Excerpt of "Guide tp Passing the HVAC Licensing Exam"

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Note: Due to amendments by each state some answers to these tests may not agree with your code book or business reference. In which case, accept your state's code and reference answer.

ABOUT THIS GUIDE

This guide has been designed as a supplemental aid for students preparing to take the state heating and/or air conditioning license exam. It is not intended to replace any manuals or materials required for study. Furthermore, in many jurisdictions, it is not an approved reference to carry into the exam room.

Preparing a study guide for the HVAC exam is a challenging event, as many states and jurisdictions that have adopted the International Codes have added their own amendments. For example, the IMC states the dryer vent shall be no longer than 35 feet. Some states, however, have amended this to 45 feet. Some tables in this guide have had footnotes added to tables. In some instances, entire sections have been added or deleted. Therefore, our section numbers may not correspond to those in your state's Mechanical and Fuel Gas Codes; however, they should be close. If any information in this guide disagrees with your state's codes, then accept your code as the final authority.

The following references were used to produce this study guide. The author understands some states do not test for knowledge of load calculations (Manuals J and N). If this is the case with your state, you may skip those chapters. However, it certainly will not hurt to learn how to perform a load calculation. After all, would you purchase an air conditioner from a contractor who is unable to properly size a system?

- International (or your state) Mechanical Code
- International (or your state) Fuel Gas Code

- ACCA - Manual J (seventh or eighth edition)
- ACCA - Manual N
- ACCA - Manual D
- NASCLA – Contractors Guide to Business Law and Project Management Optional references
- International (or your state) Energy Code
- International (or your state) Residential Building Code

Send questions and comments to energymarketingservice@gmail.com

Chapter 1

A Guide to Manual J (7th and 8th Edition)

For more than 50 years, Manual J has been the industry's leading reference tool for performing residential load calculations. With over 30 years of experience teaching Manual J, we have observed that most students only need an orderly explanation of the load calculation process. This guide puts it all together in a smooth flowing, easy to understand format. This guide does not replace Manual J, as you will need the reference material in Manual J to accurately perform a load calculation. This manual is designed to be short on words and simple on math. Let's get started.

THE FOLLOWING INFORMATION IS FOR MANUAL J8 USERS (8TH EDITION)

Manual J8 was developed to provide two methods of calculating residential loads: **average load procedure** and **peak load procedure**.

The average load procedure is used to size the equipment used for homes with **Adequate Exposure Diversity***. If the home will utilize zoning, the zone loads must be calculated using the peak load procedure.

***Adequate Exposure Diversity (AED)** - A home has AED if it has about the same amount of fenestration (glass) facing all directions.

If the home *does not* have adequate exposure diversity, the peak load procedure must be used. It may be necessary to perform a number of calculations based on time of day or time of year, and then select the load that covers the worst case.

A home does not have AED if it has a disproportional amount of glass facing any one direction.

An example of a home without AED would be one with an unusually large amount of glass facing south. Because the average load procedure is based on midsummer data, the equipment might end up undersized in October, when the sun is lower and radiates through the large amount of south facing glass.

This course will teach you the Average Load Procedure, as it will be the most prevalent method you will be using in the field.

What is a load calculation?

All structures either *lose* heat in the winter time or *gain* heat in the summer time. This heat loss or heat gain is caused by the fact that the transfer of heat, even in a super insulated house, cannot be completely stopped.

If we know how much heat is being transferred through its walls, ceilings, floors, windows and doors, ducts and through infiltration (air leakage) on an hourly basis, then we could calculate the precise size heater or air conditioner the house would need to maintain a comfortable temperature. This calculation is called a *load calculation*. The load is measured in *BTUH's* **Why do a load calculation?**

The obvious reason is to prevent installing a system that is too small to do the job.

However, if this were the only reason, why wouldn't we just put a 5-ton air conditioner and a 140,000 BTUH furnace in a 1200 sq. ft. house and never worry about it again? The real reason for a load calculation is to size the equipment in order to assure comfort, economy, and good indoor air quality.

When heating, it is important to size the system as close to the heat loss calculation as possible to prevent (1) drafts, (2) hot and cold spots, and (3) short cycling of equipment. When a furnace is grossly oversized, the unit will constantly shut off and on. It may satisfy the thermostat but leave other parts of the home either over or under heated thus, leaving the occupants uncomfortable. A correctly sized unit runs longer, resulting in a better distribution of air and reduced short cycling. Short cycling also leads to higher energy costs. Each time a furnace fires up, it must heat up the heat exchanger before the indoor fan comes on. This heat is wasted up the chimney. Short cycling (short on-off periods) increases the amount of heat wasted up the chimney. In addition, if the occupant is cold in the area he is sitting in (a cold spot), he will turn up the thermostat, which wastes fuel as other areas are over heated.

Sizing rules for *heating* (ACCA):

- **Fossil fuel furnaces** - Do not exceed 125% load calculation (may be twice the size required).
- **Electric resistance heat** - Do not exceed 110% of load calculation.
- **Heat pumps (used for heating and cooling)** - Do not exceed 125% of <u>cooling</u>

- **Heat pumps (used for heating only)** - Do not exceed 115% of heating
- **Auxiliary heat (electric resistance)** – Install only enough KW to make up for the heat pump's deficit. If more heat is desired, the additional heat must be controlled to remain off during normal heat pump operation.

Sizing an air conditioner correctly is even more important than sizing heat. Aside from causing hot and cold spots, over sizing an air conditioner can result in causing high humidity and the problems associated with it. When an air

conditioner runs, it is not only cooling, it is also dehumidifying. An oversized air conditioner will cool the house but, will not run long enough to dehumidify. High relative humidity can have two detrimental effects: (1) higher energy bills because higher humidity requires lower thermostat settings to remain comfortable, and (2) promote mold, mildew, moisture, and possibly health related problems.

NOTE: Even a correctly sized air conditioner is oversized most of the time. For example, a load calculation may call for a three-ton unit at 95-degree outdoor temperature, however, 97% of the time it is less than 95 degrees outdoors. A practical solution is to slightly undersize the unit but, talk this over with the owner.

Sizing rules for *air conditioners* (ACCA):

- **Air conditioner** - May be sized up to 115% of calculation.
- **Heat pump** - May be sized up to 125% of calculation if needed to supply extra heating capacity.

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A few basics before getting started

We're almost ready to do a load calculation. Before we get started, there are a few thermodynamic terms we need to discuss.

1st law of thermodynamics

Energy can neither be created nor destroyed but, can be converted from one form to another with some amount of heat given off during the conversion. For example, when we burn gasoline in our car we convert chemical energy (gasoline) to *mechanical energy* plus *heat energy*. A gasoline engine is about 35% efficient, leaving 65 % of the energy in a gallon of gas wasted, as heat. A furnace can convert fuel to heat with amazing efficiency (99% heat, 1% light). However, we cannot make a furnace more than 100% efficient; otherwise we would be creating energy. When we talk about a furnace being 80% efficient, we are referring to the percentage of heat (80%) that goes into the home versus the percentage of heat that goes up the chimney (20%).

2nd law of thermodynamics

Heat goes from a warm place to a cold place. **Heat does not rise. Hot air rises.** The reason for stating this law is because many people are under the impression that heat only rises; therefore, we only need to insulate ceilings. If that were true, we'd only insulate the bottom of a refrigerator or the top of a water heater. *Heat travels in all directions*—through walls, floors and ceilings—at the same rate.

How structures lose or gain heat

Heat is transferred by conduction, radiation or convection

Conduction - When heat is transferred through walls, floors, ceilings, doors and glass it passes from the cold surface to the warm surface by *conduction*. Similar to how a spoon handle gets warm after being place in a hot beverage. The rate of conduction is expressed as a *Uvalue (discussed below)*

Radiation - When heat is transferred from its source to an object without heating the medium in between. it is said to be *radiant heat*. When an infrared heater is the source and a body is the object. The heater radiates its heat to the body but does not heat the air between the two.

Convection- When fluids (air is a fluid) of different temperatures mix they assume the weighted average temperature. An air handler produces forced convection. an electric baseboard produces natural convection and open windows, or cracks, produce infiltration, another source of convection.

BTU

The amount of heat required to raise the temperature of one pound of water onedegree Fahrenheit. Burning a match produces about 1 BTU.

BTUH

The amount of heat required to raise the temperature of one pound of water onedegree Fahrenheit in <u>one hour's time</u>.

SPECIFIC HEAT

The amount of heat (BTU's) required to raise the temperature of one pound of *any* substance compared to that of water. Water has a specific heat of 1.00 while the specific heat of rock is .20 and the specific heat of ice is .50. Therefore, it takes five times more BTU's to raise the temperature of water compared to rock and two times more BTU's compared to ice. A Specific Heat Table of common substances can be found in *ASHRAE's Handbook of Fundamentals* (see Sensible Heat definition).

SENSIBLE HEAT

Heat we can measure with a thermometer. When we heat water from 70 degrees to 90 degrees we can see the thermometer rise. To determine the amount of *sensible* heat (BTUs) that is required to raise the temperature of a substance, use the following formula.

BTU (sensible) = lbs. x temp diff. x specific heat

Raise temp of 10 lbs. water

15 degrees spec heat 1.00
10 lbs. x 15 degrees TD x 1.00

= 150 BTU

Raise temp of 10 lbs. rock

15 degrees spec heat .20
10 lbs. x 15 degrees TD x .20

= 30 BTU

figure 1

Chapter 2

Useful Formulas

Chapter 3

A Guide to Manual N

The principles of Manual N are basically the same as those of Manual J. The methodology used to perform a *heat loss* calculation is virtually the same for a residence as a commercial building. However, the *commercial heat gain* calculation involves the inclusion of internal loads, number of people, infiltration from traffic, required ventilation and time of day. which has a significantly greater effect on commercial buildings than residences.

To size equipment for commercial buildings we must know the **peak load**. While three o'clock in the afternoon might be the hottest part of the day, a business may experience a peak load at some other time of day. A restaurant, for example, will experience its peak internal load between 12:00 PM and 1:30 PM, when the place is full of customers and all the cooking equipment is going full blast. Therefore, to determine the true peak load, it may be necessary to perform two load calculations, one at 3:00 PM, the hottest time of day, and one at noon, when the restaurant is going full blast.

As discussed in Manual J, **BTUH = U x TD x Area** or **BTUH = HTM x Area** (in case you've forgotten, HTM = U x TD). There are no HTM tables in Manual N, therefore you must calculate the loads using the following formulas.

To determine the winter (heat loss) use the formula:

BTUH = U x TD x Area

To determine the summer (heat gain) use the formula:

BTUH = U x CLTD x Area (for doors, walls and ceilings)

BTUH = U x TD x Area (for windows, floors and partitions)

The **CLTD** (cooling load temperature difference) takes into consideration the mass, color, direction it is facing, and, time of day.

Before you jump out the window let's see how easy it is to calculate the heat gain through a wall.

Chapter 4

Duct Sizing in Three Easy Steps

This section is based on the 1995 second edition of Manual D. However, the principles, friction charts, and fitting equivalent lengths are the same for all editions.

To size residential ductwork you need to calculate only three things:

- What is the *available static pressure* for the ductwork?
- What is the adjusted static pressure or *friction rate*?
- How many *CFM* per room is needed?

First, let's discuss pressure. Air moving down a duct exerts two types of pressure: static pressure and velocity pressure. ***Static pressure*** is the pressure of the air pushing against the sides of the duct (this is the pressure that causes a balloon to increase in size). ***Velocity pressure*** is the impact pressure of the air caused by its movement (like a baseball, the faster it's thrown the harder it hurts when you get hit). When we add both pressures together, we get the *total pressure*. Luckily, for residential applications we only have to concern ourselves with static pressure.

The manufacturers of furnaces and air handlers print charts in their specifications indicating the amount of CFM to expect when connected to a duct system designed at various static pressures. For example, in figure 8-1 page 8-2 of Manual D (Blower Performance Chart), the manufacturer is saying "If you want 1250 CFM, you must set the fan at medium speed and design an air distribution system that exerts exactly .49 inches of water column pressure (static pressure) against the fan. If the system is not designed to this static pressure and you end up with .14 in.w.c., you will get 1400 CFM." Therefore, sizing a system using the specified static pressure is important in order to assure correct CFM.

Why is the correct CFM important? It affects the temperature of the air coming out of the furnace or air handler, which in turn affects

Chapter 6

Accounting and Business Math Made Easy

One of the most dreaded and toughest courses in school is accounting. Accounting ranks up there with chemistry and physics. Fact is, if you can get your thought processes started off right, accounting becomes not only easy, it becomes completely logical. Once you see the light, you'll wonder why anyone would find accounting difficult. This section is going to start you from the very beginning. So let's get started

CASH

Cash is where accounting begins and ends. You debit cash when you receive it and you credit cash when you spend it. All other accounting entries depend on their relationship to CASH. Allow me give you an example.

Joey has just started a yo-yo company with $2000 dollars. His accounting entry will be $2000 in the debit column (left side) of his cash account. One rule of accounting states that for every debit there must be a credit (right column) and vice versa, therefore, if Joey borrowed the money to get started, he will have to credit **accounts payable**. If he had the money, perhaps from savings, he would **credit owner's equity. Nevertheless, he must credit something.** For the purpose of our discussion we will say he borrowed the money, therefore he will credit accounts payable.

At this point, if Joey were to prepare a **balance sheet** (a statement listing assets, liabilities, and owner's equity) he would show zero equity, his total **assets** are $2000 cash, and his total **liabilities** are $2000 accounts payable. **Assets minus liabilities equal owner's equity**. The only way his equity will change is if he does some business.

If he does things right he will make a **profit**, if not, he will suffer a loss. Owner's equity can be either a plus or minus figure.

Assets are items you own. **Liabilities** are items you owe. **Owner's equity** is your net worth.

Remember, when you receive cash you debit the cash account and always credit the item you received cash for. When you spend cash you credit the cash account and debit the item you paid for.

Chapter 9

Energy Code

2015- 2018 Energy Code

Almost all questions pertaining to this code will come from section R403 (residential requirements) and C403 (commercial requirements.

The highlights are:

- R8 duct insulation required for attics, R6 everywhere else.
- Automatic setback thermostats required for fossil fuel furnaces (does not apply to heat pumps).
- All residential thermostats must be programmable

Heat pump electric strips not allowed to operate when outdoor temperature is above heat pump balance point.

Chapter 10

Mechanical Code

Attempting to memorize the code at this time could test your sanity; however, you must read and highlight it. When reading the code, you may not remember the minimum size screen needed to protect outdoor intake openings or how far off the ground a duct should be, but you will know there is a code requirement. Only time and experience will make you an authority. You will be supplied plenty of time

Most items in the Mechanical Code are self-explanatory. Below, we will discuss a few things that may give you trouble.

Section 304.5

A 400 sq. ft. garage with 10 ft. ceilings, equipped with hydrogen generating equipment must have two openings on the same exterior wall. Each must be no less than _?___ sq. feet. Each located entirely within _12___ inches of the floor and ceiling

Solution: 400 sq. ft. x 10 ft. = 4000 cubic ft.

4000/1000 = 4

4 ft. x .5 = **2 sq. ft.**

Chapter 11

Fuel Gas Code

Combustion air requirements

Section 304.5 (refer to figures 304.6.x for illustrations)

Fuel fired appliances must obtain enough combustion air to enable the appliance to operate. This combustion air may come from one of two places, (1) indoors or (2) outdoors. If the air is obtained from indoors the room the appliance is placed in must have a minimum volume. There are two formulas to determine the minimum volume required to operate an appliance *without introducing additional outdoor air*

Combustion air taken from indoors

(A) If the infiltration rate is unknown, then the room must have a volume equal to or greater than 50 cubic feet per 1000 btuh total appliance capacity.**This is called the standard method** For example: Does a room measuring 10' x 30' x 8' high with a 60,000 BTUH furnace require additional air for combustion?

Answer: Yes. The volume is less than 50 cu. ft. per
1000 BTUH Solution:

Divide the total BTUH by 1000

60,000/1000 = 60 (1000's)

Then multiply the number of 1000's by 50 cubic ft.

60 x 50 =3000 cubic ft. needed

If the room is less than 3000 cu. ft., then it needs combustion air. If it is more than 3000 cu. ft. no additional combustion air is required.

The room is 2400 cu. ft. (10' x 30' x 8'); therefore, additional combustion air is required

Appendix A

Exam Practice Questions

These questions where prepared by Energy Marketing Services to give examples of the types of questions that are found on the HVAC licensing exam. They are only a representation of questions found on the exam, not actual questions.

Carefully read each question and then circle the letter of the best answer.

- A licensee may have his license revoked for which of the following? Misconduct
  1. Gross negligence
  2. Incompetence
  3. Any of the above
- If a contractor works on 15% net profit, what will his sales have to be to make $75,000? a. $500,000 $112,500 c. $862.500
  1. $600,000
- A contractor pays $750.00 for a furnace plus 7% sales tax. What will his sales price be if he wishes to make 30% gross profit? a. $1028 $1043 c. $975
  1. $1146

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4) The distance from a meter to a natural gas water heater (40,000 BTUH) is 30 feet, 20 feet further down the line is a furnace (120,000 BTUH). What is the minimum pipe size that must be used between the water heater and furnace (pressure drop =.05)?

1. 3/8"
2. 1/2"
3. 3/4"
4. 1"

5) A ceiling has a total U value of .07. What is the new R value if 19 is added?

a.30

1. 31
2. 32
3. 33

6) A 30' x 8' partition (2 x 4 studs, gypsum on both sides, no insulation) separates two rooms having a temperature difference of 20 degrees. What is the winter heat loss through the partition?

1. 15,360 BTUH
2. 3,535 BTUH
3. 1,500 BTUH
4. 2,609 BTUH

7) A 75,000 BTUH (input rating) 80% efficient furnace has a temperature rise of 45 degrees. What is the CFM?

1. 1212
2. 1667
3. 1515

4. 1175

Answer Key

1. D
2. A - $75,000 = $500,000

.15

3. D - $750.00 cost

52.50 tax (.07x$750)

$802.50 total cost

1.00-.30 = .70 802.50/.70 = **$1146.42**

4. C - Fuel Gas Code. Table 402.3 (2). The farthest appliance from the meter is 50 ft. (30 ft. +20 ft. = 50 ft.). Use column labeled 50. The section between water heater and furnace has to carry 120,000 BTUH (The water heater load has been dropped off). Go down the column until you find 120 (120,000) or greater. You should see 138 (138,000). To the right is 3/4".
5. D - All U values must be converted to R values before adding or subtracting. In this case the U value (.07) must be converted to an R value.

R= 1

= 1/.07

= 14.2

14.28 (the old R value) + 19 (the added R value) = 33.28 (the new R value)

6. C. A partition is an inside wall separating rooms; therefore, the surface air films on each side of the wall are still. Table A4-3 (R-values of common building materials), Manual J8, No. 2d indicates the R value for a non-reflective surface is .68 (there are two surfaces, one on each side of partition). Between the gypsum is a 3.5" air space (no insulation), No. 3a with an R value of .94. The 1/2" gypsum, No. 4a has an R value of .45 (there are 2 pieces of gypsum, 1 on each side of the wall). Therefore, the total R value is 3.20. 1/3.2 = .3125U, BTUH = U x Area x TD, .3125 x 240 x 20 = 1500 BTUH.

Sorry, but you have reached end of our sample excerpt of *"Guide to passing the HVAC Licensing Exam"*. If you feel like you've learned something and wish to learn a lot more, please see below or go to www.hvaclicensing.com for more information about our HVAC licensing prep course.