

# Chapter 7

## Heat Loss Considerations and Calculations

The most critical step in a properly designed radiant system is an accurate room-by-room heat-loss analysis. All decisions and calculations are based, to some extent, on the building heat-loss requirements.

This section explains how to calculate heat loss manually as well as electronically using the Uponor Advanced Design Suite™ (ADS) design program. ADS analyzes how a building will perform under design conditions (worst-case scenario) by determining the heat loss and heat gain.

### Downward Loss

Downward loss is the amount of heat energy in BTU/h transferred downward from the radiant floor at any given load. Whether calculating heat loss manually or with ADS, downward loss is a critical factor. Downward loss is significant with a radiant floor heating system and must be properly analyzed.

The importance of insulating below the floor to counteract the downward loss depends on the project. The importance increases specifically when the following are present in a design:

- An increase in the thickness of the slab
- An increase in floor covering R-value
- An increase in the differential temperature between the slab and the soil below
- The presence of a water table below the slab

- An increase in the ratio of slab perimeter area to total slab area
- Suspended floors

### Slab Thickness

Thicker slabs mean longer response times. Adding insulation prevents the downward transfer of energy, allowing for a greater amount of heat to transfer into the conditioned space.

### Floor Covering

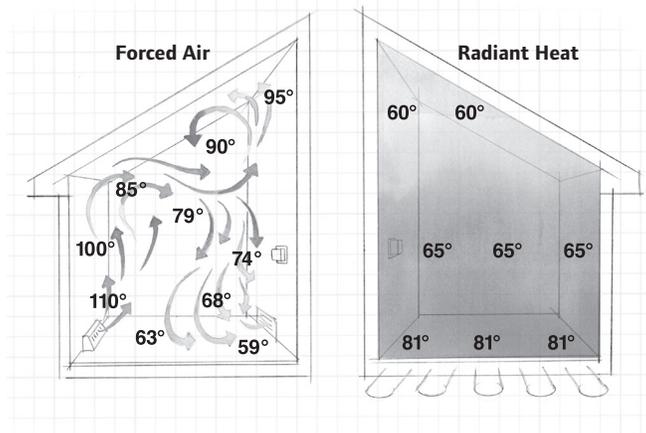
Heat follows the line of least resistance. High R-value floor coverings force heat to travel downward or laterally. Insulation will help prevent heat from traveling downward and force it into the conditioned space.

### Differential Temperature

Uponor's design software will automatically calculate the correct ground temperature and differential based on the setting or checkbox for a water table being present within 6 feet of the slab. Always insulate the slab when lower-temperature conditions are present beneath the heating slab.

### High Water Table

A water table lowers the ground temperature. The lower ground temperature increases downward loss, and higher supply water temperature is needed to overcome that loss. Properly designing and installing insulation beneath the slab in this condition will greatly minimize the downward loss.



If a high water table exists, check the box marked Water Table Present in the ADS design program. The program will change the water temperature below to 40°F. This value cannot be changed with the presence of a water table.

## Slab Areas

Three distinct areas of slab exist, each with a different potential for downward loss.

- The under-slab area is the interior portion of the slab including all but the first 4 feet around the exposed perimeter.
- The perimeter area is the first 4 feet around the exposed perimeter of the slab.
- The edge area is the exposed surface of a radiant slab, equal to the thickness of the slab multiplied by the exposed perimeter length.

Downward loss increases as the ratio of perimeter area to the total area increases. This means the perimeter is especially crucial to downward loss in residential and similarly sized applications. A perimeter without insulation will

allow excessive BTU/h movement away from the concrete slab due to the temperature differential between the slab perimeter and the ground, thus affecting the system performance and the heat loss.

**Slab Insulation** — The three slab-area insulation values are defined as follows.

- The under-slab R-value is the amount of insulation under the interior area of the slab, excluding the perimeter area.
- The perimeter R-value is the amount of insulation placed either horizontally or vertically for the first 4 feet along the perimeter of the slab.
- The edge R-value is the amount of insulation directly covering the thickness of the slab around the exposed perimeter (less than 4 feet below grade).

Uponor recommends total under-slab insulation for residential applications.

## Suspended Floors

Downward loss also exists for suspended floors. A suspended floor is defined as any floor that does not rest directly on the earth's surface. Suspended floors may be constructed of any material and may be constructed over heated or unheated spaces.

Downward loss exists in areas with a heated space below. If the heated area below uses the same heat plant as the area above, the loss does not increase the total load/heat plant load because the heat is not lost out of the structure. If downward loss to the heated space below exceeds either the upward load or 10 BTU/h/ft<sup>2</sup>, insulate the suspended floor. Without insulation, the room temperature below is impossible to control.

Excessive downward loss is likely to occur with the use of high R-value floor coverings. The suspended floor must be insulated if the space below is not heated (e.g., crawl spaces). Unheated spaces below have the greatest potential for downward losses. These areas should always be insulated.

## Summary

Calculating an accurate heat loss is the most critical step in radiant system design. Regardless of the heating system, it is good practice to insulate the area below the floor to minimize the downward loss. This is especially true with concrete slab installations. Once the concrete is poured, it's too late to add insulation. Also, an insulated slab will perform better if a finished floor with a higher R-value is added in the future.

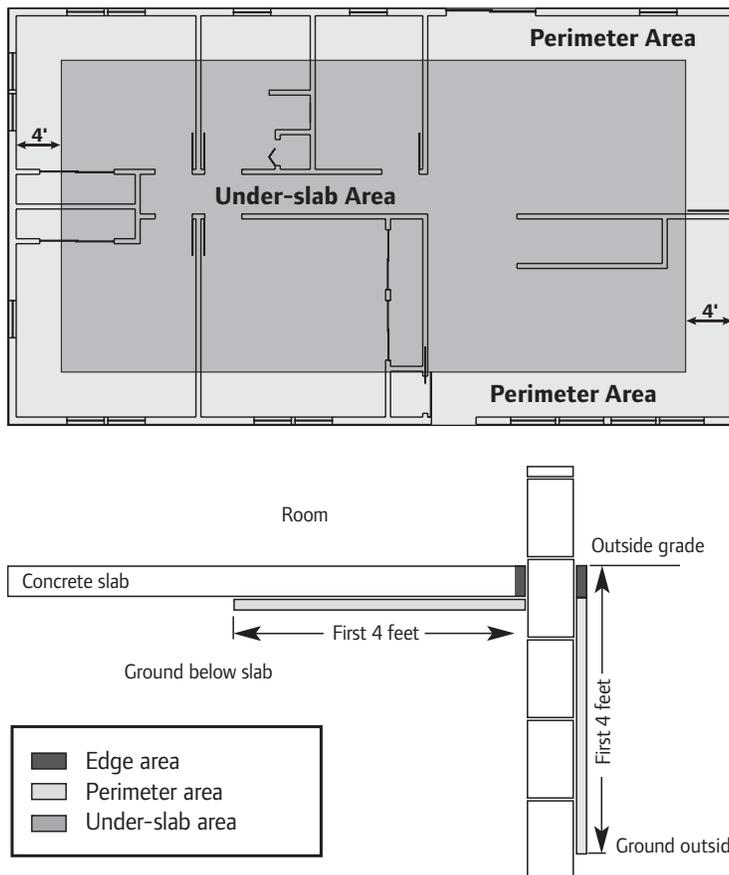


Figure 7-1: Slab Areas

## Manual Heat Loss Calculations

### Understanding the Variables

- Design Temperature Difference (DTD):** This value is the difference between the outdoor design temperature and the indoor design temperature. For this example, the indoor design temperature is 65°F, and the outdoor design temperature is 40°F — yielding a DTD of 25°F.
- Infiltration:** Infiltration is the exchange of warm air inside a building with the cold air outside. Infiltration is generally very low with radiant systems. The infiltration value used in calculating heat loss will vary based on local codes and conditions. For Minnesota, 0.33 air change per hour (ACH) is adequate; 0.33 ACH is equal to an infiltration factor of 0.006.

- Calculation Area:** This value represents the area to be analyzed. This example uses the room shown in **Figure 7-2**.
- Test Room Construction:** It is important to understand the different types of construction methods used in the analysis as well as the thermal properties of

key components such as windows, exterior walls, interior walls, floors and ceilings. This heat loss example considers the exterior walls, ceiling and windows:

- Five exterior windows: 3' x 5' each; R-value = 0.91
- Exterior walls; R-19 insulation
- 8' ceiling; R-30 insulation

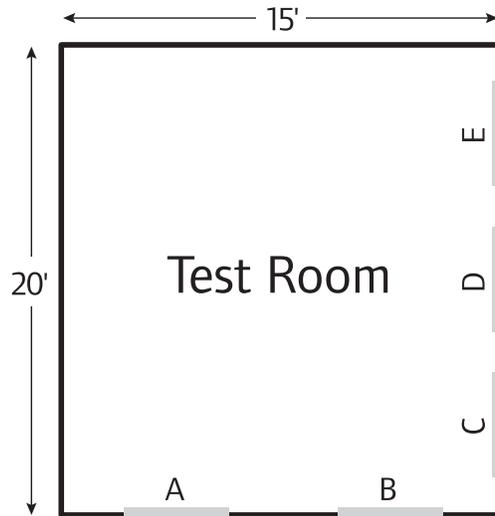


Figure 7-2: Test Room

### Doing the Math

Heat Loss	Formula
<b>Infiltration Loss =</b> 360 BTU/h =	Room Volume x DTD x Infiltration Factor $20 \times 15 \times 8 \times 25 \times 0.0006$
<b>Ceiling Loss =</b> 247.5 BTU/h =	Ceiling Area x DTD x Ceiling U-value $20 \times 15 \times 25 \times 0.033$ • Ceiling U-value = 1/R-value • Ceiling U-value = 1/30 = 0.033
<b>Exposed Wall Loss =</b> 256.25 BTU/h =	(Exposed Wall Area - Window Area) x DTD x Wall U-value $(280 - 75) \times 25 \times 0.05$ • Exposed Wall U-value = 1/R-value • Exposed Wall U-value = 1/19 = 0.05
<b>Window Loss =</b> 2,062.5 BTU/h =	Window Area x DTD x Window U-value $75 \times 25 \times 1.1$ • Window U-value = 1/R-value • Window U-value = 1/0.91 = 1.1
<b>Total Heat Loss =</b> 2,926.25 BTU/h =	Infiltration Loss + Ceiling Loss + Exposed Wall Loss + Window Loss $360 + 247.5 + 256.25 + 2,062.5$
<b>Heat Loss per Square Foot =</b> 9.75 BTU/h/ft <sup>2</sup> =	Total Heat Loss/Total Floor Area $2,962.25/300$

Table 7-1: Heat Loss Formulas



## Computer Program Design Calculations

Along with heat-loss calculations, ADS guides the system designer through the radiant panel design, system requirements and material list generation. This powerful design tool also provides the contractor with a host of business tools for a variety of job-management functions.

The calculation portion of ADS prompts the user to input the type of tubing product to be used, the design differential temperature and the specifics of floor construction. ADS analyzes the information and calculates a supply water temperature and the tubing on-center distance for each room. The program allows the user to make adjustments to the design (e.g., on-center distance, unheated area, etc.) for each room. The user assigns each room or area to a manifold. The program then calculates loop lengths, flow and feet of head.

## ADS Functions

The Uponor design software package performs several functions.

- Calculates accurate room-by-room heat loss
- Calculates system performance requirements
- Calculates total flow and pressure loss for accurate circulator sizing
- Provides mechanical specifications
- Generates an Uponor material list
- Provides current list pricing
- Creates a customer database
- Provides a job follow-up reminder
- Creates management reports for jobs won, lost and pending
- Generates job quotations for presentation to customers

## Features and Benefits

**Quick Start** — The radiant floor heating module offers a menu of house styles and room templates to begin the design.

**Updates** — Periodically, Uponor enhances the ADS software. Users can easily download the updates by clicking the Help menu.

**Easy Navigation** — Setup to look and feel like a web page, the 32-bit platform allows quick and easy movement within the program.

**Piping and Wiring Diagrams and Specification Viewer** — The program includes ManuSPEC® and Spec Data System Specifications as well as wiring and piping schematics.

**Visual Interface** — The visual interface immediately shows when design thresholds and limits are met.

**Drag-and-drop Flexibility** — Add or delete zones, move manifolds between water temperatures and move loops easily with the drag-and-drop feature.

**Advanced Settings** — Settings are available to allow either the program to determine the correct number of water temperatures for the system or the user to set the maximum number to be designed around. These settings also allow the user to set a maximum water temperature based on the heat source.

**Control Auto Selection** — Easily customize projects with the Climate Control™ Multifunction Controller and the Climate Control Zoning System.

**Snow and Ice Melting Module** — This module allows users to easily design a snow and ice melting system, either as a standalone system or as part of a radiant heating design. This module also provides expanded design parameters.

**Supply and Return Piping** — Users can select the type of material connected to the manifolds and specify the distance and the connector type in the design steps. ADS will automatically calculate the materials and report the resulting pressure drops for pump sizing.

**Cooling Module** — This module allows the user to calculate the cooling load. No additional programs are needed.

**ASHRAE Data** — A drop-down list provides complete climatic design data for areas in the U.S. and Canada. Additionally, users can add climatic information for areas not listed in the ASHRAE data.

**Pressure Loss Calculator** — This feature eliminates the need to look up pressure losses in tables or charts. Simply select the tubing size, flow rate, distance, etc., and the program generates the resulting loss. PEX, Uponor Multi-layer Composite (MLC) tubing (formerly MultiCor®) and copper are available as selections in the supply-and-return portion of the design to calculate pressure loss accurately.

**Parts Catalog** — The program includes heating and plumbing components with expanded detail.

**Loop Mapping Wizard** — The Loop Mapping Wizard automatically maps the loops to a specific coil to minimize the amount of waste or scrap in the project.

**Loop Adjustment** — ADS allows for simple adjustment of the final loop length.

**Building Templates** — The Heating Design Wizard allows users to create new building templates or edit existing templates. Users can add, rename or delete rooms.

**Radiant Ceiling** — The user can toggle between economical and normal designs in either a ceiling or supplemental heating application. Selecting the economical mode calculates the minimum amount of coverage required.

**Radiant Wall** — The user can use the wall area for a heated surface to meet the space heat loss. Selecting the wall option will calculate the minimum amount of coverage required.

**Supplemental Heat** — The supplemental heat components of the heat loss are shown in the heat-loss tree, making them easier to track.

**Global Changes** — Users can apply changes in construction, insulation values, floor coverings, etc., on a floor-plan basis, rather than room by room.

**Cv Values** — The associated pressure drops with three-way floating action and tempering valves are automatically calculated and reported.

**Manifold Mapping** — Any or all changes that are made to the manifold mapping are saved. ADS does not re-map the manifolds and the associated loops (as in earlier software versions) when other data is changed in the program.

**Manifold Configuration** — Manifolds automatically configure with 10 loops. Users can add loops up to the maximum flow limit of the manifolds.

**Exporting** — Material lists can export to Microsoft® Excel® files. Project files are stored in a file or folder locations (versus a database) to make the project data more portable.

**Fastener Preferences** — Users can edit the number of fasteners ADS automatically calculates to better reflect the habits of the installer.

**Tool and Part Preferences** — Users can specify the tools and parts they want to include with every job.

**Quantity Values** — When parts are manually added to a material list, a pop-up box is displayed to prompt the user to enter the quantity.

**Help Manual** — A comprehensive help manual is available, complete with help sections, index and graphics, which can be downloaded from [uponorpro.com](http://uponorpro.com).



