



BUILDING ENVELOPE CEM REFRESHER
ONLINE TRAINING COURSE

KRISHNAJI PAWAR, LEED AP BD+C, GSAS CGP, ISO 14001:2015, GCP
ENERGY SPECIALIST CURRICULUM





**CONDUCTIVITY, CONDUCTANCE,
AND R VALUES**

FOR ENERGY PROFESSIONALS

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WHAT SHOULD YOU LEARN





**Understand Conductivity,
Conductance, and R Values**

**Sources of Building Heat Gain/
Loss (Solar Heat Gain
Coefficient)**

INTRODUCTION

☑ Did you know as R value increases, thermal performance improves?

That is a simple concept to understand – bigger is better right?

Conversely, did you know that as U value decreases, thermal performance improves?

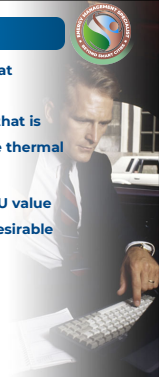
☑ These are fairly well understood realities, so it would not be surprising if your answer to both these questions is yes. Would you be surprised to know that they are actually a measurement of the same thing? Maybe not literally, but essentially. OK – maybe you do know this, but my guess is that we are starting to get some head scratching.



INTRODUCTION +

☑ R value is called “thermal resistance”, and U value is called “heat transfer coefficient” – but in reality they are quite similar. Both measurements are dependent on the thickness of the material that is being measured. They are both measurements that characterize thermal conductivity of a material.

☑ The simple difference? R value is the mathematical inverse of U value and vice versa. That is $R=1/U$ and likewise $U=1/R$ so clearly it is desirable to have large R numbers and small U values to reduce thermal conductivity.



BASIC HEAT FLOW EQUATIONS

☑ Temperature varies with time of day and season, so we often resort to this heat conduction equation

$$Q = U \times A \times DD \times 24 \quad [\text{Wh/yr}]$$

☑ where DD can be HDD or CDD. Annual units are $\frac{^{\circ}\text{C days}}{\text{yr}}$

☑ $U \times A$ is also known as the conduction part of the overall Building Load Coefficient BLC. Other parts include infiltration, ventilation, and slab-on-grade factor.



DEGREE DAYS EXAMPLE

- ✓ For three days the outside temperature averages 10 °C each day.

- ✓ The number of HDD for this three-day period is:

$$\begin{aligned}\text{HDD} &= (18.3\text{ }^{\circ}\text{C} - 10\text{ }^{\circ}\text{C}) \times 3\text{ days} \\ &= 25\text{ degree days}\end{aligned}$$



EXAMPLE

A wall has an area of 100 m² and has a thermal conductance of 1.4 W/m²·°C. If there are 3000 degree-days in the annual heating season, what is the total amount of heat that must be supplied by the heating system?

Solution:

$$Q = U \times A \times \text{DD/yr} \times 24\text{ h/day} \quad \text{Wh/yr}$$



AIR HEAT FLOW PROBLEMS

$$\begin{aligned}q &= M\Delta h \quad [\text{W}] \quad \text{General} \\ q &= M C_p \Delta T \quad [\text{W}] \quad \text{Sensible heat only}\end{aligned}$$

M = Mass Flow Rate (kg/h)

Δh = Enthalpy Difference (kJ/kg)

C_p = Heat Capacity (kJ/kg·°C)

ΔT = Temperature Difference (°C)



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Air: Sensible Heat Only

$$q = \text{LPS} \times \frac{1.204 \text{ kg}}{\text{m}^3} \times \frac{.001 \text{ m}^3}{\text{L}} \times \frac{1.006 \text{ kJ}}{\text{kg} \cdot ^\circ\text{C}} \times \Delta T \quad q = \text{LPS} \times 1.2 \times \Delta T \quad W$$

AIR WATER HEAT FLOW PROBLEMS

Air: General

$$q = \text{LPS} \times \frac{1.204 \text{ kg}}{\text{m}^3} \times \frac{.001 \text{ m}^3}{\text{L}} \times \Delta h$$

$$q = \text{LPS} \times 1.2 \times \Delta h \quad [W]$$

DUCT LOSS EXAMPLE

5,000 LPS of air leaves an air handler at 10 °C. It is delivered to a room at 18 °C. There was no air volume loss due to duct air leaks. No moisture was added, or taken away from the air in the duct. How many kW heat gain occurred because of heat transfer by conduction?

- (A) 48 kW
- (B) 20 kW
- (C) 36 kW
- (D) 60 kW
- (E) 3 kW

Water: Sensible Heat only

$$q = \text{LPS} \times \frac{1000 \text{ kg}}{\text{m}^3} \times \frac{1 \text{ m}^3}{1000 \text{ L}} \times \frac{4.2 \text{ kJ}}{\text{kg} \cdot ^\circ\text{C}} \times \Delta T \quad q = \text{LPS} \times 4.2 \times \Delta T \quad [kW]$$

Sensible Heat only

WINDOW FILM HEATING REDUCTION



- ☑ Performance of window films are measured by a shading coefficient, SC.
- ➡ SC=0 means no heat passes.
- ➡ SC=1 means it does nothing to stop heat.
- ☑ Therefore, the fractional heat flow reduction due to the window film is given by $(1-SC)$.



SHADING COEFFICIENT EXAMPLE



Savings from window films can be found using $(1 - SC)$.

The annual solar heat gain for windows facing west in a building has been calculated to be 165,000 kJ/m².

If a shading film with shading coefficient 0.6 can be applied to these windows at a cost of \$20.00 per square metre, calculate the simple payback. The COP of the air conditioner is 2.7 and electricity costs \$0.06 per kWh.



THERMALLY LIGHT AND THERMALLY HEAVY



- ☑ Thermally light - A building whose heating and cooling requirements are proportional to the weather driven outside temperatures, e.g., homes, shopping centers, and commercial office buildings
- ☑ Thermally heavy - A building whose indoor temperature remains fairly constant in the face of significant changes in the outdoor temperature, e.g., plastic injection molding facility or building with a high heat generating device or area inside.
- ☑ Q. Most of our homes and apartments are thermally light buildings. a) True b) False



CEM REVIEW PROBLEMS



An absorption chiller with a COP of 0.8 is powered by hot water that enters at 90°C and exits at 80°C at a rate of 2 LPS. The chilled water operates on a 5 °C temperature difference. Calculate the chilled water flow rate. Solution of this problem does not require a knowledge of how absorption chillers work internally.

- (A) 0.8 LPS
- (B) 1.6 LPS
- (C) 3.2 LPS
- (D) 3.6 LPS
- (E) 2.4 LPS

CEM REVIEW PROBLEMS



The conduction part of the Building Load Coefficient ($U \cdot A$) for a building is 3500 W per degree C. Estimate the seasonal energy consumption for heating if the heating season has 1800 degree days. The heating unit efficiency is 80%.

- (A) 700 GJ/yr
- (B) 350 GJ/yr
- (C) 462 GJ/yr
- (D) 720 GJ/yr
- (E) 680 GJ/yr

CEM REVIEW PROBLEMS



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- (B) 1.6 LPS
- (C) 3.2 LPS
- (D) 3.6 LPS
- (E) 2.4 LPS

ADDITIONAL

Conversions from IP to SI

- ✓ Rip x 0.1761 = Rsi
- ✓ Kip x 0.1442 = Ksi (IP K uses inches thick.)
- ✓ Uip x 5.68 = Usi



The advertisement features a person in a white lab coat interacting with a glowing digital cityscape. The text "BEYOND SMART CITIES" is prominently displayed at the top. Below it, "THANK YOU" is written in a stylized font. At the bottom, a pink banner reads "THE WORLD'S 1ST GREEN TECHNOLOGY MARKETPLACE". A circular logo on the right side of the image says "ENERGY MANAGEMENT SPECIALIST" and "BEYOND SMART CITIES".

BEYOND
SMART CITIES

THANK YOU

**THE WORLD'S 1ST GREEN TECHNOLOGY
MARKETPLACE**
