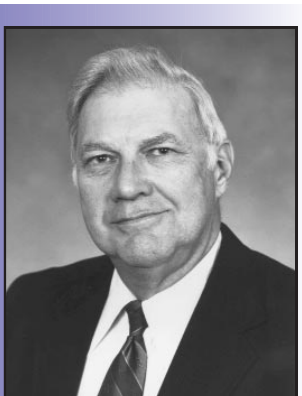
Kele 20/20

SOLUTIONS

Engineering Technical Bulletins Issue #99-10R



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Energy Approximation Tips (EATS)

These "Tips" are intended to give the owners, operators, and engineers a quick estimate of how much it costs to operate HVAC equipment and how much power can be saved when changes are made to the system. The "Tips" are not to be used in preparing energy audits or for other contract documents as they are only “rule of thumb” estimates.

Two new terms "cins" and "geets" have been coined for this discussion. Cfm Inches (cins) is a term for air transport power and is the product of the cfm times total differential pressure. Differential static pressure may be used if total pressure is not known. Gpm feet (geets) is a term for water transport power and is the product of the gpm times the pressure differential in feet of water. Both "cins" and "geets" are comparable to the power term "watts" (volts x amps). A nominal equipment efficiency factor is included in both power terms.

TIP # 1

It costs $80.00 per year per hp to continually operate a motor if energy costs one cent per kwh.

The yearly operating cost is derived from the following equation:

$$\frac{\$.01/\text{KWH} \times .746\ \text{KW/HP} \times 8760\ \text{HR/YR}}{.82\ (\text{EFFICIENCY})} = \$80.00/\text{YR/HP}$$

TIP # 2

The air transport power for fans is approximately 1 hp per 4000 "cins."

This is derived from the basic power equation for transporting air:

$$\text{Fan H.P.} = \frac{\text{C.F.M.} \times \text{S.P.}}{6355 \times \text{Efficiency}}$$

If Fan Efficiency = 63% then

1 Fan H.P. = 4,000 C.F.M. Inches (cins)

TIP # 3

The water transport power for pumps is approximately 1 hp per 3000 "geets." This is derived from the basic power equation for transporting water:

$$\text{Pump H.P.} = \frac{\text{G.P.M.} \times \text{HEAD}}{3960 \times \text{Efficiency}}$$

If Pump Efficiency = 75% then

1 Pump H.P. = 3,000 G.P.M. Feet (geets)

TIP # 4

One ton of refrigeration requires approximately 1 hp.

TIP # 5

Each hp of chilled water pump power and/or supply and return fan power must be offset with 1/5 ton of refrigeration.

$$\frac{2545\ \text{BTU / HP}}{12{,}000\ \text{BTU / TON}} \approx 1/5\ \text{TON/HP}$$

TIP # 6

Water and air flow pressure drop varies as the flow squared.

TIP # 7

Water and air transport power varies as the flow cubed.

QUICK TIP APPLICATIONS

1. **Question:** How much does it cost per year to operate a 50 hp constant volume air

handler fan motor that runs 1/2 the time and energy costs 8¢ per kwh?
Answer: 50 hp x $80.00 per year per hp x 8 (cents per kwh) x 1/2 (run time) = $16,000.00 per year [TIP #1].

2. **Question:** The constant volume AHU fan in Question #1 has a capacity of 50,000 cfm at 4" W.C. Balancing dampers are installed in all branch ducts. These dampers have an average pressure drop across them of 1/2" W.C. How much fan power is wasted on these dampers and what does the wasted energy cost the owner?
Answer: (50,000 cfm x 1/2" W.C.) ÷ (4000 cins) = 6.25 hp [TIP #2]. 6.25 hp x $80.00 per year per hp x 8 (cents per kwh) x 1/2 (run time) = $2,000.00 per year [TIP #1].

3. **Question:** How much fan energy can be saved if the air handler in Question #1 is converted to a VAV unit and the average air flow is 70% of design?

Answer: The theoretical air transport power is: 50 hp x $(0.7)^3$ = 17 hp [TIP #7]. The actual decrease in fan motor power will always be less than the theoretical reduction, depending on the method of volume control selected. Generally variable frequency drives are more efficient than inlet vanes or mechanical speed controllers. It is safe to assume that any of these methods will reduce the power to at least 50% of the theoretical reduction. Using this assumption, the new average fan hp will be 33.5 hp.

Theoretical Reduction = 50 -17 or 33 hp
Actual Reduction = 33 x 0.5 or 16.5 hp
New Average hp = 50 - 16.5 or 33.5

The new yearly AHU fan operating cost will be: 33.5 hp x $80.00 (per year per hp) x 8 (cents per kwh) x 1/2 (run time) = $10,720.00 per year. A savings of $ 5,280.00 per year [TIP #1].

4. **Question:** How much is the refrigeration operating cost reduced by the reduction in fan hp by converting to a VAV system in Question #3?

Answer: Since the average fan power is reduced by 16.5 hp, the load on the cooling coil is reduced by: 16.5 (fan hp) x 1/5 = 3.3 hp [TIP #5].

This results in an additional savings of: 3.3 hp x $80.00 (per year per hp) x 8 (cents per kwh) x 1/2 (run time) = $1,056.00 per year [TIP #1].

5. **Question:** A large central chilled water system has a balancing valve on each chiller. One 1000 ton chiller that operates continuously, has a valve that handles 2400 gpm with a 10 ft drop. How much pump hp is required for this valve and how much does this pressure drop cost the owner?

Answer: (2400 gpm x 10 ft) ÷ (3000 geets) = 8 hp [TIP #3]. 8 hp x $80.00 (per year per hp) x 8 (cents per kwh) = $5,120.00 per year [TIP #1]. In addition the chiller load is reduced 8 hp x 1/5 = 1.6 hp for a further savings of $1,024.00 per year [TIP #5].

6. **Question:** How large is the motor and how much will it cost to operate the motor on an exhaust fan with a capacity of 10,000 cfm at 2" T.P? Fan will operate about 1/3 of the time.

Answer: (10,000 cfm) x (2" T.P.) ÷ (4000 cins) = 5 hp motor [TIP #2]. 5 hp x $80.00/per year per hp x 8 (cents per kwh) x 1/3 (run time) = $1,066.00 per year [TIP #1].

7. **Question:** A high-velocity terminal handles 2000 cfm at 1" inlet pressure. What is the equivalent fan hp?

Answer: (2000 cfm) x (1" S.P.) ÷ (4000 cins) = 1/2 hp [TIP #2].

8. **Question:** If the inlet pressure is reduced to 0.5" on the high-velocity terminals in Question #7, what is the new air flow?

Answer: 2000 cfm $\sqrt{0.5/1}$ = 1414 cfm [TIP #6].

9. **Question:** What is the new equivalent fan hp?

Answer: 1/2 hp x $(1414\text{ cfm}/2000\text{ cfm})^3$ = 0.18 hp [TIP #7].

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