Load Calculation Spreadsheets
Quick Answers Without Relying on Rules of Thumb

By Steven F. Bruning, P.E., Fellow ASHRAE

Most HVAC design engineers use an array of sophisticated software calculation and modeling tools for load calculations and energy analysis. These tools offer almost total flexibility for the engineer to define physical arrangement, thermal parameters, operating schedules, internal loads and zoning. To achieve that flexibility, the input parameters are extensive and time consuming.

Especially in the early stages of a project, a large number of load assumptions must be made. Because the schedule is usually tight, using sophisticated modeling tools appropriate for detailed design can be problematic. Experienced designers often fall back on their historical assumptions of cfm/ft² or ft²/ton or heating Btu/ft² to provide initial design and budget input.

An alternative approach to traditional rules of thumb is the use of simplified input spreadsheets. These have proven quick and easy to use for early concept and helpful in evaluating impact of assumptions vs. rules of thumb (which may not be valid with new trends in code and agency requirements).

Basic Load Calculation Spreadsheets
A new cooling load calculation technique was introduced by ASHRAE Technical Committee (TC) 4.1, Load Calculation Data and Procedures, in 2001 ASHRAE Handbook—Fundamentals. This method, radiant time series (RTS), effectively merged all previous “simplified” load calculation methods (TETD-TA, CLTD-CLF and transfer function). The RTS method and data were derived from fundamen-

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tal heat balance calculations while maintaining simple concepts and component-by-component results. The new method was the result of years of ASHRAE research projects.

In 2003, TC 4.1 was asked by the ASHRAE Technical Activities Committee (umbrella group over all TCs) to develop a real-world building example load calculation for ASHRAE Handbook. The ASHRAE headquarters building, (two stories, 30,000 ft² [2787 m²]) was chosen as representative of many commercial office buildings.

To prepare that example, a series of demonstration RTS calculation spreadsheets were used. The spreadsheets were updated to incorporate results of additional ASHRAE research projects (new weather data, clear sky solar models, interior shading models, lighting heat to return air, etc.) for the 2009 Fundamentals. The 2013 Fundamentals example will be updated to incorporate the new addition and renovation of the ASHRAE headquarters building.

Those example RTS spreadsheets (“Radiant Time Series Method Load Calculation Spreadsheets” from the ASHRAE bookstore) are limited in function and are intended for educational purposes, but not to be used for full-blown commercial load calculations. While the procedures, techniques and data included in the spreadsheets are state-of-the-art, they would be impossibly cumbersome for use in typical projects involving hundreds or thousands of spaces. However, sometimes a quick analysis using the spreadsheets saves time, and the following are a few examples.

Quick Block Load Comparisons

At the earliest stage of a project, a quick block load calculation can be useful for defining mechanical spaces and cost modeling. This has been especially useful in the pricing phase of design-build competitions.

Figure 1 is a floor plan issued in an RFP. Figure 2 is the RTS spreadsheet block load for this two-story building, which took about 10 minutes to input. What was unusual about this RFP is the building was to be constructed of modular units that could be disassembled and shipped to installations all over the
world. What impact would different climates have on the heating and cooling loads?

Design weather data for the 5,564 worldwide locations included in the 2009 ASHRAE Handbook—Fundamentals CD+ is embedded in the RTS spreadsheet and selected with a simple drop-down menu. So, in another 20 minutes, block loads were identified for 14 locations (Figure 3). This particular building is a secure facility with no windows, so variations due to climate were mostly due to outside air conditions.

For curiosity’s sake, the same block loads were run for a building with 40% glass (Figure 3). This was quick because the spreadsheet includes the tabulated fenestration solar heat gain coefficient data from Chapter 15 of the 2009 ASHRAE Handbook—Fundamentals selected in a simple drop-down box.

Another useful quick evaluation is multiple identical buildings with different orientations on the same site. While the ASHRAE spreadsheet only includes four orientations (NSEW), it does include an orientation correction factor that effectively allows quick “rotation” of those orientations.

Figure 4 is a typical floor plan, and Figure 5 is a site plan for a multiple barracks project. How much difference did the various orientations make in the building block load? Figure 6 includes the results. In this case, this 10-minute exercise confirmed impact on peak due to orientation for this location and particular building type.

Using Spreadsheets for Zone Load Model

While the RTS spreadsheets are useful for simple block load calculations, with a little front-end effort, the ASHRAE RTS Example spreadsheets can provide a tool useful in evaluating peak loads for each perimeter zone vs. block loads for each floor and the building as a whole. Again, at the early concept stage of a project, this is useful, particularly for design-build competitions and space allocation input.

Many buildings boil down to mostly rectangular floor plans of one or more stories. In most cases, cooling and heating loads are broken into interior and perimeter zones. Using the ASHRAE RTS Example worksheets, a simple model with eight perimeter zones and one interior zone per floor can be assembled. A master input worksheet links dimensional data to the individual zone worksheets, and their results link back to a single-page summary. For buildings that fit within a simple rectangular concept, this provides a tool...
to quickly assess zone and overall cooling and heating loads.

As an example, Figure 7 is a floor plan from a design-build RFP with perimeter, corner and interior zones overlaid. Figure 8 is the front-end input required for the spreadsheet and the results are in Figure 9. When the impact of increasing glazing from 20% to 50% was questioned, a single input was changed and total supply air increased 8% and total cooling 4.5% to 333 tons (1171 kW), a quick way to accurately respond to a client’s questions.

Rules of Thumb

Most engineers develop a feel for building cooling and heating capacity over years of practice, forming rules of thumb: “400/ft² per ton,” “1 cfm/ft²,” and “25 Btu/h·ft²” heating. These rules have been fairly common for office buildings in some parts of the country. Two ASHRAE Standards: 90.1 and 62.1, have had a tremendous impact on the building industry over the past 30 years. But what kind of impact have they had on our rules of thumb?

Figure 7: Floor plan from a design-build project.

Figure 8: The front-end input required for the RTS spreadsheet for the design-build project.

Figure 9: RTS spreadsheet results for design-build project.

Figure 10 is a compilation of criteria from Standards 90.1 and 62.1 over the years that impact peak heating and cooling loads. Likewise, plug load trends went up during the 1980s and 1990s, but have begun to reduce due to more
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efficient desktop and laptop computers and use of LCD monitors. The RTS spreadsheets were used for block loads for a common suburban office building (five stories, 25,000 ft² [2323 m²] per floor in Atlanta) with these parameters with results in Figure 10. The impact on overall block loads and resulting rules of thumb has been significant over the past 30 years.

**Conclusions**

Today’s complex buildings require sophisticated load calculation software to account for the myriad variations in exposures, construction, zoning, load densities and occupancy. However, there are cases where a simple load calculation spreadsheet can be a time-saving, useful tool. This is especially true in early concept stages for architectural planning input, sizing of equipment spaces, shafts, etc. Simple block loads are also especially helpful in developing cost models in competition phases of design-build projects or for evaluating parameters such as location and orientation.

Likewise, comparative studies of impact of trends due to standards (such as 90.1 and 62.1) or assumptions (plug loads) can be readily evaluated with a simple spreadsheet without investing the time and energy required for a full-blown commercial software calculation. The spreadsheets can illustrate impacts of individual components relative to the overall total loads, sometimes lost with more complex tools.

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**Figure 10:** A look back at criteria from Standards 90.1 and 62.1 that impact peak heating and cooling loads.
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