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How to determine ?T (temperature differential), given volts and amps (P = EI) or amps and resistance (P = I2 R) and flow (GPM)

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HOW TO DETERMINE ΔT (TEMPERATURE DIFFERENTIAL), GIVEN VOLTS AND AMPS ($P = EI$) OR AMPS AND RESISTANCE ($P = I^2 R$) AND FLOW (GPM)

I. Take accurate flow reading with turbine flow meter. For low flow, use stop watch and known quantity container. When using the latter method, bear in mind that return pressure is 0 psi and flow will be higher than actual. If possible, using supply valve as throttle valve, try and duplicate actual ΔP (pressure differential). Supply pressure minus return pressure equals ΔP.

Once flow has been determined, compare with magnet spec. sheet. Flow should be equal to or greater than spec. sheet depending on ΔP. If flow is less than spec. sheet, clean strainer and/or flush magnet coil by coil, if possible. Recheck flow.

II. Now that correct flow has been established, ΔT can be caclulated using the following formula.

$$Q = MC\ \Delta T(°F) \qquad \text{or} \qquad \Delta T = \frac{Q}{MC}$$

Q = Heat in BTU/Min.

M = Cooling in LBS/Min.

C = Constant (Water = 1)

ΔT = Diff. in Degrees F

a) To determine heat load (Q), it is first necessary to convert known values into watts.

Example:

(1) Want to run mag. 228 at 3200 amps. Check of spec. sheet shows resistance of mag. 228 is .035 ohms. Using formula $P = I^2R$

$P = (3200A)^2$ .035 ohms P = 358,000 watts

or

(2) If at 3200 amps, voltage across magnet is 112 V, then $P = EI$

P = 112V (3200A) P = 358,400 watts

To convert power (watts) into BTU's/min. (Q), multiply by .056.

Example:

Mag. 228 is dumping 358,400 watts into cooling system-convert to BTU's/min

358,400 x .056 = 20070.4 BTU's/min.

Q = 20070.4 BTU's/min.

b) To convert established flow in gpm into lbs/min, multiply by 8.34, as water weighs 8.34 lbs. per gal.

Example:

Mag. 228 has water flow of 26 gpm

26 gpm x 8.34 = 216.84 lbs/min.

M = 216.84 lbs/min.

III. Using the formula $Q = MC\Delta T$, we can now determine the temperature differential using known values.

Example:

What will the temperature differential (ΔT) be on magnet 228, running at 3200 amps, 112 volts. Flow has been verified at 26 gpm.

(1) Rewrite formula

$$\Delta T = \frac{Q}{M(C)}$$

(2) Determine Q

Power (watts) = volts x amps

P = 112 x 3200

P = 358,400 watts

358,400 watts x .056 = 20070.4 BTU's/min.

Q = 20070.4 BTU's/min.

(3) Determine M

Flow in gallons per minute x 8.34 = flow in lbs per minute.

26 gpm x 8.34 = 216.84 lbs/min.

(4) Determine C

C is a constant which happens to be 1 for water, so it can be dropped from the equation.

Therefore

$$\Delta T = \frac{Q}{M}$$

$$\Delta T = \frac{20070.4 \text{ BTU's/min.}}{216.84 \text{ lbs/min}} \quad \begin{matrix}\text{(Heat)}\\ \text{(Cooling)}\end{matrix}$$

$$\Delta T = 92.56°F$$

Adding ΔT to supply water temperature will give return water temperature which is sensed by Klixons or Woods metals.

Suppose supply water temp.	=	75.00°F
ΔT	=	92.56°F
Return water temp.	=	167.56°F

If magnet is equipped with 160°F, Klixons or Woods metals, it will trip off before reaching 3200 A.

Solution: (To be determined by Liaison Engineer):

1. Run magnet less than 3200 A.
2. Replace Klixons/Woods metal buttons with higher limits.
3. Increase flow by raising ΔP (pressure differential) by means of a booster pump.

Formula $Q = MC\Delta T$ can be rewritten to find the following:

Q = BTU/Min = Watts x .056

M = Lbs/Min = gpm x 8.34

C = Constant (1 for water)

ΔT = Temp. differential in degrees F.

A) $Q = MC\Delta T$ - Basic Formula

B) $M = \dfrac{Q}{\Delta T}$

C) $\Delta T = \dfrac{Q}{M}$

Note: When working with water, C or (1) can be eliminated.

$\therefore\ Q = MC\Delta T$

or

$(I^2R \times .056) = (\text{gpm} \times 8.34)(1)(\Delta T)$

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