NTB, Inc.
Consulting Engineers
525 LOUISIANA AVENUE
SHREVEPORT, LOUISIANA 71101
(318) 226-9199 FAX (318) 221-1208

JOB _____

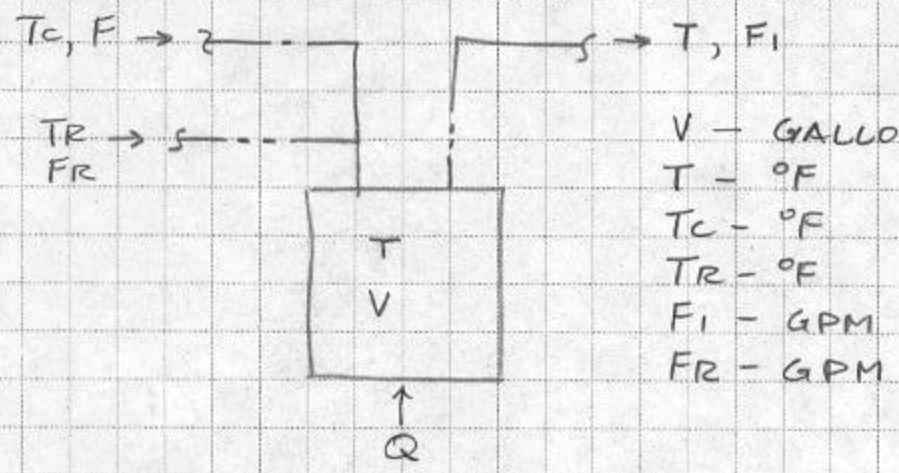
SHEET NO. _____ OF _____

CALCULATED BY _____ DATE _____

CHECKED BY _____ DATE _____

SCALE _____

STORAGE TANK WATER HEATER



V – GALLONS
T – °F
Tc – °F
TR – °F
F1 – GPM
FR – GPM

HEAT IN TANK = (#)$\left(\frac{1\ BTU}{\#\ °F}\right)$(ΔT) (DATUM IS T-Tc)

= V(8.33)(T-Tc)

I CHANGE IN HEAT CONTENT = 8.33(V)dT

II CHANGE IN HEAT CONTENT = HEAT GAIN – HEAT LOSS

HEAT GAIN = $\left(\frac{BTU}{HR}\right)\left(\frac{HR}{60\ MIN}\right)(MIN) = \frac{Q}{60}dt$ (dt = MIN.)

$+ (F_R)(dt)(T_R - T_C)\frac{(500)}{60}$

$= 8.33(F_R)(T_R - T_C)dt + \frac{Q}{60}dt$

HEAT GAIN = $\left[8.33(F_R)(T_R - T_C) + \frac{Q}{60}\right]dt$

HEAT LOSS = 8.33(F)(T-Tc)dt

LET $K_1 = 8.33(V)$, $K_2 = 8.33(F_R)(T_R - T_C)$, $K_3 = \frac{Q}{60}$, $K_4 = 8.33(F)($T-T

$\frac{GAL}{MIN} \times \frac{8.33\#}{GAL} = \frac{8.33\#}{MIN}$

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HEAT GAIN - HEAT LOSS = $(K_2 + K_3)dt - K_4(T - T_C)dt$

HEAT GAIN - HEAT LOSS = $K_1 dT$

$$(K_2 + K_3)dt - K_4(T - T_C)dt = K_1 dT$$
$$(K_2 + K_3)dt + K_4(T_C - T)dt = K_1 dT$$
$$(K_2 + K_3)dt + K_4 T_C dt - K_4 T dt = K_1 dT$$
$$K_2 dt + K_3 dt + K_4 T_C dt - K_4 T dt = K_1 dT$$

$$(K_2 + K_3 + K_4 T_C - K_4 T)dt = K_1 dT$$

$$dt = \frac{K_1 dT}{(K_2 + K_3 + K_4 T_C - K_4 T)}$$

LET $K_5 = K_2 + K_3 + K_4 T_C$

$$dt = \frac{K_1 dT}{K_5 - K_4 T}$$

$$\int_{t_1}^{t_2} dt = \int_{T_1}^{T_2} \frac{K_1 dT}{K_5 - K_4 T} = \Delta t \text{ (min.)}$$

$$\Delta t = K_1 \left[\frac{1}{-K_4} \ln(K_5 - K_4 T) \right]_{T_1}^{T_2}$$

$$\Delta t = -\frac{K_1}{K_4} \left(\ln(K_5 - K_4 T_2) - \ln(K_5 - K_4 T_1) \right)$$

$$\Delta t = \frac{K_1}{K_4} \left(\ln \left(\frac{K_5 - K_4 T_1}{K_5 - K_4 T_2} \right) \right)$$

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$$\Delta t = +\frac{K_1}{K_4} \ln\left(\frac{K_5 - K_4 T_1}{K_5 - K_4 T_2}\right) \quad (\text{MIN.})$$

$K_1 = 8.33\,(V)$ $\qquad K_2 = 8.33\,(F_R)\,(T_R - T_C)$

$K_3 = Q/60$ $\qquad K_4 = 8.33\,(F)$ $\qquad \frac{K_1}{K_4} = \frac{8.33V}{8.33F} = \frac{V}{F}$

$K_5 = K_2 + K_3 + K_4 T_C$

V = TANK VOLUME, GALLONS
F = FLOW RATE OF HOT WATER LEAVING, GPM
F_R = " " " " " RECIRCULATED, GPM
T_1 = INITIAL TANK WATER TEMP., °F
T_2 = FINAL " " " , °F
T_C = TEMP. OF INCOMING COLD WATER, °F
Q = HEAT INPUT TO WATER HEATER, BTU/HR
Δt = MIN,
T_R = TEMP. OF RECIRC. WATER

$$T_2 = \frac{K_5 - (K_5 - K_4 T_1)\, e^{K_7}}{K_4}$$

$K_6 = -\frac{K_1}{K_4}$ $\qquad K_7 = \frac{\Delta t}{K_6}$

$K_6 = -\frac{V}{F}$