The Effect of System Pressure on Head Loss Components (Part 2: Water Distribution to Groups of Buildings)

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Abstract—For varying total water distribution rates in the range of 0.88L/s to 60L/s (with corresponding numbers of sanitary appliances ranging from 17 to 204 and numbers of bungalows in the range of 1 to 16), pressure head losses due to friction and through fittings were calculated for available distribution heads of 2.5m, 5.0m, 7.5m, and 10m. The effect of available head (which is governed by the reservoir elevation) on the fraction of the total head loss which accounts for that through pipe fittings was studied. The results show that the fractions of loss due to pipe fittings decrease (with a corresponding increase in the fraction due to pipe friction) with increasing available system pressure.

Index Terms—Variation of Available Head, Water Distribution to Groups of Buildings

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1. INTRODUCTION

THE result of an earlier study on the effect of available pressure on the frictional and separation head loss components for varying system parameters in water distribution systems within buildings had indicated that the fraction of the total loss which is due to pipe fittings (i.e. the separation loss fraction) reduces with increasing system pressure [1]. In that study the pressure variation was achieved by varying the elevation of the water reservoir.

A similar study is carried out here for water distribution to groups of buildings; the results of which would be relevant to such distribution systems as in housing estates. For the present study, also, the system parameters such as the number of buildings served, total flow rate from the reservoir, and number of sanitary appliances served would be varied so as to achieve a wider application of the results.

2. ANALYTICAL METHOD

Basically the methods adopted in the earlier study [1] on water distribution within buildings are applied here.

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This involves the use of a pipe sizing graph (obtained from the Hazen-Williams formula) for obtaining the frictional loss and utilizing the fitting loss factor *K* in the D'Arcy - Weisbach equation to obtain the loss through pipe fittings [1].

3. COMPUTATIONS AND RESULTS FOR THE FIRST INDEX PIPE RUNS

To obtain rational fractions of losses due to friction and due to pipe fittings for water distribution to groups of buildings, the scenario of Fig. 1 is utilized, wherein the distribution source is an elevated storage which supplies a set of uniformly arranged 16 bungalows. Each bungalow contains 17 sanitary appliances made up of 5 water closets, 5 wash basins, 2 bath tubs, 3 water heaters, 1 shower tray and I kitchen sink. In Fig. 1 the pipe sections are labeled using boxes in which the number to the left is the pipe section number, that to the top right is the measured pipe length (in m) and that on the bottom right is the flow rate in the pipe section (in L/s).

An initial available pressure head of 2.5 m representing the difference in elevation between the outlet of the reservoir and the highest sanitary appliance supplied from the reservoir, is utilised in the analysis of losses due to friction and fittings. The procedure of the analysis is the same as that reported in the earlier study [1].

As a first step, the analysis is done for the pipe run from A to E and up to the farthest appliance supplied in bungalow 1 by the branch from E (considering the extension of the main distribution pipe from E towards P and the extension on the branch from point H towards K in Fig. 1 as non-existent). The calculations for this first step for an available head of 2.5m are presented in Table 1.

The foregoing analysis is then repeated for available heads of 5.0m, 7.5m and 10.0m. The corresponding calculation summaries using these heads are shown in Tables 2 to 4.

In the second step, Bungalow 2 is added on in the analysis (considering only the extension from H towards K, L, M, N and O, in Fig. 1, as existing). Again, using the available heads of 2.5m, 5.0m, 7.5m and 10.0m, the calculation summaries of Tables 5 to 8 are obtained for this second step.

In the third step, Bungalow 3 is added on in like manner; and up to the sixteenth step whence the first index pipe run from A to the last sanitary appliance in pipe section 39 (of Bungalow 16), which is shown in an isometric sketch of Fig. 2 is analyzed.

The general layouts of one and two bungalows are shown in Figs. 3 and 4, respectively. The progressive increase in number of bungalows in successive steps of the analysis provides the variation of the complexity of pipework in terms of number of buildings supplied from the reservoir, length of first index pipe run, total design flow rate, and number of sanitary appliances served.

The calculated head loss components as well as the ratios of loss through fittings to total loss for the varying system pressure heads for each of the sixteen first index pipe runs (corresponding to the sixteen steps of the analysis) are presented in Tables 9 to 24. Figures 5 to 20 are Excel plots which show the effect of varying the distribution pressure on the fraction of head loss due to fittings in water distribution to the group of buildings.

4. DISCUSSION OF RESULTS

Except for the cases of water distribution to 4 bungalows (having 68 sanitary appliances which are supplied with a flow of 2.35L/s) and distribution to 6 bungalows (having 102 appliances supplied with a flow of 2.90L/s), all the other fourteen cases depict a decrease in fraction of the head loss through fittings (with an increasing fraction due to pipe friction) with increasing system pressure, within the limits of system parameters used in the analysis. This variation, as in the case of distribution within buildings [1] is of second order.

The discrepancies depicted for the cases of distribution to 4 bungalows (showing no variation of the loss fractions with increasing pressure) and 6 bungalows (showing slightly increasing fractions) could be due to computational error.

The Excel plots show a general increase in the plotted ratios with increasing system complexity represented as increasing number of buildings, sanitary appliances and flow rates.

The Excel plots are useful in estimating fractions of head loss components for varying available system pressure and system complexity. For instance, from Fig. 19 for the system supplying 15 bungalows having 225 appliances with a 5.00L/s flow rate, at an available head from the reservoir of 6m, a 0.44 fraction can be predicted for the separation losses in the first index run of pipework.

Then, with a knowledge of the frictional head loss component (which is easier to estimate than the total loss through the fittings) the total head loss in the first index run is readily obtained.

5. CONCLUSION

Pressure head losses due to pipe friction and through fittings have been computed for first index pipe runs for various elevations of the reservoir and for varying numbers of buildings supplied (with corresponding numbers of sanitary appliances and flow rates) in water distribution to groups of buildings. Excel plots which depict the effect of system pressure head on the fraction of total loss through pipe fittings were thereby obtained.

Also, distribution systems serving entire settlements and towns may be analyzed by the illustrated method.

REFERENCE

1. J. I. Sodiki, "The Effect of System Pressure on Head Loss Components (Part 1: Water Distribution within Buildings)" International Journal of Scientific and Engineering Research, Submitted for Publication

Table 1: Calculations for Pipe Sizes and Head Loss Components for Water Distribution for an Available Head of 2.5m to 1 Bungalow, 17 Appliances, 0.88L/s Flow Rate

1	2	3	4	5	6	7	8	9	10	11
Pipe section No. (See Fig. 1)	Loading unit	Design Flow (L/s)	Pipe length (m)	Permissible max. H/L	Dia. (mm)	Actual H/L	Frictional head loss h_f (m)	Fittings (other than reducers)	Reducers (mm x mm)	Loss thru fittings, h_p (m)
A to B	49.5	0.88	23.3	0.037	40	0.0240	0.5592	3 elbows, 2 gate v., 1 tee	-	0.119
B to C	46.0	0.85	3.6	0.037	40	0.0220	0.0792	1 tee	-	0.046
C to D	41.0	0.80	3.4	0.037	40	0.0190	0.0646	1 tee	-	0.041
D to F	25.5	0.50	12.4	0.037	32	0.0085	0.1054	1elbow, 1 tee	40 x 32	0.064
F to G	19.0	0.43	5.6	0.037	32	0.0170	0.0952	1 tee	-	0.029
G to I	3.5	0.12	17.0	0.037	20	0.0150	0.2550	4 elbows, 1g.v., 1 tee	32 x 20	0.039
I to J	1.5	0.05	2.0	0.037	15	0.0048	0.0096	3 elbows, 1 g.v.	20 x 15	0.010
			67.3				1.1682			0.348

Table 2: Calculations for Pipe Sizes and Head Loss Components for Water Distribution for an Available Head of 5m to 1 Bungalow, 17 Appliances, 0.88L/s Flow Rate

1	2	3	4	5	6	7	8	9	10	11
Pipe section No. (See Fig. 1)	Loading unit	Design Flow (L/s)	Pipe length (m)	Permissible max. H/L	Dia. (mm)	Actual H/L	Frictional head loss h_f (m)	Fittings (other than reducers)	Reducers (mm x mm)	Loss thru fittings, h_p (m)
A to B	49.5	0.88	25.8	0.072	32	0.0600	1.5480	3 elbows, 2 gate v. 1 tee	-	0.291
B to C	46.0	0.85	3.6	0.072	32	0.0550	0.1980	1 tee	-	0.114
C to D	41.0	0.80	3.4	0.072	32	0.0500	0.1700	1 tee	-	0.101
D to F	25.5	0.50	12.4	0.072	25	0.0650	0.8060	1elbow, 1 tee	32 x 25	0.151
F to G	19.0	0.43	5.6	0.072	25	0.0500	0.2800	1 tee	-	0.078
G to I	3.5	0.12	17.0	0.072	20	0.0150	0.2550	4 elbows, 1g.v 1 tee	25 x 20	0.039
I to J	1.5	0.05	2.0	0.072	15	0.0200	0.0400	3 elbows, 1 g.v.	20 x 15	0.010
			69.8				3.2917			0.784

Table 3: Calculations for Pipe Sizes and Head Loss Components for Water Distribution for an Available Head of 7.5m to 1 Bungalow, 17 Appliances, 0.88L/s Flow Rate

1	2	3	4	5	6	7	8	9	10	11
Pipe section No. (See Fig. 1)	Loading unit	Design Flow (L/s)	Pipe length (m)	Permissible max. H/L	Dia. (mm)	Actual H/L	Frictional head loss h_f (m)	Fittings (other than reducers)	Reducers (mm x mm)	Loss thru fittings, h_p (m)
A to B	49.5	0.88	28.3	0.104	32	0.060	1.698	3 elbows, 2 gate v., 1 tee	-	0.291
B to C	46.0	0.85	3.6	0.104	32	0.055	0.198	1 tee	-	0.114
C to D	41.0	0.80	3.4	0.104	32	0.050	0.170	1 tee	-	0.101
D to F	25.5	0.50	12.4	0.104	25	0.065	0.806	1elbow, 1 tee	32 x 25	0.151
F to G	19.0	0.43	5.6	0.104	25	0.050	0.280	1 tee	-	0.078
G to I	3.5	0.12	17.0	0.104	20	0.015	0.255	4 elbows, 1g.v., 1 tee	25x 20	0.039
I to J	1.5	0.05	2.0	0.104	15	0.020	0.040	3 elbows, 1 g. v.	20 x 15	0.010
			72.3				3.417			0.784

Table 4: Calculations for Pipe Sizes and Head Loss Components for Water Distribution for an Available Head of 10.0m to 1 Bungalow, 17 Appliances, 0.88L/s Flow Rate

1	2	3	4	5	6	7	8	9	10	11
Pipe section No. (See Fig. 1)	Loading unit	Design Flow (L/s)	Pipe length (m)	Permissible max. H/L	Dia. (mm)	Actual H/L	Frictional head loss h_f (m)	Fittings (other than reducers)	Reducers (mmxmm)	Loss thru fittings, h_p (m)
A to B	49.5	0.88	30.8	0.134	32	0.060	1.848	3 elbows, 2 gate v. 1 tee	-	0.291
B to C	46.0	0.85	3.6	0.134	32	0.055	0.198	1 tee	-	0.114
C to D	41.0	0.80	3.4	0.134	32	0.050	0.170	1 tee	-	0.101
D to F	25.5	0.50	12.4	0.134	25	0.065	0.806	1 elbow, 1 tee	32 x 25	0.151
F to G	19.0	0.43	5.6	0.134	25	0.050	0.280	1 tee	-	0.078
G to I	3.5	0.12	17.0	0.134	20	0.015	1.785	4 elbows, 1g.v, 1 tee	25x 15	0.126
I to J	1.5	0.05	2.0	0.134	15	0.020	0.040	3 elbows, 1 g.v.	-	0.010
			74.8				5.127			0.871

Table 5: Calculations for Pipe Sizes and Head Loss Components for Water Distribution for an Available Head of 2.5m to 2 Bungalows, 34 Appliances, 1.35 L/s Flow Rate

1	2	3	4	5	6	7	8	9	10	11
Pipe section No. (See Fig. 1)	Loading unit	Design Flow (L/s)	Pipe length (m)	Permissible max. H/L	Dia. (mm)	Actual H/L	Frictional head loss h_f (m)	Fittings (other than reducers)	Reducers (mmxmm)	Loss thru fittings, h_p (m)
A to B	99.0	1.35	23.3	0.027	50	0.0150	0.3495	3 elbows, 2 gate v., 1 tee	-	0.115
B to C	95.5	1.30	3.6	0.027	50	0.0100	0.0360	1 tee	-	0.045
C to D	90.5	1.25	3.4	0.027	50	0.0085	0.0289	1 tee	-	0.031
D to F	75.0	1.10	12.4	0.027	50	0.0075	0.0930	1elbow, 1 tee	-	0.044
F to G	68.5	0.98	5.6	0.027	50	0.0063	0.0353	1 tee	-	0.025
G to H	53.0	0.90	4.0	0.027	40	0.0250	0.1000	1 tee	50 x 40	0.055
H to K	49.5	0.88	8.0	0.027	40	0.0240	0.1920	1g.v, 1 tee	-	0.056
K to L	25.5	0.50	7.0	0.027	32	0.0220	0.1540	1 tee	40 x 32	0.064
L to M	19.0	0.43	5.6	0.027	32	0.0170	0.0952	1 tee	-	0.029
M to N	3.5	0.12	17.0	0.027	20	0.0150	0.2550	4elbows, 1g.v, 1 tee	32 x 20	0.039
N to O	1.5	0.05	2.0	0.027	15	0.0200	0.0400	3 elbows, 1 g.v	20 x 15	0.011
			91.9				1.3719			0.514

Table 6: Calculations for Pipe Sizes and Head Loss Components for Water Distribution for an Available Head of 5m to 2 Bungalows, 34 Appliances, 1.35 L/s Flow Rate

1	2	3	4	5	6	7	8	9	10	11
Pipe section No. (See Fig. 1)	Loading unit	Design Flow (L/s)	Pipe length (m)	Permissible max. H/L	Dia. (mm)	Actual H/L	Frictional head loss h_f (m)	Fittings (other than reducers)	Reducers (mmxmm)	Loss thru fittings, h_p (m)
A to B	99.0	1.35	25.8	0.053	40	0.050	1.2900	3 elbows, 2 gate v., 1 tee	-	0.289
B to C	95.5	1.30	3.6	0.053	40	0.046	0.1656	1 tee	-	0.113
C to D	90.5	1.25	3.4	0.053	40	0.036	0.1224	1 tee	-	0.104
D to F	75.0	1.10	12.4	0.053	40	0.028	0.3472	1 elbow, 1 tee	-	0.107
F to G	68.5	0.98	5.6	0.053	40	0.028	0.1568	1 tee	-	0.062
G to H	53.0	0.90	4.0	0.053	40	0.025	0.1000	1 tee	-	0.052
H to K	49.5	0.88	8.0	0.053	40	0.024	0.1920	1 g.v, 1 tee	-	0.056
K to L	25.5	0.50	7.0	0.053	32	0.022	0.1540	1 tee	40 x 32	0.041
L to M	19.0	0.43	5.6	0.053	25	0.050	0.2800	1 tee	32 x 25	0.083
M to N	3.5	0.12	17.0	0.053	20	0.015	0.2550	4 elbows, 1 g. v, 1 tee	25 x 20	0.040
N to O	1.5	0.05	2.0	0.053	15	0.020	0.0400	3 elbows, 1 g. v.	20 x 15	0.011
			94.4				3.103			0.958

Table 7: Calculations for Pipe Sizes and Head Loss Components for Water Distribution for an Available Head of 7.5m to 2 Bungalows, 34 Appliances, 1.35 L/s Flow Rate

1	2	3	4	5	6	7	8	9	10	11
Pipe section No. (See Fig. 1)	Loading unit	Design Flow (L/s)	Pipe length (m)	Permissible max. H/L	Dia. (mm)	Actual H/L	Frictional head loss h_f (m)	Fittings (other than reducers)	Reducers (mmxmm)	Loss thru fittings, h_p (m)
A to B	99.0	1.35	28.3	0.077	40	0.050	1.4250	3 elbows, 2 gate v., 1 tee	-	0.289
B to C	95.5	1.30	3.6	0.077	40	0.046	0.1656	1 tee	-	0.113
C to D	90.5	1.25	3.4	0.077	40	0.036	0.1224	1 tee	-	0.104
D to F	75.0	1.10	12.4	0.077	40	0.028	0.3472	1 elbow, 1 tee	-	0.107
F to G	68.5	0.98	5.6	0.077	40	0.028	0.1568	1 tee	-	0.062
G to H	53.0	0.90	4.0	0.077	32	0.063	0.2520	1 tee	40 x 32	0.134
H to K	49.5	0.88	8.0	0.077	32	0.060	0.4800	1 g.v ,1 tee	-	0.174
K to L	25.5	0.50	7.0	0.077	25	0.065	0.4550	1 tee	32 x 25	0.112
L to M	19.0	0.43	5.6	0.077	25	0.050	0.2800	1 tee	-	0.078
M to N	3.5	0.12	17.0	0.077	20	0.015	0.2550	4 elbows, 1g.v, 1 tee	25 x 20	0.040
N to O	1.5	0.05	2.0	0.077	15	0.020	0.0400	3 elbows, 1 g.v	20 x 15	0.011
			96.9				3.979			1.224

Table 8: Calculations for Pipe Sizes and Head Loss Components for Water Distribution for an Available Head of 10.0m to 2 Bungalows, 34 Appliances, 1.35 L/s Flow Rate

1	2	3	4	5	6	7	8	9	10	11
Pipe section No. (See Fig. 1)	Loading unit	Design Flow (L/s)	Pipe length (m)	Permissible max. H/L	Dia. (mm)	Actual H/L	Frictional head loss h_f (m)	Fittings (other than reducers)	Reducers (mmxmm)	Loss thru fittings, h_p (m)
A to B	99.0	1.35	30.8	0.101	40	0.050	1.5400	3 elbows, 2 gate v., 1 tee	-	0.289
B to C	95.5	1.30	3.6	0.101	40	0.046	0.1656	1 tee	-	0.113
C to D	90.5	1.25	3.4	0.101	40	0.036	0.1224	1 tee	-	0.104
D to F	75.0	1.10	12.4	0.101	32	0.085	1.0540	1 elbow, 1 tee	40 x 32	0.345
F to G	68.5	0.98	5.6	0.101	32	0.080	0.4480	1 tee	-	0.192
G to H	53.0	0.80	4.0	0.101	32	0.063	0.2520	1 tee	-	0.127
H to K	49.5	0.88	8.0	0.101	32	0.060	0.4800	1 g.v, 1 tee	-	0.174
K to L	25.5	0.50	7.0	0.101	25	0.065	0.4550	1 tee	32 x 25	0.112
L to M	19.0	0.43	5.6	0.101	25	0.050	0.2800	1 tee	-	0.078
M to N	3.5	0.12	17.0	0.101	20	0.015	0.2550	4 elbow, 1g.v.,1 tee	25 x 20	0.040
N to O	1.5	0.05	2.0	0.101	15	0.020	0.0400	3 elbows, 1 g.v.	20 x 15	0.011
			99.4				5.099			1.585

Table 9: Parameters of Distribution System to 1 Bungalow of 17 Appliances and 0.88L/s Flow Rate

Available Distribution head (m)	Frictional loss in 1st index run (m)	Loss thru fittings in 1st index run (m)	Total loss in 1st index run (m)	Ratio of loss thru fittings to total loss
2.5	1.168	0.348	1.516	0.230
5.0	3.297	0.784	4.081	0.192
7.5	3.447	0.784	4.231	0.185
10.0	5.127	0.871	5.998	0.145

Table 10: Parameters of Distribution System to 2 Bungalows of 34 Appliances and 1.35L/s Flow Rate

Available Distribution head (m)	Frictional loss in 1st index run (m)	Loss thru fittings in 1st index run (m)	Total loss in 1st index run (m)	Ratio of loss thru fittings to total loss
2.5	1.379	0.514	1.893	0.272
5.0	3.103	0.958	4.061	0.236
7.5	3.979	1.224	5.203	0.235
10.0	5.092	1.585	6.677	0.237

Table 11: Parameters of Distribution System to 3 Bungalows of 51 Appliances and 1.85L/s Flow Rate

Available Distribution head (m)	Frictional loss in 1st index run (m)	Loss thru fittings in 1st index run (m)	Total loss in 1st index run (m)	Ratio of loss thru fittings to total loss
2.5	1.804	0.746	2.550	0.293
5.0	2.263	0.855	3.118	0.274
7.5	3.584	1.098	4.682	0.235
10.0	6.777	1.752	8.529	0.205

Table 12: Parameters of Distribution System to 4 Bungalows of 68 Appliances and 2.35L/s Flow Rate

Available Distribution head (m)	Frictional loss in 1st index run (m)	Loss thru fittings in 1st index run (m)	Total loss in 1st index run (m)	Ratio of loss thru fittings to total loss
2.5	1.570	0.599	2.169	0.276
5.0	2.678	1.303	3.981	0.327
7.5	3.729	1.563	5.292	0.295
10.0	4.559	1.829	6.388	0.286

Table 13: Parameters of Distribution System to 5 Bungalows of 85 Appliances and 2.65L/s Flow Rate

Available Distribution head (m)	Frictional loss in 1st index run (m)	Loss thru fittings in 1st index run (m)	Total loss in 1st index run (m)	Ratio of loss thru fittings to total loss
2.5	1.621	0.867	2.488	0.348
5.0	3.085	1.600	4.685	0.342
7.5	3.630	1.718	5.348	0.321
10.0	4.816	1.952	6.768	0.288

Table 14: Parameters of Distribution System to 6 Bungalows of 102 Appliances and 2.90L/s Flow Rate

Available Distribution head (m)	Frictional loss in 1st index run (m)	Loss thru fittings in 1st index run (m)	Total loss in 1st index run (m)	Ratio of loss thru fittings to total loss
2.5	2.263	0.969	3.232	0.300
5.0	2.598	1.524	4.122	0.370
7.5	4.267	2.340	6.607	0.354
10.0	5.117	2.534	7.651	0.331

Table 15: Parameters of Distribution System to 7 Bungalows of 119 Appliances and 3.20L/s Flow Rate

Available Distribution head (m)	Frictional loss in 1st index run (m)	Loss thru fittings in 1st index run (m)	Total loss in 1st index run (m)	Ratio of loss thru fittings to total loss
2.5	1.402	0.970	2.372	0.409
5.0	2.821	1.457	4.278	0.341
7.5	4.776	2.372	7.148	0.332
10.0	5.044	2.558	7.602	0.336

Table 16: Parameters of Distribution System to 8 Bungalows of 136 Appliances and 3.70L/s Flow Rate

Available Distribution head (m)	Frictional loss in 1st index run (m)	Loss thru fittings in 1st index run (m)	Total loss in 1st index run (m)	Ratio of loss thru fittings to total loss
2.5	1.480	1.230	2.710	0.454
5.0	3.536	1.978	5.514	0.359
7.5	4.399	2.693	7.092	0.380
10.0	4.774	2.930	7.704	0.380

Table 17: Parameters of Distribution System to 9 Bungalows of 153 Appliances and 4.00L/s Flow Rate

Available Distribution head (m)	Frictional loss in 1st index run (m)	Loss thru fittings in 1st index run (m)	Total loss in 1st index run (m)	Ratio of loss thru fittings to total loss
2.5	1.490	1.151	2.641	0.436
5.0	3.456	1.996	5.452	0.366
7.5	4.175	2.494	6.669	0.374
10.0	5.288	2.878	8.166	0.352

Table 18: Parameters of Distribution System to 10 Bungalows of 170 Appliances and 4.25L/s Flow Rate

Available Distribution head (m)	Frictional loss in 1st index run (m)	Loss thru fittings in 1st index run (m)	Total loss in 1st index run (m)	Ratio of loss thru fittings to total loss
2.5	1.647	1.460	3.107	0.470
5.0	2.928	2.115	5.043	0.419
7.5	5.319	2.785	8.104	0.344
10.0	5.433	3.439	8.872	0.388

Table 19: Parameters of Distribution System to 11 Bungalows of 187 Appliances and 4.35L/s Flow Rate

Available Distribution head (m)	Frictional loss in 1st index run (m)	Loss thru fittings in 1st index run (m)	Total loss in 1st index run (m)	Ratio of loss thru fittings to total loss
2.5	1.190	0.837	2.027	0.413
5.0	3.166	2.329	5.495	0.424
7.5	5.105	3.232	8.337	0.388
10.0	5.604	3.249	8.853	0.367

Table 20: Parameters of Distribution System to 12 Bungalows of 204 Appliances and 4.50L/s Flow Rate

Available Distribution head (m)	Frictional loss in 1st index run (m)	Loss thru fittings in 1st index run (m)	Total loss in 1st index run (m)	Ratio of loss thru fittings to total loss
2.5	1.578	1.165	2.743	0.425
5.0	3.059	2.486	5.545	0.448
7.5	4.261	3.325	7.586	0.438
10.0	6.143	3.830	9.973	0.384

Table 21: Parameters of Distribution System to 13 Bungalows of 221 Appliances and 4.64L/s Flow Rate

Available Distribution head (m)	Frictional loss in 1st index run (m)	Loss thru fittings in 1st index run (m)	Total loss in 1st index run (m)	Ratio of loss thru fittings to total loss
2.5	1.240	1.082	2.322	0.466

5.0	3.213	2.580	5.793	0.445
7.5	4.639	3.111	7.750	0.401
10.0	6.132	4.079	10.211	0.399

Table 22: Parameters of Distribution System to 14 Bungalows of 238 Appliances and 4.80L/s Flow Rate

Available Distribution head (m)	Frictional loss in 1st index run (m)	Loss thru fittings in 1st index run (m)	Total loss in 1st index run (m)	Ratio of loss thru fittings to total loss
2.5	1.278	1.328	2.606	0.510
5.0	3.031	2.630	5.661	0.465
7.5	4.283	3.368	7.651	0.440
10.0	6.631	4.859	11.490	0.423

Table 23: Parameters of Distribution System to 15 Bungalows of 255 Appliances and 5.00L/s Flow Rate

Available Distribution head (m)	Frictional loss in 1st index run (m)	Loss thru fittings in 1st index run (m)	Total loss in 1st index run (m)	Ratio of loss thru fittings to total loss
2.5	1.289	1.177	2.466	0.477
5.0	3.169	2.890	6.009	0.473
7.5	4.699	3.370	8.069	0.408
10.0	6.483	4.536	11.019	0.412

Table 24: Parameters of Distribution System to 16 Bungalows of 272 Appliances and 5.60L/s Flow Rate

Available Distribution head (m)	Frictional loss in 1st index run (m)	Loss thru fittings in 1st index run (m)	Total loss in 1st index run (m)	Ratio of loss thru fittings to total loss
2.5	1.243	1.222	2.465	0.496
5.0	2.757	2.710	4.927	0.550
7.5	3.594	3.024	6.618	0.457
10.0	6.368	4.788	11.156	0.429

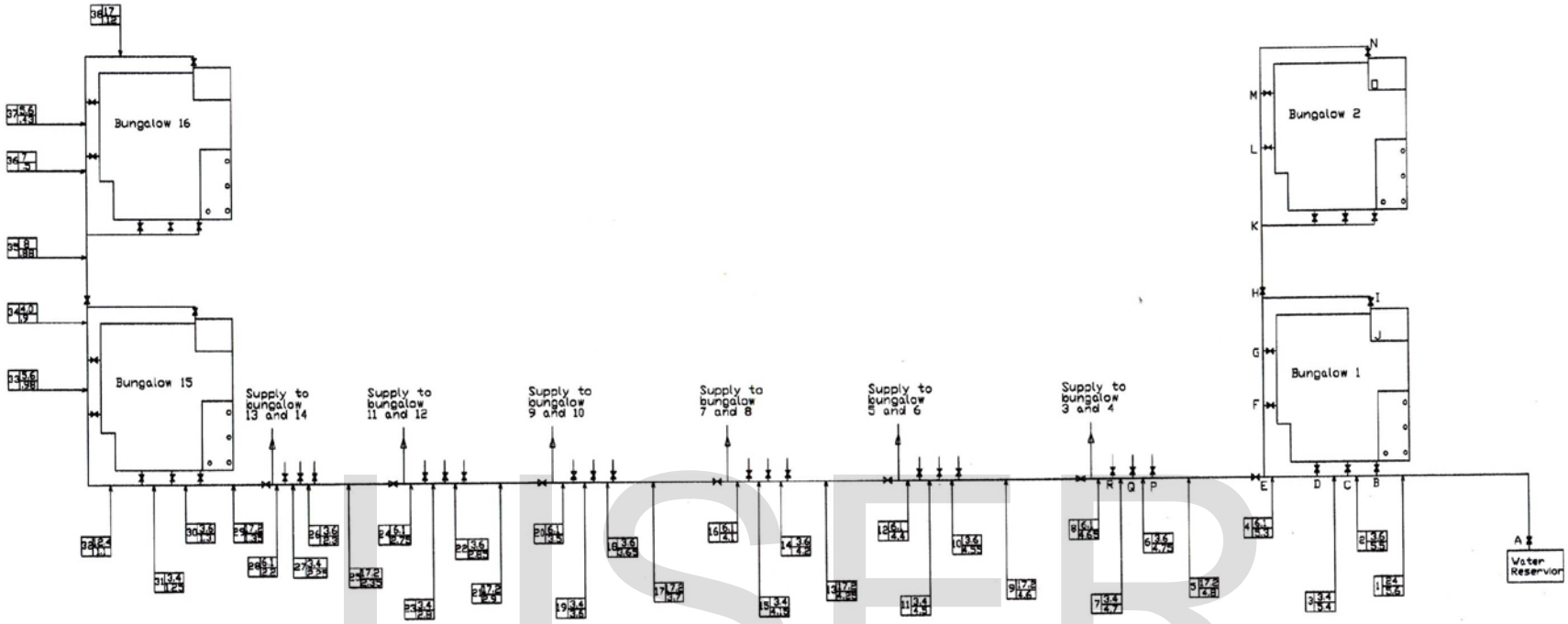
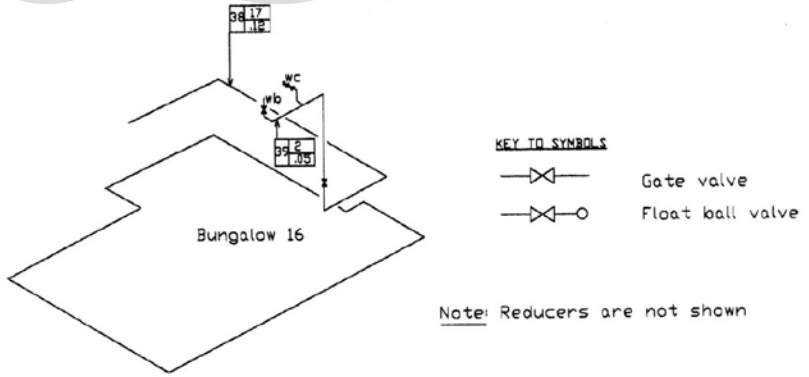


Figure 1: Water Distribution Layout to a Group of 16 Bungalows



Note: Reducers are not shown

Figure 2: Isometric Sketch Showing Last Pipe Section (Section 39)

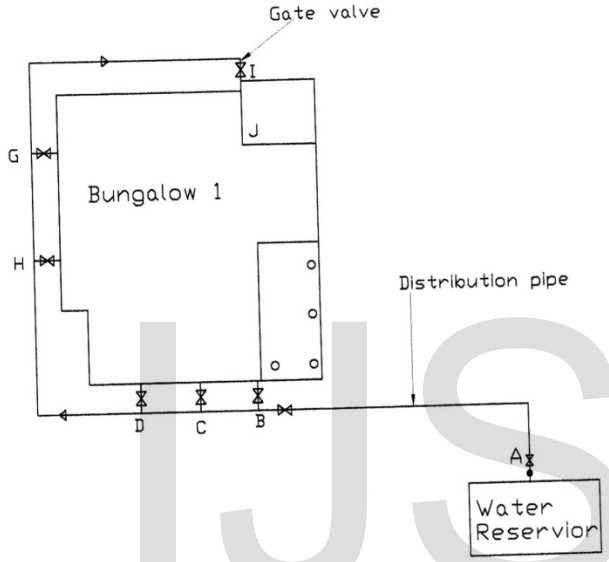


Figure 3 : Distribution Layout to One Bungalow

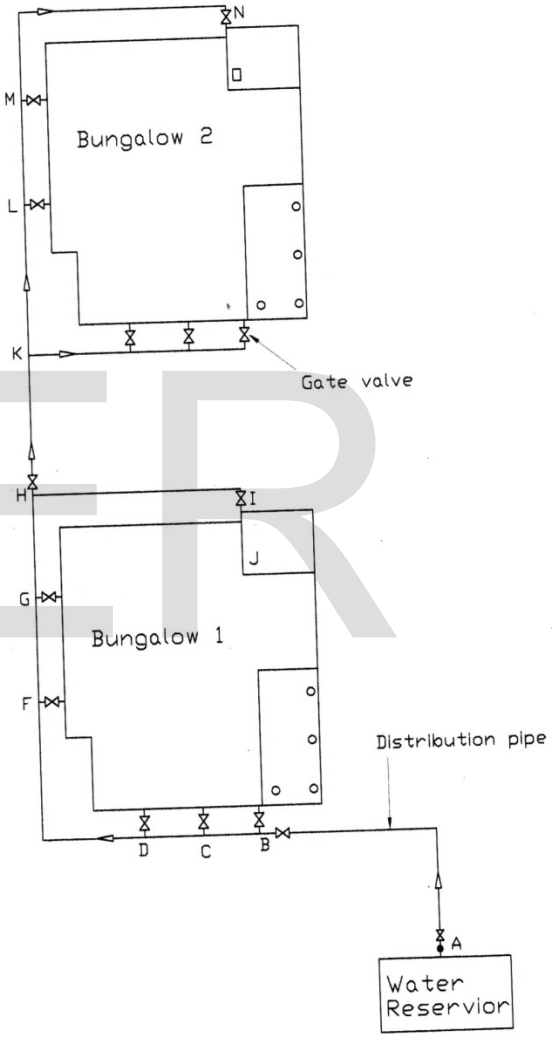


Figure 4 : Distribution Layout to Two Bungalows

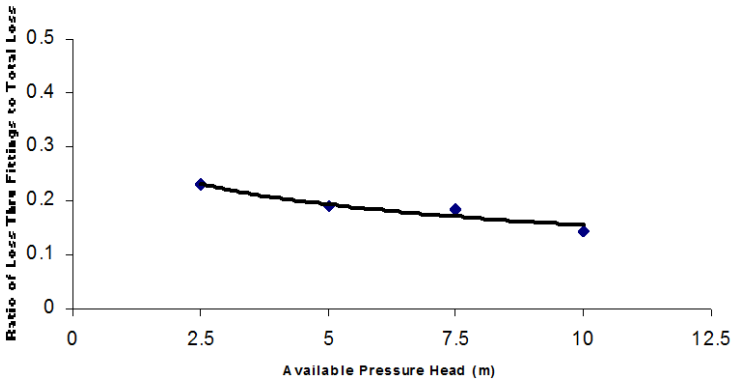


Fig. 5: Variation of Fitting Loss Fraction with Available Head for Distribution to 1 Bungalow with 17 Appliances and 0.88 L/s Flow Rate

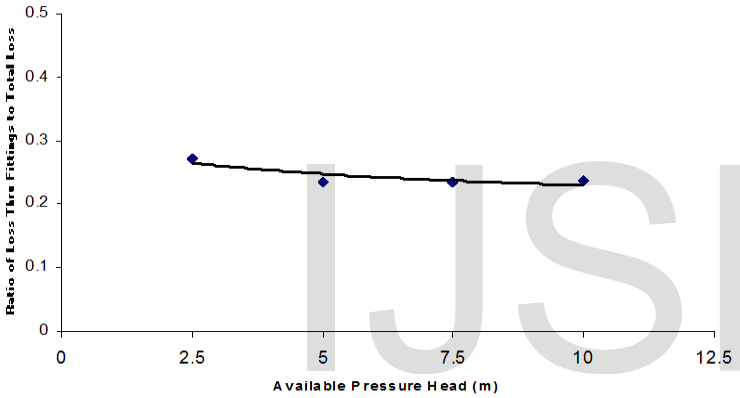


Fig. 6: Variation of Fitting Loss Fraction with Available Head for Distribution to 2 Bungalows with 34 Appliances and 1.35 L/s Flow Rate

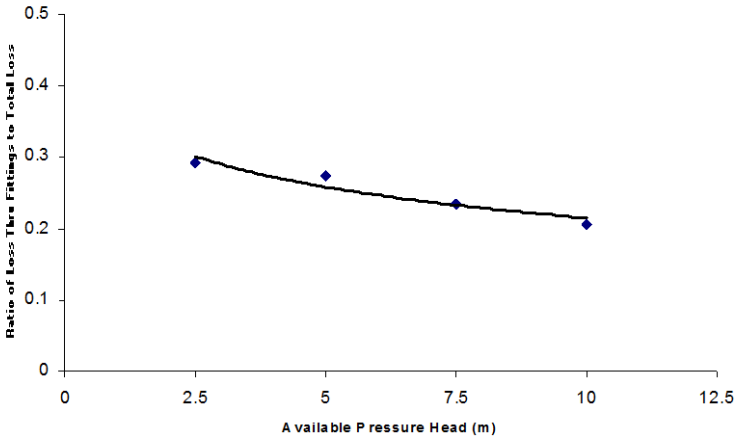


Fig. 7: Variation of Fitting Loss Fraction with Available Head for Distribution to 3 Bungalows with 51 Appliances and 1.85 L/s Flow Rate

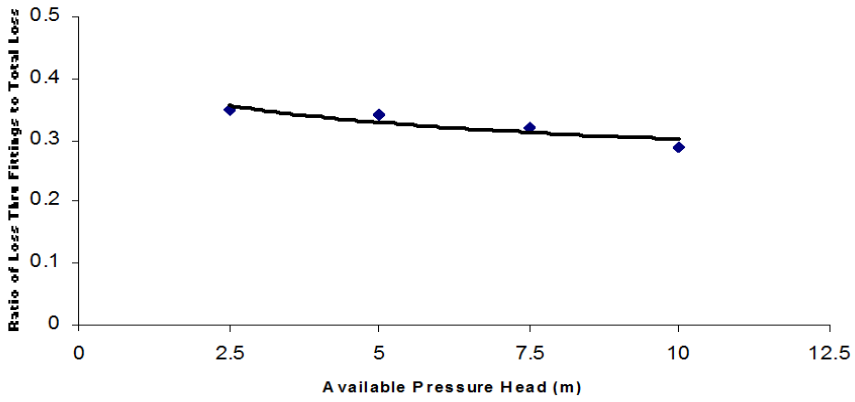


Fig. 8: Variation of Fitting Loss Fraction with Available Head for Distribution to 4 Bungalows with 68 Appliances and 2.35 L/s Flow Rate

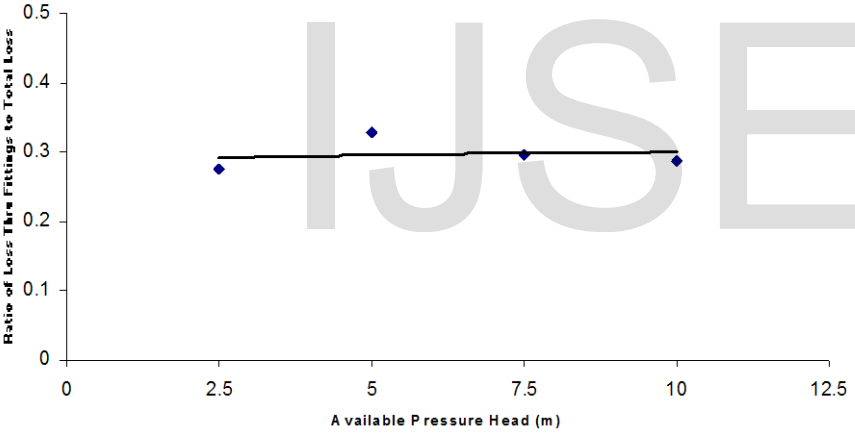


Fig. 9: Variation of Fitting Loss Fraction with Available Head for Distribution to 5 Bungalows with 85 Appliances and 2.65 L/s Flow Rate

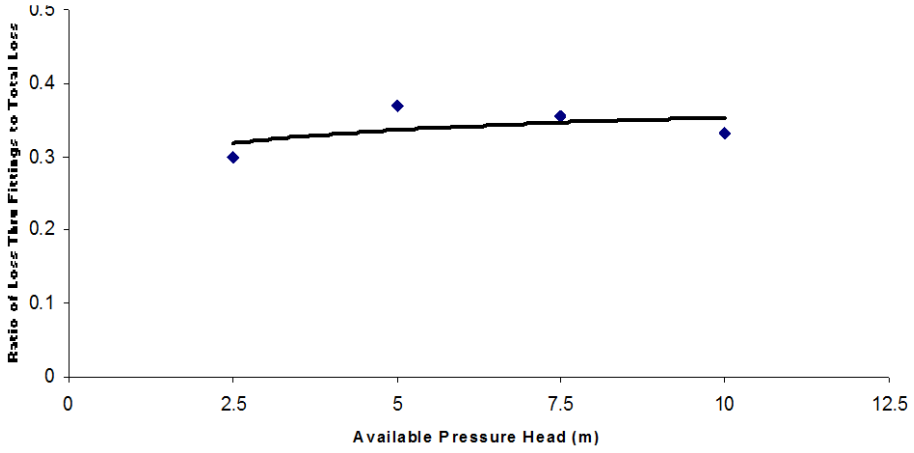


Fig. 10: Variation of Fitting Loss Fraction with Available Head for Distribution to 6 Bungalows with 102 Appliances and 2.90 L/s Flow Rate

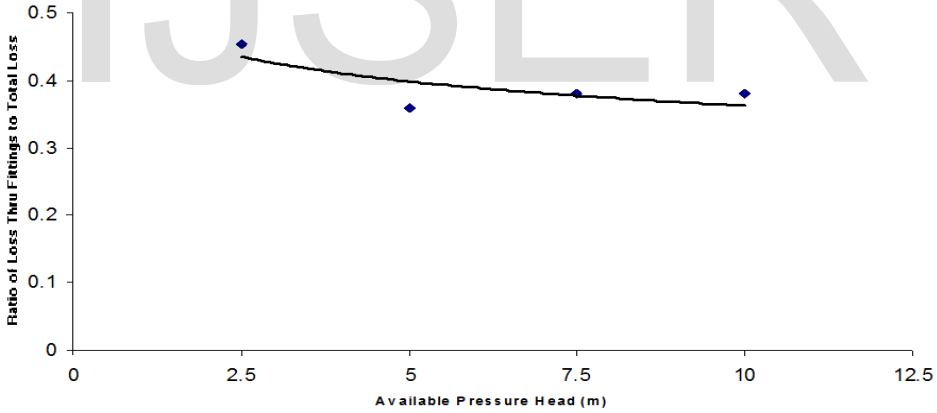


Fig. 11: Variation of Fitting Loss Fraction with Available Head for Distribution to 7 Bungalows with 119 Appliances and 3.20 L/s Flow Rate

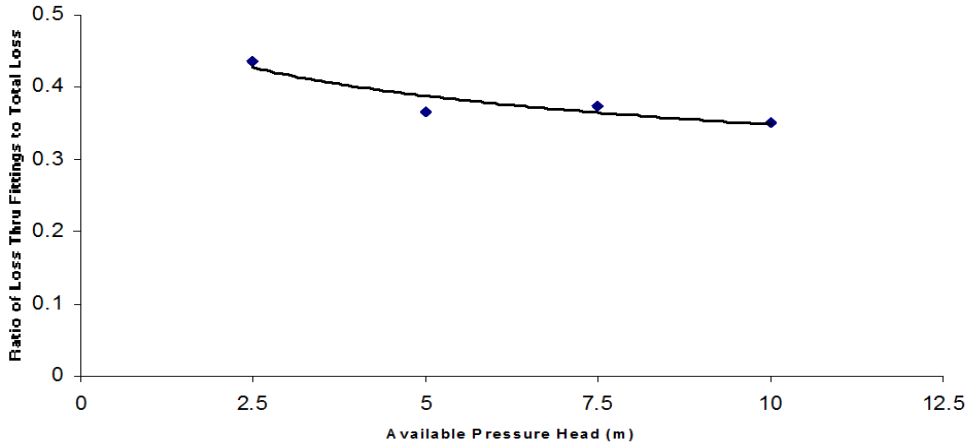


Fig. 12: Variation of Fitting Loss Fraction with Available Head for Distribution to 8 Bungalows with 136 Appliances and 3.70 L/s Flow Rate

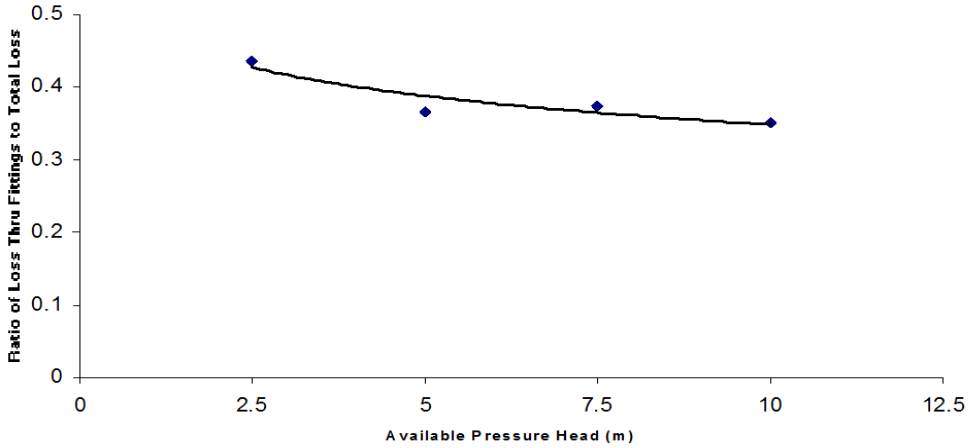


Fig. 13: Variation of Fitting Loss Fraction with Available Head for Distribution to 9 Bungalows with 153 Appliances and 4.00 L/s Flow Rate

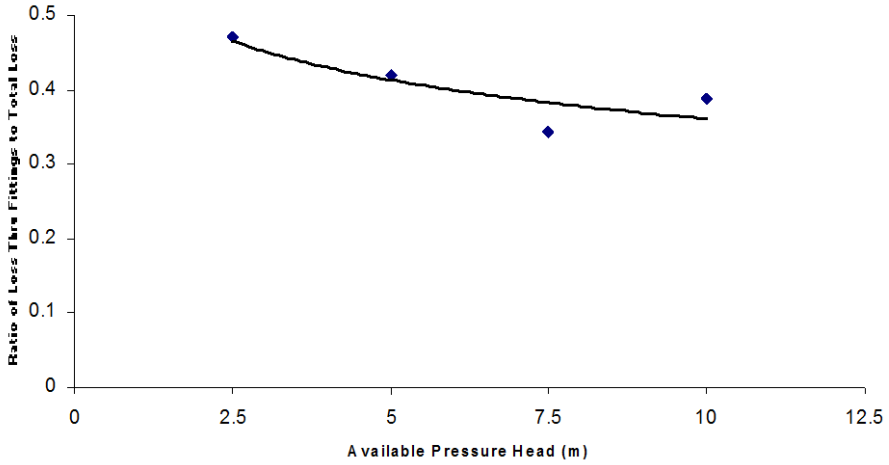


Fig. 14: Variation of Fitting Loss Fraction with Available Head for Distribution to 10 Bungalows with 170 Appliances and 4.25 L/s Flow Rate

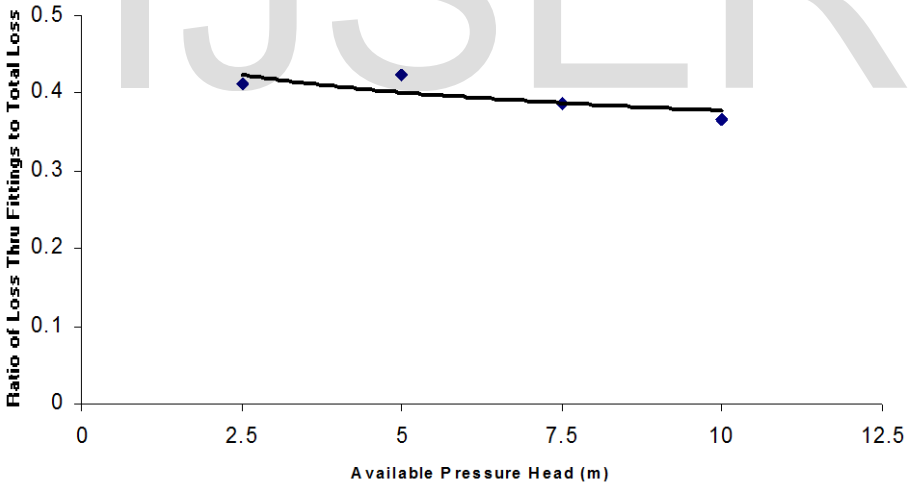


Fig. 15: Variation of Fitting Loss Fraction with Available Head for Distribution to 11 Bungalows with 187 Appliances and 4.35 L/s Flow Rate

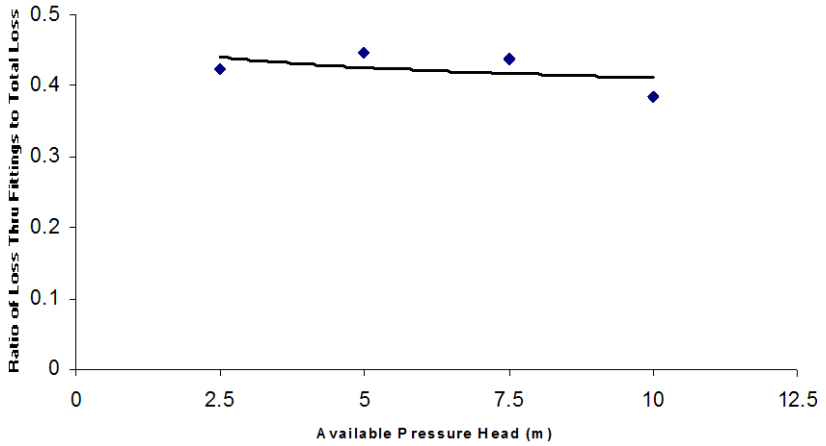


Fig. 16: Variation of Fitting Loss Fraction with Available Head for Distribution to 12 Bungalows with 204 Appliances and 4.60 L/s Flow Rate

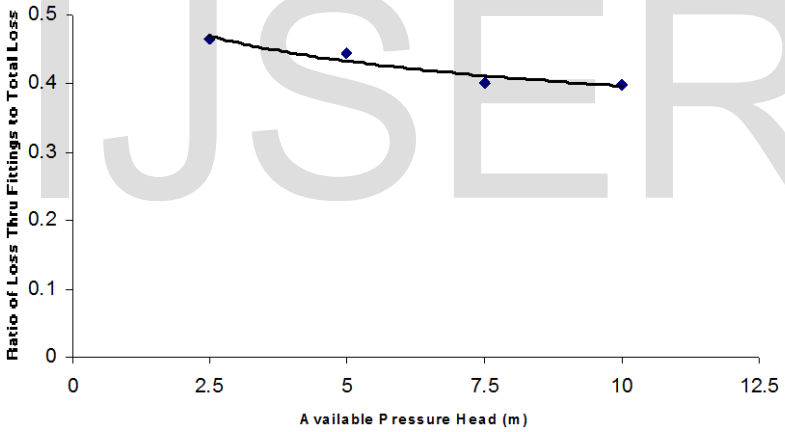


Fig. 17: Variation of Fitting Loss Fraction with Available Head for Distribution to 13 Bungalows with 221 Appliances and 4.64 L/s Flow Rate

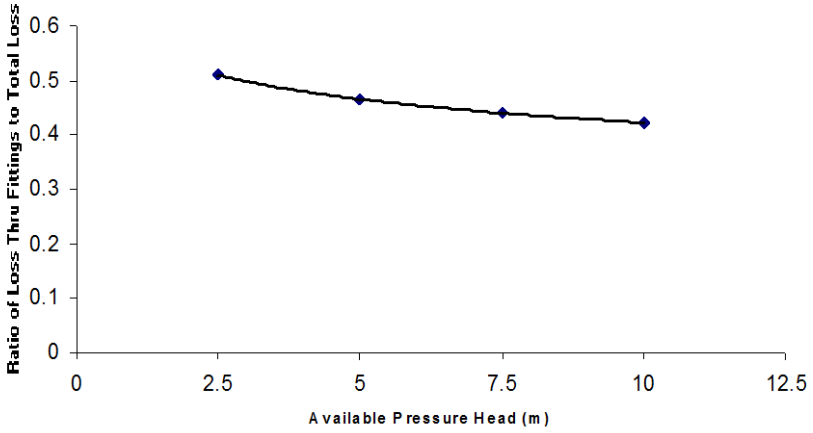


Fig. 18: Variation of Fitting Loss Fraction with Available Head for Distribution to 14 Bungalows with 238 Appliances and 4.80 L/s Flow Rate

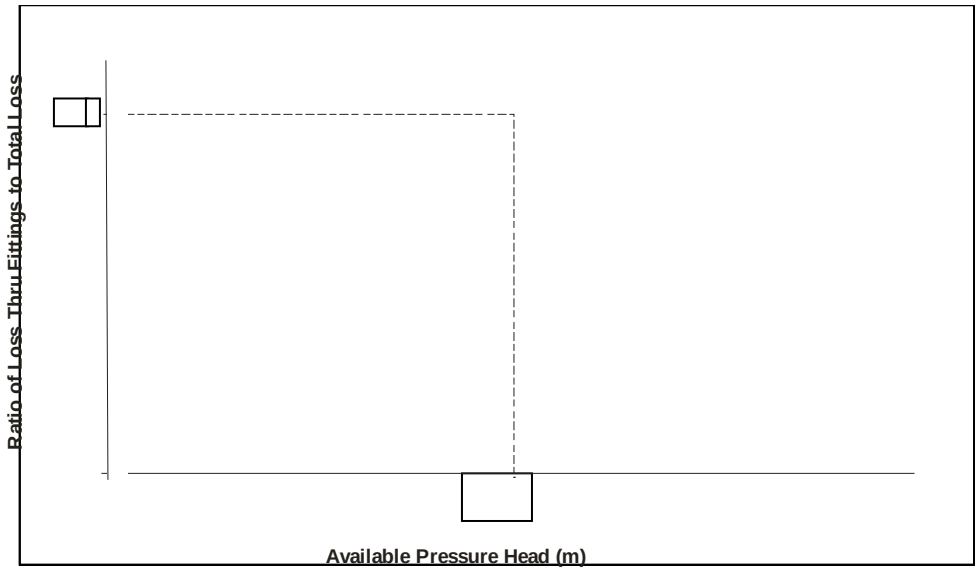


Fig. 19: Variation of Fitting Loss Fraction with Available Head for Distribution to 15 Bungalows with 255 Appliances and 5.00 L/s Flow Rate

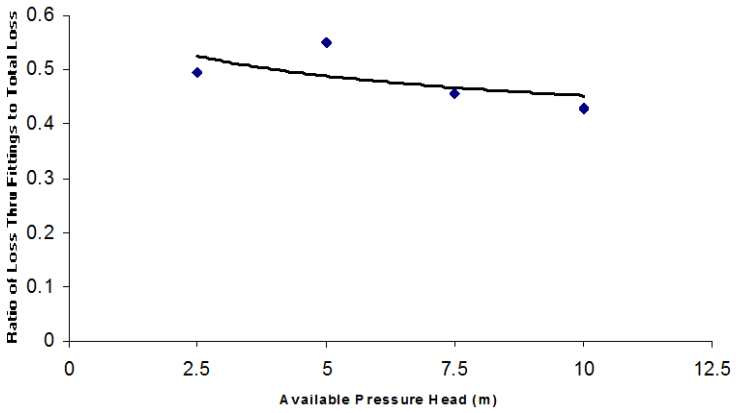


Fig. 20: Variation of Fitting Loss Fraction with Available Head for Distribution to 16 Bungalows with 272 Appliances and 5.60 L/s Flow Rate