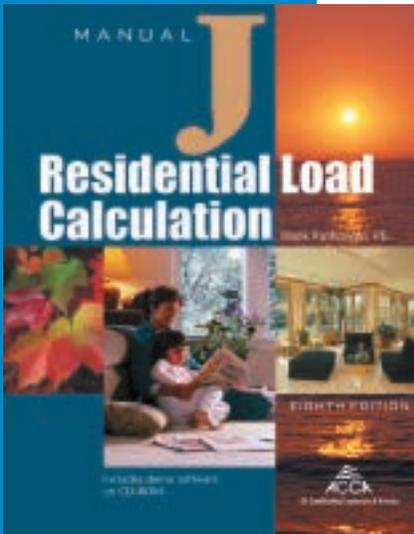


By Glenn C. Hourahan, PE
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Are YOU Using MJ8™ Correctly?



In an October 2003 article of *Contracting Business Magazine*, Stan Johnson asked: Why Aren't YOU Using Manual J8? He observed that the *Eighth Edition of Manual J® (MJ8™)* provided far greater capabilities/sensitivities than the *Seventh Edition (MJ7™)*. He noted that contractors using MJ8 will receive correct heat loss and heat gains if the MJ8 guidelines are followed. This article builds on Stan Johnson's essay and provides specific do's and don'ts to ensure your heat loss and heat gain estimates are done per Manual J guidelines.

MJ8 – MJ7 Load Differences

It should be noted that there are significant differences between the two procedures. Some of these may cause the MJ8 load to be larger, and some of these may cause the MJ8 load to be smaller than the loads obtained from MJ7. Before and since MJ8 was published, ACCA has investigated the differences between MJ7 and MJ8. The re-occurring conclusion is that for a conventional MJ7 type dwelling (generic fenestration, common construction, no special features), the resulting envelope loads (i.e., windows, doors, ceilings, foundation, walls, infiltration, etc.) are essentially the same from either procedure. Hence, when the ducts are located in the conditioned space, MJ7 and MJ8 provide equivalent load estimates (generally, within $\pm 5\%$) when equivalent assumptions are used.

However, when the ducts are in an unconditioned space (i.e., in a hot, vented attic) the MJ7 and MJ8 loads may vary quite a bit. In the worst case, depending on design elements, the MJ8 duct loads can be as much

as a full ton higher, or even more if the ducts are in very poor condition. The following considerations greatly impact MJ8 duct heat gain/loss loads:

- Tightness of the supply and return ducts (i.e., how well “sealed” or how much “leaky”)
- Effective level of insulation around the ducts
- The amount of duct surface area actually in the unconditioned space
- The temperature in the unconditioned space

Sensitivities to these factors were never present in MJ7, and hence, “the apparent load” produced by MJ8 appears larger. Yet, research clearly demonstrates that duct system efficiency/effectiveness is the single biggest issue as far as energy use is concerned (as well as health and comfort!). MJ7 gives a free pass to inefficient duct systems. MJ8 appropriately penalizes poor duct construction. On the other hand, for well-sealed, well-insulated, well-designed ducts, MJ8 produces loads that are comparable – or even smaller – than those derived from MJ7.

Old Habits Will Not Work with MJ8

In addition to the duct considerations, care must be exercised in the assumptions used when performing a Manual J calculation. If the input assumptions are not carefully selected, either Manual J procedure will produce heat loss and heat gain estimates that result in over-sized heating and air conditioning systems. This potential for over-sizing is not due to errors in the Manual J databases and calculation procedures, but rather to system designers that have a habit of weaving a collection of worst-case assumptions into their load analysis. Some examples of such practices include:

- **Manipulating the outdoor design temperature:** Although Manual J calls for use of a specific

summer design temperature, some designers arbitrarily increase the outdoor design temperature by five degrees (or to some other unjustified maximum observed temperature). Manual J stipulates that the listed summer design temperature for the specific location is to be used for the heat gain estimate. This also applies to the outdoor heating design temperature and the indoor design temperatures.

- **Ignoring internal shade devices:**

For unoccupied (or “spec”) homes, system designers almost always assume the worst case for window shading (none) and site shading (none) during sizing. This assumption can unnecessarily add one-half ton of installed cooling capacity to a 2,500 ft² home. MJ8 stipulates that drapes and blinds be assumed unless there is specific information to the contrary.

- **Not evaluating overhang benefit:**

System designers often skip the shade-by-overhang adjustment for window and glass door gain because it seems like a minor detail and because it adds complexity to the procedure. In fact it is not a minor detail; in many cases the extra effort translates to a significant reduction in the fenestration gain and smaller cooling equipment.

- **Intermittent fans equated to engineered ventilation:**

If bathroom and kitchen fans are evaluated as engineered ventilation systems, excessive (and fictitious) loads are added to the heat gain and heat loss estimates. Both editions of Manual J stipulate that such fans be excluded from the load estimating procedure.

- **Envelopes and ducts:**

When using MJ8, it is particularly important to consider duct leakage separate from envelope infiltration. Many system designers assume leaky ducts are equivalent to leaky envelopes (for infiltration loads),

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and then increase the infiltration air changes per hour (ACH) estimate to compensate for leaky ducts. This practice is equivalent to double counting leakage that is already factored into the MJ8 duct tables. In MJ8 – and in actual practice – the leakage of the envelope and the duct system are independent of each other. They can both be tight or leaky, or one can be tight and the other can be leaky; thus, they must be evaluated separately. For MJ8, Table 5 evaluates the envelope leakage and the duct leakage effect is included in the Table 7 duct load factors.

- **Using a code ventilation rate as the infiltration ACH value:** ACCA has found that code fresh air requirements (such as 0.35 ACH) are being incorrectly used as default infiltration rates without considering the actual tightness of the construction. Additionally, ACCA notes that some system designers habitually assume leaky construction without consideration of specified or observed efforts to provide efficient construction. [Ideally, duct and blower door test results should be used to obtain actual performance values and to establish track record for individual builders and duct system installers. Such tests are not always possible, but unless there is evidence to the contrary, the builder's plans and specifications deserve the benefit of the doubt as far as tightness is concerned.]

Guidance for Undertaking MJ8 Calculations

Manual J is an engineering tool that has an inherent and appropriate factor of safety. Any attempt to add other safety factors or to manipulate the procedure may result in unacceptable performance, especially at part load. The following items, noted in Manual J, are highlighted for use by all practitioners.

MJ8 Dos (Mandatory Requirements)

- Verify all construction details prior to performing Manual J calculations.
- Use the outdoor design conditions recommended by Table 1 of MJ8, unless superceded by local code.
- Use indoor conditions that are

compatible with the ASHRAE comfort chart (i.e., the default conditions recommended by Manual J), unless superceded by local code:

- The recommended indoor drybulb temperatures are 70°F for heating and 75°F for cooling.
- For wet-coil climates (positive values for Table 1 Grains), the recommended indoor relative humidity (RH) is 50% for cooling.
- For dry-coil climates (zero or negative values for Table 1 Grains), the recommended indoor RH is 45% for cooling.
- Specific duct considerations:
 - Take full credit for duct system sealing and insulation when such efforts are confidently anticipated or certifiable.
 - Use the “sealed” scenario for ducts that are reasonably sealed.
 - If the duct sealing work is not so great, seal the ducts and then use the sealed table (use the unsealed table to show why the sealing work is required). [This is a great selling tool for fixing the ducts. Putting in the properly sized (smaller) equipment will generally leave enough money to seal the ducts . . . and still leave you looking more price competitive.]
 - Match location as close as possible when selecting a duct load table. [For attic systems, consider venting, roofing material, roof color and use of a radiant barrier. For closed crawlspaces, the table-choice depends on the crawlspace wall insulation. See MJ8, page T7-1 for a list of choices.]
 - Match duct system geometry.
 - Radial and spider systems have less surface area than extended plenum and trunk and branch systems.
 - Be sure to use the adjustment factor (see MJ8, Worksheet G) for the exposed duct surface area when the actual duct system has less exposed area than the Table 7 scenario used for the duct load estimate. [Table 7 duct systems have multiple returns that do not flow more than 400 CFM of air per return. The surface area correction for a system that has one large return right at the air-handler is approximately 0.50. Such adjustment multipliers range between 0.50 and 0.90 and must

be defensible. See MJ8, Page A7-5 and A7-6.]

- Use the appropriate duct wall insulation correction if the R-value of the insulation is not R-6.
- In general, take full credit for the rated (or tested) performance of glazing assemblies, construction materials and construction features.
- Take full credit for insulation R-values:
 - As specified for new construction.
 - As installed (verify the installation conforms to methods and materials protocols).
 - As tested (see quality control programs for new construction, investigate existing construction)
- Take full credit for documented window, glass door and skylight U-values and SHGC values
 - For generic fenestration, use the Appendix 10 data provided by MJ8.
 - For NFRC fenestration, use the Table 3D-1 procedures provided by MJ8.
- Take credit for bug screens when such devices are installed or specified.
- Take credit for internal shade (per MJ8 defaults and protocols, and Table 3D-4). Windows and glass doors shall be shaded by a medium blind. However, internal shades are not applicable for purpose-built day-lighting windows.
- Take credit for overhangs (per MJ8 defaults and protocols, and Table 3E-1). The overhang adjustment shall be applied to all windows and glass doors, including purpose-built day-lighting windows.
- Consider orientation of the structure on the site.
 - Use the actual orientation whenever possible.
 - Use “best case/worst case” load estimates for cookie-cutter designs that may have varying site-orientations when built.
- Take full credit for tightness of the envelope construction.
 - As specified by builder or code.
 - As installed (verify the installation conforms to methods and materials protocols).
 - As tested (see quality control programs for new construction, investigate existing construction).
- Use a plausible estimate for the internal gain. Base such decisions on normal day-to-day and time-of-

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day occupancies, activities and events.

- If a code or regulation does not mandate a fresh air requirement, use MJ8, Table 8 procedures to determine the outdoor air requirement for the dwelling.
- Use MJ8 procedures to evaluate the
 - Infiltration load
 - Ventilation load
- If unknown, assume 500 watts for the indoor blower motor.
- Sit down with your customers or clients and educate them on these issues.

MJ8 Don'ts (Mandatory Requirements)

- Do not use Manual J for:
 - Any type of commercial application,
 - Large multi-family buildings or residential high-rise structures,
 - A room or space containing an indoor swimming pool or hot tub,
 - Earth-berm or earth-covered dwellings,
 - Solar homes that have passive or active features.

- Do not design for record-breaking weather conditions.
- Do not add a "safety factor" to the Table 1 design conditions.
- Do not design for abnormally low or high indoor temperatures or humidity conditions (unless there is a certified medical reason for doing so).
- Do not arbitrarily assume that ducts are unsealed (i.e., assume that they are leaky).
- Do not assume that there will be no internal shade on ordinary windows and glass doors (bare glass is an acceptable assumption for glass specifically installed for day-lighting).
- Do not fail to take credit for overhangs.
- Do not assume that the load for the worst-case site orientation can be used for other orientations.
- Do not reduce known ceiling, wall or floor R-values "just to be safe."
- Do not fail to give full credit for the builder's effort to produce a tight envelope.
- If a local code specifies a fresh air requirement (typically an air change per hour value), do not use the code ventilation requirement as the infiltration rate.
- Do not use internal load assumptions that cannot be defended.
 - Do not add extra occupancy loads for "entertaining groups of people."
 - Do not add extra internal loads for special events.
 - Do not make worst case "everything is going full blast" assumptions about internal loads.
- Do not fail to give full credit for efforts to provide tight, properly insulated ducts.
- Do not apply safety factors during any stage of the load calculation process.
- Do not apply a safety factor to the final answer or to the equipment selection procedure.



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Prohibited Practices

Do not use "rules-of-thumb." The idea that the required equipment capacity equals the floor area divided by some magic number is absurd. Heat loss and heat gain depends on individual circumstances. Floor area to tonnage ratios for the U.S. housing stock can

range from less than 500 ft²/ton to more than 1,200 ft²/ton. Efficient single family detached homes with a normal amount of well-distributed glass typically fall in the 700 to 1,200 ft²/ton range. Limited exposure dwellings with concentrated glass (that produces a time-of-day peak) may fall in the 500 to 800 ft²/ton range. Homes with exceptional features can be all over the map in this regard. Just rotating a home on the site can change the ratio by 100 to 400 ft²/ton.

Comfort system performance is only as good as the accuracy of the heat-loss/heat-gain estimate. Efforts to "adjust the load" to provide a "safety factor" or to produce a solution that is compatible with the "I have been doing it this way for 30 years" syndrome are forbidden.

Guidance When Using Software for Manual J Calculations

The number of input responses required by any particular third-party software package is an indication of the sensitivities and capabilities of the program and/or the number of defaults built into the program. Sensitivity is reduced when MJ8 options are replaced by nonadjustable defaults. Sensitivity is maintained by adjustable defaults. For example, a software program could:

- Default to a procedure that uses peak hour values for fenestration gain. [Early versions of some MJ8 programs had such a default or switched to the peak-hour solution when adequate exposure diversity was not maintained for windows. Later releases (or updates) of some software replaced the peak-hour toggle with an excursion adjustment. Be sure that the program you are using is not using a peak-hour toggle to estimate fenestration gain.]
- Default to generic fenestration with no internal shade, no overhang, and/or no options to use other scenarios.
- Default to a user-defined scenario for fenestration.
- Require user input for all detail relating to each piece of fenestration.

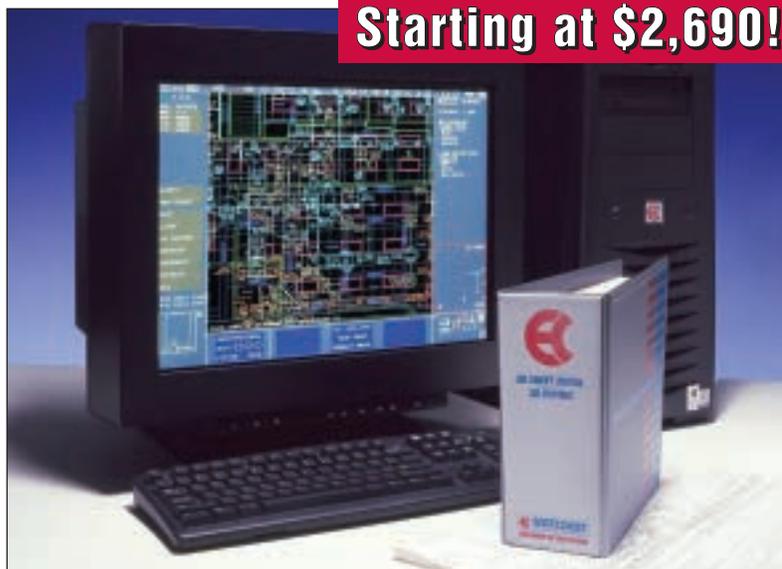
An unabridged list of the detail required for a pure application of the

complete MJ8 procedure is too large to present here. Such information can be gleaned by scrutinizing the worksheets in Appendix 2 of MJ8. Much of this is just common sense—if the software does not ask about a specific detail, it has made a decision for you. There is nothing wrong with this, providing you know about it and agree with the decision.

Conclusion

ACCA recommends that rigorous load calculations—grounded in

sound, up-to-date building science—be undertaken with proper assumptions, correct methodology and no addition of safety factors. Properly observing the above requirements will produce accurate Manual J loads. Once you know the sensible and latent loads from Manual J, consult ACCA's Manual S® for specific guidance on how to properly select the equipment that satisfies the application. ACCA has long suggested that it is better to undersize equipment by 10% than oversize it by 10%. ■



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