MPR

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CALCULATION TITLE PAGE

Client FLORIDA POWER CORPORATION	Page 1 of 41
Project REVIEW OF CALCULATION OF ALLOWABLE MAKEUP TANK PRESSURE VS. LEVEL	Task No. 102-075
Title HEAD LOSS IN BWST TO MAKEUP PUMP FLOW	Calculation No. 102075DHH02

Preparer/Date	Checker/Date	Reviewer/Date	Rev. No.
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RECORD OF REVISIONS

Calculation No.	Prepared By	Checked By	Page
102075DHH02	Harrison	RAW	2

Revision	Description
0	Original Issue, January 5, 1996.

Calculation No.	Prepared By	Checked By	Page 3
102075DHH02	W Harrison	RAW	

HEAD LOSS IN BWST TO MAKEUP PUMP FLOW

1. PURPOSE

The purpose of this calculation is to estimate the loss in total head for the flow from the BWST to the point of tie-in with the line to the makeup tank. The general arrangement of the system is shown schematically in the sketch on page 5. The head losses are calculated for Case 2F of the revised Florida Power Calculation M94-0053 Rev 2 (Ref 1.) In that case:

Flow from BWST to 14x14x6 reducing tee = 4291 gpm
Flow from tee to makeup pump 1C suction = 600 gpm

The water temperature of the BWST flow is 100°F.

2. SUMMARY OF RESULTS

For the specified conditions, the calculated loss in total head from the BWST to the makeup tank tie-in is:

Total head loss = 11.8704 ft (of water at 100°F)

Head loss in 14in pipe and through the 14x14x6 tee to the 6in pipe = 4.0608 ft

Head loss in 6in pipe from outlet of tee to tie in point = 7.8096 ft

3. SUMMARY OF METHODOLOGY

The specific length of pipe and the number and type of fittings were based on the drawings listed as Reference 9.

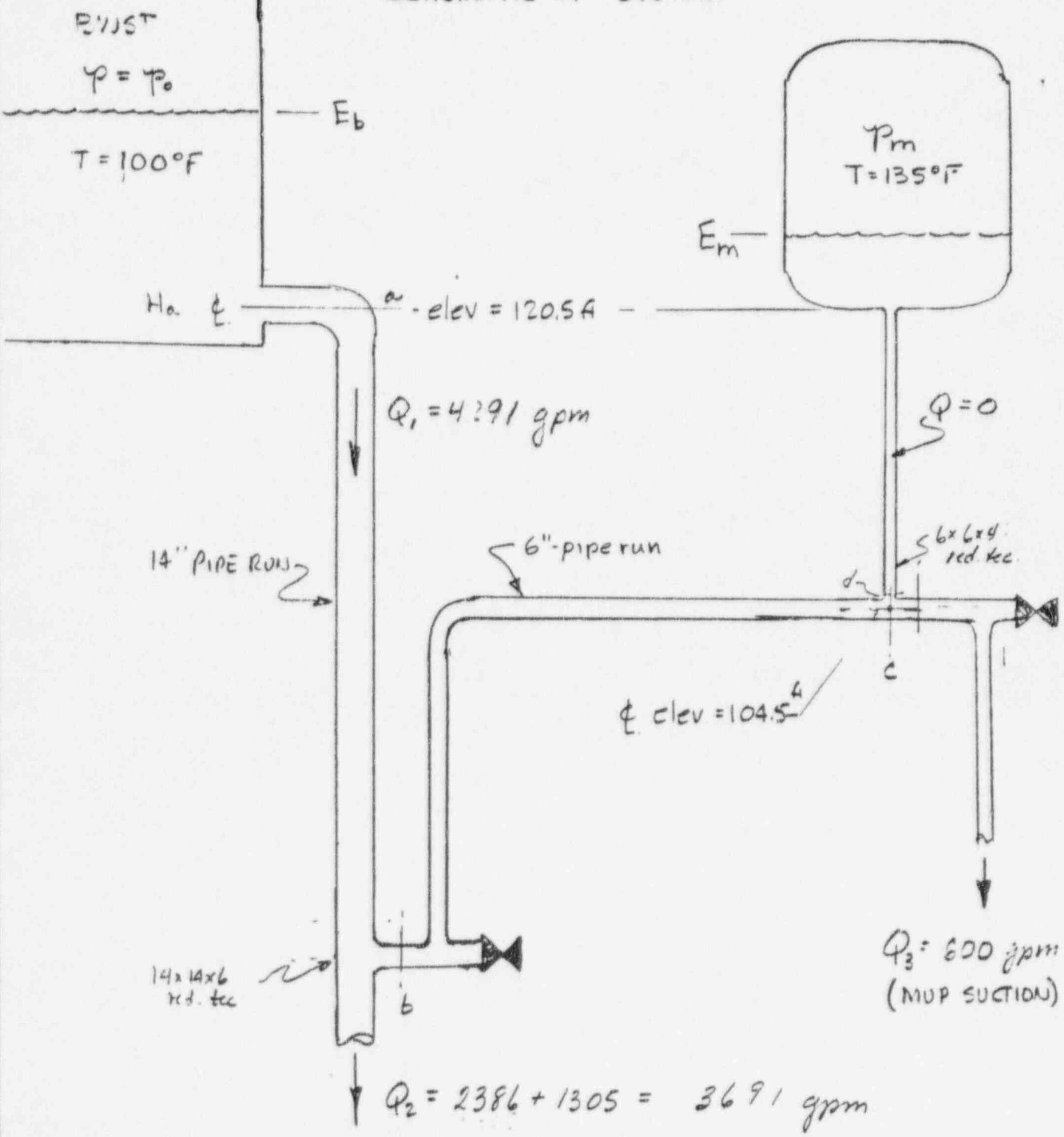
The losses due to fluid friction in the piping and the losses in the components (elbows, valves, nozzles) are calculated from the sources identified. The calculation is divided into the following sections

- Determination of fluid friction factor (Section 4)
- Determination of component loss coefficients (Sect. 5)
- Piping lengths and components (Sect. 6)

The detailed numerical summary is provided in the spreadsheet table of Appendix A

Calculation No.	Prepared By	Checked By	Page
102075D4H02	DHarrison	CAW	

SCHEMATIC OF SYSTEM



4. FRICTION FACTOR

The friction factor for the friction loss in the pipe will be based on the Darcy-Weisbach (Fanning) formula

$$h_f = f \frac{L}{D} \frac{V^2}{2g} \quad \text{for head loss}$$

or, if expressed in pressure loss (lbf/ft^2)

$$\Delta p_f = f \frac{\rho}{g} \frac{L}{D} \frac{V^2}{2}$$

where,

f is the friction factor (dimensionless)
ρ is the weight density (lb/ft^3)
g is the gravitational constant ($32.174\ ft/sec^2$)
L is the length of the run (ft)
D is the pipe inside diameter (ft)
V is the average velocity in the pipe (ft/sec)

The friction factor, f, will be determined from the Colebrook equation*:

$$\frac{1}{\sqrt{f}} = -0.86 \ln\left(\frac{\epsilon/D}{3.7} + \frac{2.51}{N_R\sqrt{f}}\right)$$

where, N_R is Reynold's No. $\frac{VD}{\nu}$ ν = kinematic viscosity ft^2/sec

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* See, for example, any standard Fluid Mechanics reference such as References 2-5, for example, Ref. 4 page 179, eqn 4-84

ϵ is the absolute roughness, ft.

For commerical, new steel pipe ϵ is usually taken as 0.00015 ft (References 3 and 4)

The friction coefficient is evaluated using Mathcad to solve the implicit relation for f. See the following page

DETERMINATION OF FRICTION FACTORS

The dynamic viscosity of water at 100F and approximately atmospheric pressure:

$$\mu := 142.0 \cdot 10^{-7} \cdot \mathrm{lbf} \cdot \frac{\mathrm{sec}}{\mathrm{ft}^2}$$ Ref. 8: ASME Steam Tables (1967), Table 10, page 280 10-20 psia, 100F

The density of water at 100F and approximately atmospheric pressure:

$$\rho := \frac{1}{0.01613} \cdot \frac{\mathrm{lb}}{\mathrm{ft}^3}$$ Ref. 8: ASME Steam Tables (1967), Table 3, page 131, 15 psia, 100F

The kinematic viscosity is then:

$$\nu := \frac{\mu}{\rho} \qquad \nu = 7.369 \cdot 10^{-6} \cdot \frac{\mathrm{ft}^2}{\mathrm{sec}}$$

The absolute roughness will be assumed to be that for commercial steel pipe. Since the piping is stainless steel, there should be little change in serivce. The value is the one normally identified with the Moody curve (see Streeter 2nd ed,. Reference 4, page 183, for example)

$$\varepsilon := 0.00015 \cdot \mathrm{ft}$$

The friction factor, f, is determined from the Colebrook equation (see Reference 4, Streeter, 2nd ed. page 179).

$$\frac{1}{\sqrt{f}} = -0.86 \cdot \ln\left(\frac{\varepsilon}{D \cdot 3.7} + \frac{2.51}{Nr \cdot \sqrt{f}}\right)$$

where, D is the pipe diameter, ft
Nr is Reynolds Number

<u>14-inch nominal pipe:</u>

$$D := 1.1042 \cdot \mathrm{ft} \quad Q := 4291 \cdot \frac{\mathrm{gal}}{\mathrm{min}} \quad V := \frac{Q}{\pi \cdot \frac{D^2}{4}} \quad V = 9.984 \cdot \frac{\mathrm{ft}}{\mathrm{sec}} \quad Nr := \frac{D \cdot V}{\nu} \quad Nr = 1.496 \cdot 10^{6}$$

Guess value $g := 0.01$ $$f := \mathrm{root}\left(-0.86 \cdot \ln\left(\frac{\varepsilon}{D \cdot 3.7} + \frac{2.51}{Nr \cdot \sqrt{g}}\right) - \frac{1}{\sqrt{g}}, g\right) \qquad f = 0.01384$$

<u>6-inch nominal pipe</u>

$$D := 0.5054 \cdot \mathrm{ft} \quad Q := 600 \cdot \frac{\mathrm{gal}}{\mathrm{min}} \quad V := \frac{Q}{\pi \cdot \frac{D^2}{4}} \quad V = 6.664 \cdot \frac{\mathrm{ft}}{\mathrm{sec}} \quad Nr := \frac{D \cdot V}{\nu} \quad Nr = 4.57 \cdot 10^{5}$$

Guess value $g := 0.01$ $$f := \mathrm{root}\left(-0.86 \cdot \ln\left(\frac{\varepsilon}{D \cdot 3.7} + \frac{2.51}{Nr \cdot \sqrt{g}}\right) - \frac{1}{\sqrt{g}}, g\right) \qquad f = 0.01667$$

5. COMPONENT LOSS COEFFICIENTS

This section develops the specific head loss coefficients for the components in the system exclusive of the straight pipe. Note that these coefficients incorporate the friction losses as part of the total loss; consequently, it is not necessary to include the length of the flow path in the friction loss determination.

In general, the simple methods outlined in such widely used references as Crane (Reference 2) are used for common components such as elbows, fully open gate valves, and sudden contractions. For the flow through tees, the more complicated methods of Miller (Reference 3) are used. The check valve flow resistance is based on test results as reported by EPRI in Reference 6.

a. BWST Exit

The exit will be assumed to be a flush, sharp edged entrance, and a value of K = 0.5 will be used (See Reference 2, p A-29).

A rounding of the entrance could reduce this somewhat; however, the tank drawings show a vortex suppression structure, but do not define its configuration. The full loss for a sharp entrance is assumed to account for this uncertainty.

6. ELBOWS.

90° Flanged or buttwelded (not threaded) $r/d = 1.5$

Crane (Ref 2, page A-29)

90° $K = 14 f_T$ where f_T is given in the table on pA-26

Note that both 14 and 6 elbows have $r/d = 1.5$, but

14-in $f_T = .013$ so $K = 14 \times .013 = \underline{0.182}$

6-in $f_T = .015$ $K = 14 \times .015 = \underline{0.210}$

45° $K = (n-1)(0.25\pi f_T \frac{r}{d} + 0.5K) + K$

where n = number of 90° bends = $\frac{1}{2}$

$r/d = 1.5$ and $K = 14 f_T$

$$K = (\tfrac{1}{2}-1)(0.25\pi f_T 1.5 + 0.5 \cdot 14 f_T) + 14 f_T$$

$$K = -\tfrac{1}{2}(1.1781 f_T + 7 f_T) + 14 f_T = 9.91 f_T$$

14-in $K = 9.91 \times .013 = \underline{0.129}$

6-in $K = 9.91 \times .015 = \underline{0.149}$

Two other reference sources were also consulted for elbow losses. Those results are presented on subsequent pages. Both the methods of Ito (Reference 10) and Miller (Reference 3) result in loss coefficients generally lower than the above values. Because of the widespread use of the Crane-based values and because they are somewhat conservative compared to other methods they will be used in the calculations.

Ito (Reference 10) presents a correlation for the total pressure loss in a smooth bend, k_t, as (for $N_R (r/R)^2 > 91$.

$$k_t = 0.00241\,\alpha\,\theta (N_R)^{-0.17} \left(\frac{R}{r}\right)^{0.84} \quad \text{where}$$

α = a constant that depends on θ and R/r.
θ = bend angle, in degrees
N_R = Reynold's number
R = radius of curvature of the bend.
r = inside radius of the pipe.

For long radius elbows $R = 1.5 \cdot 2r$ or $R/r = 3.0$
for $\theta = 90°$ $\alpha = 0.95 + 17.2 (R/r)^{-1.96}$
for $\theta = 45°$ $\alpha = 1 + 14.2 (R/r)^{-1.47}$

Ito defines the total loss coefficient as follows

$$k_t = \frac{\Delta h_t}{\frac{V^2}{2g_c}} \quad \text{where } \Delta h_t = \text{total head loss}$$

Ito's expression is evaluated for the Crystal River 14 and 6 inch pipe on page 14 using Mathcad. be compared to the Crane (Ref. 2).

14-in 90° Ito $K = 0.143$
Crane $K = 0.182$ } Ratio $= \frac{0.143}{0.182} = 0.79$
45° Ito $K = 0.093$
Crane $K = 0.129$ } Ratio $= \frac{0.093}{0.129} = 0.72$

So for the 14-in pipe Ito's correlation gives lower k by 20-25 percent

Similarly for 6-inch pipe

90° Ito K = 0.175
Crane K = 0.210 } Ratio = 0.83
45° Ito K = 0.114
Crane K = 0.149 } Ratio = 0.77

So for 6-inch pipe Ito's correlation gives lower k by about 20 percent.

EVALUATION OF ITO'S EXPRESSION FOR ELBOW HEAD LOSS

This is an evaluation of the following expression from Reference 10:

$$k_t(\alpha,\theta,N_R,R_r) := 0.00241\cdot\alpha\cdot\theta\cdot N_R^{-0.17}\cdot(R_r)^{0.84}$$

For all elbows the radius ratio is: $R_r := 3.0$ (This is a R/D of 1.5 for long radius elbows.)

For <u>14 inch nominal pipe</u>

$N_R := 1.496\cdot 10^6$

90 Degree bend: $\theta := 90$

$\alpha := 0.95 + 17.2\cdot R_r^{-1.96}$ $k_t(\alpha,\theta,N_R,R_r) = 0.143$

45 Degree bend $\theta := 45$

$\alpha := 1 + 14.2\cdot R_r^{-1.47}$ $k_t(\alpha,\theta,N_R,R_r) = 0.093$

For <u>6 inch nominal pipe</u>

$N_R := 4.57\cdot 10^5$

90 Degree bend: $\theta := 90$

$\alpha := 0.95 + 17.2\cdot R_r^{-1.96}$ $k_t(\alpha,\theta,N_R,R_r) = 0.175$

45 Degree bend $\theta := 45$

$\alpha := 1 + 14.2\cdot R_r^{-1.47}$ $k_t(\alpha,\theta,N_R,R_r) = 0.114$

Miller (Reference 3 , p80) in Fig. 5.41 provides a of bend loss coefficient as a function of r/d and the bend angle for a Reynolds number of 10^6.

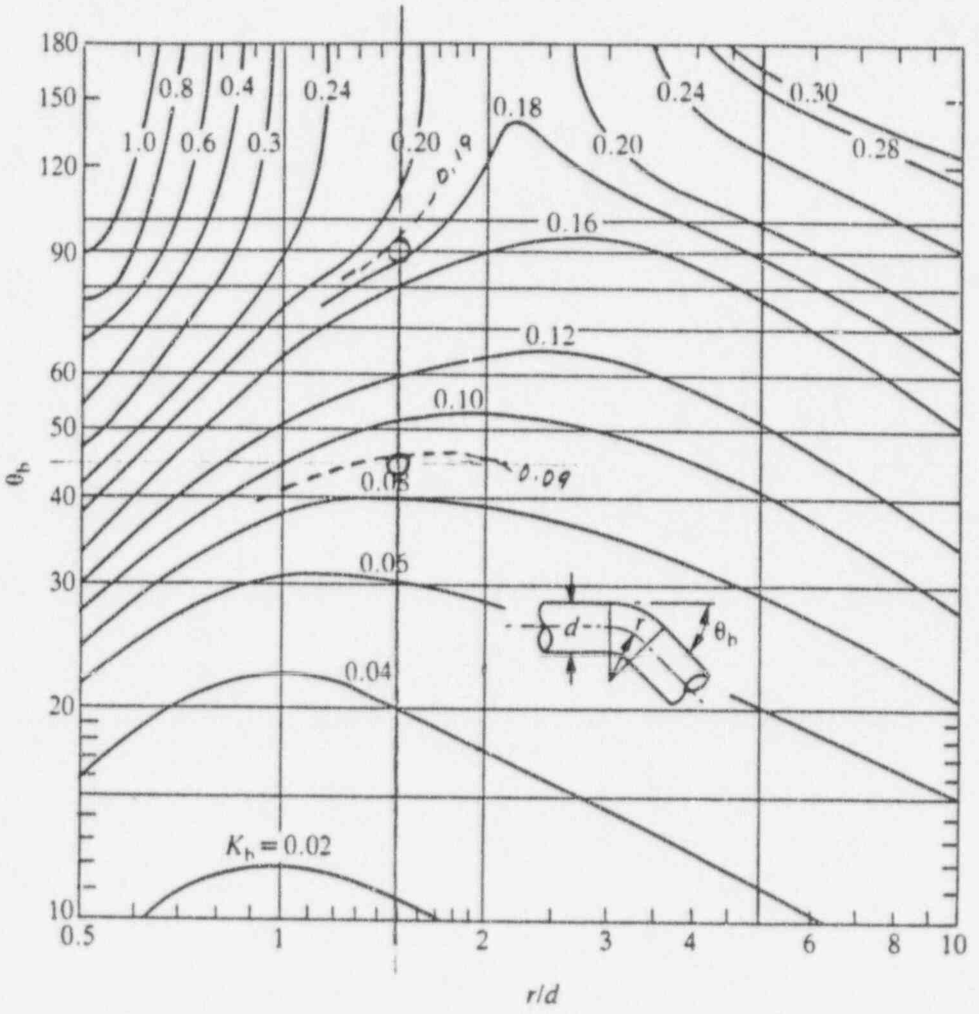


Fig. 5.41. Bend performance chart — circular cross-section (Re = 10^6)

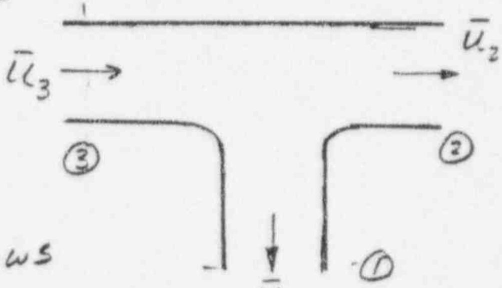
For those conditions: $K_{90} = 0.183$ $K_{45} = 0.088$

These values are lower than obtained by the Crane (Ref. 2) method for all 6-inch elbows and 45° 14-in elbows. The values for 14-in 90° elbows are essentially the same.

c. Tees

14×14×6 Reducing Tee (T1) (branch flow)

Miller (Reference 3, Ch. 13) provides a method to get the pressure change across a tee, with flow out a reduced size branch. The arrangement is as shown in the sketch at right. ūs are the mean velocities in the branches.



p 304, Miller defines a loss coefficient, K_{31}, as follows

where total $H = z + \frac{p}{\rho g} + \frac{u^2}{2g}$ and $h = z + \frac{p}{\rho g}$

$$K_{31} \equiv \frac{\left(\frac{\bar{u}_3^2}{2g} + h_3\right) - \left(\frac{\bar{u}_1^2}{2g} + h_1\right)}{\frac{\bar{u}_2^2}{2g}}$$

K_{31} is given for various values of area and flow ratios in Fig 13.21 of Ref 3 (Miller indicates (p 304) that for $N_r > 2\times10^5$ no correction for N_r is needed. N_R is both 14 and 6 inch runs are $> 2\times10^5$ so no correction is needed.)

Area Ratio:

D_3 14 in pipe = 14.00 − 2×0.375 = 13.250 in = 1.1042 ft.

D_1 = 6 in pipe = 6.625 − 2×0.280 = 6.065 in = 0.50542 ft

$$A_r = \left(\frac{0.50542}{1.1042}\right)^2 = (.45774)^2 = 0.20952$$

Flow Ratio:

Q_1 = 600 gpm Q_3 = 4291 gpm

$$\frac{Q_1}{Q_3} = \frac{600}{4291} = 0.1398$$

Using these values
from Fig 13.21 of Reference 3 (See the following page

$K_{31} = 1.2$

From the definition of K_{31} we can get the head loss, $h_3 - h_1$

$$K_{31} \frac{\bar{u}_3^2}{2g} = \frac{\bar{u}_3^2}{2g} + h_3 - \frac{\bar{u}_1^2}{2g} - h_1$$

$$h_3 - h_1 = K_{31} \frac{\bar{u}_3^2}{2g} - \left(\frac{\bar{u}_3^2}{2g} - \frac{\bar{u}_1^2}{2g} \right)$$

The total head at 1 and 3

$$H_1 = z_1 + \frac{p_1}{\rho g} + \frac{u_1^2}{2g} \qquad H_3 = z_3 + \frac{p_3}{\rho g} + \frac{u_3^2}{2g}$$

or $$H_1 = h_1 + \frac{u_1^2}{2g} \qquad H_3 = h_3 + \frac{u_3^2}{2g}$$

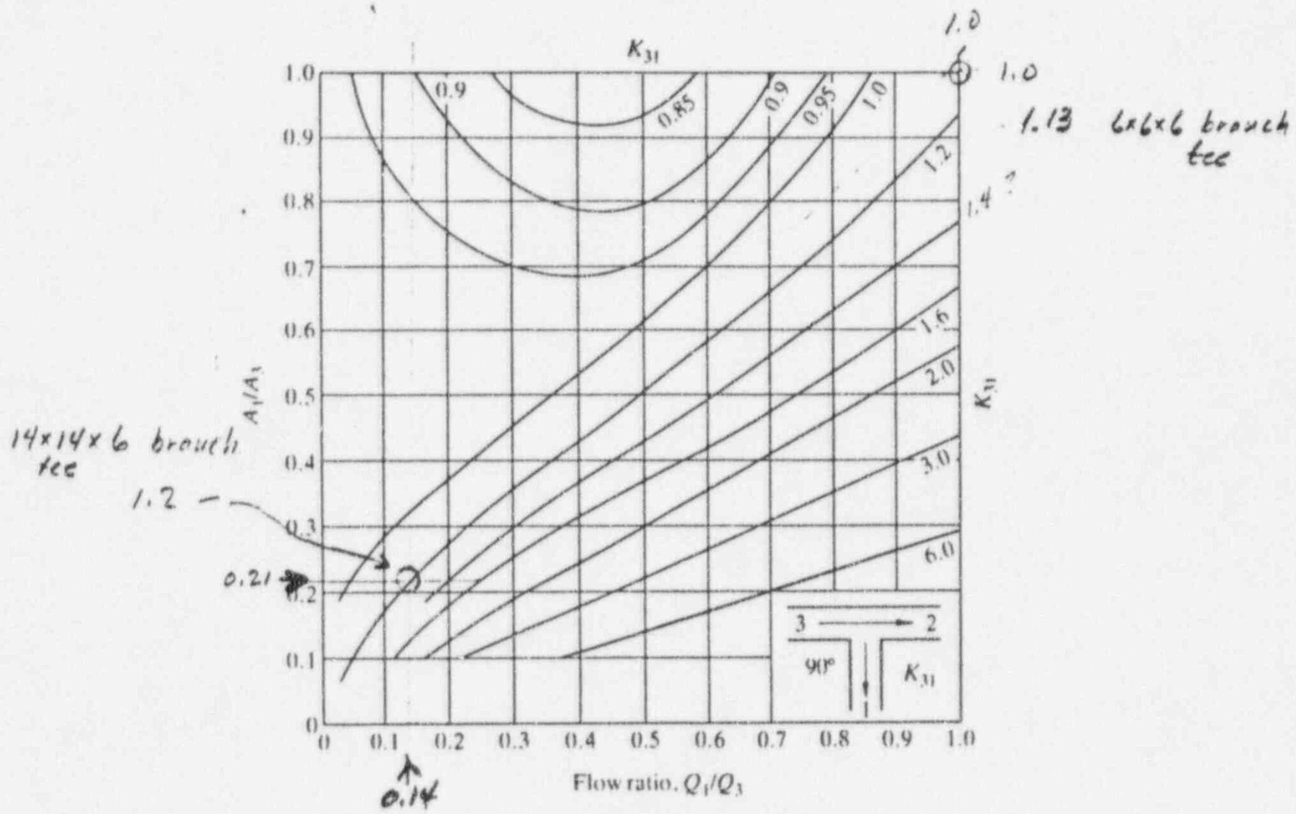
so the total head at 1 [note that this would not be the measured value, but only the apparent value after recovery ~30D]

$$H_3 - H_1 = h_3 + \frac{u_3^2}{2g} - h_1 - \frac{u_1^2}{2g} = (h_3 - h_1) + \left(\frac{u_3^2}{2g} - \frac{u_1^2}{2g} \right)$$

$$H_3 - H_1 = K_{31} \frac{u_3^2}{2g} - \left(\frac{u_3^2}{2g} - \frac{u_1^2}{2g} \right) + \left(\frac{u_3^2}{2g} - u_1^2/2g \right)$$

So $$H_3 - H_1 = K_{31} \frac{u_3^2}{2g} = 1.2 \frac{(9.984)^2}{2 \cdot 32.2} = \underline{1.8574} \text{ ft}$$

CURVE OF K_{31} VALUES FROM REFERENCE 3.



1.0

1.0

1.13 6x6x6 branch tee

14x14x6 branch tee

1.2

0.21

0.14

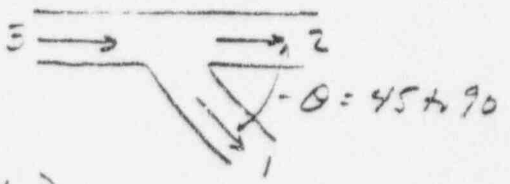
Fig. 13.21†. Dividing flow: branch angle 90°, loss coefficient K_{31}

<u>14×14×10 Reducing Tee</u> (T1a)

Flow in the <u>run</u> branch only (all 14in)

Using Miller (Ref 3, Fig 13.23) see following page.

$\frac{Q_1}{Q_3} = 0$ (no flow in branch)



$$K_{32} \equiv \frac{\left(\frac{u_3^2}{2g} + h_3\right) - \left(\frac{u_2^2}{2g} + h_2\right)}{\frac{u_3^2}{2g}}$$

Fig. 13.23 shows $K_{32} = 0.04$

since $u_3 = u_2$ (no branch flow)

$$K_{32} = \frac{h_3 - h_2}{u_3^2/2g}, \quad h_3 - h_2 = K_{32}\frac{u_3^2}{2g}$$

Compare to the friction loss alone, $L = 1.8333$ ft. $D = 1.1042$ ft

$$f\frac{L}{D} = 0.01384 \times \frac{1.8333}{1.1042} = 0.023$$

The friction loss alone is somewhat less, so use $K = 0.04$

Note, the value in Crane (Ref 2) of $20f$ would give $20 \times 0.01384 = 0.277$ however that is for a pipe thread fitting, not one with a smooth interior. It is not appropriate for this case.

FROM MILLER, Reference 3, page 319

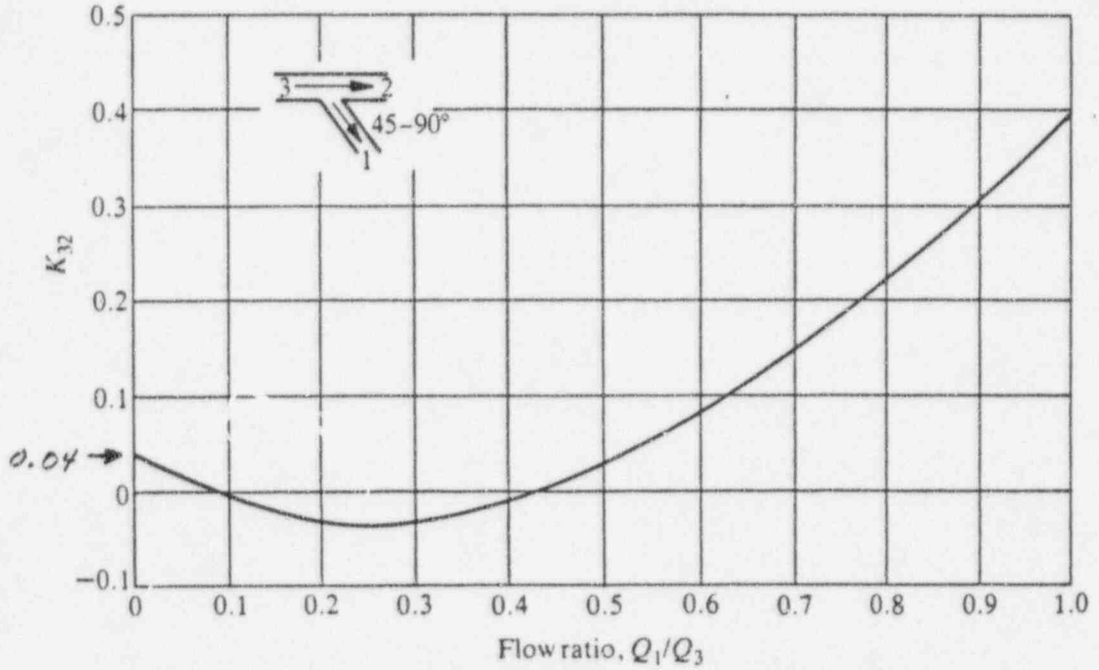
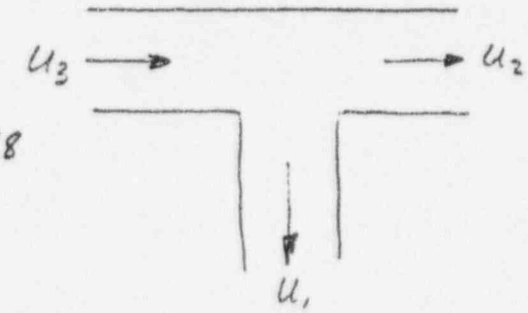


Fig. 13.23. Dividing flow: branch angles of 45–90°, loss coefficient K_{32}

<u>6x6x6 Tee</u> (T2)

Flow in run and out branch, no through run flow.

Using the method in
Miller (Ref 3)
p304 + Fig 13.21 see page 18



$A_r = 1.0$

$Q_r = 1.0$

$K_{31} = 1.13$

$$K_{31} = \frac{\left(\frac{u_3^2}{2g} + h_3\right) - \left(\frac{u_1^2}{2g} + h_1\right)}{u_3^2/2g}$$

$u_3 = u_1$

$$K_{31}\, \frac{u_3^2}{2g} = h_3 - h_1$$

$$h_3 - h_1 = \underbrace{1.13}\, \frac{u_3^2}{2g}$$

6×6×6 Tee (T3)

Flow in run branch only.

As for the 14×14×10 tee, the Fig 13.23 in Miller (Ref. 3) gives a K of 0.04

The friction loss in the run as a pipe would be:

L = 0.9367 ft. D = 0.50542 ft. f = 0.01667

so

$$f\frac{L}{D} = 0.01667 \times \frac{0.9367}{0.50542} = 0.0309$$

so only a small form loss, as would be expected.

so use

K = 0.04

6×6×4 Reducing Tee (T4)

Flow is through the run. In this case the form losses would not be fully realized until after the component; however, half of the 6×6×6 tee loss will be used.

K = 0.02

d. GATE VALVES

6 inch - (MUV-58, MUV-62, MUV-63)

These gate valves will be completely open. The drawing for MUV-58 does not show any reduction of area through the valve.

Crane (Ref. 2 , p A-27) recommends $K = 8f_T$ where f_T comes from a table on p A-26, and for 6in nominal pipe is .015, so $K = .015 \times 8$

or $K = \underline{0.12}$

e. CHECK VALVE

6 inch MUV (Crane 6in 300 lb class, swing check)

Crane (Ref 2, p A-27) gives a K value of $50 f_T$ for the condition where the disk is fully lifted.
For this case, as for the gate valve, f_T will be taken from the table on p A-26, i.e. $f_T = .015$ so

$$K = 50 \times .015 = 0.75$$

This value is correct only if the valve is fully open.

In EPRI NP-5479 (Ref. 6) actual test data are cited for a 6-600 lb Crane valve that show it was not fully open until the velocity, with cold water, reached 11 ft/sec. Consequently, MUV-60 at only 6.7 ft/sec will not be fully open. In that case the K value for the fully open valve will be too low, since the partially open disk will extend into the flow stream.

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Calculation No.	Prepared By	Checked By	Page 25
102075DHH02	Harrison	RAW	

Some test data are available in Reference 6
EPRI NP-5479, Appendix D, on the cold water
pressure drop through a conventional 6 in swing
check valve at various disk angles.
The valve was a Pacific 6"-300 lb valve. The valve
in Crystal River is a Crane 6"-300 lb valve. Although
the valves are not identical, their behavior should be
similar.

Reference 6 shows that the Pacific valve was fully open when the disk had swung to 70°. and that this fully open condition was effectively reached in the 10-14 ft/sec velocity range. The corresponds to the data cited in Fig 3-4 which shows that a Crane 6"-600 valve was fully lifted at about the same velocity ~11 ft/sec. At that point (10-11 ft/sec) the pressure drop across the valve (for 68°F water) was 0.5 psi. At the same velocity, the pressure drop for the 6"-300 Pacific valve reported in NP-5479 was essentially the same · 0.5 psi.

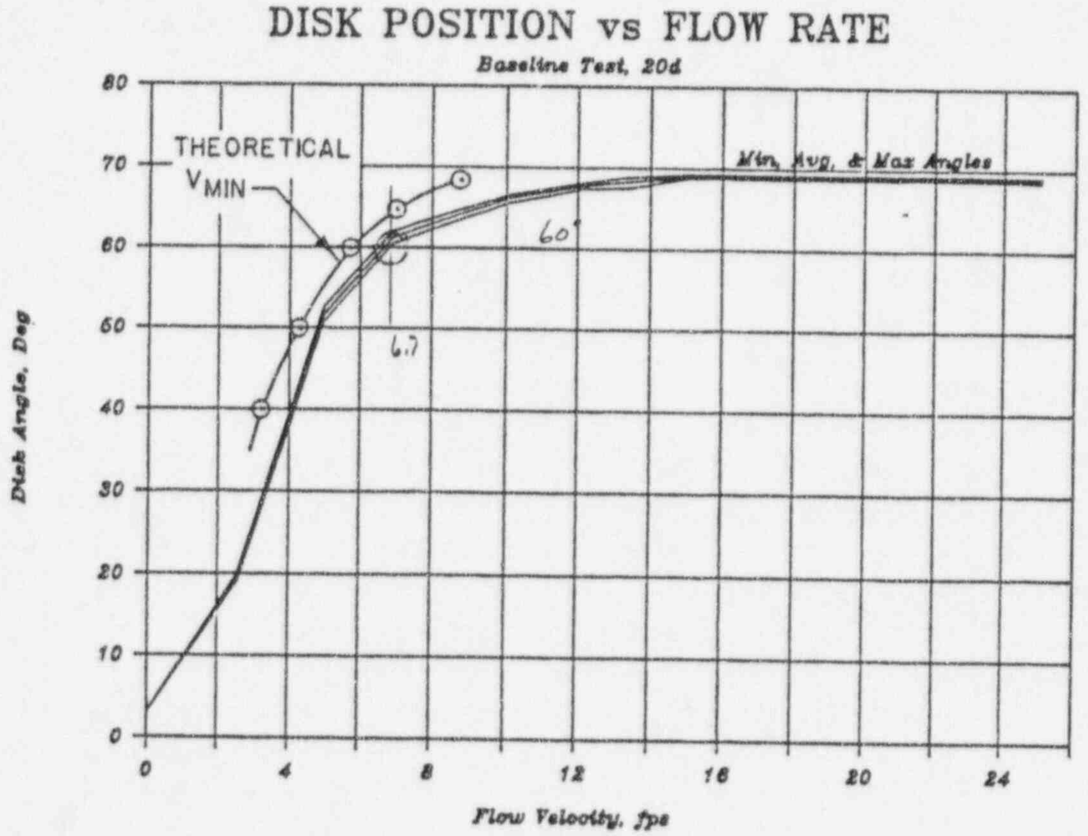
It will be assumed that the Crane 6-300 swing check valve behaves the same as the Pacific 6-300 swing check reported in Appendix D of NP-5479. The EPRI report gives for the Pacific valve:

- A curve (Fig D-7) of disk angle as a function of flow velocity.
- A curve (Fig D-17) of flow coefficient as a function of disk angle.

(See the following pages.)

At the reference velocity of 6.7 ft/sec in the 6 in piping the disk angle from Figure D-7 would be 60°.

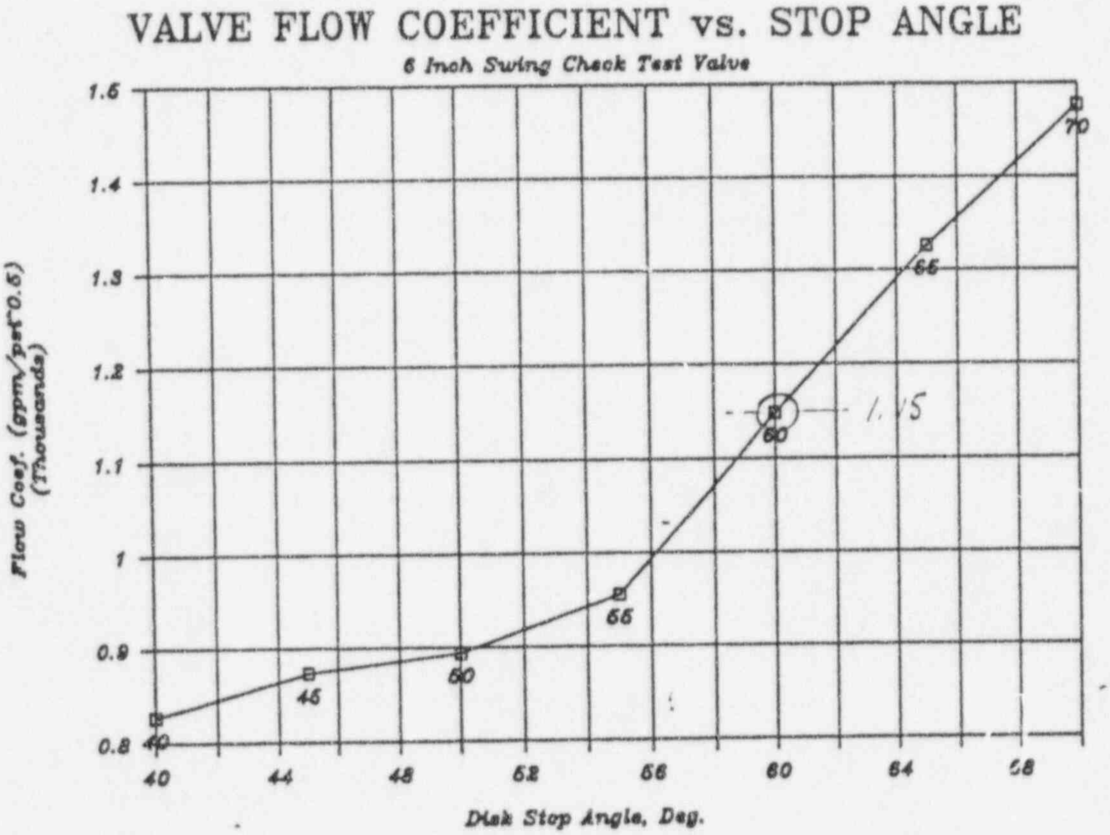
FROM EPRI NP-5479, Reference 6



BASELINE TEST RESULTS FOR 6" SWING CHECK VALVE

FIGURE D-7

FROM EPRI NP-5479 Reference 6.



C_V TEST RESULTS FOR 6" SWING CHECK VALVE

FIGURE D-17

The C_v for that disk angle from Fig D-17 is 1150 $\frac{gpm}{\sqrt{psi}}$.

C_v and K are related by the following expression (Crane, Ref. 2, p 3-4)

$$K = \frac{891\, d^4}{(C_v)^2}$$ where d is pipe ID in inches
d = 6.065 in

$$K = \frac{891\,(6.065)^4}{1150^2} = 0.9116$$

The is slightly higher than the 0.75 value obtained using Crane (Ref. 2) which recommended $50 f_T$.

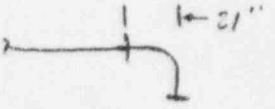
so use K = <u>0.912</u>

6. Piping Lengths and Component Identification

This section tabulates the components and length of straight pipe from the BWST outlet to tie-in to the makeup tank.

Ref. drawing PI-305-816 sh 5 of 5

- BWST Nozzle. -
- P1 - BWST - to elbow



$$L = 7'\,7\tfrac{1}{8}'' - 21'' = 7.594 - 1.750 = \underline{5.844}\ \text{ft.}\ \checkmark$$

- E1 - 90 elbow
- P2a - 90 elbow to tee run

$$L = 7'6'' - 21'' - \frac{1.833}{2} = 7.500 - 1.750 - 0.917 = \underline{4.833}\ \text{ft}\ \checkmark$$

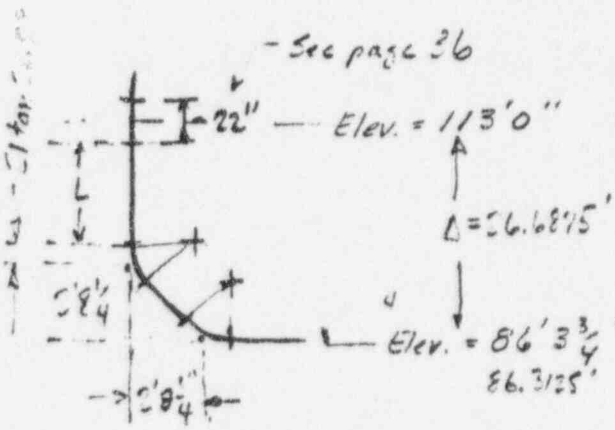
- T1a - Tee Run 14x14x10 Red. Tee
- P2b - tee to elbow

- See page 36

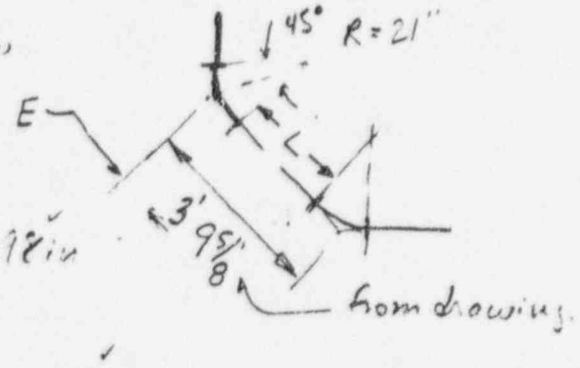
$$L = 26.6875 - 2'8\tfrac{1}{4}'' - \frac{22''}{2} - \frac{21\tan 22.5^\circ}{12}$$

$$L = 26.6875 - 2.6875 - 0.9167 - .7249$$

$$L = \underline{22.3584}\ \checkmark$$



- E2 - elbow 45°
- P3 - angled run - elbow to elbow



$$\frac{E}{21''} = \tan 22.5^\circ$$

$$E = 21 \tan 22.5^\circ = 8.698\text{in}\ \checkmark$$

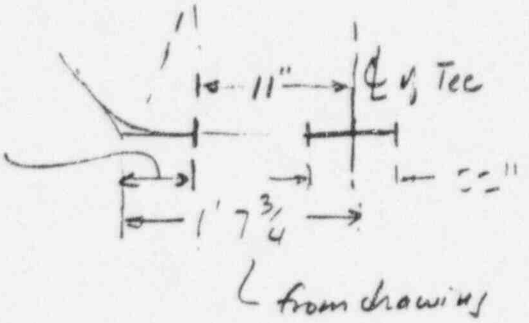
$$E = 0.725\ \text{ft.}$$

$$L = 3'\,9\tfrac{5}{8}'' - 2E = 3.802 - 2 \times 0.725 = \underline{2.352}\ \text{ft.}\ \checkmark$$

Note: Piping and component item numbers are arbitrary assignments, where shown on the drawings they are related to section identification numbers on the drawings, i.e., ㊻ etc.

Not clear whether there is a short run of pipe between the elbow and the tee.

See previous page
E = 0.725 ft



If $1'7\frac{3}{4}'' - E \approx 11''$ there is no pipe

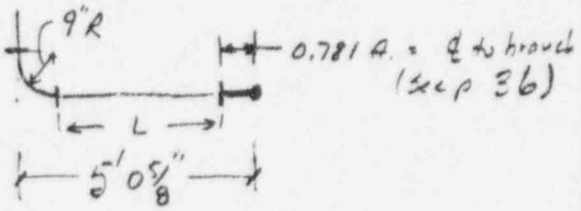
1.646 - 0.725 = 0.921 ft   11" = 0.917 ft - (no pipe)

- T1 - 14×14×6 Red Tee
- P4 - (Tee to 90 elbow)

  $L = 5'0\frac{5}{8}'' - 9'' - 0.781$ ft

  L = 5.0521 - 0.750 - 0.781

  L = 3.521 ft

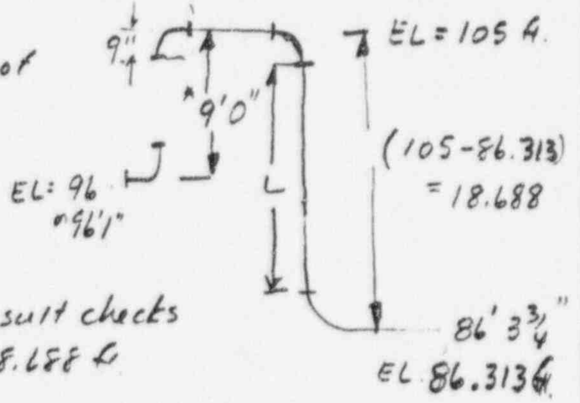


- E4 - 90° elbow
- P5 - Vert. run elbow-elbow

The drawing is not clear on the position of the horizontal pipe. So use elevations.

There is a value of $18'8\frac{1}{4}''$ on the drawing; however, the bottom of the dimension arrow is not distinct, but

$18'8\frac{1}{4}''$ = 18.688 ft - so result checks
use 18.688 ft



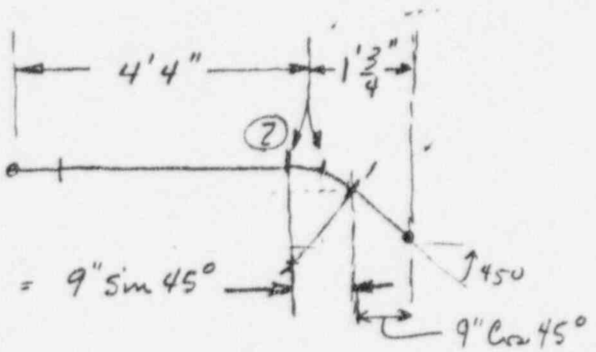
So

$L = 18.688 - 2 \times \frac{9}{12} = 17.188$ ft. ✓

- E5 90° elbow
- E5a 45° elbow

- P6 – elbow to elbow

  Drawing is not clear, there appear to be two dimensions; however, it is not evident whether they are to the match point of the 45° elbow or the weld to the straight pipe.



  <u>if</u> 9" Sin 45° + 9" Cos 45° = 12.75 in then dimension is to weld

  = 12.728 in – so dimension is to weld

  L = 4'4" – 9" = 3.583 ft.

- E6 – 90-elbow
- P7 – elbow-elbow

  L = 9.0 – 2 × 9/12 = 7.500 ft

- E7 – 90-elbow

Reference
drwg PI-303-816 sh 50, 5

drwg PI-303-816 sh 2 of 2

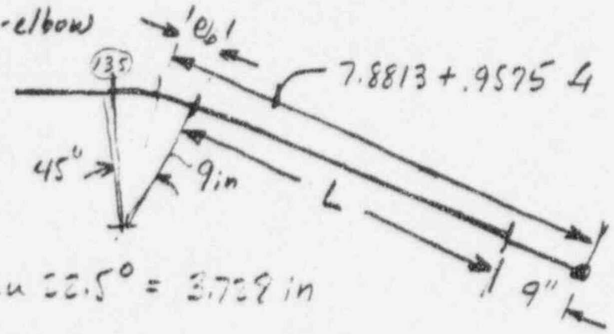
- MUV-58 – 6" Gate valve (44-47)
- P47-48 – between Valves. L = 0.5729 ft. from drawing.
- MUV-60 6" check valve (48-49)
- T2 – 6-tee – (out branch)

- PT2-129- tee to 90 elbow

  $L = 8' - \text{tee br} - \text{elbow}$ (for Tee br. see p 37)

  $L = 8.0 - 0.469 - 0.750 = \underline{6.781}$ ft

- E129-131 – 90° elbow
- P131-133- elbow-elbow

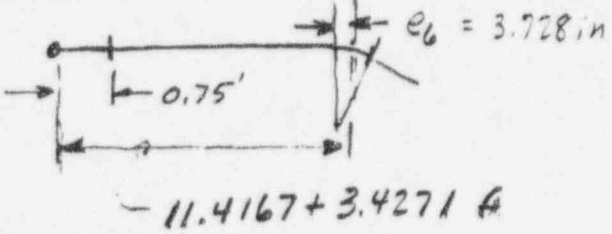


$e_6 = 9 \tan 22.5° = 3.728$ in

$L = 7.8813 + 0.9575 - \frac{3.728}{12} - \frac{9}{12} = \underline{7.778}$ ft. ✓

$\qquad\qquad\qquad\qquad\qquad 0.311 \qquad 0.750$

- E133-135 – 45° elbow
- P135-139- elbow to elbow



$L = 11.4167 + 3.4271 - 0.75 - \frac{3.728}{12} = \underline{13.783}$ ft. ✓ ✓

- E139-141 - 90-elbow
- P141-142 – elbow to elbow

  $L = 2.000 - 2 \times 0.750 = \underline{0.500}$ ft. ✓

- E142-144 – 90-elbow
- P144-151 - elbow to elbow

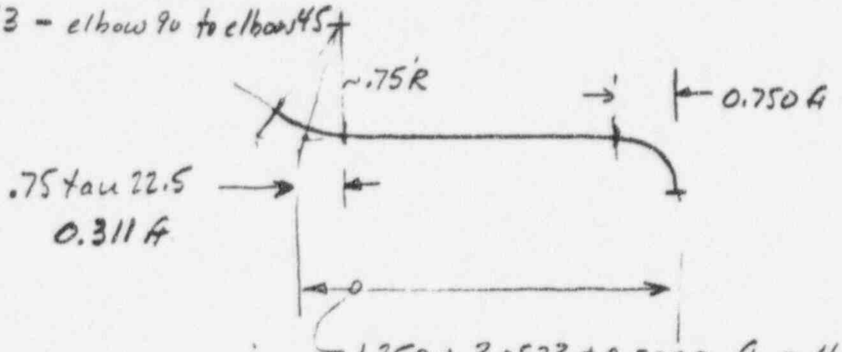
  $L = 2.500 + 11.000 + 10.000 + 10.500 - 2 \times .075 = \underline{32.50}$ ft

- E151-153 – 90-elbow

Calculation No.	Prepared By	Checked By	Page 33
102075DHH02		RAW	

DRAWING P1-303-861 sh 2 of 2

- P156-153 - elbow 90 to elbow 45

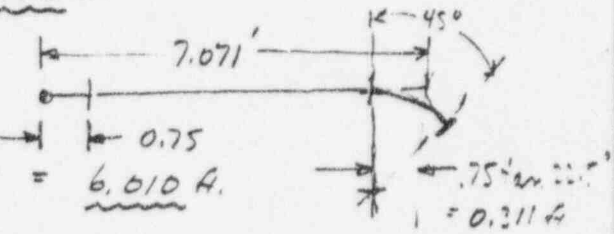


1.250 + 3.0833 + 0.5000 ft = 4.833 ft ✓

L = 4.833 - 0.311 - 0.750 = 3.772 ft ✓

- E156-158 - 45° elbow
- P160-158 - elbow-elbow

  L = 7.0710 - 0.750 - 0.311 = 6.010 ft.



- E160-162 - 90° elbow

DRAWING P1-305-858 sh 2 of 2

- E162-164 - 90° elbow
- P177-164 - elbow to elbow - L = 6.000 + 7.250 + 7.250 + 7.250 + 7.250 + 16.250 + 1.0 - 2×.750

  L = 52.20 - 1.50 = 50.750 ft
- E177-179 - 90° elbow
- P179-182 elbow to elbow

  L = 4.500 + 4.25 - 2×.750 = 8.75 - 1.50 = 7.25 ft
- E182-184 - 90° elbow
- P184-T3 - elbow to tee, (as-built dimensions used)

  $L = 5.3333 + 0.7917 + 0.8750 - 0.750 - \frac{0.938}{2}$ (For tee dimensions see p. 37)

  L = 5.781 ft
- T3 - 6×6×6 Tee-run

  (no pipe between tee and valve)
- MUV-62 6" Gate Valve
- P206-207 - valve to valve

  L = 0.9167 ft (as-built)
- MUV-63 6" Gate Valve
- P210-T4 MUV-63 to T

  L = 5.5000 + 5.5417 - 0.938/2 = 10.573 ft
- T4 - 6×6×4 tee.

Calculation No.	Prepared By	Checked By	Page
102075DHH02	ADHarrison	RAW	34

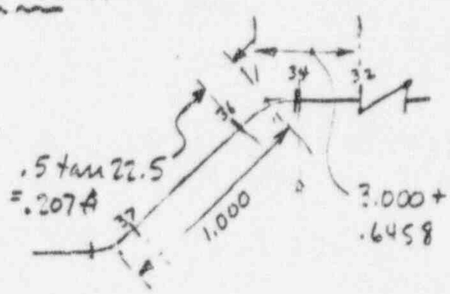
Piping from Makeup Tank to Tie-in Point

This information used to establish volume of piping.

Reference drawing PI-305-866 Sh1 of 2

- PTK-4 - makeup tank to elbow
  $L = 14.50 - 0.500 = \underline{14.00}$ ft.
- ELBOW-90°
- P6-12 - elbow to elbow
  $L = 1.500 + 1.000 + 3.250 - 2 \times 0.500 = \underline{4.750}$ ft
- ELBOW-90°
- TEE 4x4x3 - Run
- P29-27 tee to valve
  $L = 1.3333 + 2.5729 - 0.688/2 = \underline{3.562}$ ft

  (For Tee dimensions see p 37.)
- MUV-65 4" check valve. L = 1.1667 ft.
- P34-32 check valve to 45 elbow
  $L = 3.000 + 0.6458 - 0.207 = \underline{3.439}$ ft
- ELBOW-45°
- P36-37 elbow to elbow
  $L = 1.000 - 2 \times 0.207 = 0.586$ ft



- E37-39 - 45° elbow
- PV64-39 elbow to valve
  $L = 0.4167 + 1.1042 - 0.207 = \underline{1.314}$ ft.
- MUV-64 valve. L = 2 × 0.6667 ft
- P56-44 valve to elbow
  $L = 4.1667 + .3333 + 9.7500 + .8333 + 9.6667$
  $+ 4.250 + 2.0 + 4.5833 + 7.500 - 0.6667 - 0.5$
  $L = \underline{41.917}$ ft.
- ELBOW 90°
- P58-65 elbow to elbow
  $L = .8229 + 9.500 + 10.000 + 2.000 - 2 \times 0.5$
  $L = \underline{21.323}$ ft.
- ELBOW 90°

- P67-69 elbow to elbow (use as-built)

  $L = 2.3333 - 2 \times 0.5 = \underline{1.333}$ ft.
- ELBOW 90°
- P74-71 elbow to tee

  (For tee dimension see p37)

  $L = (\underset{1.5}{106 - 104.5}) - 0.500 - 0.427$

  $L = \underline{0.573}$ ft.
- TEE 6×6×4 - Branch

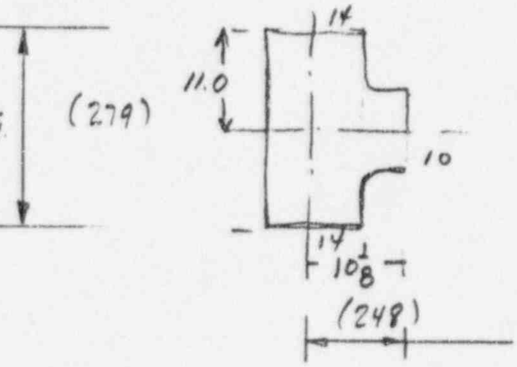
STANDARD TEE DIMENSIONS   Ref: ASME B16.9 (1993) (Ref. 7)

These dimensions are used to establish the lengths of straight pipe.

T1a. 14×14×10 Reducing Tee (Std)   Ref. 9

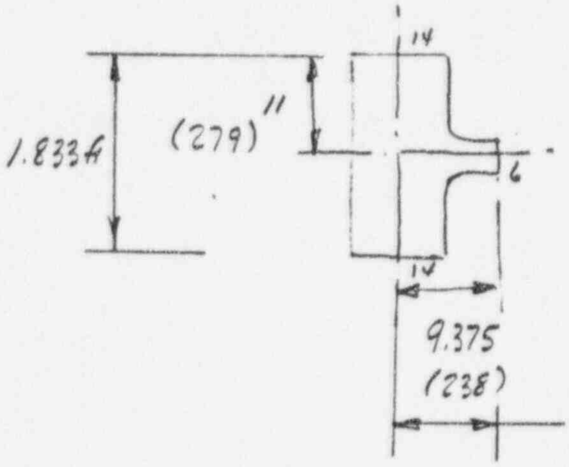
14 in Sch 30 14 OD - 0.375 in wall   Ref. 9

10.75 OD - 0.365 in wall   Ref. 9



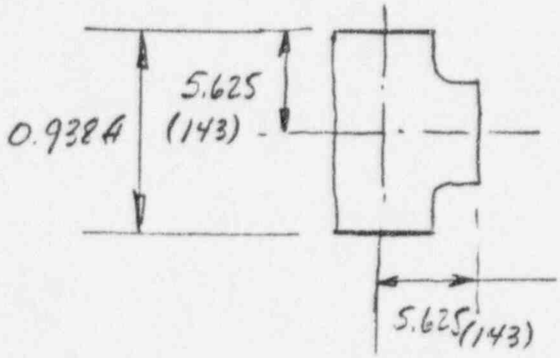
T1 14×14×6 Reducing Tee (Std)

6 in - 6.625 OD × 0.280 wall   Ref. 9.



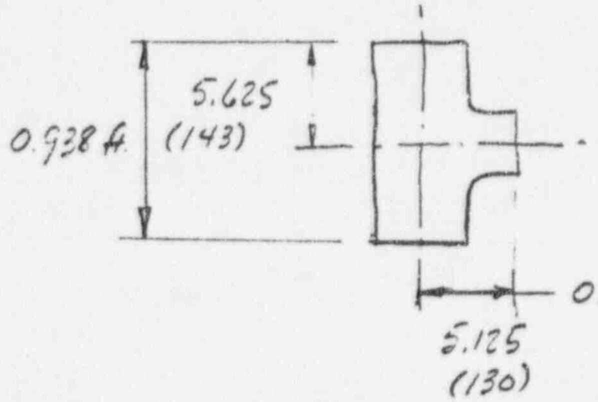
T2 6×6×6 Ref. 9

T3 6in · 6.625 × 0.280 wall Ref. 9



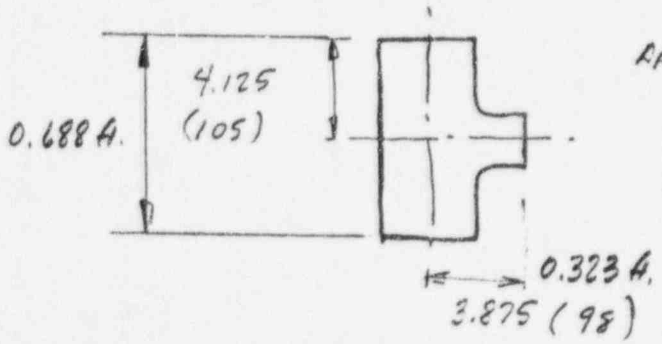
T4 6×6×4 Ref. 9

4in 4.500OD × 0.237 wall = 4.026 ID Ref. 9



Ref. 9

T5 4×4×3 3in = 3.500 OD × 0.216 wall = 3.068 ID



Approx Vol =

$$\frac{\pi}{4} 4.026^2 \times 2 \times 4.125 + \frac{\pi}{4} 3.068^2 \times \left(3.875 - \overset{2.341}{\frac{3.068}{2}}\right) =$$

$105.025 + 17.306 = 122.331\ in^3$

Calculation No. 102075DHH02	Prepared By	Checked By	Page 38

7. REFERENCES

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4. V. L. Streeter, Fluid Mechanics, Second Edition, McGraw-Hill, New York, (1958)
5. I.E. Idelchik, Handbook of Hydraulic Resistance, Second Edition, Hemisphere, Washington (1986) Translated and Edited by G.R. Malyavskaya, Martynenko, and Fried.
6. Electric Power Research Institute, "Application Guidelines for Check Valves in Nuclear Power Plants," EPRI NP-5479, January 1988.
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8. American Society of Mechanical Engineers, "ASME Steam Tables," ASME, New York 1967.

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9. Florida Power CORPORATION, CRYSTAL RIVER PLANT, UNIT No. 3 DRAWINGS

PI-305-816, sh. 5 of 5, Rev. 0 - Seismic Diagram, D.H. System, "Decay Heat Removal from Decay Heat Pump 3-B to Pen #345."

PI-305-861, sh 2 of 2, Rev. 0 - Seismic Diagram, M.U. System, "From Borated Water Storage Tank to Makeup Pump Suctions."

PI-305-858, sh 2 of 2, Rev. 0 - Seismic Diagram, M.U. System, "From MUV-69 to Make-up Pump Suctions 3A-3B-3C"

10. H. Ito, "Pressure Losses in Smooth Pipe Bends," Transactions of the ASME, Series D, Journal of Basic Engineering, March 1960, pages 131-143.

APPENDIX A

This appendix consists of a printout of the spread sheet used to perform the quantitative calculations of head loss. The majority of the values are input from other calculations. The spread sheet performs the following simple calculation:

$$\Delta H = \left(f \frac{L}{D} + K\right) \frac{V^2}{2g}$$

and then sums the values.

The "items" are identified in Section 6.

The loss factors are obtained from Section 5

The friction factors are obtained in Section 4

Item	Nom. Size in	Description	Ref Drwg	Straight Pipe Length Ft	Elevation Ft	Comp Flow Length Ft	Flow Diameter Ft	Pipe L/D	Comp. Total Loss Coef	Friction Factor	Velocity ft/sec	Velocity Head ft	Combined Head Los Coeff K	Head Loss ft
NBWST	14	outlet nozzle			120.5	0	1.1042	0	0.5	0.01384	9.984	1.548	0.5	0.7739
P1	14	pipe	-816	5.844	120.5		1.1042	5.292519		0.01384	9.984	1.548	0.073248	0.1134
E1	14	90 elbow	-816		120.5-vert	2.7489	1.1042	0	0.182	0.01384	9.984	1.548	0.182	0.2817
P2a	14	pipe	-816	4.833	vertical		1.1042	4.376924		0.01384	9.984	1.548	0.060577	0.0938
T1a	14-10-14	run tee	-816		vertical	1.8333	1.1042	0	0.04	0.01384	9.984	1.548	0.04	0.0619
P2b	14	pipe	-816	22.3584	vertical		1.1042	20.24851		0.01384	9.984	1.548	0.280239	0.4338
E2	14	45 elbow	-816		vert-45el	1.3744	1.1042	0	0.129	0.01384	9.984	1.548	0.129	0.1997
P3	14	pipe	-816	2.352	45 angle		1.1042	2.130049		0.01384	9.984	1.548	0.02948	0.0456
E3	14	45 elbow	-816		45el-86.3	1.3744	1.1042	0	0.129	0.01384	9.984	1.548	0.129	0.1997
T1	14-6-14	red br tee	-816		86.313		1.1042	0	1.2	0.01368	9.984	1.548	1.2	1.8574
Sum				35.3874				32.048	2.18				2.623544	4.0608
P4	6	pipe	-816	3.521	86.313		0.5054	6.966759		0.01667	6.664	0.690	0.116136	0.0801
E4	6	90 elbow	-816		86.313-ve	1.1781	0.5054	0	0.21	0.01667	6.664	0.690	0.21	0.1448
P5	6	pipe	-816	17.188	vertical		0.5054	34.00871		0.01667	6.664	0.690	0.566925	0.3909
E5	6	90 elbow	-816		vert-105	1.1781	0.5054	0	0.21	0.01667	6.664	0.690	0.21	0.1448
E5a	6	45 elbow	-816		105	0.58905	0.5054	0	0.149	0.01667	6.664	0.690	0.149	0.1027
P6	6	pipe	-816	3.583	105		0.5054	7.089434		0.01667	6.664	0.690	0.118181	0.0815
E6	6	90 elbow	-816		105-vert	1.1781	0.5054	0	0.21	0.01667	6.664	0.690	0.21	0.1448
P7	6	pipe	-816	7.5	vertical		0.5054	14.83973		0.01667	6.664	0.690	0.247378	0.1706
E7	6	90 elbow	-816		vert-96	1.1781	0.5054	0	0.21	0.01667	6.664	0.690	0.21	0.1448
MUV-58	6	gate vlv	-861		96	1.323	0.5054	0	0.12	0.01667	6.664	0.690	0.12	0.0827
P47-48	6	pipe	-861	0.5729	96		0.5054	1.133558		0.01667	6.664	0.690	0.018896	0.0130
MUV-60	6	check vlv	-861		96	0	0.5054	0	0.912	0.01667	6.664	0.690	0.912	0.6289
T2	6-6-6	br tee	-861		96		0.5054	0	1.13	0.01667	6.664	0.690	1.13	0.7792
P129-T2	6	pipe	-861	6.781	vertical		0.5054	13.4171		0.01667	6.664	0.690	0.223663	0.1542
E129-131	6	90 elbow	-861		vert-104	1.1781	0.5054	0	0.21	0.01667	6.664	0.690	0.21	0.1448
P131-133	6	pipe	-861	7.778	104		0.5054	15.38979		0.01667	6.664	0.690	0.256548	0.1769
E133-135	6	45 elbow	-861		104	0.58905	0.5054	0	0.149	0.01667	6.664	0.690	0.149	0.1027
P135-139	6	pipe	-861	13.783	104		0.5054	27.27147		0.01667	6.664	0.690	0.454615	0.3135
E139-141	6	90 elbow	-861		104-vert	1.1781	0.5054	0	0.21	0.01667	6.664	0.690	0.21	0.1448
P141-142	6	pipe	-861	0.5	vertical		0.5054	0.989315		0.01667	6.664	0.690	0.016492	0.0114
E142-144	6	90 elbow	-861		vert-106	1.1781	0.5054	0	0.21	0.01667	6.664	0.690	0.21	0.1448
P144-151	6	pipe	-861	32.5	106		0.5054	64.3055		0.01667	6.664	0.690	1.071973	0.7392
E151-153	6	90 elbow	-861		106	1.1781	0.5054	0	0.21	0.01667	6.664	0.690	0.21	0.1448
P156-153	6	pipe	-861	3.772	106		0.5054	7.463395		0.01667	6.664	0.690	0.124415	0.0858
E156-158	6	45 elbow	-861		106	0.58905	0.5054	0	0.149	0.01667	6.664	0.690	0.149	0.1027
P160-158	6	pipe	-861	6.01	106		0.5054	11.89157		0.01667	6.664	0.690	0.198232	0.1367
E160-162	6	90 elbow	-861		106-vert	1.1781	0.5054	0	0.21	0.01667	6.664	0.690	0.21	0.1448
E162-164	6	90 elbow	-858		vert-104.5	1.1781	0.5054	0	0.21	0.01667	6.664	0.690	0.21	0.1448
P177-164	6	pipe	-858	50.75	104.5		0.5054	100.4155		0.01667	6.664	0.690	1.673927	1.1543
E177-179	6	90 elbow	-858		104.5	1.1781	0.5054	0	0.21	0.01667	6.664	0.690	0.21	0.1448
P179-182	6	pipe	-858	7.25	104.5		0.5054	14.34507		0.01667	6.664	0.690	0.239132	0.1649
E182-184	6	90 elbow	-858		104.5	1.1781	0.5054	0	0.21	0.01667	6.664	0.690	0.21	0.1448
P184-T3	6	pipe	-858	5.781	104.5		0.5054	11.43846		0.01667	6.664	0.690	0.190679	0.1315
Sum				167.2699				330.9654	5.129				10.64619	7.3414
T3	6	run tee	-858		104.5	0.9367	0.5054	0	0.04	0.01667	6.664	0.690	0.04	0.0276
MUV-62	6	gate vlv	-858		104.5	1.1666	0.5054	0	0.12	0.01667	6.664	0.690	0.12	0.0827
P206-207	6	pipe	-858	0.9167	104.5		0.5054	1.813811		0.01667	6.664	0.690	0.030236	0.0209
MUV-63	6	gate vlv	-858		104.5	1.1666	0.5054	0	0.12	0.01667	6.664	0.690	0.12	0.0827
P210-T4	6	pipe	-858	10.573	104.5		0.5054	20.92006		0.01667	6.664	0.690	0.348737	0.2405
T4	6-4-6	half run tee	-858		104.5		0.5054	0	0.02	0.01667	6.664	0.690	0.02	0.0138
Sum				11.4897				22.73387	0.3				0.678974	0.4682
Sum all														11.8704

Prepared by: W Harrison
Checked by: RAW