Cooling and Heating Load Calculations with TideLoad4Z

The calculation of the cooling and heating loads on a building or zone is the most important step in determining the size and type of cooling and heating equipment required to maintain comfortable indoor air conditions. Building heat and moisture transfer mechanisms are complex and as unpredictable as the weather and human behavior, both of which strongly influence load calculation results. Some of the factors that influence results are:

- Conduction/convection of heat through walls, roofs, floors, doors and windows.
- Radiation through windows and heating effects on wall and roof surface temperatures
- Thermal properties of buildings (Insulation, glass transmittance, surface absorbtivity)
- Building thermal mass and corresponding delay of indoor temperature change
- Construction quality in preventing air, heat, and moisture leakage
- Heat added/lost with ventilation air needed to maintain air quality (code compliance)
- Heat generated by lights, people, appliances, and equipment
- Heat added/lost by air, water, and refrigeration distribution systems
- Heat generated by air and water distribution equipment
- Moisture added/lost with ventilation air to maintain air quality and code compliance
- Moisture movement through building envelope
- Moisture generated by occupants and equipment
- Activity level, occupancy patterns, and make-up (male, female, child) of people
- Acceptable comfort and air quality levels of occupants
- Weather conditions (temperature, moisture, wind speed, latitude, elevation,
- solar radiation, etc.)

These many factors combine to force engineers to develop procedures that minimize the load calculation complexity without compromising accuracy. A combination of measured data and detailed simulations have generated techniques that can be done with a pocket calculator and a one-page form or more complex numerical simulations that take hours to complete using modern computers. However, many assumptions and simplifications must be made for all methods.

The CLTD/CLF Method

Many engineers use some form of the Cooling Load Temperature Difference/Cooling Load Factor (CLTD/CLF) method. The combined effects of convection, conduction, radiation, and thermal lag for opaque surfaces are combined into a modification of the conduction equation:

$$q = UA \times CLTD \quad 1.$$

An array of CLTD tables are used to account for thermal mass, insulation levels, latitude, time of day, direction, temperature swing, and other variables. CLF factors are used to account for the fact that building thermal mass creates a time lag between heat generation from internal sources (lighting, people, appliances, etc.) and the corresponding cooling load. CLF factors are presented in a set of tables that account for number of hours the heat has been on, thermal mass, type of floor covering and window shading, number of walls, and the presence of ventilation hoods. A CLF represents the fraction of the heat gain that is converted to cooling load.

$$q = q_{IntLoad} \times CLF \qquad 2.$$

Solar gains through glass are computed in a similar manner with introduction of Solar Cooling Load (SCL) factors with the units of heat rate per unit area that are tabularized by facing direction (N, E, S, W, Horz.) and latitude. The fraction of solar gain that is transmitted is accounted for with a shading coefficient (SC) to correct for transmittance and shading devices.

$$q = A \times SC \times SCL \qquad 3.$$

All of these factors are summed and added to some estimate of the latent (dehumidification) load to arrive at the cooling load.

Recent publications have devoted little attention to the heating loads in larger buildings, since they are often small even in colder climates due to the internal heat generation of equipment. The most recent version of the *ASHRAE Handbook of Fundamentals* (2001) contains a one-half page discussion of heating load which provides only minimal guidance. More detailed discussions are provided for residential buildings in the *Handbook* and the parallel *Manual J Load Calculation* published by the Air Conditioning Contractors of America (ACCA). However, increased attention to heating load calculations are warranted due to the growing awareness of the need of adequate ventilation air at all times to maintain indoor air quality (IAQ). The recommended ventilation rates in high occupancy buildings often exceed the heat losses from all other components combined.

New ASHRAE Load Calculation Methods

The 2001 *ASHRAE Handbook of Fundamentals* no longer discusses the CLTD/CLF method in favor of the more complex Heat Balance (HB) method. The *Handbook* states that this method has superseded (not invalidated) other methods, including CLTD/CLF. As the name implies, this method employs a series of heat balance calculations on the outside surfaces, the surface conduction, internal surfaces, and the indoor air. Numerical methods are required and modern computers are essential. Unfortunately, a detailed presentation of this method is well beyond the scope and resources of a traditional HVAC course. A separate publication is available from ASHRAE ($95 or $35 for student members), which includes a basic software package that will calculate loads for a single zone building. Coverage of this publication would leave little time for other important

HVAC concepts. The cost and time to learn a computerized commercial version of the program is beyond the resources of most education institutions. A simplified version of the HB method is referred to as the Radiant Time Series (RTS) method. However, the publication does not provide sufficient information to use the RTS method in a wide variety of applications at this time.

Limitations of New Methods and Input Uncertainties

There are several limitations with these new methods. In there effort to be more exact with many details, the developers have failed to address or improve upon several critical heat gain/losses.

External Surfaces and Internal Loads

The new methods focus on improvements primarily in conduction and solar transmission. However, in modern buildings where most zones have zero, one, or occasionally, two exposed surfaces, these items are typically less than 20% of the total load. The 1997 and 2001 versions of the *ASHRAE Fundamentals Handbook* contained improved internal gain values for office equipment. However, limited data are available for other types of equipment and the developers recommend using 25% to 50% of the nameplate power consumption. The improved office load information suggests variations between 0.5 w/ft^2 to1.5 w/ft^2 (5.4 w/m^2 to16 w/m^2). The value used is left to the interpretation of the designer. Consider a laser printer. The load is a strong function of the frequency of use, so the engineer must be able to predict this frequency in order to "accurately" predict cooling load. This value will vary significantly from office to office. Thus, the primary source of uncertainty with regard to internal loads is not the choice of method (complex HB vs. simple CLTD/CLF) but the behavior of the occupants.

Duct Losses

Duct losses can be a significant component but they are not considered as part of the HB correlation. The 2001 *ASHRAE Fundamentals Handbook* suggests supply duct losses should be "…estimated as a percentage of space sensible cooling load (usually about 1%)…". It further suggests return duct losses are usually insignificant. The engineer is referred to another chapter (34 in the 2001 *Handbook*) to calculate heat gain/loss in the supply duct. An example problem is provided but little information is given as to how to determine the assumptions made in the problem. Furthermore, the duct loss is computed to be 39,400 Btu/h for a flow of 17,200 cfm with a 122ºF supply temperature. Assuming a 70ºF room temperature, the total heating capacity would be 984,000 Btu/h. Duct loss is therefore 4% of the total or four times the amount suggested for the HB method.

The ACCA *Manual N Commercial Load Calculation* suggests much higher supply and return duct gains and losses compare to the HB procedure. Table 16 indicates that supply gains are 10% of the sensible total and losses are 10 to 15% with insulated ducts [1 in. (2.5 cm) thickness] placed in unconditioned spaces. Return gains and losses would be approximately half the supply duct values. Percentages vary with the amount of insulation and the location of the duct. Additionally, 10% should be added for ducts that are not sealed from leakage. These discrepancies suggest the HB method will significantly under predict losses unless ducts are located inside the conditioned space where the value will be zero.

Ventilation and Infiltration Air Load

The HB method adds the sensible contribution of the ventilation and infiltration in the final air heat balance. These contributions are added to the convective transfer from the surfaces, the heat transfer from the HVAC system, and directly to the convective part of the internal loads, which the author of the HB method discussion states, "… violates the tenets of the heat balance approach…". Additionally, the author states "…the amount of infiltration air is uncertain … however it is determined." No reference for how it is computed for a commercial building is given.

Summary

There remains a high degree of uncertainty in the inputs required to determine cooling and heating loads. Much of this is due to the unpredictability of occupancy, human behavior, complex and varied building practices, lack of and variation in heat gain data for modern equipment, and introduction of new building products and HVAC equipment with unknown characteristics. These generate uncertainties that far exceed the increased error generated by simple methods, such as CLTD/CLF, compared to the far more complex HB methods. Therefore, for most applications the current added time and expense required for the HB method is likely to be unwarranted until improvements are made in reduced these uncertainties

A Revised Presentation of the CLTD/CLF Method

Previous versions of the *ASHRAE Fundamentals Handbook* presented the CLTC/CLF method as one of many load calculations methods. Several components (psychometrics, thermal properties of building materials, weather data, ventilation air rates, duct losses/gains, etc.) were discussed in other documents, other ASHRAE handbooks, or other chapters in the *Fundamentals Handbook*. The discussion of heating loads for non-residential buildings was reduced with each new publication to its current one-half page presentation.

The intention here is to discuss the CLTD/CLF procedure and related items in a single document that is integrated with a computer based spreadsheet with psychometric functions. The most recent versions of the *ASHRAE Fundamentals Handbook* (1997, 2001) will serve as references and provide more detailed discussion of many facets of load calculations.

The variety of approaches to calculating cooling and heating loads are attempts to consider the fundamental principle that heat flow rates are not instantaneously converted to cooling or heat loads primarily because of the thermal and moisture capacitance of the buildings. Thus heat input or extraction incident upon the building do not immediately result in a change in temperature. Thermally heavy buildings can effectively delay the cooling or heating load for several hours. The space temperature in an unconditioned thermally light building will rise more quickly on a hot, clear day but will also decline more rapidly as the outdoor temperature falls after sunset. The HB method accounts for these transient effects but also considers the interaction between all surfaces and loads. A previous simplification of the HB method is the Transfer Function Method (TFM) as presented in the 1997 *ASHRAE Fundamentals Handbook*. This procedure was used to develop an even more simple method by generating CLTD and CLF data for a one-step load calculation method. The accuracy of the method was improved with the recent development of SCL factors for computing the impact of solar loads through glass. CLTDs, CLFs, and SCLs all include the effect of time lag in conductive heat gain through opaque surfaces and time delay by thermal storage in converting radiant gain to cooling load. Although data is not available for all building types, the current information provides a wide array of building types so that accuracy is consistent with the TFM and the presentation is suited to instruction (*Fundamentals Handbook*, 1997).

Table 1 is a spreadsheet summary for the CLTD/CLF method for a single zone. It is a reproduction of a portion of first main sheet of the program *TideLoad4Z*, which computes the cooling and heating loads for a four-zone building. The program has additional sheets which contain CLTD, CLF, SC and SCL tables, drawings of walls and roof types, heat gains of lighting, appliances, and people, ACCA *Manual N* values for duct losses, ASHRAE Standard 62 ventilation air requirements, and table of building materials thermal properties with calculators to determine overall R and U values. Additional information (especially weather data) from the *ASHRAE Fundamentals Handbook* is a suggested supplement.

Weather Data

Information regarding the outdoor design conditions and desired indoor conditions are the starting point for the load calculation program. The Tables 1A and 1B of the *Climatic Design Information* chapter of the *Fundamentals Handbook* provides the necessary reference. Columns 2a or 2b in Table 1A are the outdoor design temperatures commonly used for the heating mode. The 99.6% subheading represents the temperature whose frequency of occurrence is exceeded 99.6% of the time. (Or the value which the outdoor temperature is equal to or lower than 0.4% of the time.) This value (20ºF for Tuscaloosa, Alabama) should be entered into cell C2 of *TideLoad4Z*. The program also calls for the local latitude and elevation which are listed in columns 1c and 1e of Table 1A and are entered into cells E7 and C7 of the program.

The cooling design conditions are listed on the facing page in Table 1B in columns 2a through 2f for the maximum outdoor air dry bulb (DB) temperature. These conditions appear in sets of dry bulb (DB) temperature and the mean coincident wet bulb (MWB) temperature since both values are needed to determine the sensible and latent (dehumidification) loads in the cooling mode. The 0.4%, 1%, and 2% represent the temperature that is exceeded 0.4%, 1% and 2% of the time on an annual basis. The 0.4% values are suggested and are entered in cells 4c and 4E in *TideLoad4Z.* These values are 95ºF and 77ºF for Tuscaloosa.

In moderate and humid climates in buildings that have significant ventilation air requirements (>10% of supply), the maximum load often occurs during periods of maximum wet bulb (WB) conditions due to the high dehumification load of humid air. Columns 3a through 3f present these values and the corresponding coincident dry bulb (MDB) temperature. The 0.4% values are 80ºF (WB) and 90ºF (MWB) for Tuscaloosa. *TideLoad4Z* will quickly recalculate the loads when the two values are substituted. The final required input from Table 1B is the design day daily range (DR) of the dry bulb temperature. This value is used to correct CLTD values and is 19.6ºF for Tuscaloosa.

<u>Indoor Conditions</u>

The *Thermal Comfort* chapter of the *Fundamentals Handbook* (Chapter 8, 2001) provides a snapshot of the psychrometric chart (Fig.5) for the summer and winter comfort zones. Recommended relative humidity levels are between 30 and 60%. The winter indoor temperature comfort range is between 68ºF and 75ºF. Occupants are typically dressed in lighter clothes in the summer and are more conditioned to warm weather so the recommended range is between 73ºF and 80ºF for the dry bulb temperature. Suggested values are a winter indoor temperature of 70ºF and 75ºF is for the summer temperature with a wet bulb temperature of 63ºF, which corresponds to a relative humidity near 50%. These values are entered in *TideLoad4Z* in cells C3, C5, and E5 respectively.

Table 1 – CLTD/CLF/SCL Spreadsheet for a Single Zone

	A	B	C	D	E	F	G	H	I
1	City =		State =						
2	Heating (Out.)	tdb(99.6%) =							
3	(Indoor)	tdb =							
4	Cooling (Out.)	tdb(0.4%) =		twb(0.4%) =		DR =		ΔT (htg.)	
5	(Indoor)	tdb =		twb =		DT(pm) =		T (mean) =	
6		W(Outdoor) =		W(Indoor)=		ΔW		CLTD(Cor) =	
7		Elev. =		Latitude =		Zone 1			
8						Area (ft^2)	qc (am)	qc(pm)	qh
9	Solar	Shade Coeff.	SCL (am)	SCL (pm)					
10	Windows (N)								
11	Windows (E)								
12	Windows (S)								
13	Windows (W)								
14	Other								
15	Conduction	U(Btu/h-ft^2-F)	CLTD(am)	CLTD(pm)	ΔT	Area (ft^2)			
16	Windows (N)								
17	Windows (E)								
18	Windows (S)								
19	Windows (W)								
20	Other								
21	Conduction	U(Btu/h-ft^2-F)	CLTD(am)	CLTD(pm)	ΔT	Area (ft^2)			
22	Walls (N)								
23	Walls (E)								
24	Walls (S)								
25	Walls (W)								
26	Other								
27	Conduction	U(Btu/h-ft^2-F)	CLTD(am)	CLTD(pm)	ΔT	Area (ft^2)			
28	Doors (N)								
29	Doors (E)								
30	Doors (S)								
31	Doors (W)								
32	Roof/Ceiling	U(Btu/h-ft^2-F)	CLTD(am)	CLTD(pm)	ΔT	Area (ft^2)			
33	Type A								
34	Type B								
35	Floor	U(Btu/h-ft^2-F)			ΔT (flr)	Area (ft^2)			
36									
37	Slab	UP(Btu/hr-ft-F)			ΔT(slab)	Per. (ft.)			
38									
39	Ventilation		ΔT (am)	ΔT (pm)	ΔT	cfm			
40	Sensible	1.1							
41	HRU Sen Eff.		ΔW	ΔW					
42	Latent	4840							
43	HRU Lat Eff.					People			
44	People	Btu/person	CLF(am)	CLF(pm)					
45	Sensible								
46	Latent		1	1					
47	Internal		CLF(am)	CLF(pm)		Watts			
48	Sensible	3.412							
49	Latent		1	1					
50			CLF(am)	CLF(pm)	F(ballast)	Watts			
51	Lighting	3.412							
52	Net Sen.								
53		U(duct)	ΔT (am)	ΔT (pm)	ΔT (htg)	Area (ft^2)			
54	Duct Cond.								
55	Alternate ?or?								
56	Duct Cond.	Duct Gain Fac.=		DuctLossFac					
57	Duct Leaks		ΔT (am)	ΔT (pm)	ΔT -duct	cfm			
58	Sensible	1.1							
59	Latent	4840							
60	Entire Building Totals					Zone 1			
61	Total Sensible	(MBtu/h)				Sensible			
62	Total Latent	(MBtu/h)				Latent			
63	Total Gain	(MBtu/h)				Tot. Gain			
64	Total Loss	(MBtu/h)		Net Loss		Tot. Loss		Net Loss	

Load Calculation Psychrometrics

The need to maintain indoor air quality (ASHRAE Standard 62) and comfort conditions (ASHARE Standard 55) has resulted in greater attention being devoted to both indoor temperature and humidity levels. Engineers must now calculate both the sensible and latent cooling loads since the ventilation air requirements are being enforced and IAQ litigation is increasing (especially mold related). The primary sources of latent load are the ventilation air, occupants, and internal sources (coffee pots, cooking, dishwashing, showers, etc.). *TideLoad4Z* includes a psychometric function that returns the humidity ratio (a.k.a. specific humidity = mass of water vapor ÷ mass of dry air) for both the indoor and outdoor air. The elevation, dry and wet bulb temperatures are entered and the outdoor and indoor humidity ratios are computed and appear in cells C6 and E6. The Function was developed from equations that appear in the *Psychrometric* chapter of the *Fundamentals Handbook* (Chapter 6, 2001).

```
Function SpcHum(db, wb, ElevInFt)

'Convert wet bulb to absolute temperature in Rankin
        RT = wb + 459.67
'Compute atmospheric pressure in psia from local elevation (Eqn. 3)
        pt = 14.696 * (1 - 0.0000068753 * ElevInFt) ^ 5.2559
'Input coefficients of Eqn. 6
        c8 = -10440.4
        c9 = -11.29465
        c10 = -0.027022355
        c11 = 0.00001289036
        c12 = -0.000000002478068
        c13 = 6.5459673
'Calculate saturation pressure using wet bulb temperature from Eqn. 6)
        pws = Exp(c8 / RT + c9 + c10 * RT + c11 * RT ^ 2 + c12 * RT ^ 3 + c13 * Log(RT))
'Compute the humidity ratio at saturation using Eqn. 23
        Wsat = (pws * 0.62198) / (pt - pws)
'Copute the humidity ratio for the given tdb and twb using equation 35
        wnom = (1093 - 0.556 * wb) * wsat - 0.24 * (db - wb)
        wdenom = 1093 + 0.444 * db - wb
        SpcHum = wnom / wdenom
End Function
```

The latent load due to the ventilation air is the product of the air flow rate, heat of vaporization, and outdoor-to-indoor humidity ratio difference.

$$q_{lat} = \rho Q h_{fg} \times (W_o - W_i),\ or\ q_{lat}(Btu/h) = 4840 \times Q(scfm) \times \Delta W\left({lb_w}/{lb_a} \right) \quad 4.$$

The value for the humidity ratio difference is computed and displayed in cell G6. In preparation for the load calculation procedure, *TideLoad4Z* also calculates the indoor-outdoor temperature for cooling (cell G5) and heating (cell I4), and average outdoor temperature in cooling (cell I5), which is used to calculate the CLTD correction (cell I6).

CLTDs for Wall, Roofs, and Doors

Table 2 contains a set of uncorrected CLTDs for six general different types of walls. Almost all conventional construction variations can be categorized under these types. Figure 1 demonstrates the type of walls that are included within these types. The insulation values for various types of building materials and insulations, which are often need to determine wall type, are shown in Table 3. CLTDs for walls that do not fall within these categories can be found in the 1997 *Fundamentals Handbook*. Table 2 only contains the CLTDs for 10 am and 3 pm. This permits loads to be calculated in the morning and afternoon in order to better determine when the peak load occurs. Other hours could be used by consulting the 1997 *Handbook*. The values are also given in 6ºlatitude increments of and the user can use interpolated values to match other latitudes. However, it should be noted that this typically only affects the south facing wall to any extent. Additionally, direct interpolation for walls facing other directions is also possible or the *Handbook* can be consulted for CLTDs for NW, NE, SW, and SE.

The values in Table 2 assume a mean of 85ºF (t_m), a room temperature (t_r) of 78ºF, a daily range (DR) of 21ºF, dark surface, and a clear sky on the July 21. When conditions are different CLTD values from the table must be corrected before being used in Equation 1. No correction is suggested for outdoor temperature since most light colored surfaces decay with time. Therefore,

$$CLTD_{cor} = CLTD_{Table} + (78 - t_r) + (t_m - 85), \text{ where } t_m = (t_o + t_r)/2 = t_o - (DR/2) \qquad 5.$$

Consider a wall in Tuscaloosa (lat. = 33.2ºN) with a face brick exterior (4”), air space, ½” blackboard sheathing, 2 x 4” wood studs on 16” centers, with “R13” (hr-ft^2-ºF/Btu) insulation, and 1/2” gypsum board (dry wall) on a single story building. This wall is best described as a medium wall (see Figure 1) with a CLTD designation of Type 10 since the wall insulation is R>11. Also note that it carries a CFF Zone Type B designation and a SCL Zone Type A designation since it is the top floor. Table 2 is consulted and the 8 CLTD values for the Type 10 wall and the closest latitude 36ºN are corrected using Equation 5 and then inserted into Table 1 in columns B and C, rows 22 through 25.

TideLoadZ enables the user to cut and paste the CLTD values. Table 1 values are located in the “CLTDs” sheet and Equation 5 is automatically applied using the value that is calculated in cell I6. The use can also click on the “Wall & Roofs” Type sheet to view Figure 1 and a similar figure for Roof/Ceiling types.

The “CLTDs” sheet also contains values for Roof/Ceiling combinations and doors.

Windows

Windows must also be considered for both conduction using CLTDs and radiation using SCLs (Btu/hr-ft^2) and SCs (dimensionless). The conduction contribution follows the standard CLTD calculation using the same values for doors. SC and SCL values are found on the “SCs & SCLs) sheet. Values for SCLs appear in a table and are input in a manner similar to input to CLTDs. A table for SC is also included but a wider range of information can be found in the Fenestration Chapter of the *ASHRAE Handbook* (Chap. 30 in the 2001 Edition).

Floor and Slabs-on-Grade

Heat gain from crawl space floors and slabs on grade are typically neglected. Heat gain through floors above open spaces (i.e. 2nd floor apartment building with open air parking garage) can be handled by using the shaded north wall CLTD value.

Heat loss from floors to open spaces is treated as a wall or roof ($q = UA\Delta t$). Heat loss calculations through floors to unconditioned areas require that the walls and/or roof of the unconditioned spaces be included in the computation of the overall U-value or total R value when applying the conduction equation ($q = U_O A\Delta t = A\Delta t/R_T$).

Heat loss from slab-on-grade foundations is a function of the slab perimeter rather than the floor area ($q_{Slab} = U_P \times \text{Perimeter} \times \Delta t$). Coefficients ($U_P$) have been developed based on the type of foundation, level of slab insulation, and location as noted by the heating degree-days (HDD) of the climate. Values are provided in Table 16, Chapter 28 of the 2001 *ASHRAE Fundamentals Handbook*. HDD = 2950 (ºF-day with 65ºF base) represents a hot southern US climate, while HDD = 5350 a moderate climate, and HDD = 7433 a cold US climate.

Ventilation Air and Infiltration

Ventilation air and infiltration of outdoor air are lumped together in *TideLoad4Z*. The sensible component ($q = 1.08\times cfm\times \Delta t$) and latent component ($q = 4840\times cfm\times \Delta W$) are considered independently using the standard air assumptions. Required values air flow rates (cfm) for both commercial and residential structures are provided on the [Vent Air] sheet in *TideLoad4Z*. This is a summary of Table 1 in the 1999 version of ASHRAE Standard 62, *Ventilation Air for Acceptable Indoor Air Quality.*

Heat Gain from People

Occupants generate both sensible and latent heat components according to activity level. The sensible heat rate increases slightly with higer activity but latent heat increases dramatically because of greter perspiration rates needed to maintain body temperature. A table of Btu/person from the *ASHRAE Handbook* is included in the [Heat Gains] sheet in *TideLoad4Z.* The entire sensible heat rate from people is not immediately converted in to cooling load because of thermal mass effects. The CLF correction must be applied and values are provided in the [CLF] sheet of *TideLoad4Z*. However, the latent component is immediately converted to cooling load so no CLF correction is necessary.

TideLoad4Z is unique in that the impact of heat recovery units on cooling and heating loads is computed by simply entering the values HRU effectiveness (percentage) in cells B47 (Sensible) and B49 (Latent).

Internal Loads and Lighting

Heat gain from equipment (office equipment, motors, video, vending machines, process equipment, kitchen equipment, etc.) is handled in a similar manner. The [Heat Gains] sheet contains a summary of values found in the *ASHRAE Handbook*. A CLF must be applied to all sensible loads, which are typically expressed in watts. So a factor of 3.412 is used to convert to Btu/h (which *TideLoad4Z* divides by 1000 to convert to MBtu/h). However, latent loads are often provided in Btu/h so the user must apply with care. Lighting loads are sensible only and heat gain values in watts are provided in the [Heat Gains] sheet and CLFs are given on the [CLF] sheet of *TideLoad4Z*.

Ductwork

Duct heat losses or heat gains can be significant if duct work is located in uninsulated attics or is poorly insulated and sealed. The *ACCA Manual N* recommends multiplying the total of all other sensible heat gains by a factor that considers duct location, insulation, sealing, and heating equipment supply temperature. A summary of the values is provided in the [Duct] sheet of *TideLoad4Z*. The factor for the supply and return duct should be averaged and entered into the cooling, heat gain factor (Cell C65) and heating, heat loss factor (Cell E65). Note that if there is no return duct the factor is zero and both factors are zero if the duct is located inside the conditioned space, a practice that is **highly recommended for high efficiency buildings**. An accurate calculation can be performed by using the *DuctHeatLoss* program available at www.geokiss.com.

Zone Data Entry

TideLoad4Z provide space for the entry of data for four zones. Note that the values for every zone are different but that values of previously discussed items are common to the entire building. Consider the basic equation for walls: q = U×A×CLTD. U and CLTD will be common for all walls facing west, but the areas will be different for each building zone. Many zones will only have no west walls. The structure of T*ideLoad4Z* requires that the user only input the values of area, cfm, number of people, etc. for the zone and entry of the other values such as CLTD, CLF, U, SC are not repeated.

When this is accomplish *TideLoad4Z* computes the heat loss/gain for each component and sums the sensible and latent cooling components for the user to analyze. This permits the user to analyze the real load to prevent over-sizing and proper equipment selection to provide adequate dehumidification in cooling. The user is also encouraged to analyze the building cooling heat gain at the maximum wet bulb temperature. This can be done by simply changing the two outdoor design temperatures. *TideLoad4Z* computes the values automatically without any other changes.

The total for the heat loss is also summed but the user is also able to see the total loss with and without the assistance of the internal heating of people, light, and equipment. Careful analysis will help prevent over-sizing of heating equipment.

Table 2 – Morning (Hr. 10) and Afternoon (Hr.15) Uncorrected CLTDs for Walls
See Figure 1 for Wall Type Description

					Wall Type 1					
Lat.	24 º N	24 º N	30 º N	30 º N	36 º N	36 º N	42 º N	42 º N	48 º N	48 º N
Dir.	Hr = 10	Hr = 15	Hr = 10	Hr = 15	Hr = 10	Hr = 15	Hr = 10	Hr = 15	Hr = 10	Hr = 15
N	**18**	**30**	**16**	**30**	**14**	**29**	**14**	**29**	**13**	**28**
E	**63**	**31**	**64**	**31**	**64**	**31**	**64**	**31**	**64**	**30**
S	**12**	**31**	**15**	**39**	**18**	**46**	**23**	**53**	**28**	**59**
W	**13**	**59**	**13**	**59**	**13**	**59**	**13**	**59**	**13**	**58**
					Wall Type 2					
Lat.	24 º N	24 º N	30 º N	30 º N	36 º N	36 º N	42 º N	42 º N	48 º N	48 º N
Dir.	Hr = 10	Hr = 15	Hr = 10	Hr = 15	Hr = 10	Hr = 15	Hr = 10	Hr = 15	Hr = 10	Hr = 15
N	**12**	**25**	**11**	**25**	**9**	**24**	**9**	**24**	**9**	**24**
E	**42**	**38**	**44**	**38**	**46**	**38**	**47**	**38**	**49**	**38**
S	**4**	**27**	**5**	**35**	**6**	**42**	**8**	**49**	**9**	**55**
W	**5**	**33**	**5**	**33**	**5**	**33**	**6**	**33**	**6**	**32**
					Wall Type 5					
Lat.	24 º N	24 º N	30 º N	30 º N	36 º N	36 º N	42 º N	42 º N	48 º N	48 º N
Dir.	Hr = 10	Hr = 15	Hr = 10	Hr = 15	Hr = 10	Hr = 15	Hr = 10	Hr = 15	Hr = 10	Hr = 15
N	**7**	**19**	**7**	**18**	**6**	**17**	**6**	**17**	**6**	**17**
E	**22**	**37**	**24**	**37**	**25**	**38**	**27**	**39**	**28**	**39**
S	**3**	**18**	**4**	**23**	**4**	**27**	**5**	**32**	**6**	**37**
W	**4**	**20**	**5**	**20**	**5**	**20**	**6**	**20**	**6**	**20**
					Wall Type 6					
Lat.	24 º N	24 º N	30 º N	30 º N	36 º N	36 º N	42 º N	42 º N	48 º N	48 º N
Dir.	Hr = 10	Hr = 15	Hr = 10	Hr = 15	Hr = 10	Hr = 15	Hr = 10	Hr = 15	Hr = 10	Hr = 15
N	**8**	**17**	**8**	**17**	**7**	**16**	**7**	**16**	**7**	**16**
E	**22**	**34**	**24**	**35**	**25**	**35**	**31**	**36**	**27**	**36**
S	**4**	**16**	**5**	**21**	**5**	**25**	**7**	**30**	**8**	**34**
W	**7**	**20**	**7**	**20**	**7**	**20**	**8**	**20**	**8**	**20**
					Wall Type 10					
Dir.	24 º N	24 º N	30 º N	30 º N	36 º N	36 º N	42 º N	42 º N	48 º N	48 º N
N	Hr = 10	Hr = 15	Hr = 10	Hr = 15	Hr = 10	Hr = 15	Hr = 10	Hr = 15	Hr = 10	Hr = 15
E	**8**	**14**	**7**	**13**	**5**	**12**	**6**	**12**	**6**	**12**
S	**15**	**30**	**15**	**33**	**14**	**35**	**15**	**36**	**16**	**36**
W	**5**	**12**	**5**	**15**	**4**	**18**	**5**	**21**	**5**	**24**
Dir.	**11**	**15**	**9**	**14**	**7**	**13**	**8**	**13**	**8**	**13**
					Wall Type 16					
Lat.	24 º N	24 º N	30 º N	30 º N	36 º N	36 º N	42 º N	42 º N	48 º N	48 º N
Dir.	Hr = 10	Hr = 15	Hr = 10	Hr = 15	Hr = 10	Hr = 15	Hr = 10	Hr = 15	Hr = 10	Hr = 15
N	**8**	**11**	**8**	**11**	**7**	**10**	**8**	**10**	**8**	**10**
E	**11**	**26**	**12**	**27**	**12**	**28**	**13**	**29**	**14**	**29**
S	**6**	**8**	**7**	**10**	**7**	**12**	**10**	**15**	**10**	**17**
W	**12**	**11**	**13**	**12**	**13**	**12**	**14**	**12**	**14**	**12**

CLTD Wall Types, CLF and SCL Zone Types

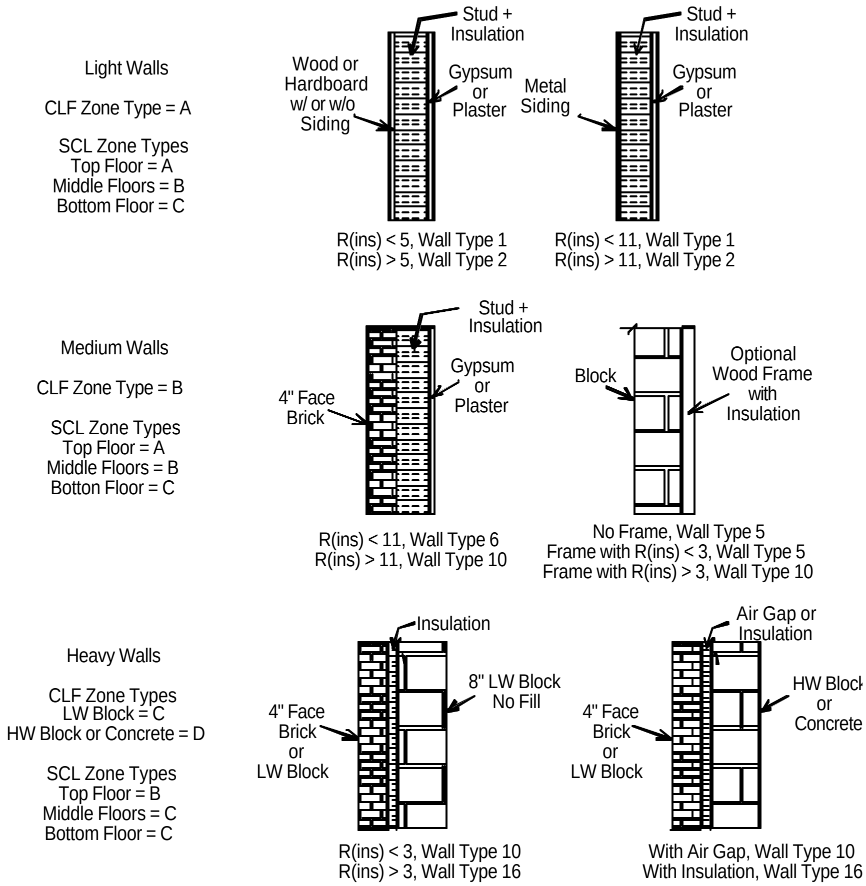

Figure 1.