16.7	27.3	7.2	6.1	5.3	2169	669
CATANIA/FONTANAROSS	37.47N	15.05E	17	1.8	3.0	35.0	23.3	33.0	23.4	31.8	23.1	26.3	30.0	25.6	29.5	25.2	20.4	28.1	24.2	19.2	27.5	10.1	8.5	7.4	1081	861
SIGONELLA	37.40N	14.92E	31	1.1	2.2	37.2	22.2	35.8	22.1	33.9	22.1	24.8	31.5	24.1	31.0	23.1	17.9	27.5	22.1	16.8	27.3	9.4	8.2	7.3	1094	989
FIRENZE/PERETOLA	43.80N	11.20E	38	-3.1	-1.2	35.1	22.2	33.8	22.0	32.1	21.4	24.3	31.4	23.5	30.3	22.2	17.0	27.0	21.2	15.9	26.6	8.4	7.1	6.1	1680	730
GENOVA/SESTRI	44.42N	8.85E	3	1.1	2.8	29.9	23.2	28.9	23.5	28.0	23.3	26.0	27.8	25.2	27.3	25.2	20.4	27.2	24.2	19.2	26.7	11.5	10.3	9.3	1378	644
GRAZZANISE	41.05N	14.07E	10	-0.9	0.2	32.2	23.1	31.1	23.1	30.1	23.1	26.5	29.5	25.5	28.9	25.7	21.0	28.8	24.2	19.1	27.7	9.9	8.3	7.0	1564	608
MILANO/LINATE	45.45N	9.27E	104	-4.9	-3.2	33.1	24.0	31.8	23.2	30.5	22.4	25.1	31.0	24.2	29.7	23.3	18.4	28.1	22.4	17.4	27.2	7.1	5.5	4.4	2196	614
NAPLES	40.90N	14.30E	93	2.0	3.2	33.5	23.6	32.1	23.2	31.0	22.9	25.9	30.9	24.9	30.2	24.2	19.3	29.3	23.1	18.1	28.4	8.2	6.8	5.7	1218	862
NAPOLI/CAPODICHINO	40.85N	14.30E	72	0.8	2.0	33.1	23.3	31.9	23.2	30.8	23.2	26.2	30.0	25.3	29.3	25.1	20.4	28.6	24.1	19.1	27.8	9.1	7.5	6.4	1319	768
PALERMO/PUNTA RAISI	38.18N	13.10E	21	6.6	7.7	33.8	22.1	31.5	22.9	30.0	23.8	26.7	29.2	26.0	28.7	26.0	21.4	28.6	25.1	20.2	28.0	13.3	11.6	10.1	797	991
PRATICA DI MARE	41.65N	12.45E	21	0.8	2.0	30.9	23.4	29.9	23.5	28.9	23.8	26.2	28.6	25.5	28.1	25.3	20.5	28.2	24.6	19.7	27.7	10.2	8.7	7.5	1374	597
ROMA FIUMICINO	41.80N	12.23E	3	-0.3	0.8	31.1	22.2	30.0	22.6	29.1	22.6	25.7	28.4	24.9	27.8	24.9	19.9	27.5	24.0	18.8	26.9	11.3	9.6	8.3	1513	556
ROMA/CIAMPINO	41.78N	12.58E	105	-1.1	0.0	33.8	21.8	32.2	21.6	31.0	21.2	24.7	28.5	23.9	28.0	23.9	19.0	26.6	22.9	17.8	26.0	11.2	9.2	7.7	1614	661
TORINO/BRIC DELLA C	45.03N	7.73E	710	-4.8	-3.2	28.1	20.4	27.0	19.9	25.8	19.4	22.7	25.7	21.8	24.8	21.8	18.0	24.2	20.8	16.9	23.8	8.8	7.0	5.5	2624	279
TORINO/CASELLE	45.22N	7.65E	287	-5.9	-4.2	30.9	22.3	29.5	21.7	28.2	21.0	23.8	28.4	22.9	27.5	22.3	17.5	25.8	21.5	16.7	25.3	6.4	4.8	4.0	2491	386

Adjacent Buffer Spaces: Assumptions

➢Residential buildings often include unconditioned buffer spaces such as garages, attics, crawlspaces, basements, or enclosed porches.

➢Reasonable assumption:

✓Under heating design conditions, adjacent uninsulated garages, and attics are at outdoor temperature.

✓The temperature in an adjacent, unheated, insulated room is the mean of the indoor and outdoor temperature

Cooling Load:

Cooling load calculation determines total sensible cooling load from heat gain:

✓ (1) through opaque surfaces (walls, floors, ceilings, and doors)

✓ (2) through transparent fenestration surfaces (windows, skylights, and glazed doors)

✓ (3) caused by infiltration and ventilation

✓ (4) because of occupancy

✓The latent portion of the cooling load is evaluated separately.

Cooling Load

❖To select a properly sized cooling unit, the peak or maximum load (block load) for each zone must be computed. The block load for a single-family detached house with one central system is the sum of all the room loads. If the house has a separate system for each zone, each zone block load is required. When a house is zoned with one central cooling system, the system size is based on the entire house block load, whereas zone components, such as distribution ducts, are sized using zone block loads.

❖In multifamily structures, each living unit has a zone load that equals the sum of the room loads. For apartments with separate systems, the block load for each unit establishes the system size.

❖Apartment buildings having a central cooling system with fan-coils in each apartment require a block load calculation for the complete structure to size the central system; each unit load establishes the size of the fan-coil and air distribution system for each apartment.

Cooling Load: Opaque Surface

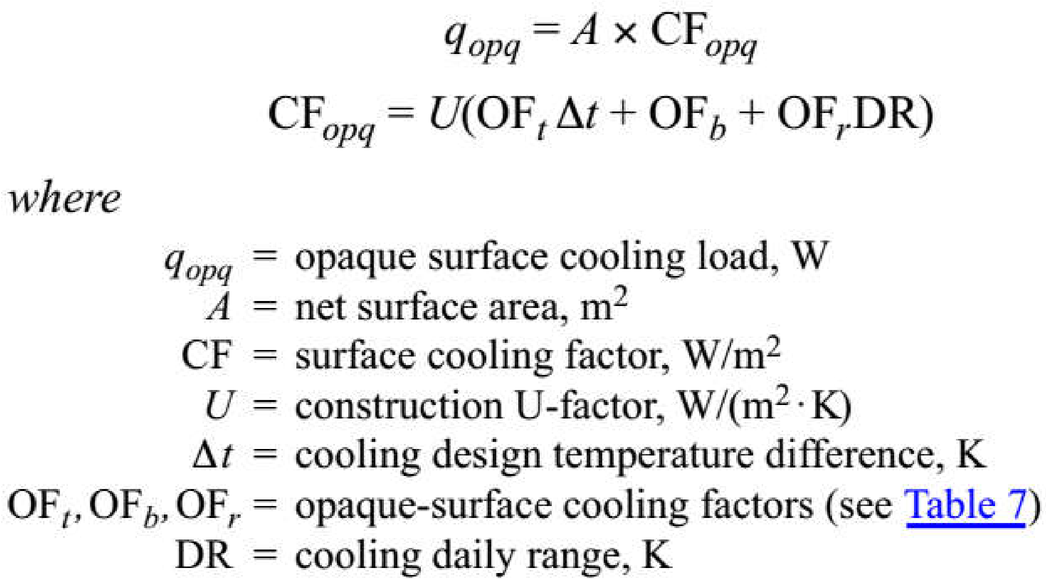
Opaque Surface

Heat gain through walls, floors, ceilings, and doors is caused by
(1) the air temperature difference across such surfaces

(2) Solar gains incident on the surfaces.

The heat capacity of typical construction moderates and delays building heat gain.

This effect is modeled in detail in the computerized RHB method, resulting in accurate simultaneous load estimates.
The RLF method uses the following to estimate cooling load:



$$q_{opq} = A \times \mathrm{CF}_{opq}$$

$$\mathrm{CF}_{opq} = U(\mathrm{OF}_t \Delta t + \mathrm{OF}_b + \mathrm{OF}_r \mathrm{DR})$$

where

q_{opq} = opaque surface cooling load, W
A = net surface area, m^2
CF = surface cooling factor, W/m^2
U = construction U-factor, $W/(m^2 \cdot K)$
Δt = cooling design temperature difference, K
$\mathrm{OF}_t, \mathrm{OF}_b, \mathrm{OF}_r$ = opaque-surface cooling factors (see Table 7)
DR = cooling daily range, K

Cooling Load: Opaque Surface

Opaque Surface

OF factors, found in Table 7, represent construction-specific physical characteristics.

OF_t values less than 1 capture the buffering effect of attics and crawlspaces,

OF_b represents incident solar gain, and OF_r captures heat storage effects by reducing the effective temperature difference.

Note also that CF can be viewed as CF = U *CLTD, the formulation used in prior residential and non-residential methods.

Surface Type	**OF_t**	**OF_b, K**	**OF_r**
Ceiling or wall adjacent to vented attic	0.62	$14.3\alpha_{roof} - 4.5$	–0.19
Ceiling/roof assembly	1	$38.3\alpha_{roof} - 7.0$	–0.36
Wall (wood frame) or door with solar exposure	1	8.2	–0.36
Wall (wood frame) or door (shaded)	1	0	–0.36
Floor over ambient	1	0	–0.06
Floor over crawlspace	0.33	0	–0.28
Slab floor (see Slab Floor section)			

α_{roof} = roof solar absorptance (see Table 8).

Table 8 Roof Solar Absorptance α_{roof}

	Color			
Material	**White**	**Light**	**Medium**	**Dark**
Asphalt shingles	0.75	0.75	0.85	0.92
Tile	0.30	0.40	0.80	0.80
Metal	0.35	0.50	0.70	0.90
Elastomeric coating	0.30			

Source: Summarized from Parker et al. 2000.

Cooling Load: Transparent Fenestration Surface

Transparent Fenestration Surface

Cooling load associated with non-door fenestration is calculated as follows:

$$q_{fen} = A \times \mathrm{CF}_{fen}$$

$$\mathrm{CF}_{fen} = U(\Delta t - 0.46\,\mathrm{DR}) + \mathrm{PXI} \times \mathrm{SHGC} \times \mathrm{IAC} \times \mathrm{FF}_s$$

where

q_{fen} = fenestration cooling load, W

A = fenestration area (including frame), m^2

CF_{fen} = surface cooling factor, $\mathrm{W/m}^2$

U = fenestration NFRC *heating* U-factor, $\mathrm{W/(m^2 \cdot K)}$

Δt = cooling design temperature difference, K

PXI = peak exterior irradiance, including shading modifications, $\mathrm{W/m}^2$ [see Equations (26) or (27)] **external shading**

SHGC = fenestration rated or estimated NFRC solar heat gain coefficient

IAC = interior shading attenuation coefficient, Equation (29) **curtain**

FF_s = fenestration solar load factor, Table 13

Cooling Load: Transparent Fenestration Surface

Peak Exterior Irradiance:

Although solar gain occurs throughout the day , RP-1199 regression studies showed that the cooling load contribution of fenestration correlates well with the peak-hour irradiance incident on the fenestration exterior. PXI is calculated as follows:

$$PXI = T_x E_t \text{ (unshaded fenestration)}$$

area of window not shaded

$$PXI = T_x [E_d + (1 - F_{shd}) E_D] \text{ (shaded fenestration)}$$

where

PXI = peak exterior irradiance, W/m^2

E_t, E_d, E_D = peak total, diffuse, and direct irradiance (Table 9 or 10), W/m^2

T_x = transmission of exterior attachment (insect screen or shade screen)

F_{shd} = fraction of fenestration shaded by permanent overhangs, fins, or environmental obstacles

Cooling Load: Transparent Fenestration Surface

For horizontal or vertical surfaces, peak irradiance values can be obtained from Table 10 for primary exposures, or from Table 9 equations for any exposure. Skylights with slope less than 30° from horizontal should be treated as horizontal.

Table 9 Peak Irradiance Equations

Horizontal surfaces

$$E_t = 952 + 6.49L - 0.166L^2$$

$$E_d = \min(E_t, 170)$$

$$E_D = E_t - E_d$$

Vertical surfaces

$$\phi = \left|\frac{\psi}{180}\right| \text{ (normalized exposure, 0 – 1)}$$

$$E_t = 453.4 + 1341\phi - 5279\phi^3 + 3260\phi^4 + 34.09\phi L + 0.2643\phi L^2 - 12.83L - 0.8425L^2 + [0.9835L^2/(\phi + 1)]$$

$$E_d = \min\left(E_t, 357 - 86.98\phi^2 + 1.764\phi L - \frac{108.4\sqrt[4]{L}}{\phi + 1}\right)$$

$$E_D = E_t - E_d$$

where

E_t, E_d, E_D = peak hourly total, diffuse, and direct irradiance, W/m^2
L = site latitude, °N
ψ = exposure (surface azimuth), ° from south (–180 to +180)

Table 10 Peak Irradiance, W/m²

		Latitude								
Exposure		**20°**	**25°**	**30°**	**35°**	**40°**	**45°**	**50°**	**55°**	**60°**
North	E_D	125	106	92	84	81	85	96	112	136
	E_d	128	115	103	93	84	76	69	62	55
	E_t	253	221	195	177	166	162	164	174	191
Northeast/Northwest	E_D	460	449	437	425	412	399	386	374	361
	E_d	177	169	162	156	151	147	143	140	137
	E_t	637	618	599	581	563	546	529	513	498
East/West	E_D	530	543	552	558	560	559	555	547	537
	E_d	200	196	193	190	189	188	187	187	187
	E_t	730	739	745	748	749	747	742	734	724
Southeast/Southwest	E_D	282	328	369	405	436	463	485	503	517
	E_d	204	203	203	204	205	207	210	212	215
	E_t	485	531	572	609	641	670	695	715	732
South	E_D	0	60	139	214	283	348	408	464	515
	E_d	166	193	196	200	204	209	214	219	225
	E_t	166	253	335	414	487	557	622	683	740
Horizontal	E_D	845	840	827	806	776	738	691	637	574
	E_d	170	170	170	170	170	170	170	170	170
	E_t	1015	1010	997	976	946	908	861	807	744

Cooling Load: Transparent Fenestration Surface

Exterior Attachments. Common window coverings can significantly reduce fenestration solar gain. Table 11 shows transmission values for typical attachments.

.

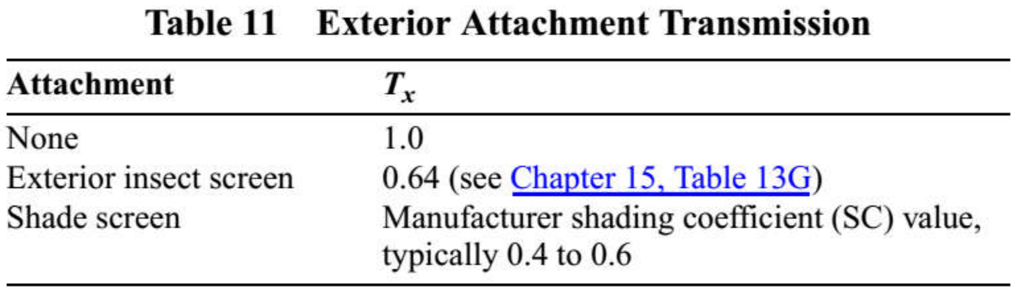


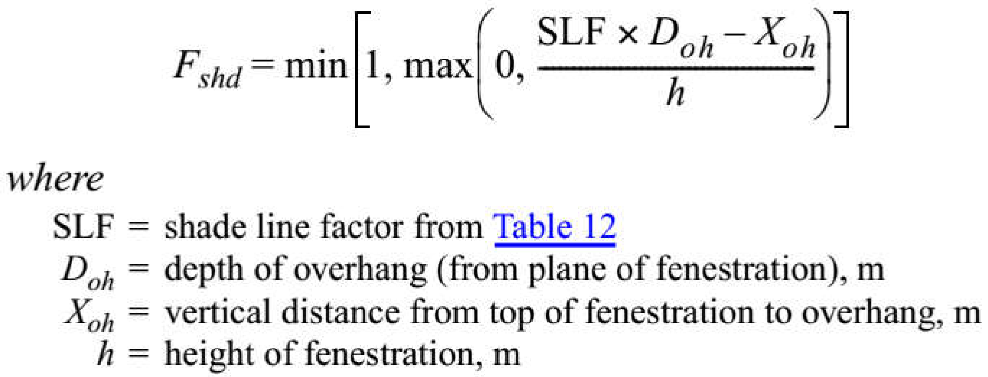
Table 11 Exterior Attachment Transmission

Attachment	T_x
None	1.0
Exterior insect screen	0.64 (see Chapter 15, Table 13G)
Shade screen	Manufacturer shading coefficient (SC) value, typically 0.4 to 0.6

Cooling Load: Transparent Fenestration Surface

Permanent Shading. The shaded fraction F_{shd} can be taken as 1for any fenestration shaded by adjacent structures during peak hours.

Simple overhang shading can be estimated using the following



$$F_{shd} = \min\left[1, \max\left(0, \frac{\mathrm{SLF} \times D_{oh} - X_{oh}}{h}\right)\right]$$

where

SLF = shade line factor from Table 12

D_{oh} = depth of overhang (from plane of fenestration), m

X_{oh} = vertical distance from top of fenestration to overhang, m

h = height of fenestration, m

Cooling Load: Transparent Fenestration Surface

The shade line factor (SLF) is the ratio of the vertical distance a shadow falls beneath the edge of an overhang to the depth of the overhang, so the shade line equals the SLF times the overhang depth. Table 12 shows SLFs for July 21 averaged over the hours of greatest solar intensity on each exposure.

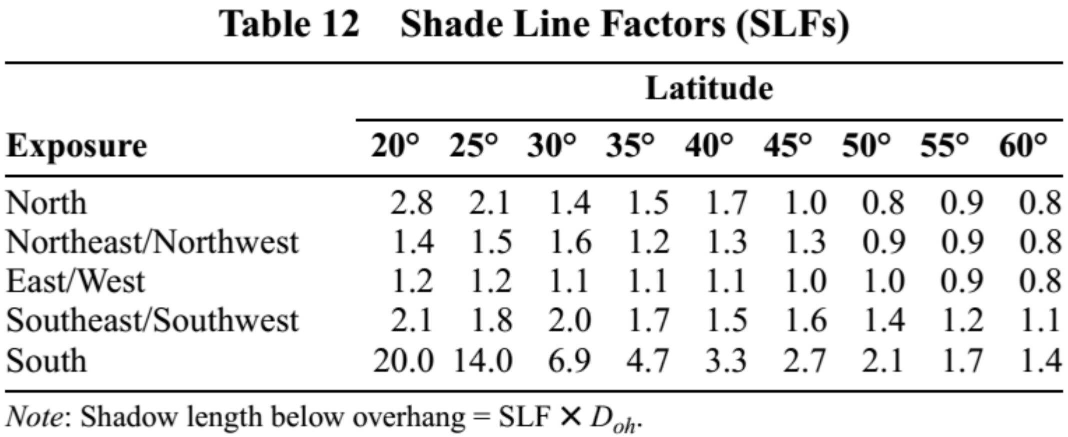


Table 12 Shade Line Factors (SLFs)

	Latitude								
Exposure	**20°**	**25°**	**30°**	**35°**	**40°**	**45°**	**50°**	**55°**	**60°**
North	2.8	2.1	1.4	1.5	1.7	1.0	0.8	0.9	0.8
Northeast/Northwest	1.4	1.5	1.6	1.2	1.3	1.3	0.9	0.9	0.8
East/West	1.2	1.2	1.1	1.1	1.1	1.0	1.0	0.9	0.8
Southeast/Southwest	2.1	1.8	2.0	1.7	1.5	1.6	1.4	1.2	1.1
South	20.0	14.0	6.9	4.7	3.3	2.7	2.1	1.7	1.4

Note: Shadow length below overhang = SLF × D_{oh}.

Cooling Load: Transparent Fenestration Surface

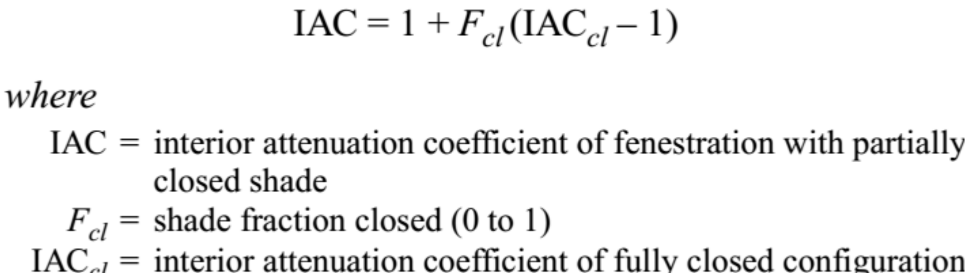
Fenestration Solar Load Factors. Fenestration solar load factors FF_s depend on fenestration exposure and are found in Table 13. The values represent the fraction of transmitted solar gain that contributes to peak cooling load. It is thus understandable that morning (east) values are lower than afternoon (west) values. Higher values are included for multifamily buildings with limited exposure.

Table 13 Fenestration Solar Load Factors FF_s

Exposure	Single Family Detached	Multifamily
North	0.44	0.27
Northeast	0.21	0.43
East	0.31	0.56
Southeast	0.37	0.54
South	0.47	0.53
Southwest	0.58	0.61
West	0.56	0.65
Northwest	0.46	0.57
Horizontal	0.58	0.73

Cooling Load: Transparent Fenestration Surface

- **Interior Shading.** Interior shading significantly reduces solar gain and is ubiquitous in residential buildings.
- Therefore, in all but special circumstances, interior shading should be assumed when calculating cooling loads.
- In the RLF method, the interior attenuation coefficient (IAC) model is used. Residential values from that chapter are consolidated in Table 14.



$$IAC = 1 + F_{cl}(IAC_{cl} - 1)$$

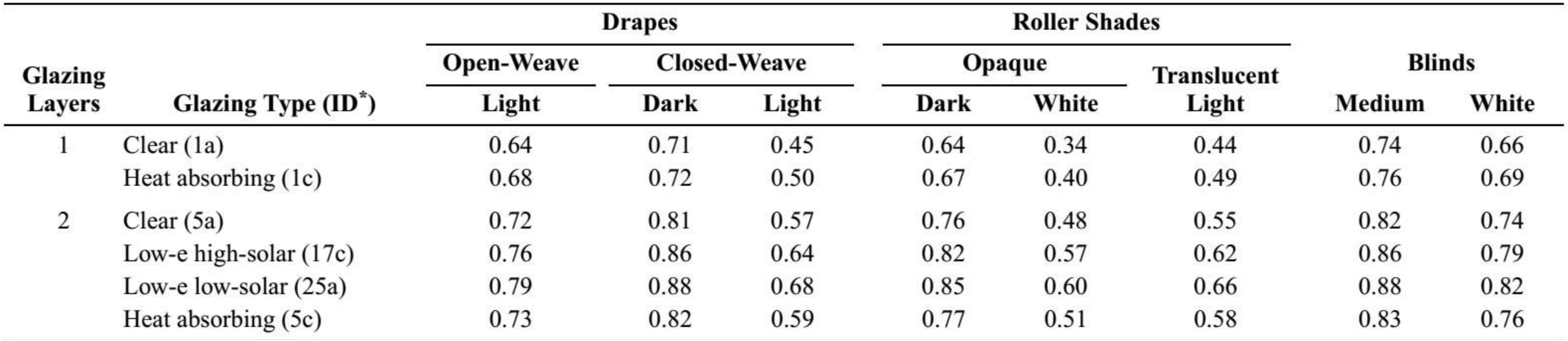
where

IAC = interior attenuation coefficient of fenestration with partially closed shade

F_{cl} = shade fraction closed (0 to 1)

IAC_{cl} = interior attenuation coefficient of fully closed configuration

Table 14 Interior Attenuation Coefficients (IAC_{cl})



		Drapes			Roller Shades			Blinds	
		Open-Weave	Closed-Weave		Opaque		Translucent		
Glazing Layers	Glazing Type (ID*)	Light	Dark	Light	Dark	White	Light	Medium	White
1	Clear (1a)	0.64	0.71	0.45	0.64	0.34	0.44	0.74	0.66
	Heat absorbing (1c)	0.68	0.72	0.50	0.67	0.40	0.49	0.76	0.69
2	Clear (5a)	0.72	0.81	0.57	0.76	0.48	0.55	0.82	0.74
	Low-e high-solar (17c)	0.76	0.86	0.64	0.82	0.57	0.62	0.86	0.79
	Low-e low-solar (25a)	0.79	0.88	0.68	0.85	0.60	0.66	0.88	0.82
	Heat absorbing (5c)	0.73	0.82	0.59	0.77	0.51	0.58	0.83	0.76

Heading Load

❖Calculating a residential heating load involves estimating the maximum heat loss of each room or space to be heated and the simultaneous maximum (block) heat loss for he building, while maintaining a selected indoor air temperature during periods of design outdoor weather conditions.

❖Heating calculations use conservative assumptions, ignoring solar and internal gains, and building heat storage. This leaves a simple steady-state heat loss calculation, with the only significant difficulty being surfaces adjacent to grade.

Heating Load: Exterior Surfaces Above Grade

❖All above-grade surfaces exposed to outdoor conditions (walls,doors, ceilings, fenestration, and raised floors) are treated identically, as follows:

$$q = A \times \mathrm{HF}$$

$$\mathrm{HF} = U\Delta t$$

where HF is the heating load factor in W/m^2.

❖Two ceiling configurations are common:

- For **ceiling/roof combinations** (e.g., flat roof or cathedral ceiling), the U-factor should be evaluated for the entire assembly.
- For **well-insulated ceilings (or walls) adjacent to vented attic space**, the U-factor should be that of the insulated assembly only (the roof is omitted) and the attic temperature assumed to equal the heating design outdoor temperature. The effect of attic radiant barriers can be neglected. In cases where the ceiling or wall is not well insulated, the adjacent buffer space procedure (Explained in the next session) can be used.

Heating Load: Surfaces Adjacent to Buffer Space

❖Heat loss to adjacent unconditioned or semiconditioned spaces can be calculated using a heating factor based on the partition temperature difference:

$$\mathrm{HF} = U(t_i - t_b)$$

❖Buffer space air temperature can be estimated using the previously explained assumptions. Generally, simple approximations are sufficient except where the partition surface is poorly insulated.