RESIDENTIAL HEAT LOSS AND HEAT GAIN CALCULATIONS

2018 Edition

FOREWORD

Careful use of this Manual should result in satisfactory sizing of heating and cooling equipment. However, the end result is in no way warranted by the Heating, Refrigeration and Air Conditioning Institute of Canada.

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PREFACE

The residential heating system must be selected and designed to provide comfort conditions in all occupied spaces regardless of the season. Temperature, humidity, air movement and ventilation must be controlled by the system. In addition, the system must perform these functions at maximum efficiency in order to minimize energy consumption.

This edition of the HRAI Residential Heat Loss and Heat Gain Manual is based on the third edition of the Canadian Standards Association CAN/CSA-F280-12 "Determining the Required Capacity of Residential Space Heating and Cooling Equipment" published in 2012. The establishment of the capacities of heating and cooling systems for Canadian houses began with the publishing of the first edition of the standard in 1986.

Major Changes to the CSA standard include Microsoft Excel spreadsheets linked to the standard for calculating heat loss associated with all types of common foundations. Also heat loss and heat gain factors needed for determining air leakage rate of the building. Additional changes include calculations for determining heat loss and heat gain due to continuous mechanical ventilation based on the type of ventilation system used.

Heat Loss and Heat Gain calculations are the basis for system design. Heat Loss and Heat Gain must be analyzed if the furnace, boiler or unitary heaters, condensing unit, fans, coils, ducts and air terminals are to be sized correctly. Comfort, efficiency and reliability are closely related to correct sizing and selection of equipment.

A Heat Loss calculation must be done for each room so that the room heating requirements can be determined. Heat Loss and Heat Gain calculations are needed for sizing unitary heaters, outlets, blowers and ducts. Whole house calculations are necessary for the entire structure in order to properly size the heating and cooling equipment.

When equipment is oversized, efficiency is reduced, operating costs are increased and control over space conditions is lessened. Optimum efficiency and control occur when the equipment operates at full load for long periods of time. Since full load conditions occur only a few times per year, properly sized equipment operates at over capacity and reduced efficiency most of the time. Over sizing of equipment aggravates this situation even more. Over sizing of equipment causes short cycles and discomfort.

HOW TO USE THIS MANUAL

This workbook takes a step-by-step approach to load calculations. It deals individually with the various elements that make up a heat loss or heat gain calculation before putting all these elements together. This approach is taken in order to provide you, the learner, with an understanding of why the calculations are done the way they are, as well as learning how to do them.

There are two main segments to the calculation procedures. They are heat loss calculations and heat gain calculations. Heat loss calculations are dealt with first since they are most commonly used. Heat gain calculations follow fairly simply from the heat loss calculations since they use much of the same information and methods.

Load calculations require access to a great deal of data such as climatic conditions, properties of materials, etc. All this necessary information is provided in the appendices located at the back of this course manual. The appendices may appear formidable but this is because enough information is provided to allow heat loss and heat gain calculations to be carried out for almost any location in Canada. The calculations for a single building require only a small fraction of the information in the appendices. This manual explains when certain information is required, where in the appendices to find it, and how to use it.

One important note to keep in mind is that in order to successfully complete a full heat loss and gain calculation, the use of Microsoft Excel spreadsheets linked to the CAN/CSA F280-12 standard must be utilized. They provide critical foundation heat loss and air leakage outputs necessary to complete these calculations. This manual walks the designer through each input required in the spreadsheets including examples of complete spreadsheets.

This manual should not be used to calculate heat loss and/or heat gain for commercial, industrial or institutional structures. Residential designs which include solariums, atriums, swimming pools and hot tubs are a few examples of unusual construction that may require additional consideration. Active or passive solar homes and underground homes are also excluded

1 Building Science

Heat loss and gain calculations for residential building envelopes are necessary in order to properly size the capacity of heating and cooling equipment. In addition, the distribution system is based on these calculations and as a result, greater accuracy will lead to greater occupant comfort. The understanding of how the design and construction of the building envelope affects its performance is also important. Many aspects of the construction are beyond the control of the HVAC designer, but must be considered in order to provide appropriate levels of comfort to the occupants, and ensure that the dwelling remains durable. There is no substitute for careful consideration of the applicable building science principles, and their communication to contractors and homeowners.

1.1 Comfort Principles

What is Comfort?

A comfortable environment is an environment which is not offensive to any of the following senses: sight, sound, touch and smell. Equipment that is installed to provide comfort should be designed with an acceptable appearance based on its intended use. Operating noise should be low and not noticeable against background or environmental sounds. Undesirable contaminants should not be added to the air by the equipment. Humidity, velocity and the temperature of air should be controlled to prevent the feeling of hot or cold.

Comfort is a subjective concept to some degree and varies with each individual. Thermal comfort, which is the satisfaction with the thermal environment (i.e. feeling too cold, hot, sticky etc) is a primary reason for installing heating and cooling systems. Temperature and humidity are two of the most important factors that determine what is considered acceptable comfort. For example, "Increased relative humidity reduces the rate at which perspiration can evaporate from the skin, and therefore the amount of heat the body can reject.

Consequently, higher relative humidity is generally experienced as a feeling of higher temperature."

ASHRAE (American Society of Heating, Refrigeration and Air-Conditioning Engineers) has a defined comfort zone for the summer and winter seasons. **Figure 1** provides a simplified version of the ASHRAE Comfort Zone chart as published in ASHRAE Standard 55 (Thermal Environmental Conditions for Human Occupancy). The effect of feeling a higher temperature with high relative humidity is evident by the slanting boundaries of the comfort zone for the upper and lower temperature limits.

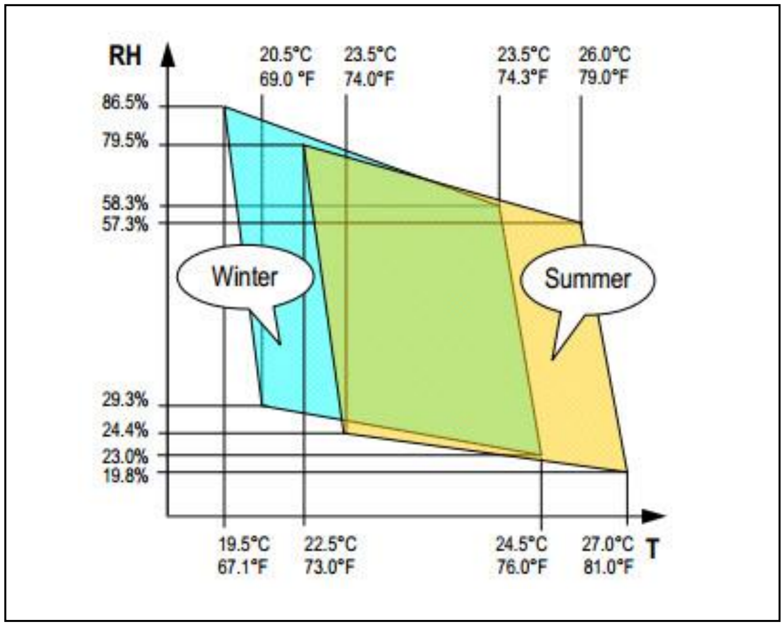
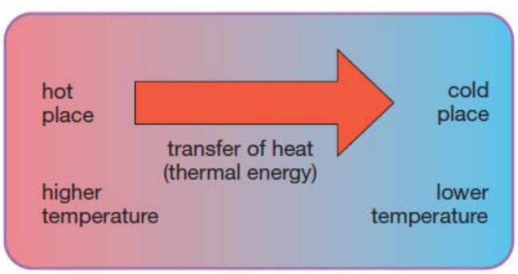


Figure 1 - ASHRAE Comfort Zone Chart

Heat



All objects contain heat. Heat is the transfer of energy from one medium or object to another or from an energy source to a medium or object. A hotter object placed next to a cooler object will always transfer heat from itself into the cooler object, until both objects are of equal temperature. Therefore, heat travels from hot to cold.