4 Rules of Heat Transfer

What is Heat Transfer?

Heat Transfer (BTU/min.)

=

Temperature Drop (Degrees F)

X

Mass Flow (lbs/min.)

X

Specific Heat (BTU/lb *Degree F)

Substance	Specific Heat BTU/lb*Deg F	Density lbs/ft^2	Density lbs/Gal
Air	0.24	0.0735	0.00983
Water	1.00	61.99	8.28677
50/50 EG H2O	0.78	67.12	8.97254
ATF	0.46	54.50	7.28551
HYD Fluid	0.45	53.34	7.13044
Characteristics at 70 deg F			

Rule #1: ***Heat transfer is proportional to temperature difference.***

If you have twice the temperature difference, you'll have twice the heat transfer rate.

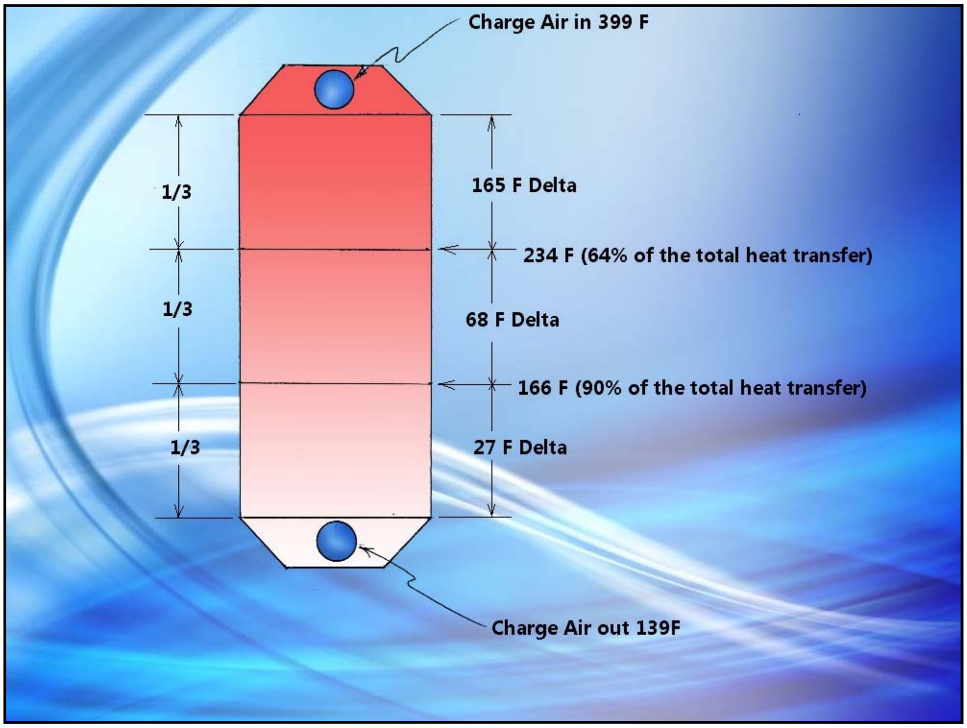
If you have half the temperature difference, you'll have half the heat transfer rate.

*If you have **no** temperature difference, **there will be no heat transfer**.*

An example of this: Say your machine's engine is operating under load at 210 F on a 110 F day.

Using that same heat load it will operate at 220 F on a 120 F day. It requires that 100 F temp difference to dissipate that heat load.

At 80% of that heat load on a 120 F day, it would require a maximum operating temp of 200 or 80 degrees over ambient.

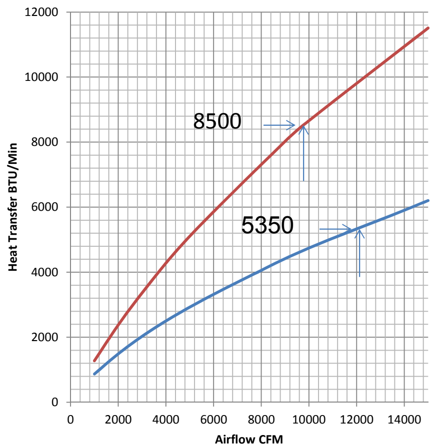


Rule #2: ***Heat transfer is proportional to area.***

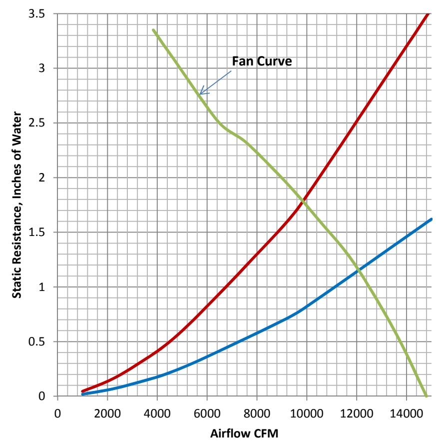
All other variables being equal, a 2 square foot heat exchanger will transfer heat twice as fast as a 1 square foot heat exchanger of the same design.

4.50” Thick Core vs 2.25” Thick Core

Heat Transfer vs Airflow

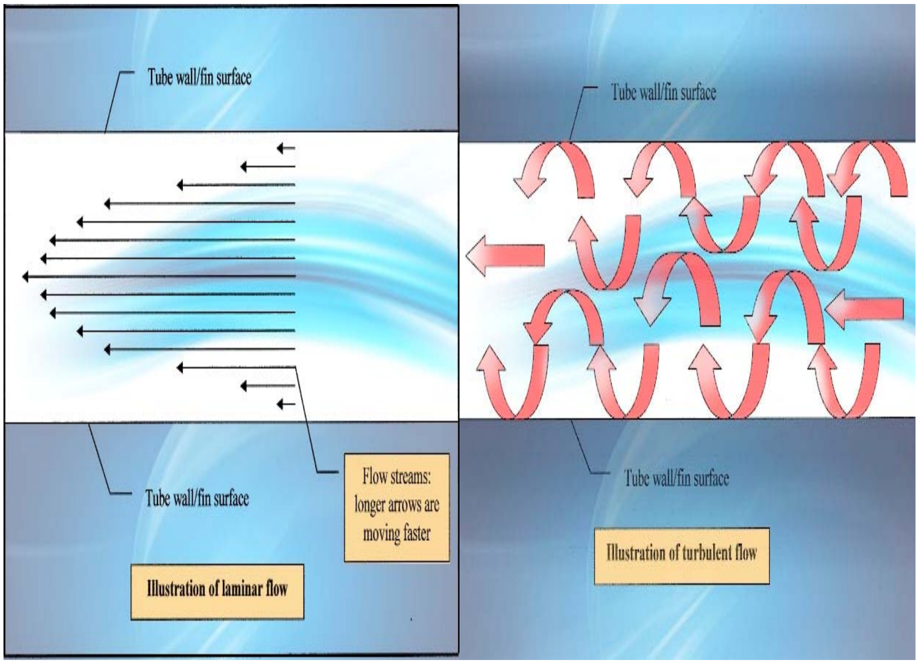


Resistance vs Airflow

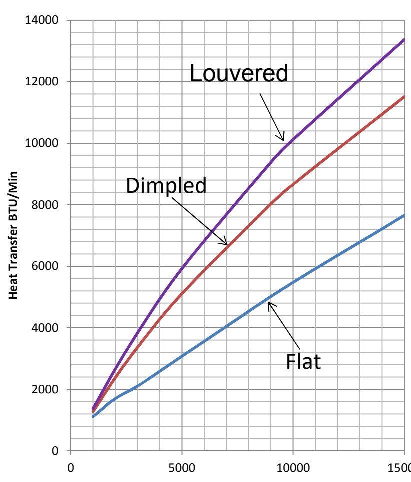


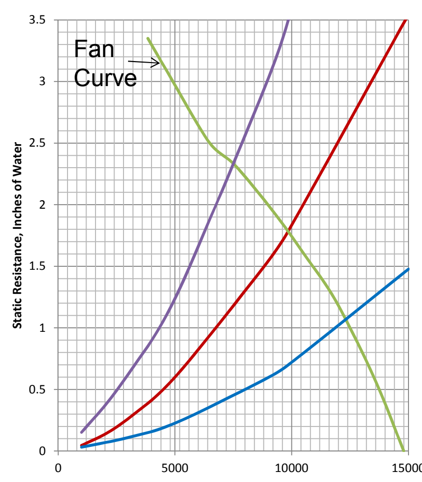
Rule #3: Laminar flow is the enemy of heat transfer; turbulent flow is its friend.

This will require some explanation. Picture a fluid moving between two parallel surfaces, like coolant flowing between two tube walls or air flowing between two fins. During *laminar flow*, the fluid molecules are moving in parallel streamlines. The fluid is moving the fastest right in the middle. As the fluid gets closer to one surface or the other, it moves slower and slower so that at the surface the fluid is not moving at all. This fluid that is not moving is called a boundary layer. It’s bad for heat transfer because the boundary layer is the only fluid that is directly experiencing the heat transfer. It in turn has to pass heat on (or absorb heat from) each subsequent flow stream, one to another, in order to affect the bulk of the fluid flowing at the center. The boundary layer insulates the moving fluid flow from the surfaces where the heat transfer is taking place.

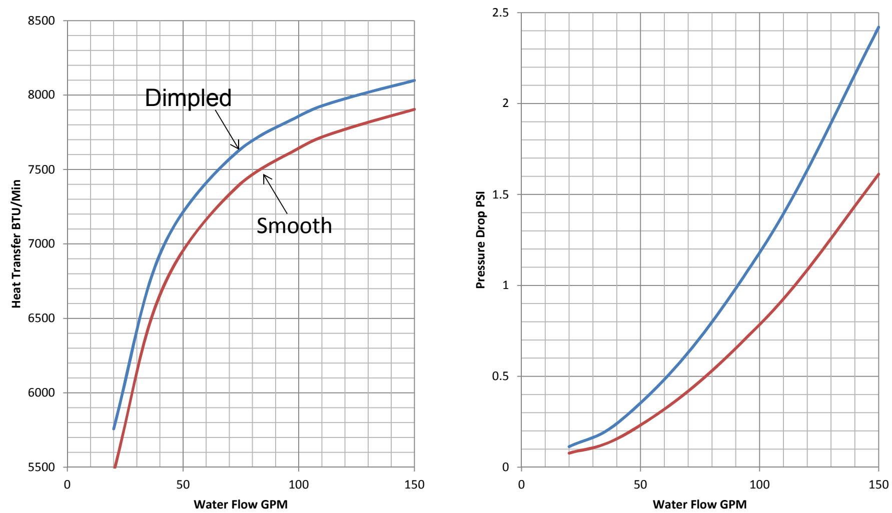


Effect of Louvering/Dimpling Fins





Effect of Dimpling Tubes



Rule #4: ***Mass flow (the pounds of air or pounds of coolant that are flowing through or over the radiator) is just as important to the heat transfer rate as the change in temperature.***

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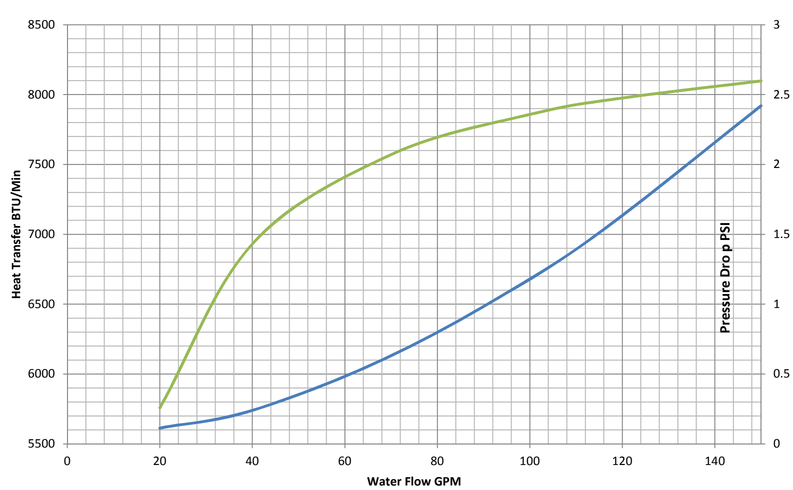
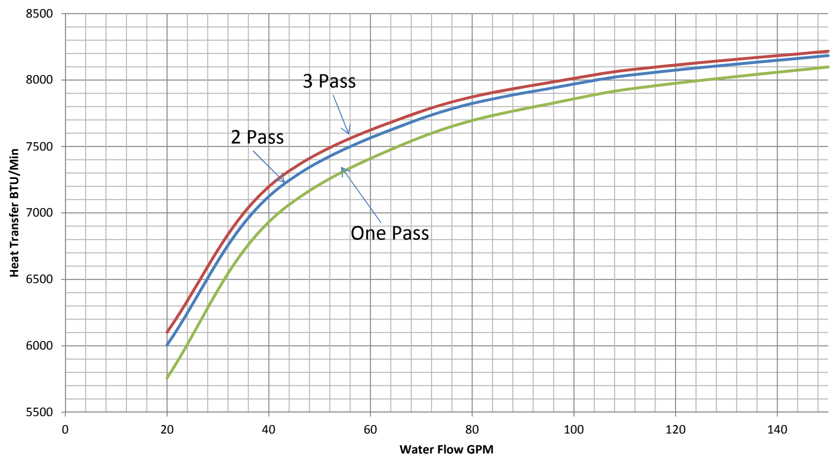
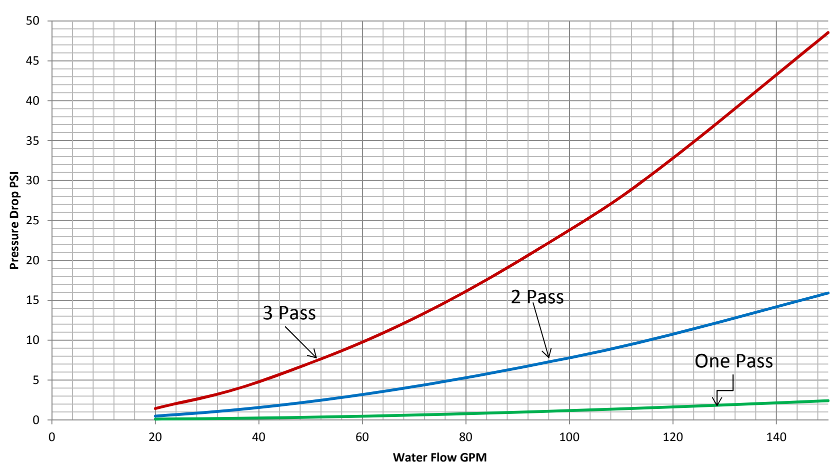


Heat Transfer vs. Coolant Flow

Performance Effects of Multipassing



Pressure Drop Effects of Multipassing



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However, consider what happens when you speed-up the fluid. Eventually you reach a point where the friction between fluid molecules starts dragging away the molecules in the boundary layer and starts mixing-up the flow. This is called *turbulent flow*. This is good for heat transfer because now each fluid molecule has an equal opportunity to experience the heat transfer, taking place at the surfaces.

Rule #4: ***Mass flow (the pounds of air or pounds of coolant that are flowing through or over the radiator) is just as important to the heat transfer rate as the change in temperature.***
In the English system, heat transfer is measured in terms of BTU's (British Thermal Units) divided by some measure of time (BTU/min., BTU/hour etc). A BTU is the amount of heat energy it takes to change 1 pound of water, 1 degree Fahrenheit. If you change the temperature of 2 lbs of water ½ degree F, the heat transfer equals one BTU (2 x ½ = 1). If you change the temperature of ½ lb of water 2 degrees F the heat transfer is still one BTU (1/2 x 2 = 1). If you change the temperature of 10 lbs of water 10 degrees F the heat transfer is 100 BTU's (10 x 10 = 100). If it does it in 1 minute, the heat transfer rate is 100 BTU/min. If it does it in 1 hour, the heat transfer rate is 100 BTU/hour.