Approximations to the Heat Balance Method

- Transfer Function Method (TFM)
- CLTD/SCL/CLF *
- TETD/TA *
- Radiant Time Series Method
- Admittance Method

* Both of these methods use data that are derived from TFM

Approximations to the Heat Balance Method

- In general, simplified methods:
  - Treat radiation and convection heat transfer together (particularly questionable when large glazing areas are involved).
  - For the exterior surface, this involves the use of a sol-air temperature.
  - The interior surfaces are assumed to convect and radiate to the room air temperature.

Approximations to the Heat Balance Method

- In general, simplified methods:
  - Use some form of precalculated response for energy storage/release in the zone.
  - Often simplify treatment of transient conduction heat transfer through walls.
  - Tend to overpredict cooling loads.

Approximations to the Heat Balance Method

- Benefits of approximate methods:
  - Simpler to use
  - Give component loads.
  - Tend to overpredict cooling loads. ☺

Approximations to the Heat Balance Method

- First, briefly cover historic simplified methods:
  - Transfer Function Method
  - CLTD/SCL/CLF Method
  - TETD/TA Method
- Second, in some detail, cover new ASHRAE procedure, Radiant Time Series Method

Transfer Function Method (1)

- Like heat balance method, uses conduction transfer functions to model transient conduction heat transfer:

$$q''_{\theta} = \sum_{n=0} b_n T_{e,\theta-n\delta} - \sum_{n=1} d_n q''_{\theta-n\delta} - T_{rc} \sum_{n=0} c_n$$

- Unlike HBM, CTFs apply from sol-air temperature to room air temperature rather than surface temperature to surface temperature.

Transfer Function Method (2)

- Zone response is modeled with room transfer functions, usually called weighting factors:

$$Q_\theta = \sum_{j=0}^{2} v_j q_{\theta - j\delta} - \sum_{k=1}^{2} w_k Q_{\theta - k\delta}$$

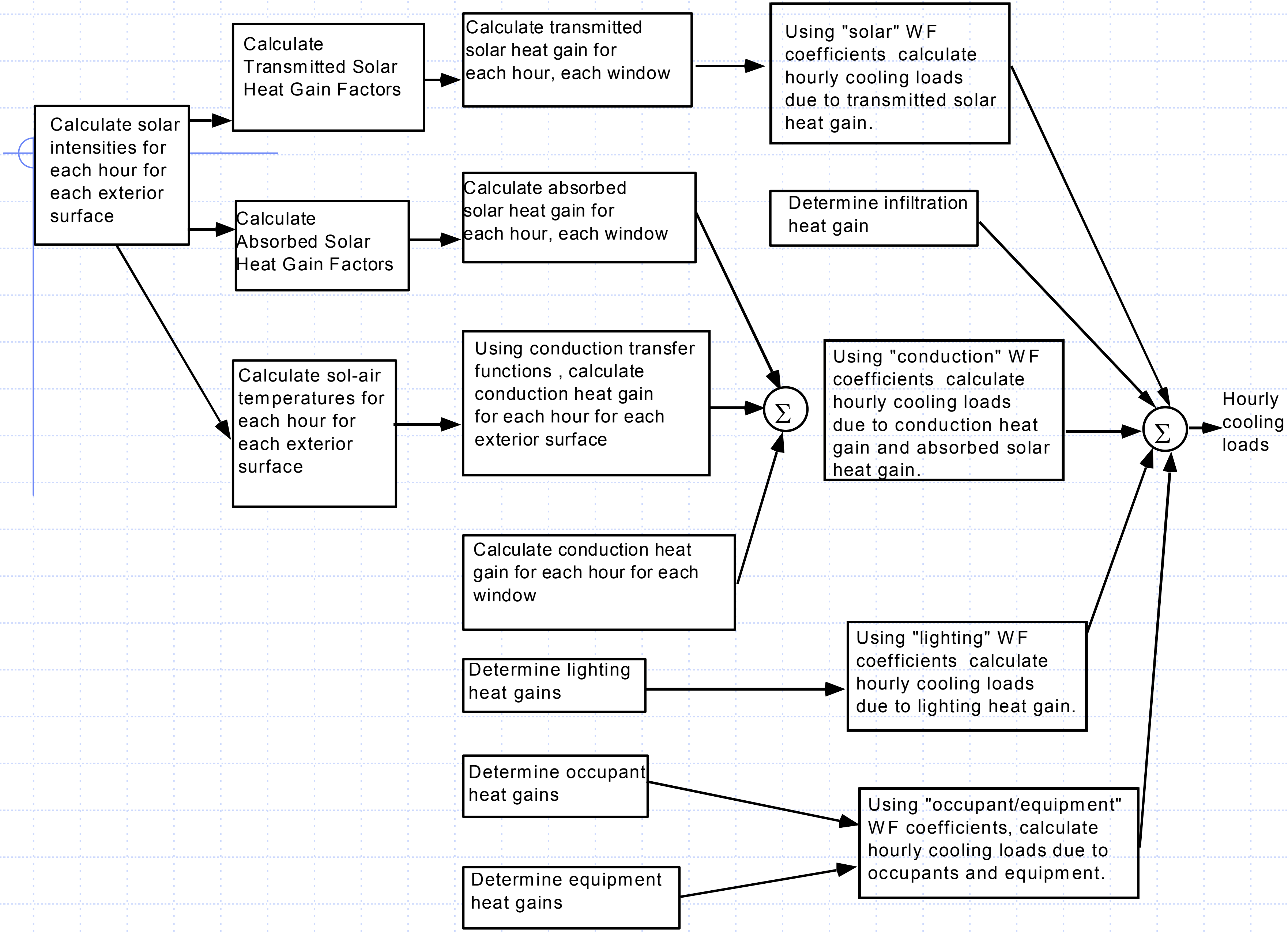
- With this equation, all heat gains are converted to cooling loads.

Transfer Function Method (3)

- Accuracy primarily depends on how coefficients of conduction transfer functions and room transfer functions are determined.
- Current ASHRAE procedure relies on a database of 41 walls and 42 roofs (tabulated in handbook) and database of 200,000+ zones with a mapping procedure.
- The mapping procedure introduced a built in overprediction for conduction heat gains and peak cooling loads

Transfer Function Method (4)

- Solar heat gain estimated with transmitted and absorbed solar heat gain factors (based on transmissivity vs. θ for single pane glass) and shading coefficient. Accuracy is dubious for advanced glazing.


Calculate solar intensities for each hour for each exterior surface
Calculate Transmitted Solar Heat Gain Factors
Calculate transmitted solar heat gain for each hour, each window
Using "solar" WF coefficients calculate hourly cooling loads due to transmitted solar heat gain.
Calculate Absorbed Solar Heat Gain Factors
Calculate absorbed solar heat gain for each hour, each window
Determine infiltration heat gain
Calculate sol-air temperatures for each hour for each exterior surface
Using conduction transfer functions , calculate conduction heat gain for each hour for each exterior surface
Σ
Using "conduction" WF coefficients calculate hourly cooling loads due to conduction heat gain and absorbed solar heat gain.
Σ
Hourly cooling loads
Calculate conduction heat gain for each hour for each window
Determine lighting heat gains
Using "lighting" WF coefficients calculate hourly cooling loads due to lighting heat gain.
Determine occupant heat gains
Using "occupant/equipment" WF coefficients, calculate hourly cooling loads due to occupants and equipment.
Determine equipment heat gains

Transfer Function Method (6)

- It is possible to estimate heat extraction rates, but coefficients are only available for light, medium, heavy constructions.
- No plausible way for heat to be conducted out of the space. (Important for high U-value zones in cooler climates.)

CLTD/SCL/CLF Method (1)

- Cooling Load Temperature Difference/Solar Cooling Load/Cooling Load Factor Method
- Transient conduction heat transfer modeled with CLTD: q=UA(CLTD)
- Accuracy depends on CLTD accuracy; if tabulated values are used, additional overprediction is included, compared to the TFM. ("Custom" CLTDs can also be generated.)

CLTD/SCL/CLF Method (2)

- Cooling load due to fenestration calculated with "Solar Cooling Load" (SCL), q_{rad}=A(SC)SCL
- SCLs were introduced because of occasional problems with previous CLTD/CLF method.
- Limited tabular data available in handbook; "custom" SCLs can be generated.
- Impossible to represent shading correctly with this method.

CLTD/SCL/CLF Method (3)

- Cooling loads for internal heat gains estimated with cooling load factors (CLF) q=(peak heat gain)(CLF)
- Accuracy depends on accuracy of CLF; again, using tabulated values of CLF introduces additional overprediction error. (Again, "custom" CLF can be generated.)

CLTD/SCL/CLF Method (4)

- When "custom" CLTD, SCL, and CLF are generated, accuracy of CLTD/SCL/CLF method is same as TFM, <u>except</u> for time-varying shading.

TETD/TA Method (1)

- Total Equivalent Temperature Difference / Time Averaging Method
- TETD is similar to CLTD:
  q=UA(TETD), but TETD is calculated by user based on sol-air temperature, and time lag and decrement factor for wall. (akin to single term CTF)
- Time lag and decrement factors are tabulated for the same 41 wall types and 42 roof types.

TETD/TA Method (2)

- Heat gains due to fenestration are estimated with SHGF.
- All heat gains are divided into radiative and convective portions; convective portions instantaneously become part of the cooling load.
- Radiative portions are treated with simple zone response model: a user-selected time-averaging period.

TETD/TA Method (3)

- Results depend heavily on user experience to select time averaging period.

Admittance Method

- Developed in the UK
- Derivation based on sinusoidal boundary conditions
- Mean and fluctuating components of loads and temperatures are calculated separately
- Transient conduction modeled with a decrement factor and time lag

Admittance Method

- Exterior solar radiation, thermal radiation, convection modeled with sol-air temp.
- Interior radiation and convection modeled with an environmental temperature

Questions?