Engineering Ethics Cases with Numerical Problems

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Civil Engineering Case 4

Heat Pump Ethics Case

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Suggested Courses:

Heat Transfer

Level:

Junior & Senior

I. Narrative

You are a engineer at a HVAC/energy consulting company in your area. Your responsibility is to design and purchase equipment on many of the projects for which you are responsible. You are involved on various new projects and retrofit projects in the community dealing with commercial buildings, schools, residential houses and industrial buildings. You are required to have a knowledge of thermodynamics, heat transfer, HVAC, energy conservation and energy conversion devices such as heat pumps.

The particular project under consideration involves the design of a new 200-room motel in you city. The architect has completed the floor plan design and overall geometry of the buildings. One part of your job as the engineer assigned to the project is to design specifications for the heating and cooling systems for the rooms and contract to purchase the systems from equipment wholesalers in the area. You have calculated that each room has about the same heating load of 20,000 Btu/hr. Several suppliers have bid on your job. One supplier has bid the equipment at about 20% below the average price of all the other suppliers. You know that since you are buying such a large number of heat pumps you can expect a good price, but this supplier's price seems too good to be true.

This supplier visits you the next week and you discuss his bid on the heat pumps. You inquire about his low bid

on the heat pumps and ask to see some performance data on his units. He provides you with engineering data.

II. Engineering Background

The supplier gives you technical performance data on his Slick Brand heat pumps. The following information is provided at the design operating conditions :

Condenser:

Air flow rate = 750 CFM

Inlet temperature = 60 F

Outlet temperature = 85 F

Evaporator:

Water flow rate = 2.6 GPM

Water inlet temperature = 52 F

Water outlet temperature = 42 F

Compressor:

Current draw = 8 amps

Other information:

The system is operated at 120 V line voltage.

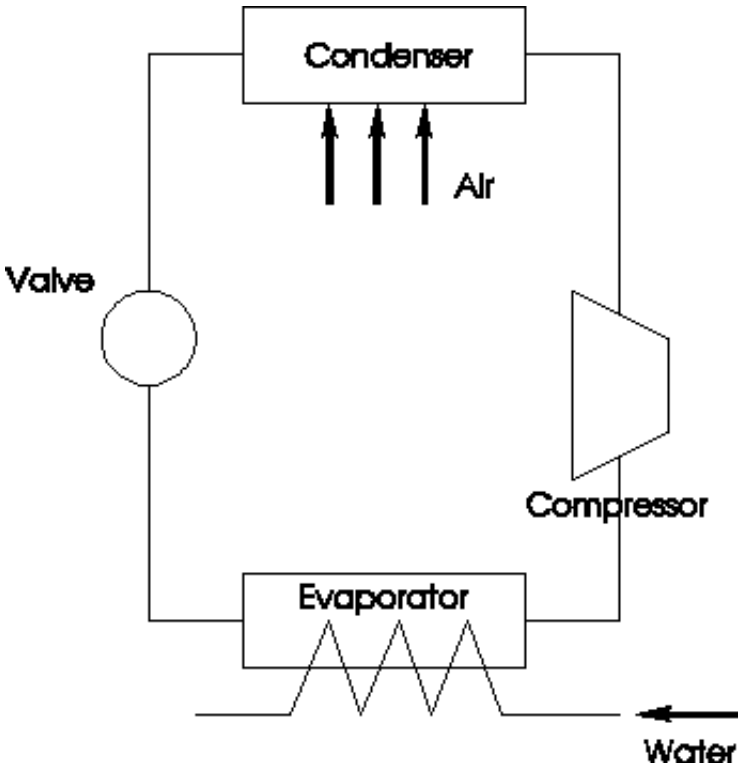

Figure 1. Heat Pump Schematic

You are suspicious of this salesman. What would you do to verify your concerns?

You find that the data on the heat pump is in error. You confront the salesman. He tells you that he is sorry that he made a mistake, and that the current draw on the compressor should be higher. He says that he really wants to sell this group of heat pumps because they use CFC 22 and the refrigerant will be phased out soon. He says that he wants to make you a "deal" and sell this batch of heat pumps at not just 20% off but now 50% lower than similar units on the market.

What do you do?

III. Engineering Problems and Solutions

Assumptions:

Constant Specific Heat of water.

Density of water 0.075 lb/ft^3

1. How would you confirm or deny the salesman's claims on the heat pump?

An energy balance on the heat pump can be performed as follows:

Condenser:

Air flow rate = 750 CFM

Inlet temperature = 60 F

Outlet temperature = 85 F

$Q_{cond} = mc(T_{out} - T_{in})$

$= 750CFM(0.075lb/ft^3)0.24btu/lb\text{-}F(85\text{-}60)F(60min/hr)$

= 20,250 btu/hr

Evaporator:

Water flow rate = 2.6 GPM

Water inlet temperature = 52 F

Water outlet temperature = 42 F

$Q_{evap} = - mc(T_{in} - T_{out})$

= - 2.6gal/min(8.3 lb/gal)(1btu/lb-R)(52-42)F(60min/hr)

= 13,000 btu/hr (with round off)

Compressor:

Current draw = 8 amps

The power input from the compressor is roughly:

Power volts x amps (neglecting the power factor)

= 120 volts x 8 amps

= 960 watts = 3275 btu/hr

Note that the input from the evaporator(13,000 btu/hr) plus the compressor work(3275 btu/hr) is not equal to the heat given off from the condenser(20,250 btu/hr).

Note also that the $COP)_h$ of this unit is not reasonable with a value of

$COP)_h = Q_{cond}/Power = 20,250/3275 = 6.2.$

Typical values of EER for heat pumps are 8 - 12.

IV. Ethical Questions and Solutions

1. What are the relevant facts of this case?

A. The heat pump product information is in error! An energy balance on the heat pump reveals this fact. See solution.

B. You need to buy 200 heat pumps.

C. The supplier has a very good price on heat pumps

D. You could save a lot of money on the initial cost of his heat pumps.

E. His units use a CFC.

2. Are there any unknown relevant facts?

A. Is the supplier violating any federal regulations such as the DOE energy rating standards for heat pumps? All appliances are required to have an energy rating such as EER (in Btu/watt-hr) posted on them. EER greater than about 13 is extremely rare. The EER is about 21 for the product information given on this heat pump. Is this rating correct?

B. Are his heat pumps reliable? Will they break down in 3 years?

C. What will the operating cost be of these units? Will they use more electricity than comparable units?

D. Is the supplier reliable? Will the original units and replacement parts be easily available?

3. What are the relevant parts of the professional codes such as the National Society of Professional Engineers Code?

The NSPE Code of Ethics of Engineers states;

1.b. "Engineers shall approve only those engineering documents which are safe for public health, property and welfare in conformity with accepted standards."

["Accepted standards" here could refer to the DOE Energy Standards which might be violated by the cheaper heat pumps]

1.c. "Engineers shall not reveal facts, data or information obtained in a professional capacity without the prior consent of the client or employer except as authorized or required by law or this Code."

1.d. "Engineers shall not permit the use of their name or firm name nor associate in business ventures with any person or firm which they have reason to believe is engaging in fraudulent or dishonest business or professional practices."

4. Are their any conflicting moral obligations in this problem?

One obligation is to abide by the professional codes, which require engineers to follow technical standards, maintain confidentiality and not associate in business ventures with those who might engage in fraudulent or dishonest business practices.

Another obligation is to get the lowest prices for your client, but also to recommend reliable equipment.

Another obligation is to protect the environment. Using CFC heat pumps may cause pollution or recycling problems, even though you may save your client money on the initial cost.

5. Design alternate solutions to present to your engineering manager. Can you find solutions that satisfy more than one of the competing moral obligations listed in question 3 above?

One solution would be to ask for a DOE test of the heat pumps in order to make sure that the rating is correct. You might also ask if there is a way to insure that the pumps are reliable, that they will not be environmentally harmful, and that there will be a long-term supply of CFC 22. If these requirements can be satisfied, you might be able to get a good deal for your client that does not pose undue harm to the environment. It is doubtful, however, that these conditions can be met. There is no obvious creative-middle-way solution that satisfies all of the competing obligations.

7. What should you do?

You probably should not use these units. They are likely to cause long-term problems for your client and for the environment.