

How to determine ΔT (temperature differential), given volts and amps ($P = EI$) or amps and resistance ($P = I^2 R$) and flow (GPM)

D. Dayton

June 1981

Collider Accelerator Department
Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

Notice: This technical note has been authored by employees of Brookhaven Science Associates, LLC under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy. The publisher by accepting the technical note for publication acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this technical note, or allow others to do so, for United States Government purposes.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Accelerator Department
BROOKHAVEN NATIONAL LABORATORY
Associated Universities, Inc.

EP&S DIVISION TECHNICAL NOTE

NO. 97

D. Dayton

June 26, 1981

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 calculated using the following formula.

$$Q = MC \Delta T(^{\circ}F) \quad \text{or} \quad \Delta T = \frac{Q}{MC}$$

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 $P = I^2R$

$$P = (3200A)^2 \cdot .035 \text{ ohms} \quad P = 358,000 \text{ watts}$$

or

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

$$P = 112V (3200A) \quad P = 358,400 \text{ watts}$$

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

$$358,400 \times .056 = 20070.4 \text{ BTU's/min.}$$

$$Q = 20070.4 \text{ BTU's/min.}$$

- 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

$$26 \text{ gpm} \times 8.34 = 216.84 \text{ lbs/min.}$$

$$M = 216.84 \text{ lbs/min.}$$

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

$$\text{Power (watts)} = \text{volts} \times \text{amps}$$

$$P = 112 \times 3200$$

$$P = 358,400 \text{ watts}$$

$$358,400 \text{ watts} \times .056 = 20070.4 \text{ BTU's/min.}$$

$$Q = 20070.4 \text{ BTU's/min.}$$

- (3) Determine M

Flow in gallons per minute \times 8.34 = flow in lbs per minute.

$$26 \text{ gpm} \times 8.34 = 216.84 \text{ lbs/min.}$$

(4) Determine C

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

Therefore

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

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

$$\Delta T = 92.56^\circ\text{F}$$

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

Suppose supply water temp. = 75.00°F

$$\Delta T = 92.56^\circ\text{F}$$

Return water temp. = 167.56°F

If magnet is equipped with 160°F , Klixon 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 Klixon/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:

$$Q = \text{BTU/Min} = \text{Watts} \times .056$$

$$M = \text{Lbs/Min} = \text{gpm} \times 8.34$$

$$C = \text{Constant (1 for water)}$$

$$\Delta T = \text{Temp. differential in degrees F.}$$

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

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

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

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

$$\therefore Q = MC\Delta T$$

or

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

cc: L. Arnold F. Kobasiuk
C. Bloxon G. Korhut
M. Candito H. Knudsen
A. Dunn G. Martin
J. Haufman A. Pendzick
R. Hubbard A. Scholtz